

# **POWER MOS DEVICES**

**DATABOOK**

1<sup>st</sup> EDITION

**JUNE 1988**

## **USE IN LIFE SUPPORT MUST BE EXPRESSLY AUTHORIZED**

SGS-THOMSON PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF SGS-THOMSON Microelectronics. As used herein:

- 1 - Life support devices or systems are devices or systems which, are intended for surgical implant into the body to support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
- 2 - A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



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# INTRODUCTION



POWER MOS devices are made using well proven SGS-THOMSON technology. POWER MOS technology stands, with equal stature, firmly alongside the company's POWER BIPOLAR technologies. This DATABOOK has been produced to complement the advances in silicon technology and isolated packaging.

The DATABOOK contains data sheets and technical notes on the range of POWER MOS devices

for applications in industrial, automotive, computer, telecommunication, professional, and consumer equipment.

Selection guides are provided in the following pages to facilitate rapid identification of the most suitable device for the intended use.

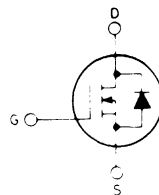
The extensive information makes it easy to evaluate the performance of the product within any required equipment design.

## N-CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

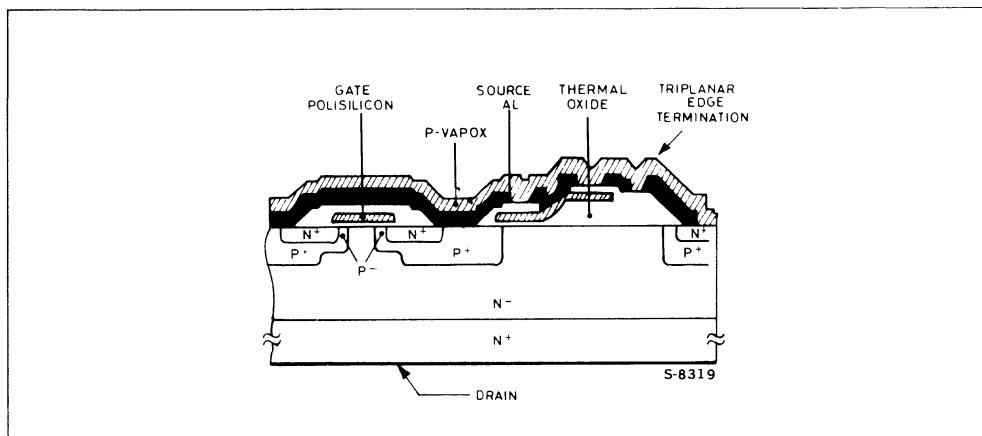
### MAIN FEATURES:

- ULTRA FAST SWITCHING
- EASY DRIVE
- VERY LOW STORAGE TIME
- LOW SWITCHING LOSSES
- NO SECONDARY BREAKDOWN

### INTERNAL SCHEMATIC DIAGRAM



### Standard structure



POWER MOS is a technology used to produce power devices featuring easy drive and high switching speed.

POWER MOS transistors are produced using a DMOS structure where the channel is obtained by lateral diffusion. The surface has a two tier structure; the lower level is the polysilicon gate, and the upper level is the source metallization. The structure is self-aligning as the polysilicon holes are used as a mask for the P<sup>-</sup> well and the N<sup>+</sup> source diffusion. The MOS channel is created by the difference in lateral diffusion of the two impurity distributions.

The resulting accuracy of this process controls the channel length to  $\leq 1.5$  microns and the use of a polycrystalline gate maintains a high stability of threshold voltage.

POWER MOS devices are available in a low voltage group, 50-250 volts  $V_{DSS}$  and high voltage range 250 to 1000 volt  $V_{DSS}$ . Devices with a maximum drain current of 52 A per chip are currently available. When used in a pulse mode,  $I_{DSS\ max} \approx 4 \times I_{DSS}$  or more.

Applications are in the field of power control and include, DC-DC converters, switching power supplies, actuator drivers, motor control, robotics etc. The latest development in POWER MOS technology has generated high density cell structures which for the same surface area increase the current density of these devices. High density POWER MOS devices are designed for breakdown voltages up to 100V, which is the maximum voltage where increasing the cell density can give real advantages in current capability (or RDSON).

# SELECTION GUIDE BY PART NUMBER

| Type      | V <sub>(BR)DSS</sub><br>(V) | R <sub>DS(on)</sub> <sup>①</sup><br>(max)<br>(Ω) | I <sub>D</sub><br>(A) | Package    | I <sub>D(max)</sub><br>(A) | P <sub>tot</sub><br>(W) | g <sub>fs</sub><br>min<br>(mho) | C <sub>iss</sub><br>max<br>(pF) | Page |
|-----------|-----------------------------|--------------------------------------------------|-----------------------|------------|----------------------------|-------------------------|---------------------------------|---------------------------------|------|
| BUZ10     | 50                          | 0.08                                             | 13.00                 | TO-220     | 20.00                      | 70                      | 8.00                            | 700typ                          | 159  |
| BUZ10A    | 50                          | 0.12                                             | 10.00                 | TO-220     | 17.00                      | 75                      | 3.00                            | 2000                            | 163  |
| BUZ11     | 50                          | 0.04                                             | 15.00                 | TO-220     | 30.00                      | 75                      | 4.00                            | 2000                            | 167  |
| BUZ11A    | 50                          | 0.06                                             | 15.00                 | TO-220     | 25.00                      | 75                      | 4.00                            | 2000                            | 173  |
| BUZ11FI   | 50                          | 0.04                                             | 15.00                 | ISOWATT220 | 20.00                      | 35                      | 4.00                            | 2000                            | 167  |
| BUZ11S2   | 60                          | 0.04                                             | 15.00                 | TO-220     | 30.00                      | 75                      | 4.00                            | 2000                            | 177  |
| BUZ11S2FI | 60                          | 0.04                                             | 15.00                 | ISOWATT220 | 20.00                      | 35                      | 4.00                            | 2000                            | 177  |
| BUZ20     | 100                         | 0.20                                             | 6.00                  | TO-220     | 12.00                      | 75                      | 2.70                            | 2000                            | 183  |
| BUZ21     | 100                         | 0.10                                             | 9.00                  | TO-220     | 19.00                      | 75                      | 4.00                            | 2000                            | 187  |
| BUZ25     | 100                         | 0.10                                             | 9.00                  | TO-3       | 19.00                      | 78                      | 4.00                            | 2000                            | 191  |
| BUZ32     | 200                         | 0.40                                             | 4.50                  | TO-220     | 9.50                       | 75                      | 2.20                            | 2000                            | 195  |
| BUZ41A    | 500                         | 1.50                                             | 2.50                  | TO-220     | 4.50                       | 75                      | 1.50                            | 2000                            | 199  |
| BUZ42     | 500                         | 2.00                                             | 2.50                  | TO-220     | 4.00                       | 75                      | 1.50                            | 2000                            | 203  |
| BUZ45     | 500                         | 0.60                                             | 5.00                  | TO-3       | 9.60                       | 125                     | 2.70                            | 4900                            | 207  |
| BUZ45A    | 500                         | 0.80                                             | 5.00                  | TO-3       | 8.30                       | 125                     | 2.70                            | 4900                            | 211  |
| BUZ60     | 400                         | 1.00                                             | 2.50                  | TO-220     | 5.50                       | 75                      | 1.70                            | 2000                            | 215  |
| BUZ60B    | 400                         | 1.50                                             | 2.50                  | TO-220     | 4.50                       | 75                      | 1.70                            | 2000                            | 219  |
| BUZ71     | 50                          | 0.10                                             | 9.00                  | TO-220     | 14.00                      | 40                      | 3.00                            | 650                             | 223  |
| BUZ71A    | 50                          | 0.12                                             | 9.00                  | TO-220     | 13.00                      | 40                      | 3.00                            | 650                             | 229  |
| BUZ71FI   | 50                          | 0.10                                             | 9.00                  | ISOWATT220 | 12.00                      | 30                      | 3.00                            | 650                             | 223  |
| BUZ72A    | 100                         | 0.25                                             | 5.00                  | TO-220     | 9.00                       | 40                      | 2.70                            | 600                             | 233  |
| BUZ74     | 500                         | 3.00                                             | 1.20                  | TO-220     | 2.40                       | 40                      | 0.80                            | 500                             | 237  |
| BUZ74A    | 500                         | 4.00                                             | 1.20                  | TO-220     | 2.00                       | 40                      | 0.80                            | 500                             | 241  |
| BUZ76     | 400                         | 1.80                                             | 1.50                  | TO-220     | 3.00                       | 40                      | 0.80                            | 500                             | 245  |
| BUZ76A    | 400                         | 2.50                                             | 1.50                  | TO-220     | 2.60                       | 40                      | 0.80                            | 500                             | 249  |
| BUZ353    | 500                         | 0.60                                             | 5.50                  | TO-220     | 9.50                       | 125                     | 2.70                            | 4900                            | 253  |
| BUZ354    | 500                         | 0.80                                             | 5.50                  | TO-218     | 8.00                       | 125                     | 2.70                            | 4900                            | 257  |
| IRF140    | 100                         | 0.077                                            | 17.00                 | TO-3       | 28.00                      | 125                     | 8.70                            | 1600                            | 261  |
| IRF141    | 80                          | 0.077                                            | 17.00                 | TO-3       | 28.00                      | 125                     | 8.70                            | 1600                            | 261  |
| IRF142    | 100                         | 0.10                                             | 17.00                 | TO-3       | 25.00                      | 125                     | 8.70                            | 1600                            | 261  |
| IRF143    | 80                          | 0.10                                             | 17.00                 | TO-3       | 25.00                      | 125                     | 8.70                            | 1600                            | 261  |
| IRF150    | 100                         | 0.055                                            | 20.00                 | TO-3       | 40.00                      | 150                     | 9.00                            | 3000                            | 267  |
| IRF151    | 60                          | 0.055                                            | 20.00                 | TO-3       | 40.00                      | 150                     | 9.00                            | 3000                            | 267  |
| IRF152    | 100                         | 0.08                                             | 20.00                 | TO-3       | 33.00                      | 150                     | 9.00                            | 3000                            | 267  |
| IRF153    | 60                          | 0.08                                             | 20.00                 | TO-3       | 33.00                      | 150                     | 9.00                            | 3000                            | 267  |
| IRF350    | 400                         | 0.30                                             | 8.00                  | TO-3       | 15.00                      | 150                     | 8.00                            | 3000                            | 273  |
| IRF450    | 500                         | 0.40                                             | 7.20                  | TO-3       | 13.00                      | 150                     | 8.70                            | 3000                            | 279  |
| IRF451    | 450                         | 0.40                                             | 7.20                  | TO-3       | 13.00                      | 150                     | 8.70                            | 3000                            | 279  |
| IRF452    | 500                         | 0.50                                             | 7.20                  | TO-3       | 11.00                      | 150                     | 8.70                            | 3000                            | 279  |
| IRF453    | 450                         | 0.50                                             | 7.20                  | TO-3       | 11.00                      | 150                     | 8.70                            | 3000                            | 279  |
| IRF520    | 100                         | 0.27                                             | 5.60                  | TO-220     | 9.20                       | 60                      | 2.70                            | 600                             | 285  |
| IRF520FI  | 100                         | 0.27                                             | 5.60                  | ISOWATT220 | 7.00                       | 30                      | 2.70                            | 600                             | 285  |
| IRF521    | 80                          | 0.27                                             | 5.60                  | TO-220     | 9.20                       | 60                      | 2.70                            | 600                             | 285  |
| IRF521FI  | 80                          | 0.27                                             | 5.60                  | ISOWATT220 | 7.00                       | 30                      | 2.70                            | 600                             | 285  |
| IRF522    | 100                         | 0.36                                             | 5.60                  | TO-220     | 8.00                       | 60                      | 2.70                            | 600                             | 285  |

# SELECTION GUIDE BY PART NUMBER

| Type     | V <sub>(BR)DSS</sub><br>(V) | R <sub>DS(on)</sub><br>(max)<br>(Ω) | I <sub>D</sub><br>(A) | Package    | I <sub>D(max)</sub><br>(A) | P <sub>tot</sub><br>(W) | g <sub>fs</sub><br>min<br>(mho) | C <sub>iss</sub><br>max<br>(pF) | Page |
|----------|-----------------------------|-------------------------------------|-----------------------|------------|----------------------------|-------------------------|---------------------------------|---------------------------------|------|
| IRF522FI | 100                         | 0.36                                | 5.60                  | ISOWATT220 | 6.00                       | 30                      | 2.70                            | 600                             | 285  |
| IRF523   | 80                          | 0.36                                | 5.60                  | TO-220     | 8.00                       | 60                      | 2.70                            | 600                             | 285  |
| IRF523FI | 80                          | 0.36                                | 5.60                  | ISOWATT220 | 6.00                       | 30                      | 2.70                            | 600                             | 285  |
| IRF530   | 100                         | 0.16                                | 8.30                  | TO-220     | 14.00                      | 79                      | 5.10                            | 800                             | 291  |
| IRF530FI | 100                         | 0.16                                | 8.30                  | ISOWATT220 | 9.00                       | 35                      | 5.10                            | 800                             | 291  |
| IRF531   | 80                          | 0.16                                | 8.30                  | TO-220     | 14.00                      | 79                      | 5.10                            | 800                             | 291  |
| IRF531FI | 80                          | 0.16                                | 8.30                  | ISOWATT220 | 9.00                       | 35                      | 5.10                            | 800                             | 291  |
| IRF532   | 100                         | 0.23                                | 8.30                  | TO-220     | 12.00                      | 79                      | 5.10                            | 800                             | 291  |
| IRF532FI | 100                         | 0.23                                | 8.30                  | ISOWATT220 | 8.00                       | 35                      | 5.10                            | 800                             | 291  |
| IRF533   | 80                          | 0.23                                | 8.30                  | TO-220     | 12.00                      | 79                      | 5.10                            | 800                             | 291  |
| IRF533FI | 80                          | 0.23                                | 8.30                  | ISOWATT220 | 8.00                       | 35                      | 5.10                            | 800                             | 291  |
| IRF540   | 100                         | 0.077                               | 17.00                 | TO-220     | 28.00                      | 125                     | 8.70                            | 1600                            | 295  |
| IRF540FI | 100                         | 0.077                               | 17.00                 | ISOWATT220 | 15.00                      | 40                      | 8.70                            | 1600                            | 295  |
| IRF541   | 80                          | 0.077                               | 17.00                 | TO-220     | 28.00                      | 125                     | 8.70                            | 1600                            | 295  |
| IRF541FI | 80                          | 0.077                               | 17.00                 | ISOWATT220 | 15.00                      | 40                      | 8.70                            | 1600                            | 295  |
| IRF542   | 100                         | 0.10                                | 17.00                 | TO-220     | 25.00                      | 125                     | 8.70                            | 1600                            | 295  |
| IRF542FI | 100                         | 0.10                                | 17.00                 | ISOWATT220 | 14.00                      | 40                      | 8.70                            | 1600                            | 295  |
| IRF543   | 80                          | 0.10                                | 17.00                 | TO-220     | 25.00                      | 125                     | 8.70                            | 1600                            | 295  |
| IRF543FI | 80                          | 0.10                                | 17.00                 | ISOWATT220 | 14.00                      | 40                      | 8.70                            | 1600                            | 295  |
| IRF620   | 200                         | 0.80                                | 2.50                  | TO-220     | 5.00                       | 40                      | 1.30                            | 600                             | 301  |
| IRF620FI | 200                         | 0.80                                | 2.50                  | ISOWATT220 | 4.00                       | 30                      | 1.30                            | 600                             | 301  |
| IRF621   | 150                         | 0.80                                | 2.50                  | TO-220     | 5.00                       | 40                      | 1.30                            | 600                             | 301  |
| IRF621FI | 150                         | 0.80                                | 2.50                  | ISOWATT220 | 4.00                       | 30                      | 1.30                            | 600                             | 301  |
| IRF622   | 200                         | 1.20                                | 2.50                  | TO-220     | 4.00                       | 40                      | 1.30                            | 600                             | 301  |
| IRF622FI | 200                         | 1.20                                | 2.50                  | ISOWATT220 | 3.50                       | 30                      | 1.30                            | 600                             | 301  |
| IRF623   | 150                         | 1.20                                | 2.50                  | TO-220     | 4.00                       | 40                      | 1.30                            | 600                             | 301  |
| IRF623FI | 150                         | 1.20                                | 2.50                  | ISOWATT220 | 3.50                       | 30                      | 1.30                            | 600                             | 301  |
| IRF720   | 400                         | 1.80                                | 1.80                  | TO-220     | 3.30                       | 50                      | 1.00                            | 600                             | 307  |
| IRF720FI | 400                         | 1.80                                | 1.80                  | ISOWATT220 | 2.50                       | 30                      | 1.00                            | 600                             | 307  |
| IRF721   | 350                         | 1.80                                | 1.80                  | TO-220     | 3.30                       | 50                      | 1.00                            | 600                             | 307  |
| IRF721FI | 350                         | 1.80                                | 1.80                  | ISOWATT220 | 2.50                       | 30                      | 1.00                            | 600                             | 307  |
| IRF722   | 400                         | 2.50                                | 1.80                  | TO-220     | 2.80                       | 50                      | 1.00                            | 600                             | 307  |
| IRF722FI | 400                         | 2.50                                | 1.80                  | ISOWATT220 | 2.00                       | 30                      | 1.00                            | 600                             | 307  |
| IRF723   | 350                         | 2.50                                | 1.80                  | TO-220     | 2.80                       | 50                      | 1.00                            | 600                             | 307  |
| IRF723FI | 350                         | 2.50                                | 1.80                  | ISOWATT220 | 2.00                       | 30                      | 1.00                            | 600                             | 307  |
| IRF730   | 400                         | 1.00                                | 3.00                  | TO-220     | 5.50                       | 74                      | 2.90                            | 800                             | 313  |
| IRF730FI | 400                         | 1.00                                | 3.00                  | ISOWATT220 | 3.50                       | 35                      | 2.90                            | 800                             | 313  |
| IRF731   | 350                         | 1.00                                | 3.00                  | TO-220     | 5.50                       | 74                      | 2.90                            | 800                             | 313  |
| IRF731FI | 350                         | 1.00                                | 3.00                  | ISOWATT220 | 3.50                       | 35                      | 2.90                            | 800                             | 313  |
| IRF732   | 400                         | 1.50                                | 3.00                  | TO-220     | 4.50                       | 74                      | 2.90                            | 800                             | 313  |
| IRF732FI | 400                         | 1.50                                | 3.00                  | ISOWATT220 | 3.00                       | 35                      | 2.90                            | 800                             | 313  |
| IRF733   | 350                         | 1.50                                | 3.00                  | TO-220     | 4.50                       | 74                      | 2.90                            | 800                             | 313  |
| IRF733FI | 350                         | 1.50                                | 3.00                  | ISOWATT220 | 3.00                       | 35                      | 2.90                            | 800                             | 313  |
| IRF740   | 400                         | 0.55                                | 5.20                  | TO-220     | 10.00                      | 125                     | 4.00                            | 1600                            | 319  |
| IRF740FI | 400                         | 0.55                                | 5.20                  | ISOWATT220 | 5.50                       | 40                      | 4.00                            | 1600                            | 319  |



# SELECTION GUIDE BY PART NUMBER

| Type      | V <sub>(BR)DSS</sub><br>(V) | R <sub>DS(on)</sub> <sup>①</sup><br>(max)<br>(Ω) | I <sub>D</sub><br>(A) | Package    | I <sub>D(max)</sub><br>(A) | P <sub>tot</sub><br>(W) | g <sub>fs</sub><br>min<br>(mho) | C <sub>iss</sub><br>max<br>(pF) | Page |
|-----------|-----------------------------|--------------------------------------------------|-----------------------|------------|----------------------------|-------------------------|---------------------------------|---------------------------------|------|
| IRF741    | 350                         | 0.55                                             | 5.20                  | TO-220     | 10.00                      | 125                     | 4.00                            | 1600                            | 319  |
| IRF741FI  | 350                         | 0.55                                             | 5.20                  | ISOWATT220 | 5.50                       | 40                      | 4.00                            | 1600                            | 319  |
| IRF742    | 400                         | 0.80                                             | 5.20                  | TO-220     | 8.30                       | 125                     | 4.00                            | 1600                            | 319  |
| IRF742FI  | 400                         | 0.80                                             | 5.20                  | ISOWATT220 | 4.50                       | 40                      | 4.00                            | 1600                            | 319  |
| IRF743    | 350                         | 0.80                                             | 5.20                  | TO-220     | 8.30                       | 125                     | 4.00                            | 1600                            | 319  |
| IRF743FI  | 350                         | 0.80                                             | 5.20                  | ISOWATT220 | 4.50                       | 40                      | 4.00                            | 1600                            | 319  |
| IRF820    | 500                         | 3.00                                             | 1.40                  | TO-220     | 2.50                       | 50                      | 1.00                            | 400                             | 325  |
| IRF820FI  | 500                         | 3.00                                             | 1.40                  | ISOWATT220 | 2.00                       | 30                      | 1.00                            | 400                             | 325  |
| IRF821    | 450                         | 3.00                                             | 1.40                  | TO-220     | 2.50                       | 50                      | 1.00                            | 400                             | 325  |
| IRF821FI  | 450                         | 3.00                                             | 1.40                  | ISOWATT220 | 2.00                       | 30                      | 1.00                            | 400                             | 325  |
| IRF822    | 500                         | 4.00                                             | 1.40                  | TO-220     | 2.20                       | 50                      | 1.00                            | 400                             | 325  |
| IRF822FI  | 500                         | 4.00                                             | 1.40                  | ISOWATT220 | 1.50                       | 30                      | 1.00                            | 400                             | 325  |
| IRF823    | 450                         | 4.00                                             | 1.40                  | TO-220     | 2.20                       | 50                      | 1.00                            | 400                             | 325  |
| IRF823FI  | 450                         | 4.00                                             | 1.40                  | ISOWATT220 | 1.50                       | 30                      | 1.00                            | 400                             | 325  |
| IRF830    | 500                         | 1.50                                             | 2.50                  | TO-220     | 4.50                       | 74                      | 2.70                            | 800                             | 331  |
| IRF830FI  | 500                         | 1.50                                             | 2.50                  | ISOWATT220 | 3.00                       | 35                      | 2.70                            | 800                             | 331  |
| IRF831    | 450                         | 1.50                                             | 2.50                  | TO-220     | 4.50                       | 74                      | 2.70                            | 800                             | 331  |
| IRF831FI  | 450                         | 1.50                                             | 2.50                  | ISOWATT220 | 3.00                       | 35                      | 2.70                            | 800                             | 331  |
| IRF832    | 500                         | 2.00                                             | 2.50                  | TO-220     | 4.00                       | 74                      | 2.70                            | 800                             | 331  |
| IRF832FI  | 500                         | 2.00                                             | 2.50                  | ISOWATT220 | 2.50                       | 35                      | 2.70                            | 800                             | 331  |
| IRF833    | 450                         | 2.00                                             | 2.50                  | TO-220     | 4.00                       | 74                      | 2.70                            | 800                             | 331  |
| IRF833FI  | 450                         | 2.00                                             | 2.50                  | ISOWATT220 | 2.50                       | 35                      | 2.70                            | 800                             | 331  |
| IRF840    | 500                         | 0.85                                             | 4.40                  | TO-220     | 8.00                       | 125                     | 4.90                            | 1600                            | 337  |
| IRF840FI  | 500                         | 0.85                                             | 4.40                  | ISOWATT220 | 4.50                       | 40                      | 4.90                            | 1600                            | 337  |
| IRF841    | 450                         | 0.85                                             | 4.40                  | TO-220     | 8.00                       | 125                     | 4.90                            | 1600                            | 337  |
| IRF841FI  | 450                         | 0.85                                             | 4.40                  | ISOWATT220 | 4.50                       | 40                      | 4.90                            | 1600                            | 337  |
| IRF842    | 500                         | 1.10                                             | 4.40                  | TO-220     | 7.00                       | 125                     | 4.90                            | 1600                            | 337  |
| IRF842FI  | 500                         | 1.10                                             | 4.40                  | ISOWATT220 | 4.00                       | 40                      | 4.90                            | 1600                            | 337  |
| IRF843    | 450                         | 1.10                                             | 4.40                  | TO-220     | 7.00                       | 125                     | 4.90                            | 1600                            | 337  |
| IRF843FI  | 450                         | 1.10                                             | 4.40                  | ISOWATT220 | 4.00                       | 40                      | 4.90                            | 1600                            | 337  |
| IRFP150   | 100                         | 0.055                                            | 22.00                 | TO-218     | 40.00                      | 150                     | 13.00                           | 3000                            | 343  |
| IRFP150FI | 100                         | 0.055                                            | 22.00                 | ISOWATT218 | 26.00                      | 65                      | 13.00                           | 3000                            | 343  |
| IRFP151   | 60                          | 0.055                                            | 22.00                 | TO-218     | 40.00                      | 150                     | 13.00                           | 3000                            | 343  |
| IRFP151FI | 60                          | 0.055                                            | 22.00                 | ISOWATT218 | 26.00                      | 65                      | 13.00                           | 3000                            | 343  |
| IRFP152   | 100                         | 0.08                                             | 22.00                 | TO-218     | 34.00                      | 150                     | 13.00                           | 3000                            | 343  |
| IRFP152FI | 100                         | 0.08                                             | 22.00                 | ISOWATT218 | 21.00                      | 65                      | 13.00                           | 3000                            | 343  |
| IRFP153   | 60                          | 0.08                                             | 22.00                 | TO-218     | 34.00                      | 150                     | 13.00                           | 3000                            | 343  |
| IRFP153FI | 60                          | 0.08                                             | 22.00                 | ISOWATT218 | 21.00                      | 65                      | 13.00                           | 3000                            | 343  |
| IRFP350FI | 400                         | 0.30                                             | 8.00                  | ISOWATT218 | 10.00                      | 70                      | 8.00                            | 3000                            | 349  |
| IRFP450   | 500                         | 0.40                                             | 7.20                  | TO-218     | 14.00                      | 180                     | 8.70                            | 3000                            | 355  |
| IRFP450FI | 500                         | 0.40                                             | 7.20                  | ISOWATT218 | 9.00                       | 70                      | 8.70                            | 3000                            | 355  |
| IRFP451   | 450                         | 0.40                                             | 7.20                  | TO-218     | 14.00                      | 180                     | 8.70                            | 3000                            | 355  |
| IRFP451FI | 450                         | 0.40                                             | 7.20                  | ISOWATT218 | 9.00                       | 70                      | 8.70                            | 3000                            | 355  |
| IRFP452   | 500                         | 0.50                                             | 7.20                  | TO-218     | 12.00                      | 180                     | 8.70                            | 3000                            | 355  |
| IRFP452FI | 500                         | 0.50                                             | 7.20                  | ISOWATT218 | 8.00                       | 70                      | 8.70                            | 3000                            | 355  |

# SELECTION GUIDE BY PART NUMBER

| Type          | V <sub>(BR)DSS</sub><br>(V) | R <sub>DS(on)</sub> <sup>①</sup><br>(max)<br>(Ω) | I <sub>D</sub><br>(A) | Package    | I <sub>D(max)</sub><br>(A) | P <sub>tot</sub><br>(W) | g <sub>fs</sub><br>min<br>(mho) | C <sub>iss</sub><br>max<br>(pF) | Page |
|---------------|-----------------------------|--------------------------------------------------|-----------------------|------------|----------------------------|-------------------------|---------------------------------|---------------------------------|------|
| IRFP453       | 450                         | 0.50                                             | 7.20                  | TO-218     | 12.00                      | 180                     | 8.70                            | 3000                            | 355  |
| IRFP453FI     | 450                         | 0.50                                             | 7.20                  | ISOWATT218 | 8.00                       | 70                      | 8.70                            | 3000                            | 355  |
| IRFZ20        | 50                          | 0.10                                             | 9.00                  | TO-220     | 15.00                      | 40                      | 5.00                            | 850                             | 361  |
| IRFZ20FI      | 50                          | 0.10                                             | 9.00                  | ISOWATT220 | 12.50                      | 30                      | 5.00                            | 850                             | 361  |
| IRFZ22        | 50                          | 0.12                                             | 9.00                  | TO-220     | 14.00                      | 40                      | 5.00                            | 850                             | 361  |
| IRFZ22FI      | 50                          | 0.12                                             | 9.00                  | ISOWATT220 | 12.00                      | 30                      | 5.00                            | 850                             | 361  |
| IRFZ40        | 50                          | 0.028                                            | 29.00                 | TO-220     | 35.00                      | 125                     | 17.00                           | 3000                            | 367  |
| IRFZ42        | 50                          | 0.035                                            | 29.00                 | TO-220     | 35.00                      | 125                     | 17.00                           | 3000                            | 367  |
| MTH6N60FI     | 600                         | 1.20                                             | 3.00                  | ISOWATT218 | 3.50                       | 40                      | 2.00                            | 1800                            | 373  |
| MTH40N06      | 60                          | 0.028                                            | 20.00                 | TO-218     | 40.00                      | 150                     | 10.00                           | 5000                            | 379  |
| MTH40N06FI    | 60                          | 0.028                                            | 20.00                 | ISOWATT218 | 26.00                      | 65                      | 10.00                           | 5000                            | 379  |
| MTP3N60       | 600                         | 2.50                                             | 1.50                  | TO-220     | 3.00                       | 75                      | 1.50                            | 1000                            | 385  |
| MTP3N60FI     | 600                         | 2.50                                             | 1.50                  | ISOWATT220 | 2.50                       | 35                      | 1.50                            | 1000                            | 385  |
| MTP6N60       | 600                         | 1.20                                             | 3.00                  | TO-220     | 6.00                       | 125                     | 2.00                            | 1800                            | 391  |
| MTP15N05L     | 50                          | 0.15                                             | 7.50                  | TO-220     | 15.00                      | 75                      | 5.00                            | 900                             | 397  |
| MTP15N05LFI   | 50                          | 0.15                                             | 7.50                  | ISOWATT220 | 10.00                      | 30                      | 5.00                            | 900                             | 397  |
| MTP15N06L     | 60                          | 0.15                                             | 7.50                  | TO-220     | 15.00                      | 75                      | 5.00                            | 900                             | 397  |
| MTP15N06LFI   | 60                          | 0.15                                             | 7.50                  | ISOWATT220 | 10.00                      | 30                      | 5.00                            | 900                             | 397  |
| MTP3055A      | 60                          | 0.15                                             | 6.00                  | TO-220     | 12.00                      | 40                      | 4.50                            | 500                             | 403  |
| MTP3055AFI    | 60                          | 0.15                                             | 6.00                  | ISOWATT220 | 10.00                      | 30                      | 4.50                            | 500                             | 403  |
| SGS30MA050D1  | 500                         | 0.20                                             | 15.00                 | TO-240     | 30.00                      | 400                     | 15.00                           | 9100                            | 409  |
| SGS35MA050D1  | 500                         | 0.16                                             | 17.50                 | TO-240     | 35.00                      | 400                     | 15.00                           | 12000                           | 415  |
| SGS100MA010D1 | 100                         | 0.014                                            | 50.00                 | TO-240     | 120.00                     | 400                     | 20.00                           | 11200                           | 421  |
| SGS150MA010D1 | 100                         | 0.009                                            | 75.00                 | TO-240     | 150.00                     | 400                     | 20.00                           | 14000                           | 427  |
| SGSP201       | 100                         | 1.40                                             | 1.20                  | SOT-82     | 2.50                       | 18                      | 0.50                            | 125                             | 433  |
| SGSP222       | 50                          | 0.13                                             | 5.00                  | SOT-82     | 10.00                      | 50                      | 3.00                            | 550                             | 439  |
| SGSP230       | 450                         | 3.00                                             | 1.20                  | SOT-82     | 2.50                       | 50                      | 0.80                            | 450                             | 445  |
| SGSP239       | 500                         | 8.50                                             | 0.60                  | SOT-82     | 1.20                       | 40                      | 0.65                            | 300                             | 451  |
| SGSP301       | 100                         | 1.40                                             | 1.20                  | TO-220     | 2.50                       | 18                      | 0.50                            | 125                             | 457  |
| SGSP311       | 100                         | 0.30                                             | 5.50                  | TO-220     | 11.00                      | 75                      | 2.00                            | 480                             | 463  |
| SGSP316       | 250                         | 1.20                                             | 2.50                  | TO-220     | 5.00                       | 75                      | 1.50                            | 500                             | 469  |
| SGSP317       | 200                         | 0.75                                             | 3.00                  | TO-220     | 6.00                       | 75                      | 1.50                            | 500                             | 469  |
| SGSP319       | 500                         | 3.80                                             | 1.40                  | TO-220     | 2.80                       | 75                      | 0.80                            | 380                             | 475  |
| SGSP321       | 60                          | 0.13                                             | 8.00                  | TO-220     | 16.00                      | 75                      | 3.00                            | 550                             | 481  |
| SGSP322       | 50                          | 0.13                                             | 8.00                  | TO-220     | 16.00                      | 75                      | 3.00                            | 550                             | 481  |
| SGSP330       | 450                         | 3.00                                             | 1.50                  | TO-220     | 3.00                       | 75                      | 0.80                            | 450                             | 487  |
| SGSP341       | 400                         | 20.00                                            | 0.30                  | TO-220     | 0.60                       | 18                      | 0.10                            | 105                             | 493  |
| SGSP351       | 100                         | 0.60                                             | 3.00                  | TO-220     | 6.00                       | 50                      | 1.00                            | 250                             | 499  |
| SGSP358       | 50                          | 0.30                                             | 3.50                  | TO-220     | 7.00                       | 50                      | 1.50                            | 270                             | 505  |
| SGSP361       | 100                         | 0.15                                             | 9.00                  | TO-220     | 18.00                      | 100                     | 4.50                            | 1200                            | 511  |
| SGSP362       | 80                          | 0.10                                             | 11.00                 | TO-220     | 22.00                      | 100                     | 4.50                            | 1200                            | 511  |
| SGSP363       | 250                         | 0.45                                             | 5.00                  | TO-220     | 10.00                      | 100                     | 3.00                            | 1200                            | 517  |
| SGSP364       | 450                         | 1.50                                             | 2.50                  | TO-220     | 5.00                       | 100                     | 3.00                            | 1000                            | 523  |
| SGSP367       | 200                         | 0.33                                             | 6.00                  | TO-220     | 12.00                      | 100                     | 3.00                            | 1200                            | 517  |
| SGSP369       | 500                         | 1.50                                             | 2.50                  | TO-220     | 5.00                       | 100                     | 3.00                            | 1000                            | 523  |

# SELECTION GUIDE BY PART NUMBER

| Type     | $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Package    | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------|----------------------|---------------------------------------|--------------|------------|---------------------|------------------|--------------------------|--------------------------|------|
| SGSP381  | 60                   | 0.06                                  | 14.00        | TO-220     | 28.00               | 100              | 5.00                     | 1400                     | 529  |
| SGSP382  | 50                   | 0.06                                  | 14.00        | TO-220     | 28.00               | 100              | 5.00                     | 1400                     | 529  |
| SGSP461  | 100                  | 0.15                                  | 10.00        | TO-218     | 20.00               | 125              | 4.50                     | 1200                     | 535  |
| SGSP462  | 80                   | 0.10                                  | 12.50        | TO-218     | 25.00               | 125              | 4.50                     | 1200                     | 535  |
| SGSP471  | 100                  | 0.075                                 | 15.00        | TO-218     | 30.00               | 150              | 9.00                     | 2200                     | 541  |
| SGSP472  | 80                   | 0.05                                  | 17.50        | TO-218     | 35.00               | 150              | 9.00                     | 2200                     | 541  |
| SGSP474  | 450                  | 0.70                                  | 4.50         | TO-218     | 9.00                | 150              | 6.00                     | 2100                     | 547  |
| SGSP475  | 400                  | 0.55                                  | 5.00         | TO-218     | 10.00               | 150              | 6.00                     | 2100                     | 547  |
| SGSP477  | 200                  | 0.17                                  | 10.00        | TO-218     | 20.00               | 150              | 8.00                     | 2200                     | 553  |
| SGSP479  | 500                  | 0.70                                  | 4.50         | TO-218     | 9.00                | 150              | 5.00                     | 1900                     | 559  |
| SGSP481  | 60                   | 0.06                                  | 15.00        | TO-218     | 30.00               | 125              | 5.00                     | 1400                     | 565  |
| SGSP482  | 50                   | 0.06                                  | 15.00        | TO-218     | 30.00               | 125              | 5.00                     | 1400                     | 565  |
| SGSP491  | 60                   | 0.033                                 | 20.00        | TO-218     | 40.00               | 150              | 10.00                    | 2800                     | 571  |
| SGSP492  | 50                   | 0.033                                 | 20.00        | TO-218     | 40.00               | 150              | 10.00                    | 2800                     | 571  |
| SGSP574  | 450                  | 0.70                                  | 4.50         | TO-3       | 9.00                | 150              | 6.00                     | 2100                     | 577  |
| SGSP575  | 400                  | 0.55                                  | 5.00         | TO-3       | 10.00               | 150              | 6.00                     | 2100                     | 577  |
| SGSP577  | 200                  | 0.17                                  | 10.00        | TO-3       | 20.00               | 150              | 8.00                     | 2200                     | 583  |
| SGSP579  | 500                  | 0.70                                  | 4.50         | TO-3       | 9.00                | 150              | 5.00                     | 1900                     | 589  |
| SGSP591  | 60                   | 0.033                                 | 20.00        | TO-3       | 40.00               | 150              | 10.00                    | 2800                     | 595  |
| SGSP592  | 50                   | 0.033                                 | 20.00        | TO-3       | 40.00               | 150              | 10.00                    | 2800                     | 595  |
| STHV82   | 800                  | 2.00                                  | 2.00         | TO-218     | 5.50                | 125              | 2.00                     | 1000                     | 601  |
| STHV102  | 1000                 | 3.50                                  | 2.00         | TO-218     | 4.20                | 125              | 2.00                     | 1200                     | 607  |
| STLT19   | 50                   | 0.15                                  | 7.50         | TO-220     | 15.00               | 75               | 5.00                     | 480                      | 611  |
| STLT19FI | 50                   | 0.15                                  | 7.50         | ISOWATT220 | 10.00               | 30               | 5.00                     | 480                      | 611  |
| STLT20   | 60                   | 0.15                                  | 7.50         | TO-220     | 15.00               | 75               | 5.00                     | 480                      | 611  |
| STLT20FI | 60                   | 0.15                                  | 7.50         | ISOWATT220 | 10.00               | 30               | 5.00                     | 480                      | 611  |
| STLT29   | 50                   | 0.08                                  | 12.50        | TO-220     | 25.00               | 100              | 9.00                     | 1200                     | 617  |
| STLT30   | 60                   | 0.08                                  | 12.50        | TO-220     | 25.00               | 100              | 9.00                     | 1200                     | 617  |
| STVHD90  | 50                   | 0.023                                 | 30.00        | TO-220     | 52.00               | 125              | 30.00                    | 3000                     | 621  |

## HIMOS (IGBT)

| Type        | $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Package    | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|-------------|----------------------|---------------------------------------|--------------|------------|---------------------|------------------|--------------------------|--------------------------|------|
| STHI07N50   | 500                  | 2.70                                  | 7.00         | TO-220     | 7.00                | 100              | 2.50                     | 950                      | 627  |
| STHI07N50FI | 500                  | 2.70                                  | 7.00         | ISOWATT220 | 7.00                | 35               | 2.50                     | 950                      | 627  |
| STHI10N50   | 500                  | 2.70                                  | 10.00        | TO-220     | 10.00               | 100              | 2.50                     | 950                      | 633  |
| STHI10N50FI | 500                  | 2.70                                  | 10.00        | ISOWATT220 | 10.00               | 35               | 2.50                     | 950                      | 633  |

# SELECTION GUIDE BY VOLTAGE

| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Package    | Type        | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|---------------------------------------|--------------|------------|-------------|---------------------|------------------|--------------------------|--------------------------|------|
| 50                   | 0.30                                  | 3.50         | TO-220     | SGSP358     | 7.00                | 50               | 1.50                     | 270                      | 505  |
| 50                   | 0.15                                  | 7.50         | TO-220     | MTP15N05L   | 15.00               | 75               | 5.00                     | 900                      | 397  |
| 50                   | 0.15                                  | 7.50         | ISOWATT220 | MTP15N05LFI | 10.00               | 30               | 5.00                     | 900                      | 397  |
| 50                   | 0.15                                  | 7.50         | TO-220     | STLT19      | 15.00               | 75               | 5.00                     | 480                      | 611  |
| 50                   | 0.15                                  | 7.50         | ISOWATT220 | STLT19FI    | 10.00               | 30               | 5.00                     | 480                      | 611  |
| 50                   | 0.13                                  | 5.00         | SOT-82     | SGSP222     | 10.00               | 50               | 3.00                     | 550                      | 439  |
| 50                   | 0.13                                  | 8.00         | TO-220     | SGSP322     | 16.00               | 75               | 3.00                     | 550                      | 481  |
| 50                   | 0.12                                  | 10.00        | TO-220     | BUZ10A      | 17.00               | 75               | 3.00                     | 2000                     | 163  |
| 50                   | 0.12                                  | 9.00         | TO-220     | BUZ71A      | 13.00               | 40               | 3.00                     | 650                      | 229  |
| 50                   | 0.12                                  | 9.00         | TO-220     | IRFZ22      | 14.00               | 40               | 5.00                     | 850                      | 361  |
| 50                   | 0.12                                  | 9.00         | ISOWATT220 | IRFZ22FI    | 12.00               | 30               | 5.00                     | 850                      | 361  |
| 50                   | 0.10                                  | 9.00         | TO-220     | BUZ71       | 14.00               | 40               | 3.00                     | 650                      | 223  |
| 50                   | 0.10                                  | 9.00         | ISOWATT220 | BUZ71FI     | 12.00               | 30               | 3.00                     | 650                      | 223  |
| 50                   | 0.10                                  | 9.00         | TO-220     | IRFZ20      | 15.00               | 40               | 5.00                     | 850                      | 361  |
| 50                   | 0.10                                  | 9.00         | ISOWATT220 | IRFZ20FI    | 12.50               | 30               | 5.00                     | 850                      | 361  |
| 50                   | 0.08                                  | 13.00        | TO-220     | BUZ10       | 20.00               | 70               | 8.00                     | 700 typ                  | 159  |
| 50                   | 0.08                                  | 12.50        | TO-220     | STLT29      | 25.00               | 100              | 9.00                     | 1200                     | 617  |
| 50                   | 0.06                                  | 15.00        | TO-220     | BUZ11A      | 25.00               | 75               | 4.00                     | 2000                     | 173  |
| 50                   | 0.06                                  | 14.00        | TO-220     | SGSP382     | 28.00               | 100              | 5.00                     | 1400                     | 529  |
| 50                   | 0.06                                  | 15.00        | TO-218     | SGSP482     | 30.00               | 125              | 5.00                     | 1400                     | 565  |
| 50                   | 0.04                                  | 15.00        | TO-220     | BUZ11       | 30.00               | 75               | 4.00                     | 2000                     | 167  |
| 50                   | 0.04                                  | 15.00        | ISOWATT220 | BUZ11FI     | 20.00               | 35               | 4.00                     | 2000                     | 167  |
| 50                   | 0.035                                 | 29.00        | TO-220     | IRFZ42      | 35.00               | 125              | 17.00                    | 3000                     | 367  |
| 50                   | 0.033                                 | 20.00        | TO-218     | SGSP492     | 40.00               | 150              | 10.00                    | 2800                     | 571  |
| 50                   | 0.033                                 | 20.00        | TO-3       | SGSP592     | 40.00               | 150              | 10.00                    | 2800                     | 595  |
| 50                   | 0.028                                 | 29.00        | TO-220     | IRFZ40      | 35.00               | 125              | 17.00                    | 3000                     | 367  |
| 50                   | 0.023                                 | 30.00        | TO-220     | STVHD90     | 52.00               | 125              | 30.00                    | 3000                     | 621  |
| 60                   | 0.15                                  | 7.50         | TO-220     | MTP15N06L   | 15.00               | 75               | 5.00                     | 900                      | 397  |
| 60                   | 0.15                                  | 7.50         | ISOWATT220 | MTP15N06LFI | 10.00               | 30               | 5.00                     | 900                      | 397  |
| 60                   | 0.15                                  | 6.00         | TO-220     | MTP3055A    | 12.00               | 40               | 4.50                     | 500                      | 403  |
| 60                   | 0.15                                  | 6.00         | ISOWATT220 | MTP3055AFI  | 10.00               | 30               | 4.50                     | 500                      | 403  |
| 60                   | 0.15                                  | 7.50         | TO-220     | STLT20      | 15.00               | 75               | 5.00                     | 480                      | 611  |
| 60                   | 0.15                                  | 7.50         | ISOWATT220 | STLT20FI    | 10.00               | 30               | 5.00                     | 480                      | 611  |
| 60                   | 0.13                                  | 8.00         | TO-220     | SGSP321     | 16.00               | 75               | 3.00                     | 550                      | 481  |
| 60                   | 0.08                                  | 20.00        | TO-3       | IRF153      | 33.00               | 150              | 9.00                     | 3000                     | 267  |
| 60                   | 0.08                                  | 22.00        | TO-218     | IRFP153     | 34.00               | 150              | 13.00                    | 3000                     | 343  |
| 60                   | 0.08                                  | 22.00        | ISOWATT218 | IRFP153FI   | 21.00               | 65               | 13.00                    | 3000                     | 343  |
| 60                   | 0.08                                  | 12.50        | TO-220     | STLT30      | 25.00               | 100              | 9.00                     | 1200                     | 617  |
| 60                   | 0.06                                  | 14.00        | TO-220     | SGSP381     | 28.00               | 100              | 5.00                     | 1400                     | 529  |
| 60                   | 0.06                                  | 15.00        | TO-218     | SGSP481     | 30.00               | 125              | 5.00                     | 1400                     | 565  |
| 60                   | 0.055                                 | 20.00        | TO-3       | IRF151      | 40.00               | 150              | 9.00                     | 3000                     | 267  |
| 60                   | 0.055                                 | 22.00        | TO-218     | IRFP151     | 40.00               | 150              | 13.00                    | 3000                     | 343  |
| 60                   | 0.055                                 | 22.00        | ISOWATT218 | IRFP151FI   | 26.00               | 65               | 13.00                    | 3000                     | 343  |
| 60                   | 0.04                                  | 15.00        | TO-220     | BUZ11S2     | 30.00               | 75               | 4.00                     | 2000                     | 177  |
| 60                   | 0.04                                  | 15.00        | ISOWATT220 | BUZ11S2FI   | 20.00               | 35               | 4.00                     | 2000                     | 177  |

# SELECTION GUIDE BY VOLTAGE

| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Package    | Type       | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|---------------------------------------|--------------|------------|------------|---------------------|------------------|--------------------------|--------------------------|------|
| 60                   | 0.033                                 | 20.00        | TO-218     | SGSP491    | 40.00               | 150              | 10.00                    | 2800                     | 571  |
| 60                   | 0.033                                 | 20.00        | TO-3       | SGSP591    | 40.00               | 150              | 10.00                    | 2800                     | 595  |
| 60                   | 0.028                                 | 20.00        | TO-218     | MTH40N06   | 40.00               | 150              | 10.00                    | 5000                     | 379  |
| 60                   | 0.028                                 | 20.00        | ISOWATT218 | MTH40N06FI | 26.00               | 65               | 10.00                    | 5000                     | 379  |
| 80                   | 0.36                                  | 5.60         | TO-220     | IRF523     | 8.00                | 60               | 2.70                     | 600                      | 285  |
| 80                   | 0.36                                  | 5.60         | ISOWATT220 | IRF523FI   | 6.00                | 30               | 2.70                     | 600                      | 285  |
| 80                   | 0.27                                  | 5.60         | TO-220     | IRF521     | 9.20                | 60               | 2.70                     | 600                      | 285  |
| 80                   | 0.27                                  | 5.60         | ISOWATT220 | IRF521FI   | 7.00                | 30               | 2.70                     | 600                      | 285  |
| 80                   | 0.23                                  | 8.30         | TO-220     | IRF533     | 12.00               | 79               | 5.10                     | 800                      | 291  |
| 80                   | 0.23                                  | 8.30         | ISOWATT220 | IRF533FI   | 8.00                | 35               | 5.10                     | 800                      | 291  |
| 80                   | 0.16                                  | 8.30         | TO-220     | IRF531     | 14.00               | 79               | 5.10                     | 800                      | 291  |
| 80                   | 0.16                                  | 8.30         | ISOWATT220 | IRF531FI   | 9.00                | 35               | 5.10                     | 800                      | 291  |
| 80                   | 0.10                                  | 17.00        | TO-3       | IRF143     | 25.00               | 125              | 8.70                     | 1600                     | 261  |
| 80                   | 0.10                                  | 17.00        | TO-220     | IRF543     | 25.00               | 125              | 8.70                     | 1600                     | 295  |
| 80                   | 0.10                                  | 17.00        | ISOWATT220 | IRF543FI   | 14.00               | 40               | 8.70                     | 1600                     | 295  |
| 80                   | 0.10                                  | 11.00        | TO-220     | SGSP362    | 22.00               | 100              | 4.50                     | 1200                     | 511  |
| 80                   | 0.10                                  | 12.50        | TO-218     | SGSP462    | 25.00               | 125              | 4.50                     | 1200                     | 535  |
| 80                   | 0.077                                 | 17.00        | TO-3       | IRF141     | 28.00               | 125              | 8.70                     | 1600                     | 261  |
| 80                   | 0.077                                 | 17.00        | TO-220     | IRF541     | 28.00               | 125              | 8.70                     | 1600                     | 295  |
| 80                   | 0.077                                 | 17.00        | ISOWATT220 | IRF541FI   | 15.00               | 40               | 8.70                     | 1600                     | 295  |
| 80                   | 0.05                                  | 17.50        | TO-218     | SGSP472    | 35.00               | 150              | 9.00                     | 2200                     | 541  |
| 100                  | 1.40                                  | 1.20         | SOT-82     | SGSP201    | 2.50                | 18               | 0.50                     | 125                      | 433  |
| 100                  | 1.40                                  | 1.20         | TO-220     | SGSP301    | 2.50                | 18               | 0.50                     | 125                      | 457  |
| 100                  | 0.60                                  | 3.00         | TO-220     | SGSP351    | 6.00                | 50               | 1.00                     | 250                      | 499  |
| 100                  | 0.36                                  | 5.60         | TO-220     | IRF522     | 8.00                | 60               | 2.70                     | 600                      | 285  |
| 100                  | 0.36                                  | 5.60         | ISOWATT220 | IRF522FI   | 6.00                | 30               | 2.70                     | 600                      | 285  |
| 100                  | 0.30                                  | 5.50         | TO-220     | SGSP311    | 11.00               | 75               | 2.00                     | 480                      | 463  |
| 100                  | 0.27                                  | 5.60         | TO-220     | IRF520     | 9.20                | 60               | 2.70                     | 600                      | 285  |
| 100                  | 0.27                                  | 5.60         | ISOWATT220 | IRF520FI   | 7.00                | 30               | 2.70                     | 600                      | 285  |
| 100                  | 0.25                                  | 5.00         | TO-220     | BUZ72A     | 9.00                | 40               | 2.70                     | 600                      | 233  |
| 100                  | 0.23                                  | 8.30         | TO-220     | IRF532     | 12.00               | 79               | 5.10                     | 800                      | 291  |
| 100                  | 0.23                                  | 8.30         | ISOWATT220 | IRF532FI   | 8.00                | 35               | 5.10                     | 800                      | 291  |
| 100                  | 0.20                                  | 6.00         | TO-220     | BUZ20      | 12.00               | 75               | 2.70                     | 2000                     | 183  |
| 100                  | 0.16                                  | 8.30         | TO-220     | IRF530     | 14.00               | 79               | 5.10                     | 800                      | 291  |
| 100                  | 0.16                                  | 8.30         | ISOWATT220 | IRF530FI   | 9.00                | 35               | 5.10                     | 800                      | 291  |
| 100                  | 0.15                                  | 9.00         | TO-220     | SGSP361    | 18.00               | 100              | 4.50                     | 1200                     | 511  |
| 100                  | 0.15                                  | 10.00        | TO-218     | SGSP461    | 20.00               | 125              | 4.50                     | 1200                     | 535  |
| 100                  | 0.10                                  | 9.00         | TO-220     | BUZ21      | 19.00               | 75               | 4.00                     | 2000                     | 187  |
| 100                  | 0.10                                  | 9.00         | TO-3       | BUZ25      | 19.00               | 78               | 4.00                     | 2000                     | 191  |
| 100                  | 0.10                                  | 17.00        | TO-3       | IRF142     | 25.00               | 125              | 8.70                     | 1600                     | 261  |
| 100                  | 0.10                                  | 17.00        | TO-220     | IRF542     | 25.00               | 125              | 8.70                     | 1600                     | 295  |
| 100                  | 0.10                                  | 17.00        | ISOWATT220 | IRF542FI   | 14.00               | 40               | 8.70                     | 1600                     | 295  |
| 100                  | 0.08                                  | 20.00        | TO-3       | IRF152     | 33.00               | 150              | 9.00                     | 3000                     | 267  |
| 100                  | 0.08                                  | 22.00        | TO-218     | IRFP152    | 34.00               | 150              | 13.00                    | 3000                     | 343  |
| 100                  | 0.08                                  | 22.00        | ISOWATT218 | IRFP152FI  | 21.00               | 65               | 13.00                    | 3000                     | 343  |

# SELECTION GUIDE BY VOLTAGE

| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Package    | Type          | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|---------------------------------------|--------------|------------|---------------|---------------------|------------------|--------------------------|--------------------------|------|
| 100                  | 0.077                                 | 17.00        | TO-3       | IRF140        | 28.00               | 125              | 8.70                     | 1600                     | 261  |
| 100                  | 0.077                                 | 17.00        | TO-220     | IRF540        | 28.00               | 125              | 8.70                     | 1600                     | 295  |
| 100                  | 0.077                                 | 17.00        | ISOWATT220 | IRF540FI      | 15.00               | 40               | 8.70                     | 1600                     | 295  |
| 100                  | 0.075                                 | 15.00        | TO-218     | SGSP471       | 30.00               | 150              | 9.00                     | 2200                     | 541  |
| 100                  | 0.055                                 | 20.00        | TO-3       | IRF150        | 40.00               | 150              | 9.00                     | 3000                     | 267  |
| 100                  | 0.055                                 | 22.00        | TO-218     | IRFP150       | 40.00               | 150              | 13.00                    | 3000                     | 343  |
| 100                  | 0.055                                 | 22.00        | ISOWATT218 | IRFP150FI     | 26.00               | 65               | 13.00                    | 3000                     | 343  |
| 100                  | 0.014                                 | 50.00        | TO-240     | SGS100MA010D1 | 120.00              | 400              | 20.00                    | 11200                    | 421  |
| 100                  | 0.009                                 | 75.00        | TO-240     | SGS150MA010D1 | 150.00              | 400              | 20.00                    | 14000                    | 427  |
| 150                  | 1.20                                  | 2.50         | TO-220     | IRF623        | 4.00                | 40               | 1.30                     | 600                      | 301  |
| 150                  | 1.20                                  | 2.50         | ISOWATT220 | IRF623FI      | 3.50                | 30               | 1.30                     | 600                      | 301  |
| 150                  | 0.80                                  | 2.50         | TO-220     | IRF621        | 5.00                | 40               | 1.30                     | 600                      | 301  |
| 150                  | 0.80                                  | 2.50         | ISOWATT220 | IRF621FI      | 4.00                | 30               | 1.30                     | 600                      | 301  |
| 200                  | 1.20                                  | 2.50         | TO-220     | IRF622        | 4.00                | 40               | 1.30                     | 600                      | 301  |
| 200                  | 1.20                                  | 2.50         | ISOWATT220 | IRF622FI      | 3.50                | 30               | 1.30                     | 600                      | 301  |
| 200                  | 0.80                                  | 2.50         | TO-220     | IRF620        | 5.00                | 40               | 1.30                     | 600                      | 301  |
| 200                  | 0.80                                  | 2.50         | ISOWATT220 | IRF620FI      | 4.00                | 30               | 1.30                     | 600                      | 301  |
| 200                  | 0.75                                  | 3.00         | TO-220     | SGSP317       | 6.00                | 75               | 1.50                     | 500                      | 469  |
| 200                  | 0.40                                  | 4.50         | TO-220     | BUZ32         | 9.50                | 75               | 2.20                     | 2000                     | 195  |
| 200                  | 0.33                                  | 6.00         | TO-220     | SGSP367       | 12.00               | 100              | 3.00                     | 1200                     | 517  |
| 200                  | 0.17                                  | 10.00        | TO-218     | SGSP477       | 20.00               | 150              | 8.00                     | 2200                     | 553  |
| 200                  | 0.17                                  | 10.00        | TO-3       | SGSP577       | 20.00               | 150              | 8.00                     | 2200                     | 583  |
| 250                  | 1.20                                  | 2.50         | TO-220     | SGSP316       | 5.00                | 75               | 1.50                     | 500                      | 469  |
| 250                  | 0.45                                  | 5.00         | TO-220     | SGSP363       | 10.00               | 100              | 3.00                     | 1200                     | 517  |
| 350                  | 2.50                                  | 1.80         | TO-220     | IRF723        | 2.80                | 50               | 1.00                     | 600                      | 307  |
| 350                  | 2.50                                  | 1.80         | ISOWATT220 | IRF723FI      | 2.00                | 30               | 1.00                     | 600                      | 307  |
| 350                  | 1.80                                  | 1.80         | TO-220     | IRF721        | 3.30                | 50               | 1.00                     | 600                      | 307  |
| 350                  | 1.80                                  | 1.80         | ISOWATT220 | IRF721FI      | 2.50                | 30               | 1.00                     | 600                      | 307  |
| 350                  | 1.50                                  | 3.00         | TO-220     | IRF733        | 4.50                | 74               | 2.90                     | 800                      | 313  |
| 350                  | 1.50                                  | 3.00         | ISOWATT220 | IRF733FI      | 3.00                | 35               | 2.90                     | 800                      | 313  |
| 350                  | 1.00                                  | 3.00         | TO-220     | IRF731        | 5.50                | 74               | 2.90                     | 800                      | 313  |
| 350                  | 1.00                                  | 3.00         | ISOWATT220 | IRF731FI      | 3.50                | 35               | 2.90                     | 800                      | 313  |
| 350                  | 0.80                                  | 5.20         | TO-220     | IRF743        | 8.30                | 125              | 4.00                     | 1600                     | 319  |
| 350                  | 0.80                                  | 5.20         | ISOWATT220 | IRF743FI      | 4.50                | 40               | 4.00                     | 1600                     | 319  |
| 350                  | 0.55                                  | 5.20         | TO-220     | IRF741        | 10.00               | 125              | 4.00                     | 1600                     | 319  |
| 350                  | 0.55                                  | 5.20         | ISOWATT220 | IRF741FI      | 5.50                | 40               | 4.00                     | 1600                     | 319  |
| 400                  | 20.00                                 | 0.30         | TO-220     | SGSP341       | 0.60                | 18               | 0.10                     | 105                      | 493  |
| 400                  | 2.50                                  | 1.50         | TO-220     | BUZ76A        | 2.60                | 40               | 0.80                     | 500                      | 249  |
| 400                  | 2.50                                  | 1.80         | TO-220     | IRF722        | 2.80                | 50               | 1.00                     | 600                      | 307  |
| 400                  | 2.50                                  | 1.80         | ISOWATT220 | IRF722FI      | 2.00                | 30               | 1.00                     | 600                      | 307  |
| 400                  | 1.80                                  | 1.50         | TO-220     | BUZ76         | 3.00                | 40               | 0.80                     | 500                      | 245  |
| 400                  | 1.80                                  | 1.80         | TO-220     | IRF720        | 3.30                | 50               | 1.00                     | 600                      | 307  |
| 400                  | 1.80                                  | 1.80         | ISOWATT220 | IRF720FI      | 2.50                | 30               | 1.00                     | 600                      | 307  |
| 400                  | 1.50                                  | 2.50         | TO-220     | BUZ60B        | 4.50                | 75               | 1.70                     | 2000                     | 219  |
| 400                  | 1.50                                  | 3.00         | TO-220     | IRF732        | 4.50                | 74               | 2.90                     | 800                      | 313  |

# SELECTION GUIDE BY VOLTAGE

| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>( $\Omega$ ) <sup>①</sup> | $I_D$<br>(A) | Package    | Type      | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|-------------------------------------------|--------------|------------|-----------|---------------------|------------------|--------------------------|--------------------------|------|
| 400                  | 1.50                                      | 3.00         | ISOWATT220 | IRF732FI  | 3.00                | 35               | 2.90                     | 800                      | 313  |
| 400                  | 1.00                                      | 2.50         | TO-220     | BUZ60     | 5.50                | 75               | 1.70                     | 2000                     | 215  |
| 400                  | 1.00                                      | 3.00         | TO-220     | IRF730    | 5.50                | 74               | 2.90                     | 800                      | 313  |
| 400                  | 1.00                                      | 3.00         | ISOWATT220 | IRF730FI  | 3.50                | 35               | 2.90                     | 800                      | 313  |
| 400                  | 0.80                                      | 5.20         | TO-220     | IRF742    | 8.30                | 125              | 4.00                     | 1600                     | 319  |
| 400                  | 0.80                                      | 5.20         | ISOWATT220 | IRF742FI  | 4.50                | 40               | 4.00                     | 1600                     | 319  |
| 400                  | 0.55                                      | 5.20         | TO-220     | IRF740    | 10.00               | 125              | 4.00                     | 1600                     | 319  |
| 400                  | 0.55                                      | 5.20         | ISOWATT220 | IRF740FI  | 5.50                | 40               | 4.00                     | 1600                     | 319  |
| 400                  | 0.55                                      | 5.00         | TO-218     | SGSP475   | 10.00               | 150              | 6.00                     | 2100                     | 547  |
| 400                  | 0.55                                      | 5.00         | TO-3       | SGSP575   | 10.00               | 150              | 6.00                     | 2100                     | 577  |
| 400                  | 0.30                                      | 8.00         | TO-3       | IRF350    | 15.00               | 150              | 8.00                     | 3000                     | 273  |
| 400                  | 0.30                                      | 8.00         | ISOWATT218 | IRFP350FI | 10.00               | 70               | 8.00                     | 3000                     | 349  |
| 450                  | 4.00                                      | 1.40         | TO-220     | IRF823    | 2.20                | 50               | 1.00                     | 400                      | 331  |
| 450                  | 4.00                                      | 1.40         | ISOWATT220 | IRF823FI  | 1.50                | 30               | 1.00                     | 400                      | 331  |
| 450                  | 3.00                                      | 1.40         | TO-220     | IRF821    | 2.50                | 50               | 1.00                     | 400                      | 331  |
| 450                  | 3.00                                      | 1.40         | ISOWATT220 | IRF821FI  | 2.00                | 30               | 1.00                     | 400                      | 331  |
| 450                  | 3.00                                      | 1.20         | SOT-82     | SGSP230   | 2.50                | 50               | 0.80                     | 450                      | 445  |
| 450                  | 3.00                                      | 1.50         | TO-220     | SGSP330   | 3.00                | 75               | 0.80                     | 450                      | 487  |
| 450                  | 2.00                                      | 2.50         | TO-220     | IRF833    | 4.00                | 74               | 2.70                     | 800                      | 331  |
| 450                  | 2.00                                      | 2.50         | ISOWATT220 | IRF833FI  | 2.50                | 35               | 2.70                     | 800                      | 331  |
| 450                  | 1.50                                      | 2.50         | TO-220     | IRF831    | 4.50                | 74               | 2.70                     | 800                      | 331  |
| 450                  | 1.50                                      | 2.50         | ISOWATT220 | IRF831FI  | 3.00                | 35               | 2.70                     | 800                      | 331  |
| 450                  | 1.50                                      | 2.50         | TO-220     | SGSP364   | 5.00                | 100              | 3.00                     | 1000                     | 523  |
| 450                  | 1.10                                      | 4.40         | TO-220     | IRF843    | 7.00                | 125              | 4.90                     | 1600                     | 337  |
| 450                  | 1.10                                      | 4.40         | ISOWATT220 | IRF843FI  | 4.00                | 40               | 4.90                     | 1600                     | 337  |
| 450                  | 0.85                                      | 4.40         | TO-220     | IRF841    | 8.00                | 125              | 4.90                     | 1600                     | 337  |
| 450                  | 0.85                                      | 4.40         | ISOWATT220 | IRF841FI  | 4.50                | 40               | 4.90                     | 1600                     | 337  |
| 450                  | 0.70                                      | 4.50         | TO-218     | SGSP474   | 9.00                | 150              | 6.00                     | 2100                     | 547  |
| 450                  | 0.70                                      | 4.50         | TO-3       | SGSP574   | 9.00                | 150              | 6.00                     | 2100                     | 577  |
| 450                  | 0.50                                      | 7.00         | TO-3       | IRF453    | 11.00               | 150              | 8.70                     | 3000                     | 279  |
| 450                  | 0.50                                      | 7.20         | TO-218     | IRFP453   | 12.00               | 150              | 8.70                     | 3000                     | 355  |
| 450                  | 0.50                                      | 7.20         | ISOWATT218 | IRFP453FI | 8.00                | 70               | 8.70                     | 3000                     | 355  |
| 450                  | 0.40                                      | 7.20         | TO-3       | IRF451    | 13.00               | 150              | 8.70                     | 3000                     | 279  |
| 450                  | 0.40                                      | 7.20         | TO-218     | IRFP451   | 14.00               | 150              | 8.70                     | 3000                     | 355  |
| 450                  | 0.40                                      | 7.20         | ISOWATT218 | IRFP451FI | 9.00                | 70               | 8.70                     | 3000                     | 355  |
| 500                  | 8.50                                      | 0.60         | SOT-82     | SGSP239   | 1.20                | 40               | 0.65                     | 300                      | 451  |
| 500                  | 4.00                                      | 1.20         | TO-220     | BUZ74A    | 2.00                | 40               | 0.80                     | 500                      | 241  |
| 500                  | 4.00                                      | 1.40         | TO-220     | IRF822    | 2.20                | 50               | 1.00                     | 400                      | 325  |
| 500                  | 4.00                                      | 1.40         | ISOWATT220 | IRF822FI  | 1.50                | 30               | 1.00                     | 400                      | 325  |
| 500                  | 3.80                                      | 1.40         | TO-220     | SGSP319   | 2.80                | 75               | 0.80                     | 380                      | 475  |
| 500                  | 3.00                                      | 1.20         | TO-220     | BUZ74     | 2.40                | 40               | 0.80                     | 500                      | 237  |
| 500                  | 3.00                                      | 1.40         | TO-220     | IRF820    | 2.50                | 50               | 1.00                     | 400                      | 325  |
| 500                  | 3.00                                      | 1.40         | ISOWATT220 | IRF820FI  | 2.00                | 30               | 1.00                     | 400                      | 325  |
| 500                  | 2.00                                      | 2.50         | TO-220     | BUZ42     | 4.00                | 75               | 1.50                     | 2000                     | 203  |
| 500                  | 2.00                                      | 2.50         | TO-220     | IRF832    | 4.00                | 74               | 2.70                     | 800                      | 325  |

## SELECTION GUIDE BY VOLTAGE

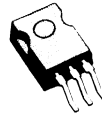
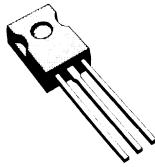
| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Package    | Type         | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|---------------------------------------|--------------|------------|--------------|---------------------|------------------|--------------------------|--------------------------|------|
| 500                  | 2.00                                  | 2.50         | ISOWATT220 | IRF832FI     | 2.50                | 35               | 2.70                     | 800                      | 325  |
| 500                  | 1.50                                  | 2.50         | TO-220     | BUZ41A       | 4.50                | 75               | 1.50                     | 2000                     | 199  |
| 500                  | 1.50                                  | 2.50         | TO-220     | IRF830       | 4.50                | 74               | 2.70                     | 800                      | 331  |
| 500                  | 1.50                                  | 2.50         | ISOWATT220 | IRF830FI     | 3.00                | 35               | 2.70                     | 800                      | 331  |
| 500                  | 1.50                                  | 2.50         | TO-220     | SGSP369      | 5.00                | 100              | 3.00                     | 1000                     | 523  |
| 500                  | 1.10                                  | 4.40         | TO-220     | IRF842       | 7.00                | 125              | 4.90                     | 1600                     | 337  |
| 500                  | 1.10                                  | 4.40         | ISOWATT220 | IRF842FI     | 4.00                | 40               | 4.90                     | 1600                     | 337  |
| 500                  | 0.85                                  | 4.40         | TO-220     | IRF840       | 8.00                | 125              | 4.90                     | 1600                     | 337  |
| 500                  | 0.85                                  | 4.40         | ISOWATT220 | IRF840FI     | 4.50                | 40               | 4.90                     | 1600                     | 337  |
| 500                  | 0.80                                  | 5.50         | TO-218     | BUZ354       | 8.00                | 125              | 2.70                     | 4900                     | 249  |
| 500                  | 0.80                                  | 5.00         | TO-3       | BUZ45A       | 8.30                | 125              | 2.70                     | 4900                     | 211  |
| 500                  | 0.70                                  | 4.50         | TO-218     | SGSP479      | 9.00                | 150              | 5.00                     | 1900                     | 559  |
| 500                  | 0.70                                  | 4.50         | TO-3       | SGSP579      | 9.00                | 150              | 5.00                     | 1900                     | 589  |
| 500                  | 0.60                                  | 5.50         | TO-218     | BUZ353       | 9.50                | 125              | 2.70                     | 4900                     | 253  |
| 500                  | 0.60                                  | 5.00         | TO-3       | BUZ45        | 9.60                | 125              | 2.70                     | 4900                     | 207  |
| 500                  | 0.50                                  | 7.20         | TO-3       | IRF452       | 11.00               | 150              | 8.70                     | 3000                     | 279  |
| 500                  | 0.50                                  | 7.20         | TO-218     | IRFP452      | 12.00               | 150              | 8.70                     | 3000                     | 355  |
| 500                  | 0.50                                  | 7.20         | ISOWATT218 | IRFP452FI    | 8.00                | 70               | 8.70                     | 3000                     | 355  |
| 500                  | 0.40                                  | 7.20         | TO-3       | IRF450       | 13.00               | 150              | 8.70                     | 3000                     | 279  |
| 500                  | 0.40                                  | 7.20         | TO-218     | IRFP450      | 14.00               | 150              | 8.70                     | 3000                     | 355  |
| 500                  | 0.40                                  | 7.20         | ISOWATT218 | IRFP450FI    | 9.00                | 70               | 8.70                     | 3000                     | 355  |
| 500                  | 0.20                                  | 15.00        | TO-240     | SGS30MA050D1 | 30.00               | 400              | 15.00                    | 9100                     | 409  |
| 500                  | 0.16                                  | 17.50        | TO-240     | SGS35MA050D1 | 35.00               | 400              | 15.00                    | 12000                    | 415  |
| 600                  | 2.50                                  | 1.50         | TO-220     | MTP3N60      | 3.00                | 75               | 1.50                     | 1000                     | 385  |
| 600                  | 2.50                                  | 1.50         | ISOWATT220 | MTP3N60FI    | 2.50                | 35               | 1.50                     | 1000                     | 385  |
| 600                  | 1.20                                  | 3.00         | ISOWATT218 | MTH6N60FI    | 3.50                | 40               | 2.00                     | 1800                     | 367  |
| 600                  | 1.20                                  | 3.00         | TO-220     | MTP6N60      | 6.00                | 125              | 2.00                     | 1800                     | 391  |
| 800                  | 2.00                                  | 2.00         | TO-218     | STHV82       | 5.50                | 125              | 2.00                     | 1000                     | 601  |
| 1000                 | 3.50                                  | 2.00         | TO-218     | STHV102      | 4.20                | 125              | 2.00                     | 1200                     | 607  |

## HIMOS (IGBT)

| $V_{(BR)DSS}$<br>(V) | $V_{DS(on)}$<br>(max)<br>(V) | $I_D$<br>(A) | Package    | Type        | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|------------------------------|--------------|------------|-------------|---------------------|------------------|--------------------------|--------------------------|------|
| 500                  | 2.70                         | 7.00         | TO-220     | STH107N50   | 7.00                | 100              | 2.50                     | 950                      | 627  |
| 500                  | 2.70                         | 7.00         | ISOWATT220 | STH10N50    | 7.00                | 35               | 2.50                     | 950                      | 627  |
| 500                  | 2.70                         | 10.00        | TO-220     | STH110N50   | 10.00               | 100              | 2.50                     | 950                      | 633  |
| 500                  | 2.70                         | 10.00        | ISOWATT220 | STH110N50FI | 10.00               | 35               | 2.50                     | 950                      | 633  |

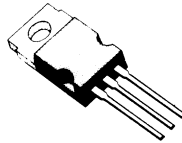


## SOT-82

OPTION  
SOT-194

| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>( $\Omega$ ) <sup>Ⓒ</sup> | $I_D$<br>(A) | Type    | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|-------------------------------------------|--------------|---------|---------------------|------------------|--------------------------|--------------------------|------|
| 50                   | 0.13                                      | 5.00         | SGSP222 | 10.00               | 50               | 3.00                     | 550                      | 439  |
| 100                  | 1.40                                      | 1.20         | SGSP201 | 2.50                | 18               | 0.50                     | 125                      | 433  |
| 450                  | 3.00                                      | 1.20         | SGSP230 | 2.50                | 50               | 0.80                     | 450                      | 445  |
| 500                  | 8.50                                      | 0.60         | SGSP239 | 1.20                | 40               | 0.65                     | 300                      | 451  |

## TO-220



| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>( $\Omega$ ) <sup>Ⓒ</sup> | $I_D$<br>(A) | Type      | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|-------------------------------------------|--------------|-----------|---------------------|------------------|--------------------------|--------------------------|------|
| 50                   | 0.30                                      | 3.50         | SGSP358   | 7.00                | 50               | 1.50                     | 270                      | 505  |
| 50                   | 0.15                                      | 7.50         | MTP15N05L | 15.00               | 75               | 5.00                     | 900                      | 397  |
| 50                   | 0.15                                      | 7.50         | STLT19    | 15.00               | 75               | 5.00                     | 480                      | 611  |
| 50                   | 0.13                                      | 8.00         | SGSP322   | 16.00               | 75               | 3.00                     | 550                      | 481  |
| 50                   | 0.12                                      | 10.00        | BUZ10A    | 17.00               | 75               | 3.00                     | 2000                     | 163  |
| 50                   | 0.12                                      | 9.00         | BUZ71A    | 13.00               | 40               | 3.00                     | 650                      | 229  |
| 50                   | 0.12                                      | 9.00         | IRFZ22    | 14.00               | 40               | 5.00                     | 850                      | 361  |
| 50                   | 0.10                                      | 9.00         | BUZ71     | 14.00               | 40               | 3.00                     | 650                      | 223  |
| 50                   | 0.10                                      | 9.00         | IRFZ20    | 15.00               | 40               | 5.00                     | 850                      | 361  |
| 50                   | 0.08                                      | 12.50        | STLT29    | 25.00               | 100              | 9.00                     | 1200                     | 617  |
| 50                   | 0.08                                      | 13.00        | BUZ10     | 20.00               | 70               | 8.00                     | 700 typ                  | 159  |
| 50                   | 0.06                                      | 15.00        | BUZ11A    | 25.00               | 75               | 4.00                     | 2000                     | 173  |
| 50                   | 0.06                                      | 14.00        | SGSP382   | 28.00               | 100              | 5.00                     | 1400                     | 529  |
| 50                   | 0.04                                      | 15.00        | BUZ11     | 30.00               | 75               | 4.00                     | 2000                     | 167  |
| 50                   | 0.035                                     | 29.00        | IRFZ42    | 35.00               | 125              | 17.00                    | 3000                     | 367  |

# SELECTION GUIDE BY PACKAGE

## TO-220 (continued)

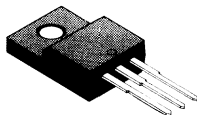
| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Type      | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|---------------------------------------|--------------|-----------|---------------------|------------------|--------------------------|--------------------------|------|
| 50                   | 0.028                                 | 29.00        | IRFZ40    | 35.00               | 125              | 17.00                    | 3000                     | 367  |
| 50                   | 0.023                                 | 30.00        | STVHD90   | 52.00               | 125              | 30.00                    | 3000                     | 621  |
| 60                   | 0.15                                  | 7.50         | MTP15N06L | 15.00               | 75               | 5.00                     | 900                      | 397  |
| 60                   | 0.15                                  | 6.00         | MTP3055A  | 12.00               | 40               | 4.50                     | 500                      | 403  |
| 60                   | 0.15                                  | 7.50         | STLT20    | 15.00               | 75               | 5.00                     | 480                      | 611  |
| 60                   | 0.13                                  | 8.00         | SGSP321   | 16.00               | 75               | 3.00                     | 550                      | 481  |
| 60                   | 0.08                                  | 12.50        | STLT30    | 25.00               | 100              | 9.00                     | 1200                     | 617  |
| 60                   | 0.06                                  | 14.00        | SGSP381   | 28.00               | 100              | 5.00                     | 1400                     | 529  |
| 60                   | 0.04                                  | 15.00        | BUZ11S2   | 30.00               | 75               | 4.00                     | 2000                     | 177  |
| 80                   | 0.36                                  | 5.60         | IRF523    | 8.00                | 60               | 2.70                     | 600                      | 285  |
| 80                   | 0.27                                  | 5.60         | IRF521    | 9.20                | 60               | 2.70                     | 600                      | 285  |
| 80                   | 0.23                                  | 8.30         | IRF533    | 12.00               | 79               | 5.10                     | 800                      | 291  |
| 80                   | 0.16                                  | 8.30         | IRF531    | 14.00               | 79               | 5.10                     | 800                      | 291  |
| 80                   | 0.10                                  | 17.00        | IRF543    | 25.00               | 125              | 8.70                     | 1600                     | 295  |
| 80                   | 0.10                                  | 11.00        | SGSP362   | 22.00               | 100              | 4.50                     | 1200                     | 511  |
| 80                   | 0.077                                 | 17.00        | IRF541    | 28.00               | 125              | 8.70                     | 1600                     | 295  |
| 100                  | 1.40                                  | 1.20         | SGSP301   | 2.50                | 18               | 0.50                     | 125                      | 457  |
| 100                  | 0.60                                  | 3.00         | SGSP351   | 6.00                | 50               | 1.00                     | 250                      | 499  |
| 100                  | 0.36                                  | 5.60         | IRF522    | 8.00                | 60               | 2.70                     | 600                      | 285  |
| 100                  | 0.30                                  | 5.50         | SGSP311   | 11.00               | 75               | 2.00                     | 480                      | 463  |
| 100                  | 0.27                                  | 5.60         | IRF520    | 9.20                | 60               | 2.70                     | 600                      | 285  |
| 100                  | 0.25                                  | 5.00         | BUZ72A    | 9.00                | 40               | 2.70                     | 600                      | 233  |
| 100                  | 0.23                                  | 8.30         | IRF532    | 12.00               | 79               | 5.10                     | 800                      | 291  |
| 100                  | 0.20                                  | 6.00         | BUZ20     | 12.00               | 75               | 2.70                     | 2000                     | 183  |
| 100                  | 0.16                                  | 8.30         | IRF530    | 14.00               | 79               | 5.10                     | 800                      | 291  |
| 100                  | 0.15                                  | 9.00         | SGSP361   | 18.00               | 100              | 4.50                     | 1200                     | 511  |
| 100                  | 0.10                                  | 9.00         | BUZ21     | 19.00               | 75               | 4.00                     | 2000                     | 187  |
| 100                  | 0.10                                  | 17.00        | IRF542    | 25.00               | 125              | 8.70                     | 1600                     | 295  |
| 100                  | 0.077                                 | 17.00        | IRF540    | 28.00               | 125              | 8.70                     | 1600                     | 295  |
| 150                  | 1.20                                  | 2.50         | IRF623    | 4.00                | 40               | 1.30                     | 600                      | 301  |
| 150                  | 0.80                                  | 2.50         | IRF621    | 5.00                | 40               | 1.30                     | 600                      | 301  |
| 200                  | 1.20                                  | 2.50         | IRF622    | 4.00                | 40               | 1.30                     | 600                      | 301  |
| 200                  | 0.80                                  | 2.50         | IRF620    | 5.00                | 40               | 1.30                     | 600                      | 301  |
| 200                  | 0.75                                  | 3.00         | SGSP317   | 6.00                | 75               | 1.50                     | 500                      | 469  |
| 200                  | 0.40                                  | 4.50         | BUZ32     | 9.50                | 75               | 2.20                     | 2000                     | 195  |
| 200                  | 0.33                                  | 6.00         | SGSP367   | 12.00               | 100              | 3.00                     | 1200                     | 517  |
| 250                  | 1.20                                  | 2.50         | SGSP316   | 5.00                | 75               | 1.50                     | 500                      | 469  |
| 250                  | 0.45                                  | 5.00         | SGSP363   | 10.00               | 100              | 3.00                     | 1200                     | 517  |
| 350                  | 2.50                                  | 1.80         | IRF723    | 2.80                | 50               | 1.00                     | 600                      | 307  |
| 350                  | 1.80                                  | 1.80         | IRF721    | 3.30                | 50               | 1.00                     | 600                      | 307  |
| 350                  | 1.50                                  | 3.00         | IRF733    | 4.50                | 74               | 2.90                     | 800                      | 313  |
| 350                  | 1.00                                  | 3.00         | IRF731    | 5.50                | 74               | 2.90                     | 800                      | 313  |
| 350                  | 0.80                                  | 5.20         | IRF743    | 8.30                | 125              | 4.00                     | 1600                     | 319  |
| 350                  | 0.55                                  | 5.20         | IRF741    | 10.00               | 125              | 4.00                     | 1600                     | 319  |
| 400                  | 20.00                                 | 0.30         | SGSP341   | 0.60                | 18               | 0.10                     | 105                      | 493  |

## TO-220 (continued)

| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>( $\Omega$ ) <sup>①</sup> | $I_D$<br>(A) | Type    | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|-------------------------------------------|--------------|---------|---------------------|------------------|--------------------------|--------------------------|------|
| 400                  | 2.50                                      | 1.50         | BUZ76A  | 2.60                | 40               | 0.80                     | 500                      | 249  |
| 400                  | 2.50                                      | 1.80         | IRF722  | 2.80                | 50               | 1.00                     | 600                      | 307  |
| 400                  | 1.80                                      | 1.50         | BUZ76   | 3.00                | 40               | 0.80                     | 500                      | 245  |
| 400                  | 1.80                                      | 1.80         | IRF720  | 3.30                | 50               | 1.00                     | 600                      | 307  |
| 400                  | 1.50                                      | 2.50         | BUZ60B  | 4.50                | 75               | 1.70                     | 2000                     | 219  |
| 400                  | 1.50                                      | 3.00         | IRF732  | 4.50                | 74               | 2.90                     | 800                      | 313  |
| 400                  | 1.00                                      | 2.50         | BUZ60   | 5.50                | 75               | 1.70                     | 2000                     | 215  |
| 400                  | 1.00                                      | 3.00         | IRF730  | 5.50                | 74               | 2.90                     | 800                      | 313  |
| 400                  | 0.80                                      | 5.20         | IRF742  | 8.30                | 125              | 4.00                     | 1600                     | 319  |
| 400                  | 0.55                                      | 5.20         | IRF740  | 10.00               | 125              | 4.00                     | 1600                     | 319  |
| 450                  | 4.00                                      | 1.40         | IRF823  | 2.20                | 50               | 1.00                     | 400                      | 325  |
| 450                  | 3.00                                      | 1.40         | IRF821  | 2.50                | 50               | 1.00                     | 400                      | 325  |
| 450                  | 3.00                                      | 1.50         | SGSP330 | 3.00                | 75               | 0.80                     | 450                      | 487  |
| 450                  | 2.00                                      | 2.50         | IRF833  | 4.00                | 74               | 2.70                     | 800                      | 331  |
| 450                  | 1.50                                      | 2.50         | IRF831  | 4.50                | 74               | 2.70                     | 800                      | 331  |
| 450                  | 1.50                                      | 2.50         | SGSP364 | 5.00                | 100              | 3.00                     | 1000                     | 523  |
| 450                  | 1.10                                      | 4.40         | IRF843  | 7.00                | 125              | 4.90                     | 1600                     | 337  |
| 450                  | 0.85                                      | 4.40         | IRF841  | 8.00                | 125              | 4.90                     | 1600                     | 337  |
| 500                  | 4.00                                      | 1.20         | BUZ74A  | 2.00                | 40               | 0.80                     | 500                      | 241  |
| 500                  | 4.00                                      | 1.40         | IRF822  | 2.20                | 50               | 1.00                     | 400                      | 325  |
| 500                  | 3.80                                      | 1.40         | SGSP319 | 2.80                | 75               | 0.80                     | 380                      | 475  |
| 500                  | 3.00                                      | 1.20         | BUZ74   | 2.40                | 40               | 0.80                     | 500                      | 237  |
| 500                  | 3.00                                      | 1.40         | IRF820  | 2.50                | 50               | 1.00                     | 400                      | 325  |
| 500                  | 2.00                                      | 2.50         | BUZ42   | 4.00                | 75               | 1.50                     | 2000                     | 203  |
| 500                  | 2.00                                      | 2.50         | IRF832  | 4.00                | 74               | 2.70                     | 800                      | 331  |
| 500                  | 1.50                                      | 2.50         | BUZ41A  | 4.50                | 75               | 1.50                     | 2000                     | 199  |
| 500                  | 1.50                                      | 2.50         | IRF830  | 4.50                | 74               | 2.70                     | 800                      | 331  |
| 500                  | 1.50                                      | 2.50         | SGSP369 | 5.00                | 100              | 3.00                     | 1000                     | 523  |
| 500                  | 1.10                                      | 4.40         | IRF842  | 7.00                | 125              | 4.90                     | 1600                     | 337  |
| 500                  | 0.85                                      | 4.40         | IRF840  | 8.00                | 125              | 4.90                     | 1600                     | 337  |
| 600                  | 2.50                                      | 1.50         | MTP3N60 | 3.00                | 75               | 1.50                     | 1000                     | 385  |
| 600                  | 1.20                                      | 3.00         | MTP6N60 | 6.00                | 125              | 2.00                     | 1800                     | 391  |

# SELECTION GUIDE BY PACKAGE

## ISOWATT220

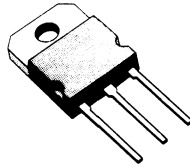


| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Type        | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|---------------------------------------|--------------|-------------|---------------------|------------------|--------------------------|--------------------------|------|
| 50                   | 0.15                                  | 7.50         | MTP15N05LFI | 10.00               | 30               | 5.00                     | 900                      | 397  |
| 50                   | 0.15                                  | 7.50         | STLT19FI    | 10.00               | 30               | 5.00                     | 480                      | 611  |
| 50                   | 0.12                                  | 9.00         | IRFZ22FI    | 12.00               | 30               | 5.00                     | 850                      | 361  |
| 50                   | 0.10                                  | 9.00         | BUZ71FI     | 12.00               | 30               | 3.00                     | 650                      | 223  |
| 50                   | 0.10                                  | 9.00         | IRFZ20FI    | 12.50               | 30               | 5.00                     | 850                      | 361  |
| 50                   | 0.04                                  | 15.00        | BUZ11FI     | 20.00               | 35               | 4.00                     | 2000                     | 167  |
| 60                   | 0.15                                  | 7.50         | MTP15N06LFI | 10.00               | 30               | 5.00                     | 900                      | 397  |
| 60                   | 0.15                                  | 6.00         | MTP3055AFI  | 10.00               | 30               | 4.50                     | 500                      | 403  |
| 60                   | 0.15                                  | 7.50         | STLT20FI    | 10.00               | 30               | 5.00                     | 480                      | 611  |
| 60                   | 0.04                                  | 15.00        | BUZ11S2FI   | 20.00               | 35               | 4.00                     | 2000                     | 177  |
| 80                   | 0.36                                  | 5.60         | IRF523FI    | 6.00                | 30               | 2.70                     | 600                      | 285  |
| 80                   | 0.27                                  | 5.60         | IRF521FI    | 7.00                | 30               | 2.70                     | 600                      | 285  |
| 80                   | 0.23                                  | 8.30         | IRF533FI    | 8.00                | 35               | 5.10                     | 800                      | 291  |
| 80                   | 0.16                                  | 8.30         | IRF531FI    | 9.00                | 35               | 5.10                     | 800                      | 291  |
| 80                   | 0.10                                  | 17.00        | IRF543FI    | 14.00               | 40               | 8.70                     | 1600                     | 295  |
| 80                   | 0.077                                 | 17.00        | IRF541FI    | 15.00               | 40               | 8.70                     | 1600                     | 295  |
| 100                  | 0.36                                  | 5.60         | IRF522FI    | 6.00                | 30               | 2.70                     | 600                      | 285  |
| 100                  | 0.27                                  | 5.60         | IRF520FI    | 7.00                | 30               | 2.70                     | 600                      | 285  |
| 100                  | 0.23                                  | 8.30         | IRF532FI    | 8.00                | 35               | 5.10                     | 800                      | 291  |
| 100                  | 0.16                                  | 8.30         | IRF530FI    | 9.00                | 35               | 5.10                     | 800                      | 291  |
| 100                  | 0.10                                  | 17.00        | IRF542FI    | 14.00               | 40               | 8.70                     | 1600                     | 295  |
| 100                  | 0.077                                 | 17.00        | IRF540FI    | 15.00               | 40               | 8.70                     | 1600                     | 295  |
| 150                  | 1.20                                  | 2.50         | IRF623FI    | 3.50                | 30               | 1.30                     | 600                      | 301  |
| 150                  | 0.80                                  | 2.50         | IRF621FI    | 4.00                | 30               | 1.30                     | 600                      | 301  |
| 200                  | 1.20                                  | 2.50         | IRF622FI    | 3.50                | 30               | 1.30                     | 600                      | 301  |
| 200                  | 0.80                                  | 2.50         | IRF620FI    | 4.00                | 30               | 1.30                     | 600                      | 301  |
| 350                  | 2.50                                  | 1.80         | IRF723FI    | 2.00                | 30               | 1.00                     | 600                      | 307  |
| 350                  | 1.80                                  | 1.80         | IRF721FI    | 2.50                | 30               | 1.00                     | 600                      | 307  |
| 350                  | 1.50                                  | 3.00         | IRF733FI    | 3.00                | 35               | 2.90                     | 800                      | 313  |
| 350                  | 1.00                                  | 3.00         | IRF731FI    | 3.50                | 35               | 2.90                     | 800                      | 313  |
| 350                  | 0.80                                  | 5.20         | IRF743FI    | 4.50                | 40               | 4.00                     | 1600                     | 319  |
| 350                  | 0.55                                  | 5.20         | IRF741FI    | 5.50                | 40               | 4.00                     | 1600                     | 319  |
| 400                  | 2.50                                  | 1.80         | IRF722FI    | 2.00                | 30               | 1.00                     | 600                      | 307  |
| 400                  | 1.80                                  | 1.80         | IRF720FI    | 2.50                | 30               | 1.00                     | 600                      | 307  |
| 400                  | 1.50                                  | 3.00         | IRF732FI    | 3.00                | 35               | 2.90                     | 800                      | 313  |

## ISOWATT220 (continued)

| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Type      | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|---------------------------------------|--------------|-----------|---------------------|------------------|--------------------------|--------------------------|------|
| 400                  | 1.00                                  | 3.00         | IRF730FI  | 3.50                | 35               | 2.90                     | 800                      | 313  |
| 400                  | 0.80                                  | 5.20         | IRF742FI  | 4.50                | 40               | 4.00                     | 1600                     | 319  |
| 400                  | 0.55                                  | 5.20         | IRF740FI  | 5.50                | 40               | 4.00                     | 1600                     | 319  |
| 450                  | 4.00                                  | 1.40         | IRF823FI  | 1.50                | 30               | 1.00                     | 400                      | 325  |
| 450                  | 3.00                                  | 1.40         | IRF821FI  | 2.00                | 30               | 1.00                     | 400                      | 325  |
| 450                  | 2.00                                  | 2.50         | IRF833FI  | 2.50                | 35               | 2.70                     | 800                      | 331  |
| 450                  | 1.50                                  | 2.50         | IRF831FI  | 3.00                | 35               | 2.70                     | 800                      | 331  |
| 450                  | 1.10                                  | 4.40         | IRF843FI  | 4.00                | 40               | 4.90                     | 1600                     | 337  |
| 450                  | 0.85                                  | 4.40         | IRF841FI  | 4.50                | 40               | 4.90                     | 1600                     | 337  |
| 500                  | 4.00                                  | 1.40         | IRF822FI  | 1.50                | 30               | 1.00                     | 400                      | 325  |
| 500                  | 3.00                                  | 1.40         | IRF820FI  | 2.00                | 30               | 1.00                     | 400                      | 325  |
| 500                  | 2.00                                  | 2.50         | IRF832FI  | 2.50                | 35               | 2.70                     | 800                      | 331  |
| 500                  | 1.50                                  | 2.50         | IRF830FI  | 3.00                | 35               | 2.70                     | 800                      | 331  |
| 500                  | 1.10                                  | 4.40         | IRF842FI  | 4.00                | 40               | 4.90                     | 1600                     | 337  |
| 500                  | 0.85                                  | 4.40         | IRF840FI  | 4.50                | 40               | 4.90                     | 1600                     | 337  |
| 600                  | 2.50                                  | 1.50         | MTP3N60FI | 2.50                | 35               | 1.50                     | 1000                     | 385  |

## TO-218



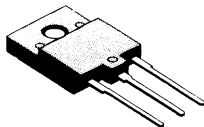
| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Type     | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|---------------------------------------|--------------|----------|---------------------|------------------|--------------------------|--------------------------|------|
| 50                   | 0.06                                  | 15.00        | SGSP482  | 30.00               | 125              | 5.00                     | 1400                     | 565  |
| 50                   | 0.033                                 | 20.00        | SGSP492  | 40.00               | 150              | 10.00                    | 2800                     | 571  |
| 60                   | 0.08                                  | 22.00        | IRFP153  | 34.00               | 150              | 13.00                    | 3000                     | 343  |
| 60                   | 0.06                                  | 15.00        | SGSP481  | 30.00               | 125              | 5.00                     | 1400                     | 565  |
| 60                   | 0.055                                 | 22.00        | IRFP151  | 40.00               | 150              | 13.00                    | 3000                     | 343  |
| 60                   | 0.033                                 | 20.00        | SGSP491  | 40.00               | 150              | 10.00                    | 2800                     | 571  |
| 60                   | 0.028                                 | 20.00        | MTH40N06 | 40.00               | 150              | 10.00                    | 5000                     | 379  |
| 80                   | 0.10                                  | 12.50        | SGSP462  | 25.00               | 125              | 4.50                     | 1200                     | 535  |
| 80                   | 0.05                                  | 17.50        | SGSP472  | 35.00               | 150              | 9.00                     | 2200                     | 541  |
| 100                  | 0.15                                  | 10.00        | SGSP461  | 20.00               | 125              | 4.50                     | 1200                     | 535  |

## SELECTION GUIDE BY PACKAGE

### TO-218 (continued)

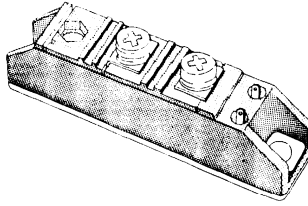
| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>( $\Omega$ ) <sup>①</sup> | $I_D$<br>(A) | Type    | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|-------------------------------------------|--------------|---------|---------------------|------------------|--------------------------|--------------------------|------|
| 100                  | 0.08                                      | 22.00        | IRFP152 | 34.00               | 150              | 13.00                    | 3000                     | 343  |
| 100                  | 0.075                                     | 15.00        | SGSP471 | 30.00               | 150              | 9.00                     | 2200                     | 541  |
| 100                  | 0.055                                     | 22.00        | IRFP150 | 40.00               | 150              | 13.00                    | 3000                     | 343  |
| 200                  | 0.17                                      | 10.00        | SGSP477 | 20.00               | 150              | 8.00                     | 2200                     | 553  |
| 400                  | 0.55                                      | 5.00         | SGSP475 | 10.00               | 150              | 6.00                     | 2100                     | 547  |
| 450                  | 0.70                                      | 4.50         | SGSP474 | 9.00                | 150              | 6.00                     | 2100                     | 547  |
| 450                  | 0.50                                      | 7.20         | IRFP453 | 12.00               | 150              | 8.70                     | 3000                     | 355  |
| 450                  | 0.40                                      | 7.20         | IRFP451 | 14.00               | 150              | 8.70                     | 3000                     | 355  |
| 500                  | 0.80                                      | 5.50         | BUZ354  | 8.00                | 125              | 2.70                     | 4900                     | 257  |
| 500                  | 0.70                                      | 4.50         | SGSP479 | 9.00                | 150              | 5.00                     | 1900                     | 559  |
| 500                  | 0.60                                      | 5.50         | BUZ353  | 9.50                | 125              | 2.70                     | 4900                     | 253  |
| 500                  | 0.50                                      | 7.20         | IRFP452 | 12.00               | 150              | 8.70                     | 3000                     | 355  |
| 500                  | 0.40                                      | 7.20         | IRFP450 | 14.00               | 150              | 8.70                     | 3000                     | 355  |
| 800                  | 2.00                                      | 2.00         | STHV82  | 5.50                | 125              | 2.00                     | 1000                     | 601  |
| 1000                 | 3.50                                      | 2.00         | STHV102 | 4.20                | 125              | 2.00                     | 1200                     | 607  |

### ISOWATT218



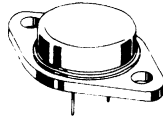
| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>( $\Omega$ ) <sup>①</sup> | $I_D$<br>(A) | Type       | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|-------------------------------------------|--------------|------------|---------------------|------------------|--------------------------|--------------------------|------|
| 60                   | 0.08                                      | 22.00        | IRFP153FI  | 21.00               | 65               | 13.00                    | 3000                     | 343  |
| 60                   | 0.055                                     | 22.00        | IRFP151FI  | 26.00               | 65               | 13.00                    | 3000                     | 343  |
| 60                   | 0.028                                     | 20.00        | MTH40N06FI | 26.00               | 65               | 10.00                    | 5000                     | 379  |
| 100                  | 0.08                                      | 22.00        | IRFP152FI  | 21.00               | 65               | 13.00                    | 3000                     | 343  |
| 100                  | 0.055                                     | 22.00        | IRFP150FI  | 26.00               | 65               | 13.00                    | 3000                     | 343  |
| 400                  | 0.30                                      | 8.00         | IRFP350FI  | 10.00               | 70               | 8.00                     | 3000                     | 349  |
| 450                  | 0.50                                      | 7.20         | IRFP453FI  | 8.00                | 70               | 8.70                     | 3000                     | 355  |
| 450                  | 0.40                                      | 7.20         | IRFP451FI  | 9.00                | 70               | 8.70                     | 3000                     | 355  |
| 500                  | 0.50                                      | 7.20         | IRFP452FI  | 8.00                | 70               | 8.70                     | 3000                     | 355  |
| 500                  | 0.40                                      | 7.20         | IRFP450FI  | 9.00                | 70               | 8.70                     | 3000                     | 355  |
| 600                  | 1.20                                      | 3.00         | MTH6N60FI  | 3.50                | 40               | 2.00                     | 1800                     | 373  |

## TO-240



| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Type          | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|---------------------------------------|--------------|---------------|---------------------|------------------|--------------------------|--------------------------|------|
| 100                  | 0.016                                 | 50.00        | SGS100MA010D1 | 120.00              | 400              | 20.00                    | 11200                    | 421  |
| 100                  | 0.009                                 | 75.00        | SGS150MA010D1 | 150.00              | 400              | 20.00                    | 14000                    | 427  |
| 500                  | 0.20                                  | 15.00        | SGS30MA050D1  | 30.00               | 400              | 15.00                    | 9100                     | 409  |
| 500                  | 0.16                                  | 17.50        | SGS35MA050D1  | 35.00               | 400              | 15.00                    | 12000                    | 415  |

## TO-3



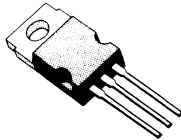
| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>( $\Omega$ ) | $I_D$<br>(A) | Type    | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|---------------------------------------|--------------|---------|---------------------|------------------|--------------------------|--------------------------|------|
| 50                   | 0.033                                 | 20.00        | SGSP592 | 40.00               | 150              | 10.00                    | 2800                     | 595  |
| 60                   | 0.08                                  | 20.00        | IRF153  | 33.00               | 150              | 9.00                     | 3000                     | 267  |
| 60                   | 0.055                                 | 20.00        | IRF151  | 40.00               | 150              | 9.00                     | 3000                     | 267  |
| 60                   | 0.033                                 | 20.00        | SGSP591 | 40.00               | 150              | 10.00                    | 2800                     | 595  |
| 80                   | 0.10                                  | 17.00        | IRF143  | 25.00               | 125              | 8.70                     | 1600                     | 261  |
| 80                   | 0.077                                 | 17.00        | IRF141  | 28.00               | 125              | 8.70                     | 1600                     | 261  |
| 100                  | 0.10                                  | 9.00         | BUZ25   | 19.00               | 78               | 4.00                     | 2000                     | 191  |
| 100                  | 0.10                                  | 17.00        | IRF142  | 25.00               | 125              | 8.70                     | 1600                     | 261  |
| 100                  | 0.08                                  | 20.00        | IRF152  | 33.00               | 150              | 9.00                     | 3000                     | 267  |
| 100                  | 0.077                                 | 17.00        | IRF140  | 28.00               | 125              | 8.70                     | 1600                     | 261  |
| 100                  | 0.055                                 | 20.00        | IRF150  | 40.00               | 150              | 9.00                     | 3000                     | 267  |
| 200                  | 0.17                                  | 10.00        | SGSP577 | 20.00               | 150              | 8.00                     | 2200                     | 583  |
| 400                  | 0.55                                  | 5.00         | SGSP575 | 10.00               | 150              | 6.00                     | 2100                     | 577  |
| 400                  | 0.30                                  | 8.00         | IRF350  | 15.00               | 150              | 8.00                     | 3000                     | 273  |
| 450                  | 0.70                                  | 4.50         | SGSP574 | 9.00                | 150              | 6.00                     | 2100                     | 577  |

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## TO-3 (continued)

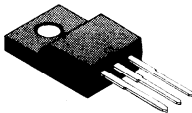
| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>( $\Omega$ ) <sup>Ⓐ</sup> | $I_D$<br>(A) | Type    | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|-------------------------------------------|--------------|---------|---------------------|------------------|--------------------------|--------------------------|------|
| 450                  | 0.50                                      | 7.20         | IRF453  | 11.00               | 150              | 8.70                     | 3000                     | 279  |
| 450                  | 0.40                                      | 7.20         | IRF451  | 13.00               | 150              | 8.70                     | 3000                     | 279  |
| 500                  | 0.80                                      | 5.00         | BUZ45A  | 8.30                | 125              | 2.70                     | 4900                     | 211  |
| 500                  | 0.70                                      | 4.50         | SGSP579 | 9.00                | 150              | 5.00                     | 1900                     | 589  |
| 500                  | 0.60                                      | 5.00         | BUZ45   | 9.60                | 125              | 2.70                     | 4900                     | 207  |
| 500                  | 0.50                                      | 7.20         | IRF452  | 11.00               | 150              | 8.70                     | 3000                     | 279  |
| 500                  | 0.40                                      | 7.20         | IRF450  | 13.00               | 150              | 8.70                     | 3000                     | 279  |

## TO-220 (HIMOS)



| $V_{(BR)DSS}$<br>(V) | $V_{DS(on)}$<br>(max)<br>(V) <sup>Ⓐ</sup> | $I_D$<br>(A) | Type      | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|-------------------------------------------|--------------|-----------|---------------------|------------------|--------------------------|--------------------------|------|
| 500                  | 2.70                                      | 7.00         | STH107N50 | 7.00                | 100              | 2.50                     | 9.50                     | 627  |
| 500                  | 2.70                                      | 10.00        | STH110N50 | 10.00               | 100              | 2.50                     | 9.50                     | 633  |

## ISOWATT220 (HIMOS)



| $V_{(BR)DSS}$<br>(V) | $R_{DS(on)}$<br>(max)<br>(V) <sup>Ⓐ</sup> | $I_D$<br>(A) | Type        | $I_{D(max)}$<br>(A) | $P_{tot}$<br>(W) | $g_{fs}$<br>min<br>(mho) | $C_{iss}$<br>max<br>(pF) | Page |
|----------------------|-------------------------------------------|--------------|-------------|---------------------|------------------|--------------------------|--------------------------|------|
| 500                  | 2.70                                      | 7.00         | STH107N50FI | 7.00                | 35               | 2.50                     | 9.50                     | 627  |
| 500                  | 2.70                                      | 10.00        | STH110N50FI | 10.00               | 35               | 2.50                     | 9.50                     | 633  |



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| 2SK295            |             | SGSP351             | 499  | BUZ11A            | BUZ11A      |                     | 173  |
| 2SK296            |             | IRF723              | 307  | BUZ11FI           | BUZ11FI     |                     | 167  |
| 2SK308            |             | IRF142              | 261  | BUZ11P            | BUZ11FI     |                     | 167  |
| 2SK310            |             | IRF722              | 307  | BUZ11S2           | BUZ11S2     |                     | 177  |
| 2SK311            |             | IRF833              | 331  | BUZ11S2FI         | BUZ11S2FI   |                     | 177  |
| 2SK312            |             | SGSP575             | 577  | BUZ14             |             | SGSP591             | 595  |
| 2SK313            |             | IRF453              | 279  | BUZ15             |             | SGSP591             | 595  |
| 2SK319            |             | IRF730              | 313  | BUZ20             | BUZ20       |                     | 183  |
| 2SK320            |             | IRF843              | 337  | BUZ21             | BUZ21       |                     | 187  |
| 2SK324            |             | SGSP575             | 577  | BUZ24             | BUZ24       |                     | *    |
| 2SK345            |             | SGSP358             | 505  | BUZ25             | BUZ25       |                     | 191  |
| 2SK346            |             | IRF523              | 285  | BUZ32             | BUZ32       |                     | 195  |
| 2SK349            |             | IRFP453             | 355  | BUZ34             | BUZ34       |                     | *    |
| 2SK350            |             | IRFP453             | 355  | BUZ41A            | BUZ41A      |                     | 199  |
| 2SK357            |             | SGSP317             | 469  | BUZ42             | BUZ42       |                     | 203  |
| 2SK382            |             | IRF822              | 325  | BUZ45             | BUZ45       |                     | 207  |
| 2SK383            |             | IRF530              | 291  | BUZ45A            | BUZ45A      |                     | 211  |
| 2SK399            |             | SGSP461             | 535  | BUZ60             | BUZ60       |                     | 215  |
| 2SK403            |             | SGSP474             | 547  | BUZ60B            | BUZ60B      |                     | 219  |
| 2SK428            |             | SGSP321             | 481  | BUZ64             |             | SGSP575             | 577  |
| 2SK440            |             | SGSP367             | 517  | BUZ71             | BUZ71       |                     | 223  |
| 2SK512            |             | IRF452              | 279  | BUZ71A            | BUZ71A      |                     | 229  |
| 2SK527            |             | MTP3055AFI          | 403  | BUZ71FI           | BUZ71FI     |                     | 223  |
| 2SK528            |             | IRF722FI            | 307  | BUZ71P            | BUZ71FI     |                     | 223  |
| 2SK532            |             | IRF540FI            | 295  | BUZ72A            | BUZ72A      |                     | 233  |
| 2SK549            |             | MTP3055A            | 403  | BUZ73A            |             | SGSP367             | 517  |
| 2SK552            |             | IRF843              | 337  | BUZ74             | BUZ74       |                     | 237  |
| 2SK553            |             | IRF842              | 337  | BUZ74A            | BUZ74A      |                     | 241  |
| 2SK554            |             | IRF841              | 337  | BUZ76             | BUZ76       |                     | 245  |
| 2SK555            |             | IRF840              | 337  | BUZ76A            | BUZ76A      |                     | 249  |
| 2SK556            |             | IRFP453             | 355  | BUZ353            | BUZ353      |                     | 253  |
| 2SK557            |             | IRFP452             | 355  | BUZ354            | BUZ354      |                     | 257  |
| 2SK560            |             | IRFP450             | 355  | IRF140            | IRF140      |                     | 261  |
| 2SK643            |             | SGSP474             | 547  | IRF141            | IRF141      |                     | 261  |
| 2SK644            |             | SGSP479             | 559  | IRF142            | IRF142      |                     | 261  |
| 2SK672            |             | BUZ72A              | 233  | IRF143            | IRF143      |                     | 261  |
| 2SK673            |             | MTP3055A            | 403  | IRF150            | IRF150      |                     | 267  |
| 2SK674            |             | SGSP381             | 529  | IRF151            | IRF151      |                     | 267  |
| 2SK708            |             | IRFP453FI           | 355  | IRF152            | IRF152      |                     | 267  |
| 2SK788            |             | IRFP452             | 355  | IRF153            | IRF153      |                     | 267  |
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| BUZ10             | BUZ10       |                     | 159  | IRF242            | IRF242      |                     | *    |
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| BUZ11             | BUZ11       |                     | 167  | IRF340            |             | SGSP575             | 577  |

\* Datasheet available on request.

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| IRF350            |             |                     | 273  | IRF541P           | IRF541FI                                            |                                                     | 295  |
| IRF351            |             | IRF350              | 273  | IRF542            | IRF542                                              |                                                     | 295  |
| IRF352            |             | IRF350              | 273  | IRF542FI          | IRF542FI                                            |                                                     | 295  |
| IRF353            |             | IRF350              | 273  | IRF542P           | IRF542FI                                            |                                                     | 295  |
| IRF440            | IRF450      | SGSP579             | 589  | IRF543            | IRF543                                              | SGSP317<br>SGSP317                                  | 295  |
| IRF441            |             | SGSP579             | 589  | IRF543FI          | IRF543FI                                            |                                                     | 295  |
| IRF442            |             | SGSP579             | 589  | IRF543P           | IRF543FI                                            |                                                     | 295  |
| IRF443            |             | SGSP579             | 589  | IRF610            |                                                     |                                                     | 469  |
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| IRF451            | IRF451      |                     | 279  | IRF612            | IRF620<br>IRF620FI<br>IRF620FI                      | SGSP317<br>SGSP317                                  | 469  |
| IRF452            | IRF452      |                     | 279  | IRF613            |                                                     |                                                     | 469  |
| IRF453            | IRF453      |                     | 279  | IRF620            |                                                     |                                                     | 301  |
| IRF510            | IRF510      |                     | *    | IRF620FI          |                                                     |                                                     | 301  |
| IRF511            | IRF511      |                     | *    | IRF620P           |                                                     |                                                     | 301  |
| IRF512            | IRF512      |                     | *    | IRF621            | IRF621                                              |                                                     | 301  |
| IRF513            | IRF513      |                     | *    | IRF621FI          | IRF621FI                                            |                                                     | 301  |
| IRF520            | IRF520      |                     | 285  | IRF621P           | IRF621FI                                            |                                                     | 301  |
| IRF520FI          | IRF520FI    |                     | 285  | IRF622            | IRF622                                              |                                                     | 301  |
| IRF520P           | IRF520FI    |                     | 285  | IRF622FI          | IRF622FI                                            |                                                     | 301  |
| IRF521            | IRF521      |                     | 285  | IRF622P           | IRF622FI                                            | SGSP367                                             | 301  |
| IRF521FI          | IRF521FI    |                     | 285  | IRF623            | IRF623                                              |                                                     | 301  |
| IRF521P           | IRF521FI    |                     | 285  | IRF623FI          | IRF623FI                                            |                                                     | 301  |
| IRF522            | IRF522      |                     | 285  | IRF623P           | IRF623FI                                            |                                                     | 301  |
| IRF522FI          | IRF522FI    |                     | 285  | IRF630            |                                                     |                                                     | 517  |
| IRF522P           | IRF522FI    |                     | 285  | IRF631            | SGSP367<br>SGSP367<br>SGSP367<br>SGSP477<br>SGSP477 | SGSP367<br>SGSP367<br>SGSP367<br>SGSP477<br>SGSP477 | 517  |
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| IRF523FI          | IRF523FI    |                     | 285  | IRF633            |                                                     |                                                     | 517  |
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| IRF530FI          | IRF530FI    |                     | 291  | IRF642            | IRF720<br>IRF720FI<br>IRF720FI                      | SGSP477<br>SGSP477                                  | 553  |
| IRF530P           | IRF530FI    |                     | 291  | IRF643            |                                                     |                                                     | 553  |
| IRF531            | IRF531      |                     | 291  | IRF720            |                                                     |                                                     | 307  |
| IRF531FI          | IRF531FI    |                     | 291  | IRF720FI          |                                                     |                                                     | 307  |
| IRF531P           | IRF531FI    |                     | 291  | IRF720P           |                                                     |                                                     | 307  |
| IRF532            | IRF532      |                     | 291  | IRF721            | IRF721                                              |                                                     | 307  |
| IRF532FI          | IRF532FI    |                     | 291  | IRF721FI          | IRF721FI                                            |                                                     | 307  |
| IRF532P           | IRF532FI    |                     | 291  | IRF721P           | IRF721FI                                            |                                                     | 307  |
| IRF533            | IRF533      |                     | 291  | IRF722            | IRF722                                              |                                                     | 307  |
| IRF533FI          | IRF533FI    |                     | 291  | IRF722FI          | IRF722FI                                            |                                                     | 307  |
| IRF533P           | IRF533FI    |                     | 291  | IRF722P           | IRF722FI                                            |                                                     | 307  |
| IRF540            | IRF540      |                     | 295  | IRF723            | IRF723                                              |                                                     | 307  |
| IRF540FI          | IRF540FI    |                     | 295  | IRF723FI          | IRF723FI                                            |                                                     | 307  |
| IRF540P           | IRF540FI    |                     | 295  | IRF723P           | IRF723FI                                            |                                                     | 307  |
| IRF541            | IRF541      |                     | 295  | IRF730            | IRF730                                              |                                                     | 313  |

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| IRF731P           | IRF731FI    |                     | 313  | IRF840P           | IRF840FI    |                     | 337  |
| IRF732            | IRF732      |                     | 313  | IRF841            | IRF841      |                     | 337  |
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| IRF733P           | IRF733FI    |                     | 313  | IRF842P           | IRF842FI    |                     | 337  |
| IRF740            | IRF740      |                     | 319  | IRF843            | IRF843      |                     | 337  |
| IRF740FI          | IRF740FI    |                     | 319  | IRF843FI          | IRF843FI    |                     | 337  |
| IRF740P           | IRF740FI    |                     | 319  | IRF843P           | IRF843FI    |                     | 337  |
| IRF741            | IRF741      |                     | 319  | IRFP140           | IRFP140     |                     | *    |
| IRF741FI          | IRF741FI    |                     | 319  | IRFP140FI         | IRFP140FI   |                     | *    |
| IRF741P           | IRF741FI    |                     | 319  | IRFP140P          | IRFP140FI   |                     | *    |
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| IRF820FI          | IRF820FI    |                     | 325  | IRFP152FI         | IRFP152FI   |                     | 343  |
| IRF820P           | IRF820FI    |                     | 325  | IRFP152P          | IRFP152FI   |                     | 343  |
| IRF821            | IRF821      |                     | 325  | IRFP153           | IRFP153     |                     | 343  |
| IRF821FI          | IRF821FI    |                     | 325  | IRFP153FI         | IRFP153FI   |                     | 343  |
| IRF821P           | IRF821FI    |                     | 325  | IRFP153P          | IRFP153FI   |                     | 343  |
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| IRF822FI          | IRF822FI    |                     | 325  | IRFP350P          | IRFP350FI   |                     | 349  |
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| IRF823FI          | IRF823FI    |                     | 325  | IRFP450P          | IRFP450FI   |                     | 355  |
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| IRF830P           | IRF830FI    |                     | 331  | IRFP452           | IRFP452     |                     | 355  |
| IRF831            | IRF831      |                     | 331  | IRFP452FI         | IRFP452FI   |                     | 355  |
| IRF831FI          | IRF831FI    |                     | 331  | IRFP452P          | IRFP452FI   |                     | 355  |
| IRF831P           | IRF831FI    |                     | 331  | IRFP453           | IRFP453     |                     | 355  |
| IRF832            | IRF832      |                     | 331  | IRFP453FI         | IRFP453FI   |                     | 355  |
| IRF832FI          | IRF832FI    |                     | 331  | IRFP453P          | IRFP453FI   |                     | 355  |
| IRF832P           | IRF832FI    |                     | 331  | IRFZ20            | IRFZ20      |                     | 361  |
| IRF833            | IRF833      |                     | 331  | IRFZ20FI          | IRFZ20FI    |                     | 361  |

\* Datasheet available on request.

## CROSS REFERENCE

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| IRFZ20P           | IRFZ20FI    |                     | 361  | MTP3N50           |             | IRF832              | 331  |
| IRFZ22            | IRFZ22      |                     | 361  | MTP3N60           | MTP3N60     |                     | 385  |
| IRFZ22FI          | IRFZ22FI    |                     | 361  | MTP3N60FI         | MTP3N60FI   |                     | 385  |
| IRFZ22P           | IRFZ22FI    |                     | 361  | MTP4N08           |             | SGSP351             | 499  |
| IRFZ40            | IRFZ40      |                     | 367  | MTP4N10           |             | SGSP351             | 499  |
| IRFZ42            | IRFZ42      |                     | 367  | MTP4N18           |             | SGSP317             | 469  |
| MTH6N60FI         | MTH6N60FI   |                     | 379  | MTP4N20           |             | SGSP317             | 469  |
| MTH7N45           |             | SGSP474             | 547  | MTP4N35           |             | IRF733              | 313  |
| MTH7N50           |             | SGSP479             | 559  | MTP4N40           |             | IRF732              | 313  |
| MTH8N35           |             | SGSP475             | 547  | MTP4N45           |             | IRF831              | 331  |
| MTH8N40           |             | SGSP475             | 547  | MTP4N50           |             | IRF830              | 331  |
| MTH15N18          |             | SGSP477             | 583  | MTP5N05           |             | SGSP351             | 499  |
| MTH15N20          |             | SGSP477             | 583  | MTP5N06           |             | SGSP351             | 499  |
| MTH25N08          |             | SGSP472             | 541  | MTP5N12           |             | IRF620              | 301  |
| MTH25N10          |             | SGSP471             | 541  | MTP5N15           |             | IRF620              | 301  |
| MTH35N05          |             | SGSP492             | 595  | MTP5N18           |             | IRF620              | 301  |
| MTH35N06          |             | SGSP491             | 595  | MTP5N20           |             | IRF620              | 301  |
| MTH40N06          | MTH40N06    |                     | 379  | MTP5N35           |             | IRF731              | 313  |
| MTH40N06FI        | MTH40N06FI  |                     | 379  | MTP5N40           |             | IRF730              | 313  |
| MTH40N06P         | MTH40N06FI  |                     | 379  | MTP6N08           |             | SGSP311             | 463  |
| MTM7N45           |             | SGSP574             | 577  | MTP6N10           | MTP6N60     | SGSP311             | 463  |
| MTM7N50           |             | SGSP579             | 589  | MTP6N60           |             |                     | 391  |
| MTM8N35           |             | SGSP575             | 577  | MTP7N05           |             | SGSP358             | 505  |
| MTM8N40           |             | SGSP575             | 577  | MTP7N12           |             | SGSP317             | 469  |
| MTM15N18          |             | SGSP577             | 583  | MTP7N15           |             | SGSP317             | 469  |
| MTM15N20          |             | SGSP577             | 583  | MTP7N18           |             | SGSP317             | 469  |
| MTM15N35          |             | IRF350              | 273  | MTP7N20           |             | SGSP317             | 469  |
| MTM15N40          |             | IRF350              | 273  | MTP8N08           |             | IRF520              | 285  |
| MTM15N45          |             | IRF451              | 279  | MTP8N10           |             | IRF520              | 285  |
| MTM15N50          |             | IRF450              | 279  | MTP8N12           |             | SGSP367             | 517  |
| MTM20N08          |             | IRF142              | 261  | MTP8N15           |             | SGSP367             | 517  |
| MTM20N10          |             | IRF142              | 261  | MTP8N18           |             | SGSP367             | 517  |
| MTM25N05          |             | IRF141              | 261  | MTP8N20           |             | SGSP367             | 517  |
| MTM25N06          |             | IRF141              | 261  | MTP8N45           |             | IRF841              | 337  |
| MTM25N08          |             | IRF140              | 261  | MTP8N50           |             | IRF840              | 337  |
| MTM25N10          |             | IRF140              | 261  | MTP10N05          |             | SGSP322             | 481  |
| MTM35N05          |             | SGSP592             | 595  | MTP10N06          |             | SGSP321             | 481  |
| MTM35N06          |             | SGSP591             | 595  | MTP10N08          |             | IRF532              | 291  |
| MTP2N35           |             | IRF721              | 307  | MTP10N10          |             | IRF532              | 291  |
| MTP2N40           |             | IRF720              | 307  | MTP10N12          |             | SGSP367             | 517  |
| MTP2N45           |             | SGSP330             | 487  | MTP10N15          |             | SGSP367             | 517  |
| MTP2N50           |             | SGSP319             | 475  | MTP10N25          |             | SGSP363             | 517  |
| MTP3N35           |             | IRF721              | 307  | MTP10N35          |             | IRF741              | 319  |
| MTP3N40           |             | IRF720              | 307  | MTP10N40          |             | IRF740              | 319  |
| MTP3N45           |             | SGSP330             | 487  | MTP12N05          |             | SGSP322             | 481  |

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| MTP12N06          |             | SGSP321             | 481  | RFM12N40          |             | IRF451              | 279  |
| MTP12N08          |             | SGSP362             | 511  | RFM15N12          |             | SGSP577             | 583  |
| MTP12N10          |             | SGSP361             | 511  | RFM15N15          |             | SGSP577             | 583  |
| MTP15N05          |             | SGSP382             | 529  | RFM18N08          |             | IRF142              | 261  |
| MTP15N05L         | MTP15N05L   |                     | 397  | RFM18N10          |             | IRF142              | 261  |
| MTP15N05LFI       | MTP15N05LFI | SGSP381             | 397  | RFM25N05          |             | IRF141              | 261  |
| MTP15N06          |             |                     | 529  | RFM25N06          |             | IRF141              | 261  |
| MTP15N06L         | MTP15N06L   |                     | 397  | RFP2N08           |             | SGSP351             | 499  |
| MTP15N06LFI       | MTP15N06LFI |                     | 397  | RFP2N10           |             | SGSP351             | 499  |
| MTP20N08          |             | IRF542              | 295  | RFP2N18           |             | SGSP317             | 469  |
| MTP20N10          |             | IRF542              | 295  | RFP2N20           |             | SGSP317             | 469  |
| MTP25N05          |             | IRF543              | 295  | RFP3N45           |             | IRF821              | 325  |
| MTP25N06          |             | IRF543              | 295  | RFP3N50           |             | IRF820              | 325  |
| MTP25N08          |             | IRF540              | 295  | RFP4N05           |             | SGSP358             | 505  |
| MTP25N10          |             | IRF540              | 295  | RFP4N35           |             | IRF733              | 313  |
| MTP3055A          | MTP3055A    | SGSP474<br>SGSP479  | 403  | RFP4N40           |             | IRF732              | 313  |
| MTP3055AFI        | MTP3055AFI  |                     | 403  | RFP6N45           |             | IRF831              | 331  |
| MTP3055AP         | MTP3055AFI  |                     | 403  | RFP6N50           |             | IRF830              | 331  |
| RFH10N45          |             |                     | 547  | RFP7N35           |             | IRF743              | 319  |
| RFH10N50          |             |                     | 559  | RFP7N40           |             | IRF742              | 319  |
| RFH12N35          |             | IRFP451             | 355  | RFP8N18           |             | SGSP367             | 517  |
| RFH12N40          |             | IRFP451             | 355  | RFP8N20           |             | SGSP367             | 517  |
| RFH25N18          |             | SGSP477             | 553  | RFP10N12          |             | SGSP367             | 517  |
| RFH25N20          |             | SGSP477             | 553  | RFP10N15          |             | SGSP367             | 517  |
| RFH35N08          |             | IRFP150             | 343  | RFP12N08          |             | SGSP362             | 511  |
| RFH35N10          |             | IRFP150             | 343  | RFP12N10          |             | SGSP361             | 511  |
| RFH45N05          |             | SGSP492             | 571  | RFP15N05          |             | SGSP322             | 481  |
| RFH45N06          |             | SGSP491             | 571  | RFP15N06          |             | SGSP321             | 481  |
| RFK10N45          |             | SGSP574             | 577  | RFP18N08          |             | IRF542              | 295  |
| RFK10N50          |             | SGSP579             | 589  | RFP18N10          |             | IRF542              | 295  |
| RFK12N35          |             | SGSP575             | 577  | RFP25N05          |             | SGSP382             | 529  |
| RFK12N40          |             | SGSP575             | 577  | RFP25N06          |             | SGSP381             | 529  |
| RFK25N18          |             | SGSP577             | 583  | SGSP201           | SGSP201     |                     | 433  |
| RFK25N20          |             | SGSP577             | 583  | SGSP202           |             |                     | 433  |
| RFK35N08          |             | IRF150              | 267  | SGSP221           |             | SGSP222             | 439  |
| RFK35N10          |             | IRF150              | 267  | SGSP222           | SGSP222     |                     | 439  |
| RFK45N05          |             | SGSP592             | 595  | SGSP230           | SGSP230     |                     | 445  |
| RFK45N06          |             | SGSP591             | 595  | SGSP231           | SGSP230     |                     | 445  |
| RFM10N12          |             | SGSP577             | 583  | SGSP232           | SGSP230     |                     | 445  |
| RFM10N15          |             | SGSP577             | 583  | SGSP238           |             | SGSP239             | 451  |
| RFM10N45          |             | SGSP579             | 589  | SGSP239           | SGSP239     |                     | 451  |
| RFM10N50          |             | SGSP579             | 589  | SGSP301           | SGSP301     |                     | 457  |
| RFM12N18          |             | SGSP577             | 583  | SGSP302           | SGSP301     |                     | 457  |
| RFM12N20          |             | SGSP577             | 583  | SGSP311           | SGSP311     |                     | 463  |
| RFM12N35          |             | IRF451              | 279  | SGSP312           | SGSP311     |                     | 463  |

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| SGSP316           | SGSP316     |                     | 469  | SGSP578           |             | SGSP579             | 589  |
| SGSP317           | SGSP317     |                     | 469  | SGSP579           | SGSP579     |                     | 589  |
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| SGSP330           | SGSP330     |                     | 487  | STHV82            | STHV82      |                     | 601  |
| SGSP331           |             | IRF722              | 307  | STHV102           | STHV102     |                     | 607  |
| SGSP332           |             | IRF723              | 307  | STLT19            | STLT19      |                     | 611  |
| SGSP340           |             | SGSP341             | 493  | STLT19FI          | STLT19FI    |                     | 611  |
| SGSP341           | SGSP341     |                     | 493  | STLT20            | STLT20      |                     | 611  |
| SGSP342           | SGSP341     |                     | 493  | STLT20FI          | STLT20FI    |                     | 611  |
| SGSP351           | SGSP351     |                     | 499  | STVHD90           | STVHD90     |                     | 621  |
| SGSP357           |             | SGSP358             | 505  |                   |             |                     |      |
| SGSP358           | SGSP358     |                     | 505  |                   |             |                     |      |
| SGSP361           | SGSP361     |                     | 511  |                   |             |                     |      |
| SGSP362           | SGSP362     |                     | 511  |                   |             |                     |      |
| SGSP363           | SGSP363     |                     | 517  |                   |             |                     |      |
| SGSP364           | SGSP364     |                     | 523  |                   |             |                     |      |
| SGSP367           | SGSP367     |                     | 517  |                   |             |                     |      |
| SGSP368           |             | IRF830              | 331  |                   |             |                     |      |
| SGSP369           | SGSP369     |                     | 523  |                   |             |                     |      |
| SGSP381           | SGSP381     |                     | 529  |                   |             |                     |      |
| SGSP382           | SGSP382     |                     | 529  |                   |             |                     |      |
| SGSP461           | SGSP461     |                     | 535  |                   |             |                     |      |
| SGSP462           | SGSP462     |                     | 535  |                   |             |                     |      |
| SGSP471           | SGSP471     |                     | 541  |                   |             |                     |      |
| SGSP472           | SGSP472     |                     | 541  |                   |             |                     |      |
| SGSP473           |             | SGSP477             | 553  |                   |             |                     |      |
| SGSP474           | SGSP474     |                     | 547  |                   |             |                     |      |
| SGSP475           | SGSP475     |                     | 547  |                   |             |                     |      |
| SGSP476           | SGSP475     |                     | 547  |                   |             |                     |      |
| SGSP477           | SGSP477     |                     | 553  |                   |             |                     |      |
| SGSP478           |             | SGSP479             | 559  |                   |             |                     |      |
| SGSP479           | SGSP479     |                     | 559  |                   |             |                     |      |
| SGSP481           | SGSP481     |                     | 565  |                   |             |                     |      |
| SGSP482           | SGSP482     |                     | 565  |                   |             |                     |      |
| SGSP491           | SGSP491     |                     | 571  |                   |             |                     |      |
| SGSP492           | SGSP492     |                     | 571  |                   |             |                     |      |
| SGSP571           |             | IRF152              | 267  |                   |             |                     |      |
| SGSP572           |             | IRF150              | 267  |                   |             |                     |      |
| SGSP573           |             | SGSP577             | 583  |                   |             |                     |      |
| SGSP574           | SGSP574     |                     | 577  |                   |             |                     |      |
| SGSP575           | SGSP575     |                     | 577  |                   |             |                     |      |
| SGSP576           | SGSP575     |                     | 577  |                   |             |                     |      |
| SGSP577           | SGSP577     |                     | 583  |                   |             |                     |      |

\* Datasheet available on request.

|                 |                                                                      |
|-----------------|----------------------------------------------------------------------|
| $C_{DB}$        | Parasitic capacitance between drain and body                         |
| $C_{DS}$        | Parasitic capacitance between drain and source                       |
| $C_{GD}$        | Parasitic capacitance between gate and drain                         |
| $C_{GS}$        | Parasitic capacitance between gate and source                        |
| $C_{iss}$       | Input capacitance                                                    |
| $C_{oss}$       | Output capacitance                                                   |
| $C_{rss}$       | Reverse transfer capacitance                                         |
| D.U.T.          | Device under test                                                    |
| $I_D$           | Drain current                                                        |
| $I_{DLM}$       | Drain peak current, inductive                                        |
| $I_{DM}$        | Drain peak current                                                   |
| $I_{DSS}$       | Zero gate voltage drain current                                      |
| $I_G$           | Gate current                                                         |
| $I_{GSS}$       | Gate-body leakage with drain short circuited to source               |
| $I_{SD}$        | Source-drain diode current                                           |
| $I_{SDM}$       | Source-drain diode peak current                                      |
| $I_{UIS}$       | Unclamped inductive switching current                                |
| L               | Load inductance of a specified circuit                               |
| PW              | Pulse width                                                          |
| $P_{tot}$       | Total power dissipation                                              |
| $R_{DS(on)}$    | Static drain-source on resistance                                    |
| $R_i$           | Generator internal resistance                                        |
| $R_L$           | Load resistance of a specified circuit                               |
| $R_{th j-amb}$  | Thermal resistance junction-ambient                                  |
| $R_{th j-case}$ | Thermal resistance junction-case                                     |
| $T_l$           | Maximum lead temperature for soldering purpose                       |
| $T_{amb}$       | Ambient temperature                                                  |
| $T_{case}$      | Case temperature                                                     |
| $T_j$           | Junction temperature                                                 |
| $T_{stg}$       | Storage temperature                                                  |
| $V_{(BR) DSS}$  | Drain-source breakdown voltage                                       |
| $V_{DG}$        | Drain-gate voltage                                                   |
| $V_{DGR}$       | Drain-gate voltage with specified resistance between gate and source |
| $V_{DS}$        | Drain-source voltage                                                 |
| $V_{DS(on)}$    | Drain-source on state voltage                                        |

## ALPHABETICAL LIST OF SYMBOLS

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|               |                                       |
|---------------|---------------------------------------|
| $V_{GS}$      | Gate-source-voltage                   |
| $V_{GS (th)}$ | Gate threshold voltage                |
| $V_{SD}$      | Source-drain diode forward on voltage |
| $V_{clamp}$   | Drain clamping voltage                |
| $V_i$         | Input voltage of a specified circuit  |
| $f$           | Frequency                             |
| $g_{fs}$      | Forward trasconductance               |
| $t_d (off)$   | Turn-off delay time                   |
| $t_d (on)$    | Turn-on delay time                    |
| $t_f$         | Fall time                             |
| $t_{on}$      | Turn-on time                          |
| $t_r$         | Rise time                             |
| $t_{rr}$      | Reverse recovery time                 |



## A. DEFINITIONS OF TERMS USED

- a. **Electronic device.** An electronic tube or valve, transistor or other semiconductor device.  
Note: This definition excludes inductors, capacitors, resistors and similar components.
- b. **Characteristic.** A characteristic is an inherent and measurable property of a device. Such a property may be electrical, mechanical, thermal, hydraulic, electro-magnetic, or nuclear and can be expressed as a value for stated or recognized conditions. A characteristic may also be a set of related values, usually shown in graphical form.
- c. **Bogey electronic device.** An electronic device whose characteristics have the published nominal values for the type. A bogey electronic device for any particular application can be obtained by considering only those characteristics which are directly related to the application.
- d. **Rating.** A value which establishes either a limiting capability or a limiting condition for an electronic device. It is determinate for specified values of environment and operation, and may be stated in any suitable terms.  
Note: Limiting conditions may be either maxima or minima.
- e. **Rating system.** The set of principles upon which ratings are established and which determines their interpretation.  
Note: The rating system indicates the division of responsibility between the device manufacturer and the circuit designer, with the object of ensuring that the working conditions do not exceed the ratings.

## B. ABSOLUTE MAXIMUM RATING SYSTEM

Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any electronic device of a specified type as defined by its published data, which should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment. The equipment manufacturer should design so that, initially and throughout life, no absolute maximum value for the intended service is exceeded with any device under the worst probable operating condi-

tions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variation in characteristics of the device under consideration and of all other electronic devices in the equipment.

## C. DESIGN - MAXIMUM RATING SYSTEM

Design-maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in the characteristics of the electronic device under consideration.

The equipment manufacturer should design so that, initially and throughout life, no design-maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation equipment, component variation, variation in characteristics of all other devices in the equipment, equipment control adjustment, load variation, signal variation and environmental conditions.

## D. DESIGN - CENTRE RATING SYSTEM

Design-centre ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under normal conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of all electronic devices.

The equipment manufacturer should design so that, initially, no design-centre value for the intended service is exceeded with a bogey electronic device in equipment operating at the stated normal supply-voltage.

The Absolute Maximum Rating System is commonly used for semiconductor devices

## PRECAUTIONS FOR PHYSICAL HANDLING OF POWER PLASTIC TRANSISTOR [TO-220, ISOWATT220, TO-218 (SOT-93), ISOWATT218, TO-126 (SOT-32), SOT-82, SOT-194]

When mounting power transistors certain precautions must be taken in operations such as bending of leads, mounting of heatsink, soldering and removal of flux residue. If these operations are not carried out correctly, the device can be damaged or reliability compromised.

### 1. Bending and cutting leads

The bending or cutting of the leads requires the following precautions:

- 1.1. When bending the leads they must be clamped tightly between the package and the bending point to avoid strain on the package (in particular in the area where the leads enter the resin) (fig. 1). This also applies to cutting the leads (fig. 2).
- 1.2. The leads must be bent at a minimum distance of 3 mm from the package (fig. 3a).

- 1.3. The leads should not be bent at an angle of more than 90° and they must be bent only once (fig. 3b).
- 1.4. The leads must never be bent laterally (fig. 3c).
- 1.5. Check that the tool used to cut or form the leads does not damage them or ruin their surface finish.

### 2. Mounting on printed circuit

During mounting operations be careful not to apply stress to the power transistor.

- 2.1. Adhere strictly to the pin spacing of the transistor to avoid forcing the leads.
- 2.2. Leave a suitable space between printed circuit and transistor, if necessary use a spacer.
- 2.3. When fixing the device to the printed circuit do not put mechanical stress on the transistor. For this purpose the device should be soldered to the printed circuit board after the transistor has been fixed to the heatsink and the heatsink to the printed circuit board.

Fig. 1 - Bending the leads

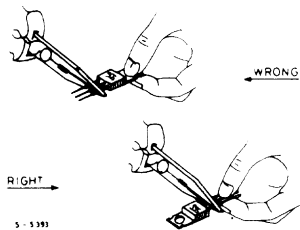


Fig. 2 - Lead forming or cutting mechanism

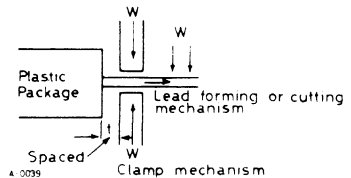
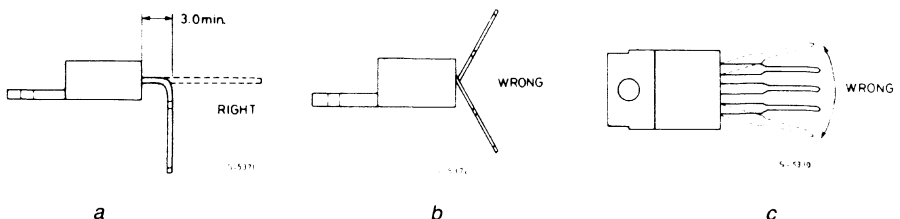


Fig. 3 - Angles for lead wire bending



## 3. Soldering

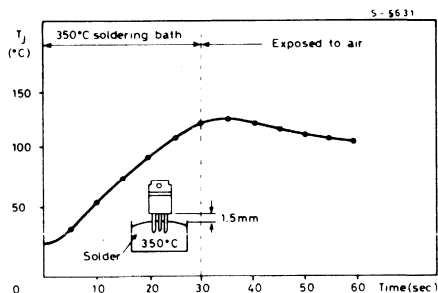
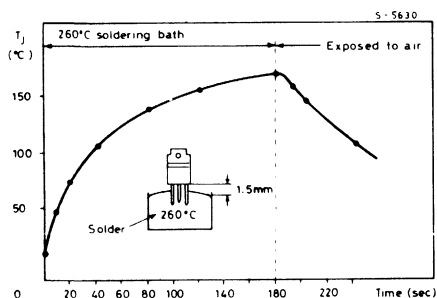
In general a transistor should never be exposed to high temperature for any length of time. It is therefore preferable to use soldering methods where the transistor is exposed to the lowest possible temperatures for a short time.

- 3.1. Tolerable conditions are 260°C for 10 sec or 350° for 3 sec. The graphs in fig. 4 give an idea of the excess junction temperature during the soldering process for a TO-220 (Ver-

sawatt). It is also important to use suitable fixes for the tin baths to avoid deterioration of the leads or of the package resin.

- 3.2. An excess of residual flux between the pins of the transistor or in contact with the resin can reduce the long-term reliability of the device. The solvent for removing excess flux must be chosen with care. The use of solvents derived from trichloroethylene is not recommended on plastic packages because the residue can cause corrosion.

Fig. 4 - Junction temperatures during soldering



## 4. Mounting at heatsink

To exploit best the performance of power transistor a heatsink with  $R_{th}$  suitable for the power that the transistor will dissipate must be used.

- 4.1. The plastic packages used by SGS-THOMSON for its power transistor (SOT-32, SOT-82, SOT-194, TO-220, ISOWATT220, TO-218, ISOWATT218) provide for the use of a single screw to fix the package to the heatsink. A compression spring (clip) can be sufficient as an alternative (fig. 5).

The screw should be properly tightened to en-

sure good contact between the back of the package and the heatsink but should not be too tight to avoid deformation of the copper part (tab) of the package causing breaking of the die or separation of the resin from the tab.

- 4.2. The contact  $R_{th}$  between device and heatsink can be improved by inserting a thin layer of silicone grease with fluidity sufficient to guarantee perfectly uniform distribution on the surface of the tab. The thermal resistance with and without silicone grease is given in fig. 6. An excessively thick layer or an excessive viscosity of the grease can degrade the  $R_{th}$ .

Fig. 5 - SOT-93 mounting examples

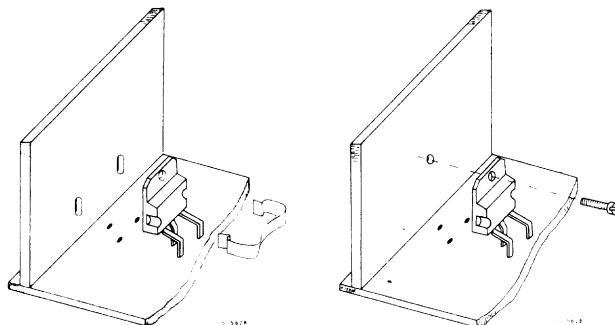
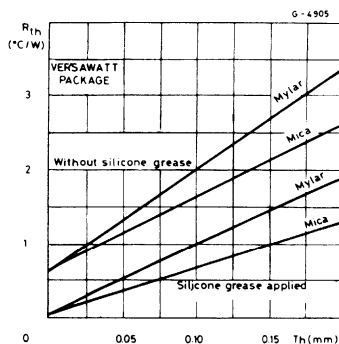


Fig. 6 - Contact thermal resistance vs. insulator thickness.

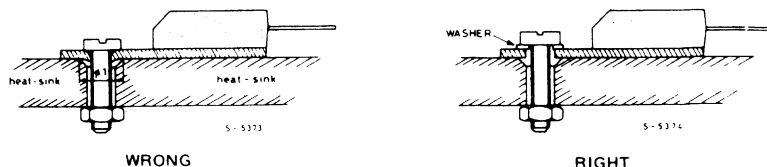


## 5. Heatsink problems

The most important aspect from the point of view of reliability of a power transistor is that the heatsink should be dimensioned to keep the  $T_j$  of the device as low as possible. From the mechanical point of view, however, the heatsink must be realized so that it does not damage the device.

- 5.1. The planarity of the contact surface between device and heatsink must be  $< 25\mu\text{m}$  for TO-220, ISOWATT220, TO-218, ISOWATT218, TO-126 (SOT-32), SOT-82, SOT-194.

Fig. 7 - Device mounting



- 5.2. If self threading screws are used there must be an outlet for the material that is deformed during formation of the thread. The diameter  $\varnothing 1$  (fig. 7) must be large enough to avoid distortion of the tab during tightening. For this purpose it may be useful to insert a washer or use of the type shown in fig. 8 where the pressure on the tab is distributed on a much larger surface. Sometimes when the hole in the heatsink is formed with a punch, around the hole or hollow there may be a ring which is lower than the heatsink surface.

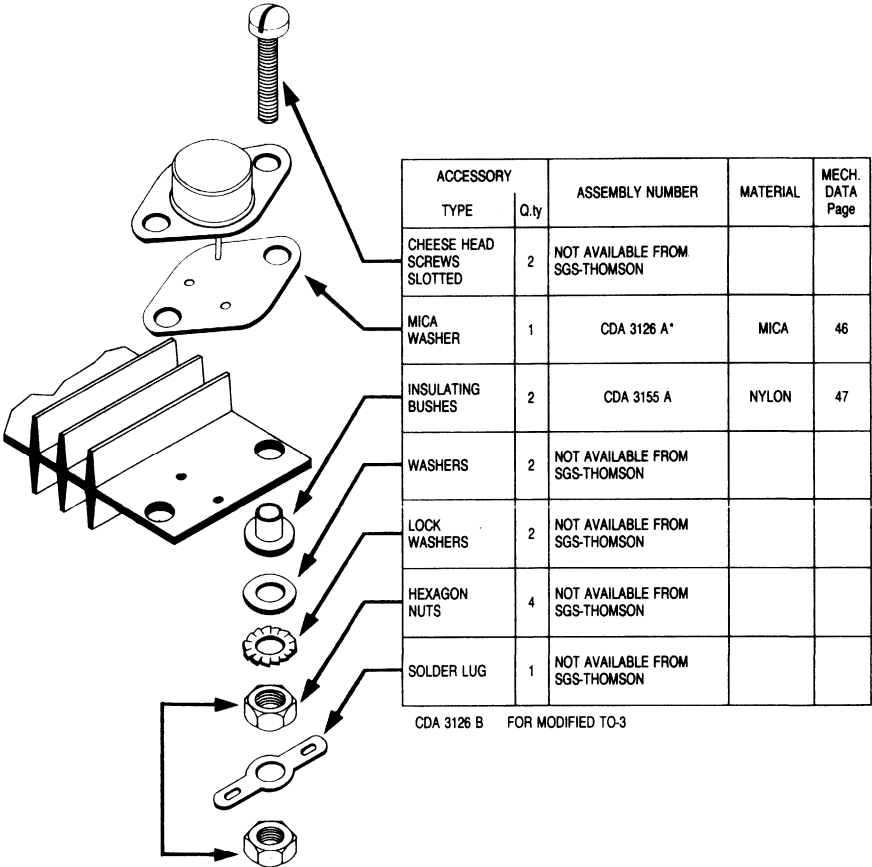
This is dangerous because it may lead to distortion of the tab as mentioned before.

- 5.3. A very serious problem is that of the rigidity between heatsink, device and printed circuit board. Once the device and the heatsink are mechanically connected, and the heatsink is fixed to the apparatus frame, the device and the PCB are bound together by the leads of the devices. A solution of this type is extremely dangerous.

Fig. 8 - Suggested screw

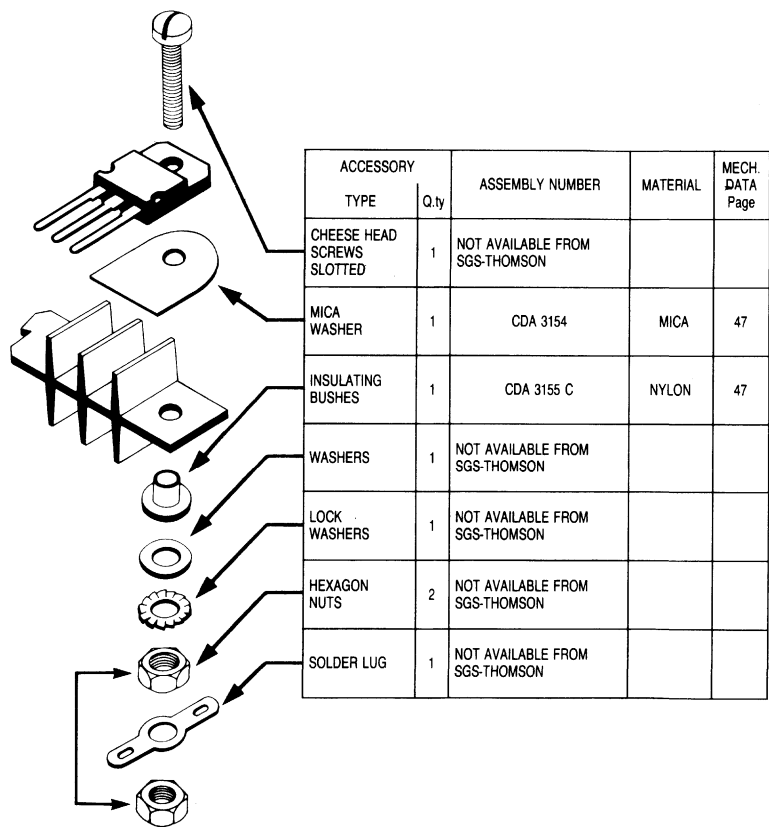


TO-3



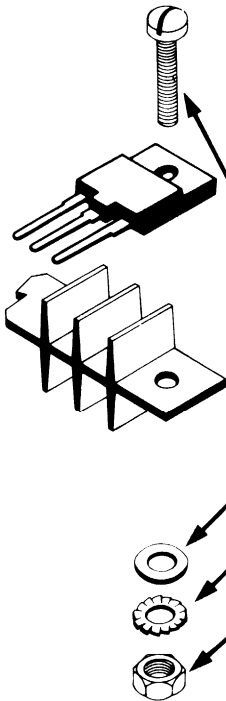
Maximum torque (applied to mounting flange)  
Recommended: 0.55 Nm  
Maximum: 1 Nm.

TO-218 (SOT-93)



Maximum torque (applied to mounting flange)  
Recommended: 0.55 Nm  
Maximum: 1 Nm.

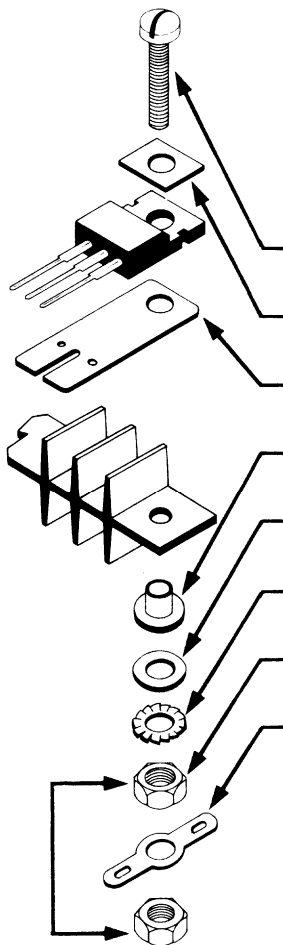
ISOWATT218



| ACCESSORY                        |      | ASSEMBLY NUMBER                   | MATERIAL | MECH. DATA<br>Page |
|----------------------------------|------|-----------------------------------|----------|--------------------|
| TYPE                             | Q.ty |                                   |          |                    |
| CHEESE HEAD<br>SCREWS<br>SLOTTED | 1    | NOT AVAILABLE FROM<br>SGS-THOMSON |          |                    |
|                                  |      |                                   |          |                    |
|                                  |      |                                   |          |                    |
| WASHERS                          | 1    | NOT AVAILABLE FROM<br>SGS-THOMSON |          |                    |
| LOCK<br>WASHERS                  | 1    | NOT AVAILABLE FROM<br>SGS-THOMSON |          |                    |
| HEXAGON<br>NUTS                  | 1    | NOT AVAILABLE FROM<br>SGS-THOMSON |          |                    |

Maximum torque (applied to mounting flange)  
Recommended: 0.55 Nm  
Maximum: 1 Nm.

TO-220



The diagram shows an exploded view of various mounting accessories for a TO-220 package. Callout lines connect the following parts to the table:

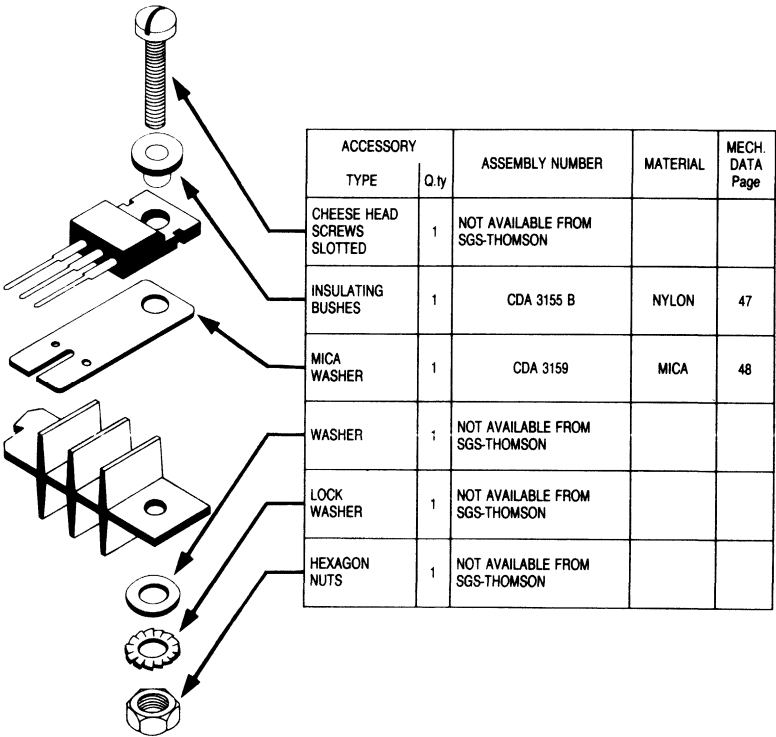
- CHEESE HEAD SCREWS SLOTTED
- RECTANGULAR WASHER
- MICA WASHER
- INSULATING BUSHES
- WASHER
- LOCK WASHER
- HEXAGON NUTS
- SOLDER LUG

| ACCESSORY TYPE             | Q.ty | ASSEMBLY NUMBER                | MATERIAL | MECH. DATA Page |
|----------------------------|------|--------------------------------|----------|-----------------|
| CHEESE HEAD SCREWS SLOTTED | 1    | NOT AVAILABLE FROM SGS-THOMSON |          |                 |
| RECTANGULAR WASHER         | 1    | CDA 3163                       |          | 48              |
| MICA WASHER                | 1    | CDA 3159                       | MICA     | 48              |
| INSULATING BUSHES          | 1    | CDA 3155 B                     | NYLON    | 47              |
| WASHER                     | 1    | NOT AVAILABLE FROM SGS-THOMSON |          |                 |
| LOCK WASHER                | 1    | NOT AVAILABLE FROM SGS-THOMSON |          |                 |
| HEXAGON NUTS               | 2    | NOT AVAILABLE FROM SGS-THOMSON |          |                 |
| SOLDER LUG                 | 1    | NOT AVAILABLE FROM SGS-THOMSON |          |                 |

Maximum torque (applied to mounting flange)  
Recommended: 0.55 Nm  
Maximum: 0.7 Nm.

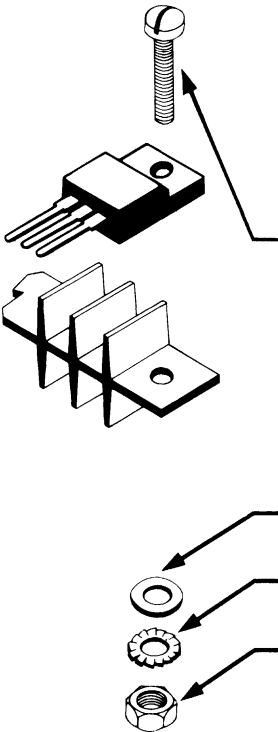


TO-220



Maximum torque (applied to mounting flange)  
Recommended: 0.55 Nm  
Maximum: 0.7 Nm.

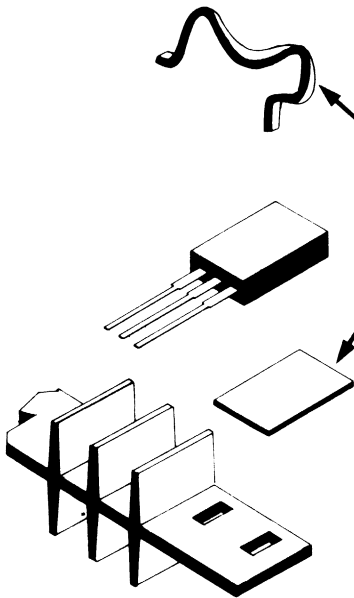
ISOWATT220



| ACCESSORY                        |      | ASSEMBLY NUMBER                   | MATERIAL | MECH. DATA<br>Page |
|----------------------------------|------|-----------------------------------|----------|--------------------|
| TYPE                             | Q.ty |                                   |          |                    |
| CHEESE HEAD<br>SCREWS<br>SLOTTED | 1    | NOT AVAILABLE FROM<br>SGS-THOMSON |          |                    |
|                                  |      |                                   |          |                    |
|                                  |      |                                   |          |                    |
|                                  |      |                                   |          |                    |
| WASHER                           | 1    | NOT AVAILABLE FROM<br>SGS-THOMSON |          |                    |
| LOCK<br>WASHER                   | 1    | NOT AVAILABLE FROM<br>SGS-THOMSON |          |                    |
| HEXAGON<br>NUTS                  | 1    | NOT AVAILABLE FROM<br>SGS-THOMSON |          |                    |

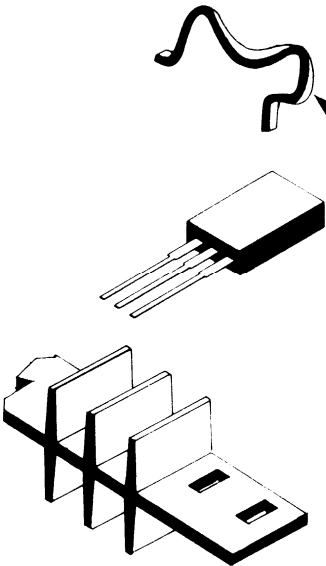
Maximum torque (applied to mounting flange)  
Recommended: 0.55 Nm  
Maximum: 0.7 Nm.

TO-126, SOT-82, SOT-194, TO-220, TO-218



| ACCESSORY TYPE | Q.ty | ASSEMBLY NUMBER                                                                                    | MATERIAL | MECH. DATA |
|----------------|------|----------------------------------------------------------------------------------------------------|----------|------------|
| SPRING CLIP    | 1    | NOT AVAILABLE FROM SGS-THOMSON                                                                     |          |            |
| MICA WASHER    | 1    | TO-126<br>SOT-82<br>SOT-194 } NOT AVAILABLE FROM SGS-THOMSON<br>TO-220: CDA3159<br>TO-218: CDA3154 | MICA     | 48<br>47   |

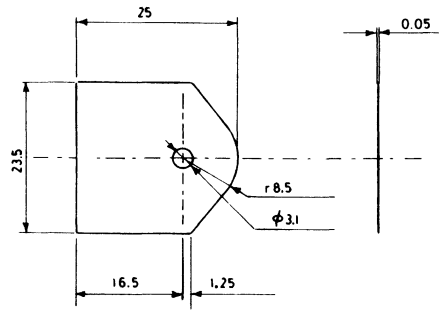
ISOWATT220, ISOWATT218



| ACCESSORY TYPE | Q.ty | ASSEMBLY NUMBER                | MATERIAL | MECH. DATA |
|----------------|------|--------------------------------|----------|------------|
| SPRING CLIP    | 1    | NOT AVAILABLE FROM SGS-THOMSON |          |            |

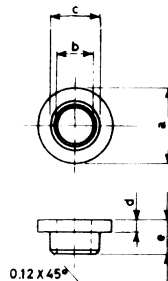


## CDA 3154



A-0042

## CDA 3155



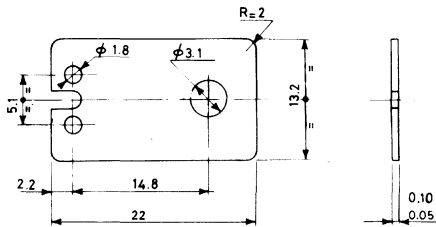
A - 0024/2

| Suffix | Package | a            | b            | c            | d            | e            |
|--------|---------|--------------|--------------|--------------|--------------|--------------|
| A      | TO-3    | 6.40 to 6.60 | 3.00 to 3.10 | 4.00 to 4.05 | 1.1 max      | 1.55 to 1.65 |
| B      | TO-220  | 5.30 to 5.50 | 3.00 to 3.10 | 3.83 to 3.88 | 0.60 to 0.65 | 1.70 to 1.80 |
| C      | SOT-93  | 6.40 to 6.60 | 3.00 to 3.10 | 4.00 to 4.05 | 1.3 to 1.4   | 2.7 to 2.9   |

Material: Nylon

Dimensions: mm

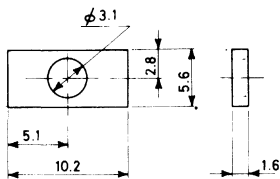
CDA 3159



A-0026/ 3

| TYPE    | MATERIAL | NOTE |
|---------|----------|------|
| CDA3159 | MICA     |      |

CDA 3163



A-0023/ 3

| TYPE    | MATERIAL            | NOTE |
|---------|---------------------|------|
| CDA3163 | Steel nickel plated |      |

Electronic components have to be protected from the hazard of static electricity, from the manufacturing stage down to where they are utilized.

MOS devices are typically voltage and electrical field sensitive; the thin oxide layers can be destroyed by an electric field.

Fig. 1

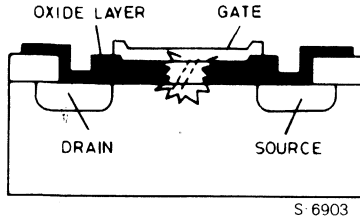
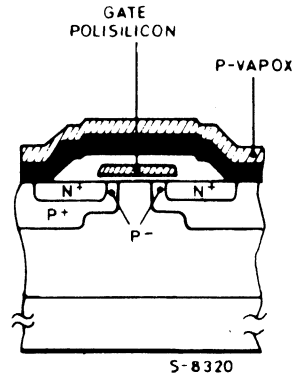


Fig. 2



This happens mostly because a charged conductor, typically a person, is rapidly discharged through the device.

There will be no net charge on any portion of the MOS structure when the induced high field exceeds the breakdown voltage of the MOS capacitor we may have a self-healing break-down, degradation or catastrophic failure.

The failure hazard is not limited to the gate region but it could occur wherever two conductive areas are separated by a thin insulator.

POWER MOS devices can generally be considered less ESD sensitive than MOS I/Cs.

The input capacitance of a POWER MOS device is typically 10 to 200 times larger, and the gate oxide thickness is similar in size to that of the largest MOS I/Cs used.

As a result, it is common practice not to consider the ESD as dangerous for POWER MOS, but this is not always true, even though they are less sensitive than MOS I/Cs

### HANDLING

SGS-THOMSON has chosen a no-compromise strategy in the MOS ESD protection. From the wafer level to the shipping of finished units, each work station and processing of the parts is guaranteed. This is achieved through total adoption of shielding and grounding media. Our final shipping of the parts is performed in antistatic tubes, bags or boxes. The suppliers greatest efforts are in vain if the end user does not provide the same level of protection and care in application.

Here are the basic static control protection rules:

A - Handle all components in a static-safe work area.

B - Transport all components in static shielding containers.

To comply with the rules the following procedures must be set up.

- 1 - Static control wrist strap (from a qualified source) used and connected properly.
- 2 - Each table top must be protected with a conductive mat, properly grounded.
- 3 - Extensive use of conductive floor mats.
- 4 - Static control shoe straps, wearing typically insulating footwear, such as with crepe or thick rubber soles.
- 5 - Ionized air blowers are a necessary part of the protective system, to neutralize static charges on conductive items.
- 6 - Use only the grounded tip variety of soldering iron.
- 7 - Single components, tubes, printed circuit cards should always be contained in static shielding bags; keep our parts in the original bags up to the very last moment on the production line.
- 8 - If bigger containers (tote box) are used for in-plant transport of devices or PC boards they must be electrically conductive, like the carbon loaded ones.

## ELECTROSTATIC DISCHARGE PROTECTION (handling precautions)

---

- 9 - All tools, persons, testing machines, which could contact device leads must be conductive and grounded.
- 10 - Avoid using high dielectric materials (like polystyrene) for sub-assembly construction, storing and transportation.
- 11 - Follow a proper power supply sequence in testing and application. Supply voltage should be applied before and removed after input signals; insertion and removal from sockets should be done with no power applied.
- 12 - Filtration, noise suppression, slow voltage surges should be guaranteed on the supply lines.
- 13 - Any open (floating) input pin is a potential hazard to your circuit: ground or short them to  $V_{DD}$  whenever possible.



# **TECHNICAL NOTES**



## AN INTRODUCTION TO POWER MOS

A POWER MOS transistor is a power transistor produced with MOS, and not the usual bipolar technology.

Special characteristics are high switching speeds and easy driving. This introductory note describes the essential points of the MOS structure when used for power devices.

### WHAT DOES MOS MEAN?

It means that the essential part (the silicon chip) of the device is made up of three layers:

- one conductive layer (M for metal) that is the control (drive) electrode
- one isolating layer (O for oxide) that prevents any current flow from the drive electrode to the other two electrodes, but does not block the electric field
- one semiconductor layer (S for semiconductor) which switches on or off depending on the electrical field imposed on it by the control electrode through the opening in the P zone of a conductive channel between the two zones.

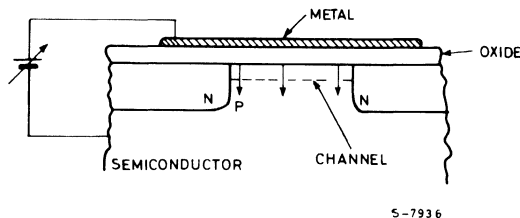
### WHAT DOES POWER MOS MEAN?

Fig. 1 shows that the device is totally implemented on the chip surface. In other words both the on and off states are implemented in a horizontal plane:

- the ON STATE i.e. the residual resistance when in the on state corresponds to conduction on the top surface of the silicon
- the OFF STATE i.e. the depletion region of one of the two PN junctions, with its resistivity and length, gives the device its voltage rating.

With the present technology the "on the surface" approach allows the production of MOS transistors that can handle tens of volts and milliamperes (as in MOS microprocessors or in MOS memories). A power transistor must be able to handle no less than a few amperes at voltages of 50-100V or higher. The approach of several devices "on the surface" connected in parallel is unsuitable due to problems of excessive connections, as each cell would have three terminals.

Fig. 1 - MOS basic structure



The best solution is to exploit the semiconductor both vertically as well horizontally. The paralleling of one of the two N doped regions of all the elementary structures in parallel occurs on the bottom face of the semiconductor.

At the same time, the PN junction that implements the off performance (its length corresponds to the voltage rating of the device) can be positioned vertically, and so avoiding the waste of horizontal space. the channel must be short (1 to 2 microns) to obtain characteristics of practical interest.

As a result, the POWER MOS device consists of multi - MOS basic cells, with all the N<sup>+</sup> type SOURCE zones connected in parallel on the top side of the semiconductor chip, as are the cell GATES. The common substrate of the chip forms the DRAIN.

### THE POSSIBLE STRUCTURES

Figures 2, 3 and 4 show the chronological progression of the different solutions used in the industry to implement the elementary POWER MOS structures.

The P doped semiconductor area that appears on the surface of the semiconductor in front of the metal electrode is the channel. There is an N<sup>-</sup>.

Fig. 5 - POWER MOS cell structure

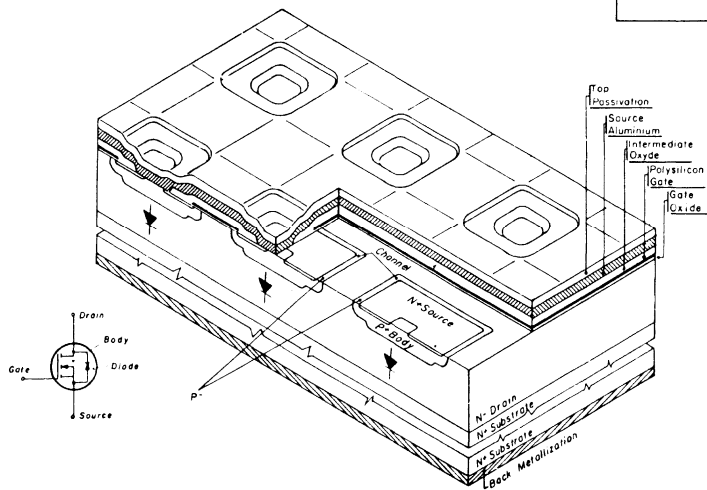


Fig. 2 - V-Groove structure

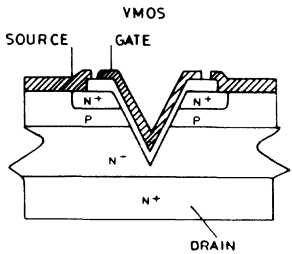


Fig. 3 - U-Groove structure

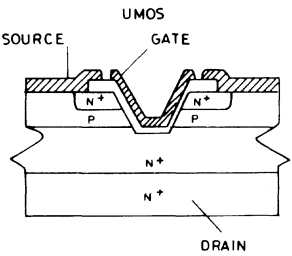
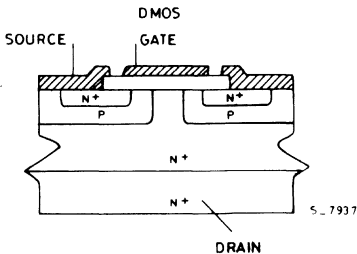


Fig. 4 - D-MOS structure



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layer with low doping (high resistivity) on one side of the channel. This N layer becomes depleted when the voltage is applied to the device, and consequently allows the device to sustain applied voltages without reaching too high an electric field at any point of the chip.

Reaching the critical field means reaching the point of voltage breakdown (primary breakdown).

“V” and “U” type structures have been abandoned because the production process is both difficult and critical. Nowadays practically all POWER MOS are of the D type as shown in Fig. 4, D as a

prefix means that the channel is produced by diffusion.

All the devices have in common the fact that the current traverses the device vertically, as a consequence two electrodes appear on the surface:

- SOURCE

- GATE

and one electrode appears on the bottom:

- DRAIN

Fig. 5 shows the actual structure of an POWER MOS in an expanded view of a piece of the chip.

All the important elements can be located in the figure.



## EVOLUTION OF POWER MOS TRANSISTORS

The vertical double diffused MOS silicon gate technology represents the final evolution of the development of a process to obtain POWER MOS devices, started in SGS in 1977.

The principal steps of this development have passed through the study of these structures (fig. 1);

- 1) V groove MOS
- 2) U groove MOS
- 3) Double diffused MOS metal gate
- 4) Double diffused MOS silicon gate

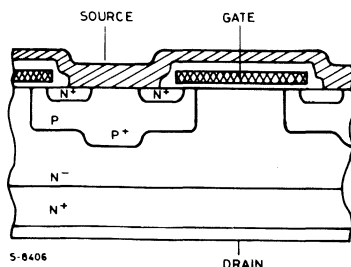
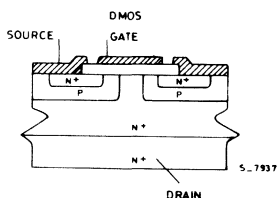
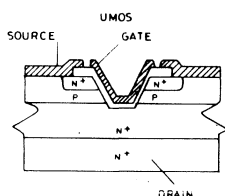
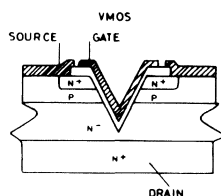
Nowadays the VDMOS silicon gate structure is used while the other three structure have become obsolete.

All these structures have as a common point the fact that the current flows through a vertical path like bipolar power devices and, as a consequence the devices have two electrodes on the top (gate and source) and one on the bottom (drain) in electrical and thermal contact with the header.

Another common point is the fact that the starting material is made of an epitaxial lightly  $N^-$  doped layer grown on a heavily  $N^+$  doped substrate (for N-channel devices).

The  $N^-$  region largely supports the applied drain potential because its doping level is much smaller than the  $P^-$  body region.

Fig. 1 - Evolution of POWER MOS devices



### VDMOS SILICON GATE

#### STRUCTURE

In the VDMOS silicon gate structure the best features of earlier technologies and design are combined with new fabrication techniques to achieve much better performance. The VDMOS silicon gate structure needs a more sophisticated technology, very similar to that of the VLSI.

VDMOS (fig. 2) is a two level structure where the lower level is the gate made of doped polycrystalline silicon and the upper level is the source metallization.

It is a self aligned structure since the polysilicon holes are the mask for the P<sup>-</sup> well and N<sup>+</sup> source diffusion.

In this way MOS channel regions are obtained by difference in lateral diffusion of the two impurity di-

stributions. The use of double diffusion achieves very short channels ( $\leq 1.5\mu$ ).

With the VDMOS silicon gate structure the resulting increase in packing density directly reduces the cost and improves the performance of the device. In fact the use of a polycrystalline gate reduces the possibility of sodium ion contamination in the gate oxide (with high stability of threshold voltage  $V_{GS(th)}$ ). Also the full surface source metallization allows a better heat dissipation.

Fig. 2a - VDMOS structure

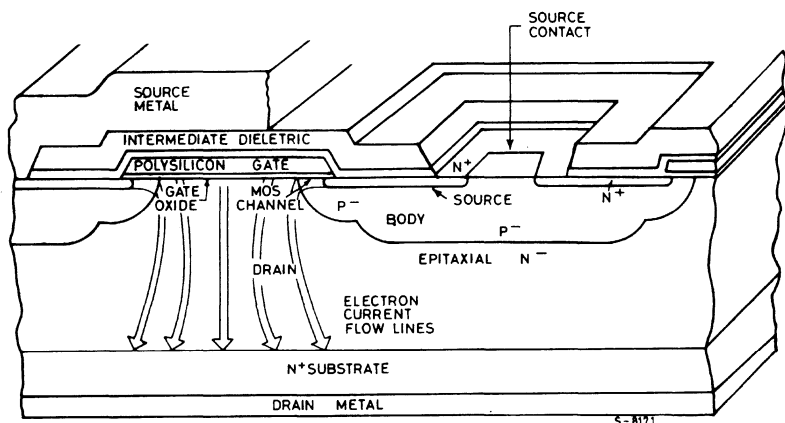
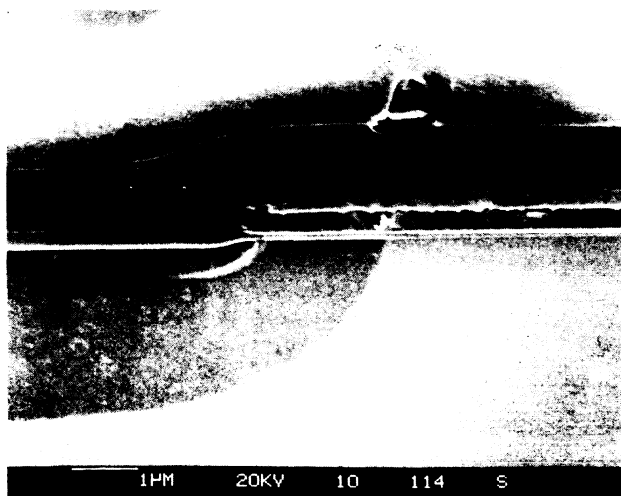


Fig. 2b - SEM microphoto of the VDMOS structure



|                         |   |        |
|-------------------------|---|--------|
| L (channel)             | ≡ | 1.75μ  |
| t (gate ex)             | ≡ | 830 Å  |
| t (gate poly)           | ≡ | 3330 Å |
| t (ox → poly-As)        | ≡ | 2500 Å |
| t (p-vapox)             | ≡ | 9580 Å |
| x <sub>i</sub> (source) | ≡ | 0.50 μ |
| x <sub>i</sub> (body)   | ≡ | 2.58 μ |



HOW IT WORKS

The structure is switched on by applying a voltage between the drain and the source and positively biasing the gate (for a N-channel device) with respect to the source. This biasing creates an electric field in the channel region which reverses the polarity of the material in the body region to create a majority carrier path from the source to the drain. Electron current flows from the source me-

tal to the source contact, laterally through the channel and then vertically through the drain and substrate to the drain metal.

The body source together with the drain creates an internal parasitic diode in inverse parallel connection. This diode conducts when the source is positive with respect to the drain and it can handle forward current equal to the drain current rating (fig. 3).

Fig. 3 - Schematic representation of POWER MOS structure

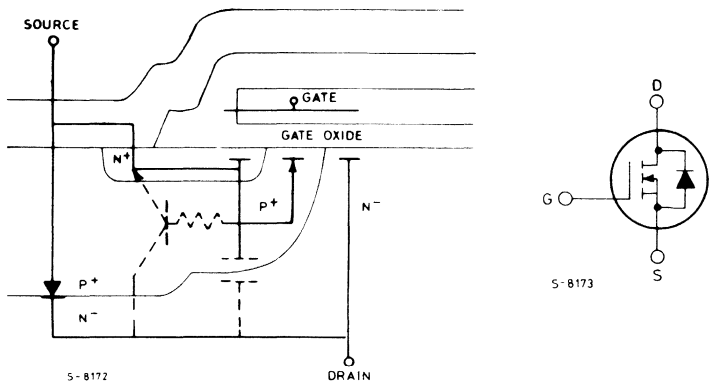
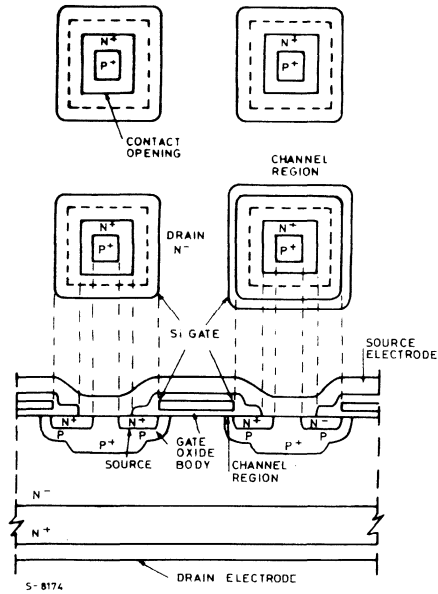


Fig. 4 - Horizontal layout and vertical structure



DESIGN OF POWER MOS

In the design of a POWER MOS transistor the parameters of interest are the device on resistance  $R_{DS(on)}$ , for a given chip area and the breakdown voltage.

ON RESISTANCE

The vertical power DMOS consists of a large number of cells interconnected in parallel on a single die (fig. 4).

$R_{DS(on)}$  parameter is strictly dependent on the topological layout, that is the shape and size of the cells and the packing density.

In order to optimize this parameter, a comparison between different geometrical solutions at both low and high voltages was made.

If the behaviour of the  $R_{DS(on)}$  components is analysed (fig. 5) it can be seen that for low voltage applications the channel has a greater effect in determining the  $R_{DS(on)}$  value. To optimize the  $R_{DS(on)}$  it is necessary to maximize the POWER MOS channel perimeter per unit area with a high packing density. Low voltage devices have a packing density of about 550 K per square inch.

For high voltage devices the epitaxial layer resistance has a greater effect than the overall on resistance (fig. 6). To optimize  $R_{DS(on)}$  it is necessary to minimize bulk resistance choosing a low packing density layout which increases the area of the epitaxial drift region. High voltage devices have a packing density of about 280.000 cells per square inch (fig. 7).

Fig. 5 - Low voltage case

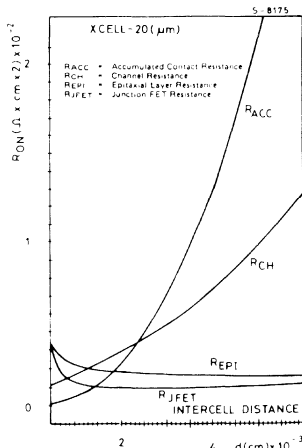


Fig. 6 - High voltage case

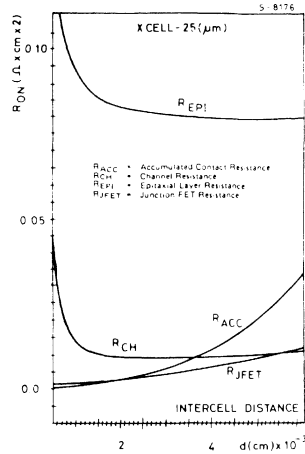
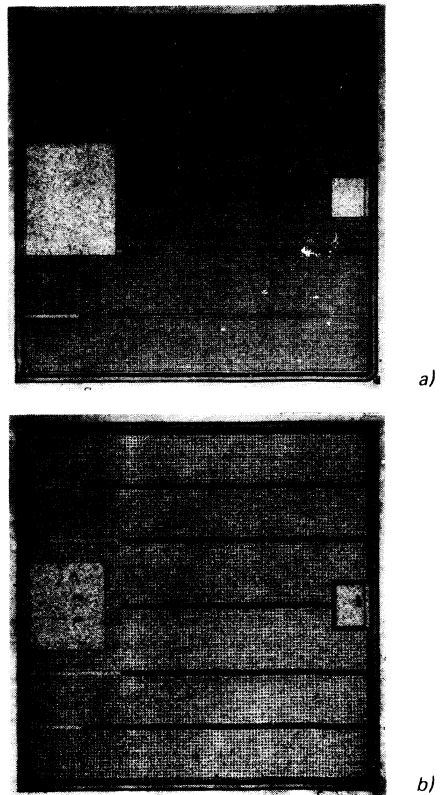


Fig. 7 - a- (100V) b- (400V)



## BREAKDOWN VOLTAGE $V_{(BR)DSS}$

The ideal breakdown voltage is bulk avalanche breakdown which corresponds to a minimum epitaxial bulk resistance requirement.

At high voltages however, the maximum drain potential is limited by junction edge breakdown below the ideal value. This is due to the effects of curvature and surface electrical field crowding.

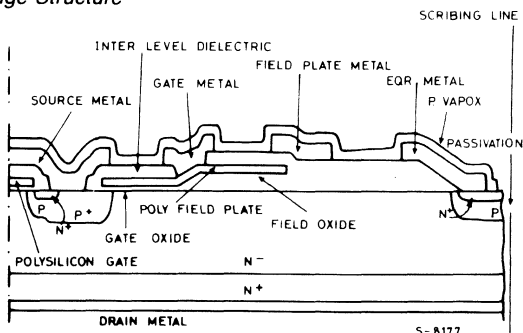
Therefore to meet a certain breakdown requirement

the epitaxial layer doping must exceed that specified by the minimum epitaxial bulk resistance requirement and this will increase the device on resistance.

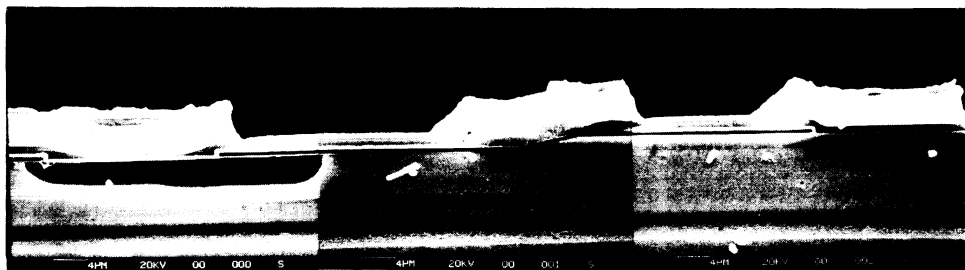
To reduce the surface electrical field and thus reach the bulk breakdown voltage, an edge structure has been developed.

This edge termination contains a field plate surrounding the silicon dioxide of three increasing thicknesses forming a triplanar structure (fig. 8).

Fig. 8 POWER MOS Edge Structure



A SEM microphoto of the POWER MOS Edge Termination



The field plate allows higher breakdown voltages by spreading the field laterally along the surface of the device.

Gradual increase of the oxide thickness at a very low angle (10 degrees to 15 degrees) from the gate oxide to the field oxide allows distribution of the voltage so that the electrical field is as uniform as possible along the surface and is below the critical electrical field (fig. 9).

This edge termination has been implemented in POWER MOS allowing breakdown voltages up to 600V with stable characteristics. A new edge termination structure allows a  $V_{(BR)DSS}$  of up to 1000V.

## THRESHOLD VOLTAGE

The value of the threshold voltage is related to the thickness of the gate oxide and to  $N_A$ , maximum peak impurity concentration in the laterally diffused body in the region between the source and the drain (fig. 10).

Channel punch-through can occur as the result of insufficient impurity charge in the channel, under strong reverse bias. To avoid punch through a trade off between  $V_{GS(th)}$  and length must be made.

For a fixed gate oxide thickness a shorter channel length implies a greater  $N_A$  maximum peak and a higher  $V_{GS(th)}$ . However, a lower  $V_{GS(th)}$  sets a lo-

wer limit to the channel length in relation to the punch through problem.

Due to the negative temperature coefficient of  $V_{GS(th)}$  its value cannot be too low. Also, if it is too

high, the devices cannot be driven directly by low voltage logic circuits.

Consequently the value of  $V_{GS(th)}$  is in the range from 2 to 4V with an oxide thickness of 850 Å.

Fig. 9 - Computer simulation of the equipotential lines of the Edge of a high voltage POWER MOS device

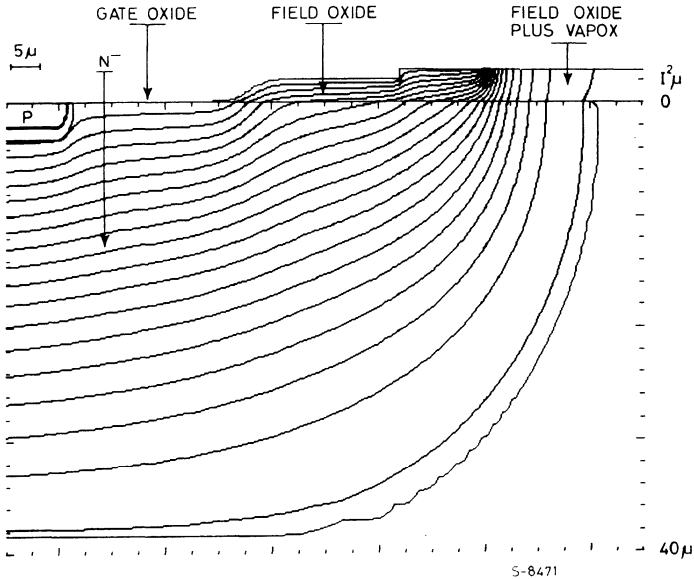
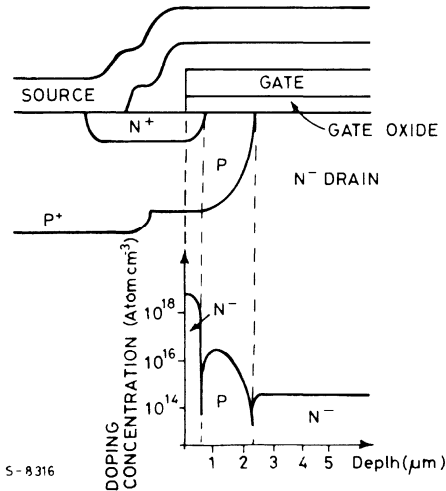


Fig. 10



## POWER MOS IN SWITCHING AN EVALUATION METHOD AND A PRACTICAL EXAMPLE

### INTRODUCTION

POWER MOS are used in switch mode power supplies, H.F. welding systems, industrial ovens, relay drivers and other similar applications. These diverse applications of POWER MOS in the field of control is due largely to their ability to handle high power at very high switching speeds up to hundreds of kHz.

The great improvement in the ability to switch power using POWER MOS is due to the recent progress made in the manufacture and technology of semiconductors. This ability to produce power devices using MOS technology has opened up new fields of applications. In POWER MOS devices the flow of current from the drain to the source is voltage controlled. Consequently the energy consumed in driving the device is much less than for a bipolar device. POWER MOS devices are unipolar and do not make use of minority carriers for conduction. This makes them very attractive to use in power switching at very high frequencies.

### SWITCHING PHASE

In practical working conditions three main phases can be distinguished:

#### On state

When the device is on and the channel open, the dissipated power is:

$$P_{(on)} = V_{DS(on)} \times I_D$$

$$P_{(on)} = V_{CE(sat)} \times I_C \quad \text{for bipolar transistors}$$

It can be reduced optimising the technology (metal back, epitaxial thickness) and the design (cell dimensions and layout).

#### Off state

When the device is off and the drain is at the supply voltage, the power dissipation is:

$$P_{off} = V_{DD} \times I_{DSS}$$

$$P_{off} = V_{CC} \times I_{CEX} \quad \text{for bipolar transistors}$$

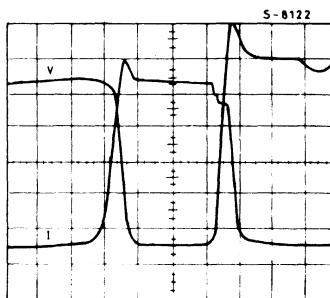
#### "TRANSITIONS"

During switching the dissipated power instant by instant is:

$$P = V_{DS} \times I_D$$

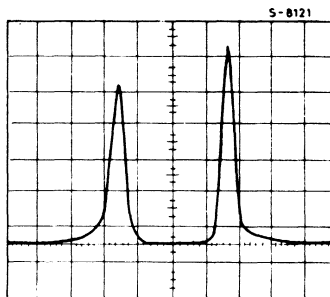
and depends on the on/off switching speed of the device as can be seen in Figs. 1 and 2.

Fig. 1 - I/V waveforms



t: 100 ns/div, V: 45V/div, I: 1.2A/div,  $V_g = 10V$ ,  $R_g = 25\Omega$

Fig. 2 - Power dissipation waveforms.



t: 100 ns/div, P: 200W/div,  $V_g = 10V$ ,  $R_g = 25\Omega$ .

### Q. THE EFFICIENCY FACTOR

The performance of POWER MOS device can therefore be rated as the ratio between the total power in switching-on and off and the energy dissipated per cycle. It can be expressed as:

$$Q = \frac{P_t}{E_{on} + E_{off} + E_p}$$

Where:

$E_{on}$  - is the energy lost in the turning-on and on phases

$E_{\text{off}}$  - is the energy lost in the turning-off and off phases

$E_p$  - is the energy lost in driving the circuit.

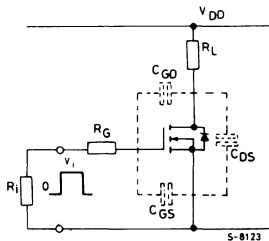
The quantity  $Q$  is a frequency and is an index of the maximum frequency at which the device can most efficiently operate, considering  $P_t$  as the maximum power that the device can dissipate in practical working conditions.

To fully understand this equation a brief analysis of switching phenomena is essential. As previously mentioned, POWER MOS do not make use of minority carriers for conduction. The recombination of these minority carriers is a switching speed limitation. In POWER MOS devices the majority carrier flow is simply controlled by the gate voltage and therefore its switching speed is limited only by the time needed to charge and discharge the parasitic input capacitances. Consequently the switching behaviour is a function only of the ability of the driving circuit to charge and discharge some hundreds of picofarads. This is why POWER MOS can switch so fast - in the range of tens of nanoseconds.

## INPUT

POWER MOS devices behave quite differently from bipolar power devices, as far as the driving energy is concerned. POWER MOS require driving power during the charge and the discharge phases of the input capacitances. Fig. 3 shows a POWER MOS driven by a voltage generator with an internal resistance  $R_i$  and an open circuit voltage  $V_i$ , where  $R_L$  is the load.

Fig. 3 - POWER MOS equivalent circuit.



The input capacitance  $C_{iss} = C_{GS} + C_{GD}$  during the switching cycle is not constant for two reasons.

- 1)  $C_{GD}$  can be seen as the capacitance between the gate electrode and the drain, where the dielectric is the depleted drain layer. The drain epilayer is fixed, but its depleted part varies according to  $V_{DS}$ . The higher  $V_{DS}$ , the thicker the depleted layer and consequently the lower the associated capacitance.

- 2) A more pronounced effect comes from the fact that the voltage across  $C_{GD}$ , when the gate source voltage rises from zero to its final value,  $V_{DS}$  must go down from  $V_{DD}$  to  $V_{DS(on)}$ . In particular  $C_{GD}$  is seen as a higher equivalent capacitance during the drain "on" transitions. The input must be fed a charge:

$$Q = C_{GD}(V_{DD} - V_{DS(on)})$$

to account for the voltage variation across  $C_{GD}$ . This happens when the gate voltage reaches  $V_{GS(th)}$ , the threshold voltage, and the drain voltage starts falling. It is not until the required charge  $Q$  is provided that  $V_{GS}$  can increase. This is called the Miller Effect. For a while the equivalent input capacitance appears infinite and  $V_{GD}$  absorbs the whole input current.

From the moment  $V_{DS}$  reaches  $V_{DS(on)}$  the input equivalent capacitance is:

$$C_{eq} = C_{GS} + C_{GD}(\text{low voltage})$$

and the transition of the output is completed.  $V_{GS}$  increases again, tending towards  $V_i$ .

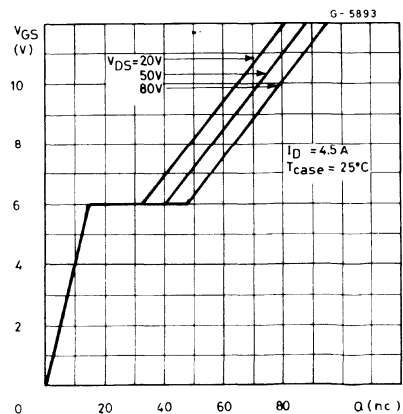
These two phenomena become apparent when looking at the gate charge versus gate source voltage diagram in the data sheets.

The diagram for SGSP471 in fig. 4 can be taken as an example.

A true capacitor would appear as a straight line starting from the origin. In fact the first segment corresponds to an equivalent capacitance:

$$C_{eq} = C_{GS} + C_{GD}(\text{high voltage})$$

Fig. 4 - Gate charge vs. gate-source voltage SGSP471



The horizontal segment corresponds to an equivalent infinite capacitance i.e. the charging of  $C_{GD}$  with the gate at  $V_{th}$  and the drain falling from  $V_{DD}$  to  $V_{DS(on)}$ . The last segment has a slope corresponding to a capacitance:

$$C_{eq} = C_{GS} + G_{GD} \text{ (low voltage)}$$

The difference in slope of the first and third segment shows how  $C_{GS}$  differs in the two cases.

The behaviour at turn-off of the input capacitance is exactly opposite, where the described phenomena occur in reverse order. At this point the drive energy required to make the POWER MOS switch can be calculated as:

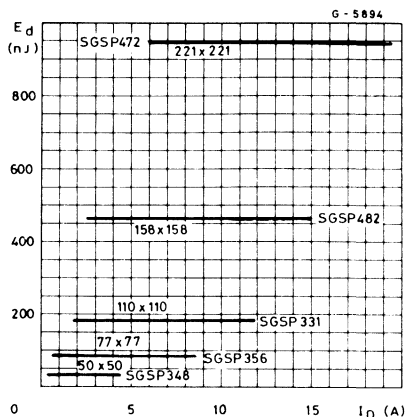
$$E_p = 1/2 C_{eq} \times V_{GS}^2 = 1/2 Q_G \times V_{GS}$$

$Q_G$  and  $V_{GS}$  can be obtained from fig. 4

The input energy can also be obtained in a more direct manner by calculating the integral of the  $I_G$  waveform during the turn-on or turn-off phase, the two areas being equal (see fig. 5). In fact this integral represents the quantity  $Q_G$  (gate charge) which in turn permits the calculation of  $E_p$ .

The values of  $E_p$  have been calculated for all POWER MOS in the present product range. They are a function of the die area only, for a given supply voltage  $V_{DD}$ , and have been represented for different die areas as a function of  $I_D$  in Fig. 6.

Fig. 6 -  $E_p$  vs  $I_D$  at  $V_{DD} = V_{(BR)} DSS / 2$



The driving energy does not vary for devices with the same die area but different breakdown voltages, if their drive supply voltage has a constant ratio to their breakdown.

In brief  $E_p$  can be plotted as a function of the die area, for a supply voltage equal to half the rated  $V_{DSS}$  of the device (see fig. 7). The method used here to calculate  $Q_G$  is different from that in the data sheet where  $Q_G$  is plotted as a function of  $V_{GS}$ .

As the results obtained in both methods were in good agreement the validity of the method used here is confirmed.

The driving circuit itself dissipates power to drive the POWER MOS device. Current only flows in the gate circuit during turn-on and turn-off periods. This current flowing through the drive circuit will dissipate energy.

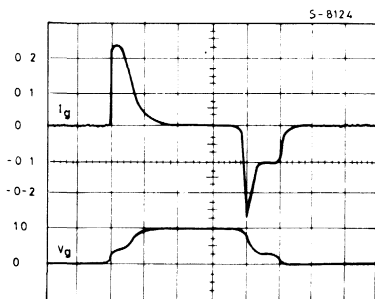
With reference to fig. 8, where the 50 ohm resistor is inserted to match the cable and the device, during the on phase, there is a constant power dissipation in the resistor  $R_1$ .

$$(V_{GS}^2 / R_1) \cdot t/T$$

Where:

$R_1 = 50 \text{ ohm}$  (typical value)  
 $t/T = \text{duty cycle}$

Fig. 5 -  $I_g$  -  $V_g$  waveforms.



t: 0.5  $\mu$ s/div, I: 0.1 A/div, V: 10 V/div

Fig. 7 -  $E_p$  versus die side ( $Sq \text{ mil}$ )

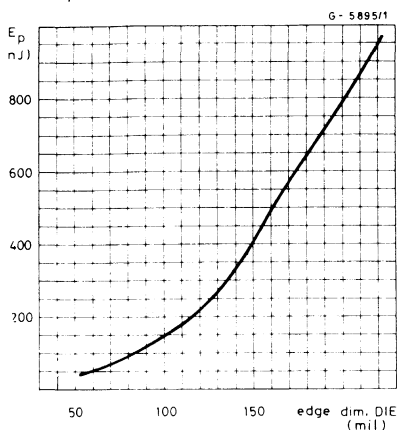


Fig. 8 - Driving circuit. A laboratory implementation

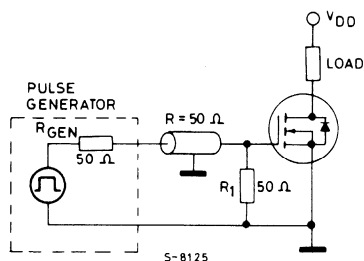


Fig. 9 - Driving circuit. A practical implementation.

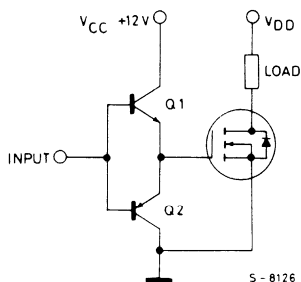


Fig. 9 shows a possible implementation that avoids steady state dissipation in the driver.

The NPN transistor, Q1, only conducts at the beginning of the on phase when charging the input capacitances. Conversely the PNP transistor, Q2, only conducts at the beginning of the off phase

when discharging the input capacitances. They never conduct at the same time. No conduction occurs during steady state. In addition, when either of the two transistors conduct their output impedance is very low thus improving the switching of the POWER MOS device. The total energy dissipated per cycle, in the input stage (including the POWER MOS input) is:

$$E_p = Q_G \times V_{CC}$$

Where:  $V_{CC}$  = input supply to driving stage voltage. This is +12V in Fig. 7.

This energy is actually dissipated in the two driving transistors, because the parasitic input capacitance of the POWER MOS acts as a non-dissipating element, storing energy from Q1 at turn-on, and giving it back to Q2 at turn-off.

## OUTPUT

### Switching times for resistive load

Fig. 10 shows the circuit used to measure the switching times of a resistive load.

Fig. 10 - test circuit

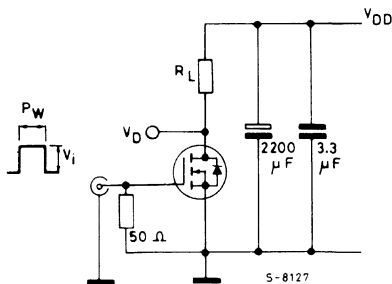
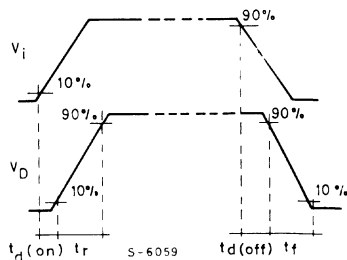


Fig. 11 -  $V_{GS}$  and  $V_{DS}$  waveforms



### Turn on delay time

Turn on delay time ( $t_{d(on)}$  in fig. 11) represents the time necessary for  $V_{GS}$  to reach the threshold le



vel  $V_{th}$  at which the device begins to conduct. The smaller the threshold voltage and the bigger the  $V_i$  value, with respect to  $V_{th}$ , the smaller the  $t_{d(on)}$  value. In fact from the equation:

$$\text{Eq.1} \quad V_{GS} = V_i(1 - e^{-t/R_i C_{iss}}).$$

where  $R_i$ ,  $C_{iss}$  is a time constant and by substituting  $V_{GS}$  with  $V_{th}$  in Eq.1 we obtain:

$$\text{Eq.2} \quad t_{d(on)} = R_i \cdot C_{iss} \ln \frac{V_i}{V_i - V_{th}}$$

considering typical values for  $V_i$  and  $V_{th}$  we have:

$$t_{d(on)} = 0.35 \times R_i \cdot C_{iss}$$

In practice this time is negligible (10 - 20 ns) when compared to others. During this time the device is off and the energy dissipated is therefore in the order of pJ and compared with the total energy loss it can be completely neglected in this analysis.

#### t-RISE AND t-FALL TIMES

t-rise and t-fall are defined by the slopes of  $V_{DS}$  as shown in fig. 11.

#### Turn-off delay time

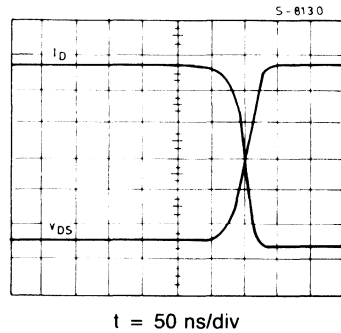
$t_{d(off)}$  can be referred to as the delay time since it represents the time necessary to remove the excess charge from the gate and channel, due to the input overvoltage.

Typical drain current and voltage waveforms ( $t = 50\text{ns/div.}$ ) are shown in fig. 12a and b.

#### PARASITIC CAPACITANCES DURING SWITCHING CYCLES

As already mentioned the switching of a POWER MOS device consists fundamentally in the loading and unloading of the input capacitor.

Fig. 12b - Turn-off



$$C_{iss} = C_{GS} + C_{GD}$$

From Eq.1 where  $R_i \cdot C_{iss}$  is the time constant  $R_i$  includes:

$R_{gen}$  - the internal resistance of the generator.

$R_1$  - the resistor between gate and source to match the driving circuit.

$R_G$  - the internal resistance of the gate.

Fig. 13a - Equivalent circuit

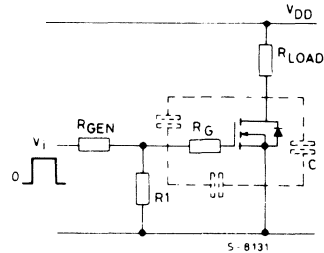


Fig. 13b - Capacitance values as a function of  $V_{DS}$

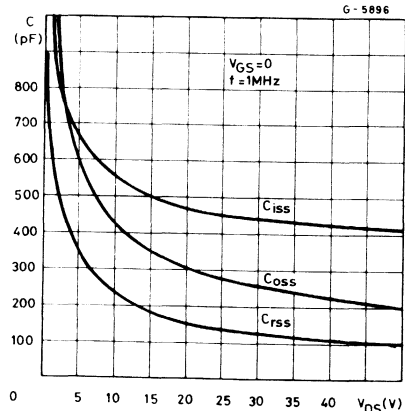
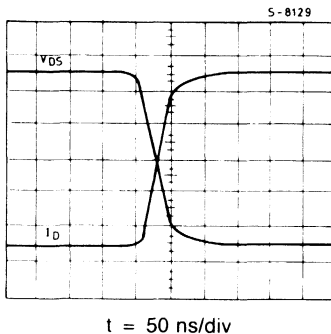


Fig. 12a - Turn-on

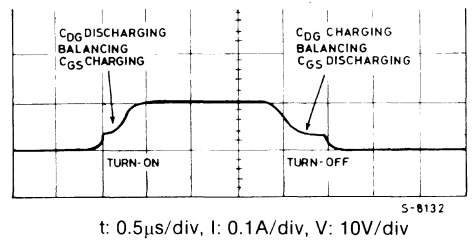


Obviously the smaller the value of  $R_i.C_{iss}$  the faster  $V_{GS}$  reaches its final value, and switches the device. To minimize this time constant the user can act on  $R_{gen}$  and  $R_i$  and the device designer on  $C_{iss}$ .

$C_{iss}$ , being a function of  $C_{GD}$ , varies as a function of the drain voltage as shown in the waveforms in fig. 13b and during switching it is subjected to the Miller effect. Consequently during the  $t_{d(on)}$  and  $t_{d(off)}$ ,  $C_{iss}$  remains constant, as does the value of  $V_{DS}$ .  $t_{d(on)}$  and  $t_{d(off)}$  are obtained from the charging and discharging laws of an RC circuit, while during the off/on and on/off transitions,  $C_{iss}$  varies. In other words, when  $V_{DS}$  decreases during turn-on to a very low value  $V_{DS(on)}$ , and  $C_{GD}$  increases, there is a delay in the increase of the value of  $V_{GS}$  since the capacitor, as long as it is not charged to  $V_{GS(on)}$ , will absorb the gate current.

During turn-off, due to  $V_{DS}$  rising, the discharge current of  $C_{GS}$  will be balanced by the charging current of  $C_{GD}$ , flattening the  $V_{GS}$  curve and making it similar to that at turn-on (Fig. 13c).

Fig. 13 c - An annotated extract from fig. 5 showing the discharging and charging of  $C_{GD}$

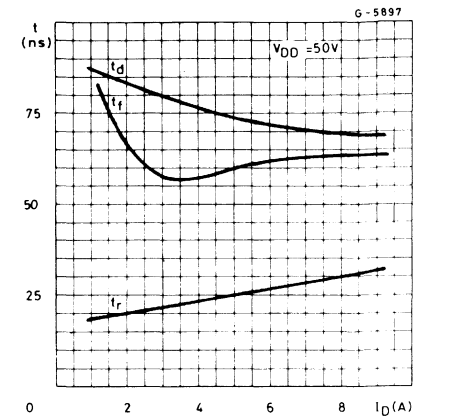


Variations in the supply voltage  $V_{DD}$  influence these effects: the higher the supply voltage the greater the charge and therefore the  $t_f$  and driving energy required (see fig. 8 in the section OUTPUT).

Figs. 14, 15, 16 and 17 show the switching time waveform as a function of both the supply voltage  $V_{DD}$  and the load current  $I_D$ , for two devices with different voltages and die sizes.

SGSP311 110V 7A 0.3 ohm 110 × 110mils<sup>2</sup>  
 SGSP369 500V 5A 1.75ohm 156 × 156mils<sup>2</sup>

Fig. 14 - Time measurement  $t_d$ ,  $t_f$ , and  $t_r$  as functions of  $I_D$ . (SGSP311)



The  $t_r$  and  $t_f$  waveforms versus  $V_{DD}$  are similar to those of  $E_p$  versus  $V_{DD}$  since they are both caused by the same phenomena.  $t_d$  is independent of  $V_{DD}$  as it is a function of  $C_{iss}$  only (which, since the Miller effect is not present, is constant during this phase).

- $t_d$  = delay time
- $t_d$  = fall time
- $t_r$  = rise time

Fig. 15 - Time measurements  $t_d$ ,  $t_f$  and  $t_r$  as functions of the drain voltage for a low voltage POWER MOS. (SGSP311)

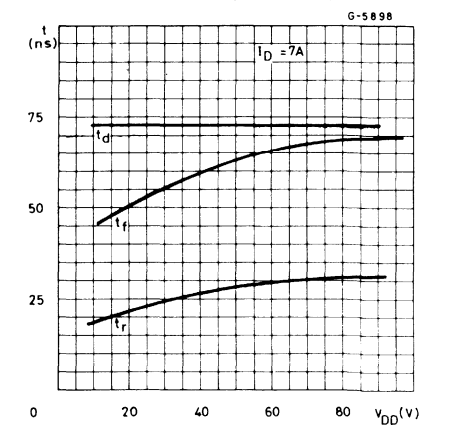


Fig. 16 - Time measurement  $t_d$ ,  $t_r$  and  $t_f$  as functions of the drain current for high voltage POWER MOS (SGSP365)

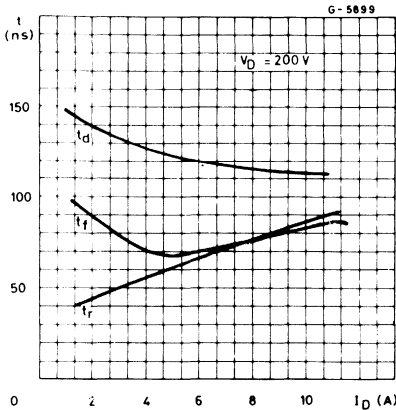
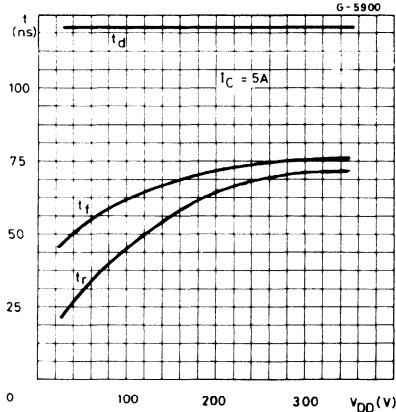


Fig. 17 - Time measurements  $t_d$ ,  $t_r$  and  $t_f$  as functions of the drain voltage for high voltage POWER MOS.



### Switching times for inductive loads

In the majority of applications POWER MOS are used in switching power through inductive loads (motor control, switching power supply etc.).

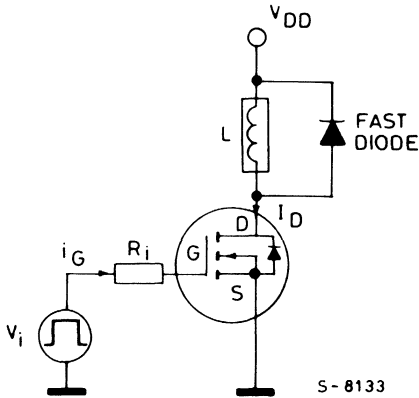
The fundamental objective of the device is to switch high quantities of power very quickly, in other words to maximize the ratio:

$$\frac{\text{total power switched}}{\text{energy dissipated per cycle}}$$

which depends principally on the switching times. Understanding switching with POWER MOS requires consideration of both the physical phenomenon and the energy dissipation occurring during each switching cycle.

The typical clamped inductive load circuit shown in fig. 18 is used as an example.

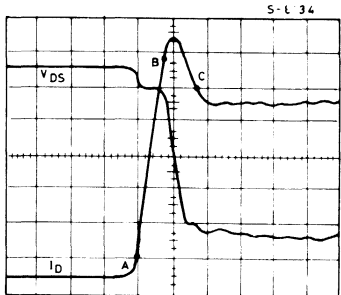
Fig. 18 - POWERMOS with clamped inductive load.



### TURN - ON

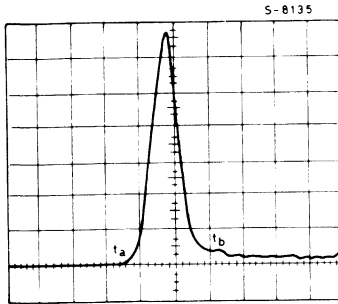
A detailed explanation of the turn-on phenomena in a POWER MOS device when the load is inductive is given by Fig. 19 and 20.

Fig. 19 - Current and voltage waveforms during turn-on



t: 50ns/div, I: 1.2A/div, V: 40V/div, R = 25 $\Omega$

Fig. 20 - Output energy consumption during turn-on.



t: 50ns/div, P: 200W/div, E: 67.5  $\mu$ J

Before the turn-on phase the diode is freewheeling the load current.

Turn-on can be divided into two subphases:

1) point A to point B (Fig. 19).

Part of the current in the load (constant during the switching operations) starts to flow in the POWER MOS device. The diode is recovering its reverse state. The voltage across the POWER MOS device is almost equal to that of the supply since the diode still acts as a short circuit for the load at this point. There is a small step in  $V_{DS}$  waveform due to the voltage drops on the parasitic inductances  $L_D$  and  $L_S$ . The size of this step depends on the current slope  $dI_D/dt$  ( $L_S$  and  $L_D$  depend on the circuit layout).

2) point B to point C (Fig. 19).

In this phase the diode is reverse biased. The current in the POWER MOS device is the sum of the current in the load plus that in the diode, which causes the peak in the  $I_D$  waveform. (see fig. 24)

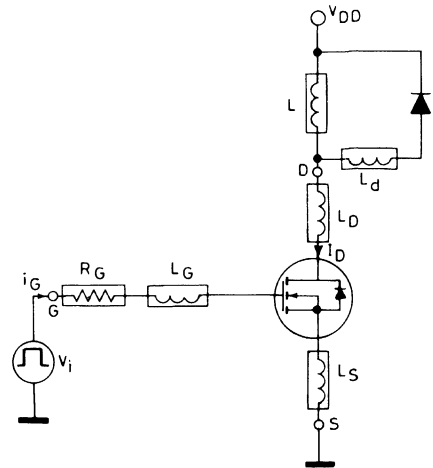
The  $V_{DS}$  voltage falls to  $V_{DS(on)}$  as the freewheeling diode, being reverse biased, is no longer a short circuit. However the fall of  $V_{DS}$  is delayed by the Miller effect, which increases  $C_{iss}$ .

All these phenomena cause a high crossover between the  $I_D$  and the  $V_{DS}$  waveforms even if the switching is very fast. In fig. 20 the output energy consumption per turn-on phase is represented. To decrease this energy, the  $dI_D/dt$  (A-B phase) and the reverse recovery of the freewheeling diode (B-C phase) must be improved.

### IMPROVING $dI_D/dt$

Reference to the circuit in Fig. 21 shows the controlling parameters for  $dI_D/dt$ .

Fig. 21 - Circuit which includes the parasitic inductances.



S-8136/1

In this circuit the following elements have been taken into consideration:

$L_d$  - is the parasitic inductance due the connections between the clamping diode and the load.

$L_D$  - is the parasitic inductance between the drain of the POWER MOS device and the load.

$L_G$  - is the parasitic inductance between the gate and the driving circuit.

$L_S$  - is the parasitic inductance between the source and the ground.

The equation that applies to the input loop is:

$$V_i = R_i \times i_G + L_G di_G/dt + V_{GS} + L_S dI_D/dt$$

Where  $R_i$  is the equivalent resistance of the driving circuit. When considering the phase when  $I_D$  increases it is possible to neglect the term  $L_G di_G/dt$  as  $di_G/dt = 0$ .

During this phase the threshold voltage has already been overcome,  $i_G$  is constant. In addition  $V_{GS}$  follows the law of charging a constant capacitance. The Miller effect is not present as  $V_{DS}$  is constant.

It follows that:

$$dI_D/dt = \frac{V_i - R_i I_G - V_{GS}}{L_S}$$

and  $dI_D/dt$  can be improved by increasing  $V_i$  and decreasing  $R_G$  and  $L_S$ .

Fig. 22 -  $di_D/dt$  as a function of  $V_i$  ( $R_G = 25\Omega$ ) for SGSP369

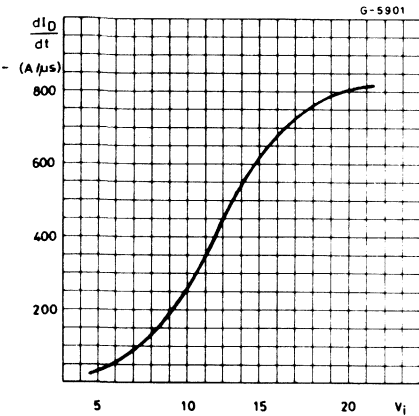
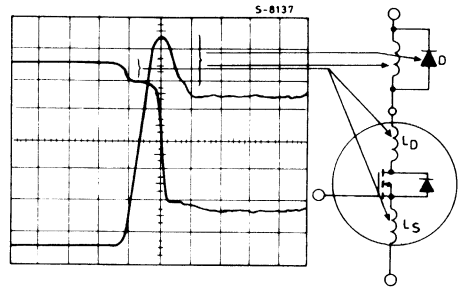


Fig. 24 - Shows the effect of the parasitic inductances  $L_D$  and  $L_S$  and of the diode connections respectively on  $V_{DS}$  and  $I_D$  waveforms

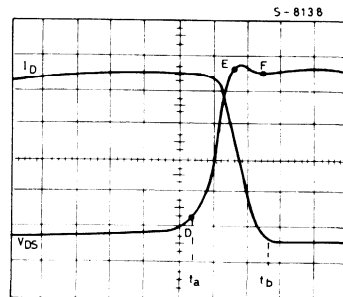


## TURN-OFF

The circuit in Fig. 18 is still useful in evaluating the behaviour of an POWER MOS device turning off an inductive load. The initial conditions can be assumed to be:

- 1)  $I_D = I_{LOAD}$
- 2)  $V_{DS} = V_{DS(on)} = R_{DS(on)} \times I_D$
- 3) Freewheeling diode reverse biased. In fig. 25 typical waveforms for  $V_{DS}$  and  $I_D$  during turn-off phase are represented

Fig. 25 -  $V_{DS}$  and  $I_D$  during turn-off



t: 50ns/div, V:40V/div, I:1.2A/div,  $R_G = 25\Omega$ ,  $V_g = 10V$

## IMPROVING THE REVERSE RECOVERY OF THE DIODE

As previously mentioned, the clamping diode plays an important role in determining the waveforms of  $I_D$  at turn-on; the faster the diode, the lower the current peak in the POWER MOS, the lower the reverse recovery time of the diode ( $t_{rr}$ ) and the energy consumption. For this reason fast recovery diodes are typically used in these circuits.

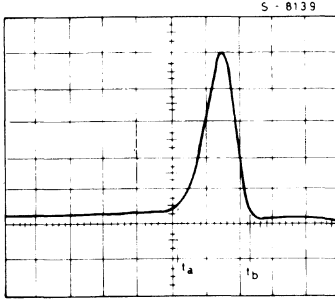
SGS-THOMSON has developed a wide range of fast recovery diodes some of whose characteristics are shown below (fig. 23).

Fig. 23 - SGS-THOMSON Fast recovery diodes.

| DEVICE          | $V_{reverse}$ | $I_{forward}$  | $t_{rr}$ | PACKAGE  |
|-----------------|---------------|----------------|----------|----------|
| BYW80-50/200    | 50/200V       | 8A             | 35 ns    | DO-220AB |
| BYW51-50/200    | 50/200V       | $2 \times 10A$ | 35 ns    | TO-220   |
| BYT30P 400/1000 | 400/1000V     | 30A            | 50/70 ns | DOP-3    |
| BYT60P 200/400  | 200/400V      | 60A            | 70 ns    | DOP-3    |

The effect of parasitic inductances  $L_D$  and  $L_S$  and of the diode connections respectively on  $V_{DS}$  and  $I_D$  are shown in Fig. 24.

Fig. 26 - Output Energy during turn-off phase.



t: 50ns/div, P: 200W/div, E = 70.6μJ

It is possible to distinguish two phases:

- 1) From point D to point E (Fig. 25). During this phase  $V_{DS}$  increases while  $I_D$ , the diode being reversed biased, remains constant and equal to  $I_{LOAD}$ .
- 2) From point E to point F (Fig. 25). During this phase the diode begins conducting allowing the current in the load to flow through itself and  $I_D$  of the POWER MOS device to fall. In Fig. 26 the output energy consumption during the turn-off phase is represented.

Also in this case a high cross over between  $V_{DS}$  and  $I_D$  occurs, even if there is no reverse recovery of the diode as during the turn-off phase. The Miller effect in the POWER MOS device delays the rise of  $V_{DS}$  and therefore the switch-on of the freewheeling diode D.

## ENERGY IN SWITCHING

From the energy point of view there are four distinct phases, each contributing in a different way to the total dissipated energy per cycle. They are:

- 1) ON-STATE
- 2) OFF-STATE
- 3) Transition ON-OFF
- 4) Transition OFF-ON

### The ON-STATE

In the ON-STATE, when the channel is completely open, POWER MOS devices have a minimum  $R_{DS(on)}$  which is temperature dependent. The Power dissipation at a given instant is obtained from the equation:.

$$P_{D(ON-STATE)} = R_{DS(on)}(T_j) \times I_D^2$$

$$= R_{DS(on)} \times [1 + \alpha(T_j - 25^\circ C)] \times I_D^2$$

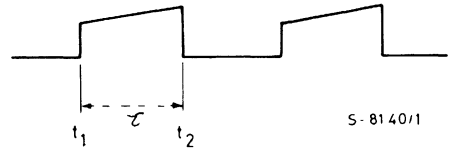
where  $\alpha = 8 \times 10^{-3} \text{ } ^\circ\text{C}^{-1}$ , a positive coefficient.

The lower  $R_{DS(on)}$  the lower the power dissipation. The manufacturers can control  $R_{DS(on)}$ :

- 1) by improving the back metalization of the chip and its attachment to the case.
- 2) by controlling the epitaxial growth of the DRAIN.
- 3) by optimizing the horizontal lay-out of the POWER MOS structure (high cell density).

Fig. 27 - Can be used to calculate the energy consumption during the ON phase

Fig. 27 -  $i_D$  waveform during the working cycle



The slope of  $I_D$  during the conduction phase is given by  $dI_D = V_{DD}/L$  (see Fig. 19).

The lost energy per cycle is given by:

$$E_{on} = \int_0^{\tau} I_D^2(t) \times R_{DS(on)} \times dt$$

where  $\tau$  is the pulse width.

In most cases the slope of  $I_D$  is quite gentle so if we call  $I$  the average  $I_D$  between  $t_1$  and  $t_2$ , ( $t_1 - t_2 = \tau$ ) in Fig. 27, this energy can be calculated with good approximation as follows:

$$E_{on} = R_{DS(on)}(T_j) \times I^2 \times \tau$$

In Fig. 28, 29, and 30 the curves of  $E_{on}$  are shown for three different devices. Each curve is characterized by different values of  $\tau$ .

Fig. 28 - On state energy values as a function of the drain current for SGSP301

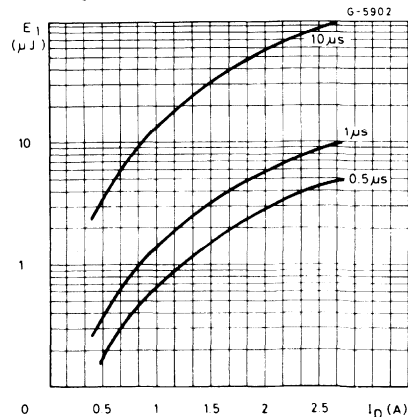


Fig. 29 - On-state energy waveforms as a function of the drain current SGSP575.

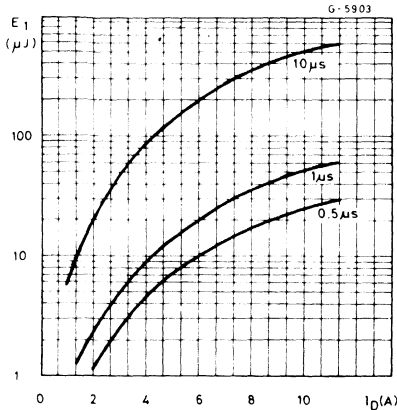
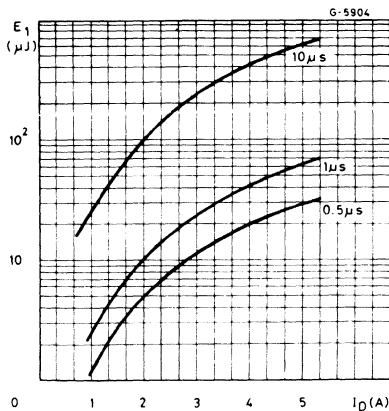


Fig. 30 - On-state energy values a function of the drain current SGSP531



## OFF-STATE

When the device is switched off the  $V_{DS}$  voltage is equal to  $V_{DD}$  (see Fig. 25). Only the leakage current  $I_{DSS}$  flows through the device. The energy consumption during this period is given by:

$$E_o = V_{DD} \times I_{DSS} \times t_{off}$$

This energy is the range of pJ and it is negligible in comparison to that dissipated during the switching and the ON-STATE.

## Transitions

During transitions the dissipated power, instant by instant, is:

$$P(t) = V_{DS}(t) \times I_D(t)$$

The power waveform is triangular in shape (see Fig. 20 and Fig. 26).

Integrating  $P(t)$ , the energy consumption per cycle during OFF-ON and ON-OFF transitions can be obtained by:

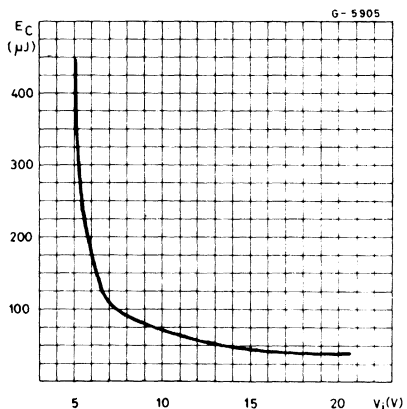
$$E = \int_{t_a}^{t_b} P(t) dt = \int_{t_a}^{t_b} V_{DS}(t) I_D(t) dt$$

Where  $t_a$  and  $t_b$  respectively represent the beginning and the end of transitions. These amounts of energy principally depend on the intersecting point between voltage and current, and on the switching speed.

In both transitions the intersecting points are very high and occur at a voltage value close to that of the supply. The intersecting points represent the power to be switched, consequently in order to optimise the energy consumption the time interval  $t_a - t_b$  must be reduced by acting on different driving and lay-out parameters ( $V_{GS}$ ,  $R_{GS}$ , parasitic inductances).

Fig. 31 - Shows the energy lost per cycle during the ON/OFF transition, as a function of  $V_i$  for an SGSP369 switching 4A at 200 V.

Fig. 31 - Values of the energy lost per cycle as a function of the gate voltage



## COMPUTING THE TOTAL ENERGY CONSUMPTION PER CYCLE

The previous analysis allows us to calculate the total energy dissipated per cycle in an POWER MOS device. In fact the total energy can be expressed as:

$$\text{Eq. 3 } E_{\text{TOT}} = E_{\text{On}} + E_{\text{off}} + E_{\text{off/on}} + E_{\text{on/off}} + E_p$$

where:

$E_{\text{TOT}}$  = total energy dissipated per cycle

$E_{\text{on}}$  = energy dissipated during the on-state

$E_{\text{off}}$  = energy dissipated during the off-state

$E_{\text{off/on}}$  = energy dissipated during the turn-on

$E_{\text{on/off}}$  = energy dissipated during the turn-off

$E_p$  = total energy dissipated by the drive circuit

Neglecting  $E_{\text{off}}$  (=  $\mu\text{J}$ ) and  $E_p$  (=  $\text{nJ}$ ) Eq.3 can be rewritten as:

$$\text{Eq. 4 } E_{\text{TOT}} = E_{\text{on}} + E_{\text{off/on}} + E_{\text{on/off}}$$

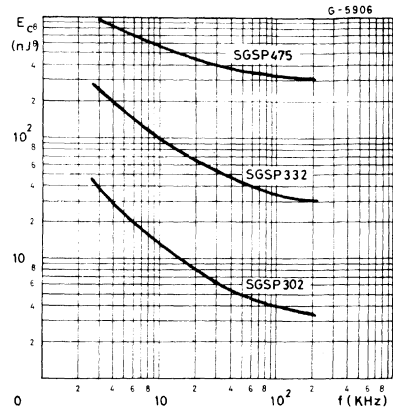
These three terms in Eq.4 depend in differing amounts on the operating conditions of the device  $I_D$ ,  $V_{DD}$  and the duty cycle.

To give some idea of the total energy dissipated per switching cycle the following operating conditions have been fixed and the results of energy measurements made shown in Fig. 32.

$V_{DD} = 1/2 V_{(\text{BR}) \text{ DSS}}$  of the device under test

$I_D = 3/4 I_{D\text{max}}$  of the device under test  
duty cycle = 50%

Fig. 32 - Total energy lost per cycle as a function of the frequency with a fixed duty cycle of 50%



The curves tend towards a horizontal asymptote that represents the cross-over energy (turn-on + turn-off, which is frequency independent). It is clear that the effect of  $E_{\text{on}}$  is of great importance at low frequencies, and the higher the  $R_{\text{DS(on)}}$  the greatest the effect.



## STUDY OF A MODEL FOR POWER MOSFET GATE-CHARGE

### INTRODUCTION

The increasing interest in POWER MOSFET devices is due especially to their ability to switch power at high frequencies and the simple drive requirements needed to achieve this.

Fast switching requires low energy loss during voltage-current cross-over. Easy driving requires only a very simple circuit and low drive energy.

Optimising these advantages requires a sound knowledge of the physical phenomenon which controls their operation.

A valid guide for this purpose is given by the gate charge curve which allows simple evaluation of the drive energy and the switching times.

The influence of the electrical parameters, both external to the device (e.g.  $I_D$ ,  $V_{DD}$ ) and the internal ones ( $V_{TH}$ ,  $G_M$ ,  $C_{ISS}$ ,  $C_{RSS}$ ,  $C_{OSS}$ ) have been analysed.

This analysis of the shape of the gate charge curve, shows its influence on the behaviour of the device.

An analytical expression has been derived that gives a good approximation to the total gate charge and relates it to the internal and external parameters controlling POWER MOSFETs.

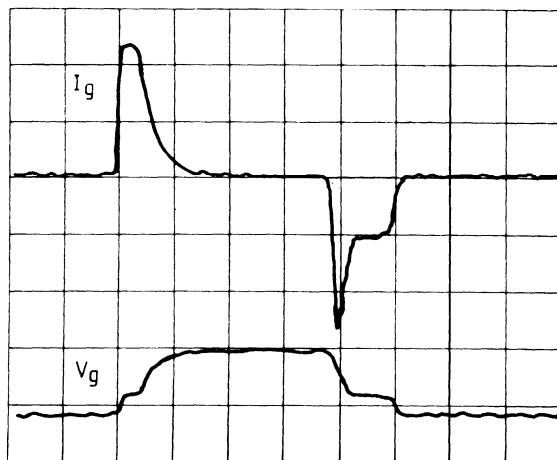
It is interesting to note that this analytical expression represents a valid aid in optimising design when using a software tool.

### GATE CHARGE MEASUREMENT

During the switching of a POWER MOSFET, the gate current has the typical behaviour of current in an RC circuit, see figure 1.

The transient lasts for some tens of nanoseconds or more, due essentially to the RC time constant

Fig. 1 -  $I_G$  -  $V_G$  waveforms

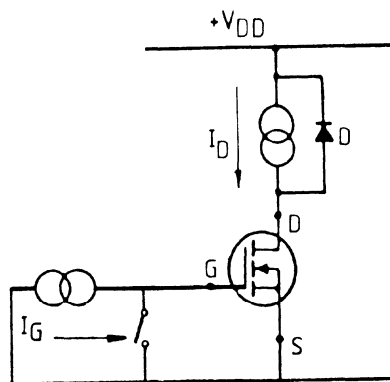


and the maximum current available in the generator. If the current in the gate,  $I_G$ , is constant and small enough, the switching time can be increased to a level where the voltage and the current waveforms are free from the parasitic effects caused by the stray inductances that are usually associated with high frequency power switching.

In this way it is possible to isolate the influence of the external factors and analyse just the internal parameters.

The measurement is made as shown in the circuit in figure 2.

Fig. 2 - Test circuit



## THEORETICAL ANALYSIS OF THE GATE CHARGE

To get a better understanding of the phenomena which occur during switching it is useful to refer to the model of the POWER MOSFET shown in figure 3. The fig. 3a shows a cross section of a single cell illustrating the parasitic capacitances.

These capacitances correspond to the capacitances quoted in the POWER MOS databook as follows:

$$C_{iss} = C1 + (C2 \cdot C4)/(C2 + C4) + (C3 \cdot C5)/(C3 + C5)$$

$$C_{rss} = (C3 \cdot C5)/(C3 + C5)$$

$$C_{oss} = (C3 \cdot C5)/(C3 + C5) + C6$$

If we take into account the actual test conditions ( $V_{GS} = 0$ ,  $f = 1\text{MHz}$ ,  $V_{DS} = 25\text{V}$ ) the above equations are well approximated as follows:

$$C_{iss} = C1 + C2 + C5$$

$$C_{rss} = C5$$

$$C_{oss} = C5 + C6$$

This approximation is correct since  $C2 \ll C4$  and  $C5 \ll C3$ .

During the switching phase the value of these capacitances change as a function of  $V_{GS}$  and this approximation no longer holds.

Fig. 3 - Simplified cross section of a POWER MOSFET cell (a) and its electrical equivalent (b).

Fig. 3a

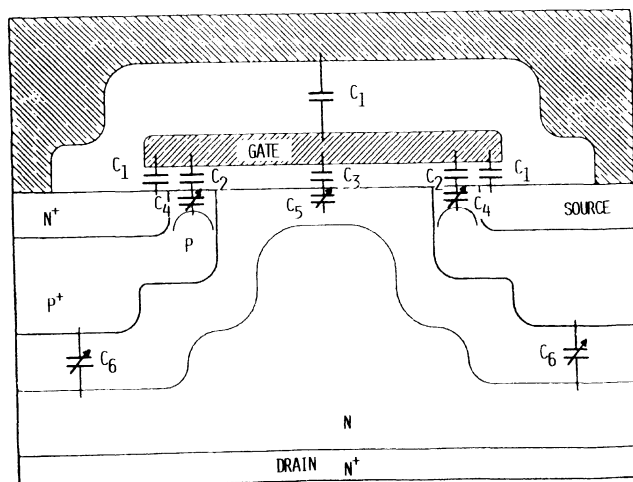
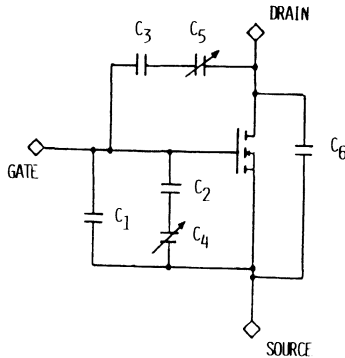


Fig. 3b)



- $C_1$  : Capacitance between gate and source (both  $N^+$  and metal)
- $C_2$  : Capacitance between gate and P zone.
- $C_3$  : Capacitance between gate and epi N.
- $C_4$  : Capacitance of the channel depletion zone.
- $C_5$  : Capacitance of the depletion zone in the superficial epi.
- $C_6$  : Capacitance of the body-drain junction.

Referring to figure 4 and 5 and distinguishing the load line during turn-on we can identify the following phases:

0: the device is off ( $I_D = i$  leakage,  $V_{DS} = V_{DD}$ )

and the capacitances  $C_{GS}$  and  $C_{GD}$  are respectively equal to  $C_{iss}$  and  $C_{rss}$  measured with  $V_{DS} = V_{DD}$ .

0 → 1: the gate voltage reaches  $V_{TH}$  by charging  $C_{GS}$  from  $(C_1 + C_2 + C_5)$  to  $(C_1 + C_4 + C_5)$ .

Fig. 4 - Load line during turn-on

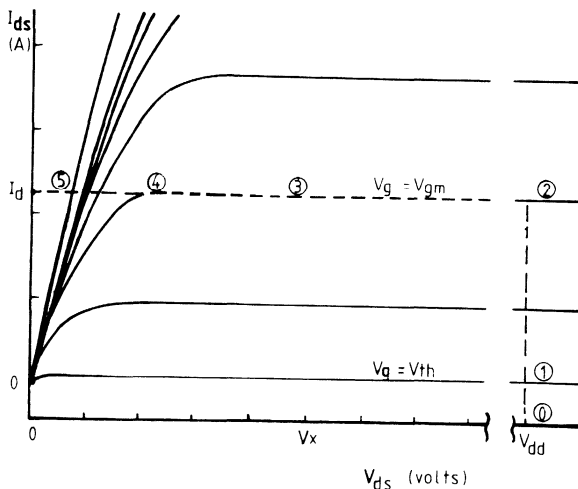
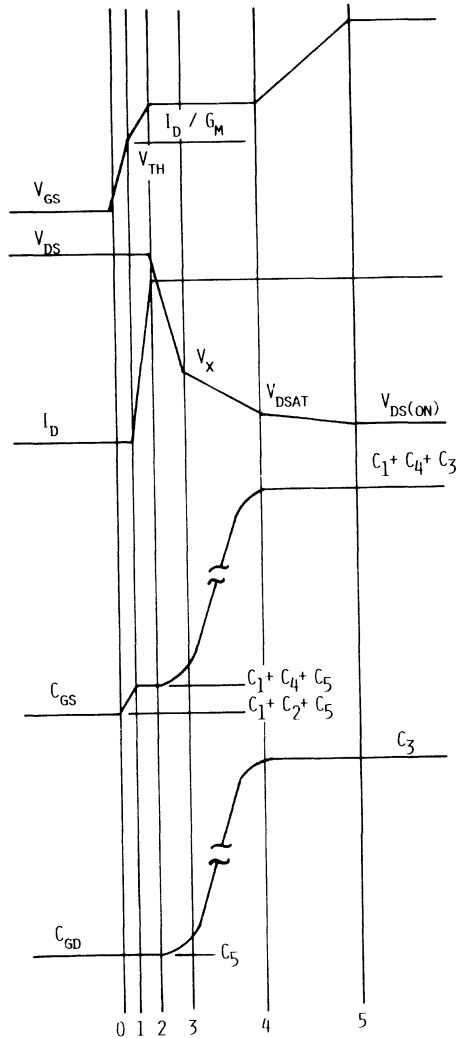


Fig. 5 - Switching waveforms and capacitance modulation



The total increase, is due to modulation of the depletion layer between the body and drain close to the channel. This is caused by the small drain current flowing when the gate voltage is near to  $V_{TH}$ . The variation is about 10%.

1 → 2: in this phase  $C_{GS}$  and  $C_{GD}$  are almost constant.  $V_{DS}$  is clamped to  $V_{DD}$  by the diode until  $I_{DS}$

reaches its final value. In this phase the device exhibits typical pentode characteristics (see figure 4) with  $V_{DS}$  constant.

During this phase, modulation of the depletion zone is due solely to the increasing drain current.

Figure 6a shows how the current flux spreads inside the drain.

Fig. 6a - Depletion layer and current distribution for a POWER MOSFET in the pentode region

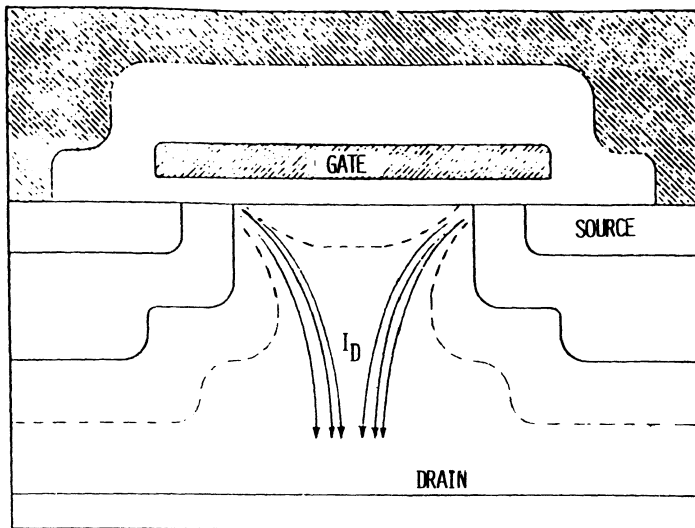
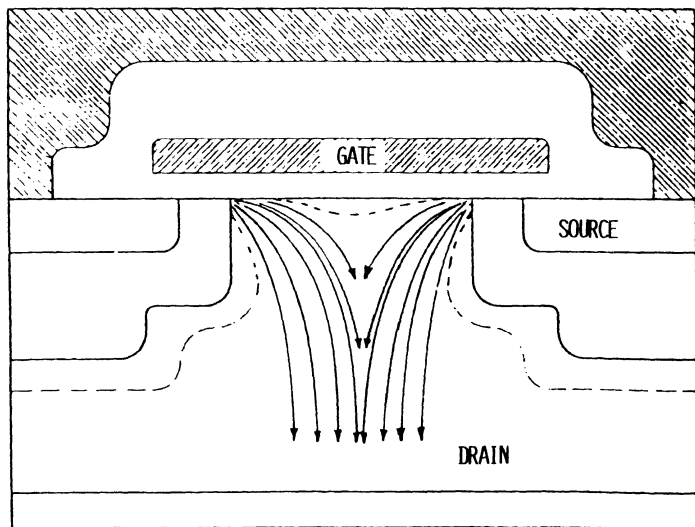


Fig. 6b - Depletion layer and current distribution for a POWER MOSFET in the linear region



The gate voltage, starting from the  $V_{TH}$ , reaches the value  $V_G = V_{TH} + I_D/G_M$ , where  $G_M$  is the large signal transconductance.

The variation of the gate voltage slope, due to the high current density under the gate region in the N zone is in reality much less pronounced than that shown in figure 5.

The actual increase of the capacitance, both during the first and second phase, due to this modulation effect, happens gradually and is more evident near the threshold voltage.

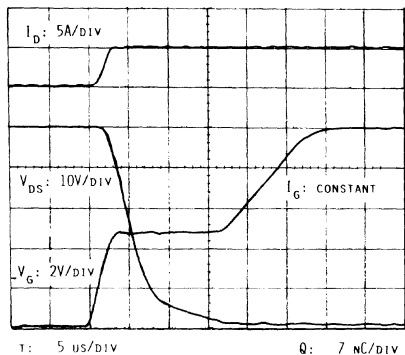
Since, in these two phases, the average increase of the capacitance has been evaluated as about 10%, the charge supplied to the gate can be approximated using the following equation:

$$Q1 + Q2 = 1.1 \cdot C_{ISS} \cdot (V_{TH} + I_D/G_M)$$

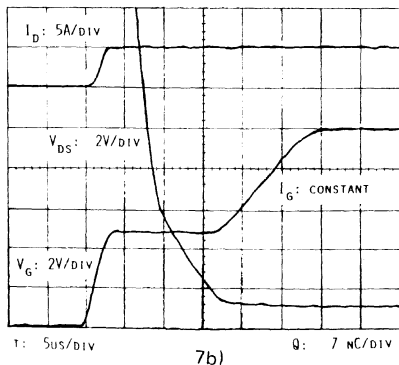
2 → 4: during this phase the drain voltage decreases, with consequent modulation of the depletion zone and increase in capacitance of C5.

**Figs. 7a) and 7b) -  $V_G$ ,  $I_D$ ,  $V_{DS}$  waveforms for SGSP362**

SGSP362 at 50V 5A



SGSP362 at 50V 5A



This phenomenon, known as the Miller effect, has a specific action on the gate voltage. As charge is supplied to the gate, the voltage remains constant, the capacitance appearing to be infinite during this phase. Also  $V_{DS}$  has two different slopes; first there is little variation in C5, therefore of both  $C_{GS}$  and  $C_{GD}$ , and second, the variation in C5 is very high.

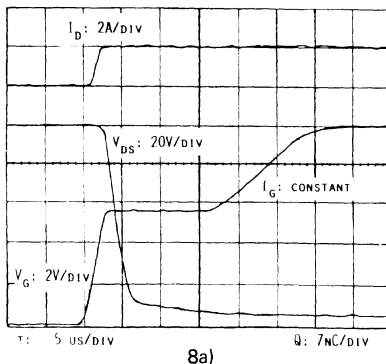
The variation of C5 as a function of  $V_{DS}$  is typical of a MOSFET structure. The only difference is due to the fact that modulation of the depletion zone is caused not only by the voltage but also by lateral injection of the charges coming from the channel.

At the end of this transition  $C_{GD}$  will have the value of C3 and consequently  $C_{GS}$  the value ( $C1 + C4 + C3$ ).

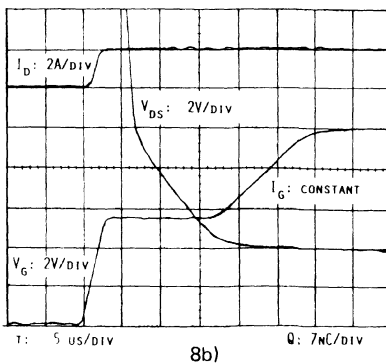
The drain voltage, on the slope, is indicated as  $V_X$ , in figure 4.

**Figs. 8a) and 8b) -  $V_G$ ,  $I_D$ ,  $V_{DS}$  waveforms for SGSP369**

SGSP369 at 100V 2A



SGSP369 at 100V 2A



Physically this point indicates the transition from a highly charged P zone to simple depletion of the MOSFET capacitor that exists between the deep body cells. We can state:

$$V_X = V_{TH} + V_{TH-epi} + (R_{epi} \cdot I_D)$$

Figure 7a/7b and 8a/8b show test measurements carried out on both low and high voltage POWER MOSFET devices.

At the end of this phase  $V_{DS}$  has reached  $V_{D sat}$ . This is illustrated in figure 5 and figure 6b.

The charge supplied to the gate is:

$$Q3 = 1.1 \cdot C_{rss} \cdot (V_{DD} - V_X)$$

$$Q4 = C3 \cdot (V_X - V_{D sat})$$

Where Q3 and Q4 are the transitions across phase 3 and phase 4 respectively.

The coefficient introduced in the formula for Q3 is derived as follows:  $V_{DS}$ , starting at  $V_{DD}$  reaches  $V_X$ ;  $C_{rss}$  undergoes a slight variation (as described earlier). This variation has been evaluated as about 10% to 15%.

4 → 5: as soon as the Miller effect finishes, the gate voltage can increase again and reach its final value. The rate of this increase is controlled by  $C_{GS}$  where  $C_{GS} = C1 + (C4 + dC4) + C3$ , a constant from this point on.

Referring to figure 4 again,  $I_D$  crosses the characteristic curves, as  $I_D$  is constant, until  $V_{DS on}$  is reached. The charge supplied during the final phase is:

$$Q5 = (C1 + C3 + dC4) \cdot (V_{G max} - V_{TH} - I_D/G_M)$$

The total charge supplied to the gate during turn-on can now be derived from the sum of the single contributions of the five phases:

## EFFECTS OF THE PHYSICAL AND ELECTRICAL PARAMETERS ON $Q_{tot}$

The previous discussion has shown that the total charge supplied to the gate is influenced by several parameters, which are essentially:

- electrical parameters ( $V_{DD}$ ,  $I_D$ ,  $V_{G max}$ )
- structural parameters (capacitances,  $V_{TH}$ ,  $G_M$ ,  $V_{D sat}$ ).

The electrical parameters are imposed by the external circuit and depend on the application; the structural parameters are typical of the device and can be adjusted during the device design stage in order to optimise its performance.

Figure 9 shows the influence of  $I_D$  and  $V_{DD}$  on the shape of the gate charge curve. Figure 10 and 11 show the influence of the capacitances and the transconductance,  $G_M$  on the same curve.

The following discussion shows the consequence of varying a single parameter, on the perfor-

mance of the device.

Fig. 9 - Gate charge curves as a function on  $I_D$  and  $V_{DD}$

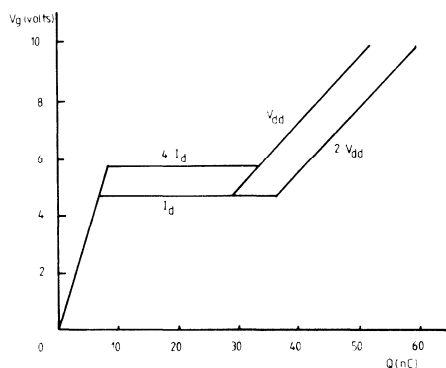


Fig. 10 - Gate charge curves as a function  $C_r$  and  $G_M$

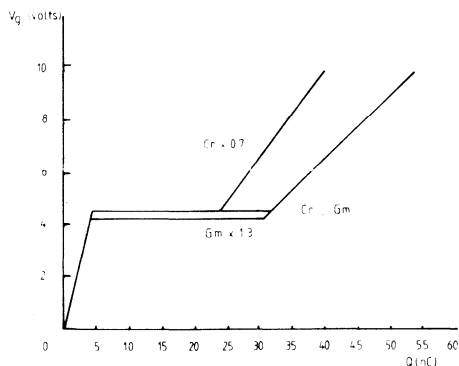
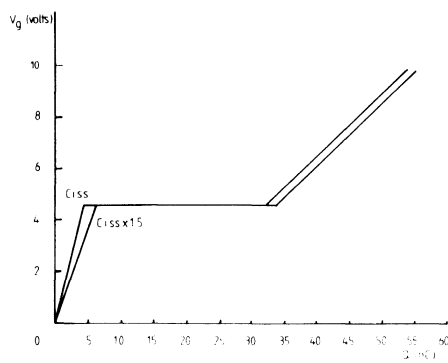


Fig. 11 - Gate charge curves as a function of  $C_{iss}$



The horizontal axes of these graphs are in nano-coulombs ( $Q = I_G \cdot t$ ,  $I_G = \text{const.}$ ) while the vertical axes are in volts.

- the area under the gate-charge curve represents the driving energy of the device,  $E_p$ :

$$E_p = \int V_G(Q) \cdot dQ$$

- the energy lost during the cross-over period determined by measuring  $t_{rise}$  and  $t_{fall}$ , is proportional to the amplitude and length of the 'flat' region - (Miller), of the gate charge curve.

From these figures it can easily be seen than in order to obtain fast switching, and low energy dissipation during the cross-over, the optimum device should have:

- LOW  $C_{rss}$
- HIGH  $G_M$
- LOW  $C_{iss}$

$C_{iss}$  has less influence in comparison to  $C_{rss}$  and  $G_M$ . Consider two different devices showing the same characteristic but the  $C_{iss}$ ,  $G_M$  and  $C_{rss}$  with:

$$\begin{aligned} C_{iss2} &= 2 \cdot C_{iss1} \\ G_{M2} &= 1.3 \cdot G_{M1} \\ C_{rss2} &= 0.7 \cdot C_{rss1} \end{aligned}$$

figure 12 shows that device 2, despite higher input capacitances, shows better behaviour regarding both the switching times and the driving energy.

A merit coefficient commonly used to give a "measure" of performance is:

$$K = G_M/C_{rss}$$

Increasing this coefficient can be achieved at the design stage, by optimising the perimeter of the channel,  $W$ . This has the effect of increasing  $G_M$  ( $G_M$  is proportional to  $W/L$ ).  $C_{rss}$  can be decreased by reducing the overlap area between gate and

drain and by adjusting the doping of the epitaxial layer.

This latter solution, if we take into account that the doping in the epitaxial layer is controlled by the required  $BV_{DSS}$ , would require an epitaxial growth with a variable doping profile which decreases near the surface.

This would cause a slight increase in the accumulation resistance, which would require characterising.

The feasible solution is to decrease the inter cell distance; in this way, for the same active area, a greater channel perimeter and a smaller overlap area is obtained.

Figure 13 illustrates this by depicting  $K$ , for devices having the same chip-size, as a function of  $BV_{DSS}$  (N epi); the same figure shows the gain obtained for devices having greater cell density.

Fig. 12 - Comparison of gate charge curves of two devices with different values, of  $C_{iss}$ ,  $G_M$  and  $C_{rss}$

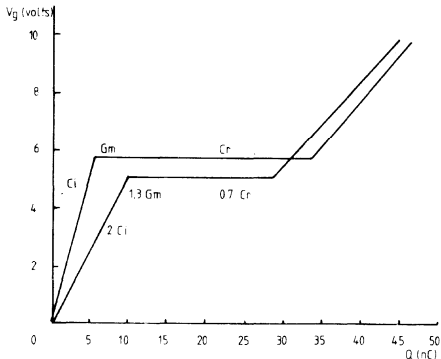
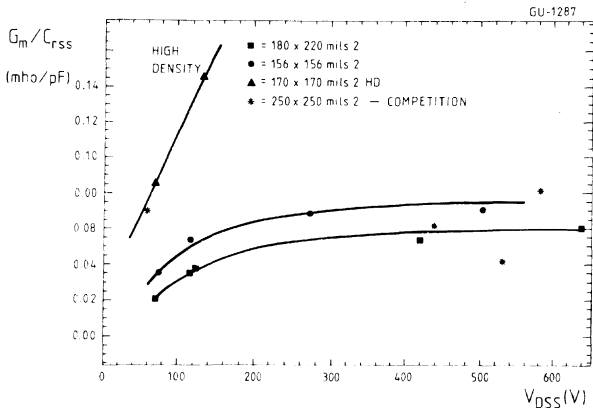


Fig. 13 -  $G_M/C_{rss}$  ratio vs breakdown





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## CONCLUSION

The gate charge curve supplies useful information about the actual behaviour when the device switches.

From the users point of view, these curves allow the correct design of the drive circuit and correct choice of the device which best satisfies the design criteria.

The use of a simulation of this model allows designers to evaluate the consequences of varying one or more of the parameters of the final characteristics of the devices.

Further research is being carried out to solve the problem caused when the capacitance is modulated by the injection of charge due to the drain current.



## COMPARISON OF POWER MOS AND BIPOLAR POWER TRANSISTORS

It is highly predictable that in the near future POWER MOS will, in many applications, gradually replace power bipolar devices due to the numerous advantages they offer.

Table 1 lists the principal differences between

POWER MOS and bipolar transistors. In addition to their inherent high switching speed resulting from the lack of minority carrier injection during operation, POWER MOS with their insulated gates require negligible input gate-drive current. Other

| MOS                                                                                                 | BIPOLAR                                                                                                        |
|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Majority-carrier device                                                                             | Minority-carrier device                                                                                        |
| No charge-storage effects                                                                           | Charge stored in the base and collector                                                                        |
| High switching speeds less temperature sensitive than bipolar devices                               | Low switching speed temperature sensitive                                                                      |
| Drift current (fast process)                                                                        | Diffusion current (slow process)                                                                               |
| Voltage driven                                                                                      | Current driven                                                                                                 |
| Purely capacitive input impedance; no dc current required                                           | Low input impedance; dc current required                                                                       |
| Simple drive circuitry                                                                              | Complex drive circuitry (resulting from high base-current requirements)                                        |
| Predominantly negative temperature coefficient on resistance                                        | Positive temperature coefficient of collector current                                                          |
| No Thermal runaway                                                                                  | Thermal runaway                                                                                                |
| Devices can be paralleled with some precautions                                                     | Devices cannot be easily paralleled because of $V_{BE}$ matching problems and local current concentration      |
| Less susceptible to second breakdown                                                                | Susceptible to second breakdown                                                                                |
| Square-law I-V characteristics at low current; linear I-V features at high current                  | Exponential I-V characteristics                                                                                |
| Greater linear operating and fewer harmonics                                                        | More intermodulation and cross-modulation products                                                             |
| High-on resistance and, therefore, larger conduction loss                                           | Low on-resistance (low saturation voltage) because of conductivity modulation of high resistivity drift region |
| Drain current proportional to channel width                                                         | Collector current approximately proportional to emitter stripe length and area                                 |
| Low transconductance                                                                                | High transconductance                                                                                          |
| High breakdown voltage as the result of a lightly doped region of a channel-drain blocking junction | High breakdown voltage as the result of a lightly doped region of a base collector blocking junction           |

advantages are related to the negative temperature coefficient of their current, which prevents the formation of thermal instabilities and makes the paralleling of devices much more reliable. In contrast, bipolar transistors require ballasting or careful device matching to prevent thermal runaway.

Only in high voltage cases is POWER MOS on-resistance higher than in bipolar transistors.

This leads to slightly larger steady state power dissipation and could offset the advantages.

## PERFORMANCE COMPARISON

At this point a comparison between POWER MOS and bipolar devices can be made in order to evaluate their switching speeds which give an indication of the energy consumption during transitions, and their different values of  $V_{DS(on)}$  and  $V_{CE sat}$  related to energy consumption during the on state. The two devices used in the comparison are:

SGSP565: POWER MOS; 400V; 6A  
 $R_{RD(on)} = 1\Omega$

SGSD00036: BIPOLAR; 400V; 6A (very fast switching)

$$V_{DD}/V_{CC} = 200V$$

$$I_L = 5A \text{ (average value)}$$

Since the input losses were neglected the bipolar devices have an advantages in this comparison.

$E_{TOT}$  (the energy losses per cycle) as a function of the operation frequency, for different values of the duty cycle can be seen in fig. 1. For a bipolar device, the energy used during the on phase has only a slight influence with frequency variation. POWER MOS however are influenced by these variations, and as a result two curves, relative to the same duty cycle, are obtained. The intersecting points of these curves can be considered as a guideline to the use of the devices.

In other words if both the duty cycle and the power to be switched are fixed there is a frequency value above which the dissipated energy per cycle for an POWER MOS transistor is less than for a bipolar device. This means the higher the frequency the more advantageous it is to use a POWER MOS.

Under relatively low frequency conditions the value of the duty cycle "d" is fundamental in determining the advantages of both bipolar and POWER MOS technologies. From the graph in Fig. 2 the best working condition for both devices can be seen.

Fig. 1 -  $E_{TOT}$  versus frequency (kHz)

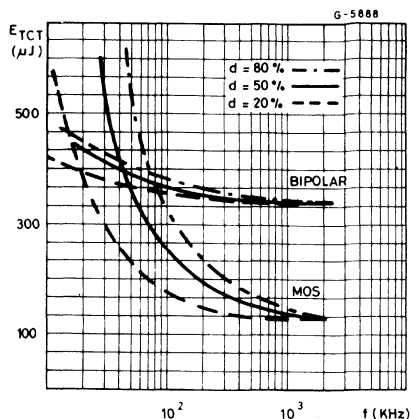
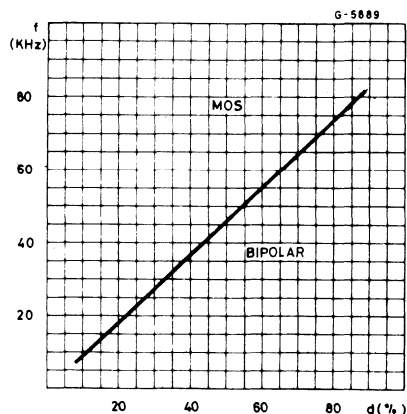


Fig. 2



A POWER MOS is most suited to high frequency conditions ( $> 100$  kHz) for any given value of "d". Maximum frequency limitations are of a thermal nature only and depend on the die size.

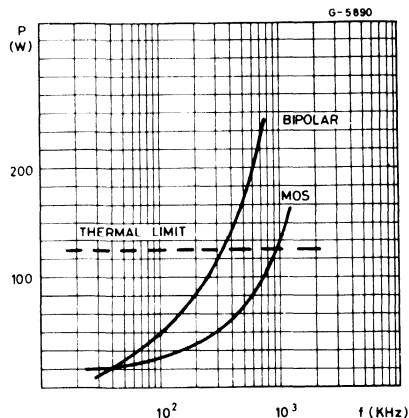
For the POWER MOS under consideration the maximum power dissipated is 100W when  $R_{thj-case} = 1^\circ C/W$  and  $T_{j max} = 150^\circ C$ .

By plotting the power dissipated as a function of the frequency, when  $d = 50\%$  the actual limits of the two technologies can be seen (Fig. 3).

## THERMAL STABILITY

The greater thermal stability of SGS-THOMSON POWER MOS with respect to bipolar devices is essentially due to the different response that the two

Fig. 3



devices exhibit when they are subjected to external power pulses.

The intrinsic mechanism which could lead to thermal runaway in bipolar and in a POWER MOS device, are as follows.

In a bipolar an external power pulse results in an increase in the junction temperature ( $T_j$ ).

This causes the collector current to increase and this consequently further increases  $T_j$ . This positive feedback is compensated only by the base widening effect at high currents (that is a higher recombination of the minority carriers). At high voltages the base widening effect is not present so that any hot spots lead to thermal runaway.

These phenomena, if not controlled, could seriously damage a bipolar device.

A power pulse in a POWER MOS device would cause:

- 1) an increase in temperature of the device
- 2) a decrease in the threshold voltage

$$V_{GS(th)} = V_{GS(th)}(25^\circ\text{C}) \times (1 - \alpha [(T_j - 25^\circ\text{C})])$$

where alpha is a positive coefficient of temperature ( $\alpha = 2 \cdot 10^{-3}$ ).

This is positive feedback and similar to a decrease of  $V_{BE}$  in bipolar devices.

But in a POWER MOS device there is also a very important negative feedback. That is an increase of  $R_{DS(on)}$  with temperature:

$$R_{DS(on)}(T) = R_{DS(on)}(25^\circ\text{C}) \times [1 + \alpha (T - 25^\circ\text{C})]$$

where alpha is the temperature coefficient (alpha

$= 8 \cdot 10^{-3}^\circ\text{C}^{-1}$ ). The effect of a increase in  $R_{DS(on)}$  is greater than the variation in  $V_{GS(th)}$ . As a result POWER MOS devices are thermally stable. The difference in behaviour of the two devices is even more exaggerated when dealing with paralleled chips.

Two comparisons between bipolar and SGS-THOMSON POWER MOS devices have been made.

The first deals with the behaviour of single chips in SOT-93 (TO-218) package.

The SGS POWER MOS used in this test is the SGSP475 (400V, 12A, 0,55 $\Omega$ ).

The power bipolar device used in the BUV48 (400A, 10A).

The parameter used to measure the thermal unbalance of the devices is the variation of the thermal resistance  $R_{thj-case}$  due to an external power pulse.

In fact an increase of  $R_{thj-case}$  implies a decrease of the active area of the chip and therefore a disuniformity in the spreading of the heat, with a creation of hot spot and thermal and electrical unbalancing. The devices have been tested under several conditions, with respect to the power dissipation and the voltage across them ( $V_{DS}$  for SGSP471,  $V_{CE}$  for BUV48). The results are shown in Fig. 4 and Fig. 5).

SGSP475 shows optimum thermal stability under all conditions while bipolars, with  $V_{CE} = 45\text{V}$  and  $P > 45\text{W}$ , show a degrading of the thermal performances.

The best electrical and thermal performance of the SGS-THOMSON POWER MOS are confirmed by the thermal maps which show a uniform distribution of heat under different working conditions (Fig. 6 and 7).

Fig. 4 - Variation of  $R_{thj-case}$  vs. P (POWER MOS) SGSP475 SOT-93

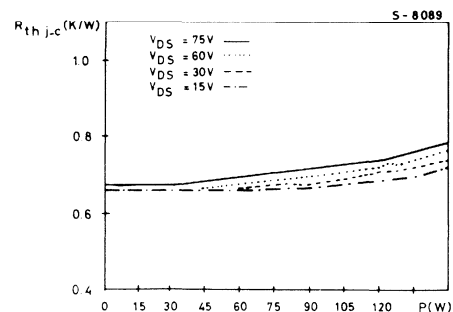


Fig. 5 - Variation of  $R_{thj-case}$  vs.  $P$  (BIPOLAR)  
BUV48 SOT-93.

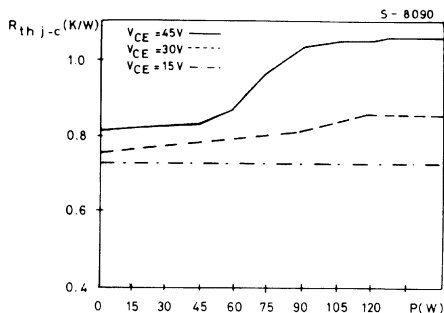


Fig. 6

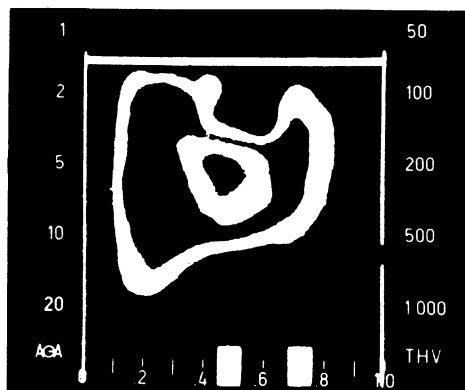
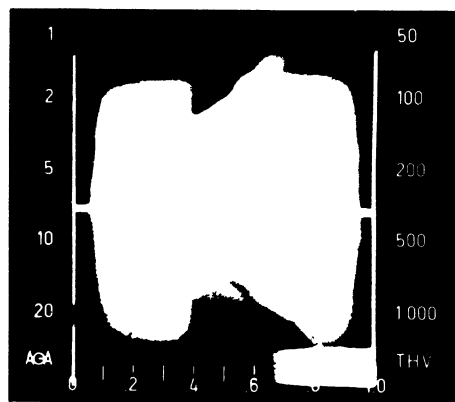


Fig. 7



It is only at  $V_{DS} = 75V$  that it is possible to notice a slight variation in the working temperature.

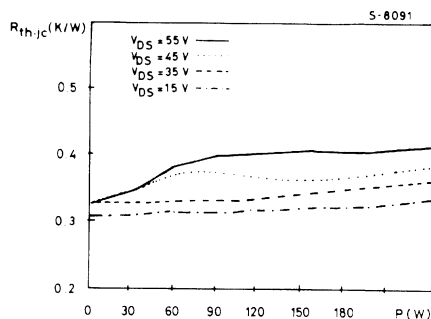
The thermal instability has a greater effect when the die are assembled in parallel since any unconformity would be enhanced leading to an overloading of some of the die.

The second thermal comparison was made between SGS-THOMSON POWER MOS and bipolar devices in multiple chips mounted in a parallel configuration.

The SGS-THOMSON POWER MOS device under test was:

SGS30MA050D1: four POWER MOS chips paralleled in TO-240 a package  $I_{Dmax} = 30A$ ,  $V_{DSS} = 500V$ ,  $R_{DS(on)} = 0.250\Omega$

Fig. 8 - Variation of  $T_{thj-case}$  vs.  $P$  (POWER MOS)  
SGS30M050D TO-240

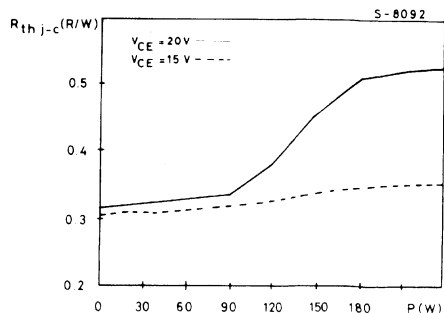


The bipolar device under test was:

SGS40TA045D: four bipolar chips paralleled in TO-240 package  $I_C = 40A$ ,  $V_{CEO} = 450V$

The results are shown in Fig. 8 and 9 and reveal a much better thermal stability for the POWER MOS than for the bipolar device.

Fig. 9 - Variation of  $R_{thj-case}$  vs.  $P$  (BIPOLAR)  
SGS400T045D TO-240



## A BRIEF LOOK AT STATIC $dV/dt$ IN POWER MOSFETS

### INTRODUCTION

The normal safe operating area of POWER MOSFETS may be insufficient when used in very fast switching circuits, such as those required in SMPS push-pull applications. When there is a high slew rate between the drain and the source of a POWER MOSFET, it may go into breakdown at a voltage less than its breakdown voltage,  $V_{(BR)DSS}$ , due to the spurious turn on of its parasitic bipolar transistor. This in turn could damage its internal structure or cause a malfunction of the circuitry.

The critical values of  $dV/dt$  may vary with the operating conditions of the POWER MOSFET device used; when it is under stress and completely inactive, (static  $dV/dt$ ) or when its intrinsic diode is conducting (dynamic  $dV/dt$ ). This note discusses the safe operating conditions for POWER MOSFET transistors that experience static  $dV/dt$  stress.

The explanation of the measurement circuit describes the difficulty in attaining the value of destructive  $dV/dt$ .

### STATIC $dV/dt$ TURN-ON

Figures 1 and 2 show the simplified equivalent circuit for a POWER MOSFET when a high slew rate exists between the drain and the source. POWER MOSFETS initially in the off state, conduct in two different ways due to  $dV/dt$ :

- by spurious turn-on of the POWER MOSFET
- by spurious turn-on of the parastatic bipolar transistor.

Fig. 1 - Simplified electrical behaviour of POWER MOSFETS under the effect of  $dV/dt$

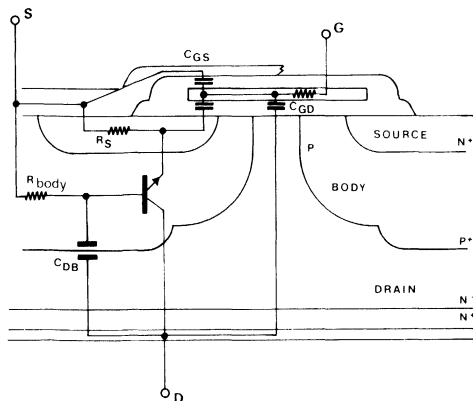


Fig. 2 - Simplified equivalent circuit

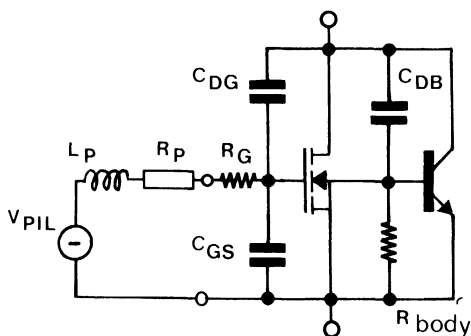


Figure 3 shows the equivalent circuit for conduction by spurious turn-on of the POWER MOSFET. Figure 4 shows current waveforms generated by a fast voltage variation across the POWER MOSFET capacitance. The current pulse passing through the external impedance ( $Z_{gs}$ ),

positioned between the gate and source (driving impedance), creates a voltage pulse. If this voltage pulse reaches the threshold voltage the POWER MOSFET switches on. This type of switching thrives on a high input impedance,  $Z_{gs}$ , but is not normally destructive.

Fig. 3 - Equivalent circuit for conduction by spurious turn-on of POWER MOSFETS

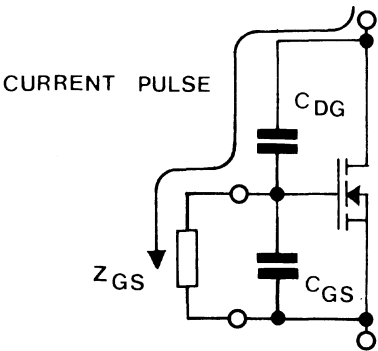
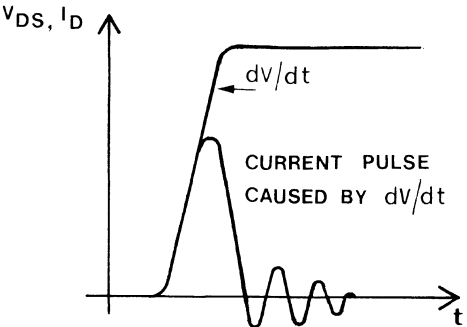


Fig. 4 - Equivalent waveforms for the fast voltage variation across the POWER MOSFET capacitances.



The equivalent circuit for conduction by spurious turn-on of the parasitic transistor, is shown in figure 5. A current pulse passes through the capacitance  $C_{DB}$  and the body. If the voltage drop across the body resistance rises above 0.65V, the body source junction is polarized, this produces current injection in the base of the parasitic transistor which consequently turns on. If  $V_{DS}$  is

more than the breakdown voltage of the parasitic transistor, avalanche breakdown occurs. If the current,  $I_D$ , is not limited externally the device may be destroyed. Unlike the first mechanism the critical value of  $dV/dt$  depends only on the structure of the device ( $R_{body}$ ,  $C_{DB}$  and the resistance between the base and the emitter of the parasitic transistor).

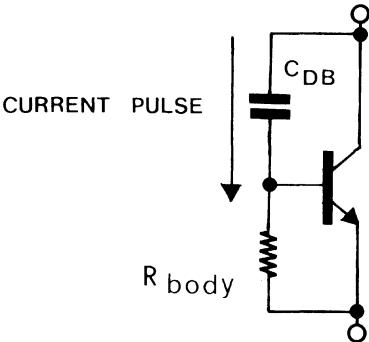


Fig. 5 - Equivalent circuit for conduction by spurious turn-on of the parasitic transistor



This type of conduction may be destructive, depending on the value of the supply voltage,  $V_{DS}$ , applied and the collector-emitter breakdown,  $V_{CEX}$ , of the parasitic transistor. This value is between  $V_{(BR)DSS}/2$  and  $V_{(BR)DSS}$ .

In SGS-THOMSON POWER MOSFETs  $V_{CEX}$  is near  $V_{(BR)DSS}$ , thanks to a large reduction of the emitter-base resistance of the parasitic transistor (body and source in short circuit).

## Measurement Circuit

The circuit in fig. 6a is a hypothetical application where a POWER MOSFET could be stressed by static  $dV/dt$ . The POWER MOSFETs  $P_1$ ,  $P_2$  conduct alternately, and apply the voltage  $+V_{DD}/2$  and  $-V_{DD}/2$  on the transformer. During switching between  $P_1$  and  $P_2$  there is always a period in which one of the POWER MOSFETs is turned off. The load is therefore fed with AC.

Fig. 6a - Typical application where DMOS can be stressed in static  $dV/dt$

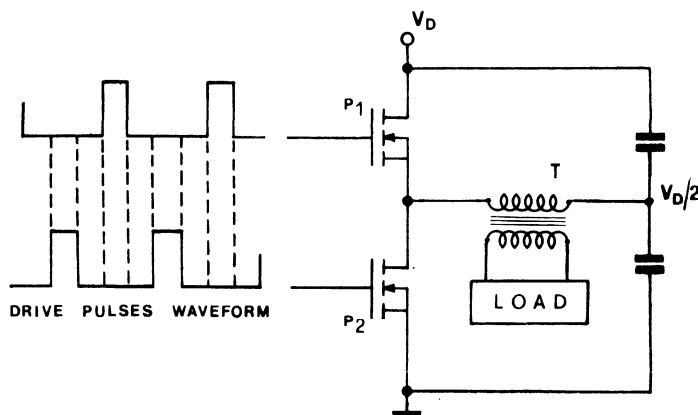
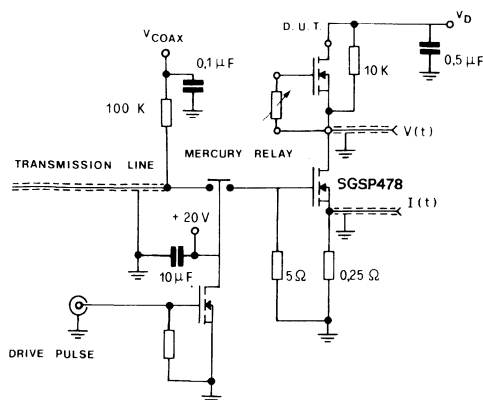


Fig. 6b - Test circuit for POWER MOSFETs stressed by static  $dV/dt$



The  $dV/dt$  stress occurs when, for example,  $P_2$  turns on and the source of  $P_1$  decreases from the voltage  $V_D$  to zero with a speed equal to the switching speed of  $P_2$ .

The turn-on of the parasitic transistor occurs when the switching times are in the range of 3-5ns. This switching speed was obtained using the circuit in figure 6b where the active POWER MOSFET is driven by a low impedance pulse generator.

The pulse generator consists of a transmission line with a characteristic impedance of 5 ohm, which during the turn-on of the mercury relay creates a voltage waveform on the gate of the active POWER MOSFET. A mercury relay is used to obtain very steep edges. The transmission line consists of 10 coaxial cables in parallel with a characteristic impedance of 50ohm and infinite impedance load. Each cable is 6m. long in order to generate a pulse lasting about 50ns.

All the connections were made in order to reduce to a minimum the inductance and the parasitic capacitance.

Acting on the load voltage ( $V_{COAX}$ ) of the transmission lines the switching speed of the POWER MOSFET varies until it reaches the critical value of  $dV/dt$ ; all the values measured are shown on the graph in fig. 7.

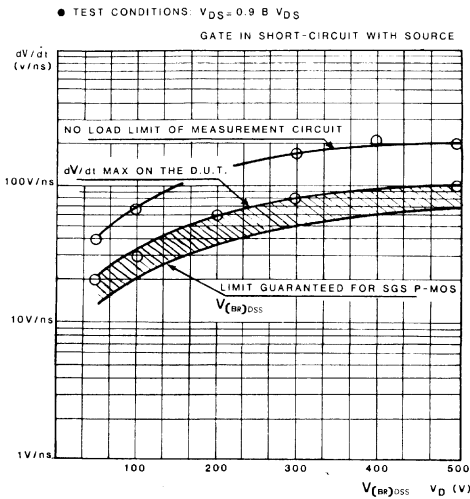


Fig. 7 -  $dV/dt$  for the test circuit with and without a POWER MOSFET load and limit guaranteed for POWER MOSFET versus breakdown voltage

## TEST WITH GATE & SOURCE SHORT CIRCUITED

The measurement conditions of all the devices are:

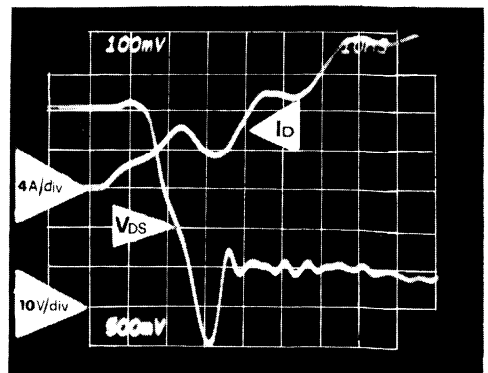
- a)  $Z_{GS} = 0$
- b)  $V_{DS} = 0.9 V_{(BR) DSS}$
- c) DUT = turned-off

The gate is short circuited to the source in order to switch-on only one of the parasitic bipolar transistors.

The maximum value of  $dV/dt$  reached when the DUT is connected in the circuit is shown by the upper limit of the shaded part of the graph in fig. 7. The part below it represents the safety limit of the SGS-THOMSON device.

Photograph 1 shows the voltage-current waveforms for SGSP221 when it switches on its parasitic transistor. In this case the device is not destroyed, as the  $V_{DS}$  is limited to a voltage of 40V, when  $V_{(BR)DSS}$  of the POWER MOSFETs is 65V.

Photo 1 - Drain current and voltage waveforms for SGSP221 on turn of its parasitic transistor



$I_D = 10A/div.$ ;  $V_{DS} = 10V/div.$ ; 5 ns/div.

It must also be mentioned that the large drain current also circulates in the active POWER MOSFET and could destroy it. Photo 2 shows the

waveform of  $V_{DS}$ ,  $I_D$  for SGSP478 under a  $dV_{DS}/dt$  of 50V/ns.

Fig. 8 - Turn-on of the parasitic transistor on SGSP221

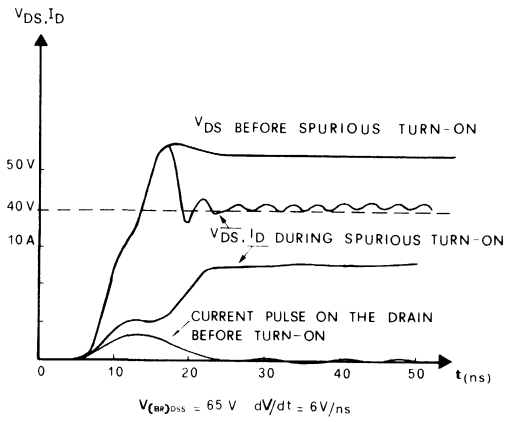
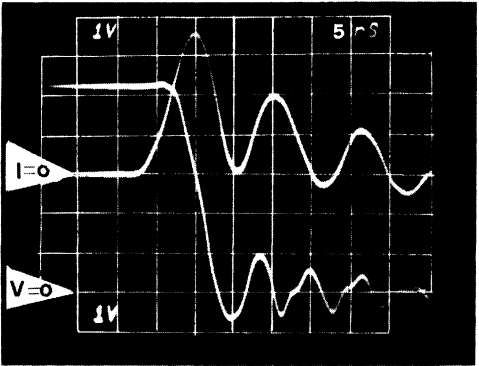


Photo 2 - Drain current and voltage waveforms for SGSP478



$V_{DS} = 100V/div.$   $I_D = 5A/div.$   $5ns/div.$

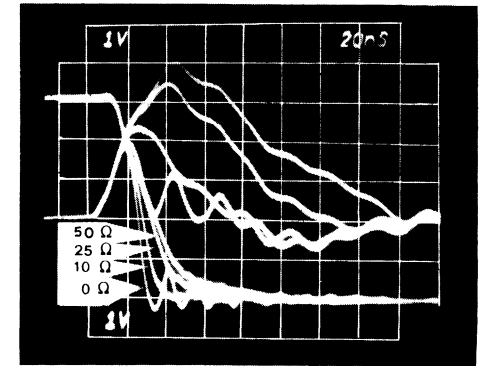
### TEST WITH GATE & SOURCE NOT IN SHORT CIRCUIT

Photos 3 and 4 show the  $V_{DS}$  voltage and  $I_D$  current waveforms for both SGSP478 and SGSP221 when the impedance  $Z_g$  between the gate and source varies, while maintaining the driving conditions of the active POWER MOSFET constant and at the maximum  $V_{DS}$ .

Photo 3 - Drain source voltage and drain current waveforms for SGSP478

With  $Z_g > 0$  the D.U.T. can conduct as in the case of spurious turn-on of the POWER MOSFET transistor.

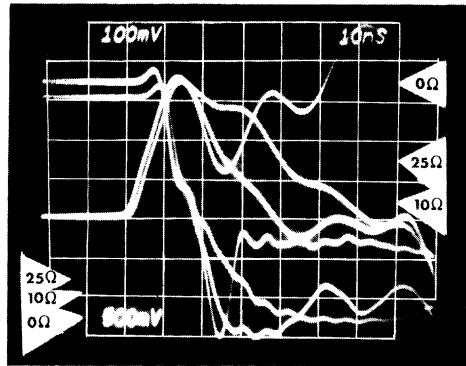
Conduction in POWER MOSFETS tends to limit the  $dV/dt$  which has caused the stray turn-on. Their switching time therefore increases and a large current passes during the transition, this avoids the turn-on of the parasitic transistor, due to the reduction of  $dV/dt$ , but unfortunately there is a large increase in the switching losses.



$V_{DS} = 100V/div.;$   $I_D = 8A/div.;$   $20ns/div.$

In photo 4 it can be seen that  $Z_g = 0$ , the parasitic transistor is turned on and that the insertion of  $Z_g = 10ohm$  eliminates this effect.

Photo 4 - Drain source voltage and drain current waveforms for SGSP221



$V_{DS} = 10V/div.; I_D = 4A/div.; 10ns/div.$

## CONCLUSION

It has been seen that a POWER MOSFET stressed by a very fast slew rate can cause malfunction in the circuit or even destroy the device because of:

- stray turn-on of the POWER MOSFET itself
- turn-on of the POWER MOSFET parasitic transistor.

The critical value of  $dV_{DS}/dt$  at the turn-on of the parasitic bipolar transistor does not depend on the external circuit, but on the structure of the POWER MOSFET. SGS-THOMSON POWER MOSFETs resist  $dV/dt$  stress due to optimization of their design (resistance between base and emitter of the bipolar transistor reduced to a minimum). The

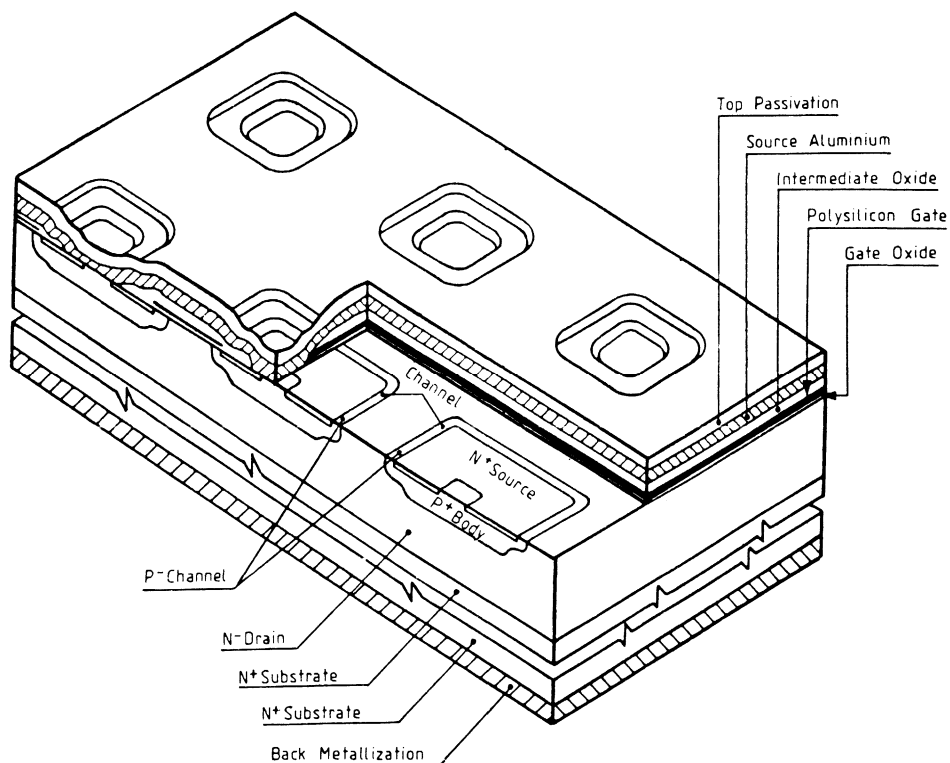
destructive values of  $dV_{DS}/dt$  are difficult to attain in practical applications, since they exist when switching times are in the order of 5ns.

The stray turn-on of POWER MOSFET can occur at lower values of  $dV_{DS}/dt$ . These values depend on the values of impedance between the gate and source. This type of conduction does not damage the POWER MOSFET but increases losses in switching. This can be avoided by:

- Limiting the switching speed
- Driving the POWER MOSFET with a low input impedance.

## HIGH DENSITY POWER MOSFETS

Fig. 1 - SGS POWER MOSFET structure



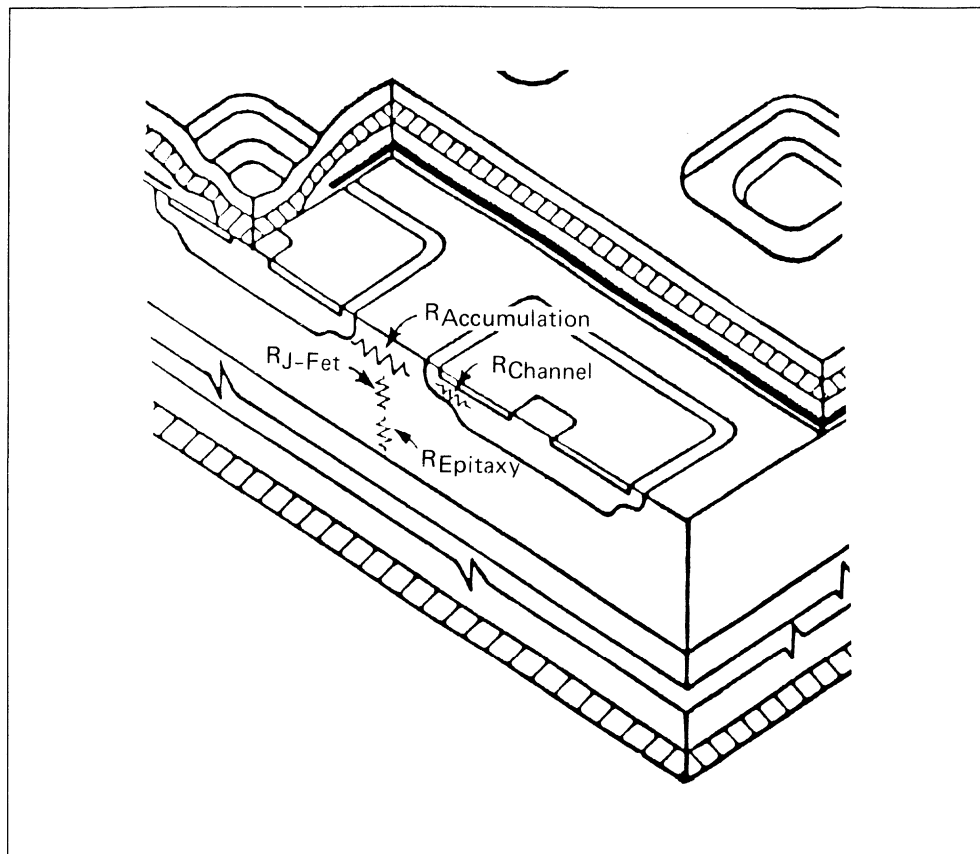
### INTRODUCTION

POWER MOSFET transistors are fabricated using VLSI technology. A simple chip contains thousands of identical cells. By optimising the geometry of the VLSI design it is possible to achieve HIGH DENSITY POWER MOSFET transistors. An increase in

cell density gives an improved operation together with a reduction of silicon area.

In order to fully appreciate high density POWER MOSFETS it is necessary to examine the factors controlling their output characteristics. Figure 2 shows the area associated with each resistive element contributing to the total on-resistance.

Fig. 2 - Resistive elements in SGS POWER MOSFETS structure



The on-resistance of a POWER MOSFET is made up of four separate terms:

$$R_{ON} = R_{CH} + R_{ACC} + R_{JFET} + R_{EPI}$$

where:  $R_{ON}$  = device on-resistance

$R_{CH}$  = channel resistance

$R_{ACC}$  = resistance of accumulated region

$R_{JFET}$  = junction FET resistance

$R_{EPI}$  = drain epitaxial layer resistance

$R_{CH}$ ,  $R_{ACC}$ , and  $R_{JF}$  depend primarily on the layout of the device.  $R_{EPI}$  depends on the structure of the drain.

Figures 3a and 3b show the relationship between the on resistance and the cell spacing for devices

with a 100V and 500V breakdown voltage respectively.

It can clearly be seen that there is an optimum cell spacing of about 12  $\mu\text{m}$  for low voltage devices and 30  $\mu\text{m}$  for high voltage. Moreover, in high voltage devices the resistance of the drain epitaxial layer is the most significant of the four terms. The most effective way of obtaining a lower  $R_{ON}$  is to make the higher  $V_{(BR)DSS}$  compatible with the drain resistivity. SGS-Thomson uses an edge termination structure that gives a breakdown voltage near the theoretical value.

For low voltage devices  $R_{ON}$  can be reduced by varying the channel and/or accumulation resistance.

Fig. 3 - Influence of the inter-cell spacing on the  $R_{DS(on)}$  elements

Fig. 3a - Low voltage case  $V_{(BR) DSS} = 100V$

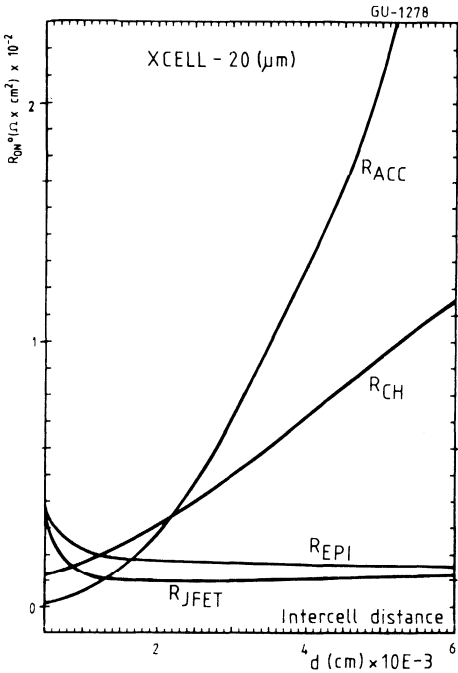
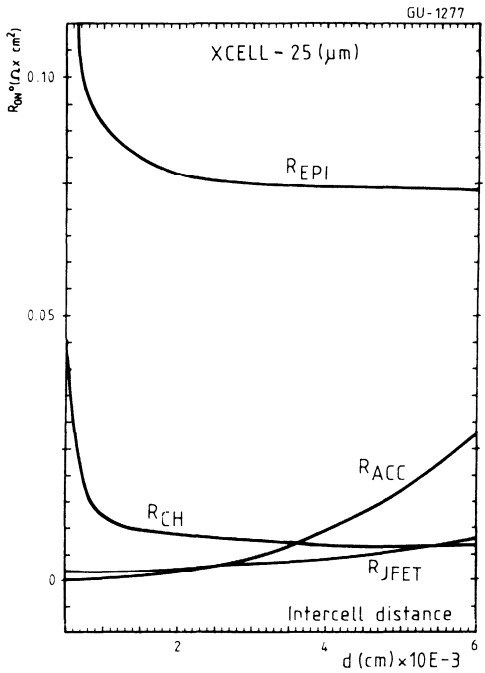


Fig. 3b - High voltage  $V_{(BR) DSS} = 500V$



From the expressions:

a)  $R_{CH} = \frac{L_{CH}}{\mu (V_G) \cdot W \cdot C_{OX} \cdot (V_G - V_T)}$

b)  $R_{ACC} = \frac{D/2}{3 \cdot \mu (V_G) \cdot W \cdot C_{OX} \cdot (V_G - V_{TACC})}$

where:  $\mu$  = carrier mobility  
 $W$  = channel perimeter  
 $L_{CH}$  = channel length  
 $C_{OX}$  = capacitance of oxide per area unit  
 $D$  = Inter-cell distance

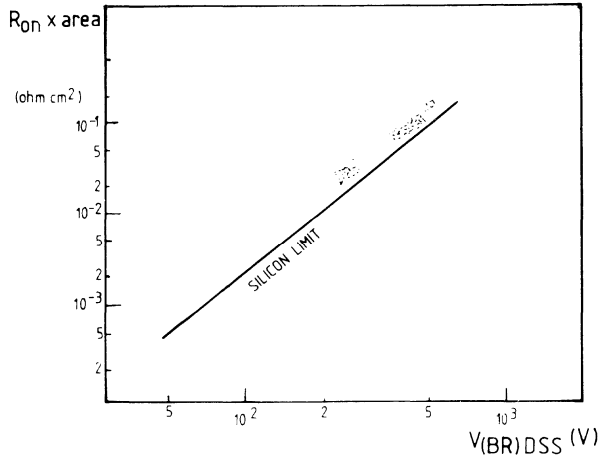
It follows that a reduction of dimensions  $L_{CH}$ ,  $D$ , and the increase of  $W$  leads to a large reduction of both  $R_{ON}$  for cell densities from 500K cells/inch sq. to 10 million cells/inch sq. for  $V_{(BR) DSS} = 60V$ .

Table 1

| Cell density<br>(N. Cells/inch.sq.) | $R_{CH}$ | $R_{ACC}$ | $R_{EPI}$ |
|-------------------------------------|----------|-----------|-----------|
| 558K                                | 18.5     | 11.8      | 0.144     |
| 1.333M                              | 11.9     | 4.9       | 0.125     |
| 3.82M                               | 2.7      | 1.9       | 0.107     |
| 10M                                 | 1.42     | 0.59      | 0.09      |

VLSI technology offers the possibility of fabricating these high cell densities.  
Fig. 4 shows on resistance per unit area for SGS-Thomson devices over a voltage range from 50V to 700V.  
The continuous line represents the theoretical limit of silicon, without conductivity modulation.  
For low voltage devices, where the divergence from the theoretical limit is the greatest, the performance can be improved by modifying the design rules of the horizontal geometry.

Fig. 4 -  $R_{DS(on)}$  vs. breakdown voltage



**SGS-Thomson STATE-OF-THE-ART**

SGS-Thomson uses a cell density of 558K cells/inch sq. in its standard low voltage technology. Recently, another technology with a cell density as high as 1.33 million cells/inch sq. been developed<sup>(1)</sup>, and devices are now in production.

For comparison between the two technologies fig. 5 and photos 1 and 2 show two devices with breakdown voltages of about 60V and an on-resistance of about 0.04 $\Omega$ , one with the standard cell and the

other the high density structure.

The chips in the device produced with the standard technology are 180 x 220 mils<sup>2</sup> in area; those produced with the new technology are 170 x 170 mils<sup>2</sup>.

There are both static and dynamic advantages to be gained from using high density devices. Their static characteristics such as  $R_{ON}$ , capacity, and their dynamic characteristics such as switching times, energy per cycle and gate charge are improved.

Photo 1 - SEM photo of high density POWER MOSFET - 1.33 million cells in<sup>2</sup>

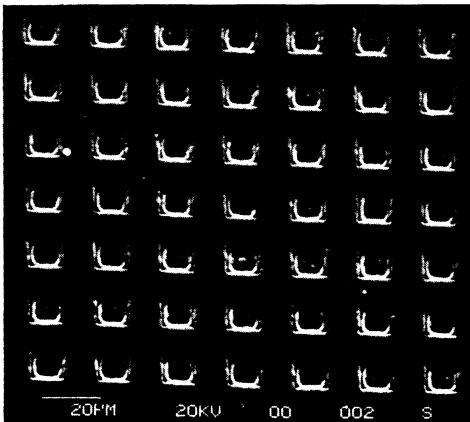
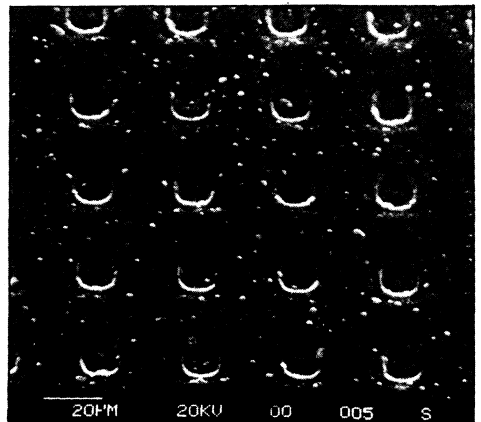


Photo 2 - SEM photo of standard POWER MOSFET - 550K cells in<sup>2</sup>



Note 1: See additional information on page 104



Fig. 5 - Dice comparison

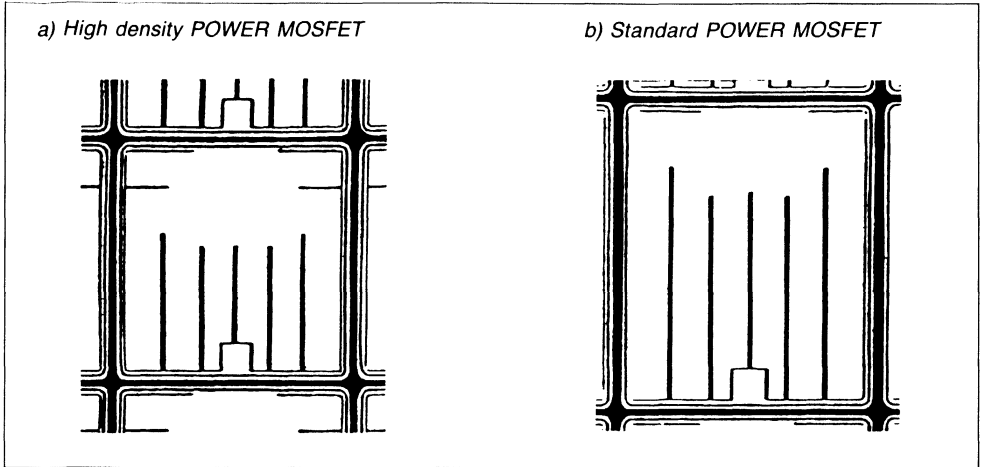
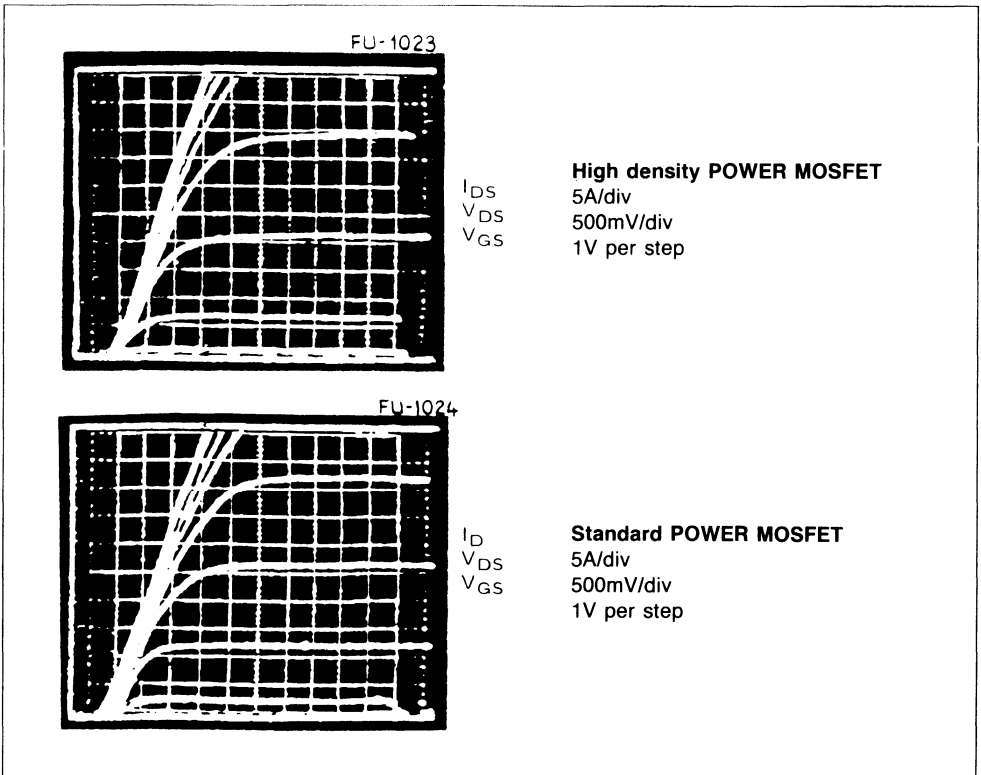


Fig. 6 - Output characteristics



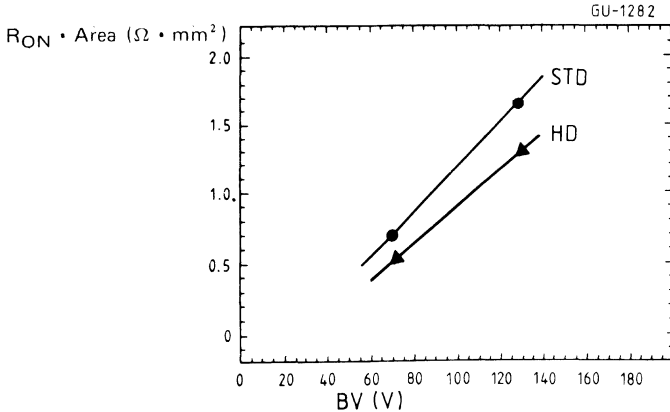
## STATIC CHARACTERISTICS

The on-resistance per unit area of a POWER MOSFET chip is an index of the optimization of the silicon; the channel perimeter and reducing the

inter-cell distance are the most important factors in reducing the on-resistance.

A figure of merit,  $R_{ON} \cdot \text{AREA}$ , allows a comparison of technologies. Fig. 7 compares the values of  $R_{ON} \cdot \text{AREA}$  for both technologies.

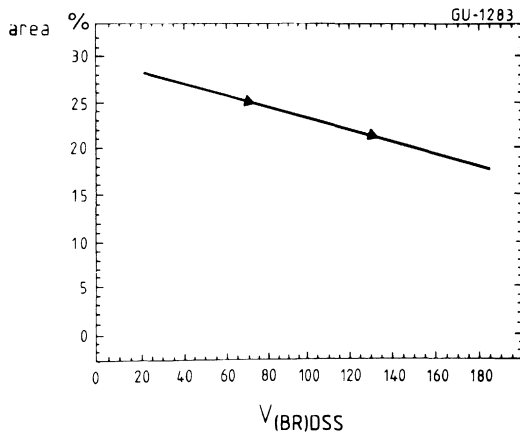
Fig. 7 - Behaviour of  $R_{ON}$  area vs. breakdown voltage.



As predicted, the increase in efficiency, as the cell density increases, becomes less as the breakdown voltage increases. This is due to the increase in the resistance on the drain ( $R_{EP1}$ ). The chip area for high density devices is reduced by 25% at 70V

breakdown and 21% at 130V breakdown compared to standard POWER MOSFET devices. Figure 8 shows the decrease in chip efficiency with the increase in voltage.

Fig. 8 - Decrease in efficiency as breakdown voltage rises



## DYNAMIC CHARACTERISTICS

Although not as obvious the effect of the cell density on the dynamic characteristic is just as inter-

esting. In switching applications, the gate charge in a POWER MOSFET device is of fundamental importance in evaluating both the driving energy and

the switching time. The total energy required by the gate for switching depends on various parameters, which are mainly electrical (supply voltage, drain current, gate voltage) or structural (reverse capacitance, gate threshold voltage, transconductance). The electrical parameters are external and depend on the type of application. The structural parameters, instead, depend on the device itself and can

be varied by optimizing its design. Using the electrical configuration shown in fig. 9 it is possible to examine the device gate charge. Fig. 10 shows the comparison between the gate charge curves of devices with the same static characteristics but with different cell densities. The total gate charge for high density types is about half that of standard POWER MOSFETS.

Fig. 9 - Gate charge test circuit

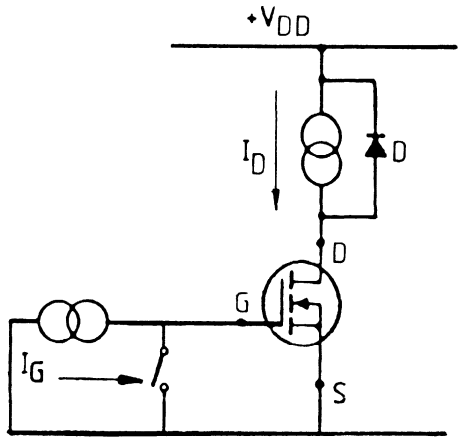
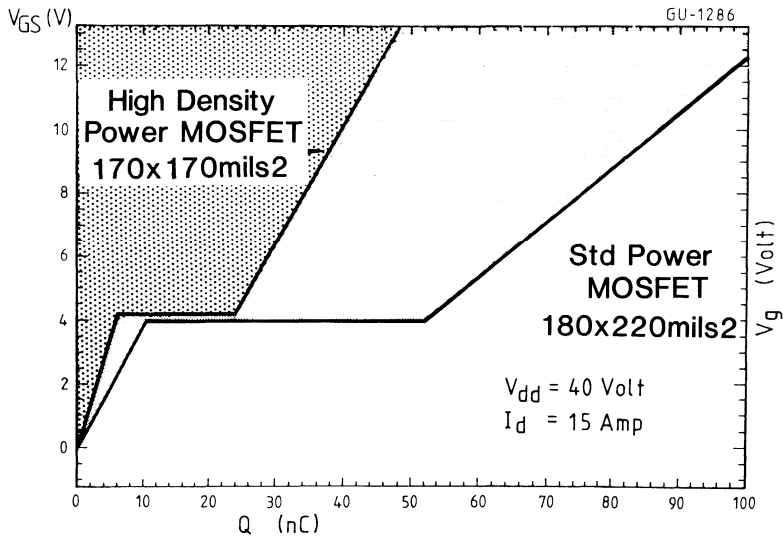


Fig. 10 - Gate charge curve



The relation between the gate charge curves and the dynamic characteristics of the devices is defined in figure 11. The  $I_d - V_d$  characteristics in switching are strongly correlated to different slopes of the gate charge curves. Analyzing the gate charge we can consider that:

- 1) the initial steep slope depends on the input capacitance  $C_{iss}$ . Reducing  $C_{iss}$ , the slope increases
- 2) the horizontal part of the curves depend on  $C_{rss}$  and  $G_M$
- 3) the third part of the slope is again due to  $C_{gs}$  which in turn is related to the geometry

Fig. 11 - Dynamic characteristics vs. gate charge

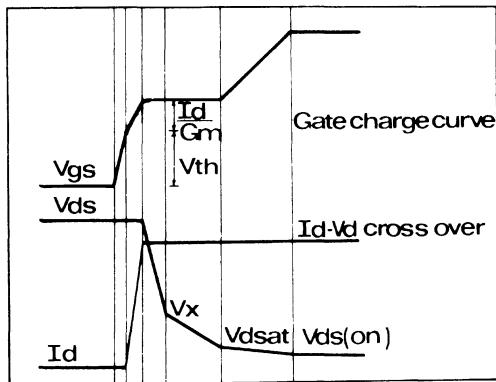
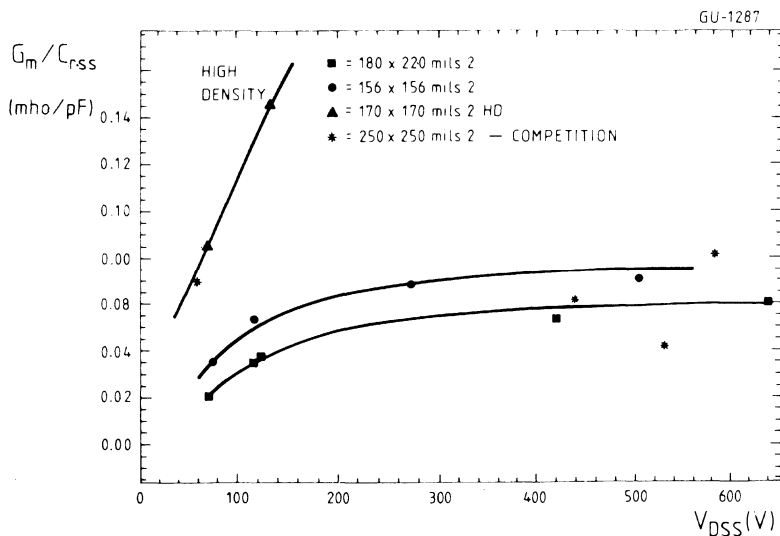


Fig. 12 - Quality factor K vs. breakdown voltage



It is obvious that for a given driving circuit resistance, the switching times and the cross-over energy losses are strongly defined by the gate charge curves. The most significant parameter for switching performance is  $C_{RSS}$ .

The drive energy,  $(E_p = \int V_G(Q) \cdot dQ)$ , is represented by the area under the curve. The switching time and consequently the energy dissipated at cross-over, is related to the width of the flat section of the gate charge curve. From this it can be deduced that the optimum device must have a low  $C_{RSS}$  and a high  $G_M$ . By introducing a second merit coefficient  $K = G_M/C_{RSS}$ , the efficiency of the device in dynamic working conditions can be calculated.

In order to increase the merit factor  $K$ , it is necessary to increase the transconductance and decrease the reverse capacitance. The best way to improve the transconductance is to increase the

perimeter of the channel, i.e. by increasing the cell density.

$C_{RSS}$  can be decreased by reducing the overlap area between the gate and drain, that is by reducing the distance between each cell.

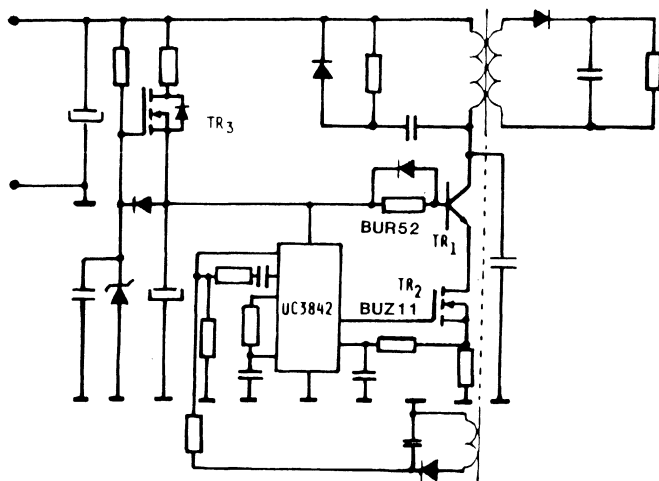
Both these actions lead to an increase in the cell density.

Fig. 12 shows the value of  $K$  (for equal areas) as a function of the breakdown voltage,  $V_{(BR)DSS}$ , for POWER MOSFET devices produced by both standard and high density technology.

Thermal measurements on both standards and high density POWER MOSFET were made using the circuit in Fig. 13.

The circuit is designed around an emitter switching configuration working at 100KHz with 50% duty cycle and  $I_b = 10A$ .

Fig. 13 - Emitter switching circuit



The power dissipation of the POWER MOSFETS devices were approx 8W for BUZ11 and 6W for high density BUZ11. The power dissipation depends on two factors:

$$P_{on-state} \text{ loss} = I_d^2 \cdot R_{on}(T) \cdot d$$

$$P_{crossover} \text{ loss} = f \cdot \int V_d \cdot I_d \cdot dt$$

The on-state power dissipation is the same for both devices. The second term, depending on the cross-

over point of the switching waveforms for the devices causes the difference in power dissipated. Considering that the junction to ambient, thermal resistance  $R_{thj-amb}$ , with heatsink, is  $13^\circ C/W$ , the devices reach a working junction temperature of  $104^\circ C + T_{(amb)}$  and  $78^\circ C + T_{(ambient)}$  respectively. Under conditions where  $T_{amb} = 50^\circ C$  the standard device is operates outside the maximum thermal ratings while the high density device remains within the thermal safe operating area.

CONCLUSION

Table 2 lists some of the significant advantages the introduction of high cell density in SGS-Thomson POWER MOSFETS offer.

Table 2

|                              | Standard | high density |
|------------------------------|----------|--------------|
| Energy loss/cycle ( $\mu$ J) | 45       | 25           |
| $C_{rss}$ (pF)               | 420      | 140          |
| $G_m/C_{rss}$ (mho/pF)       | 0.028    | 0.085        |
| $Q_g$ (nC)                   | 56       | 38           |

A reduction of the input capacitance decreases the driving energy with consequent cost reduction of the drive circuitry.

The improved dynamic characteristics, due to feedback capacitance reduction increases the maximum operating frequency.

An increase of the safe operating area is obtained by thermal improvement.

VERY HIGH DENSITY

This article would not be complete without reference to this latest addition to the SGS-Thomson POWER MOSFET devices.

The most recent advance in our high density technology is the introduction of the very high density cell structure with a cell density of 2.3 million cells per square inch. This gives a further improvement in device static and dynamic performance and an even smaller chip area for a given current rating than chips with 1.3 million cells per square inch. The photographs show the very high density cell structure compared to the standard 550k cells in<sup>2</sup>

Photo 1: 2.3 million cells in<sup>2</sup>

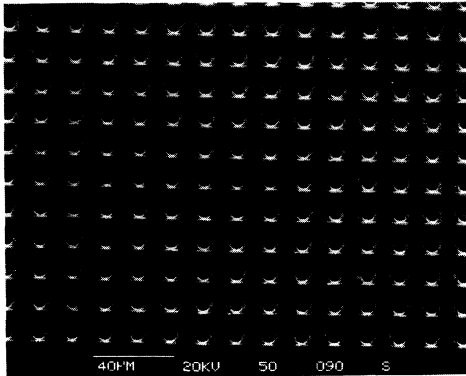
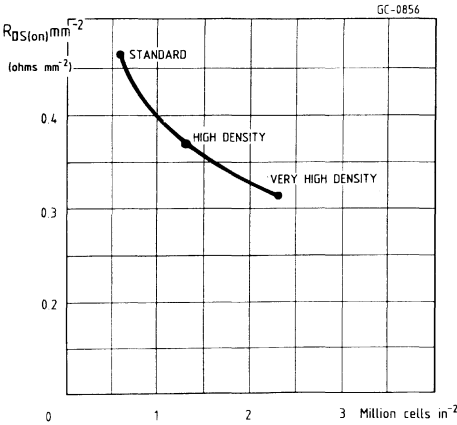


Table 3 compares the STVHD90 with 2.3 million cells/in<sup>2</sup> and chip size of 180 x 220 mils<sup>2</sup> to a standard 550k cells in<sup>2</sup> with a chip size of 180 x 220 mils<sup>2</sup>.

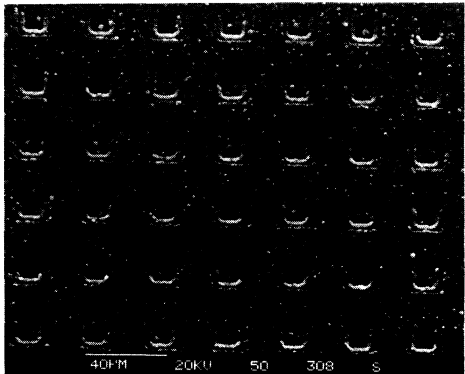
|                                | STVHD90   | SGSP386   |
|--------------------------------|-----------|-----------|
| cell density/in <sup>2</sup>   | 2.3       | 550       |
| chip size (mils <sup>2</sup> ) | 180 x 220 | 180 x 220 |
| $R_{ds(on)}$ (milliohms)       | 23        | 40        |
| $C_{iss}$ (pF)                 | 3000      | 1800      |
| $C_{oss}$ (pF)                 | 1000      | 1100      |
| $C_{rss}$ (pF)                 | 180       | 550       |
| Gate charge (nC)               | 47        | 74        |

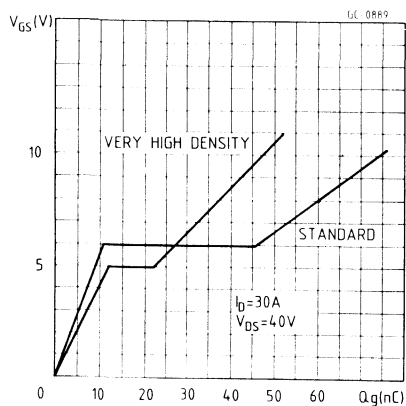
The static characteristics are very much improved as  $R_{DS(on)}$  is reduced 23 milliohms, see figure 14.



Cell density versus  $R_{DS(on)}$  mm<sup>2</sup>

Photo 2: 550k cells in<sup>2</sup>





The dynamic characteristics for switching are also improved in the STVHD90. This can easily be seen from the comparison of the gate charge curves, STVHD90 versus the standard type, figure 15. The flat section of the graph is very reduced hence reducing the switching time and gate drive energy. This is due to lower reverse capacitance,  $C_{RSS}$ , and higher transconductance,  $g_{fs}$ , in the STVHD90.

Gate charge: Very high density compared with an equal area chip with the same breakdown voltage





## HIGH VOLTAGE TRANSISTORS WITH POWER MOS EMITTER SWITCHING

### INTRODUCTION

This paper summarizes the results of an investigation carried out on power devices with both MOS and BIPOLAR parts working together in the same circuit. The "emitter drive" configuration was considered, with switching power supply applications in mind.

The devices used are:

|                                |                  |
|--------------------------------|------------------|
| Power MOS:                     | SGSP321, SGSP352 |
| Bipolar transistors:           | BUV48, BU508A    |
| Ultrafast bipolar transistors: | SGSD00035        |
| (Hollow Emitter)               | SGSD00039        |
| Fast darlington:               | SGSD00031, BU810 |

In the case of flyback switching power supplies a practical example is also described.

### CIRCUIT DESCRIPTION

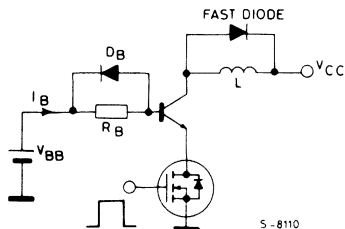
The term "emitter switching" describes a circuit configuration where a low voltage transistor (MOS or Bipolar) switches off the emitter current of a high voltage transistor, and consequently the transistor itself.

This configuration combines the fast switching of a low voltage device with the high power switching of a high voltage device, since:  
high current  $\times$  high voltage = high power switching.

The combination of a high voltage bipolar and a low voltage Power MOS is preferable due to the high switching speed and the low driving energy of the combined power switch.

The base of the high voltage bipolar device is driven by a constant voltage source. The energy dissipated to drive the high voltage bipolar device depends on the losses that the forward bias current  $I_{B1}$  generates in the resistance in series with  $R_B$ ,  $I_{B1}^2 \cdot R_B \cdot t$ . This power dissipation can only be reduced by using high gain transistors or darlington.  
(See fig. 1)

Fig. 1 - The basic circuit used for the evaluation of the emitter switching system. The base drive circuit used is shown for comparison



The diode in series with the base serves to clamp the base overvoltage at turn-off.

The two transistor stage is driven by the gate of the low voltage Power MOS. Very low driving energies, about 180nJ per cycle, are involved in the charging of the input capacitances.

Consequently the stage can be directly driven by the output of suitable linear integrated circuits.

The possibility of direct driving by an IC output together with the excellent switching speed make this configuration extremely suitable for switching power supplies at frequencies of 50kHz or higher.

### CIRCUIT OPERATION

As we have seen, the forward base current  $I_{B1}$  is fixed by the external circuitry:

$$I_{B1} = \frac{V_{BB} - V_{BEsat} - V_{Dson}}{R_B}$$

The collector current instead depends on the load, and in general, varies with the time.

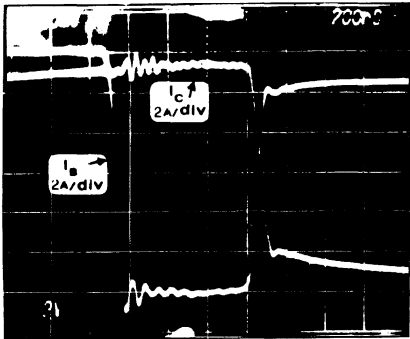
The turn-on and turn-off phases can be analysed separately.

### TURN-OFF

When the driving signal to the Power MOS is low the drain current is interrupted and the emitter cur-

rent of the high voltage bipolar falls to zero. The emitter reaches the base voltage and will not carry any more current. As a result the collector current can only flow through the base, becoming a reverse base current that depletes the base to collector junction. This reverse base current  $I_{B2}$ , from the moment when the emitter current disappears, coincides with the collector current. See photo 1. The stored charge is removed in a typically very violent, and consequently rapid manner.

Photo 1 - Base and collector current at turn-off



As a result the storage time is substantially reduced. The fall time, which is related to the recombination under the emitter, is also generally reduced. Typical values for the fall and storage time of the SGS-Thomson devices used in the test are shown in Table 1, for both emitter and the base drive circuits.

Table 1 - Typical  $t_f$  and  $t_s$  on inductive load

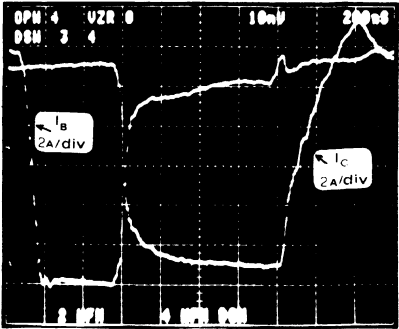
| Device    | $I_C(A)$ | EMITTER SWITCHING |            | BASE SWITCHING |            |
|-----------|----------|-------------------|------------|----------------|------------|
|           |          | $t_{storage}$     | $t_{fall}$ | $t_{storage}$  | $t_{fall}$ |
| BUX48     | 10       | 500ns             | 100ns      | 2μs            | 200ns      |
| BU508A    | 5        | 800ns             | 300ns      | 6μs            | 400ns      |
| SGSD00031 | 10       | 400ns             | 100ns      | 1.2μs          | 100ns      |
| BU810     | 5        | 300ns             | 150ns      | 800ns          | 150ns      |
| SGSD00035 | 10       | 300ns             | 50ns       | 800ns          | 50ns       |
| SGSD00039 | 5        | 300ns             | 40ns       | 700ns          | 50ns       |

### TURN-ON

When the Power MOS is the on state, the bipolar device also starts conducting. The dynamic behaviour (See Photo 2) does not differ in any substan-

tial way from the usual case of the base drive.

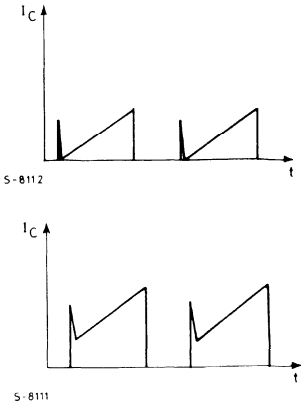
Photo 2 - Base and collector current at turn-on



The dynamic saturation transient  $V_{CEsat\ dyn}$  is also practically the same with a base drive as with an emitter drive. The collector current, when the collector load is the primary winding of a switching transformer, can vary according to two possibilities. (See Fig. 2)

- a) After the initial peak due to the recovery of the diode present on the secondary winding, the collector current increases linearly starting from zero
- b) After the same initial peak, the collector current increases linearly starting from the value memorized in the magnetic circuit at the end of the previous cycle.

Fig. 2 - Collector current waveforms with varying load



## REVERSE BIAS SAFE OPERATING AREA

A problem that occurs in bipolar transistors is damage caused by "current crowding".

Fig. 3a illustrates current flowing in a typical bipolar device. Fig. 3b shows how, when the device is turned off and the current begins to die away, the current focuses with a high concentration under the emitter. This high current density can damage or destroy the transistor.

Fig. 3a

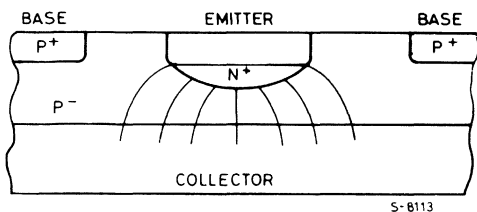
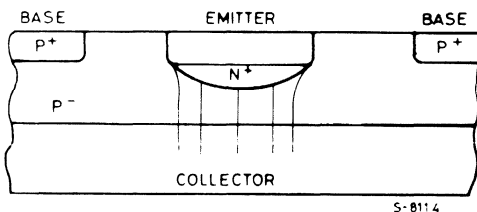


Fig. 3b



The energy dissipated within a bipolar power transistor at turn-off can be found graphically from a plot of  $I_C$  versus  $V_{CE}$  at turn-off. Three cases are shown in Fig. 4a, b and c. The shaded area is proportional to the energy that is dissipated in the device during turn-off.

Consequently turn-off times affect the SOA of the device, (Fig. 5b). These problems can be overcome using emitter switching.

Fig. 4a - Slow turn-off. No crowding but high average heating

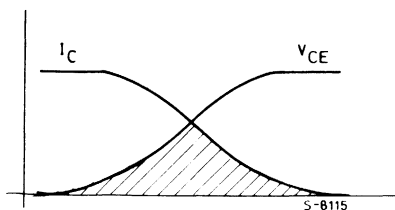


Fig. 4b - Fast turn-off. crowding with low average heating but possible high peak power

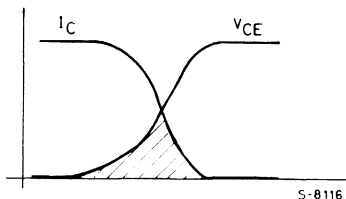
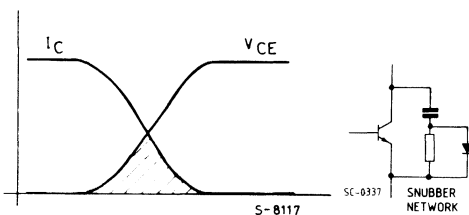


Fig. 4c - Fast turn-off (with  $V_{CE}$  delayed by snubber network)



The way the stored charge is swept away in the high voltage bipolar device when it is driven by the emitter, produces some interesting consequences.

The stored charges are evacuated through the base contact when the emitter current is zeroed and not later than a few tens of nanoseconds after the beginning of the storage interval. Consequently, during the turn-off, no charge is injected from the emitter into the base. Although the reverse base current is quite relevant, no focusing of the current in the centre of the emitter fingers takes place.

The bipolar device therefore exhibits an energy absorbing ability at the turn-off RBSOA that is substantially higher than if a normal base drive were used. With a base drive the emitter would inject charges and the voltage drop across the distributed base resistance would induce the "emitter crowding" phenomenon.

The practical evidence for all the transistors investigated (BUV48, BU508A, SGSD00035, SGSD00039) shows that the reverse bias operating area (RBSOA) extends right up to the  $BV_{CES}$ ! (See fig. 5).

This extreme effect is unfortunately much less pronounced when using fast darlington transistors. The higher complexity of the charge extraction mechanism and the charge injection from the emitter into the base

in the driver transistor imply that the RBSOA extension is almost irrelevant

Fig. 5a - reverse bias safe operating area

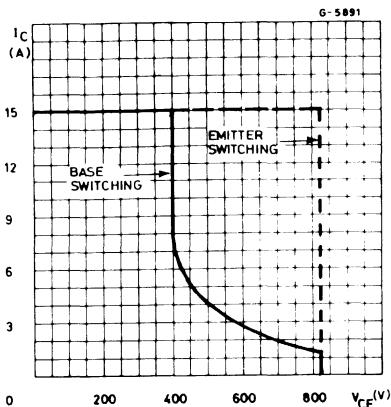
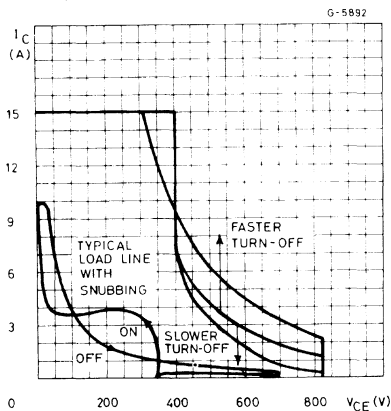


Fig. 5b - How reverse bias safe operating area changes for:

- i) slow turn-off
- ii) fast turn-off



## A POSSIBLE APPLICATION

A possible application of the "emitter switching" configuration is shown in Figure 6, where a switching power supply operating in a "flyback" mode has been implemented.

The basic criteria used in choosing the value of the circuit elements are given below. The purpose of the study was to demonstrate the feasibility and to evaluate the advantages. Exact circuit element values can be further optimized, especially in the case

of the transformer.

The power source in the mains singlephase, 220V a.c., and the switching frequency can be set to 50KHz or more.

The devices used were:

- Q1: fast darlington with  $BV_{CES} \geq 600V$  for 110V line
  - SGSBU810 for current up to 5A
  - SGSD0031 for current above 5A
- Fast transistor with  $BV_{CES} \geq 800V$  for 220V line
  - SGSD00039 for currents up to 5A
  - SGSD00035 for current up to 10A
- Q2: Low voltage POWER MOS ( $BV_{DSS} = 50V$ )
  - SGSP352 for currents up to 5A
  - SGSP322 for currents over 5A
- Q3: High voltage, low current POWER MOS ( $V_{(BR) DSS} < 450V$ )

Control

- IC: UC3842
- DZ2: Zener diode 2W/20V
- D1: 25V diode, with  $I_C$  peak rating as high as 10A for 500ns
- C6: Electrolytic capacitor, 100 $\mu$ F, 25V. It absorbs possible variations of  $V_{BB}$ .
- R3: Resistor setting the forward bias base current of the darlington:

$$R3 = \frac{V_{CE} - V_{BE sat} - V_{DSon} - R_7 I_D}{I_{B1}}$$

Its power rating must exceed  $R3 \cdot I_{B1}^2 \cdot t$  (in practice 3W)

- R7: Shunt resistor to sense the switch current. The over current  $I_{Smax}$  protection is set according to

$$R7 = \frac{1V}{I_{Smax}}$$

- C4,R6: RC network, filtering the disturbances induced by the switching transients on the  $I_{Smax}$  protection input.

- C3,R5: RC network, setting the switching frequency and the maximum duty cycle, according to the UC3842 data sheet.

$$\begin{aligned} t_{charge} &= 0.55 R_5 C_3 \\ t_{discharge} &= R_5 \times C_3 \ln [(6.3 R_5 - 2.7)/(6.3 R_5 - 4)] \\ f &= 1/(t_c + t_d) \end{aligned}$$

- R8,R9: Resistive divider of the feedback voltage from a secondary sense winding, rectified by D5 and C5. The divided voltage is compared by the control IC to an internal reference of 2.5V.
- C2,R4: Compensating network in the error amplifier of the feed-back voltage.
- R1: Resistor biasing the Q3 gate (1.2 MΩ, 1/4 W)
- R2: Resistor that limits the inrush current through the POWER MOS, Q3, at the turn-off (1.2Ω, 2W)
- D4: Fast recovery diode  
Its voltage/current ratings depend on the particular secondary winding it rectifies.
- D5: Low current/low voltage diode
- D3,R10, C8: Snubber network (Fig. 6 shows just one of the possible configurations).

$$C8 = \frac{L_d I_c^2}{V_{DS}^2}$$

$$R10 = 1/4fC8$$

$$P(R10) = 1/2 L_d I_D^2 \cdot f$$

where:

$f$  = switching frequency

$L_d$  = stray inductance of the transformer

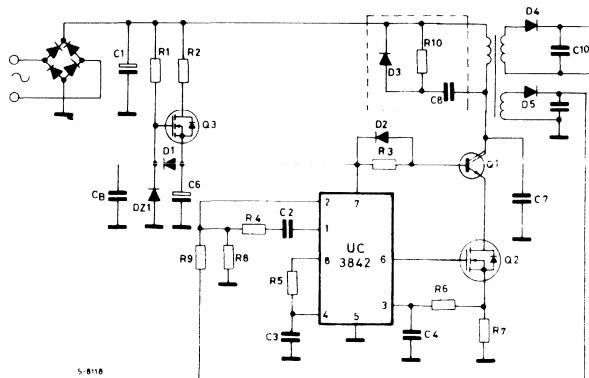
$V_{OS}$  = maximum voltage overshoot admitted

D3: A 400V fast recovery diode

C7: The use of a capacitor reduces the crossover of the Darlington (3 to 6nF)

It is important to note that, the power transistor Q3 acts only at the turn-on of the power supply and when the capacitor C6 supplies more energy to the base of the darlington and to the supply input of the IC than is returned to C6 during the turn-off of the darlington, Q1.

Fig. 6 - "Emitter switching" circuit



## CONCLUSION

The "emitter drive" configuration exhibits some clear differences with respect to the usual "base drive" configuration, and they can be particularly useful in switching power supply applications:

- Substantial reduction of the storage time and improvement of the fall time.

Switching frequencies of 50kHz and higher are possible

- The dynamic drive circuitry is simplified. The negative voltage supply is not required to remove the stored charge from the base. The energy needed to drive the gate of the POWER MOS is very low (180 nJ per cycle).

- Extremely high ruggedness at the turn-off of the inductive load (i.e. very large RBSOA) if the high voltage bipolar part is a transistor.

- Higher power dissipation in the on-state, due to the additional losses in the POWER MOS ( $I_D^2 R_{DS(on)} t_{on}$ ).

This last point is the only disadvantage, but it is more than compensated for if switching at high frequencies. The lower switching losses (a saving each cycle) can justify the higher on-state losses (a fixed expenditure) as soon as the switching frequency is high enough, which is often the case in switching power supplies.



## A WIDE RANGE INPUT DC-DC POWER CONVERTER

### INTRODUCTION

This 300W DC-DC converter, shown in Fig. 1 has a flyback topology and works in continuous mode with single output and features primary side control.

The Power switch is designed around an emitter switching configuration. This arrangement uses three bipolar devices, BUX 12, and with POWER MOS device in cascode.

The pulse width modulation (PWM) controller is the SGSUC3840 linear integrated circuit. The characteristics of this IC are pulse by pulse current limiting with shut-down for short circuit protection, over and under voltage sensing with protective shut-down, soft start, voltage feed-forward for excellent line regulation (without regulation by feed back network). These facilities are used to advantage in this design.

### CIRCUIT DESCRIPTION

A DC input voltage is chopped at a high frequency, 80KHz is possible.

This high switching frequency allows the use of a very small transformer with respect to the output power.

In the configuration, shown in Fig. 1, an additional low-voltage winding,  $N_B$ , (two turns on this transformer) is used to provide continuous operating power for the base of the bipolar power device.

The resulting base current is proportional to the load.

The polarity of the transformer windings is configured as a flyback converter. When transistor Q6 conducts, the output diodes are reverse biased and energy is stored in the primary inductance. When Q6 turns-off, the voltage polarity of the primary winding reverses and the stored energy is delivered to the output.

Fig. 1 300W DC-DC converter circuit diagram.

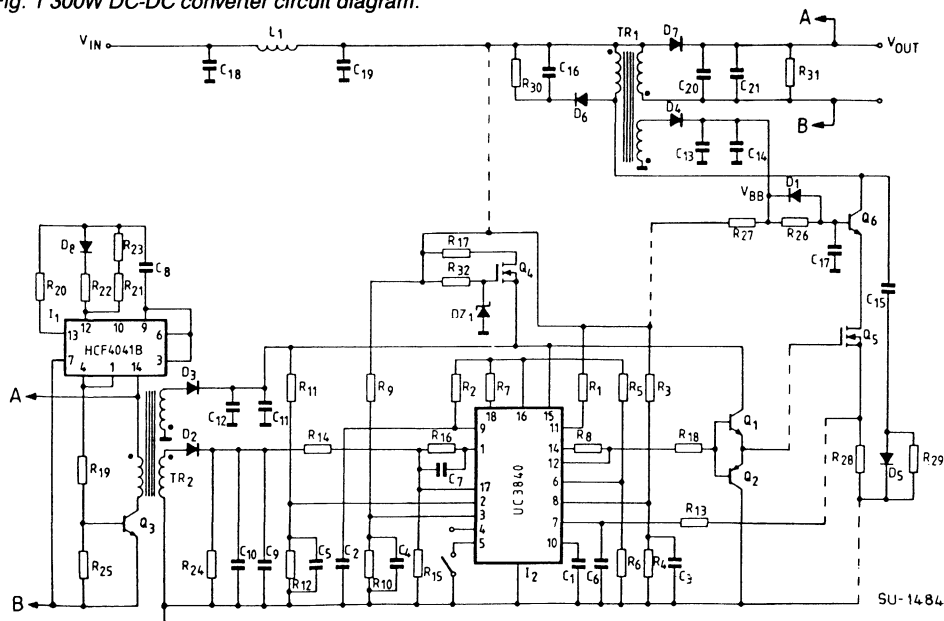


Table 1 - Power Supply Specifications

|                                              |   |                         |
|----------------------------------------------|---|-------------------------|
| Operating mode                               | : | Flyback Continuous Mode |
| DC Input Voltage                             | : | 48V to 80V DC           |
| Switching frequency                          | : | 80KHz $\pm$ 10%         |
| Output Power                                 | : | 300W                    |
| Output Voltage                               | : | 12V $\pm$ 5%            |
| Output Current                               | : | 2 to 25A                |
| Line Regulation                              | : | 0.03%/V                 |
| Load regulation                              | : | 0.17%/A (med. value)    |
| Efficiency $\text{\textcircled{C}}$ 300W     |   |                         |
| $V_{IN} = 48 V_{DC}$                         | : | 70%                     |
| $V_{IN} = 80 V_{DC}$                         | : | 75%                     |
| Efficiency max $\text{\textcircled{C}}$ 150W |   |                         |
| $V_{IN} = 70 V_{DC}$                         | : | 80%                     |
| Output Ripple $\text{\textcircled{C}}$ 25A   | : | 400mV                   |

The power supply operates in continuous mode: the energy stored in the primary inductance is not completely transferred to the load during each cycle, for this reason the current in the primary winding has a trapezoidal waveform, Fig. 3.

The emitter switching configuration of the power switch allows the bipolar transistor to operate at higher frequencies since this technique gives a substantial reduction in the bipolar storage time.

Other advantages are:

- The dynamic drive circuitry is simplified and the energy needed to drive the gate of the POWER MOS device is very low (800nJ per cycle).
- Greater ruggedness than in a single bipolar switch at turn-off with the inductive load. Consequently there can be smaller snubber networks and a higher leakage inductance in the transformer.
- The power dissipation during on time is lower than the on losses of a single POWER MOS device with the same characteristics ( $I_C$ ,  $BV_{CE}$ ) of the bipolar device.

For better load regulation with isolated output, a smaller converter (transformer Tr2 with a small signal transistor Q3, as a switch) is used instead of a feedback winding.

This converter, operating at a fixed frequency (160KHz) and duty-cycle, provides on the first secondary winding,  $N_f$  with forward polarity, a voltage proportional to the output regulating voltage, which is used as a feedback signal.

The other secondary winding of this converter (with flyback polarity)  $N_i$ , is used to provide continuous operating power for the UC3840 and the IRFZ42 gate drive.

Table 2 - Tr2 specifications

|                 |                  |
|-----------------|------------------|
| - Core          | Siemens E20, N30 |
| - Primary       | $N_p = 38$ turns |
| - Feedback sec. | $N_f = 30$ turns |
| - Supply sec.   | $N_i = 56$ turns |

The start-up of the power supply is obtained by resistor R27 which supplies the transistor base and by the network (formed by POWER MOS device Q4, DZ1, R17, R32) which supplies the PWM circuit and IRFZ42 gate drive transistors Q1 and Q2. When the voltage on the secondary winding of Tr2 increases, the POWER MOS device, Q4, is automatically turned-off, Q4 is a low voltage, low current POWER MOS device: an SGSP301 was selected. It is interesting to note that the DC safe operating area of a POWER MOS transistor used under these conditions is greater than that of an equivalent bipolar device.

The circuit was mounted on two printed boards. Board 1 holds the control circuit and board 2 the power switch. Board 2 has a copper thickness of about 300 $\mu$ m. The high current areas are double sided.

## TRANSFORMER

Designing the transformer leads to trade off decisions involving factors such as leakage inductance specifications, insulation, size, power dissipation, and cost.

The core selected for this power supply is a Siemens EC70-N27 with the following characteristics:

- Effective core Area  $A = 279 \text{ mm}^2$
- Saturation flux density  $\text{\textcircled{C}}$  20°C = 470 mT
- Maximum working flux density  $B = 300 \text{ mT}$



The design starts with a calculation of the maximum duty cycle,  $\Delta$ , and the maximum on time  $T_{on \max}$ , Fig. 2.

With  $V_{CC \min} = 48V$ ,  $V_{reset} = 45V$ ,  $T = 12.5\mu s$  (80KHz).

The maximum duty cycle is;

$$\Delta = \frac{V_{reset}}{V_{reset} + V_{CC \min}} = \frac{45}{45 + 48} = 48\% \quad T_{on \max} = 6\mu s$$

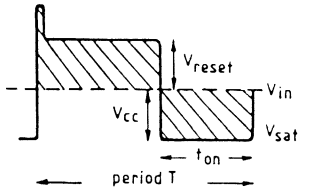
Eqn. 1

By equating the volts/second areas - the shaded areas in Fig. 2 the turns ratio can be calculated using the worst case as follows: (see Fig. 2).

$$\begin{aligned} n_{primary} (V_o + V_t) \cdot (T - T_{on \max}) &= n_{secondary} (V_{CC \min} \cdot T_{on \max}) \\ n_{(p/s)} &= \frac{V_{CC \min} \cdot T_{on \max}}{(V_o + V_t) \cdot (T - T_{on \max})} = \frac{48 \cdot 6 \cdot 10^{-6}}{(12 + 1) \cdot 6.5 \cdot 10^{-6}} = 3.4 \end{aligned}$$

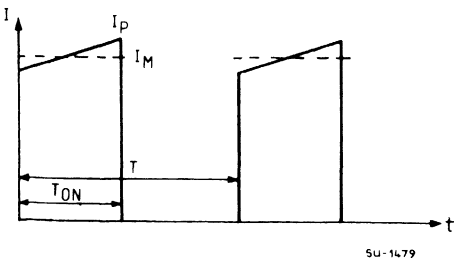
Eqn. 2

Fig. 2 - Switching waveforms at the collector of Q6



SU-1485

Fig. 3 - Current waveform in the primary inductance



SU-1479

Fig. 3 shows the mean current value ( $I_{mean}$ ) in the primary inductance during the on state. It can be calculated as follows using the minimum input voltage:

$$I_{mean} = \frac{P_{max} \cdot T}{\eta \cdot V_{CC \min} \cdot T_{on \max}} = \frac{300 \cdot 12.5}{0.7 \cdot 48 \cdot 6} = 18.6A$$

Eqn. 3

The primary inductance  $L_p$  can be calculated by fixing a maximum peak value for primary current  $I_p = 20A$ ;

$$L_p = \frac{V_{CC \min} \cdot T_{on \max}}{2 (I_p - I_{mean})} = \frac{48 \cdot 6 \cdot 10^{-10}}{2 \cdot 1.4} = 100\mu H$$

Eqn. 4

At full load and at  $V_{CC \max}$  we have

$$T_{on} = \frac{n \cdot (V_o + V_t) \cdot T}{V_{CC} + n (V_o + V_t)} = 4.4 \mu s$$

Eqn. 5

The flux balance in the transformer core depends on equal volts-second products being applied during charge and reset phases.

$$I_{man} (@ 80V) = \frac{P_{max} \cdot T}{n \cdot V_{max} \cdot T_{on \min}} = 16A$$

$$I_p = 17.1A$$

With an air-gap,  $g = 3mm$ , then  $Al = 140nH$ ,  $N_p$  can be calculated as follows:

$$N_p = \sqrt{L/Al} \text{ (from manufactures data book)}$$

Eqn. 6

$$N_p = \sqrt{100 \cdot 10^3 nH / 140nH} = 27 \text{ turns}$$

The minimum air gap with working flux density  $B = 250mT$  is:

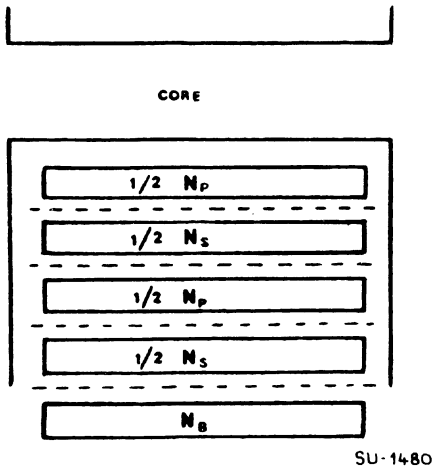
$$g = \frac{I \cdot N_p \cdot \mu_o}{B} = 2.7 \text{ mA}$$

$\mu_o = 12.56 \cdot 10^{-7} \text{ Hm}^{-1}$  (permeability of free space)

Since we have  $g = 3mm$  at all working conditions  $B < 250mT$ .

$$N_s (+12) = N_p / n = 27 / 3.4 = 8 \text{ turns}$$

Fig. 4 - Transformer construction showing the winding pattern for reduced for leakage induction.



To reduce the skin effect in the transformer windings at 80KHz, multistrand conductors must be used. The prototype specifications are given in table 3.

Table 3 - Winding specifications

|                |            |                      |                    |
|----------------|------------|----------------------|--------------------|
| Primary        | $N_p$      | = 27 turns, 6 wires  | $0 = 0.8\text{mm}$ |
| Secondary out. | $N_s(+12)$ | = 8 turns, 16 wires, | $0 = 0.8\text{mm}$ |
| Secondary aux. | $N_B(+3)$  | = 2 turns, 1 wire,   | $0 = 0.8\text{mm}$ |

Fig. 4 shows the transformer construction.

POWER SWITCH

In this application the peak switching current is 20A and the correspondent peak collector voltage is approximately 280 volts including the 180 volts spike caused by leakage inductance, Fig. 2.

The bipolar transistors selected are 3 × BUX12 in parallel and the POWER MOS selected is the IRFZ42.

BUX12 × 3

$BV_{CEO} = 250V$   
 $BV_{CES} = 300V$   
 $I_C \text{ CONT} = 50A$

IRFZ42

$BV_{DSS} = 50V$   
 $R_{DS \text{ ON}} = 35 \text{ m}\Omega$   
 $I_D = 35A$

The emitter switching configuration gives very short storage time  $t_s$  for 3 × BUX12: at full load we have  $t_s = 300\text{ns}$  max, and fall time is 150ns maximum. (Photo n. 5).

When the voltage falls on pin 12 of the UC3840, Q1 is off and Q2 conducts. The POWER MOS Q5 is then off and interrupts the emitter current of Q6: at this time current,  $I_C$ , flows through the base, becoming a reverse base current  $I_{B2}$  that extracts the stored charge from the collector region. The voltage on the drain of Q5 is held at the same value as  $V_{BB}$ .

SNUBBERS

To protect the power switch we have two snubber networks .

The first network of C15, R29 and D5 is used to reduce the switch-off power losses of Q6 by delaying the transistor  $V_{CE}$  rise while the current falls at turn-off.

$$C15 = \frac{I_p \cdot t_f}{2 \cdot V_{VE \text{ max}}} = \frac{20 \cdot 150 \cdot 10^{-10}}{2 \cdot 280} = 5.35\text{nF}$$

5.6nF was selected

R29 resistor is selected to discharge C15 with a time constant of  $3\mu\text{s}$  (about  $T_{on \text{ min}}$ ).

$$R29 = \frac{3 \cdot 10^{-6}}{2C15} = 270\Omega$$

The power dissipated in this resistor is:

$$P = 1/2 C15 \cdot (V_{CE \text{ max}})^2 \cdot f = 17W$$

The second network, C16, R30 D6 is used to limit the overvoltage due to the transformer leakage inductance when Q6 turns-off.

$$C16 = \frac{L_d \cdot I_p^2}{(V_{res} + V_p)^2 - V_{res}^2}$$

Where:  $L_d$  = Leakage inductance (about  $1\mu\text{H}$ )  
 $V_{res}$  = Reset voltage 45V  
 $V_p$  = Allowable voltage spike (180V)  
 $C16 = 8.2\text{nF}$

R30 value is selected so that the voltage across C16 is equal to the reset voltage at the end of the discharge period. Since D6 conducts for about  $2.5\mu\text{s}$  C16 discharge period is about  $10\mu\text{s}$ , then R30 value is calculated as follows:

$$R30 = \frac{(V_{reset} + V_p) \cdot 10 \cdot 10^{-6}}{V_p \cdot C16} = 1.5K$$

The power dissipated in this resistor is:

$$P = 1/2 L_d \cdot I^2 \cdot f = 16W$$

Due to non-linear effects the power dissipated is about 100W.

## PWM CONTROLLER

- Operating frequency is set by R2, C2:

$$\text{With } R2 = 8.2K, C2 = 1.5nF, f = 1/R2 \cdot C2 = 80KHz$$

- Start-up is achieved by the network of Q4, R17, R32, DZ1. With a start up current of 60mA we have:

$$R17 = \frac{V_{CC \min}}{60 \cdot 10^{-3}} = 800\Omega \quad R32 = 47K$$

- $V_{\text{start}}$  and undervoltage threshold are set by R11, R12. These are calculated by equating the current through the node using Kirchoffs laws.

$$V_{\text{start}} = \frac{3V(R11 + R12)}{R12} + 0.2mA \cdot R11 = 13V$$

similarly:

$$V_{uv(\text{fault})} = \frac{3V(R11 + R12)}{R12} = 9.5V$$

solving these equation for R11 and R12 then we get the nearest preferred values of:

$$R11 = 18K \quad R12 = 8.2K$$

- Over voltage fault:

Setting the overvoltage fault to  $V_{CC} = 100V$  we have:

$$100 = 3V \frac{R9 + R10}{R10} \quad R9 = 33 \cdot R10, R9 = 220K \\ R10 = 6.8K$$

- Duty cycle clamp - soft start:

The duty clamp reduces the duty cycle value to below 48% when the input voltage  $V_{IN}$  falls below 48V.

The divider R3, R4, is set to provide 3.9 volts at pin 8. With  $V_{IN(\min)} = 46V$ ,  $R3 = 507K$  and  $R4 = 17K$ . With  $C3 = 47nF$  the soft start time is about 6ms.

The feed forward function provides a variable - slope ramp waveform on pin 10 which is one of the inputs to the PWM comparator. The ramp is proportional to the DC input voltage; in this way the pulse width is immediately reduced when the input voltage rises. The result will be a constant volt - second product delivered to the transformer primary resulting in good open-

loop line regulation.

With  $T_{on} = 6\mu s @ 48V$  we have:

$$\frac{dV}{(dt) \min} = \frac{V_p - V_{\text{valley}}}{6} = \frac{4.2 - 0.5}{6} = 0.616V/\mu s$$

using this value and  $V_{DC \min} = 48V$

with  $C1 = \leq C2$

$$\frac{dV}{dt} = \frac{V_{DC \min}}{R1 \cdot C1} \quad R1 \cdot C1 = 77.8\mu s \\ R1 = 220K \quad C1 = 350pF$$

- Current limit.

The resistive divider of R5 (18K) and R6 (1.5K) provides a  $V_{ref} = 0.38V$  on pin 7 which is the positive input of error amplifier. For a current limiting value  $I_{\text{short circuit}} = 22A$  the R28 value is set as:

$$R28 = V_{ref}/I_{sc} = 18m\Omega$$

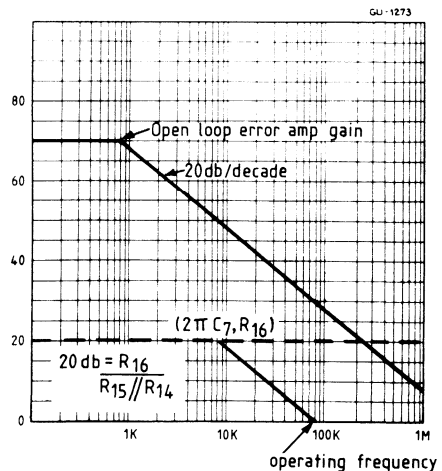
the shut down current value is defined as:

$$I_{SD} = \frac{V_{ref} + 0.4}{R28} = 44A$$

- Voltage control loop.

The error amplifier is set-up for an added DC gain of about 20dB and a second pole at 9KHz. The pole introduced by C17/R16 reduces the gain from 20dB at about 9KHz to 0dB at 80KHz to meet the loop stability criteria.

Fig. 5 - Gain setting for the error amplifier



## OUTPUT CAPACITORS

For the high output current of this application the most important characteristics of an output capacitor is its equivalent series resistance, E.S.R. In fact the voltage output ripple is mainly due to losses on the capacitor equivalent series resistance. E.S.R. specification is:

$$\text{E.S.R.} < V_o / I_c \quad \text{where:}$$

$V_o$  = Allowable peak-to-peak output ripple voltage  
 $I_c$  = Ripple current in the output capacitor

The mean current in the secondary winding of the transformer while the output diodes conduct is:

$$I_{\text{mean}} = I_{\text{max output}} / (1 - f \cdot t_{\text{on max}}) = 48\text{A}$$

The secondary peak current  $I_{\text{pk}}$  which corresponds to  $I_c$  is:

$$I_{\text{pk}} = I_c = I_{\text{mean}} + 1/2 [\Delta I_{\text{prim}} \cdot n \cdot t_{\text{on}} / T - t_{\text{on}}] = 52.4\text{A}$$

With  $V_o = 0.4\text{V}$  we have:

$$\text{E.S.R.} < 0.4/52.4 = 0.0075\Omega$$

## POWER OUTPUT RECTIFIER

The power output rectifier must be of a fast recovery type in order to reduce losses and the current spike at turn-on of the power switch.

Power diodes with low forward voltages reduce the output filter losses.

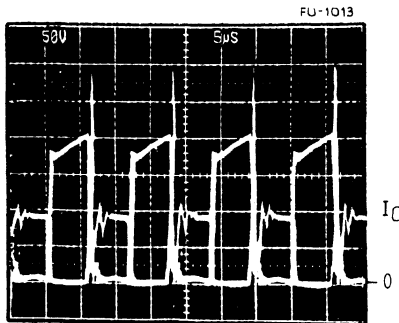
A BYV52 - 50A fast recovery low  $V_f$  diode is the solution chosen for this converter.

## TESTS ON THE CIRCUIT

The power supply was tested in several operating conditions: with minimum, maximum and rated input voltage, and with various load configurations.

Photograph No. 1 shows the collector voltage and current waveform of the bipolar switch at maximum load ( $I_{\text{out}} = 25\text{A}$ ) and at minimum input voltage.

Photo 1 -  $I_c$ ,  $V_{CE}$  on bipolar switch ( $I_c = 5\text{A/div}$ ,  $V_{CE} = 50\text{V/div}$ )



This is the worst case because it has a higher primary current and consequently a higher voltage spike on bipolar collectors (due to leakage inductance).

Photograph Nos. 2 and 3 show the details of photograph No. 1 during turn-off and turn-on respectively.

Photograph No. 4 shows bipolar device base current and POWER MOS device gate voltage with the same operating conditions as Photograph No. 1.

Photograph No. 5 shows the collector current,  $I_c$  and the base current,  $I_b$  waveforms of the bipolar device at turn-off; we can see the high value of reverse base current  $I_{B2}$  and the very short storage time (about 300ns).

Photograph No. 6 shows the output ripple at maximum load with  $V_{\text{IN}} = 48\text{V}$ . (Worst case).

Photo 2 - Turn-off, bipolar switch ( $I_c = 5\text{A/div}$ ,  $V_{CE} = 50\text{V/div}$ )

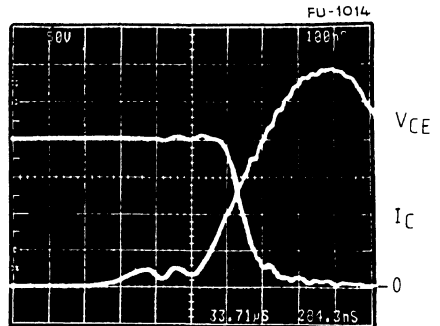


Photo 3 - Turn-on, bipolar switch ( $I_c = 5\text{A/div}$ ,  $V_{CE} = 50\text{V/div}$ )

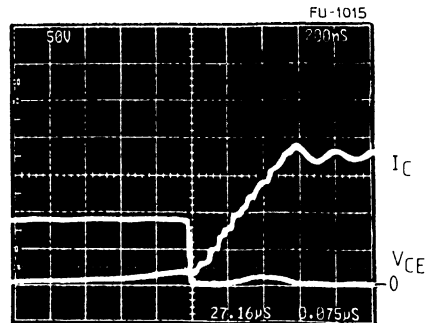


Photo 4 -  $I_B = 2A/div$ ,  $V_{gate} = 5V/div$

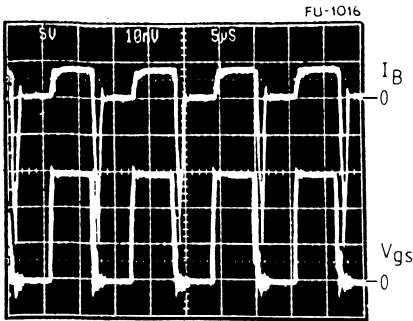


Photo 5 - Storage time bipolar switch ( $I_B = 5A/div$ ,  $I_C = 5A/div$ )

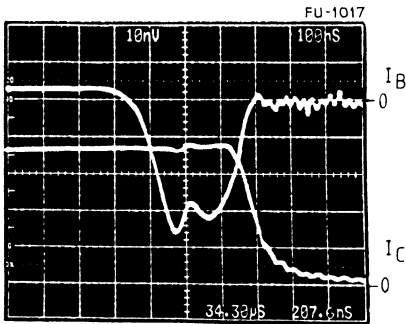


Photo 6 - Output ripple  $v = 200mV/div$

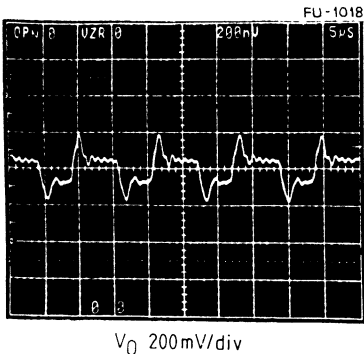


Photo 7 - Transient response  $V = 200mV/div$

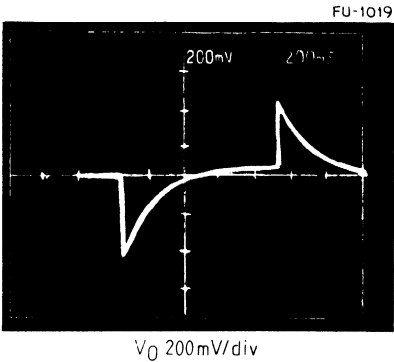


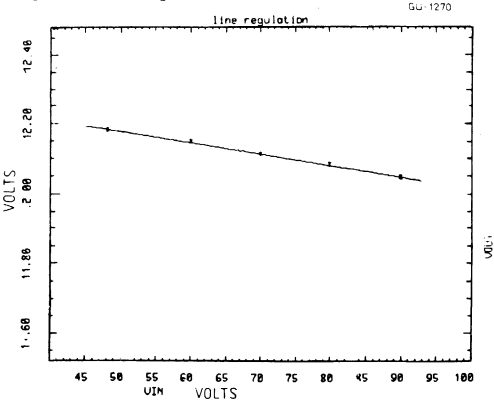
Fig. 6 and fig. shows the line regulation and the load regulation ( $V_{IN} = 70V$ ) respectively. The line regulation is 0.03%/V with an overall variation of 1.1% and the load regulation is 0.17%/A with an overall variation of 2.9% over the operating range.

Fig. No. 8 shows the efficiency of the DC-DC converter at  $V_{IN} = 70V$ . At full load ( $I_{out} = 25A$ ) the efficiency is 75% and the power losses on the circuit are about 100W. The power losses are divided approximately as follows: (Table 4)

Table 4

|        |                            |
|--------|----------------------------|
| — 25W  | Losses on output diodes    |
| — 27W  | Losses on transformer      |
| — 27W  | Losses on the two snubbers |
| — 5W   | Losses on IRFZ42           |
| — 10W  | Losses on bipolar devices  |
| — 2W   | Losses on resistor R26     |
| — 2W   | Losses on resistor R28     |
| — 1.5W | Losses on resistor R31     |

Fig. 6 - Line regulation



Photograph No. 7 shows the transitory response of load regulation due to a load variation from 1A to 25A and from 25A to 1A.

Fig. 7 - Line regulation

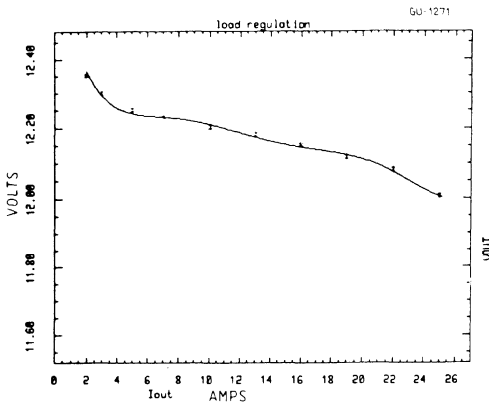
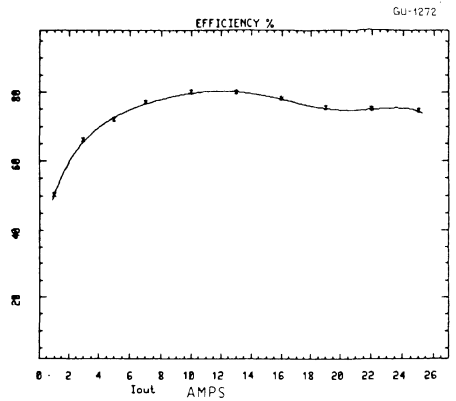


Fig. 8 - Efficiency



## CONCLUSION

By using the emitter switching technique this DC-DC converter design uses its switching element to maximum advantage having a very rugged RBSOA and the ability to operate at high frequency. This allows the construction of a compact power supply. The technique also allows high frequency swit-

ching with a relatively simple driving circuit. In addition to these advantages the efficiency of the converter at half and full load under a wide range of input voltages, is acceptable as is the output ripple. The efficiency could be further improved by replacing the fast recovery epitaxial diodes in the secondary winding with Schottky diodes.

## APPENDIX - Components list of the circuit diagram in fig. 7

|                         |                 |                                 |
|-------------------------|-----------------|---------------------------------|
| R1 = 220KΩ              | R27 = 4.7KΩ 2W  | C14 = 1.5μF                     |
| R2 = 8.2KΩ              | R28 = 18mΩ 5W   | C15 = 5.6nF 300V                |
| R3 = 507KΩ              | R29 = 270Ω 20W  | C16 = 8.2nF 300V                |
| R4 = 47KΩ               | R30 = 1.5KΩ 15W | C17 = 47nF                      |
| R5 = 18KΩ               | R31 = 100Ω 2W   | C18 = 100μF 100V                |
| R6 = 1.5KΩ              | R32 = 47KΩ      | C19 = 100μF 100V low E.S.R.     |
| R7 = 15KΩ               |                 | C20 = 4.7μF                     |
| R8 = 470Ω               | Q1 = SGS2N2222A | C21 = 5 × 4700μF 16V low E.S.R. |
| R9 = 220KΩ              | Q2 = SGS2N2907  |                                 |
| R10 = 6.8KΩ             | Q3 = SGS2N2222A | D1 = BYW81 - 50A                |
| R11 = 18KΩ              | Q4 = SGSP301    | D2 = 1N4148                     |
| R12 = 8.2KΩ             | Q5 = IRFZ42     | D3 = 1N4148                     |
| R13 = 18KΩ              | Q6 = 3 × BUX12  | D4 = BYW80 - 50A                |
| R14 = 19KΩ              |                 | D5 = BYTO8P - 300A              |
| R15 = 28.9KΩ            | C1 = 350pF      | D6 = BYV52 - 50A                |
| R16 = 82KΩ              | C2 = 1.5nF      | D7 = 4 × BYW81P - 100A          |
| R17 = 820Ω 1/2W         | C3 = 47nF       | D8 = 1N4148                     |
| R18 = 82Ω               | C4 = 6.8nF      | DZ1 = 1N4112                    |
| R19 = 560Ω              | C5 = 6.8nF      |                                 |
| R20 = 47KΩ              | C6 = 220pF      | IC1 = SGS HCFF 4041B            |
| R21 = 1.5KΩ             | C7 = 220pF      | IC2 = SGS UC 3840               |
| R22 = 1.8KΩ             | C8 = 330pF      |                                 |
| R23 = 2KΩ potentiometer | C9 = 470pF      | Tr1 core : Siemens EC 70 N27    |
| R24 = 820Ω              | C10 = 220nF     | Tr2 core : Siemens E 20 N30     |
| R25 = 82Ω               | C11 = 47μF      | L1 core : TDK P2616             |
| R26 = 1.8Ω 5W           | C12 = 470nF     |                                 |
|                         | C13 = 47μF      |                                 |

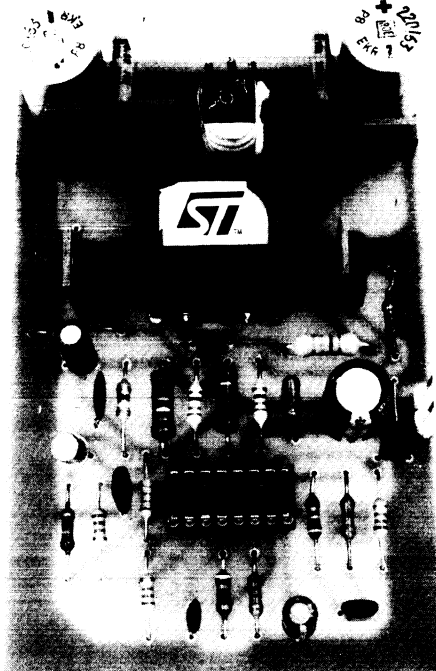
## 200KHz 15W PUSH PULL DC-DC CONVERTER

### INTRODUCTION

The 15W DC-DC converter, shown in Fig. 1 has a push-pull topology and works in continuous mode with two outputs (+6V, -6V) and features primary side control with full protection against fault con-

ditions. There is no insulation between the primary and secondary side.

Due to the high working frequency, the power switches used are the new SGS-THOMSON advanced POWER MOS type: IRFZ20 with high



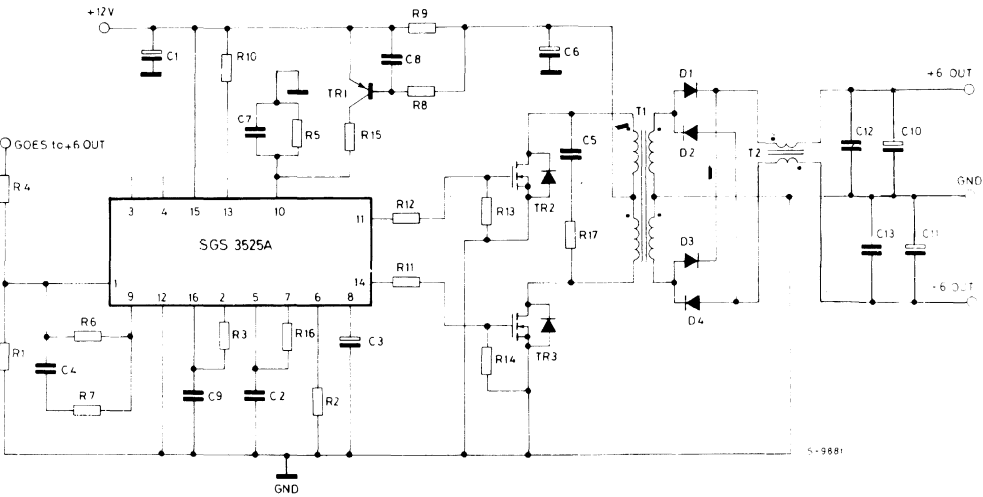
density and bonding on the active area.  
The PWM controller is the linear integrated circuit SGS3525A, with dual source/sink output drivers,

internal soft-start, pulse by pulse shut-down and adjustable dead time control.  
Table 1 shows the power supply specifications.

TABLE 1

|                                                              |   |                                                      |
|--------------------------------------------------------------|---|------------------------------------------------------|
| Operating mode                                               | : | push-pull                                            |
| DC input voltage                                             | : | 10V DC to 18V DC                                     |
| Switching frequency                                          | : | 200KHz $\pm$ 10%                                     |
| Total power output                                           | : | 15W                                                  |
| Outputs                                                      | : | +6V $\pm$ 5% 0.1 to 1.3A<br>-6V $\pm$ 5% 0.1 to 1.3A |
| Line regulation (+6 output)                                  | : | 0.05%/V                                              |
| Load regulation (+6 output)                                  | : | 0.2%/A                                               |
| Efficiency (@ 1/2 load)                                      | : | 76%                                                  |
| Output ripple @ max load +6V, -6V outputs: 50mV peak to peak |   |                                                      |

Fig. 1



CIRCUIT DESCRIPTION

The DC input is chopped at a high frequency (200KHz). This high switching frequency allows the use of a very small transformer.  
Due to the push-pull configuration of the converter the POWER MOS devices, the transformer and the diodes work at the frequency of 100KHz (photo 1, 2); the output filters and the oscillator of PWM controller work at a frequency of 200 KHz (photo 3).

When Tr2 is on and Tr3 is off, diodes D2, D3 conduct and diodes D1, D4 are off. When Tr3 is on and Tr2 is off diodes D1, D4 conduct and diodes D2, D3 are off.  
The snubber formed by C5, R17 is used to clamp the voltage spikes on Tr2 and Tr3 drains. With a leakage inductance  $L_d = 0.5\mu H$ , a primary current  $I_p = 2.8A @ V_{IN MIN}$  and maximum load and an allowable voltage spikes  $V_p = 30V$  we can calculate



C5 as follows:

$$C5 = \frac{L_d \cdot I_p^2}{(2V_{MIN} + V_p)^2 - (2V_{IN})^2} = 1.8nF \quad \text{Eq. 1}$$

The PWM controller SGS352A has the two drive outputs in totem-pole configuration in order to drive the POWER MOS. The feedback signal for the PWM is directly connected to pin (inverted input of error amplifier) from +6V output by the resistive divider R4-R1. The maximum current protection was sensed by Tr1, R9, R8 and is connected to pin 10 (shut-down).

The magnetic coupling of the series inductance in the output filter is very important for good regula-

tion of the voltages. In this way when the load is very different in the two outputs (+6V max load; -6V min load or viceversa) the indirectly regulated output (-6V) has a very stable output voltage (see fig. 2).

The efficiency is excellent: 70% over a wide range (Fig. 3).

The transient response is very fast: about 50ms. Photo 4 shows the transient response of load regulation due to a load variation from 100mA to 1.3A and from 1.3A to 100 mA (+6V output).

Fig. 4 shows the P.C. board (track layout) and the component positions.

Fig. 2

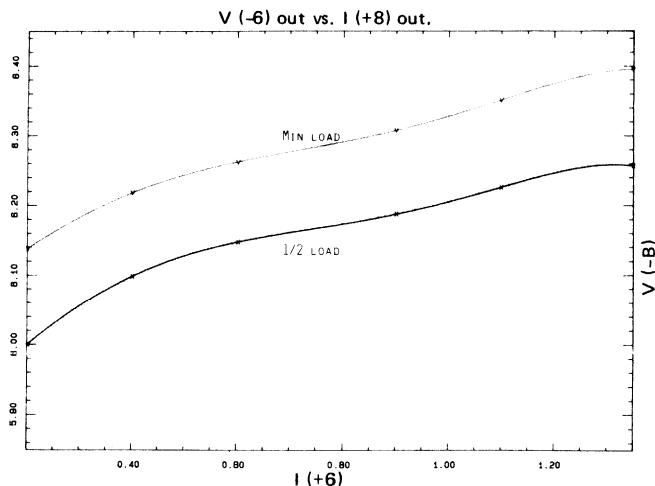


Fig. 3

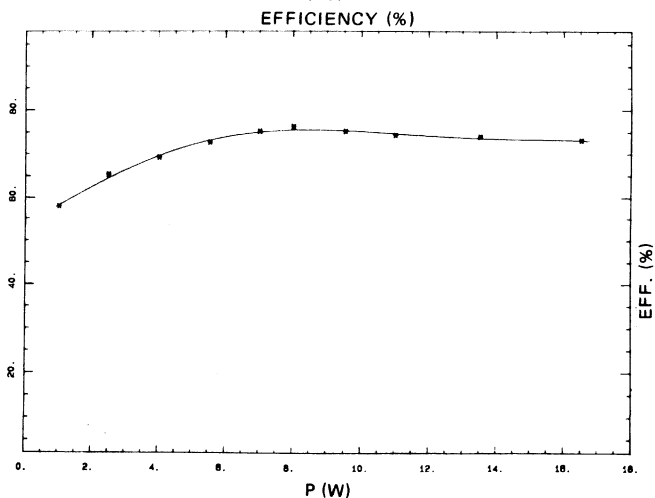
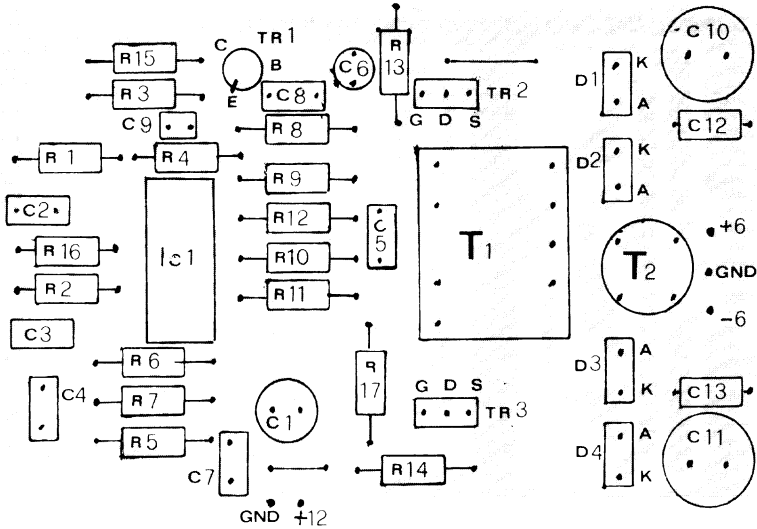


Fig. 4 - P.C. board and components layout (1:1 scale)



## TRANSFORMER

For this design a Tominta E core of 2E 6 ferrite material was chosen. To calculate the core size we used the following equations:

$$A_e \cdot A_n > \frac{10^5 \cdot P_{OUT}}{1.16 \cdot \Delta B \cdot f \cdot d} = 0.143 \text{ cm}^4 \quad \text{Eq. 2}$$

where:

$P_{OUT}$  = output 15 (W)

$\Delta B$  = flux density swing (T) we chose  $\Delta B = 200 \text{ mT}$

$d$  = current density we chose =  $450 \text{ A/cm}^2$

$f$  = working frequency of transformer

$A_e$  = effective area of magnetic path [ $\text{cm}^2$ ]

$A_n$  = useful winding cross section [ $\text{cm}^2$ ]

The core size is then EE  $25 \times 6.5$  with  $A_e = 0.42 \text{ cm}^2$ ,  $A_n = 0.45 \text{ cm}^2$  and  $A_e \cdot A_n = 0.189 \text{ cm}^4 > 0.143 \text{ cm}^4$ .

The maximum value of primary current at  $V_{MIN}$  is:

$$I_p = \frac{P_{OUT}}{\mu \cdot \delta_{MAX} \cdot (V_{MIN} - \Delta V)} = \frac{15}{0.75 \cdot 0.8 \cdot 9} = 2.8 \text{ A} \quad \text{Eq. 3}$$

Where  $\Delta V$  is the voltage drop on the R9 resistor

and on the POWER MOS,  $\delta_{MAX}$  = maximum duty cycle,  $\eta$  = efficiency.

The turns ratio is given by the following equations:

$$n = \frac{V_{prim.}}{V_{sec.}} \cdot \delta_{MAX} = \frac{V_{MIN} - \Delta V}{V_{OUT} + V_f} \cdot \delta_{MAX} = 1.03 \quad \text{Eq. 4}$$

The number of turns  $N_p$  is calculated as follows:

$$N_{p MIN} = \frac{V_{MIN} [V] \cdot \delta_{MAX}}{\Delta B [T] \cdot A_e [\text{cm}^2] \cdot f [\text{Hz}]} \cdot 10^4 = 9.5 \text{ turns} \quad \text{Eq. 5}$$

The number of turns used was  $N_p = 10$  and  $N_s = 10$

The primary inductance is then the same as the secondary inductance.

$$L_p = L_s = N_p^2 \cdot A_L = 100 \cdot 2400 \text{ nH} = 240 \mu\text{H}$$

The value of  $L_d$  (leakage inductance) was measured on the transformer:

$$L_d = 0.5 \mu\text{H}$$

## OUTPUT FILTER

The most interesting part of the output filter is the transformer T2 which, coupling the output series inductance of the two outputs, gives good regulation of the -6V output (magnetic regulator).

T2 construction is very simple because the two inductance are directly wound on the same cylindrical ferrite core. Each winding is made up of 200 turns and is:  $L(+6V) = L(-6V) = 17\mu H$ .

The four fast recovery diodes used are BYW29-100 type.

Capacitors C10, C11 are 220 $\mu F$  Roederstein EKR low ESR type for application in switching power supplies.

The ripple value obtained is very low: 50mV peak to peak (photo 3).

Photo 1 - Tr2, Tr3,  $V_{ds}$  ( $V_{ds} = 20V/div.$ )

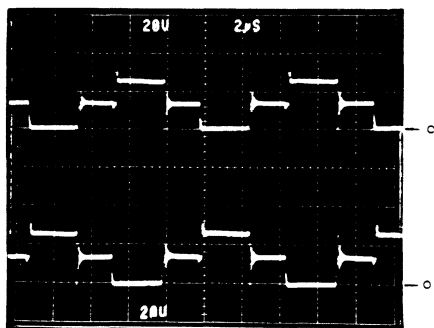
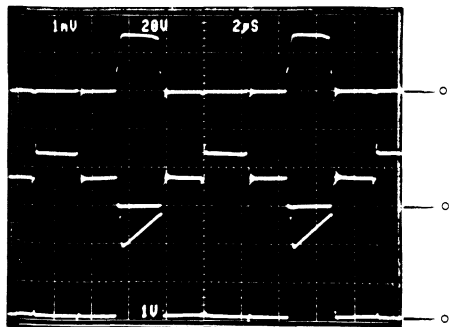


Photo 2 - Tr3 waveforms ( $V_G = 10V/div$ ,  $V_{ds} = 20V/div$ ,  $I_d = 1A/div.$ )



## COMPONENT LIST

### Resistors

|     |   |               |      |
|-----|---|---------------|------|
| R1  | = | 8.2K          | 1/4W |
| R2  | = | 5.6K          | 1/4W |
| R3  | = | 1.2K          | 1/4W |
| R4  | = | 1.5K          | 1/4W |
| R5  | = | 1.2K          | 1/4W |
| R6  | = | 470K          | 1/4W |
| R7  | = | 3.3K          | 1/4W |
| R8  | = | 390 $\Omega$  | 1/4W |
| R9  | = | 0.22 $\Omega$ | 1W   |
| R10 | = | 10 $\Omega$   | 1/4W |
| R11 | = | 22 $\Omega$   | 1/4W |
| R12 | = | 22 $\Omega$   | 1/4W |
| R13 | = | 5.6K          | 1/4W |
| R14 | = | 5.6K          | 1/4W |
| R15 | = | 18 $\Omega$   | 1/4W |
| R16 | = | 47 $\Omega$   | 1/4W |
| R17 | = | 33 $\Omega$   | 1/2W |

### Capacitors

|     |   |             |
|-----|---|-------------|
| C1  | = | 100 $\mu F$ |
| C2  | = | 1nF         |
| C3  | = | 1 $\mu F$   |
| C4  | = | 10nF        |
| C5  | = | 1.8nF       |
| C6  | = | 2.2 $\mu F$ |
| C7  | = | 10nF        |
| C8  | = | 2.7nF       |
| C9  | = | 10nF        |
| C10 | = | 220 $\mu F$ |
| C11 | = | 220 $\mu F$ |
| C12 | = | 330nF       |
| C13 | = | 330nF       |

### Transistors

|          |   |        |
|----------|---|--------|
| TR1      | = | 2N2907 |
| TR2, TR3 | = | IRFZ20 |

### Diodes

|                |   |             |
|----------------|---|-------------|
| D1, D2, D3, D4 | = | BYW2929-100 |
|----------------|---|-------------|

### ICs

|    |   |          |
|----|---|----------|
| I1 | = | SGS3525A |
|----|---|----------|

### Transformers

|         |   |                              |
|---------|---|------------------------------|
| T1 core | = | TOMITA EE 25 $\times$ 6.5    |
|         |   | 2E6 Material                 |
| T2 core | = | cylindrical 30 $\times$ 20mm |

Photo 2a - Turn ON

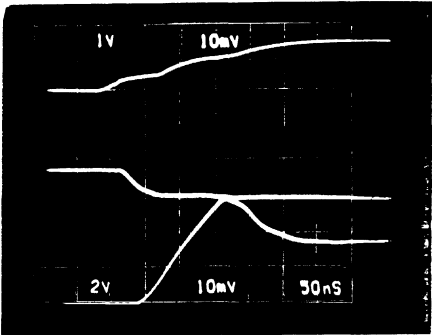


Photo 2b - Turn OFF

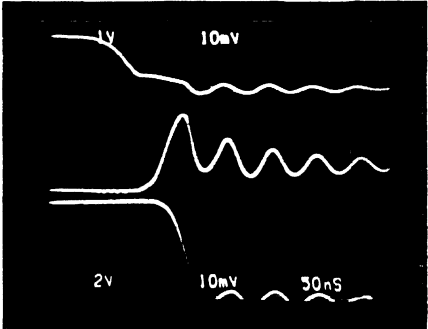


Photo 3 - Ripple on +6V and -6V outputs (20mV/div.)

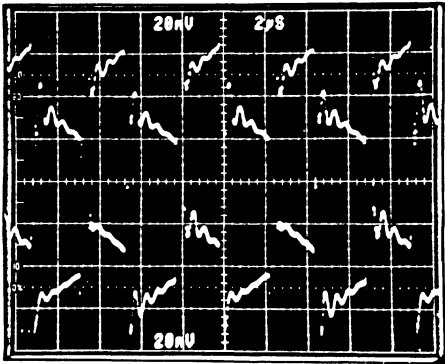
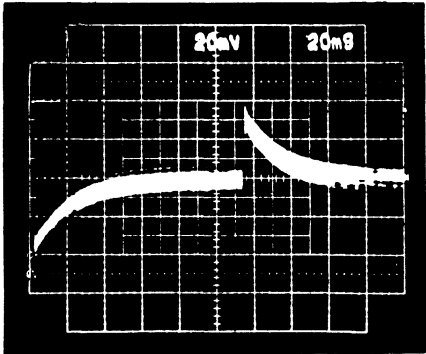


Photo 4 - Transient response (20mV/div)



## DRIVE CIRCUIT FOR AN ELECTRIC FUEL CUT-OFF VALVE

### INTRODUCTION

The circuit described in this application note has been designed to drive the solenoid of an electric valve. The solenoid has the following characteristics:

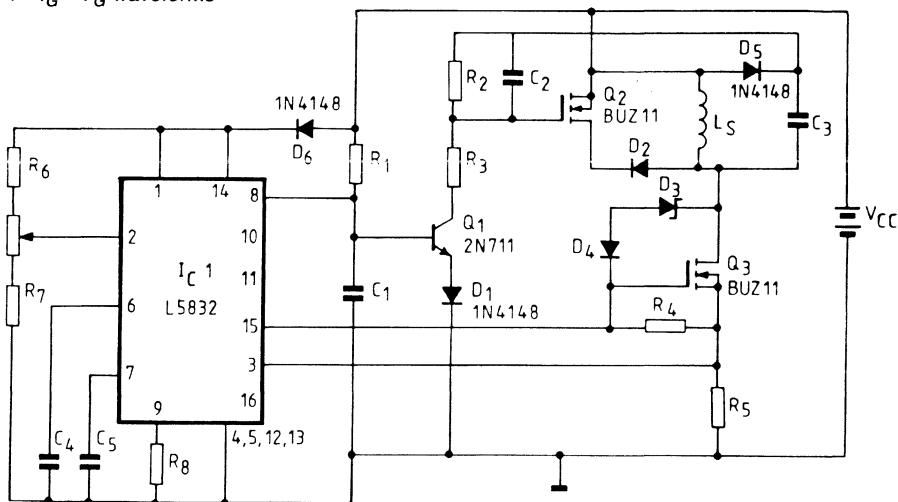
|            |   |                 |
|------------|---|-----------------|
| $L_S$      | = | 2mH @ 1 KHz     |
| $R_S$      | = | 0.62 $\Omega$   |
| $I_{pull}$ | = | 38A per 100msec |
| $I_{hold}$ | = | 5A              |

### CIRCUIT DESCRIPTION

The problem this circuit, figure 1, sets out to resolve is to produce an initial current peak of 38A for 100 milliseconds followed by a continuous reduced holding current of 5A.

This design note uses the features of the L5832 together with two external power transistors, both the peak and the holding current level are regulated by the switchmode circuitry of the L5832. The

Fig. 1 -  $I_G$  -  $V_G$  waveforms



5U-1473

### COMPONENT LIST (See Fig. 1)

|             |            |     |                   |       |                    |
|-------------|------------|-----|-------------------|-------|--------------------|
| C1          | 4.7nF      | D3  | $V_Z = 24V, 1W$   | R5    | 0.01 $\Omega$      |
| C2          | 15nF       | IC1 | L5832             | R6    | 15K $\Omega$ 1/2W  |
| C3          | 1 $\mu$ F  | P1  | 100 $\Omega$      | R7    | 56 $\Omega$ 1/2W   |
| C4          | 8 $\mu$ F  | R1  | 470 $\Omega$ 1/2W | R8    | 1.2K $\Omega$ 1/2W |
| C5          | 27nF       | R2  | 100 $\Omega$ 1/2W | Q1    | 2N1711             |
| D1-D2-D5-D6 | 1N4148     | R3  | 68 $\Omega$ 1/2W  | Q2-Q3 | BUZ11 or STVHD90   |
| D2          | BYV52PI-50 | R4  | 470 $\Omega$ 1/2W |       |                    |

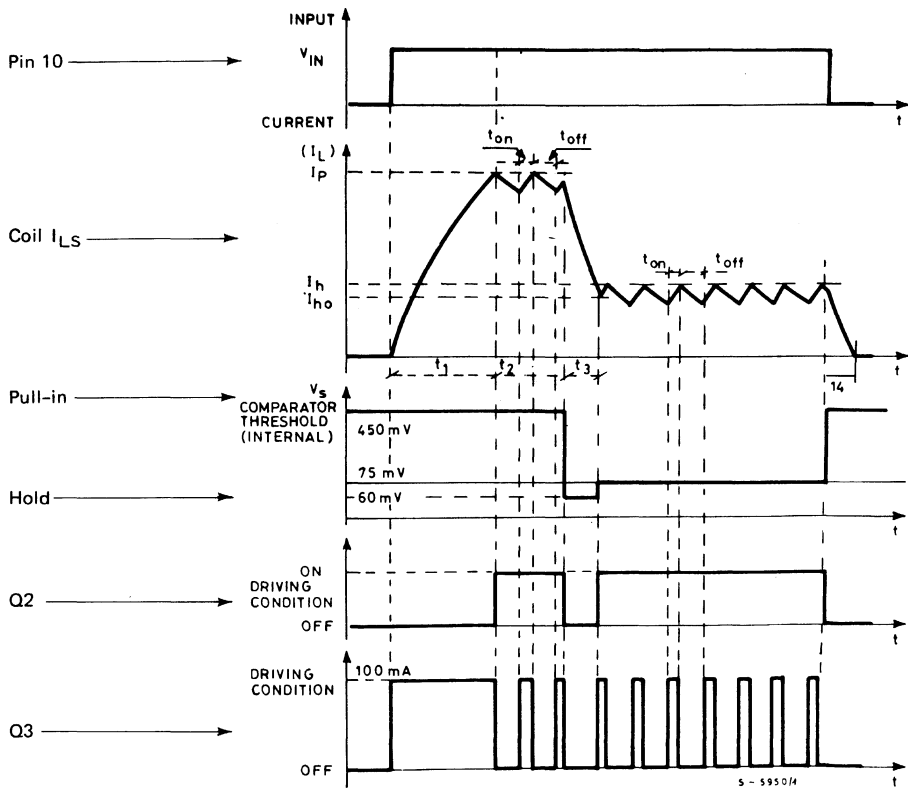
duration of the peak, the peak current level and holding current level are fixed by external components. The power stage consists of two BUZ11 POWER MOS transistors and one BYV52PI-50 high current fast recovery diode. The component list is given in table 1.

CIRCUIT BEHAVIOUR

The operating waveforms are shown in figure 2. Q3 energises the inductive load  $L_S$ . When the current through  $L_S$  reaches  $I_{pull}$ , the L5832 starts to re-

gulate  $I_{LS}$ . During the regulation D2 and Q2 recirculate the  $L_S$  current with a slow  $di/dt$ . A fast transition from  $I_{pull}$  to  $I_{hold}$  is ensured by the action of the zener diode D3 turning on Q3. At  $I_{hold}$  the L5832 starts to regulate  $I_{LS}$  again. Q2 gate is driven by the bootstrap circuit C3, D5, R2 and C2. Q1 ensures that Q2 is off when the current decreases from  $I_{pull}$  to  $I_{hold}$ . The figures 4 and 5 show the circuit behaviour. Figure 5 has a faster time-base than figure 4 this enable it to show the PWM control of solenoid or coil current.

Fig. 2 - Operating waveforms



CONCLUSION

At high current, when the current supplied by the L5832 is insufficient to drive bipolar darlington transistors, the circuit proposed offers a solution to the

dilemma. If current regulation is not too important (steeper ramp, i.e. increased ripple) it is possible to simplify the driving of Q2 and reduce the number of external components as in figure 3.

Fig. 3 - Simplified driving of Q2

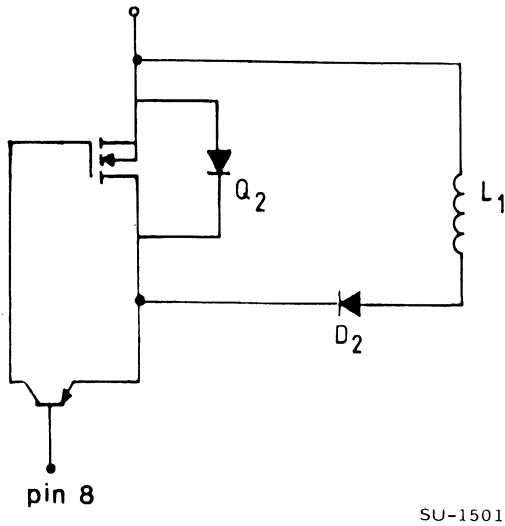


Figure 4

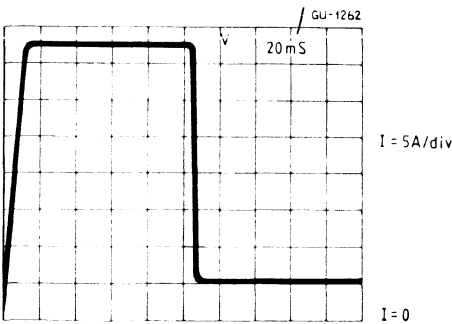
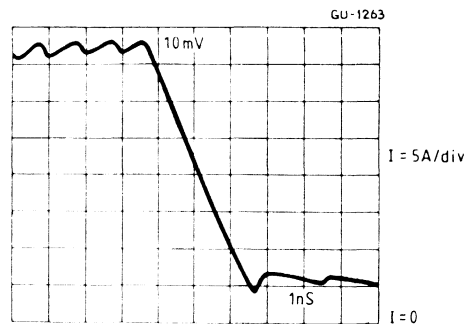


Figure 5



The power lost in power devices is:

**At 38 Amp ( $I_{pull}$ )**

$$\left. \begin{aligned} P_{Q2} &= 2 \times 38 = 76W \\ P_{D2} &= 0.8 \times 38 = 30.4W \\ P_{Q3} &= 2 \times 38 = 76W \end{aligned} \right\} \text{ per 100msec.}$$

**At 5Amp ( $I_{hold}$ )**

$$\begin{aligned} P_{Q2} &= 1.2 \times 5 = 6W \\ P_{D2} &= 0.8 \times 5 = 4W \\ P_{Q3} &= 0.4 \times 5 = 2W \end{aligned}$$





## NOVEL PROTECTION AND GATE DRIVES FOR MOSFETs USED IN BRIDGE-LEG CONFIGURATIONS

### INTRODUCTION

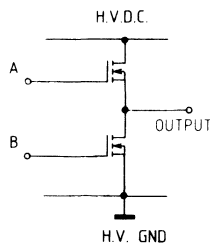
The bridge-leg is an important building block for many applications such as drives and switch-mode power supplies. Simple gate drives with protection for POWER MOSFETs need to be designed for the "low-side" and the "high-side" switches in the bridge-leg. The POWER MOSFET can conduct a peak drain current,  $I_D$ , which is more than three times its continuous current rating. The POWER MOSFET peak current capability and its linear operating mode are used to good effect in designing device protection circuitry.

Bridge-leg configurations have a direct bearing on the degree of protection that can be incorporated. Consequently, bridge-leg configurations, protection concepts and gate drives are created simultaneously to design optimised and reliable power electronic circuits.

### H-BRIDGE USING POWER MOSFETs

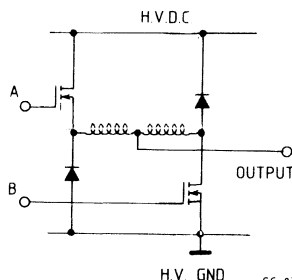
Three POWER MOSFET based bridge configurations are illustrated in figure 1. Figure 1a illustrates a bridge-leg which uses the internal parasitic diode as a free-wheeling diode thus reducing cost. However, since the reverse recovery of this parasitic diode is in the order of a microsecond, the turn-on switching times of the POWER MOSFET have to be increased in order to reduce the reverse recovery current. The turn-on time of the POWER MOSFET is controlled such that pulse current rating of the internal diode is not exceeded. Hence a compromise is made between maintaining the safe operating area of the MOSFET and reducing turn-on switching losses. For example, an SGSP477 MOSFET has a diode pulse current rating in excess of 80 A and a typical diode reverse time of 300 ns. A rate of change of current at turn-on, limited to  $50A/\mu s$ , is a realistic compromise between reverse recovery current magnitude and turn-on losses. Consequently switching speed is sacrificed for cost. For switching frequencies up to 10kHz, when operating on a 400 V DC high voltage rail, this configuration can be chosen as switching losses are limited, thus enabling a realistic thermal design.

Fig. 1 - Bridge configurations



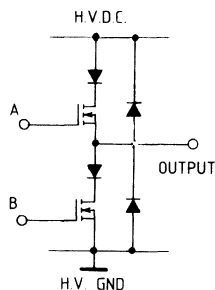
SC-0323

a) Bridge-leg using internal parasitic diode



SC-0324

b) Asymmetrical bridge-leg providing di/dt protection



SC-0325

c) Bridge-leg with blocking diodes

The turn-off speed of the POWER MOSFET in this configuration has no restrictions. Thus a fast turn-off is desirable to reduce turn-off losses. As the rate of change of current is limited, radio frequency interference (RFI) and electromagnetic interference (EMI) are reduced.

An asymmetrical bridge-leg, illustrated in figure 1b; can be used to limit  $di/dt$  during a short-circuit condition thus providing sufficient time to switch-off the appropriate power devices. The inductors limit the rate of rise of output current. They also limit the free-wheeling current through the internal parasitic diodes of the MOSFETs. Adding external free-wheel diodes and inductors increases reliability at the cost of increased complexity. The inductors reduce RFI and EMI as the rate of change of current is limited.

The configuration illustrated in figure 1c has Schottky "blocking" diodes to prevent current going through the MOSFET internal parasitic diodes. Schottky diodes are often used since conduction losses are kept to a minimum.

Bridge configurations shown in figure 1b and 1c are considered for high frequency switching applications. The advantage of the asymmetrical bridge-leg configuration over the bridge configurations in figures 1a and 1c is that the bridge-leg is capable of withstanding simultaneous conduction of the two devices in the bridge-leg since there are series inductors which reduce the  $di/dt$  under this condition. Hence the short-circuit detection loop time is not so critical and the devices are not stressed with high  $di/dt$  and high pulse currents.

The choice of the bridge configuration depends on the technical specification of the application. For example, if the technical specification for a specific application can be met by using the configuration shown in figure 1a, then this configuration should be used as costs are lower than with the other two configurations shown in figures 1b and 1c.

## GATE DRIVE CIRCUITS

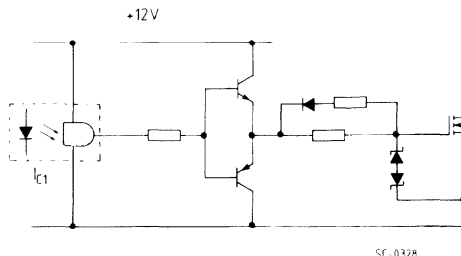
The POWER MOSFET is a voltage controlled device, unlike the bipolar transistor which requires a continuous base drive. An application of a positive voltage between the gate and the source results in the device conducting a drain current. The gate to source voltage sets up an electric field which modulates the drain to source resistance. The following precautions should be considered when designing the gate drive;

- 1 - Limit  $V_{GS}$  to  $\pm 20V$  maximum. A gate to source voltage in excess of 16V has a marked effect on the lifetime of the device.

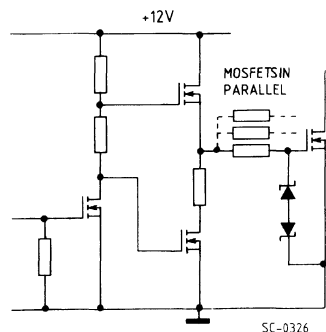
- 2 - Gate drive parasitic inductance can cause oscillations with the MOSFET input capacitance. This problem becomes more pronounced when connecting devices in parallel.
- 3 - There should be sufficient gate to source voltage for the transistor to be fully conducting.

Fig. 2 - Gate drive circuits

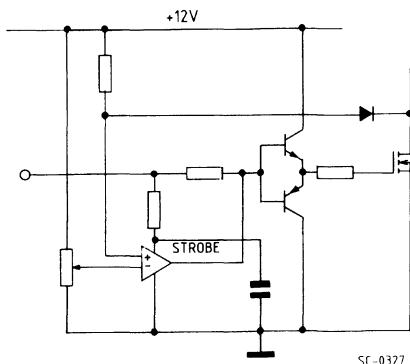
- a) Isolated gate drive with controllable switching times



- b) Simple gate drive for N-Channel MOSFETs in parallel



- c) Gate drive with  $V_{DS(on)}$  control for short-circuit protection



Bipolar, MOSFET, CMOS or open-collector TTL logic can be used in the design of simple high performance gate drives. Totem-pole buffers, (figure 2a), are often effectively used to control the turn-on and turn-off individually. Figure 2b illustrates a total MOSFET based gate drive with which the switching speeds at turn-off can be individually controlled. CMOS or open-collector TTL logic can be used to drive MOSFETs directly, provided an ultrafast switching speed ( $\leq 50\text{ns}$ ) is not necessary. In motor drive applications switching speeds of 100 to 200 nanoseconds are sufficient as switching frequency is seldom in excess of 50kHz. Discrete buffers are used to provide high current source and sinking capability when improved switching speeds are required or when MOSFETs are connected in parallel.

Short-circuit protection techniques similar to bipolar transistors may be considered for MOSFETs.

$V_{DS(on)}$  monitoring permits the detection of short-circuit conditions which lead to device failure. The device can be switched off before the drain current reaches a value in excess of the peak pulse current capability of the MOSFET. This form of protection is very effective with MOSFETs as they can sustain a pulse current in excess of three times the nominal continuous current. Figure 2c illustrates a gate drive which incorporates  $V_{DS(on)}$  monitoring and linear operating mode detection for the MOSFET in the case of short-circuit conditions. When the MOSFET is turned on the on-state voltage of the device ( $V_{DS(on)}$ ) is compared with a fixed reference voltage. At turn-on,  $V_{DS(on)}$  monitoring is inhibited for a period of approximately 400ns in order to allow the MOSFET to turn-on fully. After this period, if  $V_{DS(on)}$  becomes greater than the reference value, the device is latched-off until the control signal is turned-off and turned-on again.

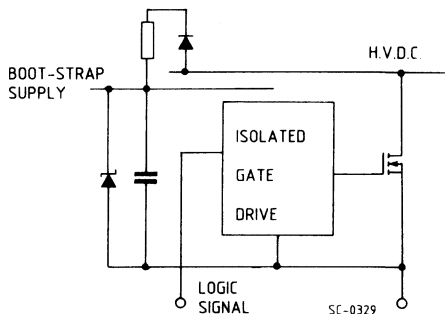
### "HIGH-SIDE" SWITCH GATE DRIVES

The top transistor in a bridge-leg requires a "high-side" gate drive circuit with respect to the bridge ground. Three possible gate drive concepts are shown in figure 3:

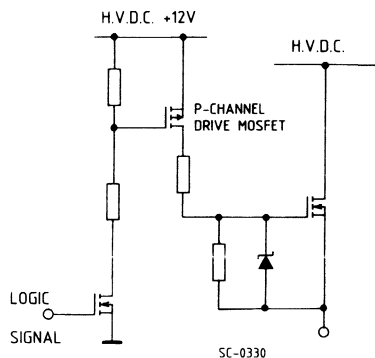
- The "bootstrap" drive, requiring logic signal isolation, but no auxiliary floating supply.
- The level shifting drive.
- The floating gate drive with optically coupled isolators, pulse transformers or DC to DC chopper circuit with transformer isolation.

Fig. 3 - Gate drives for top transistor of inverter leg.

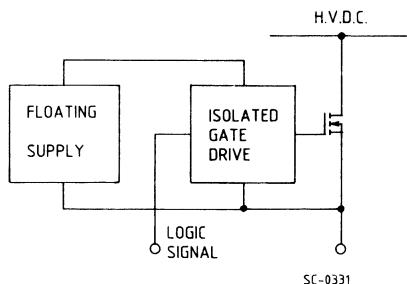
a) "Bootstrap" supply floating gate drive.



b) Level shifting gate drive.



c) Floating supply isolated gate drive.



Bootstrap supplies are particularly well suited for POWER MOSFET gate drives which require low power consumption. Figure 4 illustrates two bootstrap supply techniques. Bootstrap supplies limit transistor duty cycle since they require a minimum transistor off time during which they are refreshed.

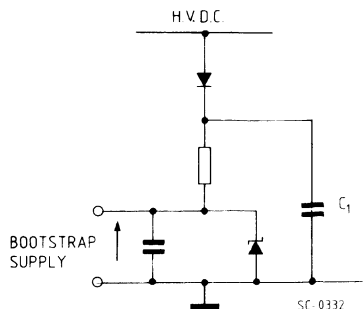
Supply efficiency and maximum duty-cycle are parameters which govern the design of the bootstrap. Figure 4a illustrates a conventional bootstrap with an additional capacitor,  $C_1$ , which improves the maximum duty cycle as the supply is refreshed even during transistor on time by this capacitor. Figure 4b illustrates a high efficiency bootstrap supply which uses a small MOSFET, Q1, for regulation. In this design a low power bootstrap drives the gate of Q1.

The level shifting gate drive, (figure 3b), requires a high voltage p-channel MOSFET which drives the n-channel power device. The p-channel MOSFET is switched using a resistor divider network. No floating supplies are required. A power supply of 12V, referenced to the high voltage d.c., is used to provide positive gate source voltage for n-channel POWER MOSFET. This circuit eliminates the need for logic signal isolation and a floating supply. The disadvantage of this circuit is the high cost of the p-channel drive MOSFET.

Figure 3c illustrates a floating gate drive with a floating supply. This drive is the most expensive out of the three shown in figure 3. However, the floating supply need only have a low output power, since MOSFETs are voltage controlled devices. The advantages of this drive are its high efficiency and unrestricted transistor duty-cycle.

Fig. 4 - Bootstrap supply techniques

a) Conventional bootstrap with additional capacitor  $C_1$ .



b) High efficiency bootstrap.

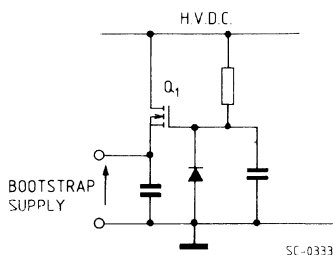
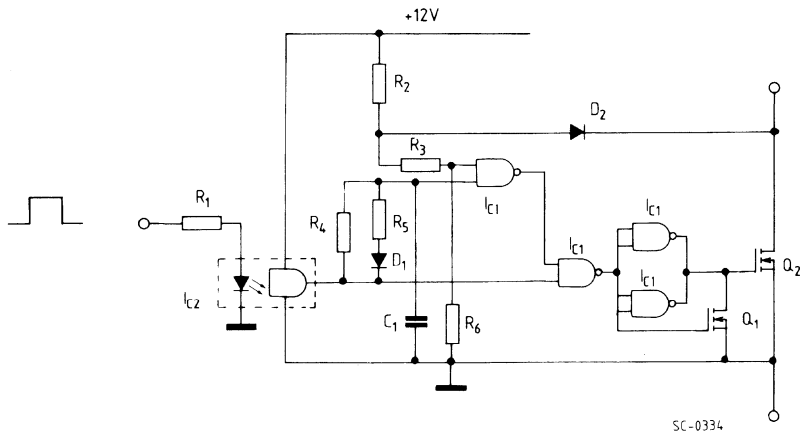


Fig 5 - Isolated CMOS drive with  $V_{DS}$  control for short-circuit protection



R1 = Dependent on application  
R2 = 10kΩ  
R3 = 22kΩ

R4 = 1kΩ  
R5 = 120Ω  
R6 = 56kΩ  
 $I_{C1}$  = HCF4093

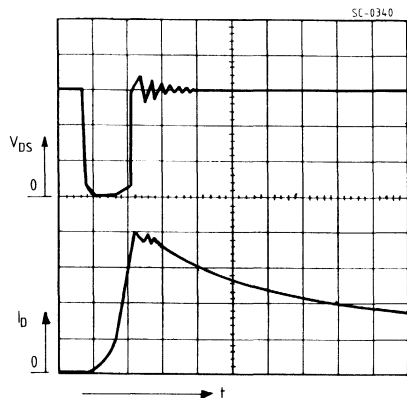
$I_{C2}$  = HCPL2200  
C1 = 560 pF  
D1 = 1N4148  
D2 = BYT11/600

Q1 = BSS100  
Q2 = SGSP477

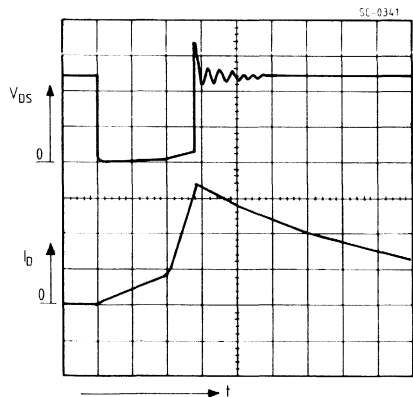
Fig. 6 - Short-circuit conditions for an SGSP477  
 $V_{DS}$  &  $I_D$

$V_{DS}$ : 50V/DIV  
 $I_D$ : 10A/DIV  
 $t$ : 2 $\mu$ s/DIV

a) Output to high voltage short-circuit



b) Output to output short circuit



## PROTECTION

Power electronic circuits such as bridge-legs are often required to have protection against output to output short-circuit, over-temperature, simultaneous conduction of devices in series in a bridge-leg and output to high voltage supply or ground rail short-circuit. These power stages are generally part of an expensive system such as a machine-tool or a robot motor drive. Thus the additional cost of protection circuitry is commercially acceptable. A com-

promise is generally reached between equipment costs and the degree of protection required.

Short-circuit protection of a power MOSFET can be achieved by either  $V_{DS(on)}$  monitoring or a current image. In the previous section gate drives using the  $V_{DS(on)}$  monitoring technique were presented. Figure 6 illustrates the MOSFET drain to source voltage,  $V_{DS}$ , and the drain current,  $I_D$ , when short-circuits are experienced by the POWER MOSFET, SGSP477, driven by the gate drive illustrated in figure 5.

The MOSFET is turned-off when the drain current increases sufficiently and  $V_{DS(on)}$  monitoring is inhibited for a period of 400ns to allow the device to turn-on fully.

An inductor is used in series with the device, as illustrated in figure 1b. This inductor saturates when a large short-circuit current flows. The rate of change of the short-circuit current due to the saturation of this inductor is illustrated in figure 6a and 6b. Figure 6a illustrates the POWER MOSFET drain to source voltage,  $V_{DS}$ , and the drain current,  $I_D$ , when a bridge-leg output to high voltage supply rail short-circuit occurs. Figure 6b illustrates an output to output short-circuit of two bridge-legs.

Another protection technique uses the "current mirror concept", (1). An image of drain current is obtained by having a small MOSFET, (integral or discrete), in parallel with the main power MOSFET as illustrated in figure 7.

Fig. 7: The current mirror.

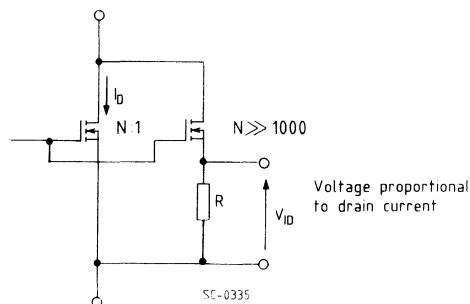
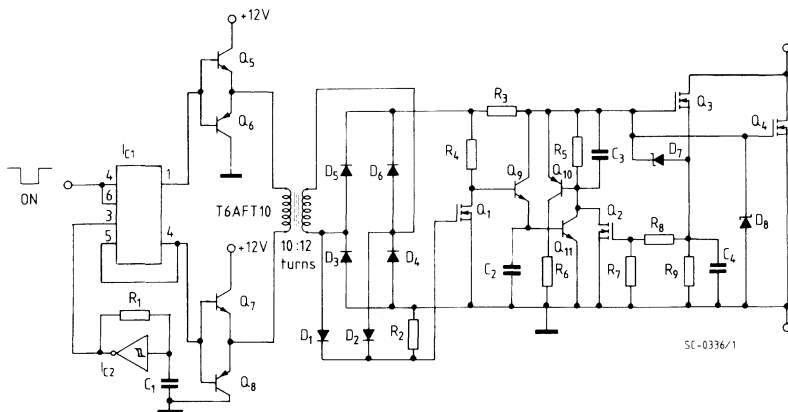


Figure 8 illustrates a floating gate drive which utilizes a pulse transformer for transmitting simultaneously the MOSFET on-signal together and the gate to source capacitance charging current. The current mirror technique is used to provide short-circuit and over-load current protection. The pulse transformer operates at an oscillating frequency of 1MHz when a turn-on control signal is present.

The secondary is rectified to provide the gate source capacitance charging voltage. The current mirror provides a voltage "image" of the main MOSFET drain current. This voltage is compared with a fixed reference voltage in order that the gate

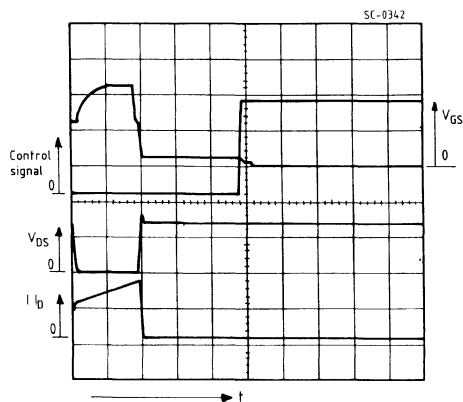
drive be latched-off when the drain current becomes in excess of a specified value. Figure 9 illustrates how the MOSFET, SGSP477, is latched-off when the drain current exceeds 10A with this gate drive circuit.

Figure 8: Pulse transformer gate drive with current mirror protection for an SGSP477.



|           |             |                |              |
|-----------|-------------|----------------|--------------|
| R1 = 470Ω | R9 = 100Ω   | D4 = 1M4148    | Q4 = SGSP477 |
| R2 = 1kΩ  | C1 = 330pF  | D5 = 1M4148    | Q5 = BC337   |
| R3 = 33Ω  | C2 = 10nF   | D6 = 1M4148    | Q6 = BC327   |
| R4 = 2kΩ  | C3 = 10nF   | D7 = BZX85C15  | Q7 = BC337   |
| R5 = 100Ω | C4 = 220pF  | D8 = BZX85C15V | Q8 = BC327   |
| R6 = 100Ω | D1 = 1M4148 | Q1 = BSS100    | Q9 = BC337   |
| R7 = 100Ω | D2 = 1M4148 | Q2 = BSS100    | Q10 = BC327  |
| R8 = 100Ω | D3 = 1M4148 | Q3 = BSS100    | Q11 = BC337  |

Fig. 9 - Overload current protection using current mirror concept with the gate drive of figure 8 for an SGSP477.



Time scale: 5μs/DIV - ID: 5A/DIV - VDS: 100V/DIV  
Control signal: 5V/DIV - VGS: 5V/DIV

## CONCLUSION

MOSFET based bridge-leg configurations requiring protection and floating gate drives have been presented. Novel self-protecting gate drives for the "high-side" and "low-side" switching have been discussed. These drives provide protection against output to high voltage d.c., output to ground and output short-circuit. For the high-side switch "bootstrap" supply gate drive, level shifting gate drive and floating supply isolated gate drives have been compared.

Protection against short-circuit conditions has been demonstrated using  $V_{DS(on)}$  monitoring and the current mirror concept. Both techniques are well suited for protection against short-circuit conditions. However, the current mirror concept also provides a sufficiently linear image of the current for regulation.

## REFERENCES:

- Fuy G.
- Current-mirror FETs cut costs and sensing losses EDN September 4 th, 1986

## HIGH VOLTAGE POWER MOSFET STHV102

### INTRODUCTION

This note deals with the basic characteristics and the possible applications of STHV102 POWER MOSFET transistor, rated at 1000 V, 4A.

A completely new configuration for the edge structure has been designed in order to obtain a high breakdown device with characteristics of high reliability. The advantages offered by the static and dynamic characteristics of this device are demonstrated by two applications.

### DEVICE DESCRIPTION

The very first problem to be solved in the design of a POWER MOSFET with  $V_{(BR)DSS} > 1000V$  is to achieve a high breakdown efficiency as defined by the expression:

$$\epsilon = \frac{V_{(BR)DSS}}{V_{(BR)DSS \text{ theoretical limit}}} < 1$$

The ratio,  $\epsilon$ , is the ratio between the actual breakdown voltage of the device and that of an idealised planar junction.

It is well known that the closer  $\epsilon$  is to 1, the more efficient is the edge structure.

The merit coefficient,  $\epsilon$ , is important for any semiconductor device. When conduction occurs by majority carriers, the drain resistance is the output resistance of the POWER MOSFET. So a higher edge efficiency implies the use of a drain epitaxial structure having minimum resistivity and

thickness and consequently a much improved  $R_{DS(on)}$  compared with existing high voltage, POWER MOSFETs.

The edge structure designed for this class of device is shown in figure 1a - 1b (See page 2).

It is planar, having a graded impurity concentration in the silicon combined with a metal field plate on the surface.

When the device is subjected to a high voltage, the equi-potential lines are accurately spaced as a result of the graded p type region minimizing the electric field strength at the surface.

The very low value of the surface electric field makes the devices insensitive to the surface conditions, allowing significant reliability improvement (see fig. 1b).

The STHV102 is the first POWER MOSFET commercially produced using the structure described. Its dimensions are  $(180 \times 220)$  mils<sup>2</sup>; the photos 1 and 2 show its static characteristics: the resistance of this device is typically 2.5 ohm with a value of  $R_{on} \times \text{Area} = 0.64 \text{ ohm cm}^2$  which represents a notable achievement.

Photo 1 shows the breakdown characteristics after 1000 hours of HTRB testing, and is indicative of its highly reliable structure.

Fig. 2 shows the variation of the leakage current  $I_{DSS}$  after 1000 hours of HTRB test: the alignment to the line shows the high stability achieved using the graded ring structure.

Fig. 1a - Cross section of the new graded edge structure

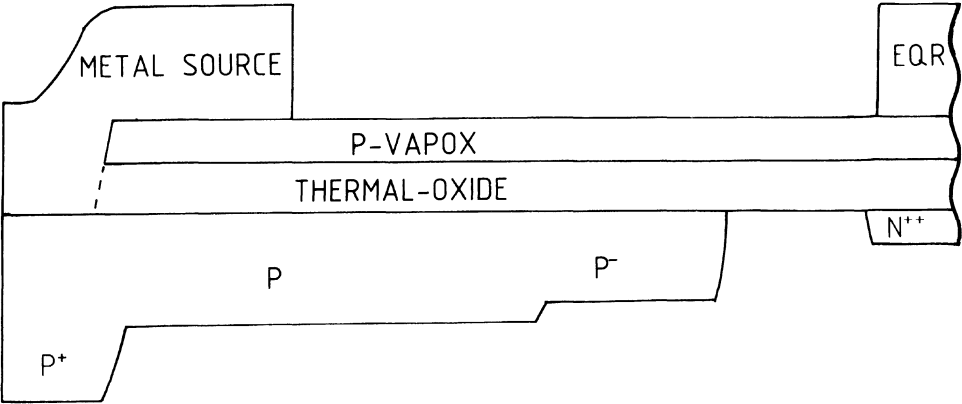


Fig. 1b - Electric field diagram illustrating the low surface electric field

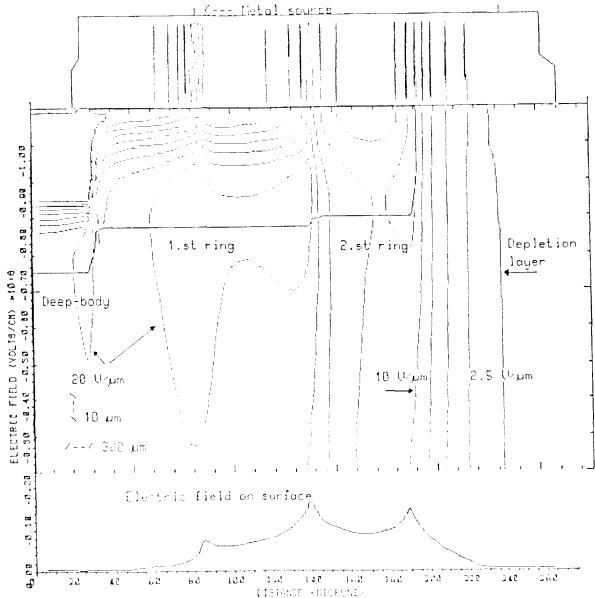




Photo 1 - Breakdown voltage after 1000hrs of HTRB.  $V_{DS} = 200V/div$

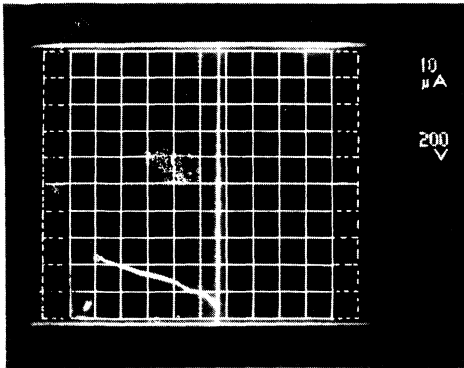


Photo 2 - Output characteristics  $I_D = 0.5A/div$ ,  $V_{DS} = 2V/div$ . STHV102 static characteristics

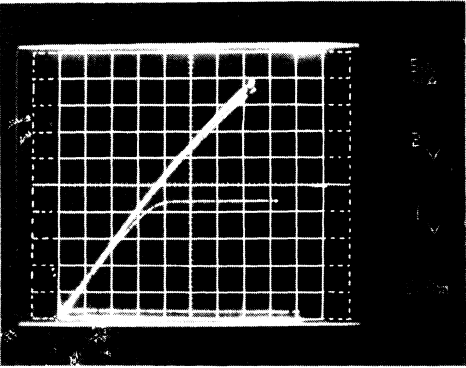


Fig. 2 - Graph showing the effect on drain source leakage current,  $I_{DSS}$  of 1000hrs HTRB testing

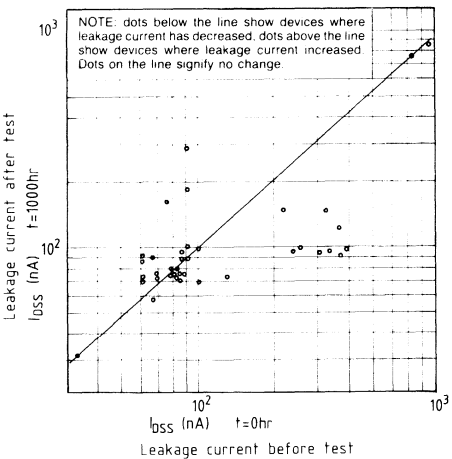
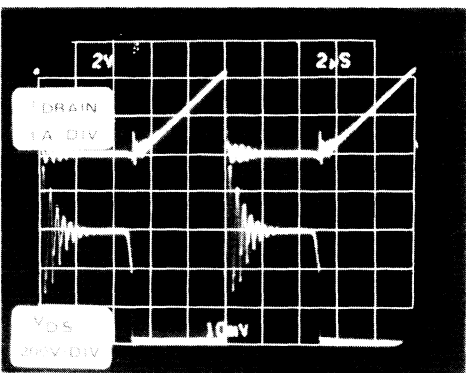


Photo 3 - Drain current and voltage waveforms with  $T_{case} = 80^{\circ}C$



APPLICATIONS

The STHV 102 is ideally suited to applications where high drain voltage, high switching speeds and low drive energy are needed. Typically in high frequency switch mode power supplies and in high resolution horizontal deflection circuits.

The low value of its input capacitance — a direct result of the optimised edge structure, allows the component to be used in high frequency applications, with very low switching and driving losses.

1. A 150W 100kHz FLYBACK SMPS

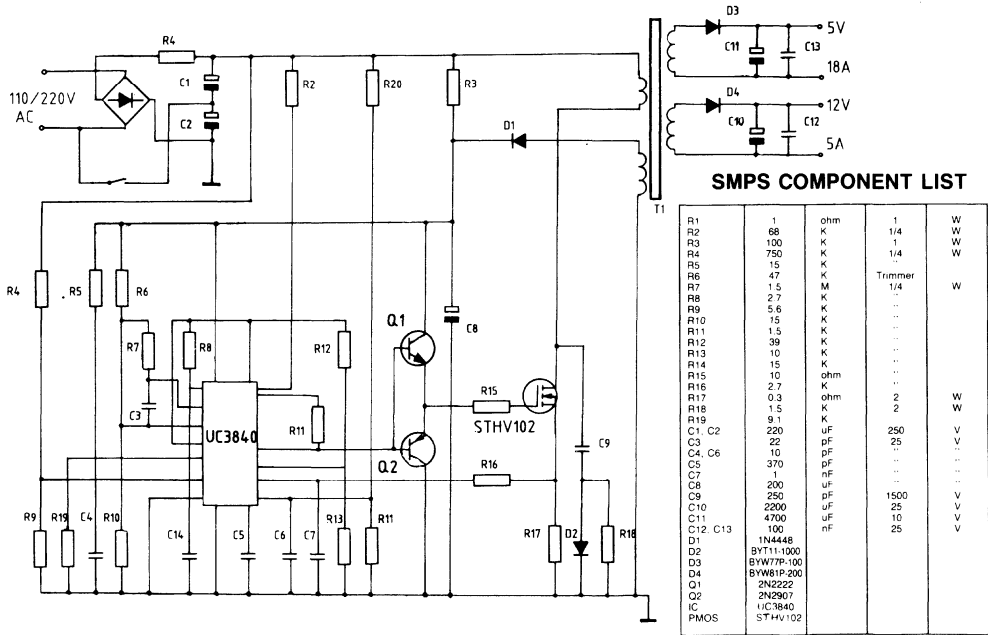
Figure 3 shows the SMPS electrical circuit and the photos 3, 4 and 4 show current and voltage waveforms for the POWER MOSFET.

An analysis of the waveforms gives us a better appreciation of the advantages of this device:

- a) The high drain voltage capability permits minimum snubbing even when the transformer exhibits a high leakage inductance (Photo 3).
- b) The high working frequency shrinks the transformer size and the filter circuit dimensions. Photo 5 shows the small amount of charge needed to turn off the device (120nC), implying that the STHV102 can be easily used also at higher frequencies.

A high performance with a conversion efficiency of 87% at 150W has been achieved with this device.

Fig. 3 - Isolated fly-back Switch Mode Power Supply using a high voltage STHV102 Power MOSFET



Power output : 150W

Frequency : 100kHz

Photo 4 - Drain current at turn-off with  
 $T_{case} = 80^{\circ}C$

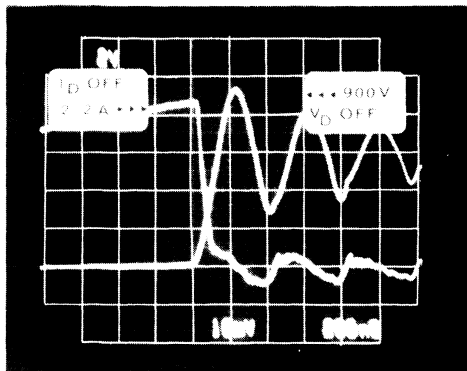
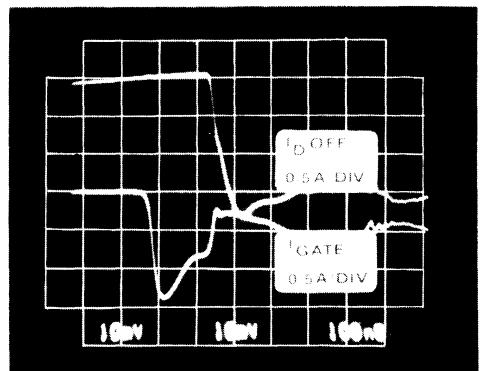


Photo 5 - An indication of gate charge ( $Q = it$ ) for  
 STHV102 turn-off



The importance of using high voltage POWER MOSFETs in SMPS designs is also illustrated by the reduced size and cost of other components and in lower power dissipation in the snubber network. By comparing similar flyback circuits using a power darlington in one and a POWER MOSFET in the other, as the switching element, shows the following savings.

|                         | Darlington           | POWER MOSFET        |
|-------------------------|----------------------|---------------------|
| Switching frequency     | 30kHz                | 100kHz              |
| Transformer volume      | 23.3 cm <sup>3</sup> | 6.5 cm <sup>3</sup> |
| Filter capacitor        | 10,000 $\mu$ F       | 3000 $\mu$ F        |
| Snubber capacitor       | 1800pF               | 250pF               |
| Snubber losses          | 7W                   | 3W                  |
| Relative cost of device | 1                    | 4                   |

## 2. HIGH RESOLUTION HORIZONTAL DEFLECTION CIRCUIT.

The use of advanced graphic monitors and the experimentation on telecast systems has resulted in the use of complex horizontal deflection circuits and the requirement for fast and reliable high voltage power transistors.

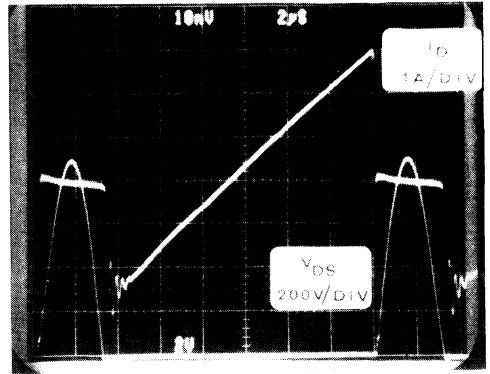
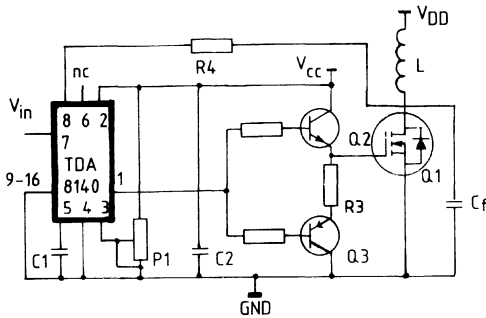
STHV102 represents a good solution, in fact, it brings together the speed of POWER MOSFET devices and a high voltage breakdown (1000 V). In view of this, its application in a 64Khz horizontal deflection circuit has been studied.

Figure 4 shows the electrical circuit.

Photo 6 illustrates the drain current and the drain-source voltage waveforms.

The "negative" region of the drain current is that which flows in the internal source-drain diode of Q1. The fly-back voltage reaches 920V. During operation at  $T_c = 80^{\circ}C$  the device dissipates only 5.5W while generating a 64 KHz, 5A peak-to-peak deflection coil current.

Photo 6 - Drain current and voltage waveforms at  
 $T_{case} = 80^{\circ}C$



#### HIGH RESOLUTION DEFLECTION COMPONENT LIST

|     |         |     |      |   |
|-----|---------|-----|------|---|
| R1  | 47      | ohm | 1/4  | W |
| R2  | 100     | "   | "    | " |
| R3  | 10      | "   | "    | " |
| R4  | 680     | K   | "    | " |
| C1  | 15      | pF  | "    | " |
| C2  | 470     | uF  | 40   | V |
| Q1  | STHV102 |     |      |   |
| Q2  | 2N2222  |     |      |   |
| Q3  | 2N2907  |     |      |   |
| IC1 | TDAB140 |     |      |   |
| L   | 250     | uH  | 1500 | V |
| Cf  | 3.3     | nF  |      |   |
| VDD | 120     | V   |      |   |
| VBB | 12      | V   |      |   |

Fig. 4 - High resolution horizontal deflection circuit  
 using a high voltage Power MOSFET transistor,  
 STHV102

## AN INTRODUCTION TO HIMOS

### INTRODUCTION

The structure and characteristics of HIMOS (High Injection MOS) devices, provide circuit designers with an INSULATED GATE BIPOLAR TRANSISTOR (IGBT) capable of handling high voltages at high current densities. The principle characteristics of these new devices are the simplicity with which they can be driven - similar to a POWER MOSFET - and their low conduction losses when switching high voltages. These characteristics, together with their excellent ruggedness make HIMOS a natural evolution of POWER MOS for high voltage applications. Typical uses for HIMOS transistors are switching circuits requiring high voltage and high current, with a switching frequency in the order of 10kHz to 20kHz.

### THE BASIC STRUCTURE

Figure 1a shows a single cell of the multicell structure of a HIMOS device.

Figure 1b shows the structure of a POWER MOS for comparison. Figures 1c and 1d show two models for the HIMOS structure. The drain region of HIMOS represents the major difference in structure from that of POWER MOSFETs.

This region contains a P<sup>+</sup> doped layer. The presence of the P<sup>+</sup> N junction drastically reduces the on-resistance during conduction because conduction causes holes to be injected into the drain which, in turn, modulates the conductivity of this region. However, the addition of the P<sup>+</sup> layer to the drain also gives rise to a parasitic thyristor structure PNP, created by the NPN - PNP parasitic bipolar structure. In order to avoid the influence of this parasitic thyristor we have designed a modified structure for the device and a new process for its manufacture.

### STATIC ELECTRICAL CHARACTERISTICS

Current flow in HIMOS devices during conduction is shown in figure 2a. The total current,  $I_{DS}$  is the sum of the two currents  $I_c(h)$  and  $I_b(h)$  where: -

-  $I_c(h)$  is the current due to holes injected from the substrate P<sup>+</sup> layer, which are collected on the surface of the source region and

-  $I_b(h)$  is the current due to holes that combine with electron current flowing through the MOS channel in the base region of the PNP bipolar junction transistor, (BJT).

Fig. 1a - HIMOS - Basic structure

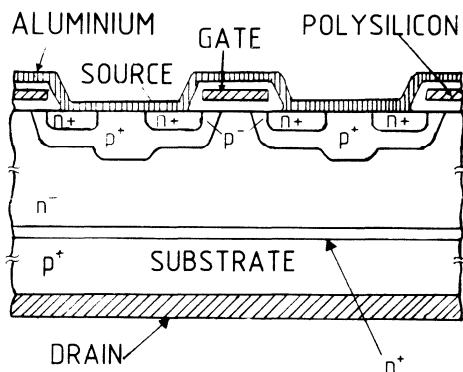


Fig. 1b - POWER MOSFET - Basic structure

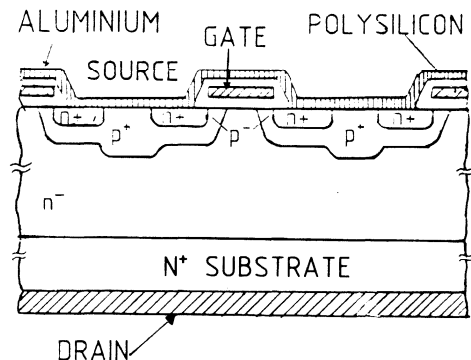


Fig. 1c and 1d - Two electrical models for the HIMOS structure.

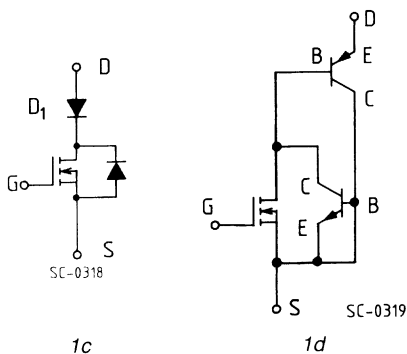
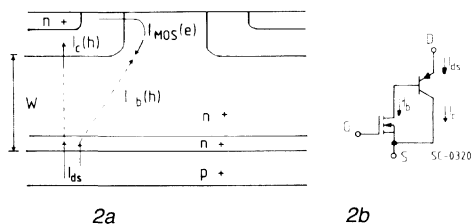


Fig. 2a and 2b - Current flow in HIMOS during conduction



Since MOS behave like a BJT whose base current is provided by a MOSFET, it follows that the drain current of the HIMOS is the sum of the bipolar base and collector currents.

$$I_{ds} \approx I_{mos}(1 + \beta_{PNP}) \quad \text{Eq. 1}$$

These features underlie the advantages of HIMOS devices particularly in respect of their current capability and low  $R_{DS(on)}$  compared with POWER MOS devices. A comparison of the output characteristics of a HIMOS and three POWER MOS transistor with equal chip size but different breakdown voltages is shown in photographs 1-4

The comparison highlights two major points. The first is the difference in the current flowing for a given gate voltage. This shows that HIMOS have a greater current handling capability and a lower  $V_{DS(on)}$  than the equivalent POWER MOS device. The low  $R_{DS(on)}$  is due to conductivity modulation of the substrate caused by high injection of holes from the P+ region.

The presence of the P+N junction in the drain produces an offset in the output characteristics of 0.6V-0.8V. This diode exhibits a reverse breakdown voltage in the range 30V-70V, see Photograph 5.

Photo 1 -  $V_{(BR) DSS} = 100V$

SGSP361

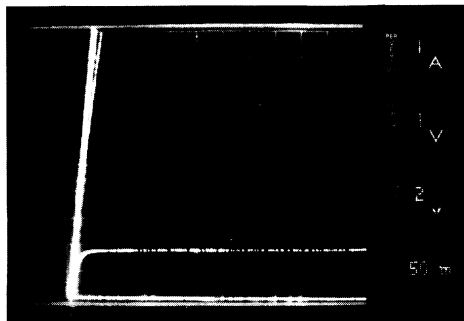


Photo 2 -  $V_{(BR) DSS} = 250V$

SGSP363

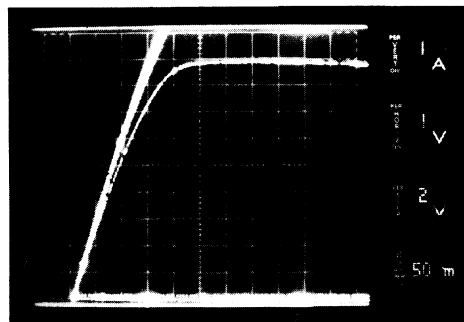


Photo 3 -  $V_{(BR) DSS} = 500V$

SGSP369

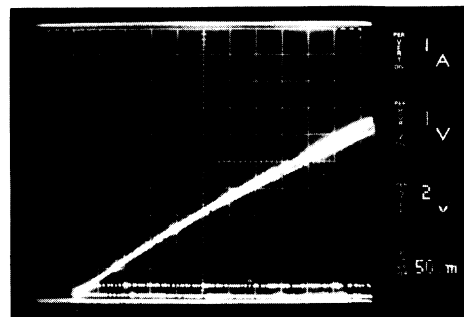


Photo 4 -  $V_{(BR) DSS} = 500V$

STH10N50

Fig. 3 - Test circuit for HIMOS transistors

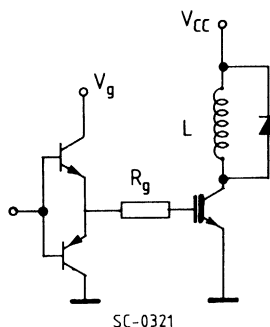
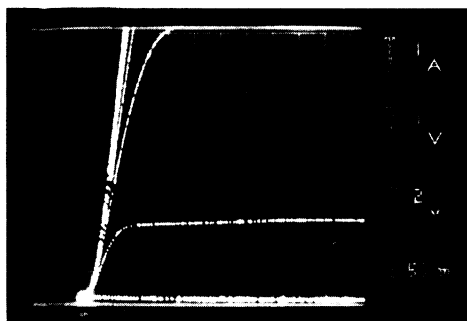
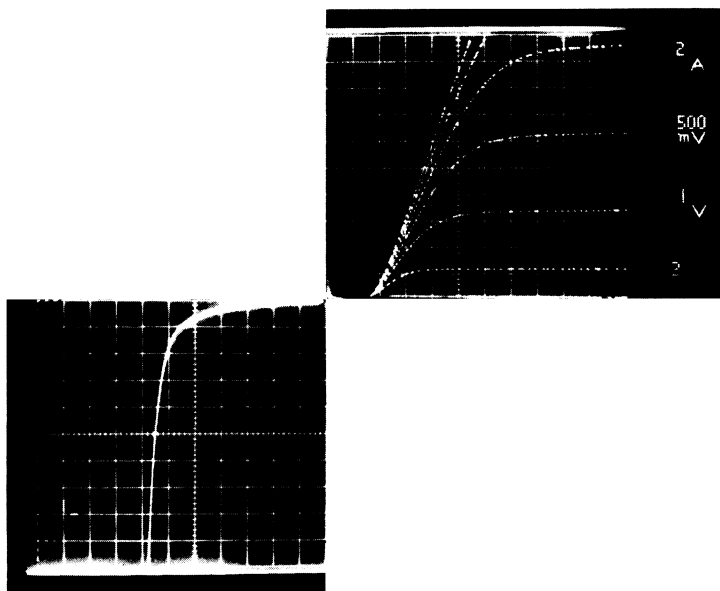


Photo 5 - Output characteristics of a HIMOS device



## SWITCHING CHARACTERISTICS

Figures 1 and 3 show the HIMOS equivalent circuit and the test circuit for evaluating the switching characteristics. When the gate-source voltage,  $V_{GS}$ , is greater than the threshold voltage,  $V_{TH}$ , the MOS section of the structure turns on. The MOS drain current is the base current of the parasitic PNP transistor and it turns on the PNP transistor in about 10nsec. HIMOS turn-on time is a function of the impedance of the driver circuit and the applied gate voltage. Photograph 6 shows typical turn-on waveforms.

## TURN-OFF

Turn-off in HIMOS has typical features of both POWER MOSFET and BJT turn-off due to the use of conductivity modulation for increased current density. Figure 4 shows how the turn-off can be divided into three regions.

During the first phase, I, the gate voltage decreases to a point where the Miller effect begins and  $V_{DS}$  begins to rise. In the second phase the gate voltage is constant - the Miller effect. During this period increasing  $V_{DS}$  decreases the gate capaci-

tance and an inversion of the gate polarity, with respect to the drain voltage occurs as  $V_{DS}$  rises above the gate potential.  $V_{DS}$  increases to a maximum value with a rate controlled by the driver circuit. These two phases, I and II, are dependent on the MOS behaviour as the base collector junction of the PNP transistor is reverse biased. The last region, which defines  $t_{fall}$ , can be divided into two parts. The first part is the MOS turn-off and is very fast. The second is slow and starts when the MOS channel is closed and the PNP transistor has an open base. This terminates turn-off by recombination of excess carriers. The first part of the fall time can therefore be controlled by the gate drive circuit. The second part is dependent on the PNP transistor lifetime and gain.

Photo 6 - HIMOS turn-on wave form

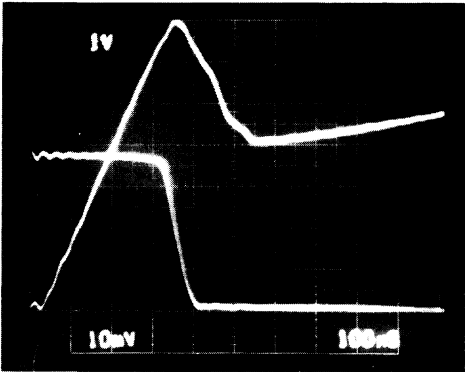


Fig. 4 HIMOS turn-off showing three turn-off regions

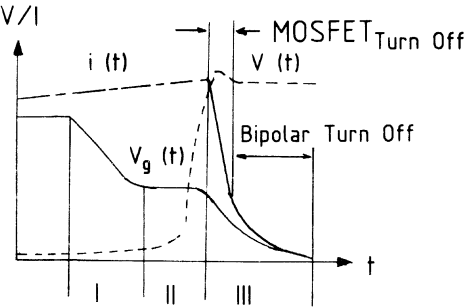


Figure 5 shows how  $t_{fall}$  varies with  $V_{DS}$ . As  $V_{DS}$  increases so the gain of the PNP transistor increases. This is due to the reduction of the base thickness caused by increasing the depletion region. The dependence of  $t_{fall}$  on temperature is shown

in figure 6 and confirms the correlation between  $t_{fall}$  and the PNP transistor gain. The lifetime of the minority carriers in the N<sup>-</sup> region versus  $t_{fall}$  is shown in figure 7.

Fig. 5 - Variation of  $t_{fall}$  with  $V_{ds}$

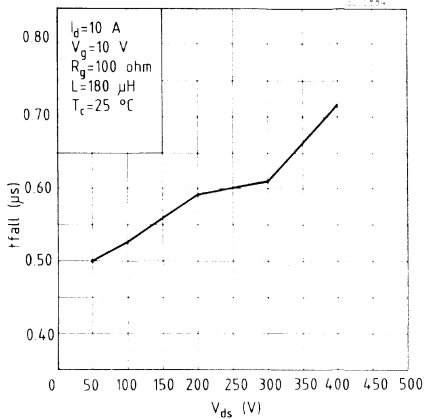
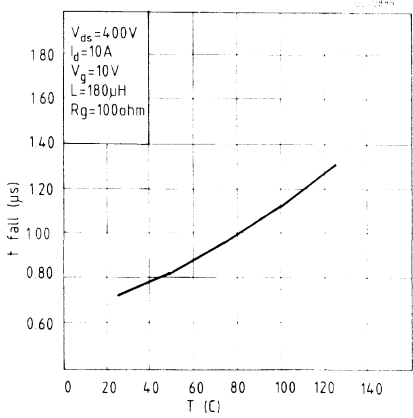


Fig. 6 - Variation of  $t_{fall}$  with temperature



### LATCH-UP AND SAFE OPERATING AREA

The device current begins to loop regeneratively when the total current reaches the latch-up value,  $I_{latch}$ . If the current attains this value then gate control is lost. Looking at figure 1c we have:

$$I_s = [\alpha_{npn} \cdot I_c] / [1 - (\alpha_{npn} + \alpha_{pnp})]$$

where  $\alpha_{pnp}$  and  $\alpha_{npn}$  are the gains of the transistor structures and  $I_i$  is the recombination current. The device enters into a regenerative loop and it fails when  $\alpha_{pnp} + \alpha_{npn} \geq 1$ . In order to redu-



ce  $\alpha_{PNP}$  and  $\alpha_{NPN}$  so that their sum is less than 1, some structural and processing changes in fabrication of the device are necessary. By using appropriate doping and shorting the base-emitter junction (POWER MOSFET body-source) it is possible to reduce  $\alpha_{PNP}$ .  $\alpha_{NPN}$  is reduced by the introduction of a buffer heavily doped with  $N^+$  and the introduction of lifetime killers.

Fig. 7 - Variation of  $t_{fall}$  with the lifetime of the minority carriers in the  $n^-$  region

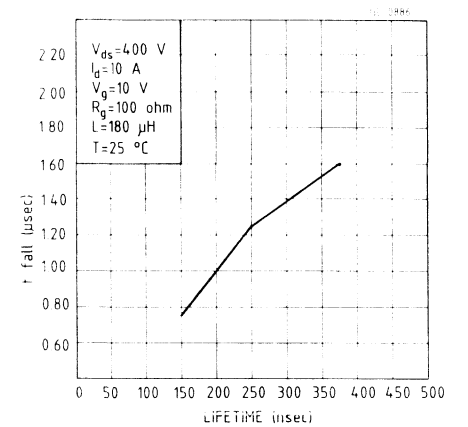
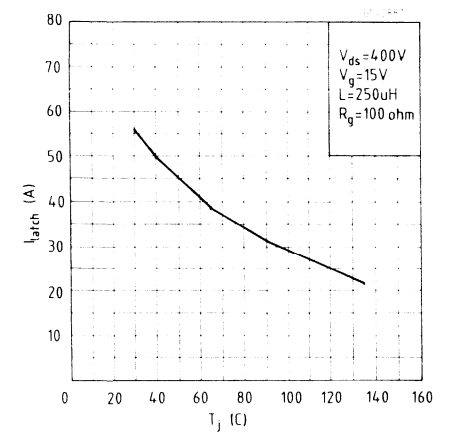


Fig. 8 - Variation of  $I_{latch}$  with temperature



$I_{latch}$  decreasing with temperature, figure 7, or with increasing  $V_{DS}$  is correlated to the gain variations they cause in the two parasitic transistors. Exter

nally, from an electrical point of view, latch-up can be seen in the safe operating area curve, figure 8, for a working temperature of 100°C.

Fig. 9 - HIMOS reverse bias operating area

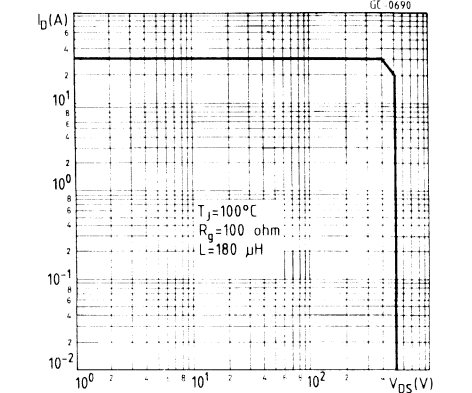
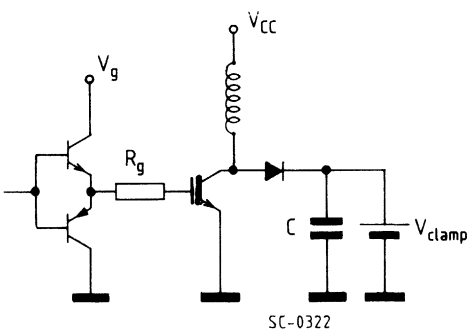


Fig. 10 - Test circuit HIMOS reverse bias safe operating area



### CONCLUSION

HIMOS devices are a natural development of POWER MOSFET transistors for use in high voltage applications in the range of 500V - 1000V. They present the user with high current devices which have low  $V_{DS(on)}$  typical of bipolar devices and the simplicity of drive typical of POWER MOSFETs.

Increasing the latch - up current and reducing the lifetime of the minority has opened up new field for HIMOS.





The PWM controller IC used is STUC3842. It is a popular, economic eight pin IC widely used for off-line and DC to DC converters. STUC3842 provides the features necessary to implement fixed frequency current mode control scheme with a minimal external parts count.

Internally implemented circuits include under voltage lockout featuring start-up current less than 1mA, a precision reference, logic to insure latched operation, a PWM comparator which provides current limit control and a totem pole output stage. It can directly drive the gate of the 500V 10A HIMOS switch STH10N50. The choice of this IC and its current mode working matches the requirements of economy and simplicity of this application.

Fig. 2 - STH10N50 output characteristics  
(I step = 6V)

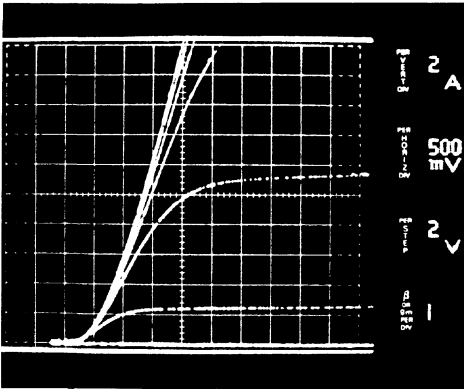
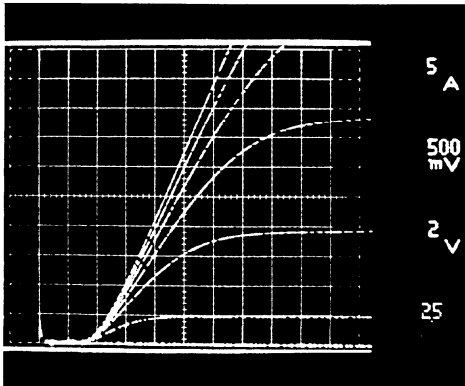


Fig. 3 - STH20N50 output characteristics  
(I step = 6V)



The motor speed is controlled by the error voltage which is variable from 0V to +5V, and is applied to pin 2 of the IC by means of R9. This voltage sets a constant current level at which the IC interrupts, pulse by pulse, the current in the power switch: the PWM control is therefore a "current mode" type. The HIMOS switch used is STH10N50, for higher power motors STH20N50 can be used simply by changing resistors R2 and R6 and free-wheeling diode D1. Figures 2 and 3 show respectively the output characteristics of STH10N50 and STH20N50 devices.

An important part of the circuit is the snubber consisting of R3, C9, D2. This accomplishes two functions:

- it provides power for the UC3842 using the charge current of C9 during the STH10N50 turn-off; infact the IC requires about 20 mA DC as supply current and cannot be biased simply through resistor R1 which should be 10Kohm 10W. Instead, using this active snubber, R1 can be set to a value of 56Kohm 2W in order to apply the start up power to the UC3842.
- it reduces the energy dissipated in the power switch during turn-off; consequently a smaller heatsink can be used for STH10N50 giving additional cost reduction.

To insure a continuous power supply to the IC, using the active snubber C9, R3, D2, it is necessary that the capacitor C9 must be completely discharged before turn-off. Because C9 is discharged by means of R3 during the ON phase of the power switch, there is a limit to the minimum ON time which cannot be less than 8  $\mu$ s, consequently the minimum duty-cycle is 6%.

Considering a peak current  $I_p = 4A$ , a fall time  $t_f = 1.5 \mu$ s and the minimum ON time of 8  $\mu$ s, the values of the snubber components are calculated as follows:

$$C9 = (I_p \cdot t_f) / 2V_{cc} = 10 \text{ nF}$$

$$R3 = T_{on(\min)} / 2 \cdot C9 = 400\text{ohm}$$

The power dissipated across R3 is:

$$P = 1/2 \cdot C9 \cdot V^2 \cdot f = 3W$$

The adoption of this snubber does not affect the efficiency of the circuit during normal operation because its power dissipation is very low and it has the additional benefit of using this energy to supply the IC so reducing the dissipation in the power switch. The extra cost is negligible with respect to the cost of a transformer for supplying the low voltage power to the IC.

The network of Tr2 and R6 adds a fraction of the ramp oscillator voltage to the "current sense" si-

gnal at pin 3 of the IC (via transistor Tr2 2N2222) to allow slope compensation. Consequently duty-cycles as high as 50% can be obtained. Diodes D1 (BYT08PI400) and D2 (BYT03400) are fast recovery types and have been used in order to minimize stresses on the power switch.

### MEASUREMENTS ON THE CIRCUIT

The DC motor drive was tested in several operating conditions. These were maximum and rated output current and in blocked rotor conditions. The waveforms of the drain voltage,  $V_{DS}$ , drain current,  $I_D$ , and gate voltage,  $V_G$ , both with and without the snubber can be seen in figures 5 and 6 respectively.

Fig. 4 - STH10N50 turn-off with snubber  $I_d = 1A/div$ ,  $V_{ds} = 50V/div$ ,  $V_g = 5V/div$

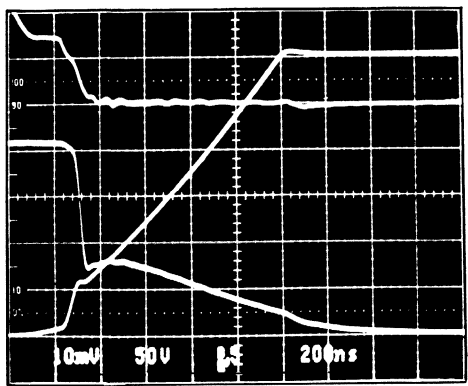
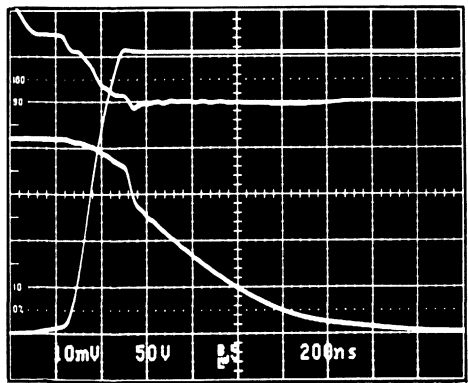


Fig. 5 - STH10N50 turn-off without snubber  $I_d = 1A/div$ ,  $V_{ds} = 50V/div$ ,  $V_g = 5V/div$



Here you can see the typical behaviour of a HIMOS device at the turn-off when typical features of both Power MOSFET and BJT are involved. The storage phase of the turn-off is dependent on the MOS behaviour as the base collector junction of the PNP transistor is reversed biased: the gate voltage decreases to a point where the Miller effect begins to control the current in the drain and  $V_{DS}$  start to rise. The fall time phase can be divided into two parts: the first part is the MOS turn-off and is very fast, the second is slow and starts when the MOS channel is closed and the PNP transistor has an open base turn-off and is dominated by recombination of excess carriers. Therefore the first part of the time is controlled by the gate drive circuit, the second part is dependent on the PNP transistor life-time and gain.

Since the PNP gain increases as  $V_{DS}$  increase, the fall time consequently varies with  $V_{DS}$ . Therefore, when the snubber is used and the  $V_{DS}$  slope is dominated by the capacitance, the fall time region due to the MOS is more evident (figure 6).

Figure 6 shows the turn-on behaviour of the HIMOS: it very fast (t-rise 30ns) and, as with Power MOS devices, is a function of the impedance of the driver circuit and the applied gate voltage.

Fig. 6 - STH10N50 turn-on  $I_d = 1A/div$ ,  $V_{ds} = 50V/div$

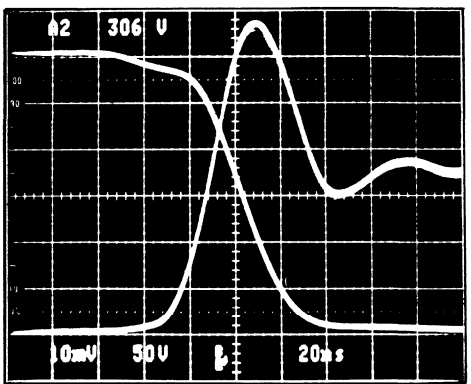
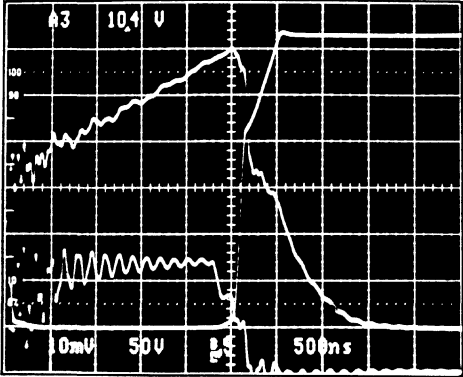


Figure 7 shows the behaviour in the case of a blocked rotor and with the current control set at the maximum 4A. This condition was simulated, as worst case, with an inductance of 300uH and a resistance of 1  $\Omega$ : the current does not exceed 6A. The over-current of 2A, with respect the control current of 4A, is due to the delay introduced by the network

of R7, C7 of about 2  $\mu$ s. This filter network is necessary to suppress the leading edge spikes on the IC current sense comparator input.

Fig. 7 - Blocked rotor' behaviour  $I_d = 1A/div$ ,  
 $V_{ds} = 50V/div$ ,  $V_g = 5V/div$



The losses in the circuit, for the maximum rating of each component are approximately as follows:  $P(R1) = 2W$ ,  $P(R3) = 3W$ ,  $P(R2) = 3W$ ,  $P(D1) = 4W$ ,  $P(Tr1) = 7W$ .

### CONCLUSION

A 300V 4A DC permanent magnet single quadrant motor drive was developed with objectives of maximum circuit simplicity and economy. Consequently a current mode PWM control with a popular IC was adopted and an STH10N50 HIMOS (an IGBT) was used.

The low drive energy requirement due to the high input impedance of the HIMOS allows substantial cost reduction in the control circuit. Conductivity modulation of the drain produces a low ON resistance, an essential feature to work with high peak currents in the switching element. The ruggedness, due to the excellent safe operating areas, is especially relevant for motor control applications.

The easy drive, high current handling and excellent ruggedness make HIMOS the new way of power switching in the motor control field.

## IMPROVED POWER MOSFET RUGGEDNESS IN UNCLAMPED INDUCTIVE SWITCHING

### INTRODUCTION

Recent development work by SGS-Thomson has resulted in the production of POWER MOSFETs with improved performance in terms of unclamped inductive switching at high current values. This has led to the production of a new class of POWER MOSFET device that operates reliably in application circuits even when accidental overvoltages may occur at high current, caused as a result of the high switching speed of POWER MOSFETs and random supply voltages.

POWER MOSFET devices have a clamped  $E_{s/b}$  safe operating area that extends to the breakdown voltage. In some applications, such as SMPS and Motor Control, ruggedness of this nature can be insufficient because, during turn-off, the device can be stressed by random overvoltages at high drain current values so creating avalanche conditions.

SGS-Thomson is introducing this new POWER MOSFET generation guaranteed in terms of an unclamped inductive switching test (U.I.S.). The latter parameters meet real operating conditions found in Power applications.

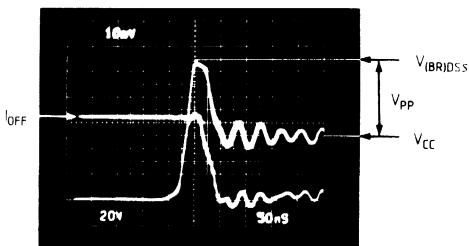
### USEFUL PARAMETERS IN POWER MOSFET RUGGEDNESS

POWER MOSFETs are very fast switching devices and can generate high values of  $di/dt$  (over  $1000A/\mu s$ ). For this reason, layout leakage inductance can create dangerous overvoltages. Photo 1 shows a POWER MOSFET drain current and voltage waveforms in a typical switching circuit (see figure 1). These current and voltage waveforms are typical in POWER MOSFET applications. It can be observed that the overvoltage exceeds the POWER MOSFET breakdown for very short times but at very high currents.

The energy dissipated in breakdown conditions in one cycle is very low,

$$E = \frac{1}{2} L I^2 \frac{V_{(BR) DSS}}{V_{(BR) DSS} - V_{CC}} = 40 \mu J,$$

Photo 1 -  $I = 5A/div$ ,  $V = 20V/div$   
Turn-off with parasitic inductance  
 $\approx 0.15\mu H$   $e \approx 40\mu J$



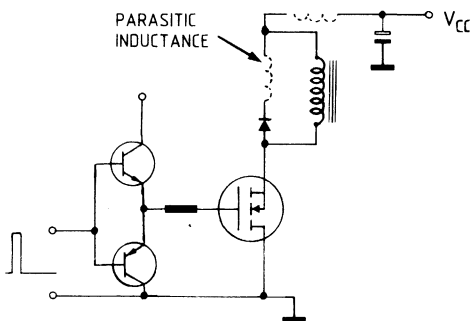
with a small duty cycle, but the initial breakdown currents are almost equal to those at turn-off.

It is important to test the device under actual operating conditions of voltage, current and working temperature typically found in actual application.

### THE FAILURE MECHANISM

Figure 2 shows possible current paths during breakdown. Current flows through the diffused body resistance and generates a voltage drop which

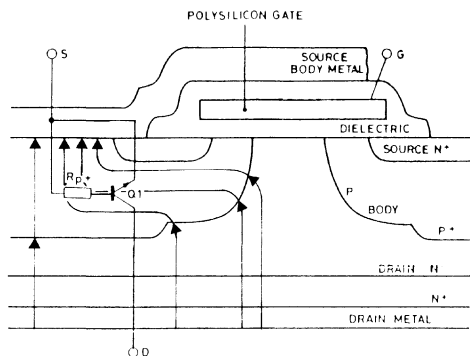
Fig. 1 - Typical circuit where breakdown can occur during turn-off



can be greater than the parasitic bipolar transistor threshold voltage. If turn-on of the parasitic bipo-

lar transistor occurs, the whole current is focused into a few cells destroying them. At increased temperature, this phenomenon happens at lower current values because the parasitic bipolar transistor threshold voltage decreases.

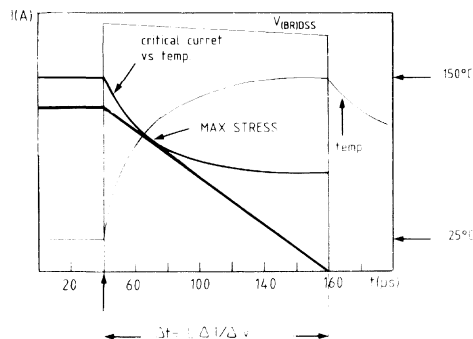
**Fig. 2 - Cross section of a POWER MOSFET showing possible current paths during sustaining**



Measurements show that failure current halves at  $t_j = 150^\circ\text{C}$  in comparison to the value of the current at  $t_j = 25^\circ\text{C}$ .

The energy dissipated in the failure phenomenon is not important because if this were the case there would only be a thermal problem. Figure 3 shows current, voltage and temperature behaviour during turn-off with high inductive energy. The graph shows that at turn-off the temperature increases

**Fig. 3 - Waveforms during turn-off, with a high energy value,  $L = 5\text{mH}$**

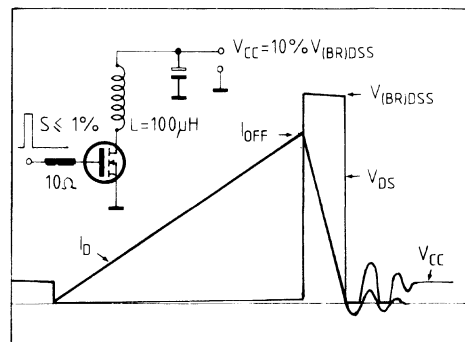


abruptly, and as a consequence, the critical current decreases so that, if critical current becomes less than the discharge current the device fails. Therefore it is possible to dissipate high inductive energy at a low current.

## U.I.S. TEST

Fig. 4 shows the current and voltage diagrams for the U.I.S. test.

**Fig. 4 - U.I.S. test waveforms and test circuit**



Energy stored in the inductive load is dissipated in the device under test, D.U.T., during turn-off. Measurements are made bearing in mind the following criteria:

- 1) The energy is not the most important parameter causing device failure. Additionally, where the stored inductive energy has a high value, it is difficult to recognize the point at which maximum stress occurs during the discharge of the inductive load because there is an instantaneous increase of temperature, see figure 3.
- 2) In real application circuits, the device should only dissipate a little energy.
- 3) DUT's failure depends on initial breakdown current.
- 4) Junction temperature  $T_j$  is an important parameter.

For these reasons we chose a small value of inductive load - this avoids the device's failure being depend on thermal effects. The new generation of SGS-Thomson POWER MOSFETs are tested using the following test conditions:

for  $T_j = 25^\circ\text{C}$ ,  $V_{dd} = 10\% V_{(BR) DSS}$  and  $L = 100\mu\text{H}$  and duty cycle  $\leq 1\%$ ,  $I_{off} = I_{nominal} (A)$  and  $T_j = 100^\circ\text{C}$ ,  $V_{dd} = 10\% V_{(BR) DSS}$  and  $L = 100\mu\text{H}$  and duty cycle  $\leq 1\%$ ,  $I_{off} = 0.7 \times I_{nominal} (A)$



Fig. 5 - guaranteed breakdown current versus temperature, and failure point for IRF450, BUZ45, BUZ21

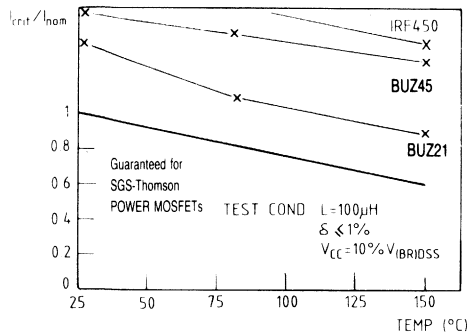


Figure 5 shows a temperature derating for guaranteed turn-off current (normalized at nominal current), where the three upper traces indicate the failure points for three different devices.

## CONCLUSION

Usually an application circuit is designed in a way that avoids avalanche breakdown under normal operating conditions, for example using fast external clamping circuits. Occasional overvoltages, however, can stress the devices and create avalanche breakdown conditions. New SGS-Thomson POWER MOSFETs release circuit designers from this type of constraint.



# DATASHEETS



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

**ADVANCE DATA**

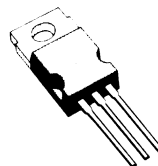
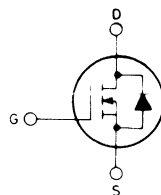
| TYPE  | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------|------------------|---------------------|----------------|
| BUZ10 | 50 V             | 0.08 Ω              | 20 A           |

- HIGH SPEED SWITCHING
- LOW R<sub>DS (ON)</sub>
- EASY DRIVE FOR COST EFFECTIVE APPLICATIONS.

**INDUSTRIAL APPLICATIONS:**

- AUTOMOTIVE POWER ACTUATOR DRIVES
- MOTOR CONTROLS
- DC-DC CONVERTERS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistors ideal for high speed switching circuits in applications such as power actuator driving, motor drives including brushless motors, hydraulic actuators and many other uses in automotive and automatic guided vehicle applications. It is also used in DC/DC converters and uninterruptible power supplies.


**TO-220**
**INTERNAL SCHEMATIC  
DIAGRAM**

**ABSOLUTE MAXIMUM RATINGS**

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 50          | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 50          | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ± 20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 30°C | 20          | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 80          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 70          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

THERMAL DATA

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.78 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75   | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                             |    |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|-----------------------------|----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$                                      | $V_{GS} = 0$                | 50 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^{\circ}\text{C}$ |    |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                  |                             |    |  | $\pm 100$   | nA                             |

ON

|               |                                   |                         |                      |     |  |     |          |
|---------------|-----------------------------------|-------------------------|----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1 \text{ mA}$ | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ | $I_D = 13 \text{ A}$ |     |  | 0.1 | $\Omega$ |

DYNAMIC

|           |                              |                                         |                      |   |     |  |     |
|-----------|------------------------------|-----------------------------------------|----------------------|---|-----|--|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 \text{ V}$                 | $I_D = 13 \text{ A}$ | 8 |     |  | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$  |   | 700 |  | pF  |
| $C_{oss}$ | Output capacitance           |                                         |                      |   | 450 |  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                         |                      |   | 180 |  | pF  |

SWITCHING

|               |                     |                                                 |                                                |  |     |  |    |
|---------------|---------------------|-------------------------------------------------|------------------------------------------------|--|-----|--|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 30 \text{ V}$<br>$R_{GS} = 50 \Omega$ | $I_D = 3 \text{ A}$<br>$V_{GS} = 10 \text{ V}$ |  | 20  |  | ns |
| $t_r$         | Rise time           |                                                 |                                                |  | 70  |  | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                 |                                                |  | 110 |  | ns |
| $t_f$         | Fall time           |                                                 |                                                |  | 80  |  | ns |

## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

## SOURCE DRAIN DIODE

|           |                               |                          |                                   |  |     |               |
|-----------|-------------------------------|--------------------------|-----------------------------------|--|-----|---------------|
| $I_{SD}$  | Source-drain current          | $T_c = 25^\circ\text{C}$ |                                   |  | 20  | A             |
| $I_{SDM}$ | Source-drain current (pulsed) |                          |                                   |  | 20  | A             |
| $V_{SD}$  | Forward on voltage            | $I_{SD} = 40\text{ A}$   | $V_{GS} = 0$                      |  | 1.5 | V             |
| $t_{rr}$  | Reverse recovery time         | $I_{SD} = 20\text{ A}$   | $di/dt = 100\text{A}/\mu\text{s}$ |  | 150 | ns            |
| $Q_{rr}$  | Reverse recovered charge      |                          |                                   |  | 1.0 | $\mu\text{C}$ |





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

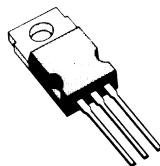
| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| BUZ10A | 50 V             | 0.12 Ω              | 17 A           |

- HIGH SPEED SWITCHING
- LOW R<sub>DS (ON)</sub>
- EASY DRIVE FOR COST EFFECTIVE APPLICATIONS.

### INDUSTRIAL APPLICATIONS:

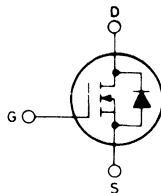
- AUTOMOTIVE POWER ACTUATOR DRIVES
- MOTOR CONTROLS
- DC-DC CONVERTERS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching circuits in applications such as power actuator driving, motor drives including brushless motors, hydraulic actuators and many other uses in automotive and automatic guided vehicle applications. It is also used in DC/DC converters and uninterruptible power supplies.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 50          | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 50          | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ± 20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 30°C | 17          | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 65          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 75          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

THERMAL DATA

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.67 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75   | °C/W |

ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                           |    |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|---------------------------|----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 1\text{ mA}$                                          | $V_{GS} = 0$              | 50 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^\circ\text{C}$ |    |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$                                   |                           |    |  | $\pm 100$   | nA                             |

ON

|               |                                   |                        |                     |     |  |      |          |
|---------------|-----------------------------------|------------------------|---------------------|-----|--|------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$      | $I_D = 1\text{ mA}$ | 2.1 |  | 4    | V        |
| $R_{DS(on)}$  | Static drain-source on resistance | $V_{GS} = 10\text{ V}$ | $I_D = 10\text{ A}$ |     |  | 0.12 | $\Omega$ |

DYNAMIC

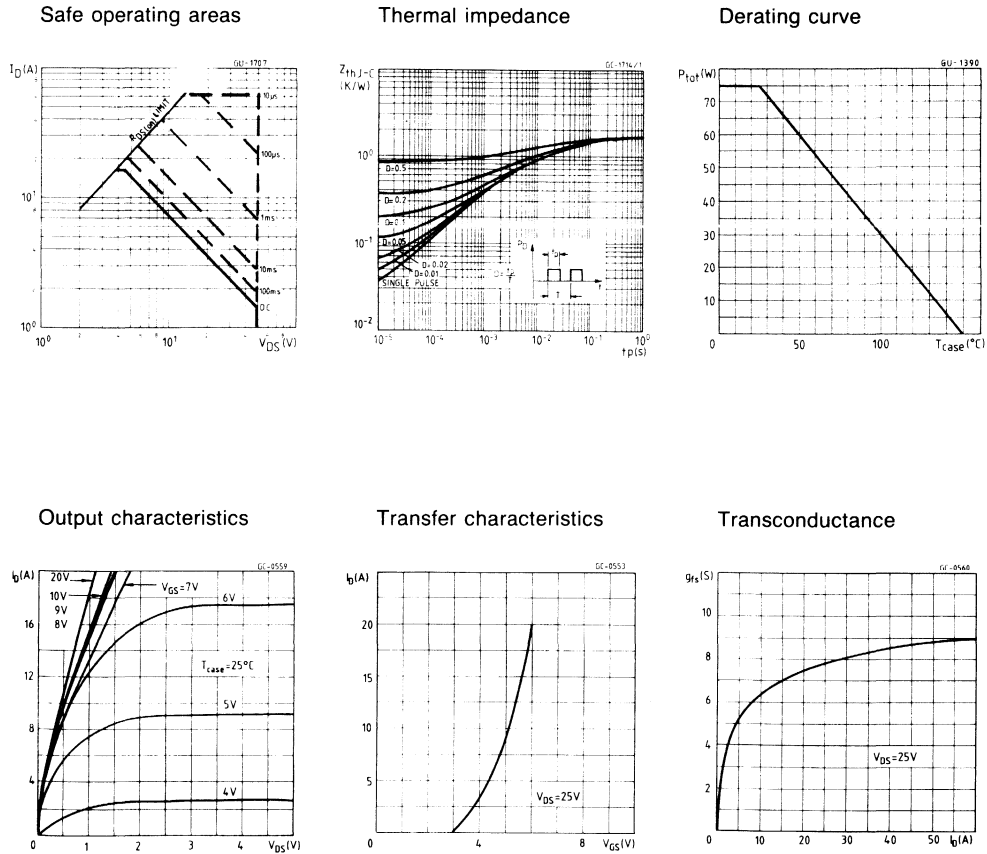
|                                     |                                                                         |                                        |                     |     |  |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|----------------------------------------|---------------------|-----|--|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25\text{ V}$                 | $I_D = 10\text{ A}$ | 3.0 |  |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\text{ V}$<br>$V_{GS} = 0$ | $f = 1\text{ MHz}$  |     |  | 2000<br>800<br>300 | pF<br>pF<br>pF |

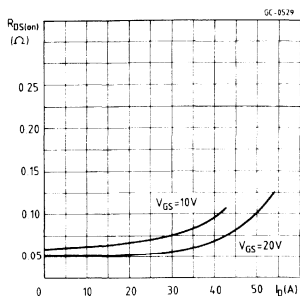
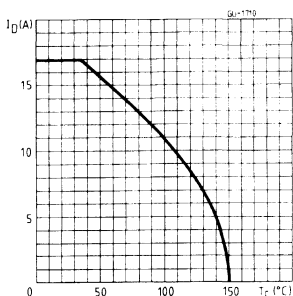
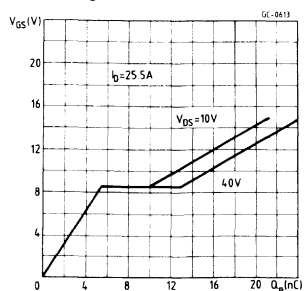
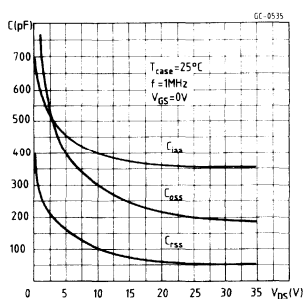
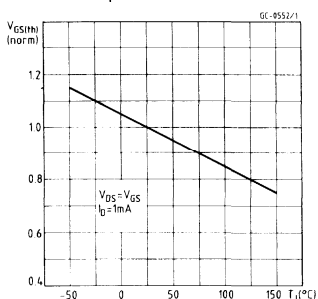
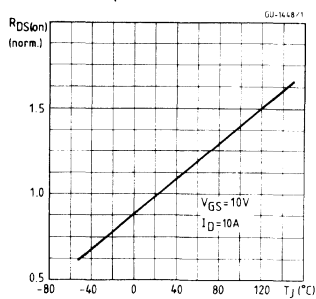
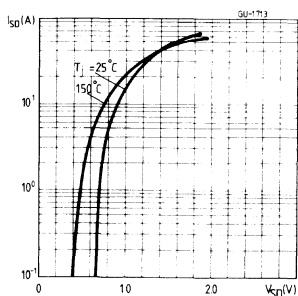
SWITCHING

|             |                     |                        |                        |  |  |     |    |
|-------------|---------------------|------------------------|------------------------|--|--|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30\text{ V}$ | $I_D = 3.0\text{ A}$   |  |  | 45  | ns |
| $t_r$       | Rise time           | $R_{GS} = 50\ \Omega$  | $V_{GS} = 10\text{ V}$ |  |  | 90  | ns |
| $t_d (off)$ | Turn-off delay time |                        |                        |  |  | 170 | ns |
| $t_f$       | Fall time           |                        |                        |  |  | 140 | ns |

ELECTRICAL CHARACTERISTICS (Continued)

| Parameters            | Test Conditions                                                                                           | Min. | Typ.       | Max.     | Unit          |
|-----------------------|-----------------------------------------------------------------------------------------------------------|------|------------|----------|---------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed)<br>$T_c = 25^{\circ}C$                           |      |            | 17<br>65 | A<br>A        |
| $V_{SD}$              | Forward on voltage<br>$I_{SD} = 34\text{ A}$<br>$V_{GS} = 0$                                              |      |            | 1.5      | V             |
| $t_{rr}$<br>$Q_{rr}$  | Reverse recovery<br>time<br>Reverse recovered<br>charge<br>$I_{SD} = 17\text{ A}$<br>$di/dt = 100A/\mu s$ |      | 150<br>1.0 |          | ns<br>$\mu C$ |



**Static drain-source on resistance**

**Maximum drain current vs temperature**

**Gate charge vs gate-source voltage**

**Capacitance variation**

**Gate threshold voltage vs temperature**

**Drain-source on resistance vs temperature**

**Source-drain diode forward characteristics**


## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

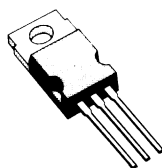
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> <sup>■</sup> |
|---------|------------------|---------------------|-----------------------------|
| BUZ11   | 50 V             | 0.04 Ω              | 30 A                        |
| BUZ11FI | 50 V             | 0.04 Ω              | 20 A                        |

- HIGH SPEED SWITCHING
- VERY LOW ON-LOSSES
- LOW DRIVE ENERGY FOR EASY DRIVE
- HIGH TRANSCONDUCTANCE/C<sub>rss</sub> RATIO

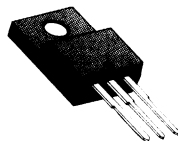
### INDUSTRIAL APPLICATIONS:

- AUTOMATIVE POWER ACTUATORS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching circuits in applications such as power actuator driving, motor drive including brushless motors, hydraulic actuators and many other uses in automotive applications. They also find use in DC/DC converters and uninterruptible power supplies.

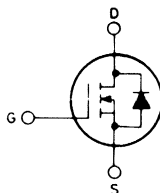


**TO-220**



**ISOWATT 220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                               |                                                  |                     |                      |
|-------------------------------|--------------------------------------------------|---------------------|----------------------|
| V <sub>DS</sub>               | Drain-source voltage (V <sub>GS</sub> = 0)       | 50                  | V                    |
| V <sub>DGR</sub>              | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 50                  | V                    |
| V <sub>GS</sub>               | Gate-source voltage                              | ±20                 | V                    |
| I <sub>DM</sub>               | Drain current (pulsed) T <sub>c</sub> = 25°C     | 120                 | A                    |
| I <sub>D</sub> <sup>■</sup>   | Drain current (continuous) T <sub>c</sub> = 30°C | <b>BUZ 11</b><br>30 | <b>BUZ11FI</b><br>20 |
| P <sub>tot</sub> <sup>■</sup> | Total dissipation at T <sub>c</sub> < 25°C       | 75                  | 35                   |
| T <sub>stg</sub>              | Storage temperature                              | - 55 to 150         |                      |
| T <sub>j</sub>                | Max. operating junction temperature              | 150                 |                      |
|                               | DIN humidity category (DIN 40040)                | E                   |                      |
|                               | IEC climatic category (DIN IEC 68-1)             | 55/150/56           |                      |

■ See note on ISOWATT 220 in this datasheet

THERMAL DATA

|                  |                                     | TO-220 |      | ISOWATT 220 |      |
|------------------|-------------------------------------|--------|------|-------------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max    | 1.67 | 3.57        | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max    | 75   |             | °C/W |

ELECTRICAL CHARACTERISTICS
(T<sub>J</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                              |                              |    |  |             |                    |
|----------------|--------------------------------------------------|------------------------------|------------------------------|----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$            | $V_{GS} = 0$                 | 50 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$ | $V_{DS} = \text{Max Rating}$ |    |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$          |                              |    |  | $\pm 100$   | nA                 |

ON

|               |                                   |                   |                      |     |  |      |          |
|---------------|-----------------------------------|-------------------|----------------------|-----|--|------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ | $I_D = 1 \text{ mA}$ | 2.1 |  | 4    | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$   | $I_D = 15 A$         |     |  | 0.04 | $\Omega$ |

DYNAMIC

|           |                              |                 |                     |   |  |      |     |
|-----------|------------------------------|-----------------|---------------------|---|--|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$ | $I_D = 15 A$        | 4 |  |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$ | $f = 1 \text{ MHz}$ |   |  | 2000 | pF  |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$    |                     |   |  | 1100 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                 |                     |   |  | 400  | pF  |

SWITCHING

|             |                     |                      |                 |  |  |     |    |
|-------------|---------------------|----------------------|-----------------|--|--|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30 V$      | $I_D = 3 A$     |  |  | 45  | ns |
| $t_r$       | Rise time           | $R_{GS} = 50 \Omega$ | $V_{GS} = 10 V$ |  |  | 110 | ns |
| $t_d (off)$ | Turn-off delay time |                      |                 |  |  | 230 | ns |
| $t_f$       | Fall time           |                      |                 |  |  | 170 | ns |

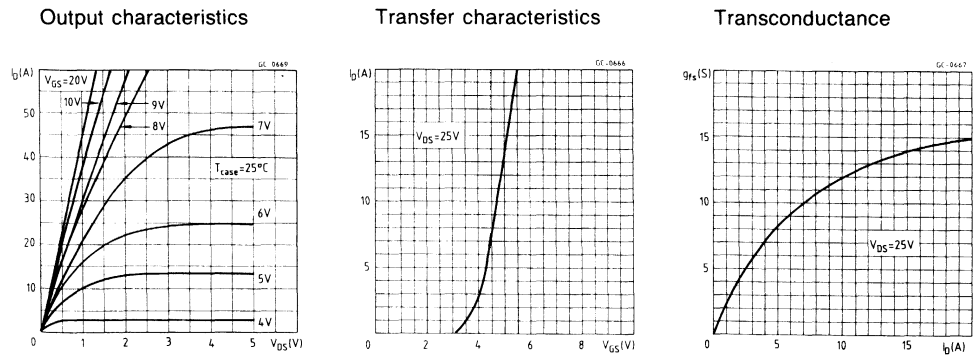
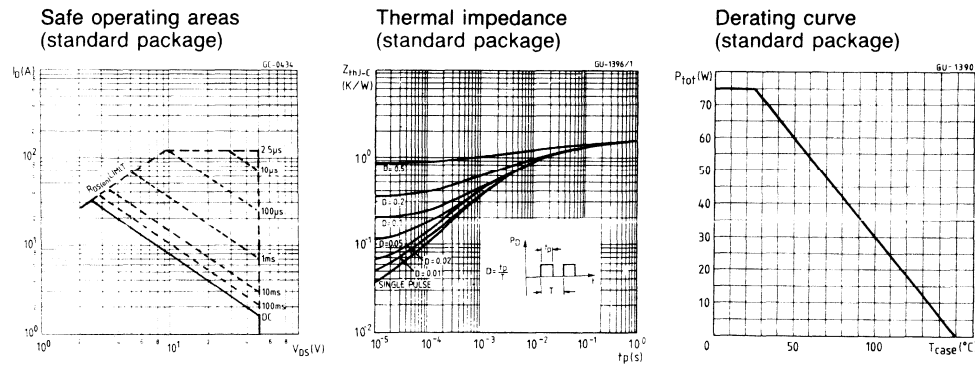
■ See note on ISOWATT 220 in this datasheet

ELECTRICAL CHARACTERISTICS (Continued)

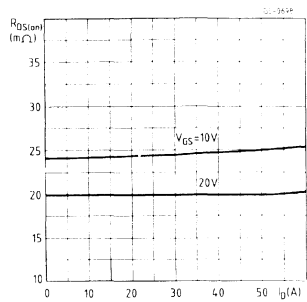
| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

SOURCE DRAIN DIODE

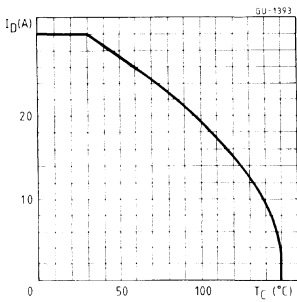
|                       |                                                          |                                                              |             |           |                     |
|-----------------------|----------------------------------------------------------|--------------------------------------------------------------|-------------|-----------|---------------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) | $T_c = 25^{\circ}\text{C}$                                   |             | 30<br>120 | A<br>A              |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 60\text{ A}$<br>$V_{GS} = 0$                       |             | 2.6       | V                   |
| $t_{rr}$<br>$Q_{rr}$  | Reverse recovery<br>time<br>Reverse recovered<br>charge  | $I_{SD} = 30\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ | 200<br>0.25 |           | ns<br>$\mu\text{C}$ |



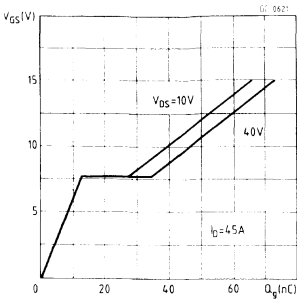
Static drain-source on resistance



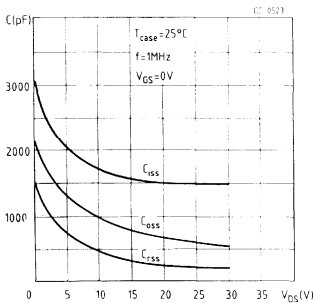
Maximum drain current vs temperature



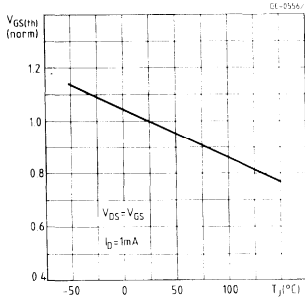
Gate charge vs gate-source voltage



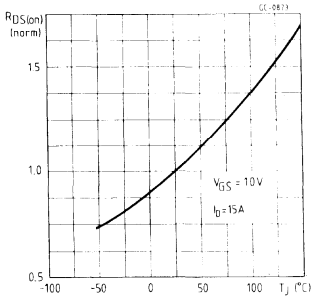
Capacitance variation



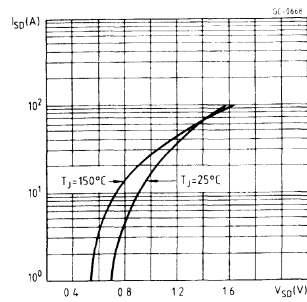
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics





## ISOWATT220 PACKAGE CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

## THERMAL IMPEDANCE OF ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th \text{ (tot)}}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

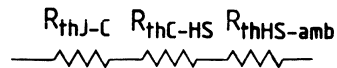
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

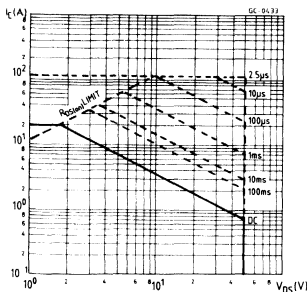
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

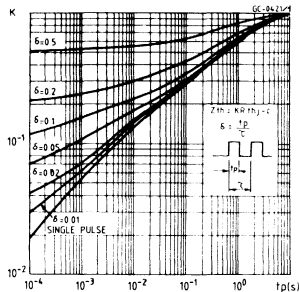


## ISOWATT DATA

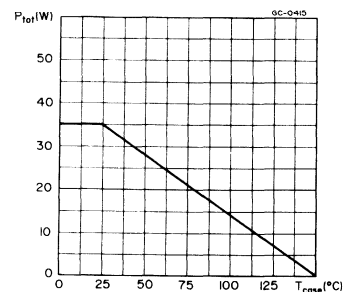
Safe operating areas



Thermal impedance



Derating curve





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

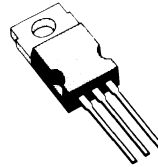
| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| BUZ11A | 50 V             | 0.06 Ω              | 25 A           |

- HIGH CURRENT
- ULTRA FAST SWITCHING
- VERY LOW ON-LOSSES
- LOW DRIVE ENERGY FOR EASY DRIVE

### INDUSTRIAL APPLICATIONS:

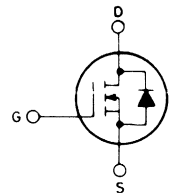
- AUTOMOTIVE POWER ACTUATORS
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical uses include power actuator driving, motor drive including brushless motors, hydraulic actuators and many other uses in automotive applications. It also finds use in DC/DC converters and uninterruptible power supplies.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 50          | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 50          | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ± 20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 25°C | 25          | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 100         | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 75          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

THERMAL DATA

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.67 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75   | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                             |    |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|-----------------------------|----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$                                     | $V_{GS} = 0$                | 50 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^{\circ}\text{C}$ |    |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\ \text{V}$                                  |                             |    |  | $\pm 100$   | nA                             |

ON

|               |                                   |                         |                      |     |  |      |          |
|---------------|-----------------------------------|-------------------------|----------------------|-----|--|------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1\ \text{mA}$ | 2.1 |  | 4    | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10\ \text{V}$ | $I_D = 15\ \text{A}$ |     |  | 0.06 | $\Omega$ |

DYNAMIC

|                                     |                                                                         |                                         |                      |     |  |                     |                |
|-------------------------------------|-------------------------------------------------------------------------|-----------------------------------------|----------------------|-----|--|---------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25\ \text{V}$                 | $I_D = 15\ \text{A}$ | 4.0 |  |                     | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\ \text{V}$<br>$V_{GS} = 0$ | $f = 1\ \text{MHz}$  |     |  | 2000<br>1100<br>400 | pF<br>pF<br>pF |

SWITCHING

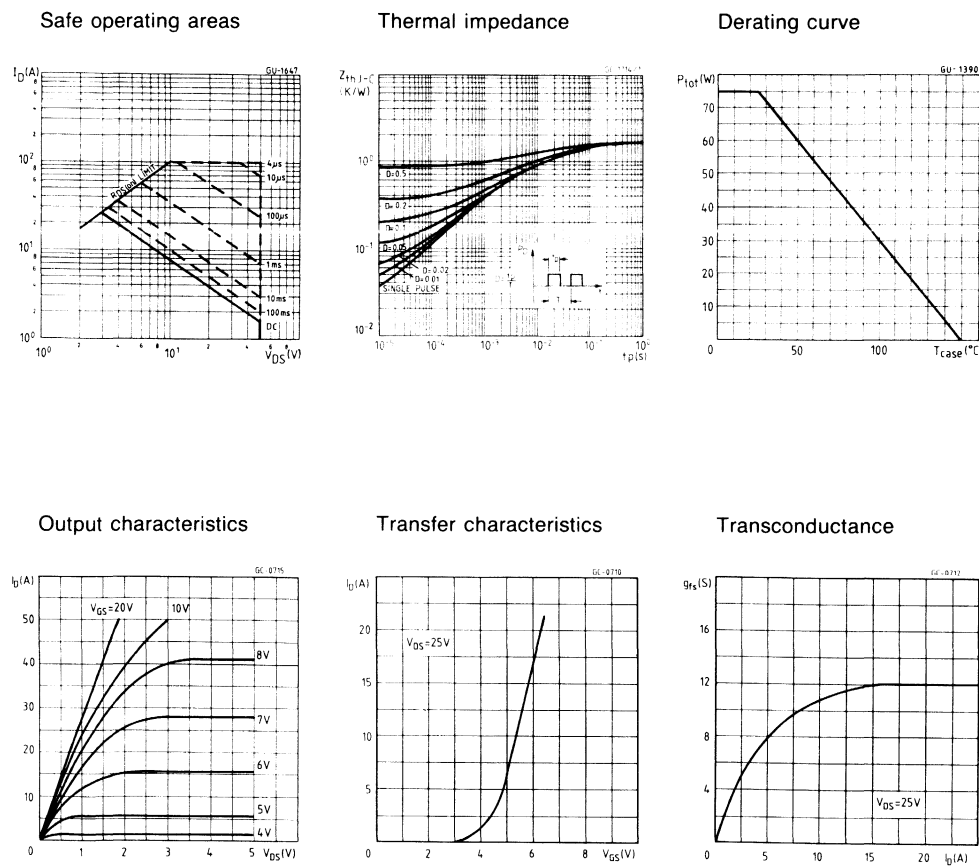
|             |                     |                         |                         |  |  |     |    |
|-------------|---------------------|-------------------------|-------------------------|--|--|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30\ \text{V}$ | $I_D = 3\ \text{A}$     |  |  | 45  | ns |
| $t_r$       | Rise time           | $R_{GS} = 50\ \Omega$   | $V_{GS} = 10\ \text{V}$ |  |  | 110 | ns |
| $t_d (off)$ | Turn-off delay time |                         |                         |  |  | 230 | ns |
| $t_f$       | Fall time           |                         |                         |  |  | 170 | ns |

ELECTRICAL CHARACTERISTICS (Continued)

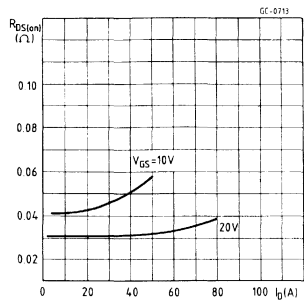
| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

SOURCE DRAIN DIODE

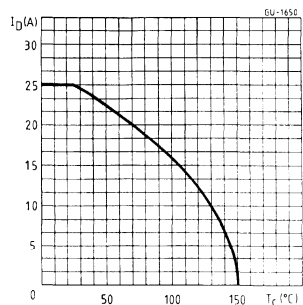
|                       |                                                          |                                                              |  |      |           |               |
|-----------------------|----------------------------------------------------------|--------------------------------------------------------------|--|------|-----------|---------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) | $T_c = 25^{\circ}\text{C}$                                   |  |      | 25<br>100 | A<br>A        |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 50\text{ A}$<br>$V_{GS} = 0$                       |  |      | 2.4       | V             |
| $t_{rr}$              | Reverse recovery<br>time                                 |                                                              |  | 200  |           | ns            |
| $Q_{rr}$              | Reverse recovered<br>charge                              | $I_{SD} = 25\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |  | 0.25 |           | $\mu\text{C}$ |



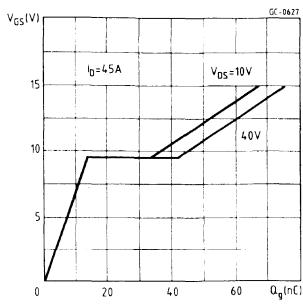
Static drain-source on resistance



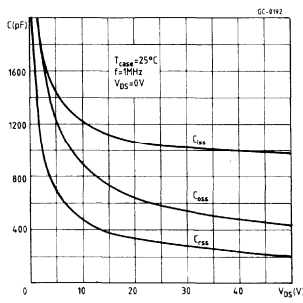
Maximum drain current vs temperature



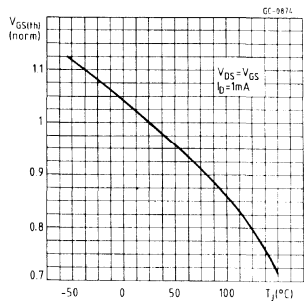
Gate charge vs gate-source voltage



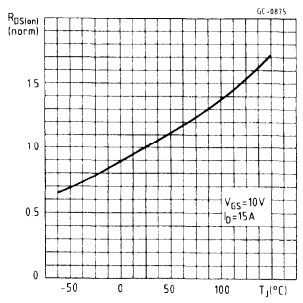
Capacitance variation



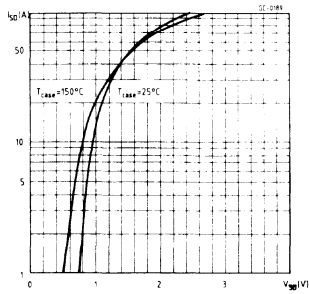
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

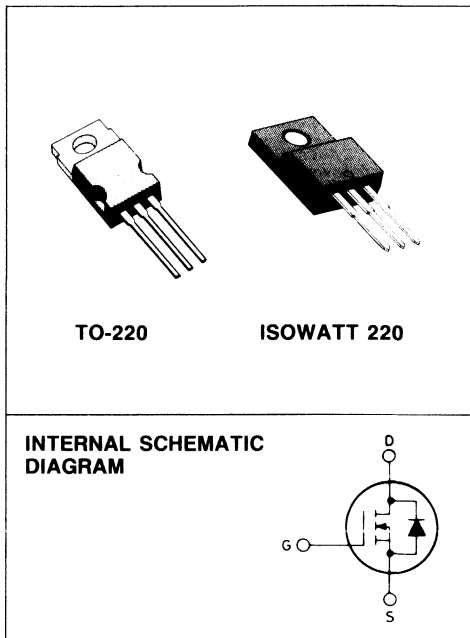
| TYPE      | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> <sup>■</sup> |
|-----------|------------------|---------------------|-----------------------------|
| BUZ11S2   | 60 V             | 0.04 Ω              | 30 A                        |
| BUZ11S2FI | 60 V             | 0.04 Ω              | 20 A                        |

- VERY LOW ON-LOSSES
- LOW DRIVE ENERGY FOR EASY DRIVE
- HIGH TRANSCONDUCTANCE/C<sub>rss</sub> RATIO

### INDUSTRIAL APPLICATIONS:

- AUTOMOTIVE POWER ACTUATORS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching circuits in applications such as power actuator driving, motor drive including brushless motors, hydraulic actuators and many other uses in automotive applications. They also find use in DC/DC converters and uninterruptible power supplies.



### ABSOLUTE MAXIMUM RATINGS

|                               |                                                  |                      |                        |
|-------------------------------|--------------------------------------------------|----------------------|------------------------|
| V <sub>DS</sub>               | Drain-source voltage (V <sub>GS</sub> = 0)       | 60                   | V                      |
| V <sub>DGR</sub>              | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 60                   | V                      |
| V <sub>GS</sub>               | Gate-source voltage                              | ±20                  | V                      |
| I <sub>DM</sub>               | Drain current (pulsed) T <sub>c</sub> = 25°C     | 120                  | A                      |
| I <sub>D</sub> <sup>■</sup>   | Drain current (continuous) T <sub>c</sub> = 30°C | <b>BUZ11S2</b><br>30 | <b>BUZ11S2FI</b><br>20 |
| P <sub>tot</sub> <sup>■</sup> | Total dissipation at T <sub>c</sub> < 25°C       | 75                   | 35                     |
| T <sub>stg</sub>              | Storage temperature                              | – 55 to 150          | °C                     |
| T <sub>j</sub>                | Max. operating junction temperature              | 150                  | °C                     |
|                               | DIN humidity category (DIN 40040)                | E                    |                        |
|                               | IEC climatic category (DIN IEC 68-1)             | 55/150/56            |                        |

■ See note on ISOWATT 220 in this datasheet

THERMAL DATA ■

TO-220 | ISOWATT220

|                  |                                     |     |      |      |      |
|------------------|-------------------------------------|-----|------|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.67 | 3.57 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75   |      | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                             |    |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|-----------------------------|----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$                                      | $V_{GS} = 0$                | 60 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^{\circ}\text{C}$ |    |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                  |                             |    |  | $\pm 100$   | nA                             |

ON

|               |                                   |                         |                      |     |  |      |          |
|---------------|-----------------------------------|-------------------------|----------------------|-----|--|------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1 \text{ mA}$ | 2.1 |  | 4    | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ | $I_D = 15 \text{ A}$ |     |  | 0.04 | $\Omega$ |

DYNAMIC

|           |                              |                                         |                      |   |  |      |     |
|-----------|------------------------------|-----------------------------------------|----------------------|---|--|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 \text{ V}$                 | $I_D = 15 \text{ A}$ | 4 |  |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$  |   |  | 2000 | pF  |
| $C_{oss}$ | Output capacitance           |                                         |                      |   |  | 1100 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                         |                      |   |  | 400  | pF  |

SWITCHING

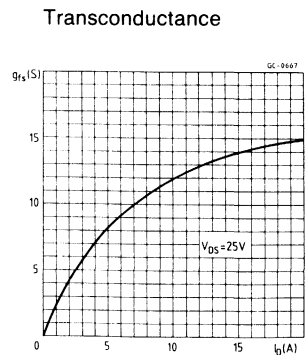
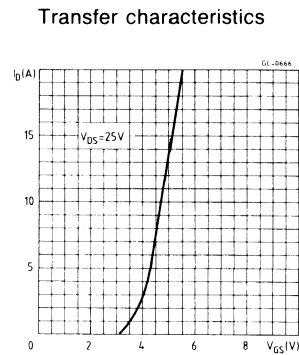
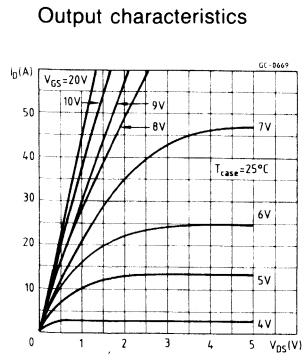
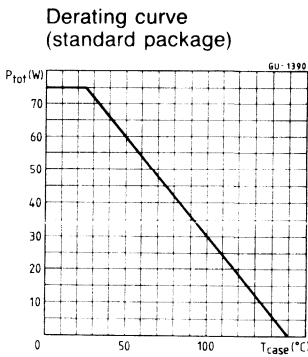
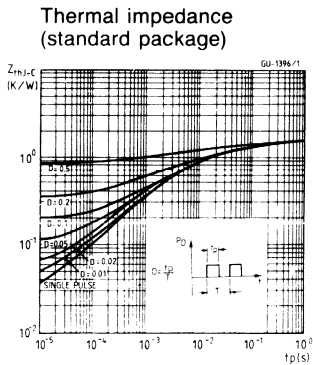
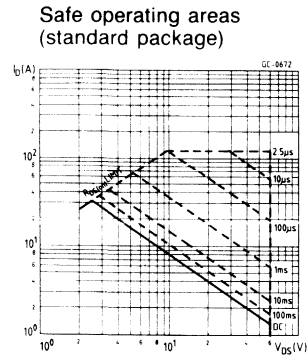
|               |                     |                         |                         |  |  |     |    |
|---------------|---------------------|-------------------------|-------------------------|--|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 30 \text{ V}$ | $I_D = 3 \text{ A}$     |  |  | 45  | ns |
| $t_r$         | Rise time           | $R_{GS} = 50 \Omega$    | $V_{GS} = 10 \text{ V}$ |  |  | 110 | ns |
| $t_{d (off)}$ | Turn-off delay time |                         |                         |  |  | 230 | ns |
| $t_f$         | Fall time           |                         |                         |  |  | 170 | ns |

■ See note on ISOWATT 220 in this datasheet

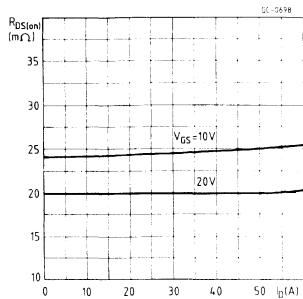


ELECTRICAL CHARACTERISTICS (Continued)

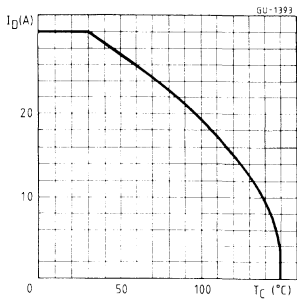
| Parameters            |                                                       | Test Conditions            |                                    | Min. | Typ. | Max.      | Unit          |
|-----------------------|-------------------------------------------------------|----------------------------|------------------------------------|------|------|-----------|---------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current (pulsed) | $T_c = 25^{\circ}\text{C}$ |                                    |      |      | 30<br>120 | A<br>A        |
| $V_{SD}$              | Forward on voltage                                    | $I_{SD} = 60\text{ A}$     | $V_{GS} = 0$                       |      |      | 2.6       | V             |
| $t_{rr}$              | Reverse recovery time                                 |                            |                                    |      | 200  |           | ns            |
| $Q_{rr}$              | Reverse recovered charge                              | $I_{SD} = 30\text{ A}$     | $di/dt = 100\text{ A}/\mu\text{s}$ |      | 0.25 |           | $\mu\text{C}$ |



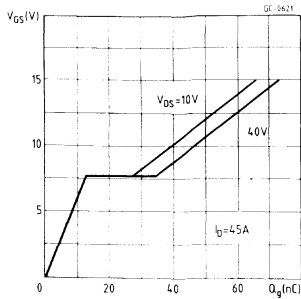
Static drain-source on resistance



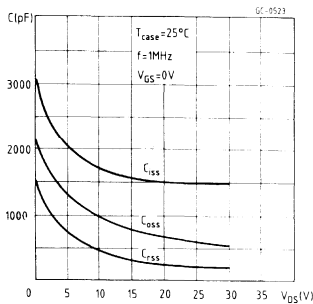
Maximum drain current vs temperature



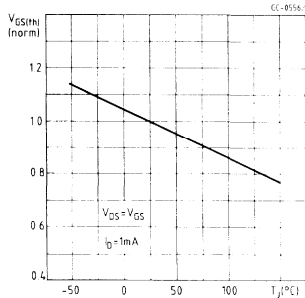
Gate charge vs gate-source voltage



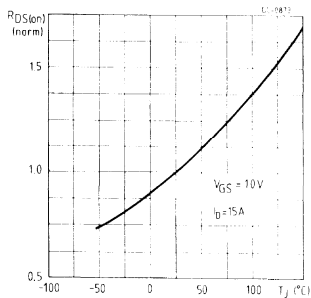
Capacitance variation



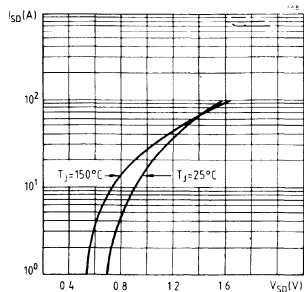
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## ISOWATT220 PACKAGE CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

## THERMAL IMPEDANCE OF ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th(tot)}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

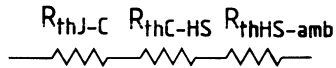
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

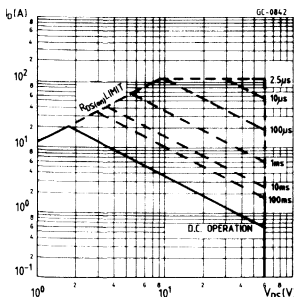
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

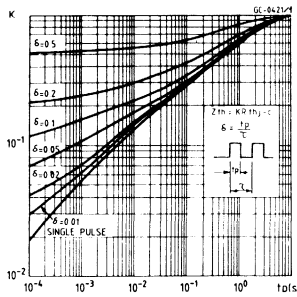


## ISOWATT DATA

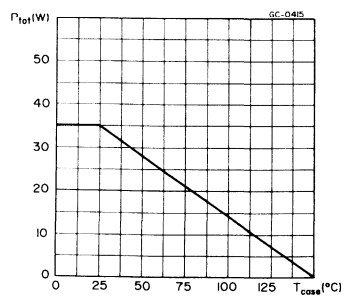
Safe operating areas



Thermal impedance



Derating curve





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

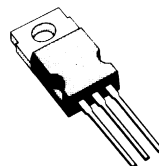
| TYPE  | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------|------------------|---------------------|----------------|
| BUZ20 | 100 V            | 0.2 Ω               | 12 A           |

- 100 VOLTS - FOR UPS APPLICATIONS
- ULTRA FAST SWITCHING
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- EASY DRIVE - FOR REDUCED AND COST

### INDUSTRIAL APPLICATIONS:

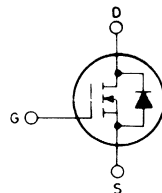
- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include UPS, battery chargers, printer hammer drivers, solenoid drivers and motor control.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 100         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 100         | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ±20         | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 25°C | 12          | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 48          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 75          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

♦ Introduced in 1988 week 44

**THERMAL DATA**

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.67 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75   | °C/W |

**ELECTRICAL CHARACTERISTICS** ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                              |                             |     |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|-----------------------------|-----|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$                                     | $V_{GS} = 0$                | 100 |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^{\circ}\text{C}$ |     | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\ \text{V}$                                  |                             |     | $\pm 100$   | nA                             |

**ON**

|               |                                   |                         |                      |     |     |          |
|---------------|-----------------------------------|-------------------------|----------------------|-----|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1\ \text{mA}$ | 2.1 | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10\ \text{V}$ | $I_D = 6\ \text{A}$  |     | 0.2 | $\Omega$ |

**ENERGY TEST**

|           |                                                      |                                                                |                        |    |  |   |
|-----------|------------------------------------------------------|----------------------------------------------------------------|------------------------|----|--|---|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30\ \text{V}$<br>starting $T_j = 25^{\circ}\text{C}$ | $L = 100\ \mu\text{H}$ | 12 |  | A |
|-----------|------------------------------------------------------|----------------------------------------------------------------|------------------------|----|--|---|

**DYNAMIC**

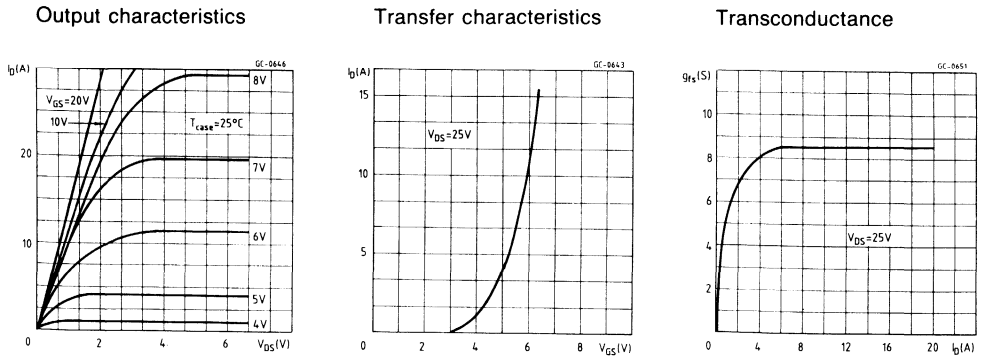
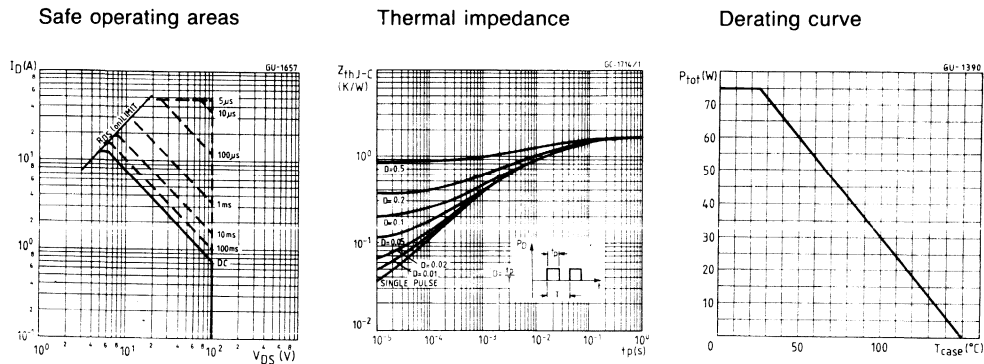
|           |                              |                         |                     |     |      |     |
|-----------|------------------------------|-------------------------|---------------------|-----|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25\ \text{V}$ | $I_D = 6\ \text{A}$ | 2.7 |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25\ \text{V}$ | $f = 1\ \text{MHz}$ |     | 2000 | pF  |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$            |                     |     | 500  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                         |                     |     | 140  | pF  |

**SWITCHING**

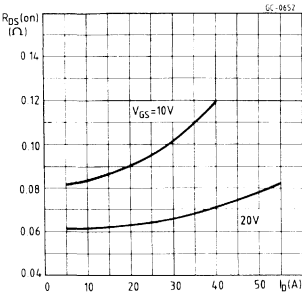
|             |                     |                         |                         |  |     |    |
|-------------|---------------------|-------------------------|-------------------------|--|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30\ \text{V}$ | $I_D = 2.9\ \text{A}$   |  | 45  | ns |
| $t_r$       | Rise time           | $R_{GS} = 50\ \Omega$   | $V_{GS} = 10\ \text{V}$ |  | 75  | ns |
| $t_d (off)$ | Turn-off delay time |                         |                         |  | 140 | ns |
| $t_f$       | Fall time           |                         |                         |  | 80  | ns |

ELECTRICAL CHARACTERISTICS (Continued)

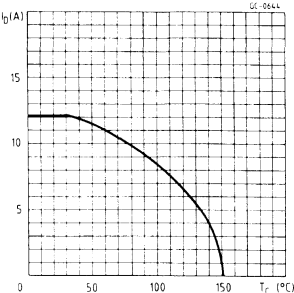
| Parameters            | Test Conditions                                                                                                             | Min. | Typ.       | Max.     | Unit                |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------|------|------------|----------|---------------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed)<br><br>$T_c = 25^{\circ}C$                                         |      |            | 12<br>48 | A<br>A              |
| $V_{SD}$              | Forward on voltage<br><br>$I_{SD} = 24\text{ A}$<br>$V_{GS} = 0$                                                            |      |            | 1.8      | V                   |
| $t_{rr}$<br>$Q_{rr}$  | Reverse recovery<br>time<br>Reverse recovered<br>charge<br><br>$I_{SD} = 12\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |      | 200<br>1.6 |          | ns<br>$\mu\text{C}$ |



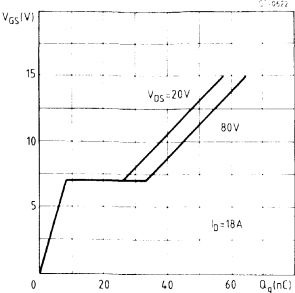
Static drain-source on resistance



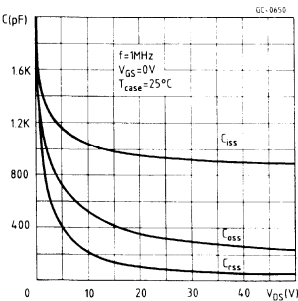
Maximum drain current vs temperature



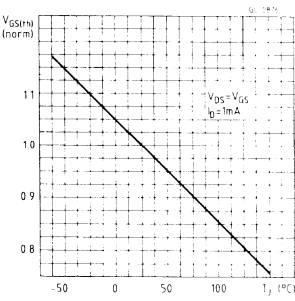
Gate charge vs gate-source voltage



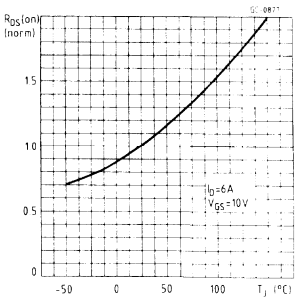
Capacitance variation



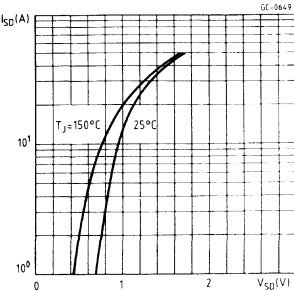
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE  | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------|------------------|---------------------|----------------|
| BUZ21 | 100 V            | 0.1 Ω               | 19 A           |

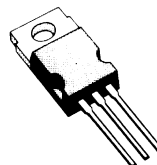
- 100 VOLTS - FOR DC/DC CONVERTERS
- HIGH CURRENT
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- ULTRA FAST SWITCHING
- EASY DRIVE -FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- UNINTERRUPTABLE POWER SUPPLIES
- MOTOR CONTROLS

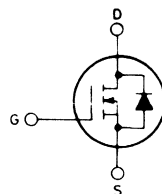
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Typical applications include DC/DC converters, UPS, battery chargers, secondary regulators servo control, audio power amplifiers and robotics.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 100         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 100         | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ±20         | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 30°C | 19          | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 75          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 75          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

♦ Introduced in 1988 week 44

THERMAL DATA

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.67 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75   | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                             |     |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|-----------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$                                     | $V_{GS} = 0$                | 100 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^{\circ}\text{C}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\ \text{V}$                                  |                             |     |  | $\pm 100$   | nA                             |

ON

|               |                                   |                         |                      |     |  |     |          |
|---------------|-----------------------------------|-------------------------|----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1\ \text{mA}$ | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10\ \text{V}$ | $I_D = 9\ \text{A}$  |     |  | 0.1 | $\Omega$ |

ENERGY TEST

|           |                                                      |                                                                |                        |    |  |  |   |
|-----------|------------------------------------------------------|----------------------------------------------------------------|------------------------|----|--|--|---|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30\ \text{V}$<br>starting $T_j = 25^{\circ}\text{C}$ | $L = 100\ \mu\text{H}$ | 19 |  |  | A |
|-----------|------------------------------------------------------|----------------------------------------------------------------|------------------------|----|--|--|---|

DYNAMIC

|           |                              |                         |                     |     |  |      |     |
|-----------|------------------------------|-------------------------|---------------------|-----|--|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25\ \text{V}$ | $I_D = 9\ \text{A}$ | 4.0 |  |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25\ \text{V}$ | $f = 1\ \text{MHz}$ |     |  | 2000 | pF  |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$            |                     |     |  | 700  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                         |                     |     |  | 240  | pF  |

SWITCHING

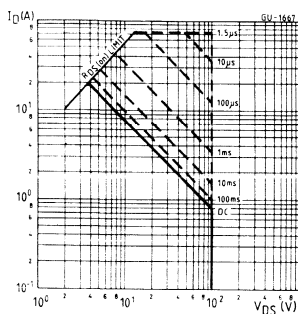
|               |                     |                         |                         |  |  |     |    |
|---------------|---------------------|-------------------------|-------------------------|--|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 30\ \text{V}$ | $I_D = 3\ \text{A}$     |  |  | 45  | ns |
| $t_r$         | Rise time           | $R_{GS} = 50\ \Omega$   | $V_{GS} = 10\ \text{V}$ |  |  | 75  | ns |
| $t_{d (off)}$ | Turn-off delay time |                         |                         |  |  | 220 | ns |
| $t_f$         | Fall time           |                         |                         |  |  | 110 | ns |

## ELECTRICAL CHARACTERISTICS (Continued)

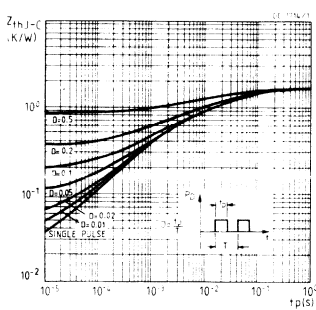
| Parameters                                                               | Test Conditions                                           | Min. | Typ.        | Max.     | Unit                |
|--------------------------------------------------------------------------|-----------------------------------------------------------|------|-------------|----------|---------------------|
| $I_{SD}$ Source-drain current<br>$I_{SDM}$ Source-drain current (pulsed) | $T_c = 25^\circ\text{C}$                                  |      |             | 19<br>75 | A<br>A              |
| $V_{SD}$ Forward on voltage                                              | $I_{SD} = 38\text{ A}$ $V_{GS} = 0$                       |      |             | 2.1      | V                   |
| $t_{rr}$ Reverse recovery time<br>$Q_{rr}$ Reverse recovered charge      | $I_{SD} = 19\text{ A}$ $di/dt = 100\text{ A}/\mu\text{s}$ |      | 200<br>0.25 |          | ns<br>$\mu\text{C}$ |

## SOURCE DRAIN DIODE

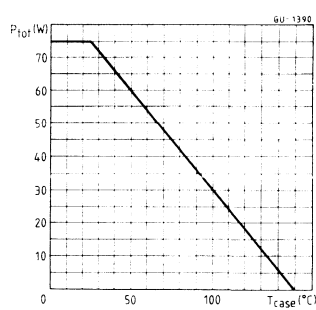
Safe operating areas



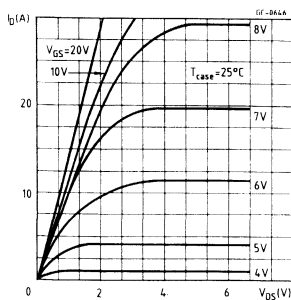
Thermal impedance



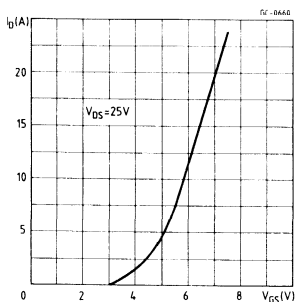
Derating curve



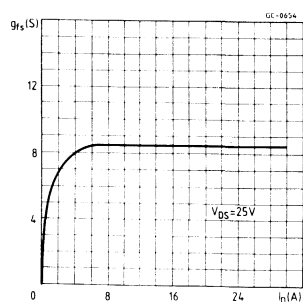
Output characteristics



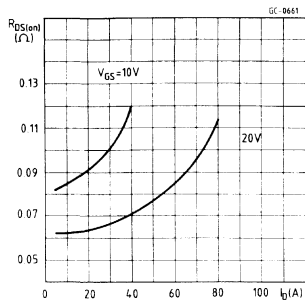
Transfer characteristics



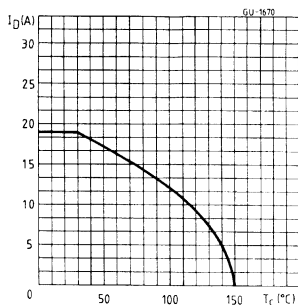
Transconductance



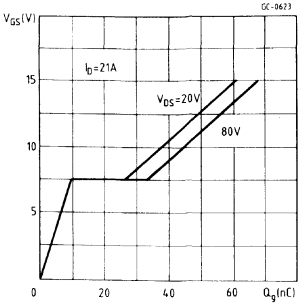
Static drain-source on resistance



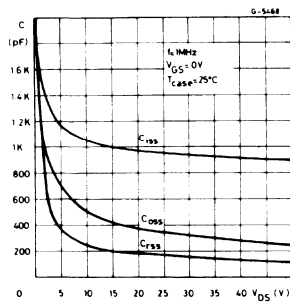
Maximum drain current vs temperature



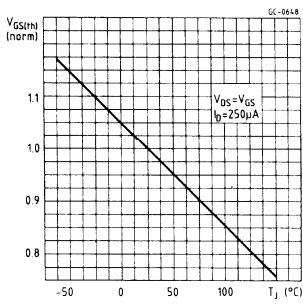
Gate charge vs gate-source voltage



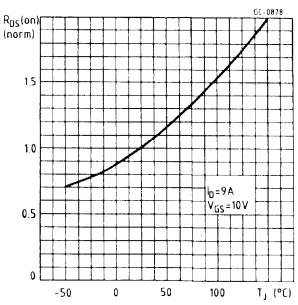
Capacitance variation



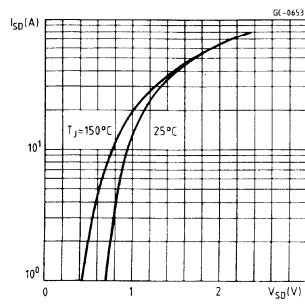
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE  | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------|------------------|---------------------|----------------|
| BUZ25 | 100 V            | 0.1 Ω               | 19 A           |

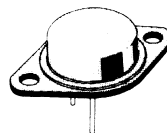
- 100 VOLTS - FOR DC/DC CONVERTERS
- HIGH CURRENT
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

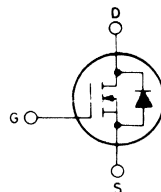
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Typical applications include DC/DC converters, UPS, battery chargers, secondary regulators, servo control, power audio amplifiers and robotics.



**TO-3**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 100         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 100         | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ± 20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 35°C | 19          | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 75          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 78          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | C           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

♦ Introduced in 1988 week 44

THERMAL DATA

|                  |                                     |     |     |      |
|------------------|-------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.6 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 35  | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                             |     |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|-----------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$                                     | $V_{GS} = 0$                | 100 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^{\circ}\text{C}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\ \text{V}$                                  |                             |     |  | $\pm 100$   | nA                             |

ON

|               |                                   |                         |                      |     |  |     |          |
|---------------|-----------------------------------|-------------------------|----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1\ \text{mA}$ | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10\ \text{V}$ | $I_D = 9\ \text{A}$  |     |  | 0.1 | $\Omega$ |

ENERGY TEST

|           |                                                      |                                                                |                        |    |  |  |   |
|-----------|------------------------------------------------------|----------------------------------------------------------------|------------------------|----|--|--|---|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30\ \text{V}$<br>starting $T_j = 25^{\circ}\text{C}$ | $L = 100\ \mu\text{H}$ | 19 |  |  | A |
|-----------|------------------------------------------------------|----------------------------------------------------------------|------------------------|----|--|--|---|

DYNAMIC

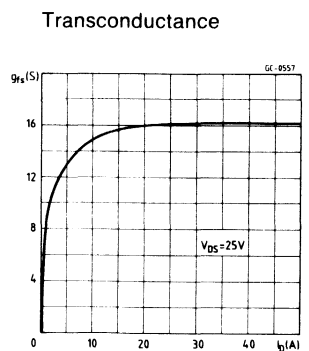
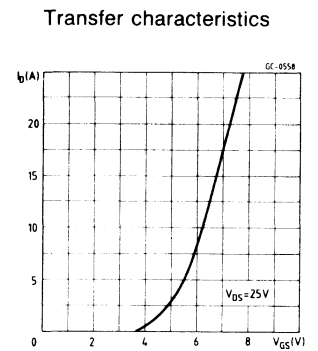
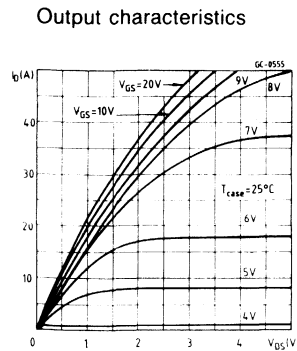
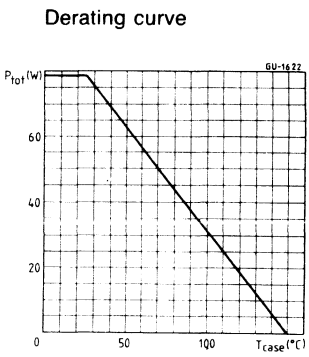
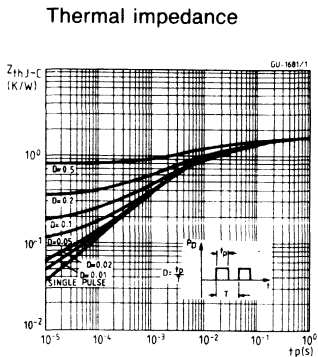
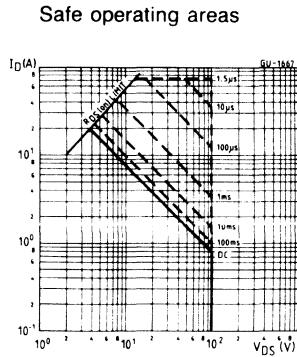
|                                     |                                                                         |                                         |                     |     |  |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|-----------------------------------------|---------------------|-----|--|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25\ \text{V}$                 | $I_D = 9\ \text{A}$ | 4.0 |  |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\ \text{V}$<br>$V_{GS} = 0$ | $f = 1\ \text{MHz}$ |     |  | 2000<br>700<br>240 | pF<br>pF<br>pF |

SWITCHING

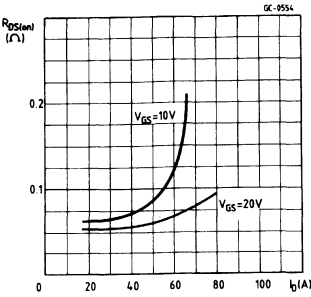
|               |                     |                         |                         |  |  |     |    |
|---------------|---------------------|-------------------------|-------------------------|--|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 30\ \text{V}$ | $I_D = 3\ \text{A}$     |  |  | 45  | ns |
| $t_r$         | Rise time           | $R_{GS} = 50\ \Omega$   | $V_{GS} = 10\ \text{V}$ |  |  | 75  | ns |
| $t_{d (off)}$ | Turn-off delay time |                         |                         |  |  | 220 | ns |
| $t_f$         | Fall time           |                         |                         |  |  | 110 | ns |

ELECTRICAL CHARACTERISTICS (Continued)

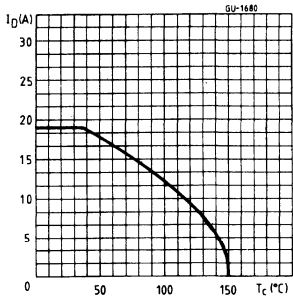
| Parameters |                               | Test Conditions            |                                    | Min. | Typ. | Max. | Unit          |
|------------|-------------------------------|----------------------------|------------------------------------|------|------|------|---------------|
| $I_{SD}$   | Source-drain current          | $T_c = 25^{\circ}\text{C}$ |                                    |      |      | 19   | A             |
| $I_{SDM}$  | Source-drain current (pulsed) |                            |                                    |      |      | 75   | A             |
| $V_{SD}$   | Forward on voltage            | $I_{SD} = 38\text{ A}$     | $V_{GS} = 0$                       |      |      | 2.1  | V             |
| $t_{rr}$   | Reverse recovery time         | $I_{SD} = 19\text{ A}$     | $di/dt = 100\text{ A}/\mu\text{s}$ |      | 200  |      | ns            |
| $Q_{rr}$   | Reverse recovered charge      |                            |                                    |      | 0.25 |      | $\mu\text{C}$ |



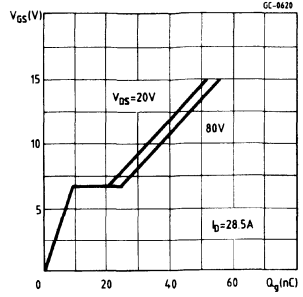
Static drain-source on resistance



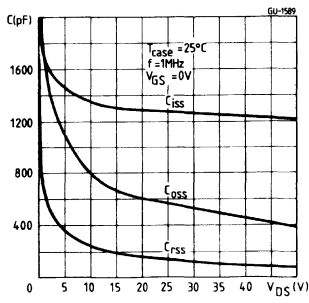
Maximum drain current vs temperature



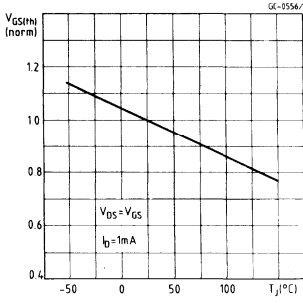
Gate charge vs gate-source voltage



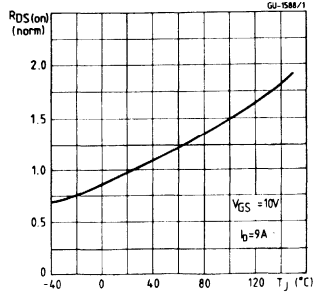
Capacitance variation



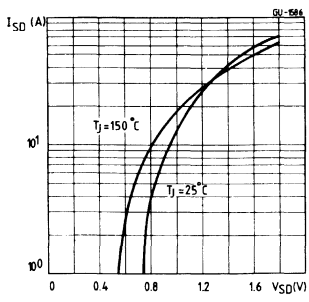
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE  | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------|------------------|---------------------|----------------|
| BUZ32 | 200 V            | 0.4 Ω               | 9.5 A          |

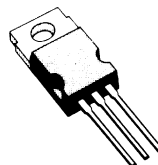
- 200 VOLTS FOR TELECOMS APPLICATIONS
- HIGH CURRENT - FOR PULSED LASER DRIVES
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCHING MODE POWER SUPPLIES
- MOTOR CONTROLS FOR ROBOTICS

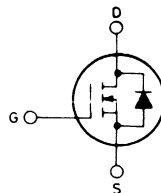
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Typical uses include robotics, laser diode drives, UPS, SMPS, DC/DC, DC switch for telecomms and electric vehicle drives.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 200         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 200         | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ± 20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 25°C | 9.5         | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 38          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 75          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

♦ Introduced in 1989 week 1

**THERMAL DATA**

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.67 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75   | °C/W |

**ELECTRICAL CHARACTERISTICS** ( $T_j = 25^\circ\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                              |                           |     |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|---------------------------|-----|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$                                      | $V_{GS} = 0$              | 200 |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^\circ\text{C}$ |     | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                  |                           |     | $\pm 100$   | nA                             |

**ON**

|               |                                   |                         |                       |     |  |     |          |
|---------------|-----------------------------------|-------------------------|-----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1 \text{ mA}$  | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ | $I_D = 4.5 \text{ A}$ |     |  | 0.4 | $\Omega$ |

**ENERGY TEST**

|           |                                                      |                                                              |                       |     |  |  |   |
|-----------|------------------------------------------------------|--------------------------------------------------------------|-----------------------|-----|--|--|---|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 \text{ V}$<br>starting $T_j = 25^\circ\text{C}$ | $L = 100 \mu\text{H}$ | 9.5 |  |  | A |
|-----------|------------------------------------------------------|--------------------------------------------------------------|-----------------------|-----|--|--|---|

**DYNAMIC**

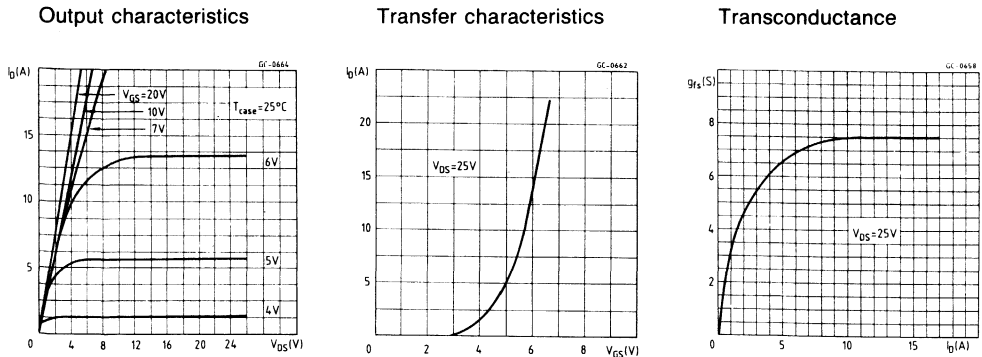
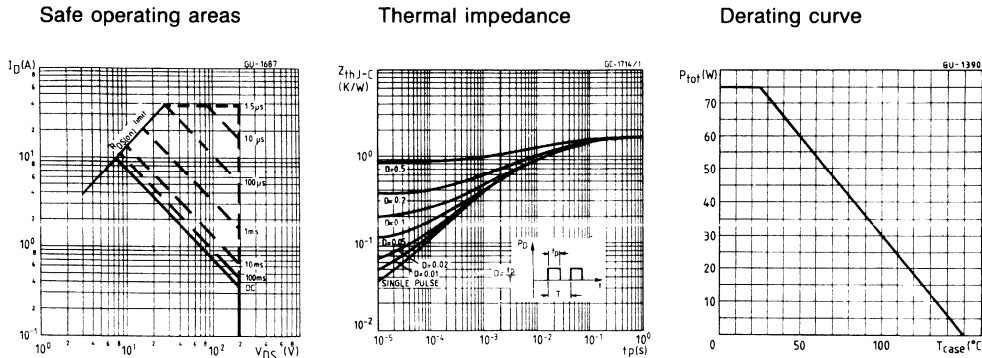
|           |                              |                         |                       |     |  |      |     |
|-----------|------------------------------|-------------------------|-----------------------|-----|--|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 \text{ V}$ | $I_D = 4.5 \text{ A}$ | 2.2 |  |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$ | $f = 1 \text{ MHz}$   |     |  | 2000 | pF  |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$            |                       |     |  | 400  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                         |                       |     |  | 120  | pF  |

**SWITCHING**

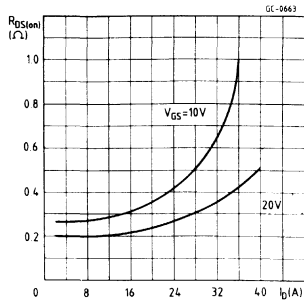
|             |                     |                         |                         |  |  |     |    |
|-------------|---------------------|-------------------------|-------------------------|--|--|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30 \text{ V}$ | $I_D = 2.9 \text{ A}$   |  |  | 45  | ns |
| $t_r$       | Rise time           | $R_{GS} = 50 \Omega$    | $V_{GS} = 10 \text{ V}$ |  |  | 60  | ns |
| $t_d (off)$ | Turn-off delay time |                         |                         |  |  | 140 | ns |
| $t_f$       | Fall time           |                         |                         |  |  | 80  | ns |

ELECTRICAL CHARACTERISTICS (Continued)

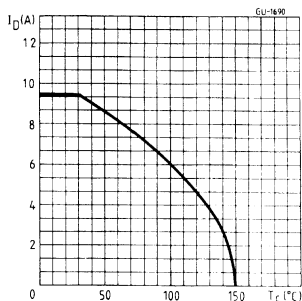
| Parameters            |                                                          | Test Conditions         |                      | Min. | Typ. | Max.      | Unit    |
|-----------------------|----------------------------------------------------------|-------------------------|----------------------|------|------|-----------|---------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) | $T_c = 25^{\circ}C$     |                      |      |      | 9.5<br>38 | A<br>A  |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 19\text{ A}$  | $V_{GS} = 0$         |      |      | 1.7       | V       |
| $t_{rr}$              | Reverse recovery<br>time                                 |                         |                      |      | 400  |           | ns      |
| $Q_{rr}$              | Reverse recovered<br>charge                              | $I_{SD} = 9.5\text{ A}$ | $di/dt = 100A/\mu s$ |      | 6    |           | $\mu C$ |



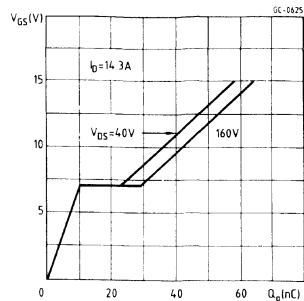
**Static drain-source on resistance**



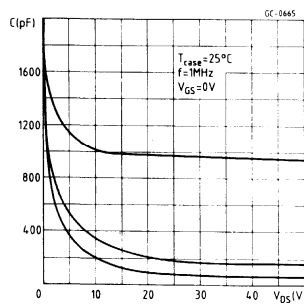
**Maximum drain current vs temperature**



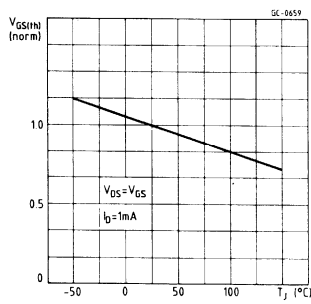
**Gate charge vs gate-source voltage**



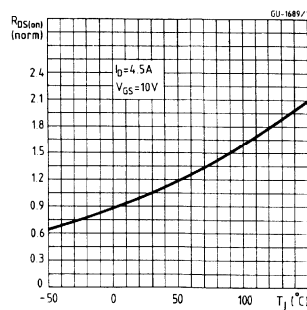
**Capacitance variation**



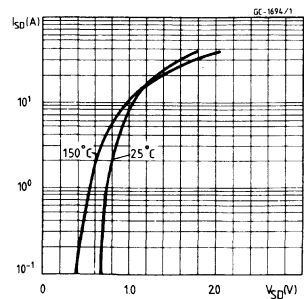
**Gate threshold voltage vs temperature**



**Drain-source on resistance vs temperature**



**Source-drain diode forward characteristics**



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| BUZ41A | 500 V            | 1.5 Ω               | 4.5 A          |

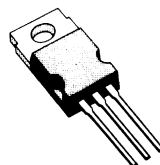
- HIGH VOLTAGE - FOR OFF-LINE SMPS
- ULTRA FAST SWITCHING FOR OPERATION AT < 100KHz
- EASY DRIVE - FOR REDUCED COST AND COST

### INDUSTRIAL APPLICATIONS:

- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS

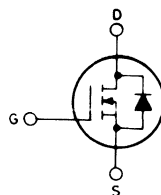
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Typical applications include switching power supplies and motor speed control.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 500         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 500         | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ± 20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 35°C | 4.5         | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 18          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 75          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

THERMAL DATA

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.67 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75   | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                             |     |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|-----------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$                                     | $V_{GS} = 0$                | 500 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^{\circ}\text{C}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\ \text{V}$                                  |                             |     |  | $\pm 100$   | nA                             |

ON

|               |                                   |                         |                       |     |  |     |          |
|---------------|-----------------------------------|-------------------------|-----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1\ \text{mA}$  | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10\ \text{V}$ | $I_D = 2.5\ \text{A}$ |     |  | 1.5 | $\Omega$ |

DYNAMIC

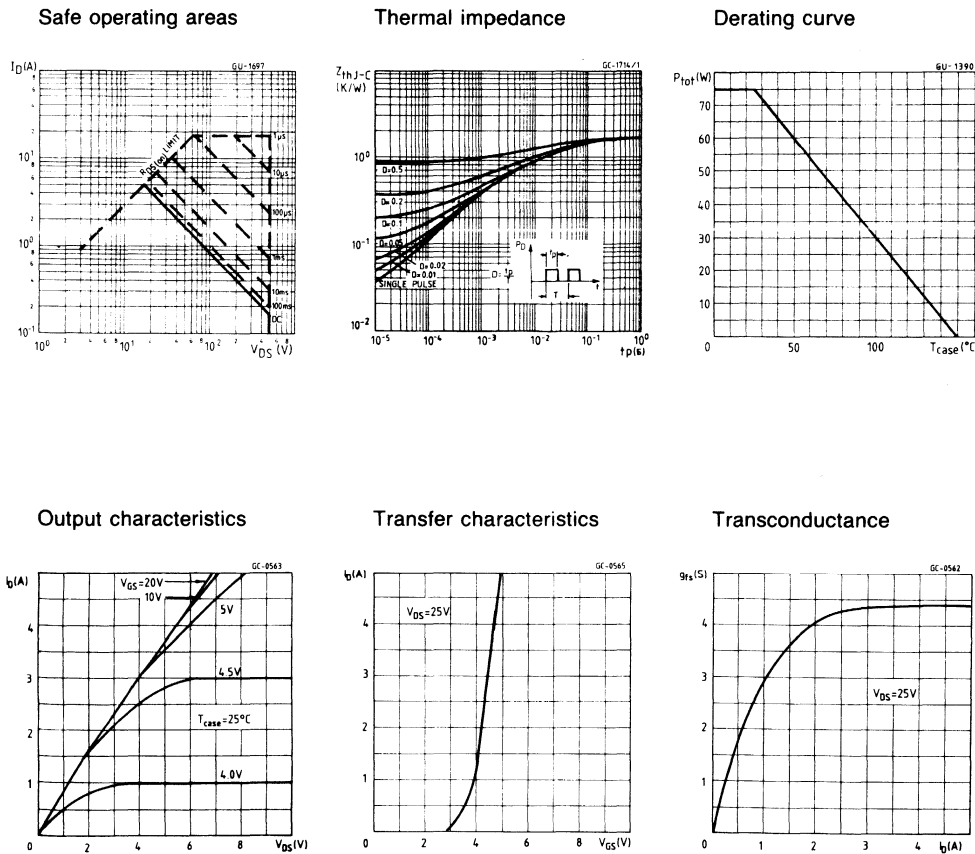
|           |                              |                                         |                       |     |  |      |     |
|-----------|------------------------------|-----------------------------------------|-----------------------|-----|--|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25\ \text{V}$                 | $I_D = 2.5\ \text{A}$ | 1.5 |  |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25\ \text{V}$<br>$V_{GS} = 0$ | $f = 1\ \text{MHz}$   |     |  | 2000 | pF  |
| $C_{oss}$ | Output capacitance           |                                         |                       |     |  | 170  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                         |                       |     |  | 70   | pF  |

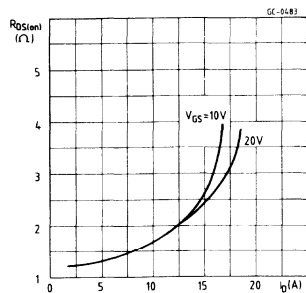
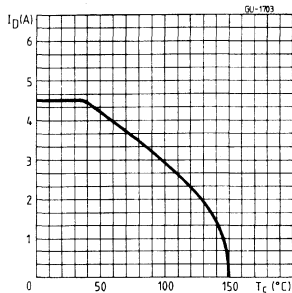
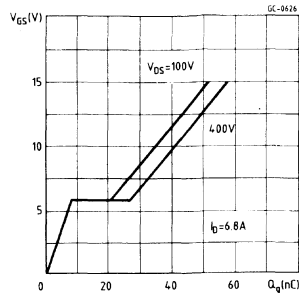
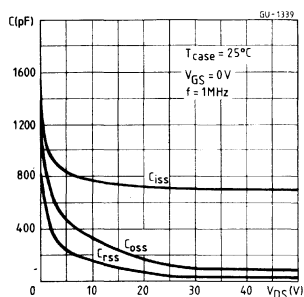
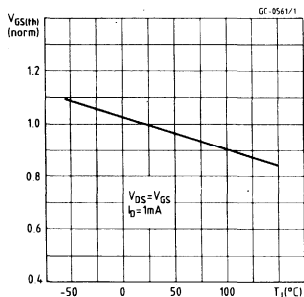
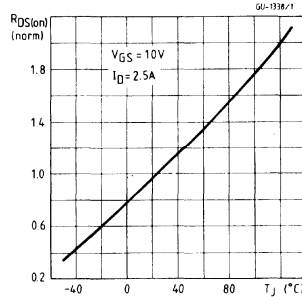
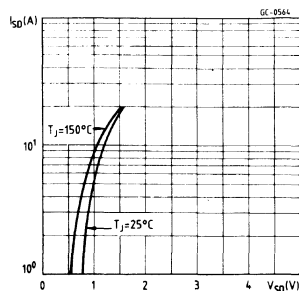
SWITCHING

|             |                     |                         |                         |  |  |     |    |
|-------------|---------------------|-------------------------|-------------------------|--|--|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30\ \text{V}$ | $I_D = 2.6\ \text{A}$   |  |  | 45  | ns |
| $t_r$       | Rise time           | $R_{GS} = 50\ \Omega$   | $V_{GS} = 10\ \text{V}$ |  |  | 60  | ns |
| $t_d (off)$ | Turn-off delay time |                         |                         |  |  | 140 | ns |
| $t_f$       | Fall time           |                         |                         |  |  | 65  | ns |

ELECTRICAL CHARACTERISTICS (Continued)

| Parameters            | Test Conditions                                                                                            | Min. | Typ.      | Max.      | Unit          |
|-----------------------|------------------------------------------------------------------------------------------------------------|------|-----------|-----------|---------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed)<br>$T_c = 25^{\circ}C$                            |      |           | 4.5<br>18 | A<br>A        |
| $V_{SD}$              | Forward on voltage<br>$I_{SD} = 9\text{ A}$<br>$V_{GS} = 0$                                                |      |           | 1.5       | V             |
| $t_{rr}$<br>$Q_{rr}$  | Reverse recovery<br>time<br>Reverse recovered<br>charge<br>$I_{SD} = 4.5\text{ A}$<br>$di/dt = 100A/\mu s$ |      | 1200<br>6 |           | ns<br>$\mu C$ |



**Static drain-source on resistance**

**Maximum drain current vs temperature**

**Gate charge vs gate-source voltage**

**Capacitance variation**

**Gate threshold voltage vs temperature**

**Drain-source on resistance vs temperature**

**Source-drain diode forward characteristics**




## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE  | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------|------------------|---------------------|----------------|
| BUZ42 | 500 V            | 2 Ω                 | 4 A            |

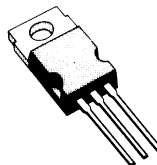
- HIGH VOLTAGE - FOR OFF-LINE SMPS
- ULTRA FAST SWITCHING FOR OPERATION AT <100KHz
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS

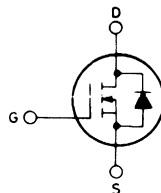
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Typical applications include switching power supplies and motor speed control.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 500         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 500         | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ± 20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 30°C | 4           | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 16          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 75          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

THERMAL DATA

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.67 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75   | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                             |     |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|-----------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$                                      | $V_{GS} = 0$                | 500 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^{\circ}\text{C}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                  |                             |     |  | $\pm 100$   | nA                             |

ON

|               |                                   |                         |                       |     |  |   |          |
|---------------|-----------------------------------|-------------------------|-----------------------|-----|--|---|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1 \text{ mA}$  | 2.1 |  | 4 | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ | $I_D = 2.5 \text{ A}$ |     |  | 2 | $\Omega$ |

DYNAMIC

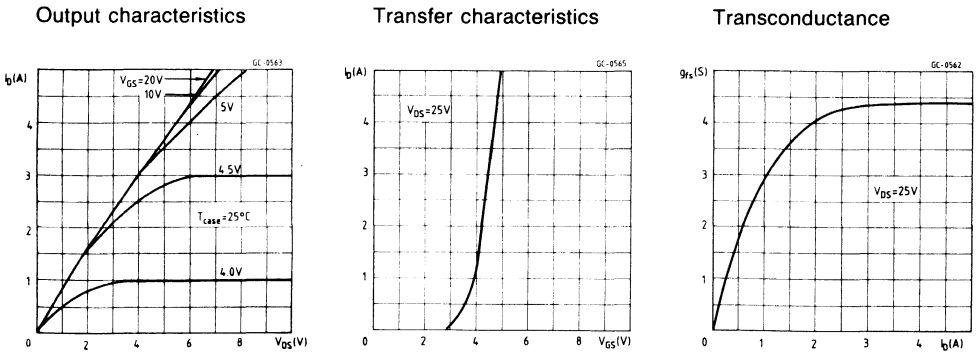
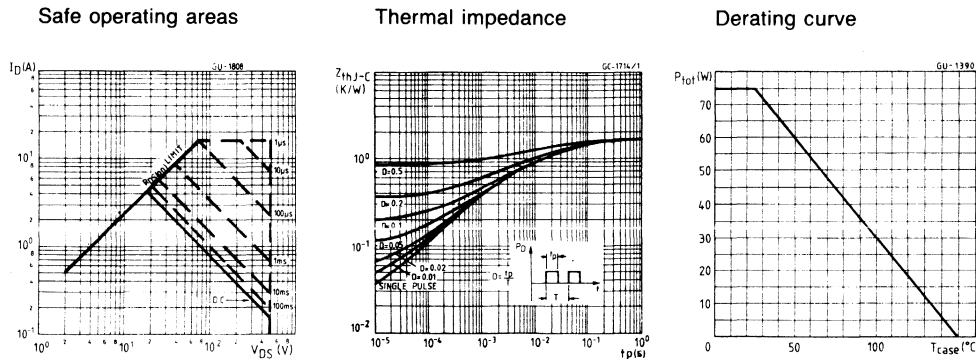
|                                     |                                                                         |                                         |                       |     |  |                   |                |
|-------------------------------------|-------------------------------------------------------------------------|-----------------------------------------|-----------------------|-----|--|-------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 \text{ V}$                 | $I_D = 2.5 \text{ A}$ | 1.5 |  |                   | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{res}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$   |     |  | 2000<br>170<br>70 | pF<br>pF<br>pF |

SWITCHING

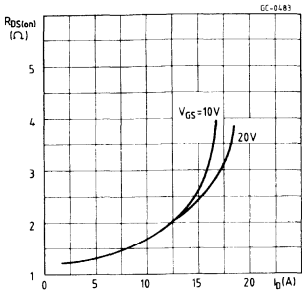
|             |                     |                         |                         |  |  |     |    |
|-------------|---------------------|-------------------------|-------------------------|--|--|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30 \text{ V}$ | $I_D = 2.5 \text{ A}$   |  |  | 45  | ns |
| $t_r$       | Rise time           | $R_{GS} = 50 \Omega$    | $V_{GS} = 10 \text{ V}$ |  |  | 60  | ns |
| $t_d (off)$ | Turn-off delay time |                         |                         |  |  | 140 | ns |
| $t_f$       | Fall time           |                         |                         |  |  | 65  | ns |

ELECTRICAL CHARACTERISTICS (Continued)

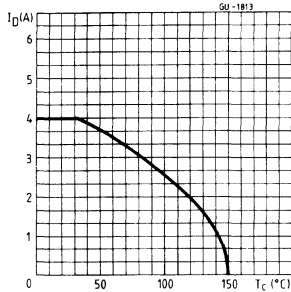
| Parameters            |                                                       | Test Conditions                                          | Min. | Typ.      | Max.    | Unit                |
|-----------------------|-------------------------------------------------------|----------------------------------------------------------|------|-----------|---------|---------------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current (pulsed) | $T_c = 25^{\circ}\text{C}$                               |      |           | 4<br>16 | A<br>A              |
| $V_{SD}$              | Forward on voltage                                    | $I_{SD} = 8\text{ A}$ $V_{GS} = 0$                       |      |           | 1.5     | V                   |
| $t_{rr}$<br>$Q_{rr}$  | Reverse recovery time<br>Reverse recovered charge     | $I_{SD} = 4\text{ A}$ $di/dt = 100\text{ A}/\mu\text{s}$ |      | 1200<br>6 |         | ns<br>$\mu\text{C}$ |



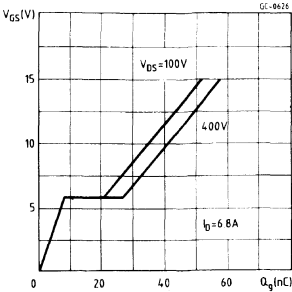
Static drain-source on resistance



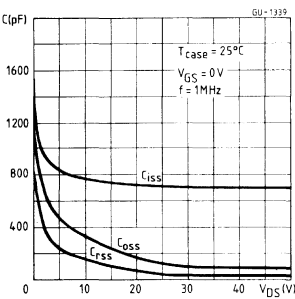
Maximum drain current vs temperature



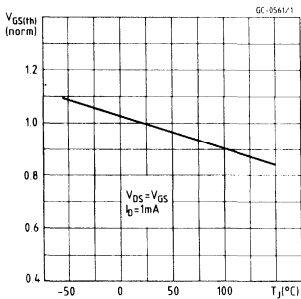
Gate charge vs gate-source voltage



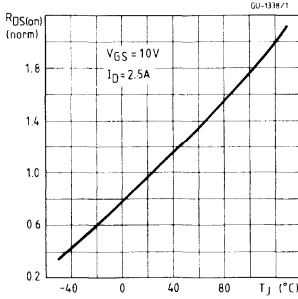
Capacitance variation



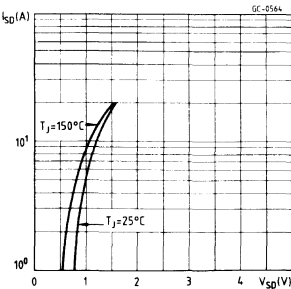
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE  | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------|------------------|---------------------|----------------|
| BUZ45 | 500 V            | 0.6 Ω               | 9.6 A          |

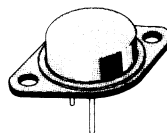
- HIGH VOLTAGE - FOR OFF-LINE SMPS
- ULTRA FAST SWITCHING FOR OPERATION AT <100KHz
- EASY DRIVE - FOR REDUCED COST AND SIZE

**INDUSTRIAL APPLICATIONS:**

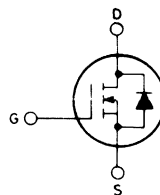
- SWITCH MODE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Typical applications include switching power supplies and motor speed control.



**TO-3**

**INTERNAL SCHEMATIC  
DIAGRAM**

**ABSOLUTE MAXIMUM RATINGS**

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 500         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 500         | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ±20         | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 25°C | 9.6         | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 38          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 125         | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | C           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

THERMAL DATA

|                  |                                     |     |     |      |
|------------------|-------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.0 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 35  | °C/W |

ELECTRICAL CHARACTERISTICS (T<sub>J</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                     |     |  |             |                    |
|----------------|--------------------------------------------------|--------------------------------------------------------------|---------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$                                            | $V_{GS} = 0$        | 500 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_J = 125^\circ C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                          |                     |     |  | $\pm 100$   | nA                 |

ON

|               |                                   |                   |                      |     |  |     |          |
|---------------|-----------------------------------|-------------------|----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ | $I_D = 1 \text{ mA}$ | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$   | $I_D = 5 A$          |     |  | 0.6 | $\Omega$ |

DYNAMIC

|                                     |                                                                         |                                 |                     |     |  |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|---------------------|-----|--|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$                 | $I_D = 5 A$         | 2.7 |  |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$ |     |  | 4900<br>400<br>170 | pF<br>pF<br>pF |

SWITCHING

|             |                     |                      |                 |  |  |     |    |
|-------------|---------------------|----------------------|-----------------|--|--|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30 V$      | $I_D = 2.8 A$   |  |  | 75  | ns |
| $t_r$       | Rise time           | $R_{GS} = 50 \Omega$ | $V_{GS} = 10 V$ |  |  | 120 | ns |
| $t_d (off)$ | Turn-off delay time |                      |                 |  |  | 430 | ns |
| $t_f$       | Fall time           |                      |                 |  |  | 140 | ns |

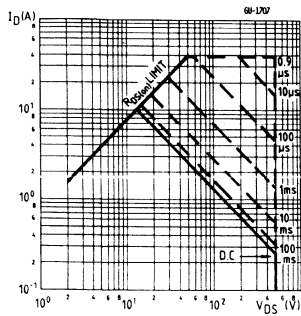
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

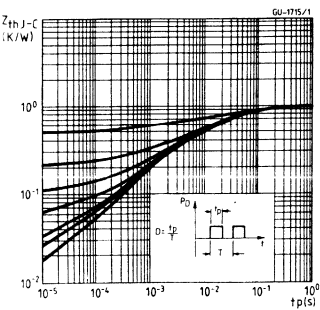
SOURCE DRAIN DIODE

|                       |                                                          |                                                 |            |           |               |
|-----------------------|----------------------------------------------------------|-------------------------------------------------|------------|-----------|---------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) | $T_C = 25^{\circ}C$                             |            | 9.6<br>38 | A<br>A        |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 19.2\text{ A}$<br>$V_{GS} = 0$        |            | 1.7       | V             |
| $t_{rr}$<br>$Q_{rr}$  | Reverse recovery<br>time<br>Reverse recovered<br>charge  | $I_{SD} = 9.6\text{ A}$<br>$di/dt = 100A/\mu s$ | 1200<br>12 |           | ns<br>$\mu C$ |

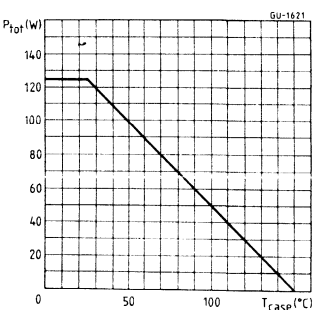
Safe operating areas



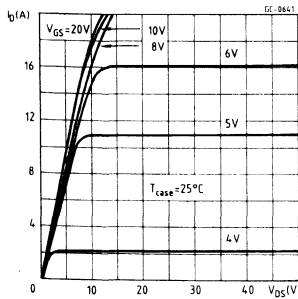
Thermal impedance



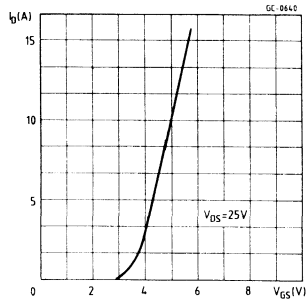
Derating curve



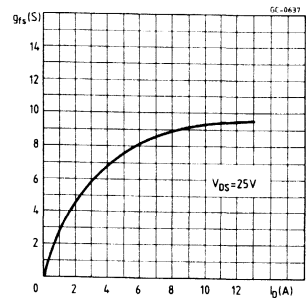
Output characteristics



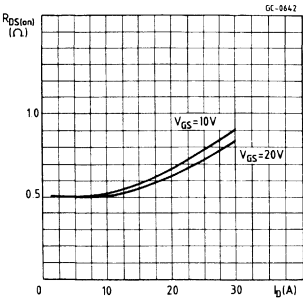
Transfer characteristics



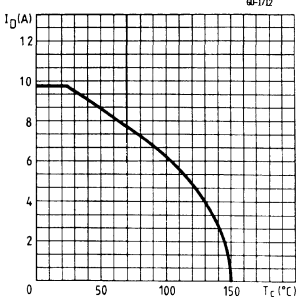
Transconductance



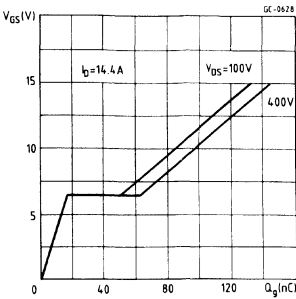
Static drain-source on resistance



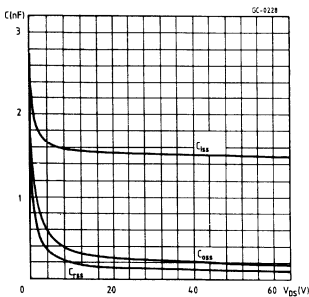
Maximum drain current vs temperature



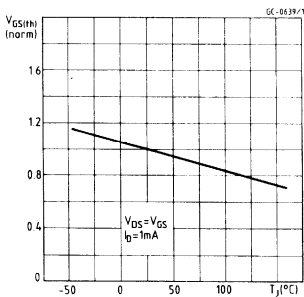
Gate charge vs gate-source voltage



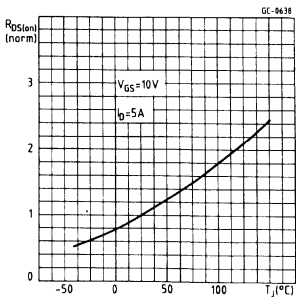
Capacitance variation



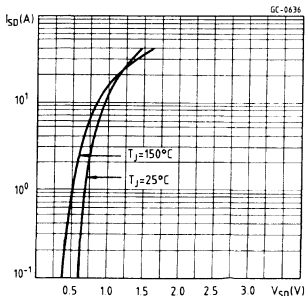
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| BUZ45A | 500 V            | 0.8 $\Omega$        | 8.3 A          |

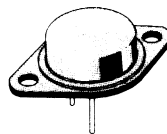
- HIGH VOLTAGE - FOR OFF-LINE SMPS
- ULTRA FAST SWITCHING FOR OPERATION AT < 100KHz
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCH MODE POWER SUPPLIES
- MOTOR CONTROLS

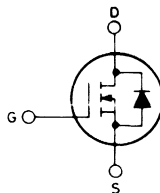
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Typical applications include switching power supplies, uninterruptable power supplies and motor speed control.



**TO-3**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                       |             |    |
|------------------|-------------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)            | 500         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 500         | V  |
| V <sub>GS</sub>  | Gate-source voltage                                   | $\pm 20$    | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 25°C      | 8.3         | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                                | 33          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C            | 125         | W  |
| T <sub>stg</sub> | Storage temperature                                   | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature                   | 150         | °C |
|                  | DIN humidity category (DIN 40040)                     | C           |    |
|                  | IEC climatic category (DIN IEC 68-1)                  | 55/150/56   |    |

THERMAL DATA

|                  |                                     |     |     |      |
|------------------|-------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.0 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 35  | °C/W |

ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                     |     |  |             |                    |
|----------------|--------------------------------------------------|--------------------------------------------------------------|---------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$                                            | $V_{GS} = 0$        | 500 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^\circ C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                          |                     |     |  | $\pm 100$   | nA                 |

ON

|               |                                   |                   |              |     |  |     |          |
|---------------|-----------------------------------|-------------------|--------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ | $I_D = 1 mA$ | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$   | $I_D = 5 A$  |     |  | 0.8 | $\Omega$ |

DYNAMIC

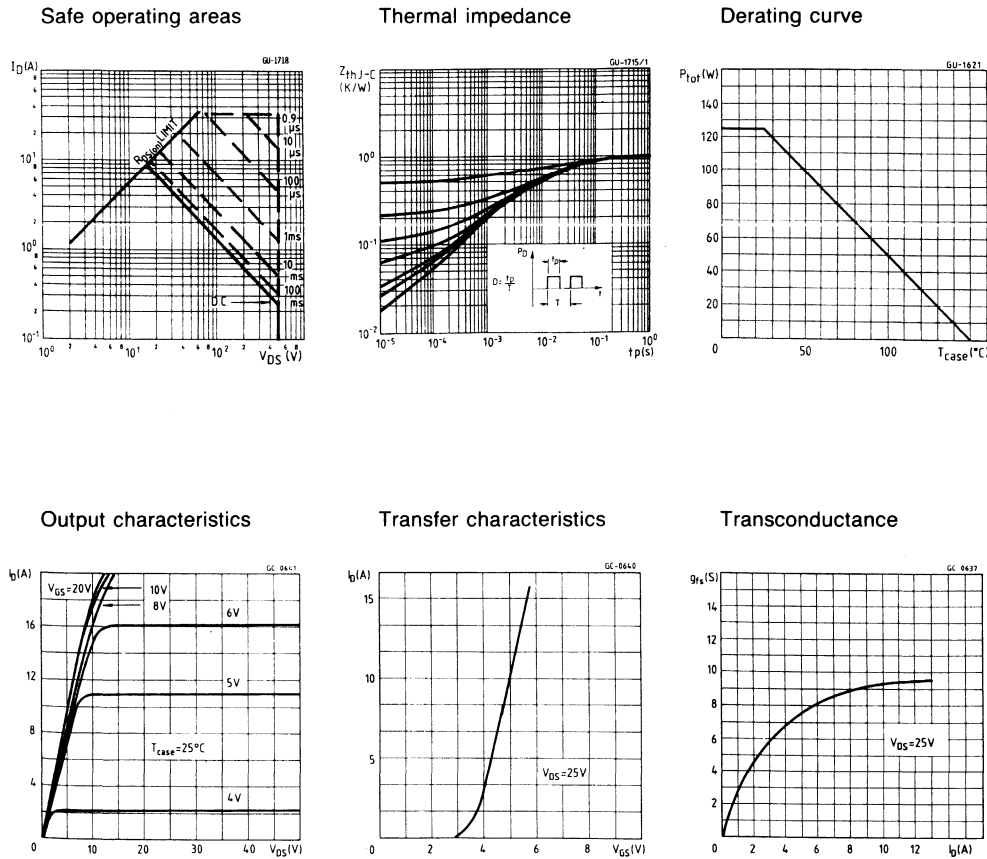
|                                     |                                                                         |                                 |             |     |  |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|-------------|-----|--|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$                 | $I_D = 5 A$ | 2.7 |  |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 MHz$ |     |  | 4900<br>400<br>170 | pF<br>pF<br>pF |

SWITCHING

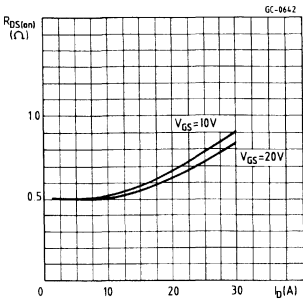
|                                             |                                                               |                                         |                                  |  |  |                         |                      |
|---------------------------------------------|---------------------------------------------------------------|-----------------------------------------|----------------------------------|--|--|-------------------------|----------------------|
| $t_d (on)$<br>$t_r$<br>$t_d (off)$<br>$t_f$ | Turn-on time<br>Rise time<br>Turn-off delay time<br>Fall time | $V_{DD} = 30 V$<br>$R_{GS} = 50 \Omega$ | $I_D = 2.8 A$<br>$V_{GS} = 10 V$ |  |  | 75<br>120<br>430<br>140 | ns<br>ns<br>ns<br>ns |
|---------------------------------------------|---------------------------------------------------------------|-----------------------------------------|----------------------------------|--|--|-------------------------|----------------------|

ELECTRICAL CHARACTERISTICS (Continued)

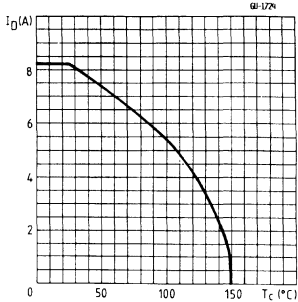
| Parameters            |                                                          | Test Conditions            |                                    | Min. | Typ. | Max.      | Unit          |
|-----------------------|----------------------------------------------------------|----------------------------|------------------------------------|------|------|-----------|---------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) | $T_c = 25^{\circ}\text{C}$ |                                    |      |      | 8.3<br>33 | A<br>A        |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 16.6\text{ A}$   | $V_{GS} = 0$                       |      |      | 1.6       | V             |
| $t_{rr}$              | Reverse recovery<br>time                                 |                            |                                    |      | 1200 |           | ns            |
| $Q_{rr}$              | Reverse recovered<br>charge                              | $I_{SD} = 8.3\text{ A}$    | $di/dt = 100\text{ A}/\mu\text{s}$ |      | 12   |           | $\mu\text{C}$ |



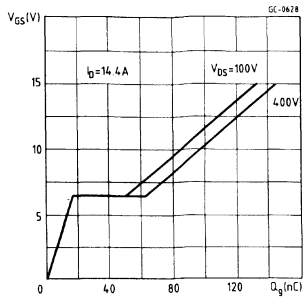
Static drain-source on resistance



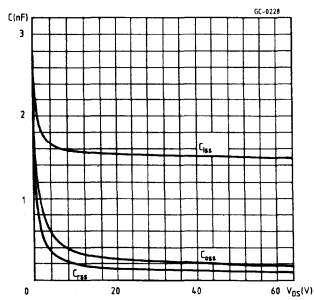
Maximum drain current vs temperature



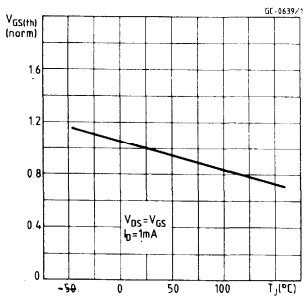
Gate charge vs gate-source voltage



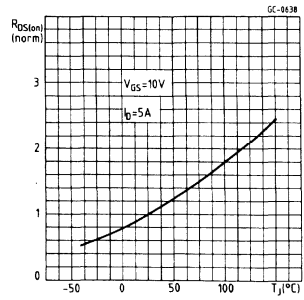
Capacitance variation



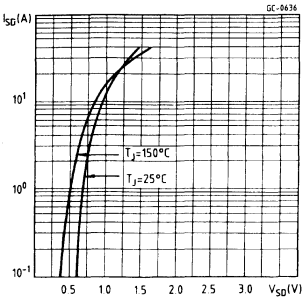
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE  | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------|------------------|---------------------|----------------|
| BUZ60 | 400 V            | 1.0 Ω               | 5.5 A          |

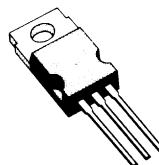
- HIGH VOLTAGE - FOR OFF-LINE APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- ELECTRONIC LAMP BALLAST
- DC SWITCH

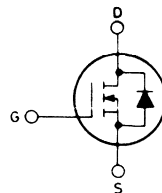
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Applications include DC switch, constant current source, ultrasonic equipment and electronic ballast for fluorescent lamps.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |            |    |
|------------------|--------------------------------------------------|------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 400        | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 400        | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ±20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 35°C | 5.5        | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 22         | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 75         | W  |
| T <sub>stg</sub> | Storage temperature                              | -55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150        | °C |
|                  | DIN humidity category (DIN 40040)                | E          |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56  |    |

THERMAL DATA

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.67 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75   | °C/W |

ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                     |     |  |             |                    |
|----------------|--------------------------------------------------|--------------------------------------------------------------|---------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$                                            | $V_{GS} = 0$        | 400 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^\circ C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                          |                     |     |  | $\pm 100$   | nA                 |

ON

|               |                                   |                   |                      |     |  |     |          |
|---------------|-----------------------------------|-------------------|----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ | $I_D = 1 \text{ mA}$ | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$   | $I_D = 2.5 A$        |     |  | 1.0 | $\Omega$ |

DYNAMIC

|           |                              |                                 |                     |     |  |      |     |
|-----------|------------------------------|---------------------------------|---------------------|-----|--|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$                 | $I_D = 2.5 A$       | 1.7 |  |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$ |     |  | 2000 | pF  |
| $C_{oss}$ | Output capacitance           |                                 |                     |     |  | 180  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                 |                     |     |  | 60   | pF  |

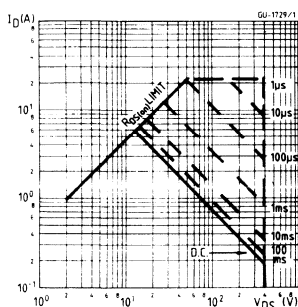
SWITCHING

|             |                     |                      |                 |  |  |     |    |
|-------------|---------------------|----------------------|-----------------|--|--|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30 V$      | $I_D = 2.7 A$   |  |  | 45  | ns |
| $t_r$       | Rise time           | $R_{GS} = 50 \Omega$ | $V_{GS} = 10 V$ |  |  | 60  | ns |
| $t_d (off)$ | Turn-off delay time |                      |                 |  |  | 140 | ns |
| $t_f$       | Fall time           |                      |                 |  |  | 65  | ns |

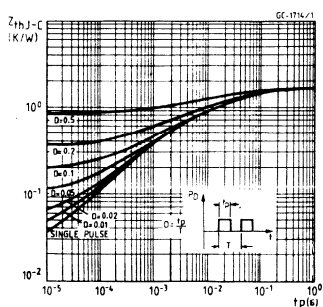
# ELECTRICAL CHARACTERISTICS (Continued)

| Parameters            | Test Conditions                                          | Min.                    | Typ.                               | Max.      | Unit                |
|-----------------------|----------------------------------------------------------|-------------------------|------------------------------------|-----------|---------------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) |                         |                                    | 5.5<br>22 | A<br>A              |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 11\text{ A}$  | $V_{GS} = 0$                       | 1.6       | V                   |
| $t_{rr}$<br>$Q_{rr}$  | Reverse recovery<br>time<br>Reverse recovered<br>charge  | $I_{SD} = 5.5\text{ A}$ | $di/dt = 100\text{ A}/\mu\text{s}$ | 1000<br>5 | ns<br>$\mu\text{C}$ |

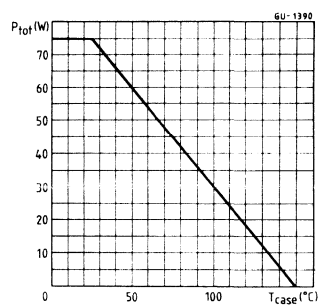
Safe operating areas



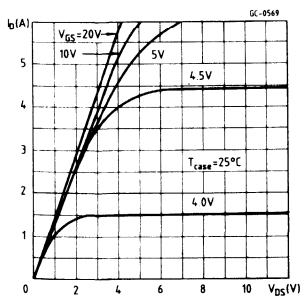
Thermal impedance



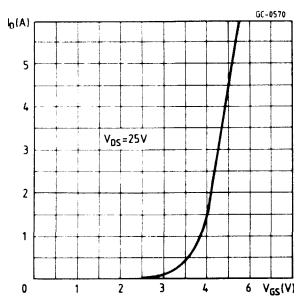
Derating curve



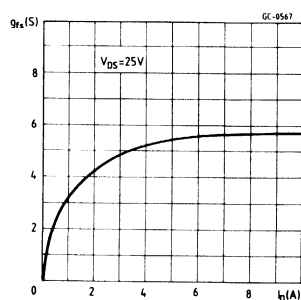
Output characteristics



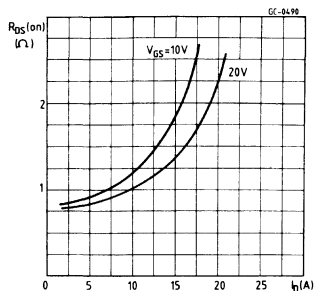
Transfer characteristics



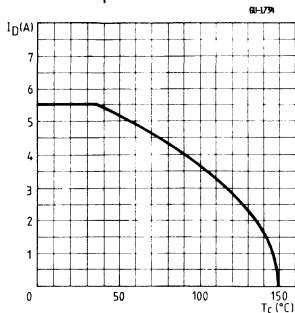
Transconductance



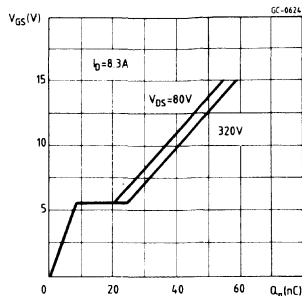
Static drain-source on resistance



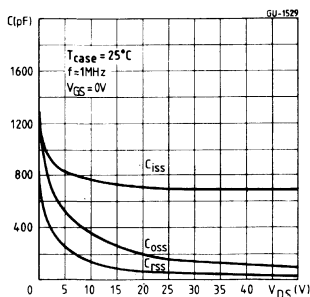
Maximum drain current vs temperature



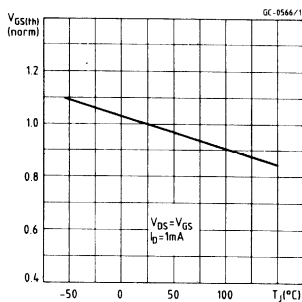
Gate charge vs gate-source voltage



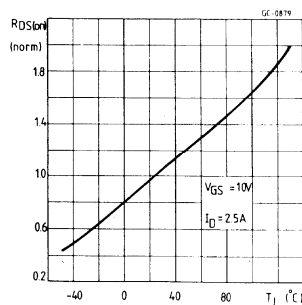
Capacitance variation



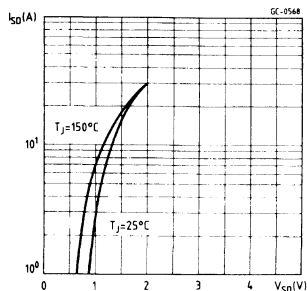
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

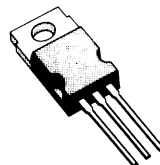
| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| BUZ60B | 400 V            | 1.5 Ω               | 4.5 A          |

- HIGH VOLTAGE - FOR OFF-LINE APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

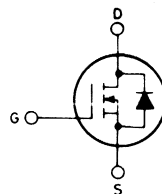
- ELECTRONIC LAMP BALLAST
- DC SWITCH

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Applications include DC switch, constant current source, ultrasonic equipment and electronic ballast for fluorescent lamps.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 400         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 400         | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ±20         | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 25°C | 4.5         | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 18          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 75          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

THERMAL DATA

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.67 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75   | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                             |     |  |             |                                |
|----------------|--------------------------------------------------|---------------------------------------------------------------------------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$<br>$V_{GS} = 0$                                                    | 400 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$<br>$T_j = 125^{\circ}\text{C}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\ \text{V}$                                                                 |     |  | $\pm 100$   | nA                             |

ON

|               |                                   |                                                  |     |  |     |          |
|---------------|-----------------------------------|--------------------------------------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 1\ \text{mA}$        | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10\ \text{V}$<br>$I_D = 2.5\ \text{A}$ |     |  | 1.5 | $\Omega$ |

DYNAMIC

|           |                              |                                                                |     |  |      |     |
|-----------|------------------------------|----------------------------------------------------------------|-----|--|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25\ \text{V}$<br>$I_D = 2.5\ \text{A}$               | 1.7 |  |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25\ \text{V}$<br>$V_{GS} = 0$<br>$f = 1\ \text{MHz}$ |     |  | 2000 | pF  |
| $C_{oss}$ | Output capacitance           |                                                                |     |  | 180  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                                |     |  | 60   | pF  |

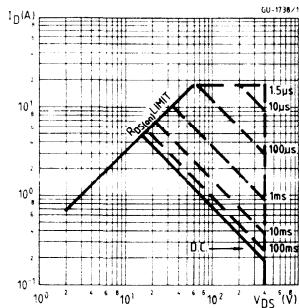
SWITCHING

|             |                     |                                                                                                      |  |  |     |    |
|-------------|---------------------|------------------------------------------------------------------------------------------------------|--|--|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30\ \text{V}$<br>$R_{GS} = 50\ \Omega$<br>$I_D = 2.5\ \text{A}$<br>$V_{GS} = 10\ \text{V}$ |  |  | 45  | ns |
| $t_r$       | Rise time           |                                                                                                      |  |  | 60  | ns |
| $t_d (off)$ | Turn-off delay time |                                                                                                      |  |  | 140 | ns |
| $t_f$       | Fall time           |                                                                                                      |  |  | 65  | ns |

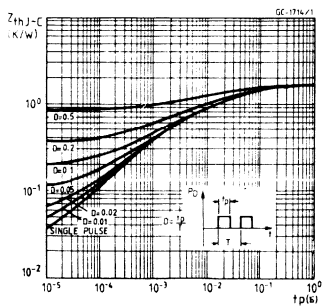
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                                                        | Test Conditions                                 | Min. | Typ.      | Max.      | Unit          |
|-----------------------------------------------------------------------------------|-------------------------------------------------|------|-----------|-----------|---------------|
| $I_{SD}$<br>$I_{SDM}$<br>Source-drain current<br>Source-drain current<br>(pulsed) | $T_c = 25^{\circ}C$                             |      |           | 4.5<br>18 | A<br>A        |
| $V_{SD}$<br>Forward on voltage                                                    | $I_{SD} = 9\text{ A}$<br>$V_{GS} = 0$           |      |           | 1.5       | V             |
| $t_{rr}$<br>$Q_{rr}$<br>Reverse recovery<br>time<br>Reverse recovered<br>charge   | $I_{SD} = 4.5\text{ A}$<br>$di/dt = 100A/\mu s$ |      | 1000<br>5 |           | ns<br>$\mu C$ |

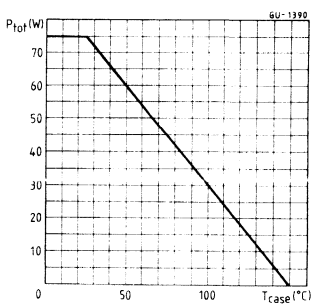
Safe operating areas



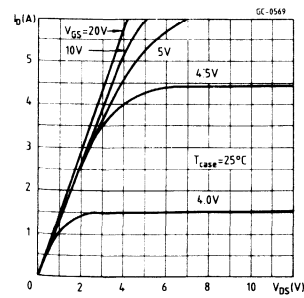
Thermal impedance



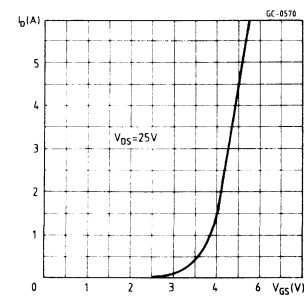
Derating curve



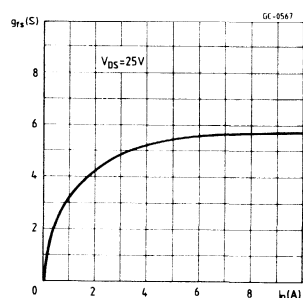
Output characteristics



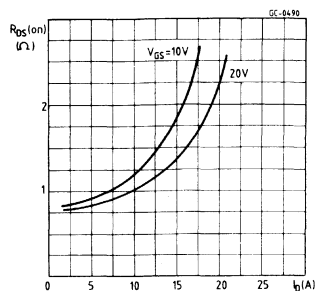
Transfer characteristics



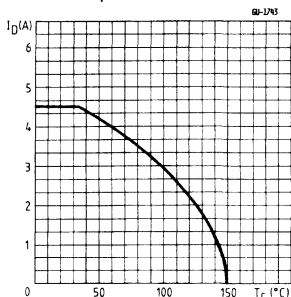
Transconductance



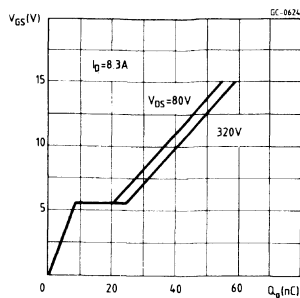
Static drain-source on resistance



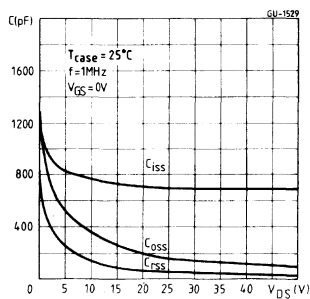
Maximum drain current vs temperature



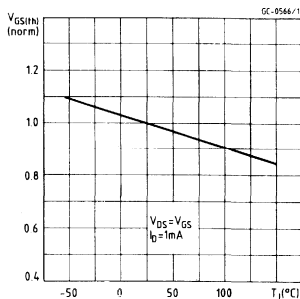
Gate charge vs gate-source voltage



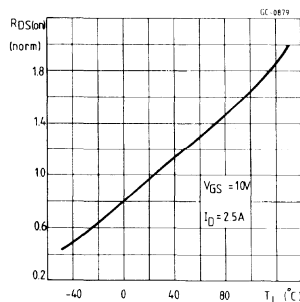
Capacitance variation



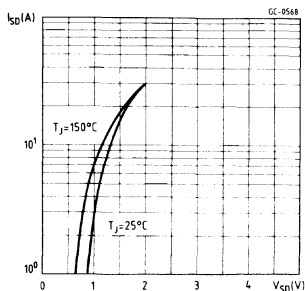
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

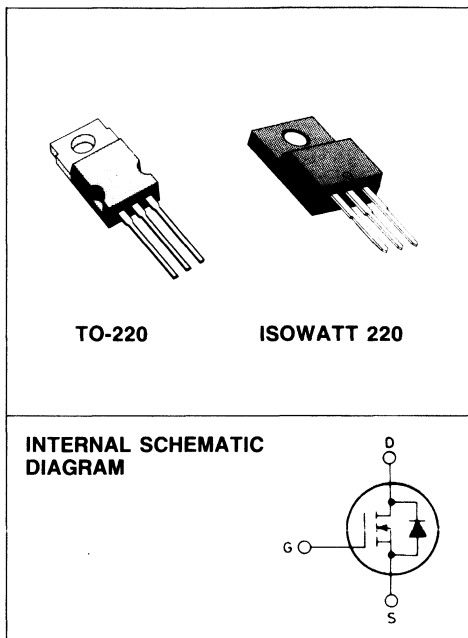
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> ■ |
|---------|------------------|---------------------|------------------|
| BUZ71   | 50 V             | 0.1 Ω               | 14 A             |
| BUZ71FI | 50 V             | 0.1 Ω               | 12 A             |

- VERY FAST SWITCHING
- LOW DRIVE ENERGY FOR EASY DRIVE, REDUCED SIZE AND COST
- HIGH PULSED CURRENT - 56A FOR POWER APPLICATIONS

### INDUSTRIAL APPLICATIONS:

- POWER ACTUATORS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching circuits in applications such as power actuator driving, motor drive including brushless motors, robotics, actuators and many other uses in automotive control applications. They also find use in DC/DC converters and uninterruptible power supplies.



### ABSOLUTE MAXIMUM RATINGS

|                    |                                                  |                    |                        |
|--------------------|--------------------------------------------------|--------------------|------------------------|
| V <sub>DS</sub>    | Drain-source voltage (V <sub>GS</sub> = 0)       | 50                 | V                      |
| V <sub>DGR</sub>   | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 50                 | V                      |
| V <sub>GS</sub>    | Gate-source voltage                              | ±20                | V                      |
| I <sub>DM</sub>    | Drain current (pulsed) T <sub>c</sub> = 25°C     | 56                 | A                      |
| I <sub>D</sub> ■   | Drain current (continuous) T <sub>c</sub> = 30°C | <b>BUZ71</b><br>14 | <b>BUZ71FI</b><br>12 A |
| P <sub>tot</sub> ■ | Total dissipation at T <sub>c</sub> < 25°C       | 40                 | 30 W                   |
| T <sub>stg</sub>   | Storage temperature                              | -55 to 150         | °C                     |
| T <sub>j</sub>     | Max. operating junction temperature              | 150                | °C                     |
|                    | DIN humidity category (DIN 40040)                | E                  |                        |
|                    | IEC climatic category (DIN IEC 68-1)             | 55/150/56          |                        |

■ See note on ISOWATT 220 in this datasheet

THERMAL DATA ■

|                  |                                     | TO-220 |     | ISOWATT220 |      |
|------------------|-------------------------------------|--------|-----|------------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max    | 3.1 | 4.16       | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max    | 75  |            | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                             |    |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|-----------------------------|----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$                                      | $V_{GS} = 0$                | 50 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^{\circ}\text{C}$ |    |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                  |                             |    |  | $\pm 100$   | nA                             |

ON

|               |                                   |                         |                      |     |  |     |          |
|---------------|-----------------------------------|-------------------------|----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1 \text{ mA}$ | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ | $I_D = 9 \text{ A}$  |     |  | 0.1 | $\Omega$ |

DYNAMIC

|           |                              |                                         |                     |   |  |     |     |
|-----------|------------------------------|-----------------------------------------|---------------------|---|--|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 \text{ V}$                 | $I_D = 9 \text{ A}$ | 3 |  |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$ |   |  | 650 | pF  |
| $C_{oss}$ | Output capacitance           |                                         |                     |   |  | 450 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                         |                     |   |  | 280 | pF  |

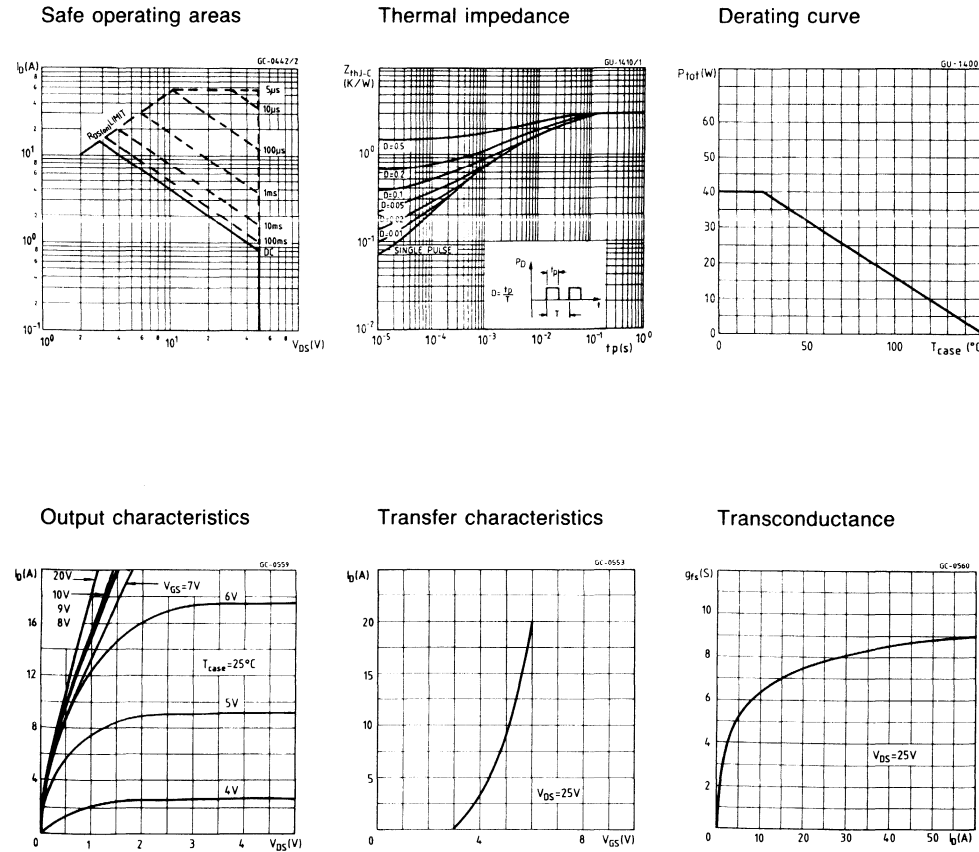
SWITCHING

|             |                     |                         |                         |  |  |     |    |
|-------------|---------------------|-------------------------|-------------------------|--|--|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30 \text{ V}$ | $I_D = 3 \text{ A}$     |  |  | 30  | ns |
| $t_r$       | Rise time           | $R_{GS} = 50 \Omega$    | $V_{GS} = 10 \text{ V}$ |  |  | 85  | ns |
| $t_d (off)$ | Turn-off delay time |                         |                         |  |  | 90  | ns |
| $t_f$       | Fall time           |                         |                         |  |  | 110 | ns |

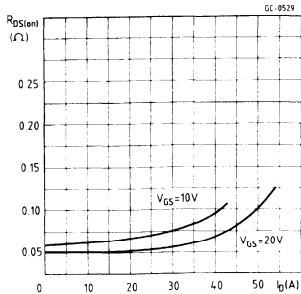
■ See note on ISOWATT 220 in this datasheet

ELECTRICAL CHARACTERISTICS (Continued)

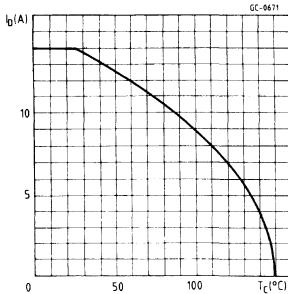
| Parameters |                               | Test Conditions        |                                    | Min. | Typ. | Max. | Unit          |
|------------|-------------------------------|------------------------|------------------------------------|------|------|------|---------------|
| $I_{SD}$   | Source-drain current          |                        |                                    |      |      | 14   | A             |
| $I_{SDM}$  | Source-drain current (pulsed) |                        |                                    |      |      | 56   | A             |
| $V_{SD}$   | Forward on voltage            | $I_{SD} = 28\text{ A}$ | $V_{GS} = 0$                       |      |      | 1.8  | V             |
| $t_{rr}$   | Reverse recovery time         |                        |                                    |      | 120  |      | ns            |
| $Q_{rr}$   | Reverse recovered charge      | $I_{SD} = 14\text{ A}$ | $di/dt = 100\text{ A}/\mu\text{s}$ |      | 0.15 |      | $\mu\text{C}$ |



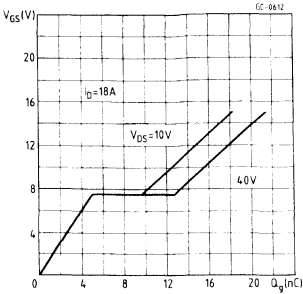
Static drain-source on resistance



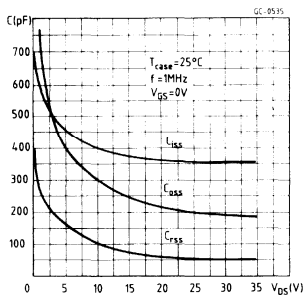
Maximum drain current vs temperature



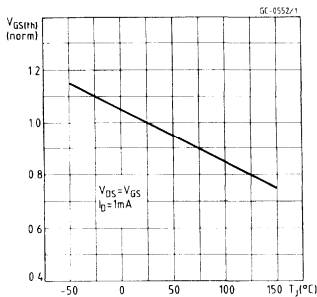
Gate charge vs gate-source voltage



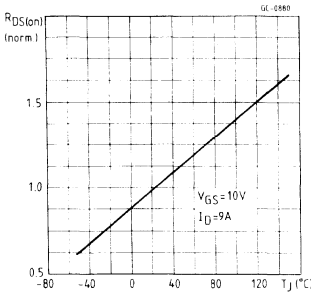
Capacitance variation



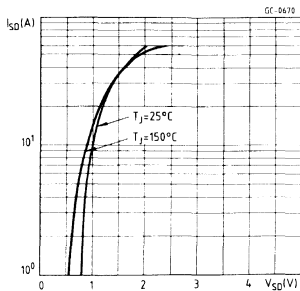
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics





## ISOWATT220 PACKAGE CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

## THERMAL IMPEDANCE OF ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th(tot)}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

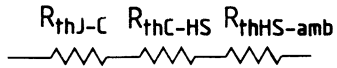
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

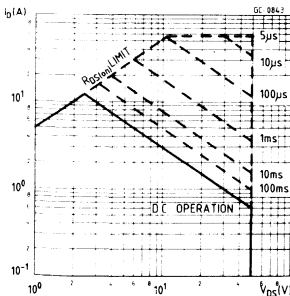
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

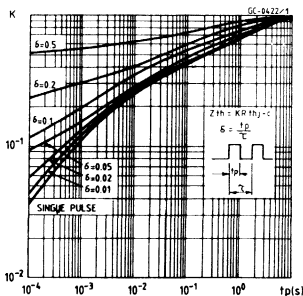


## ISOWATT DATA

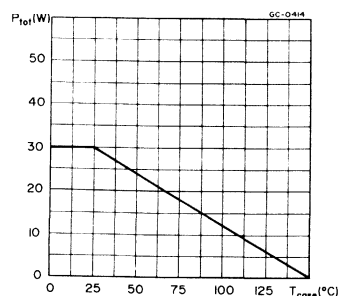
### Safe operating areas



### Thermal impedance



### Derating curve





**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR**

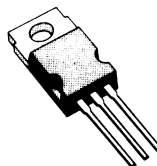
| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| BUZ71A | 50 V             | 0.12 Ω              | 13 A           |

- ULTRA FAST SWITCHING
- LOW DRIVE ENERGY FOR EASY DRIVE
- COST EFFECTIVE

**INDUSTRIAL APPLICATIONS:**

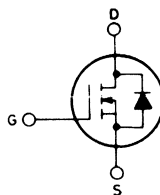
- AUTOMOTIVE POWER ACTUATORS
- MOTORS CONTROL
- INVERTERS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications such as power actuator driving, motor drive including brushless motors, hydraulic actuators and many other uses in automotive and automotive and automatic guided vehicle applications. It also finds use in DC/DC converters and uninterruptable power supplies.



**TO-220**

**INTERNAL SCHEMATIC  
DIAGRAM**



**ABSOLUTE MAXIMUM RATINGS**

|                  |                                                  |            |    |
|------------------|--------------------------------------------------|------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 50         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 50         | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ±20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 25°C | 13         | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 52         | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 40         | W  |
| T <sub>stg</sub> | Storage temperature                              | -55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150        | °C |
|                  | DIN humidity category (DIN 40040)                | E          |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56  |    |

THERMAL DATA

|                  |                                     |     |     |      |
|------------------|-------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 3.1 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75  | °C/W |

ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                     |    |   |             |                    |
|----------------|--------------------------------------------------|--------------------------------------------------------------|---------------------|----|---|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$                                            | $V_{GS} = 0$        | 50 |   |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^\circ C$ |    |   | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                  |                     |    | - | $\pm 100$   | nA                 |

ON

|               |                                   |                         |                      |     |  |      |          |
|---------------|-----------------------------------|-------------------------|----------------------|-----|--|------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1 \text{ mA}$ | 2.1 |  | 4    | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ | $I_D = 9 \text{ A}$  |     |  | 0.12 | $\Omega$ |

DYNAMIC

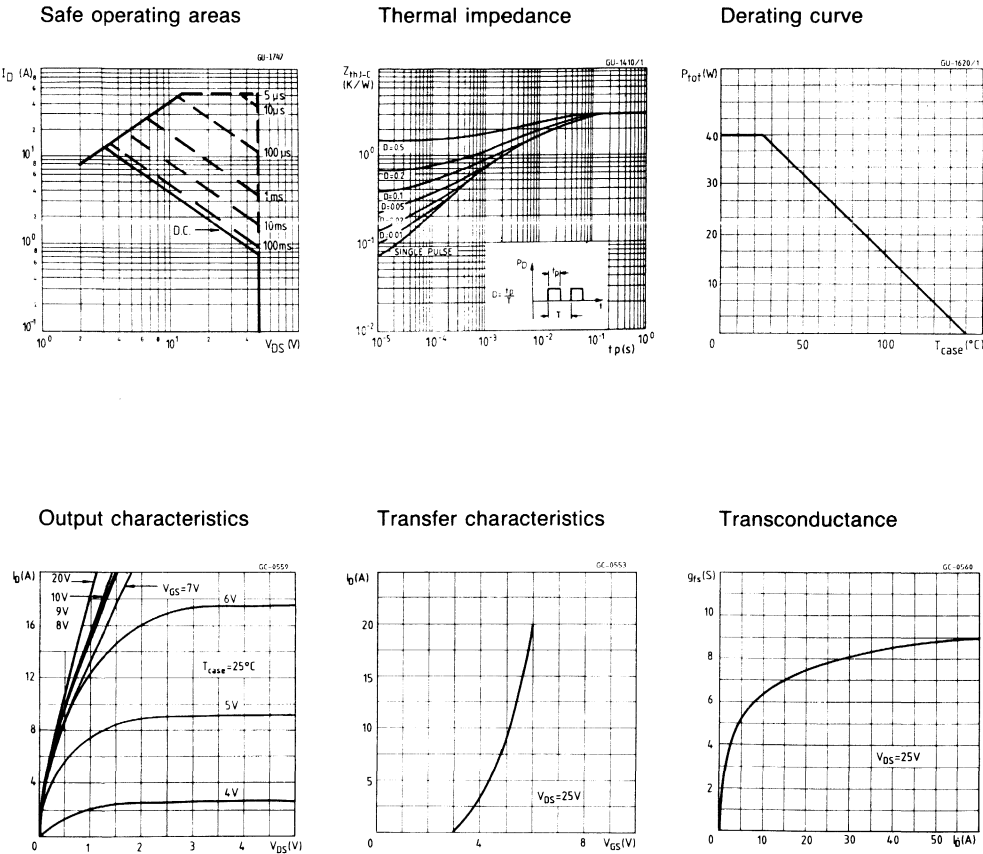
|           |                              |                         |                     |   |  |     |     |
|-----------|------------------------------|-------------------------|---------------------|---|--|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 \text{ V}$ | $I_D = 9 \text{ A}$ | 3 |  |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$ | $f = 1 \text{ MHz}$ |   |  | 650 | pF  |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$            |                     |   |  | 450 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                         |                     |   |  | 280 | pF  |

SWITCHING

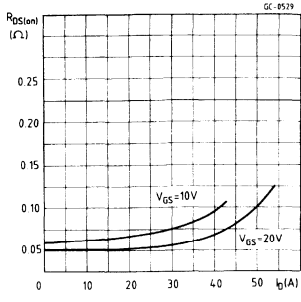
|               |                     |                         |                         |  |  |     |    |
|---------------|---------------------|-------------------------|-------------------------|--|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 30 \text{ V}$ | $I_D = 3 \text{ A}$     |  |  | 30  | ns |
| $t_r$         | Rise time           | $R_{GS} = 50 \Omega$    | $V_{GS} = 10 \text{ V}$ |  |  | 85  | ns |
| $t_{d (off)}$ | Turn-off delay time |                         |                         |  |  | 90  | ns |
| $t_f$         | Fall time           |                         |                         |  |  | 110 | ns |

ELECTRICAL CHARACTERISTICS (Continued)

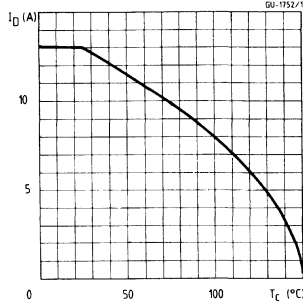
| Parameters |                               | Test Conditions        |                      | Min. | Typ. | Max. | Unit    |
|------------|-------------------------------|------------------------|----------------------|------|------|------|---------|
| $I_{SD}$   | Source-drain current          | $T_c = 25^{\circ}C$    |                      |      |      | 13   | A       |
| $I_{SDM}$  | Source-drain current (pulsed) |                        |                      |      |      | 52   | A       |
| $V_{SD}$   | Forward on voltage            | $I_{SD} = 26\text{ A}$ | $V_{GS} = 0$         |      |      | 2.2  | V       |
| $t_{rr}$   | Reverse recovery time         |                        |                      |      | 120  |      | ns      |
| $Q_{rr}$   | Reverse recovered charge      | $I_{SD} = 13\text{ A}$ | $di/dt = 100A/\mu s$ |      | 0.15 |      | $\mu C$ |



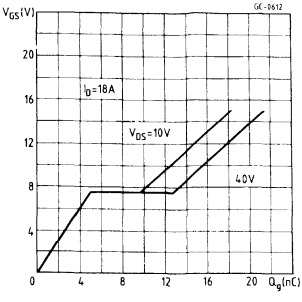
Static drain-source on resistance



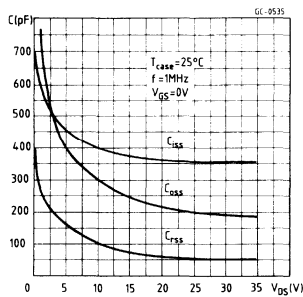
Maximum drain current vs temperature



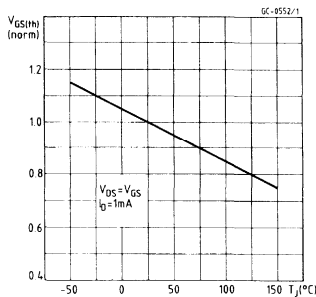
Gate charge vs gate-source voltage



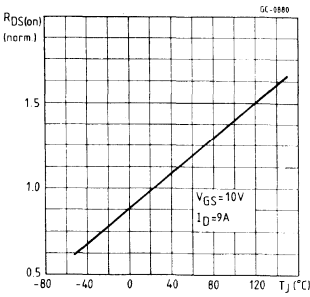
Capacitance variation



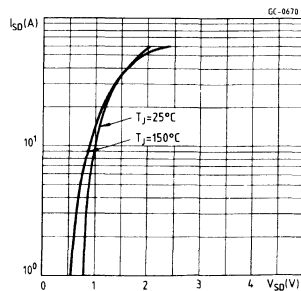
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| BUZ72A | 100 V            | 0.25 $\Omega$       | 9 A            |

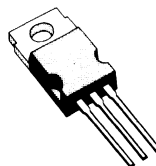
- 100 VOLTS - FOR UPS APPLICATIONS
- ULTRA FAST SWITCHING
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- EASY DRIVE - FOR REDUCED SIZE AND COST

### INDUSTRIAL APPLICATIONS:

- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

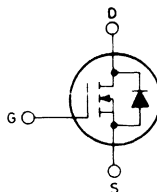
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching application.

Typical applications include UPS, battery changers, printer hammer drivers, solenoid drivers and motor control.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                       |             |    |
|------------------|-------------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)            | 100         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 100         | V  |
| V <sub>GS</sub>  | Gate-source voltage                                   | $\pm 20$    | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 25°C      | 9           | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                                | 36          | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C            | 40          | W  |
| T <sub>stg</sub> | Storage temperature                                   | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature                   | 150         | °C |
|                  | DIN humidity category (DIN 40040)                     | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)                  | 55/150/56   |    |

♦ Introduced in 1989 week 1

**THERMAL DATA**

|                  |                                     |     |     |      |
|------------------|-------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 3.1 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75  | °C/W |

**ELECTRICAL CHARACTERISTICS** ( $T_j = 25^\circ\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                              |                           |     |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|---------------------------|-----|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$                                      | $V_{GS} = 0$              | 100 |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^\circ\text{C}$ |     | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                  |                           |     | $\pm 100$   | nA                             |

**ON**

|               |                                   |                         |                      |     |  |      |          |
|---------------|-----------------------------------|-------------------------|----------------------|-----|--|------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1 \text{ mA}$ | 2.1 |  | 4    | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ | $I_D = 5 \text{ A}$  |     |  | 0.25 | $\Omega$ |

**ENERGY TEST**

|           |                                                      |                                                              |                       |   |  |  |   |
|-----------|------------------------------------------------------|--------------------------------------------------------------|-----------------------|---|--|--|---|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 \text{ V}$<br>starting $T_j = 25^\circ\text{C}$ | $L = 100 \mu\text{H}$ | 9 |  |  | A |
|-----------|------------------------------------------------------|--------------------------------------------------------------|-----------------------|---|--|--|---|

**DYNAMIC**

|           |                              |                                         |                     |     |  |     |     |
|-----------|------------------------------|-----------------------------------------|---------------------|-----|--|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 \text{ V}$                 | $I_D = 5 \text{ A}$ | 2.7 |  |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$ |     |  | 600 | pF  |
| $C_{oss}$ | Output capacitance           |                                         |                     |     |  | 240 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                         |                     |     |  | 130 | pF  |

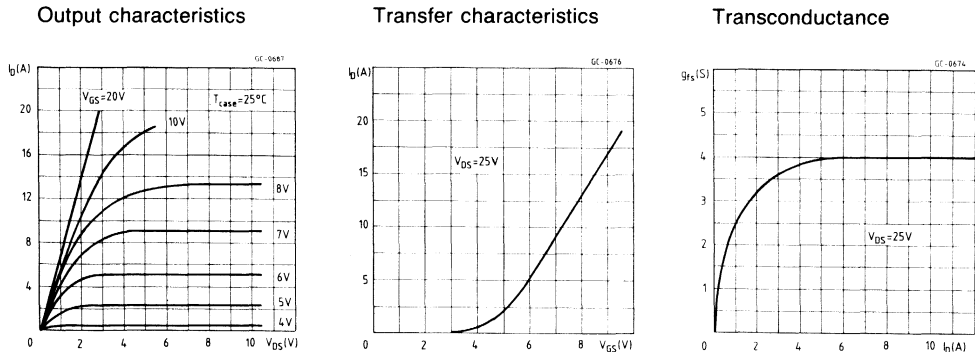
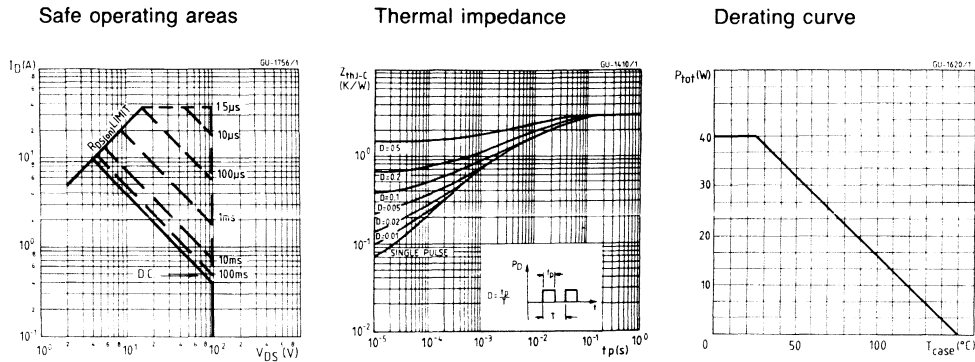
**SWITCHING**

|               |                     |                                                 |                                                  |  |  |    |    |
|---------------|---------------------|-------------------------------------------------|--------------------------------------------------|--|--|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 30 \text{ V}$<br>$R_{GS} = 50 \Omega$ | $I_D = 2.9 \text{ A}$<br>$V_{GS} = 10 \text{ V}$ |  |  | 30 | ns |
| $t_r$         | Rise time           |                                                 |                                                  |  |  | 70 | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                 |                                                  |  |  | 90 | ns |
| $t_f$         | Fall time           |                                                 |                                                  |  |  | 70 | ns |

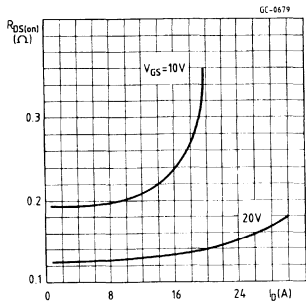


ELECTRICAL CHARACTERISTICS (Continued)

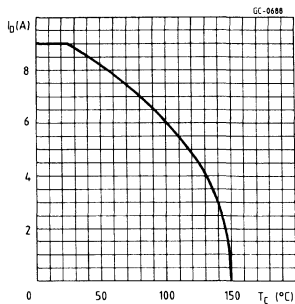
| Parameters            | Test Conditions                                                                                    | Min. | Typ.        | Max.    | Unit          |
|-----------------------|----------------------------------------------------------------------------------------------------|------|-------------|---------|---------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current (pulsed)<br>$T_c = 25^{\circ}C$                       |      |             | 9<br>36 | A<br>A        |
| $V_{SD}$              | Forward on voltage<br>$I_{SD} = 18\text{ A}$<br>$V_{GS} = 0$                                       |      |             | 2       | V             |
| $t_{rr}$<br>$Q_{rr}$  | Reverse recovery time<br>Reverse recovered charge<br>$I_{SD} = 9\text{ A}$<br>$di/dt = 100A/\mu s$ |      | 170<br>0.30 |         | ns<br>$\mu C$ |



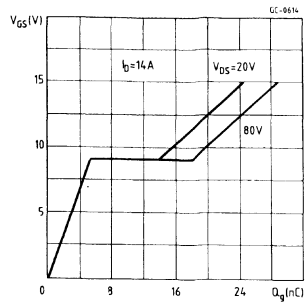
Static drain-source on resistance



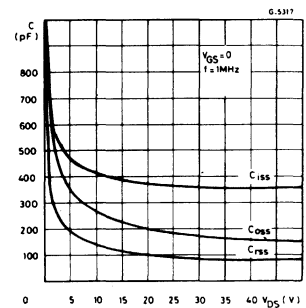
Maximum drain current vs temperature



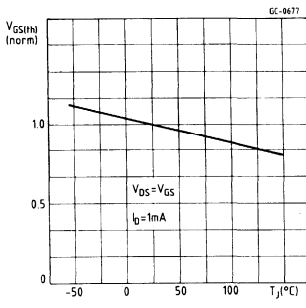
Gate charge vs gate-source voltage



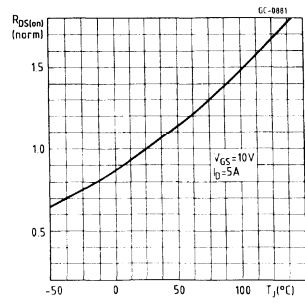
Capacitance variation



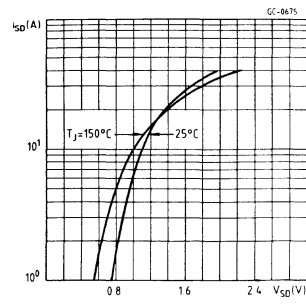
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE  | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------|------------------|---------------------|----------------|
| BUZ74 | 500 V            | 3.0 Ω               | 2.4 A          |

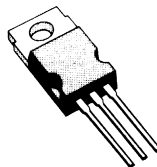
- HIGH SPEED SWITCHING APPLICATIONS
- HIGH VOLTAGE - 500V FOR OFF-LINE SMPS
- ULTRA FAST SWITCHING FOR OPERATION AT > 100KHz
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCH MODE POWER SUPPLIES
- MOTOR CONTROLS

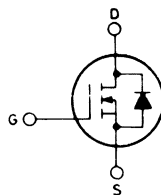
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Typical applications include switching power supplies, uninterruptible power supplies and motor speed control.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 500         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 500         | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ± 20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 30°C | 2.4         | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 9.6         | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 40          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

**THERMAL DATA**

|                  |                                     |     |     |      |
|------------------|-------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 3.1 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75  | °C/W |

**ELECTRICAL CHARACTERISTICS** ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                              |                              |     |  |             |                                |
|----------------|--------------------------------------------------|------------------------------|------------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$     | $V_{GS} = 0$                 | 500 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$ | $V_{DS} = \text{Max Rating}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\ \text{V}$  |                              |     |  | $\pm 100$   | nA                             |

**ON**

|               |                                   |                         |                       |     |  |     |          |
|---------------|-----------------------------------|-------------------------|-----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1\ \text{mA}$  | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10\ \text{V}$ | $I_D = 1.2\ \text{A}$ |     |  | 3.0 | $\Omega$ |

**DYNAMIC**

|           |                              |                         |                       |     |  |     |     |
|-----------|------------------------------|-------------------------|-----------------------|-----|--|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25\ \text{V}$ | $I_D = 1.2\ \text{A}$ | 0.8 |  |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25\ \text{V}$ | $f = 1\ \text{MHz}$   |     |  | 500 | pF  |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$            |                       |     |  | 80  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                         |                       |     |  | 55  | pF  |

**SWITCHING**

|             |                     |                         |                         |  |  |    |    |
|-------------|---------------------|-------------------------|-------------------------|--|--|----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30\ \text{V}$ | $I_D = 2.3\ \text{A}$   |  |  | 20 | ns |
| $t_r$       | Rise time           | $R_{GS} = 50\ \Omega$   | $V_{GS} = 10\ \text{V}$ |  |  | 60 | ns |
| $t_d (off)$ | Turn-off delay time |                         |                         |  |  | 65 | ns |
| $t_f$       | Fall time           |                         |                         |  |  | 40 | ns |

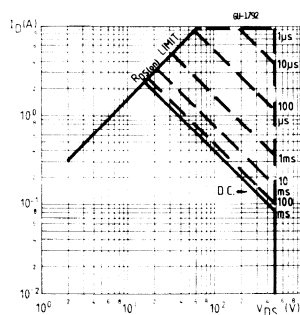
## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

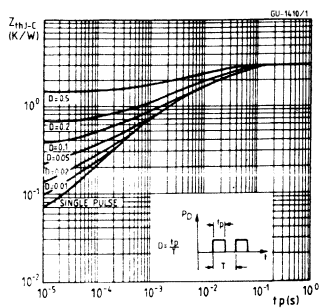
## SOURCE DRAIN DIODE

|                       |                                                          |                                                               |            |            |                     |
|-----------------------|----------------------------------------------------------|---------------------------------------------------------------|------------|------------|---------------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) | $T_c = 25^\circ\text{C}$                                      |            | 2.4<br>9.5 | A<br>A              |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 4.8\text{ A}$<br>$V_{GS} = 0$                       |            | 1.3        | V                   |
| $t_{rr}$<br>$Q_{rr}$  | Reverse recovery<br>time<br>Reverse recovered<br>charge  | $I_{SD} = 2.4\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ | 350<br>3.5 |            | ns<br>$\mu\text{C}$ |

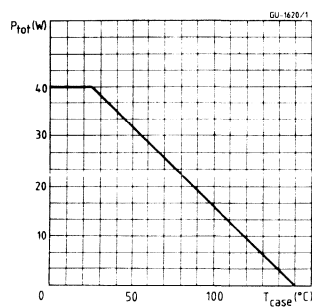
Safe operating areas



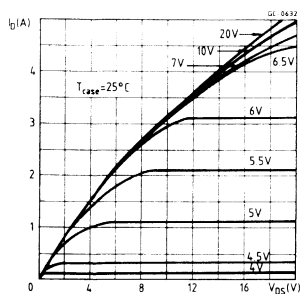
Thermal impedance



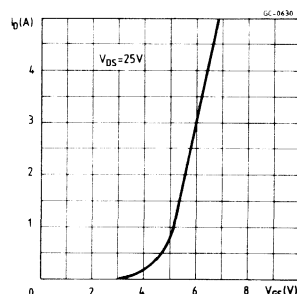
Derating curve



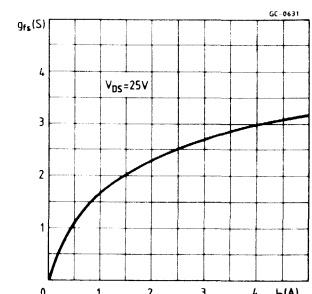
Output characteristics



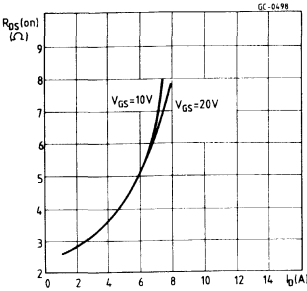
Transfer characteristics



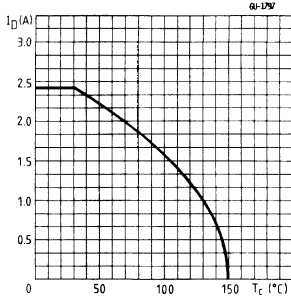
Transconductance



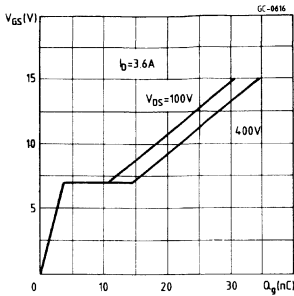
Static drain-source on resistance



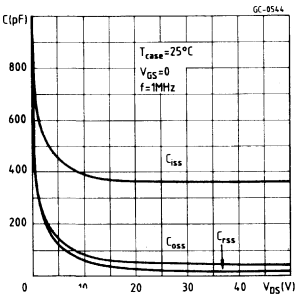
Maximum drain current vs temperature



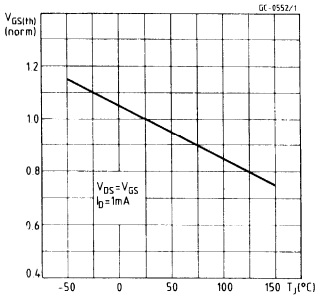
Gate charge vs gate-source voltage



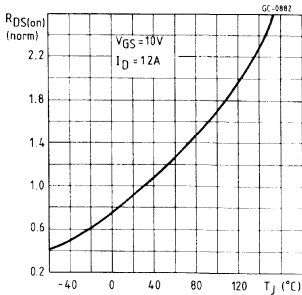
Capacitance variation



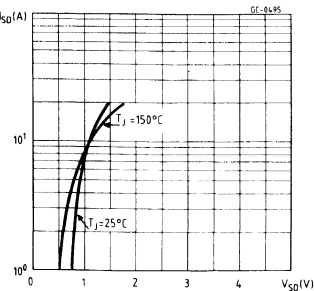
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| BUZ74A | 500 V            | 4 Ω                 | 2 A            |

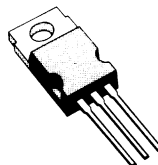
- HIGH VOLTAGE - FOR OFF-LINE SMPS
- ULTRA FAST SWITCHING FOR OPERATION AT > 100KHz
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCH MODE POWER SUPPLIES
- MOTOR CONTROLS

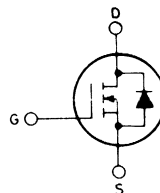
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Typical applications include switching power supplies, uninterruptible power supplies and motor speed control.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |             |    |
|------------------|--------------------------------------------------|-------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 500         | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 500         | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ±20         | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 40°C | 2           | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 8           | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 40          | W  |
| T <sub>stg</sub> | Storage temperature                              | - 55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150         | °C |
|                  | DIN humidity category (DIN 40040)                | E           |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56   |    |

THERMAL DATA

|                  |                                     |     |     |      |
|------------------|-------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 3.1 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75  | °C/W |

ELECTRICAL CHARACTERISTICS
(T<sub>J</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                     |     |             |                    |
|----------------|--------------------------------------------------|--------------------------------------------------------------|---------------------|-----|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$                                            | $V_{GS} = 0$        | 500 |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_J = 125^\circ C$ |     | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                          |                     |     | $\pm 100$   | nA                 |

ON

|               |                                   |                   |                      |     |  |     |          |
|---------------|-----------------------------------|-------------------|----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ | $I_D = 1 \text{ mA}$ | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$   | $I_D = 1.2 A$        |     |  | 4.0 | $\Omega$ |

DYNAMIC

|           |                              |                                 |                     |     |  |     |     |
|-----------|------------------------------|---------------------------------|---------------------|-----|--|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$                 | $I_D = 1.2 A$       | 0.8 |  |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$ |     |  | 500 | pF  |
| $C_{oss}$ | Output capacitance           |                                 |                     |     |  | 80  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                 |                     |     |  | 55  | pF  |

SWITCHING

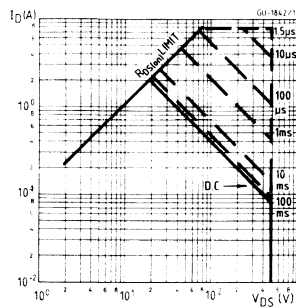
|               |                     |                                         |                                  |  |  |    |    |
|---------------|---------------------|-----------------------------------------|----------------------------------|--|--|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 30 V$<br>$R_{GS} = 50 \Omega$ | $I_D = 2.1 A$<br>$V_{GS} = 10 V$ |  |  | 20 | ns |
| $t_r$         | Rise time           |                                         |                                  |  |  | 60 | ns |
| $t_{d (off)}$ | Turn-off delay time |                                         |                                  |  |  | 65 | ns |
| $t_f$         | Fall time           |                                         |                                  |  |  | 40 | ns |



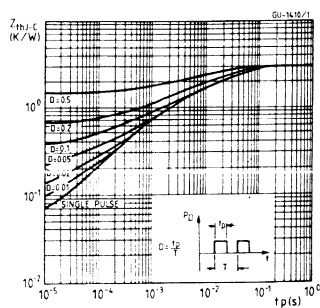
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters            |                                                          | Test Conditions                                            |              | Min. | Typ.       | Max.   | Unit                |
|-----------------------|----------------------------------------------------------|------------------------------------------------------------|--------------|------|------------|--------|---------------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) | $T_c = 25^{\circ}\text{C}$                                 |              |      |            | 2<br>8 | A<br>A              |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 4\text{ A}$                                      | $V_{GS} = 0$ |      |            | 1.3    | V                   |
| $t_{rr}$<br>$Q_{rr}$  | Reverse recovery<br>time<br>Reverse recovered<br>charge  | $I_{SD} = 2\text{ A}$<br>$di/dt = 100\text{A}/\mu\text{s}$ |              |      | 350<br>3.5 |        | ns<br>$\mu\text{C}$ |

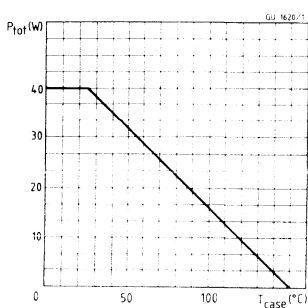
Safe operating areas



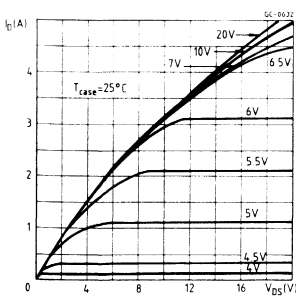
Thermal impedance



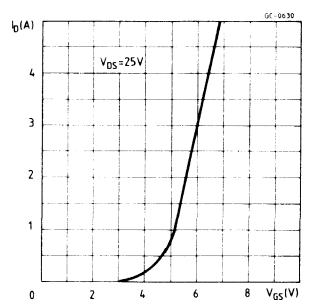
Derating curve



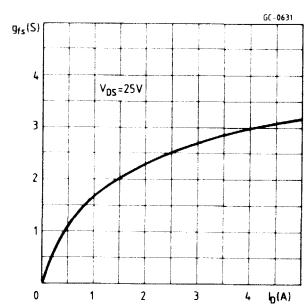
Output characteristics



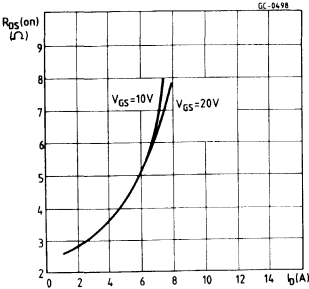
Transfer characteristics



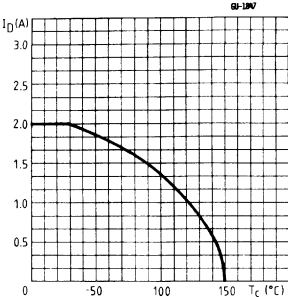
Transconductance



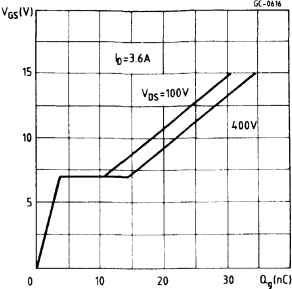
Static drain-source on resistance



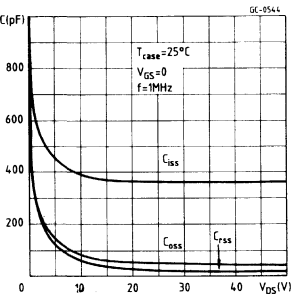
Maximum drain current vs temperature



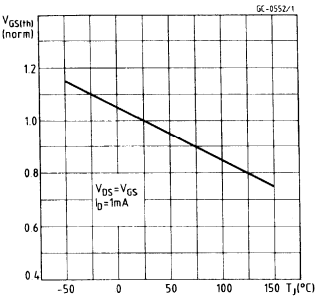
Gate charge vs gate-source voltage



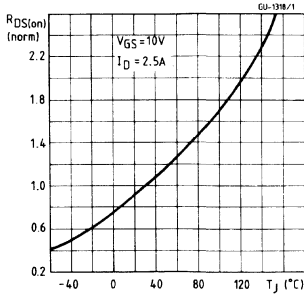
Capacitance variation



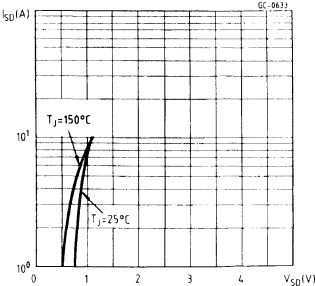
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE  | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------|------------------|---------------------|----------------|
| BUZ76 | 400 V            | 1.8 Ω               | 3 A            |

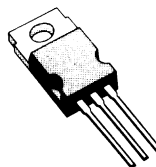
- HIGH VOLTAGE - FOR OFF-LINE APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- ELECTRONIC LAMP BALLAST
- DC SWITCH

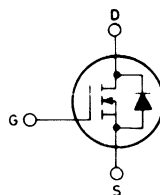
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Applications include off-line use, constant current source, ultrasonic equipment and switching power supply start-up circuits.



TO-220

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |            |    |
|------------------|--------------------------------------------------|------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 400        | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 400        | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ±20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 35°C | 3          | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 12         | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 40         | W  |
| T <sub>stg</sub> | Storage temperature                              | -55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150        | °C |
|                  | DIN humidity category (DIN 40040)                | E          |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56  |    |

THERMAL DATA

|                  |                                     |     |     |      |
|------------------|-------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 3.1 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75  | °C/W |

ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                     |     |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                   | 400 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$<br>$T_j = 125^\circ C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                 |     |  | $\pm 100$   | nA                 |

ON

|               |                                   |                                           |     |  |     |          |
|---------------|-----------------------------------|-------------------------------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 1 \text{ mA}$ | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$I_D = 1.5 A$          |     |  | 1.8 | $\Omega$ |

DYNAMIC

|           |                              |                                                        |     |  |     |     |
|-----------|------------------------------|--------------------------------------------------------|-----|--|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$<br>$I_D = 1.5 A$                       | 0.8 |  |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 \text{ MHz}$ |     |  | 500 | pF  |
| $C_{oss}$ | Output capacitance           |                                                        |     |  | 80  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                        |     |  | 60  | pF  |

SWITCHING

|             |                     |                                                                             |  |  |    |    |
|-------------|---------------------|-----------------------------------------------------------------------------|--|--|----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 30 V$<br>$R_{GS} = 50 \Omega$<br>$I_D = 2.5 A$<br>$V_{GS} = 10 V$ |  |  | 20 | ns |
| $t_r$       | Rise time           |                                                                             |  |  | 60 | ns |
| $t_d (off)$ | Turn-off delay time |                                                                             |  |  | 65 | ns |
| $t_f$       | Fall time           |                                                                             |  |  | 40 | ns |

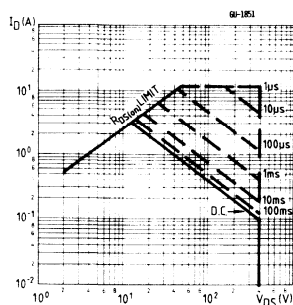
## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

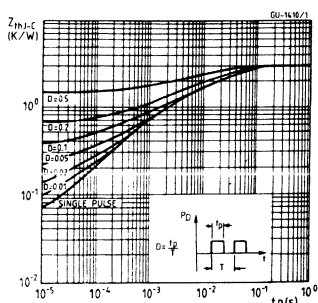
## SOURCE DRAIN DIODE

|           |                               |                          |                                    |     |               |
|-----------|-------------------------------|--------------------------|------------------------------------|-----|---------------|
| $I_{SD}$  | Source-drain current          | $T_c = 25^\circ\text{C}$ |                                    | 3   | A             |
| $I_{SDM}$ | Source-drain current (pulsed) |                          |                                    |     |               |
| $V_{SD}$  | Forward on voltage            | $I_{SD} = 6\text{ A}$    | $V_{GS} = 0$                       | 1.4 | V             |
| $t_{rr}$  | Reverse recovery time         | $I_{SD} = 3\text{ A}$    | $di/dt = 100\text{ A}/\mu\text{s}$ | 300 | ns            |
| $Q_{rr}$  | Reverse recovered charge      |                          |                                    | 2.5 | $\mu\text{C}$ |

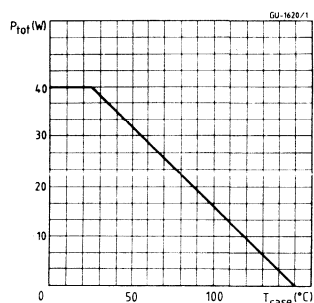
Safe operating areas



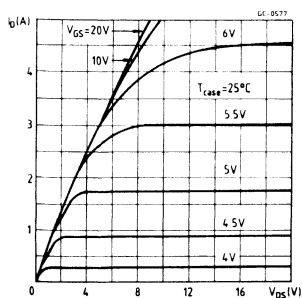
Thermal impedance



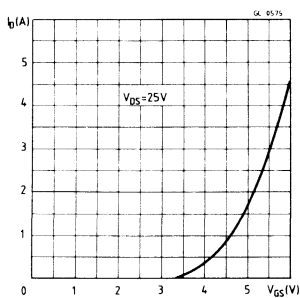
Derating curve



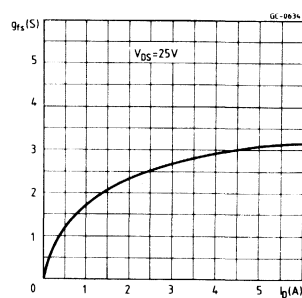
Output characteristics



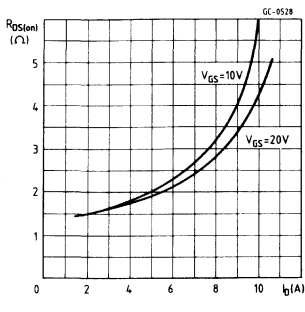
Transfer characteristics



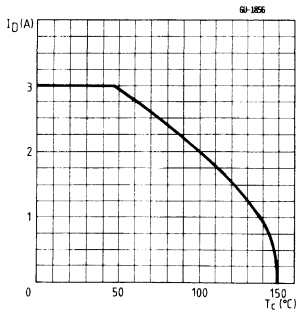
Transconductance



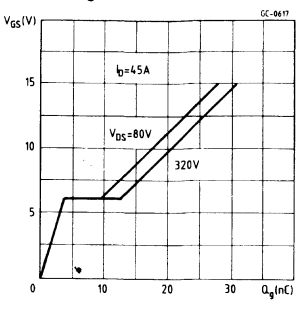
Static drain-source on resistance



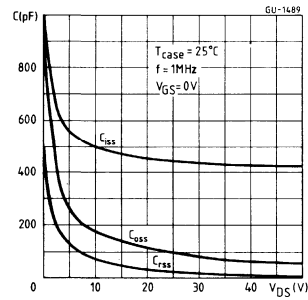
Maximum drain current vs temperature



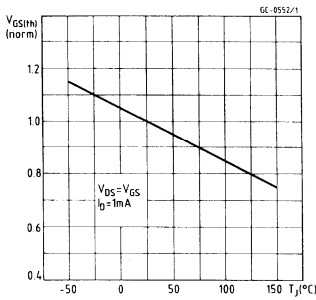
Gate charge vs gate-source voltage



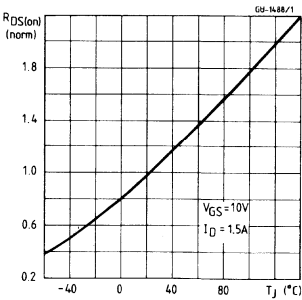
Capacitance variation



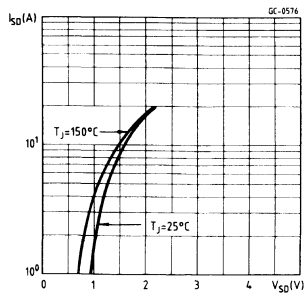
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| BUZ76A | 400 V            | 2.5 Ω               | 2.6 A          |

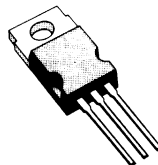
- HIGH VOLTAGE - FOR OFF-LINE APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- ELECTRONIC LAMP BALLAST
- DC SWITCH

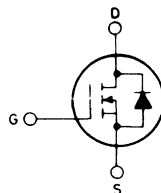
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Applications include off-line use, constant current source, ultrasonic equipment and switching power supply start-up circuits.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |            |    |
|------------------|--------------------------------------------------|------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 400        | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 400        | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ±20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 30°C | 2.6        | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 10         | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 40         | W  |
| T <sub>stg</sub> | Storage temperature                              | -55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150        | °C |
|                  | DIN humidity category (DIN 40040)                | E          |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56  |    |

THERMAL DATA

|                  |                                     |     |     |      |
|------------------|-------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 3.1 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 75  | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                             |     |  |             |                                |
|----------------|--------------------------------------------------|---------------------------------------------------------------------------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$<br>$V_{GS} = 0$                                                     | 400 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$<br>$T_j = 125^{\circ}\text{C}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                                                 |     |  | $\pm 100$   | nA                             |

ON

|               |                                   |                                                  |     |  |     |          |
|---------------|-----------------------------------|--------------------------------------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 1 \text{ mA}$        | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$<br>$I_D = 1.5 \text{ A}$ |     |  | 2.5 | $\Omega$ |

DYNAMIC

|           |                              |                                                                |     |  |     |     |
|-----------|------------------------------|----------------------------------------------------------------|-----|--|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 \text{ V}$<br>$I_D = 1.5 \text{ A}$               | 0.8 |  |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$<br>$f = 1 \text{ MHz}$ |     |  | 500 | pF  |
| $C_{oss}$ | Output capacitance           |                                                                |     |  | 80  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                                |     |  | 60  | pF  |

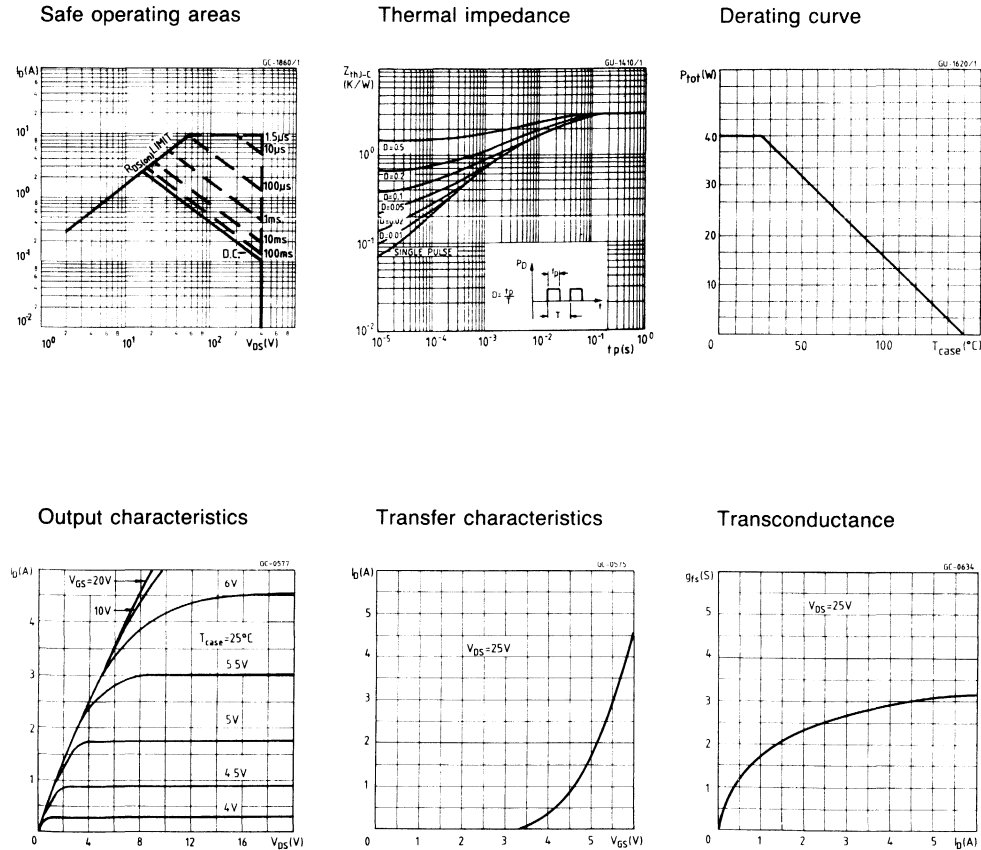
SWITCHING

|               |                     |                                                                                                     |  |  |    |    |
|---------------|---------------------|-----------------------------------------------------------------------------------------------------|--|--|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 30 \text{ V}$<br>$R_{GS} = 50 \Omega$<br>$I_D = 2.4 \text{ A}$<br>$V_{GS} = 10 \text{ V}$ |  |  | 20 | ns |
| $t_r$         | Rise time           |                                                                                                     |  |  | 60 | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                                                                     |  |  | 65 | ns |
| $t_f$         | Fall time           |                                                                                                     |  |  | 40 | ns |

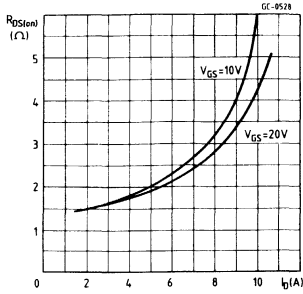


ELECTRICAL CHARACTERISTICS (Continued)

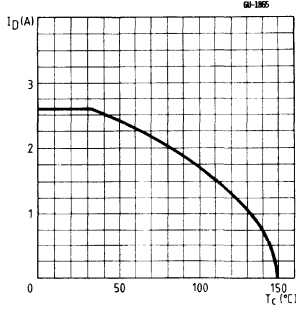
| Parameters            |                               | Test Conditions         |                      | Min. | Typ. | Max. | Unit    |
|-----------------------|-------------------------------|-------------------------|----------------------|------|------|------|---------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current          | $T_c = 25^{\circ}C$     |                      |      |      | 2.6  | A       |
|                       | Source-drain current (pulsed) |                         |                      |      |      | 10   | A       |
| $V_{SD}$              | Forward on voltage            | $I_{SD} = 5.2\text{ A}$ | $V_{GS} = 0$         |      |      | 1.4  | V       |
| $t_{rr}$              | Reverse recovery time         |                         |                      |      | 300  |      | ns      |
| $Q_{rr}$              | Reverse recovered charge      | $I_{SD} = 2.6\text{ A}$ | $di/dt = 100A/\mu s$ |      | 2.5  |      | $\mu C$ |



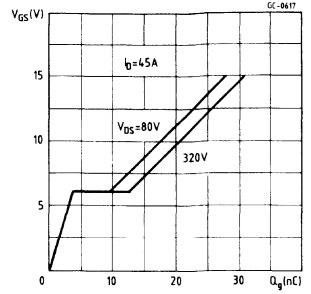
Static drain-source on resistance



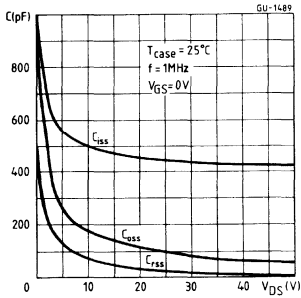
Maximum drain current vs temperature



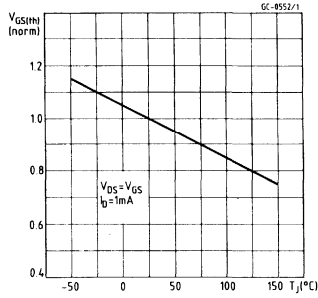
Gate charge vs gate-source voltage



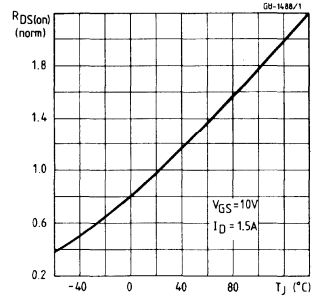
Capacitance variation



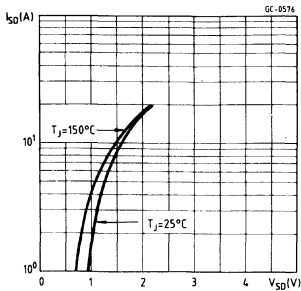
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| BUZ353 | 500 V            | 0.6 Ω               | 9.5 A          |

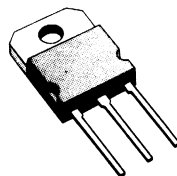
- HIGH SPEED SWITCHING
- HIGH VOLTAGE - 500V FOR OFF-LINE SMPS
- HIGH CURRENT - 9.5A FOR UP TO 250W SMPS
- ULTRA FAST SWITCHING FOR OPERATION AT <100KHz
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS

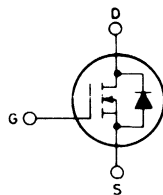
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Typical applications include switching mode power supplies, uninterruptible power supplies and motor speed control.



TO-218

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                  |            |    |
|------------------|--------------------------------------------------|------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)       | 500        | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)     | 500        | V  |
| V <sub>GS</sub>  | Gate-source voltage                              | ±20        | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 25°C | 9.5        | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                           | 38         | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C       | 125        | W  |
| T <sub>stg</sub> | Storage temperature                              | -55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature              | 150        | °C |
|                  | DIN humidity category (DIN 40040)                | E          |    |
|                  | IEC climatic category (DIN IEC 68-1)             | 55/150/56  |    |

THERMAL DATA

|                  |                                     |     |     |      |
|------------------|-------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.0 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 45  | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                             |     |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------|-----------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$                                      | $V_{GS} = 0$                | 500 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^{\circ}\text{C}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                  |                             |     |  | $\pm 100$   | nA                             |

ON

|               |                                   |                         |                       |     |  |     |          |
|---------------|-----------------------------------|-------------------------|-----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 1 \text{ mA}$  | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ | $I_D = 5.5 \text{ A}$ |     |  | 0.6 | $\Omega$ |

DYNAMIC

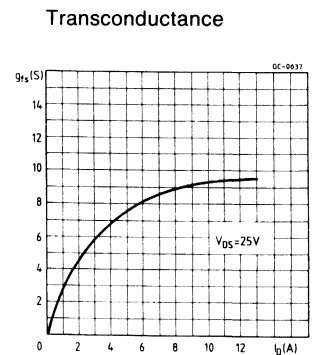
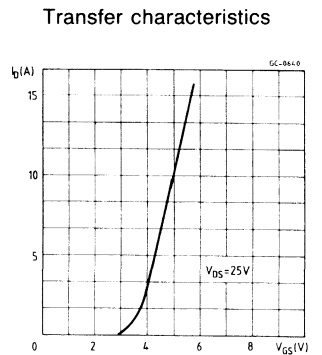
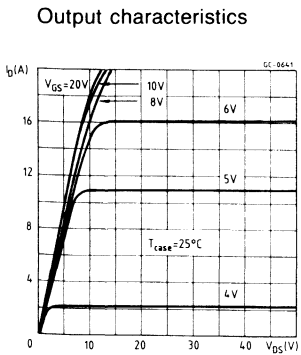
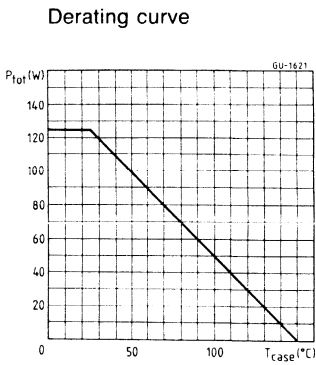
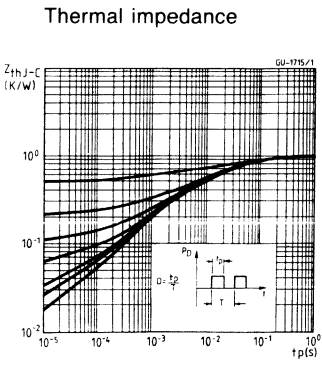
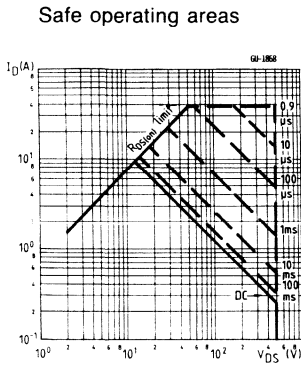
|                                     |                                                                         |                                         |                       |     |  |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|-----------------------------------------|-----------------------|-----|--|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 \text{ V}$                 | $I_D = 5.5 \text{ A}$ | 2.7 |  |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$   |     |  | 4900<br>400<br>170 | pF<br>pF<br>pF |

SWITCHING

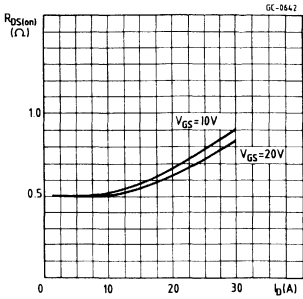
|               |                     |                         |                         |  |  |     |    |
|---------------|---------------------|-------------------------|-------------------------|--|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 30 \text{ V}$ | $I_D = 2.8 \text{ A}$   |  |  | 75  | ns |
| $t_r$         | Rise time           | $R_{GS} = 50 \Omega$    | $V_{GS} = 10 \text{ V}$ |  |  | 120 | ns |
| $t_{d (off)}$ | Turn-off delay time |                         |                         |  |  | 430 | ns |
| $t_f$         | Fall time           |                         |                         |  |  | 140 | ns |

ELECTRICAL CHARACTERISTICS (Continued)

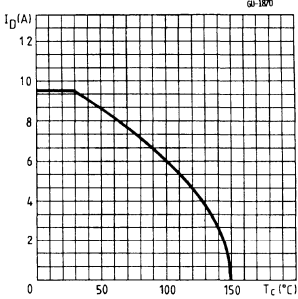
| Parameters |                               | Test Conditions            |                                    | Min. | Typ. | Max. | Unit          |
|------------|-------------------------------|----------------------------|------------------------------------|------|------|------|---------------|
| $I_{SD}$   | Source-drain current          | $T_c = 25^{\circ}\text{C}$ |                                    |      |      | 9.5  | A             |
| $I_{SDM}$  | Source-drain current (pulsed) |                            |                                    |      |      | 38   | A             |
| $V_{SD}$   | Forward on voltage            | $I_{SD} = 19\text{ A}$     | $V_{GS} = 0$                       |      |      | 1.7  | V             |
| $t_{rr}$   | Reverse recovery time         | $I_{SD} = 9.5\text{ A}$    | $di/dt = 100\text{ A}/\mu\text{s}$ |      | 1200 |      | ns            |
| $Q_{rr}$   | Reverse recovered charge      |                            |                                    |      | 12   |      | $\mu\text{C}$ |



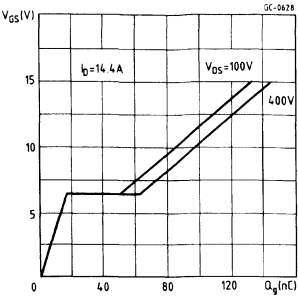
Static drain-source on resistance



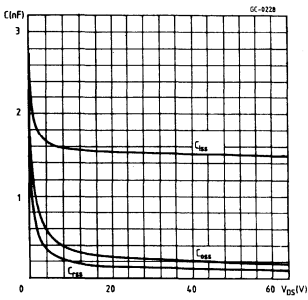
Maximum drain current vs temperature



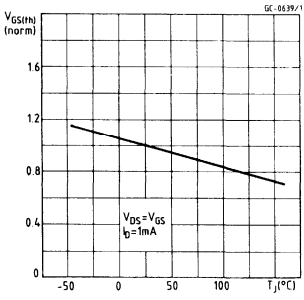
Gate charge vs gate-source voltage



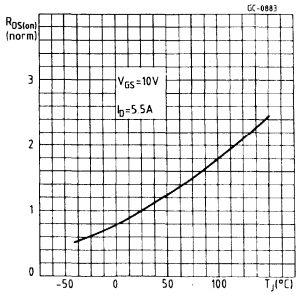
Capacitance variation



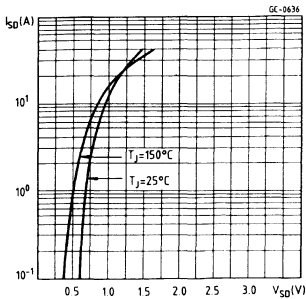
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| BUZ354 | 500 V            | 0.8 $\Omega$        | 8 A            |

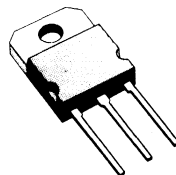
- HIGH SPEED SWITCHING
- HIGH VOLTAGE - 500V FOR OFF-LINE SMPS
- HIGH CURRENT - 8A FOR UP TO 200W SMPS
- ULTRA FAST SWITCHING - FOR OPERATION AT < 100KHz
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS

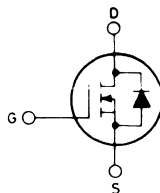
N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications.

Typical uses include switching mode power supplies, uninterruptible power supplies and motor speed control.



TO-218

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                       |            |    |
|------------------|-------------------------------------------------------|------------|----|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)            | 500        | V  |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 500        | V  |
| V <sub>GS</sub>  | Gate-source voltage                                   | $\pm 20$   | V  |
| I <sub>D</sub>   | Drain current (continuous) T <sub>c</sub> = 25°C      | 8          | A  |
| I <sub>DM</sub>  | Drain current (pulsed)                                | 32         | A  |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C            | 125        | W  |
| T <sub>stg</sub> | Storage temperature                                   | -55 to 150 | °C |
| T <sub>j</sub>   | Max. operating junction temperature                   | 150        | °C |
|                  | DIN humidity category (DIN 40040)                     | E          |    |
|                  | IEC climatic category (DIN IEC 68-1)                  | 55/150/56  |    |

THERMAL DATA

|                  |                                     |     |     |      |
|------------------|-------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.0 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 45  | °C/W |

ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                     |     |  |             |                    |
|----------------|--------------------------------------------------|--------------------------------------------------------------|---------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$                                            | $V_{GS} = 0$        | 500 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^\circ C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                          |                     |     |  | $\pm 100$   | nA                 |

ON

|               |                                   |                   |                      |     |  |     |          |
|---------------|-----------------------------------|-------------------|----------------------|-----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ | $I_D = 1 \text{ mA}$ | 2.1 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$   | $I_D = 5.5 A$        |     |  | 0.8 | $\Omega$ |

DYNAMIC

|           |                              |                                 |                     |     |  |      |     |
|-----------|------------------------------|---------------------------------|---------------------|-----|--|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$                 | $I_D = 5.5 A$       | 2.7 |  |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$ |     |  | 4900 | pF  |
| $C_{oss}$ | Output capacitance           |                                 |                     |     |  | 400  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                 |                     |     |  | 170  | pF  |

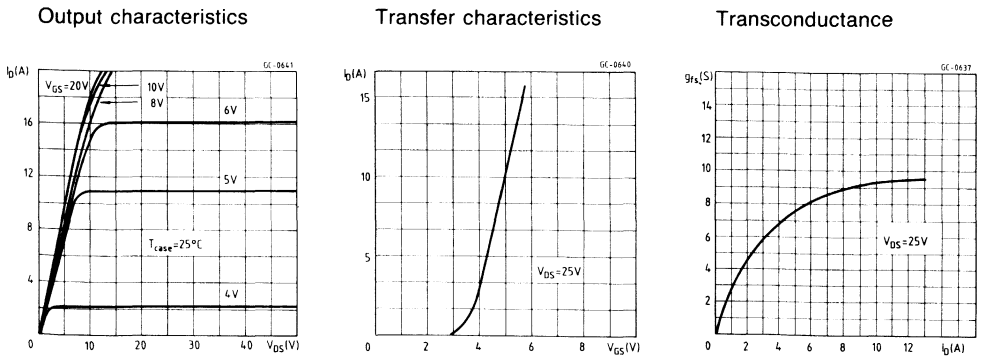
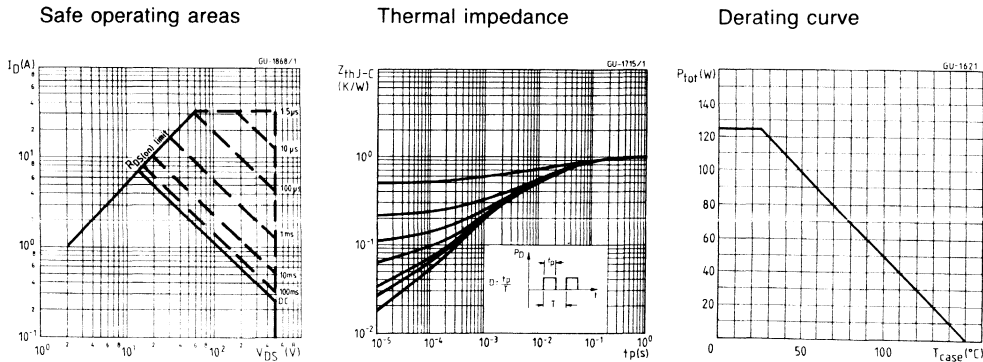
SWITCHING

|               |                     |                      |                 |  |  |     |    |
|---------------|---------------------|----------------------|-----------------|--|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 30 V$      | $I_D = 2.8 A$   |  |  | 75  | ns |
| $t_r$         | Rise time           | $R_{GS} = 50 \Omega$ | $V_{GS} = 10 V$ |  |  | 120 | ns |
| $t_{d (off)}$ | Turn-off delay time |                      |                 |  |  | 430 | ns |
| $t_f$         | Fall time           |                      |                 |  |  | 140 | ns |

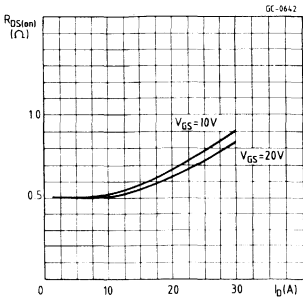


ELECTRICAL CHARACTERISTICS (Continued)

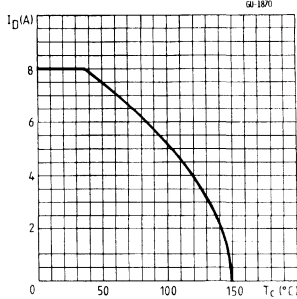
| Parameters            |                               | Test Conditions                                             |              | Min. | Typ. | Max. | Unit          |
|-----------------------|-------------------------------|-------------------------------------------------------------|--------------|------|------|------|---------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current          | $T_c = 25^{\circ}\text{C}$                                  |              |      |      | 8    | A             |
|                       | Source-drain current (pulsed) |                                                             |              |      |      | 32   | A             |
| $V_{SD}$              | Forward on voltage            | $I_{SD} = 16\text{ A}$                                      | $V_{GS} = 0$ |      |      | 1.6  | V             |
| $t_{rr}$              | Reverse recovery time         | $I_{SD} = 8\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |              |      | 1200 |      | ns            |
| $Q_{rr}$              | Reverse recovered charge      |                                                             |              |      | 12   |      | $\mu\text{C}$ |



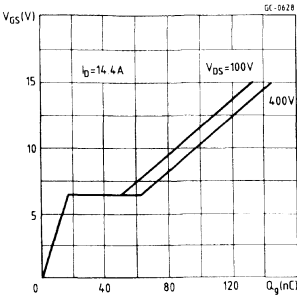
Static drain-source on resistance



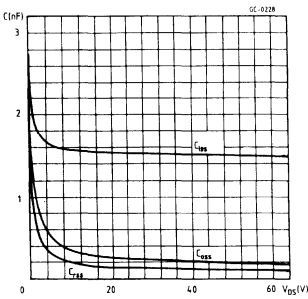
Maximum drain current vs temperature



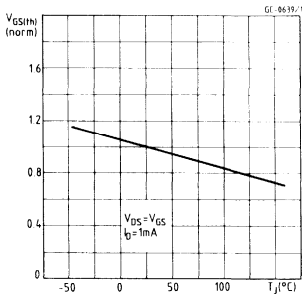
Gate charge vs gate-source voltage



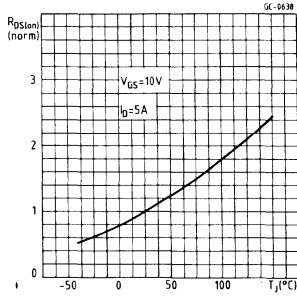
Capacitance variation



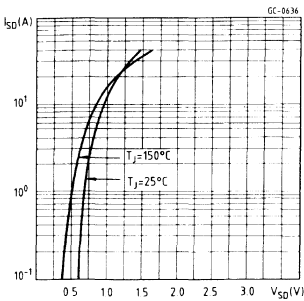
Gate threshold voltage vs temperature



Drain-source on resistance vs temperature



Source-drain diode forward characteristics



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

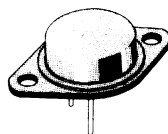
| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| IRF140 | 100 V            | 0.077 Ω             | 28 A           |
| IRF141 | 80 V             | 0.077 Ω             | 28 A           |
| IRF142 | 100 V            | 0.100 Ω             | 25 A           |
| IRF143 | 80 V             | 0.100 Ω             | 25 A           |

- 80-100 VOLTS - FOR DC/DC CONVERTERS
- HIGH CURRENT
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

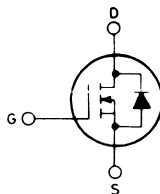
- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Applications include DC/DC converters, UPS, battery chargers, secondary regulators, servo control, power audio amplifiers and robotics.



**TO-3**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | IRF |            |      |     |
|---------------------|-------------------------------------------------|-----|------------|------|-----|
|                     |                                                 | 140 | 141        | 142  | 143 |
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      | 100 | 80         | 100  | 80  |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 100 | 80         | 100  | 80  |
| V <sub>GS</sub>     | Gate-source voltage                             |     |            | ± 20 |     |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 28  | 28         | 25   | 25  |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 20  | 20         | 17   | 17  |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 110 | 110        | 100  | 100 |
| I <sub>DLM</sub>    | Drain inductive current, clamped (L = 100 μH)   | 110 | 110        | 100  | 100 |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      |     | 125        |      |     |
|                     | Derating factor                                 |     | 1          |      |     |
| T <sub>stg</sub>    | Storage temperature                             |     | -55 to 150 |      |     |
| T <sub>j</sub>      | Max. operating junction temperature             |     | 150        |      |     |

\* T<sub>j</sub> = 25°C to 125°C

(\*) Repetitive Rating: Pulse width limited by max junction temperature

# THERMAL DATA

|                  |                                                |     |     |      |
|------------------|------------------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1   | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.1 | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 30  | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300 | °C   |

# ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$ unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

## OFF

|                |                                                  |                                                                           |                      |           |             |                    |
|----------------|--------------------------------------------------|---------------------------------------------------------------------------|----------------------|-----------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>IRF140/IRF142</b><br>for <b>IRF141/IRF143</b> | $V_{GS} = 0$         | 100<br>80 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$   | $T_c = 125^{\circ}C$ |           | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                       |                      |           | $\pm 100$   | nA                 |

## ON \*\*

|              |                                   |                                                                                                    |                   |          |  |                |                      |
|--------------|-----------------------------------|----------------------------------------------------------------------------------------------------|-------------------|----------|--|----------------|----------------------|
| $V_{GS(th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                  | $I_D = 250 \mu A$ | 2        |  | 4              | V                    |
| $I_{D(on)}$  | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$<br>for <b>IRF140/IRF141</b><br>for <b>IRF142/IRF143</b> | $V_{GS} = 10 V$   | 28<br>25 |  |                | A<br>A               |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>for <b>IRF140/IRF141</b><br>for <b>IRF142/IRF143</b>                            | $I_D = 17 A$      |          |  | 0.077<br>0.100 | $\Omega$<br>$\Omega$ |

## DYNAMIC

|               |                              |                                                            |             |     |  |      |     |
|---------------|------------------------------|------------------------------------------------------------|-------------|-----|--|------|-----|
| $g_{fs}^{**}$ | Forward transconductance     | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$<br>$I_D = 17 A$ |             | 8.7 |  |      | mho |
| $C_{iss}$     | Input capacitance            |                                                            |             |     |  | 1600 | pF  |
| $C_{oss}$     | Output capacitance           | $V_{DS} = 25 V$                                            | $f = 1 MHz$ |     |  | 800  | pF  |
| $C_{rss}$     | Reverse transfer capacitance | $V_{GS} = 0$                                               |             |     |  | 300  | pF  |

## SWITCHING

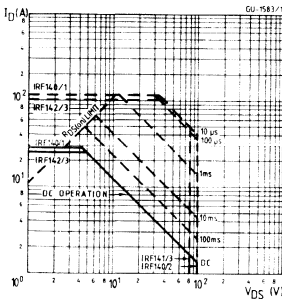
|              |                     |                                                                                  |              |  |  |    |    |
|--------------|---------------------|----------------------------------------------------------------------------------|--------------|--|--|----|----|
| $t_{d(on)}$  | Turn-on time        | $V_{DD} = 30 V$                                                                  | $I_D = 15 A$ |  |  | 30 | ns |
| $t_r$        | Rise time           | $R_i = 4.7 \Omega$                                                               |              |  |  | 60 | ns |
| $t_{d(off)}$ | Turn-off delay time | (see test circuit)                                                               |              |  |  | 80 | ns |
| $t_f$        | Fall time           |                                                                                  |              |  |  | 30 | ns |
| $Q_g$        | Total gate charge   | $V_{GS} = 10 V$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) | $I_D = 28 A$ |  |  | 59 | nC |

ELECTRICAL CHARACTERISTICS (Continued)

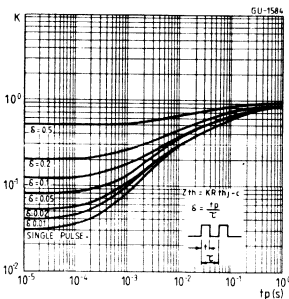
| Parameters                                    | Test Conditions                                             | Min. | Typ. | Max. | Unit          |
|-----------------------------------------------|-------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$ Source-drain current                 |                                                             |      |      | 28   | A             |
| $I_{SDM}^{(*)}$ Source-drain current (pulsed) |                                                             |      |      | 110  | A             |
| $V_{SD}^{**}$ Forward on voltage              | $I_{SD} = 28 \text{ A}$ $V_{GS} = 0$                        |      |      | 2.5  | V             |
| $t_{rr}$ Reverse recovery time                | $T_J = 150^\circ\text{C}$                                   |      | 500  |      | ns            |
| $Q_{rr}$ Reverse recovered charge             | $I_{SD} = 28 \text{ A}$ $di/dt = 100 \text{ A}/\mu\text{s}$ |      | 2.9  |      | $\mu\text{C}$ |

\*\* Pulsed: Pulse duration  $\leq 300 \mu\text{s}$ , duty cycle  $\leq 2\%$   
 (\*) Repetitive Rating: Pulse width limited by max junction temperature

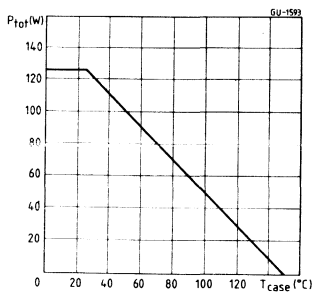
Safe operating areas



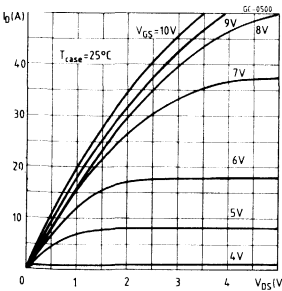
Thermal impedance



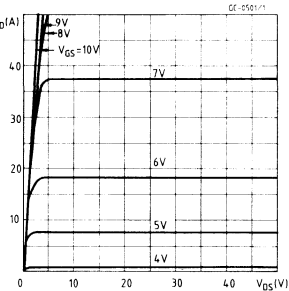
Derating curve



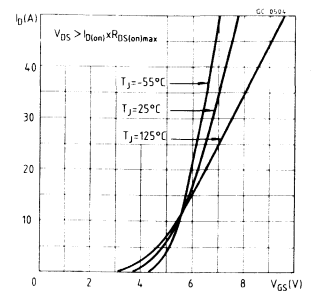
Output characteristics



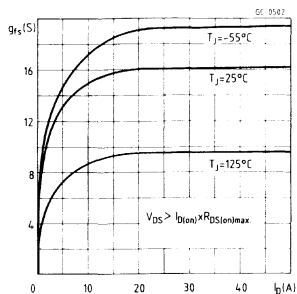
Output characteristics



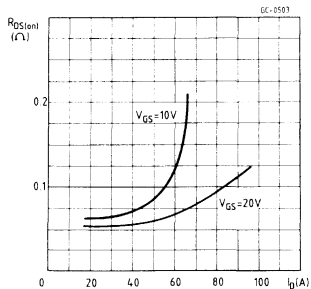
Transfer characteristics



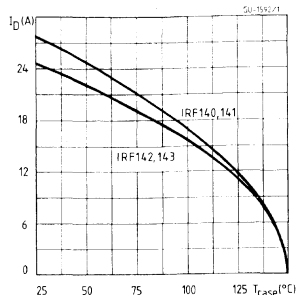
Transconductance



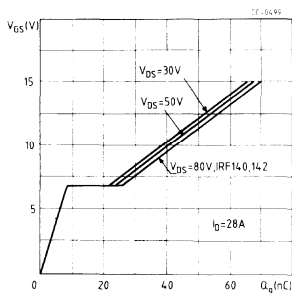
Static drain-source on resistance



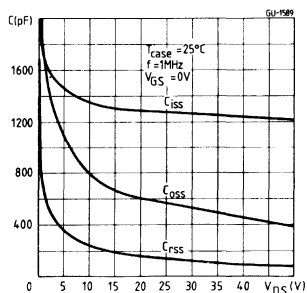
Maximum drain current vs temperature



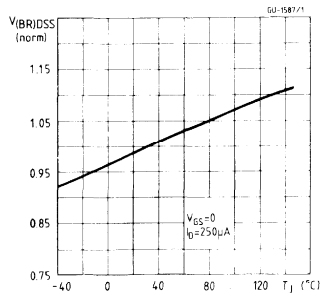
Gate charge vs gate-source voltage



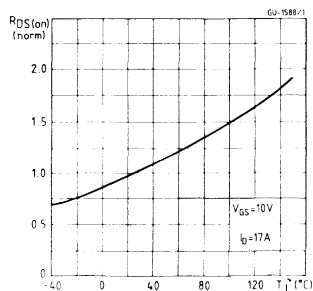
Capacitance variation



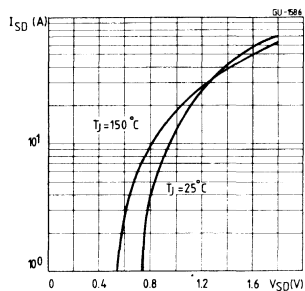
Normalized breakdown voltage vs temperature



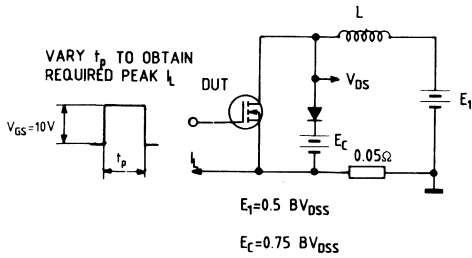
Normalized on resistance vs temperature



Source-drain diode forward characteristics

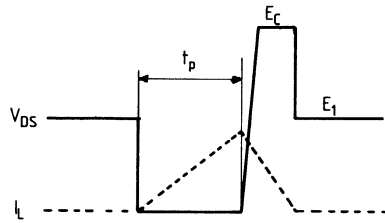


### Clamped inductive test circuit



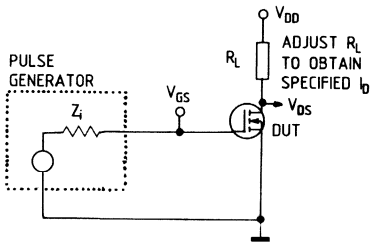
SC-0242

### Clamped inductive waveforms



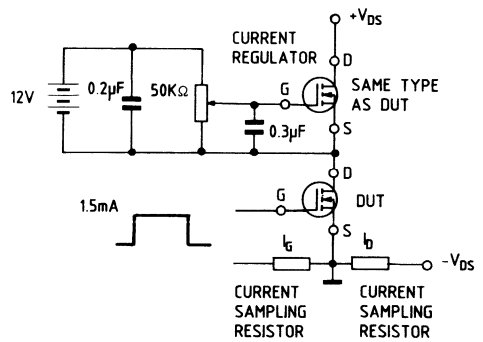
SC-0243

### Switching times test circuit



SC-0246

### Gate charge test circuit



SC-0244





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

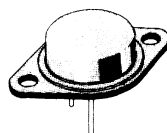
| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| IRF150 | 100 V            | 0.055 Ω             | 40 A           |
| IRF151 | 60 V             | 0.055 Ω             | 40 A           |
| IRF152 | 100 V            | 0.08 Ω              | 33 A           |
| IRF153 | 60 V             | 0.08 Ω              | 33 A           |

- 60-100 VOLTS - FOR DC/DC CONVERTERS
- HIGH CURRENT
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

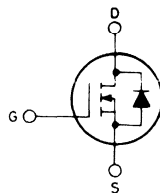
- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Applications include DC/DC converters, UPS, battery chargers, secondary regulators, servo control, power audio amplifiers and robotics.



TO-3

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | IRF        |     |     |       |
|---------------------|-------------------------------------------------|------------|-----|-----|-------|
|                     |                                                 | 150        | 151 | 152 | 153   |
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      | 100        | 60  | 100 | 60 V  |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 100        | 60  | 100 | 60 V  |
| V <sub>GS</sub>     | Gate-source voltage                             | ± 20       |     |     | V     |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 40         | 40  | 33  | 33 A  |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 25         | 25  | 20  | 20 A  |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 160        | 160 | 132 | 132 A |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      | 150        |     |     | W     |
|                     | Derating factor                                 | 1.2        |     |     | W/°C  |
| T <sub>stg</sub>    | Storage temperature                             | -55 to 150 |     |     | °C    |
| T <sub>j</sub>      | Max. operating junction temperature             | 150        |     |     | °C    |

\* T<sub>j</sub> = 25°C to 125°C

(\*) Repetitive Rating: Pulse width limited by max junction temperature

♦ Introduced in 1988 week 44

**THERMAL DATA**

|                  |                                                |     |      |               |
|------------------|------------------------------------------------|-----|------|---------------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | $^{\circ}C/W$ |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.1  | $^{\circ}C/W$ |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 30   | $^{\circ}C/W$ |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300  | $^{\circ}C$   |

**ELECTRICAL CHARACTERISTICS** ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                                           |                      |           |             |                    |
|----------------|--------------------------------------------------|---------------------------------------------------------------------------|----------------------|-----------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>IRF150/IRF152</b><br>for <b>IRF151/IRF153</b> | $V_{GS} = 0$         | 100<br>60 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$   | $T_c = 125^{\circ}C$ |           | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                       |                      |           | $\pm 100$   | nA                 |

**ON \*\***

|              |                                   |                                                                                                            |                   |          |  |               |                      |
|--------------|-----------------------------------|------------------------------------------------------------------------------------------------------------|-------------------|----------|--|---------------|----------------------|
| $V_{GS(th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                          | $I_D = 250 \mu A$ | 2        |  | 4             | V                    |
| $I_{D(on)}$  | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$<br>for <b>IRF150/IRF151</b><br>for <b>IRF152/IRF153</b> | $V_{GS} = 10 V$   | 40<br>33 |  |               | A<br>A               |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>for <b>IRF150/IRF151</b><br>for <b>IRF152/IRF153</b>                                    | $I_D = 20 A$      |          |  | 0.055<br>0.08 | $\Omega$<br>$\Omega$ |

**ENERGY TEST**

|           |                                                      |                                                                                                         |                 |          |  |  |        |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-----------------|----------|--|--|--------|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 V$<br>starting $T_j = 25^{\circ}C$<br>for <b>IRF150/IRF151</b><br>for <b>IRF152/IRF153</b> | $L = 100 \mu H$ | 40<br>33 |  |  | A<br>A |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-----------------|----------|--|--|--------|

**DYNAMIC**

|               |                              |                                                                    |                     |   |  |      |     |
|---------------|------------------------------|--------------------------------------------------------------------|---------------------|---|--|------|-----|
| $g_{fs}^{**}$ | Forward transconductance     | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$<br>$I_D = 20 A$ |                     | 9 |  |      | mho |
| $C_{iss}$     | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$                                    | $f = 1 \text{ MHz}$ |   |  | 3000 | pF  |
| $C_{oss}$     | Output capacitance           |                                                                    |                     |   |  | 1500 | pF  |
| $C_{rss}$     | Reverse transfer capacitance |                                                                    |                     |   |  | 500  | pF  |

ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

SWITCHING

|                                             |                                                               |                                                                                             |  |                         |                      |
|---------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------------------------------|--|-------------------------|----------------------|
| $t_d$ (on)<br>$t_r$<br>$t_d$ (off)<br>$t_f$ | Turn-on time<br>Rise time<br>Turn-off delay time<br>Fall time | $V_{DD} = 24 \text{ V}$<br>$R_i = 4.7 \Omega$<br>$I_D = 20 \text{ A}$<br>(see test circuit) |  | 35<br>100<br>125<br>100 | ns<br>ns<br>ns<br>ns |
| $Q_g$                                       | Total Gate Charge                                             | $V_{GS} = 10 \text{ V}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit)    |  | 120                     | nC                   |

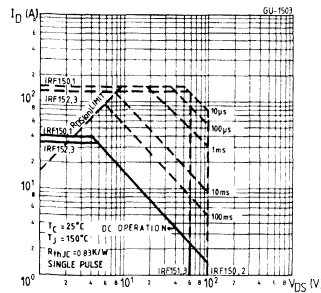
SOURCE DRAIN DIODE

|                      |                                                   |                                                                                                                      |            |            |                     |
|----------------------|---------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|------------|------------|---------------------|
| $I_{SD}$             | Source-drain current                              | for <b>IRF150/IRF151</b><br>for <b>IRF152/IRF153</b>                                                                 |            | 40<br>33   | A<br>A              |
| $I_{SDM}$ (*)        | Source-drain current (pulsed)                     | for <b>IRF150/IRF151</b><br>for <b>IRF152/IRF153</b>                                                                 |            | 160<br>132 | A<br>A              |
| $V_{SD}^{**}$        | Forward on voltage                                | $V_{GS} = 0$<br>for <b>IRF150/IRF151</b> $I_{SD} = 40 \text{ A}$<br>for <b>IRF152/IRF153</b> $I_{SD} = 33 \text{ A}$ |            | 2.5<br>2.3 | V<br>V              |
| $t_{rr}$<br>$Q_{rr}$ | Reverse recovery time<br>Reverse recovered charge | $T_J = 150^\circ\text{C}$<br>$I_{SD} = 40 \text{ A}$<br>$di/dt = 100 \text{ A}/\mu\text{s}$                          | 600<br>3.3 |            | ns<br>$\mu\text{C}$ |

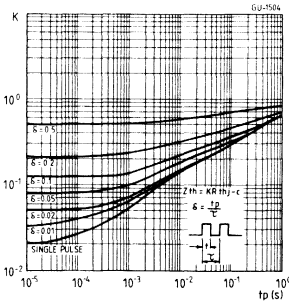
\*\* Pulsed: Pulse duration  $\leq 300 \mu\text{s}$ , duty cycle  $\leq 2\%$

(\*) Repetitive Rating: Pulse width limited by max junction temperature

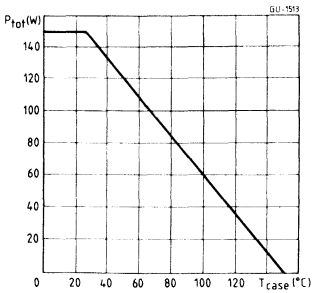
Safe operating areas



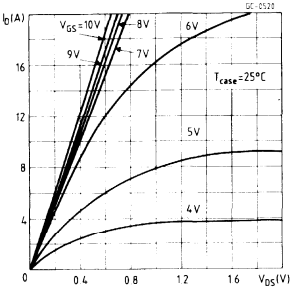
Thermal impedance



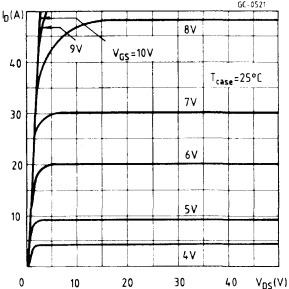
Derating curve



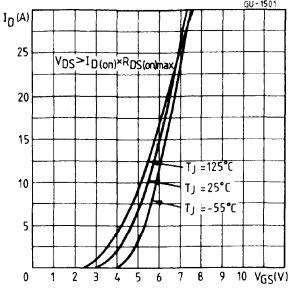
Output characteristics



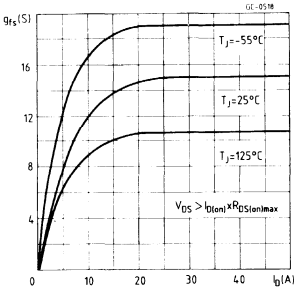
Output characteristics



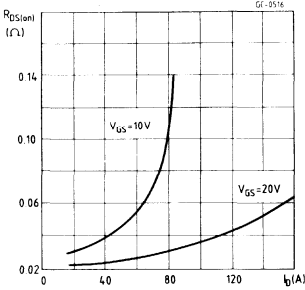
Transfer characteristics



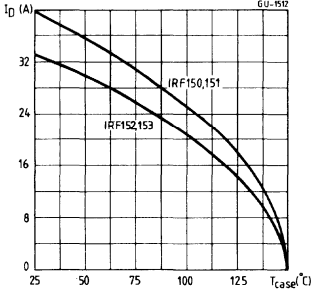
Transconductance



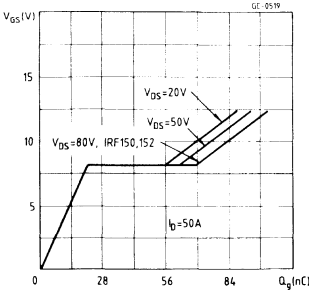
Static drain-source on resistance



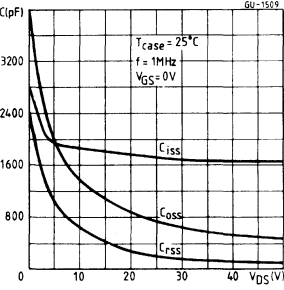
Maximum drain current vs temperature



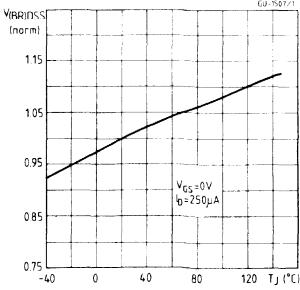
Gate charge vs gate-source voltage



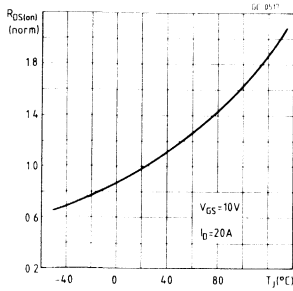
Capacitance variation



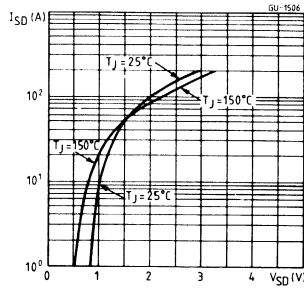
Normalized breakdown voltage vs temperature



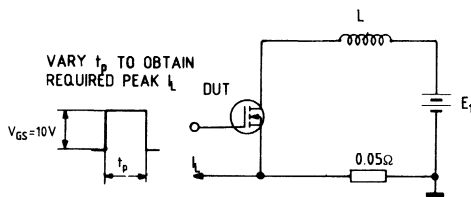
Normalized on resistance  
vs temperature



Source-drain diode forward  
characteristics

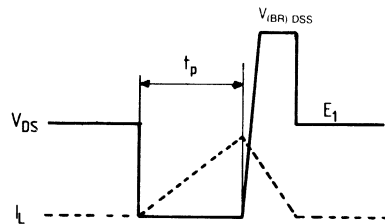


Unclamped inductive test circuit



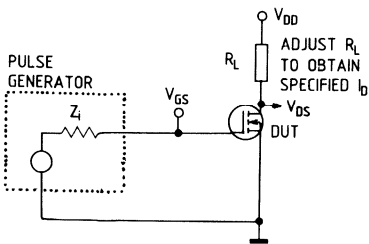
SC-0339

Unclamped inductive waveforms



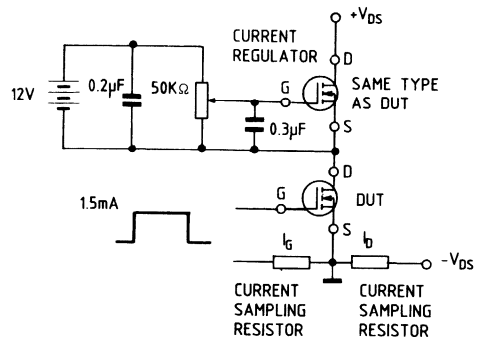
SC-0338

Switching times test circuit



SC-0246

Gate charge test circuit



SC-0244



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

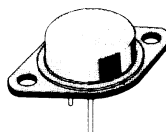
| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| IRF350 | 400 V            | 0.3 Ω               | 15 A           |

- HIGH VOLTAGE - FOR OFF-LINE SMPS
- HIGH CURRENT - FOR SMPS UP TO 350W
- ULTRA FAST SWITCHING - FOR OPERATION AT > 100KHz
- EASY DRIVE - REDUCES SIZE AND COST

### INDUSTRIAL APPLICATIONS:

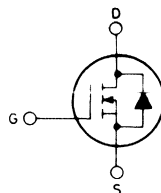
- SWITCHING MODE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Fast switching and easy drive make this POWER MOS transistor ideal for high voltage. Switching applications include electronic welders, switched mode power supplies and sonar equipment.



TO-3

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 |            |      |
|---------------------|-------------------------------------------------|------------|------|
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      | 400        | V    |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 400        | V    |
| V <sub>GS</sub>     | Gate-source voltage                             | ± 20       | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 15         | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 9          | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 60         | A    |
| I <sub>DLM</sub>    | Drain inductive current, clamped (L = 100 μH)   | 60         | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      | 150        | W    |
|                     | Derating factor                                 | 1.2        | W/°C |
| T <sub>stg</sub>    | Storage temperature                             | -55 to 150 | °C   |
| T <sub>j</sub>      | Max. operating junction temperature             | 150        | °C   |

\* T<sub>j</sub> = 25°C to 125°C

(\*) Repetitive Rating: Pulse width limited by max junction temperature

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.1  | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient            | max | 30   | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300  | °C   |

ELECTRICAL CHARACTERISTICS
( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                     |     |  |             |                                |
|----------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$<br>$V_{GS} = 0$                                                            | 400 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_j = 125^{\circ}\text{C}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\ \text{V}$                                                                         |     |  | $\pm 100$   | nA                             |

ON \*\*

|               |                                   |                                                                        |    |  |     |          |
|---------------|-----------------------------------|------------------------------------------------------------------------|----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250\ \mu\text{A}$                          | 2  |  | 4   | V        |
| $I_{D (on)}$  | On-state drain current            | $V_{DS} > I_{D (on)} \times R_{DS (on) max}$ , $V_{GS} = 10\ \text{V}$ | 15 |  |     | A        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10\ \text{V}$<br>$I_D = 8\ \text{A}$                         |    |  | 0.3 | $\Omega$ |

DYNAMIC

|               |                              |                                                                     |   |  |      |     |
|---------------|------------------------------|---------------------------------------------------------------------|---|--|------|-----|
| $g_{fs}^{**}$ | Forward transconductance     | $V_{DS} > I_{D (on)} \times R_{DS (on) max}$<br>$I_D = 8\ \text{A}$ | 8 |  |      | mho |
| $C_{iss}$     | Input capacitance            | $V_{DS} = 25\ \text{V}$<br>$V_{GS} = 0$<br>$f = 1\ \text{MHz}$      |   |  | 3000 | pF  |
| $C_{oss}$     | Output capacitance           |                                                                     |   |  | 600  | pF  |
| $C_{rss}$     | Reverse transfer capacitance |                                                                     |   |  | 200  | pF  |

SWITCHING

|               |                     |                                                                                          |  |  |     |    |
|---------------|---------------------|------------------------------------------------------------------------------------------|--|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 180\ \text{V}$<br>$R_i = 4.7\ \Omega$<br>(see test circuit)                    |  |  | 35  | ns |
| $t_r$         | Rise time           |                                                                                          |  |  | 65  | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                                                          |  |  | 150 | ns |
| $t_f$         | Fall time           |                                                                                          |  |  | 75  | ns |
| $Q_g$         | Total Gate Charge   | $V_{GS} = 10\ \text{V}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) |  |  | 120 | nC |



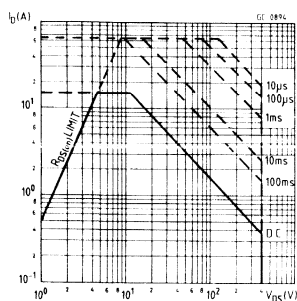
## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                  | Test Conditions                                           | Min. | Typ. | Max. | Unit          |
|---------------------------------------------|-----------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$ Source-drain current               |                                                           |      |      | 15   | A             |
| $I_{SDM}$ (*) Source-drain current (pulsed) |                                                           |      |      | 60   | A             |
| $V_{SD}^{**}$ Forward on voltage            | $I_{SD} = 15\text{ A}$ $V_{GS} = 0$                       |      |      | 1.6  | V             |
| $t_{rr}$ Reverse recovery time              | $T_J = 150^\circ\text{C}$                                 |      | 1000 |      | ns            |
| $Q_{rr}$ Reverse recovered charge           | $I_{SD} = 15\text{ A}$ $di/dt = 100\text{ A}/\mu\text{s}$ |      | 6.6  |      | $\mu\text{C}$ |

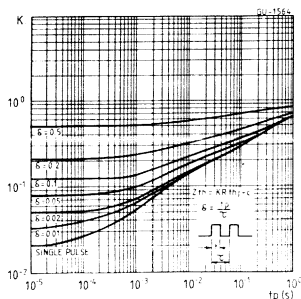
\*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$

(\*) Repetitive Rating: Pulse width limited by max junction temperature

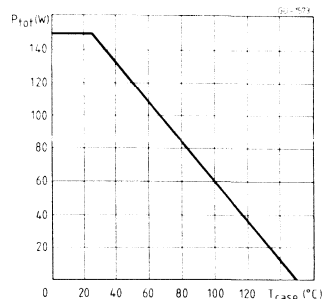
Safe operating areas



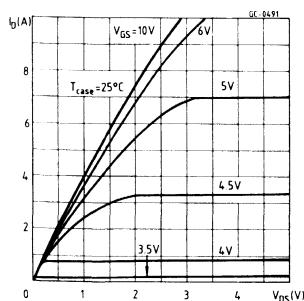
Thermal impedance



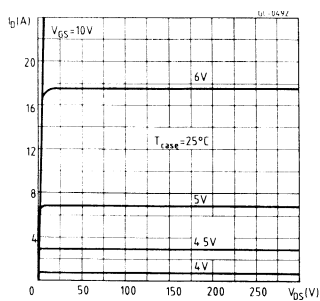
Derating curve



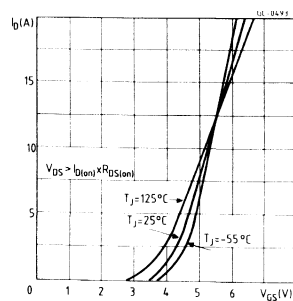
Output characteristics



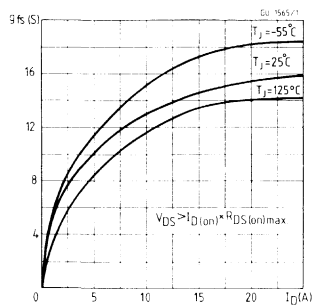
Output characteristics



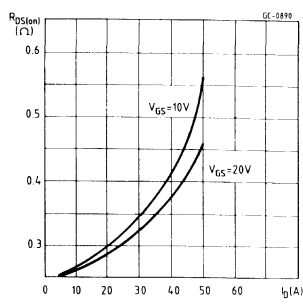
Transfer characteristics



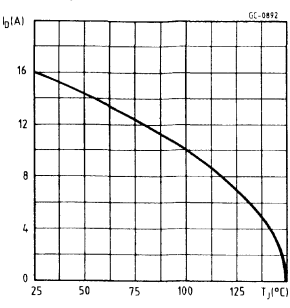
Transconductance



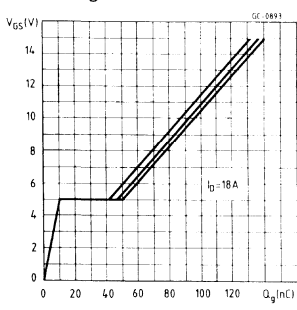
Static drain-source on resistance



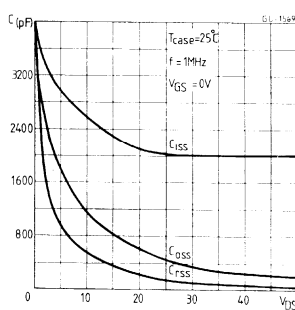
Maximum drain current vs temperature



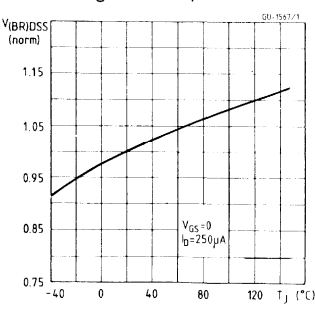
Gate charge vs gate-source voltage



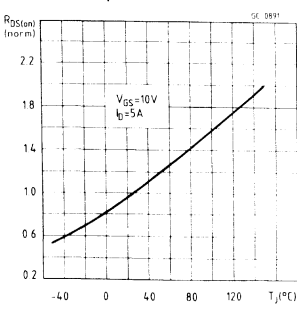
Capacitance variation



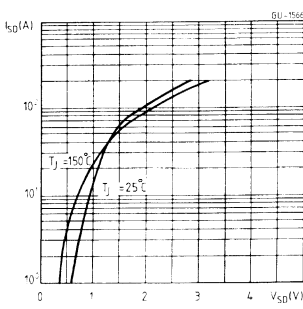
Normalized breakdown voltage vs temperature



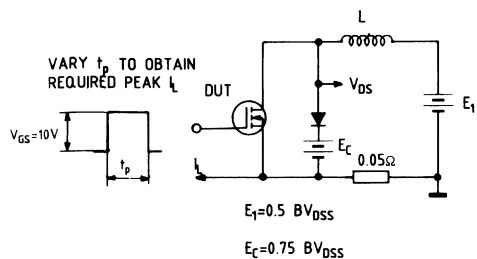
Normalized on resistance vs temperature



Source-drain diode forward characteristics

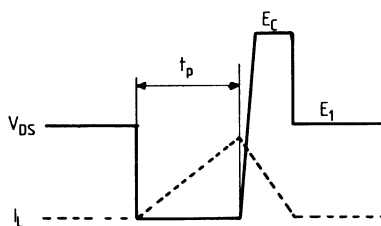


## Clamped inductive test circuit



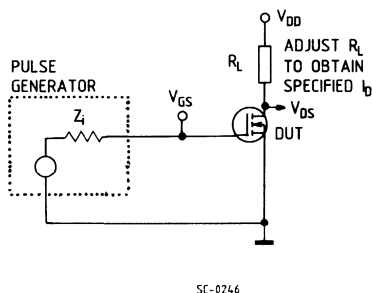
SC-0242

## Clamped inductive waveforms



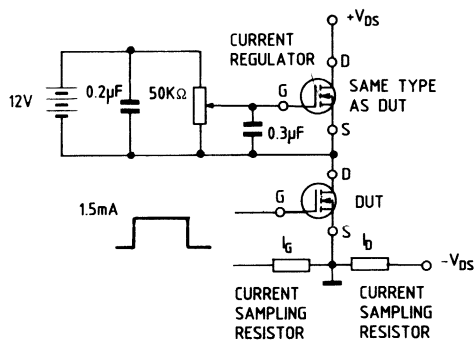
SC-0243

## Switching times test circuit



SC-0246

## Gate charge test circuit



SC-0244



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

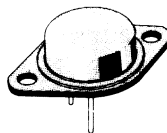
| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| IRF450 | 500 V            | 0.4 Ω               | 13 A           |
| IRF451 | 450 V            | 0.4 Ω               | 13 A           |
| IRF452 | 500 V            | 0.5 Ω               | 11 A           |
| IRF453 | 450 V            | 0.5 Ω               | 11 A           |

- HIGH VOLTAGE - 450V FOR OFF LINE SMPS
- HIGH CURRENT - 11A FOR UP TO 350W SMPS
- ULTRA FAST SWITCHING - FOR OPERATION AT > 100 KHz
- EASY DRIVE - REDUCES COST AND SIZE
- HERMETIC PACKAGE TO-3

### INDUSTRIAL APPLICATIONS:

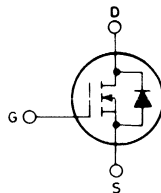
- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Typical applications include switched mode power supplies, uninterruptable power supplies and motor speed control.



**TO-3**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | IRF        |     |     |     |
|---------------------|-------------------------------------------------|------------|-----|-----|-----|
|                     |                                                 | 450        | 451 | 452 | 453 |
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      | 500        | 450 | 500 | 450 |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 500        | 450 | 500 | 450 |
| V <sub>GS</sub>     | Gate-source voltage                             | ± 20       |     |     |     |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 13         | 13  | 11  | 11  |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 8.1        | 8.1 | 7.2 | 7.2 |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 52         | 52  | 44  | 44  |
| I <sub>DLM</sub>    | Drain inductive current, clamped (L = 100 μH)   | 52         | 52  | 44  | 44  |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      | 150        |     |     |     |
|                     | Derating factor                                 | 1.2        |     |     |     |
| T <sub>stg</sub>    | Storage temperature                             | -55 to 150 |     |     |     |
| T <sub>j</sub>      | Max. operating junction temperature             | 150        |     |     |     |

\* T<sub>j</sub> = 25°C to 125°C

(\*) Repetitive Rating: Pulse width limited by max junction temperature

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.1  | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 30   | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                           |                      |            |             |                    |
|----------------|--------------------------------------------------|---------------------------------------------------------------------------|----------------------|------------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>IRF450/IRF452</b><br>for <b>IRF451/IRF453</b> | $V_{GS} = 0$         | 500<br>450 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$   | $T_c = 125^{\circ}C$ |            | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                       |                      |            | $\pm 100$   | nA                 |

ON \*\*

|               |                                   |                                                                                                             |                   |          |  |            |                      |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------|----------|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                           | $I_D = 250 \mu A$ | 2        |  | 4          | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D (on)} \times R_{DS(on) \text{ max}}$<br>for <b>IRF450/IRF451</b><br>for <b>IRF452/IRF453</b> | $V_{GS} = 10 V$   | 13<br>11 |  |            | A<br>A               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>for <b>IRF450/IRF451</b><br>for <b>IRF452/IRF453</b>                                     | $I_D = 7.2 A$     |          |  | 0.4<br>0.5 | $\Omega$<br>$\Omega$ |

DYNAMIC

|               |                              |                                                                       |                     |     |  |      |     |
|---------------|------------------------------|-----------------------------------------------------------------------|---------------------|-----|--|------|-----|
| $g_{fs}^{**}$ | Forward transconductance     | $V_{DS} > I_{D (on)} \times R_{DS (on) \text{ max}}$<br>$I_D = 7.2 A$ |                     | 8.7 |  |      | mho |
| $C_{iss}$     | Input capacitance            | $V_{DS} = 25 V$                                                       | $f = 1 \text{ MHz}$ |     |  | 3000 | pF  |
| $C_{oss}$     | Output capacitance           | $V_{GS} = 0$                                                          |                     |     |  | 600  | pF  |
| $C_{rss}$     | Reverse transfer capacitance |                                                                       |                     |     |  | 200  | pF  |

SWITCHING

|               |                     |                                                                                  |               |  |  |     |    |
|---------------|---------------------|----------------------------------------------------------------------------------|---------------|--|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 210 V$                                                                 | $I_D = 7.0 A$ |  |  | 35  | ns |
| $t_r$         | Rise time           | $R_i = 4.7 \Omega$                                                               |               |  |  | 50  | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit)                                                               |               |  |  | 150 | ns |
| $t_f$         | Fall time           |                                                                                  |               |  |  | 70  | ns |
| $Q_g$         | Total Gate Charge   | $V_{GS} = 10 V$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) | $I_D = 13 A$  |  |  | 120 | nC |

ELECTRICAL CHARACTERISTICS (Continued)

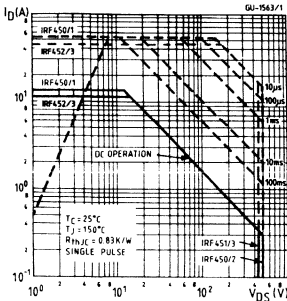
| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

SOURCE DRAIN DIODE

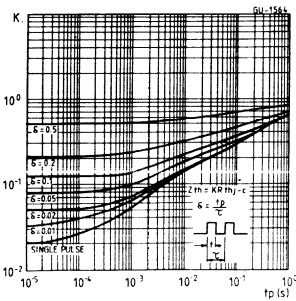
|                             |                                                          |                                                                                             |  |             |                     |
|-----------------------------|----------------------------------------------------------|---------------------------------------------------------------------------------------------|--|-------------|---------------------|
| $I_{SD}$<br>$I_{SDM}^{(*)}$ | Source-drain current<br>Source-drain current<br>(pulsed) |                                                                                             |  | 13<br>52    | A<br>A              |
| $V_{SD}^{**}$               | Forward on voltage                                       | $I_{SD} = 13\text{ A}$<br>$V_{GS} = 0$                                                      |  | 1.4         | V                   |
| $t_{rr}$<br>$Q_{rr}$        | Reverse recovery<br>time<br>Reverse recovered<br>charge  | $T_J = 150^{\circ}\text{C}$<br>$I_{SD} = 13\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |  | 1300<br>7.4 | ns<br>$\mu\text{C}$ |

\*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 1.5\%$   
(\*) Repetitive Rating: Pulse width limited by max junction temperature

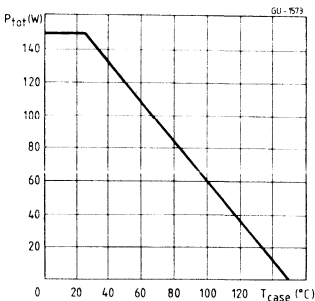
Safe operating areas



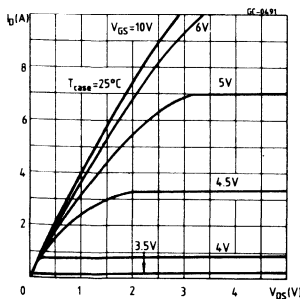
Thermal impedance



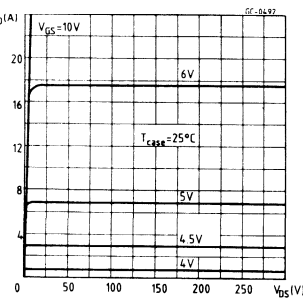
Derating curve



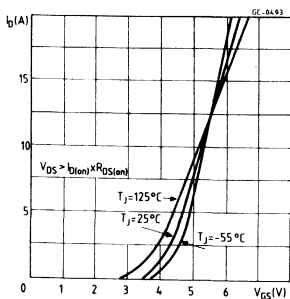
Output characteristics



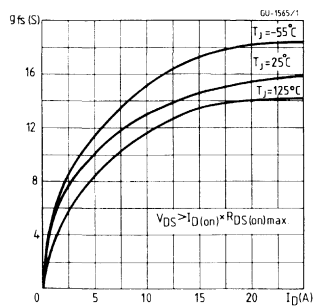
Output characteristics



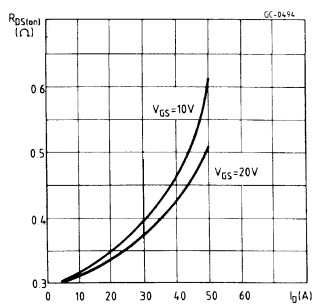
Transfer characteristics



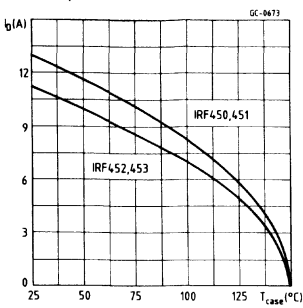
Transconductance



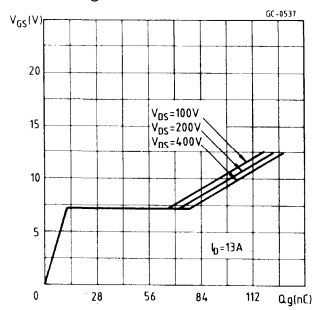
Static drain-source on resistance



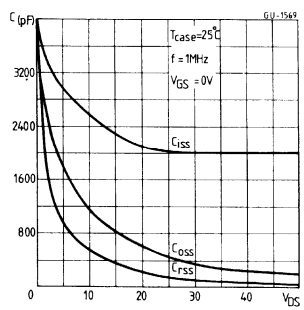
Maximum drain current vs temperature



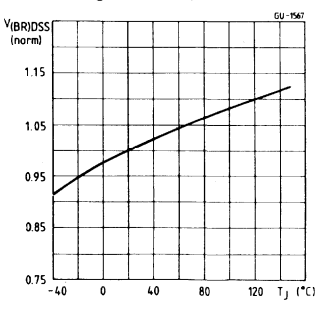
Gate charge vs gate-source voltage



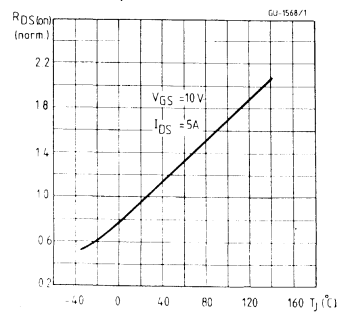
Capacitance variation



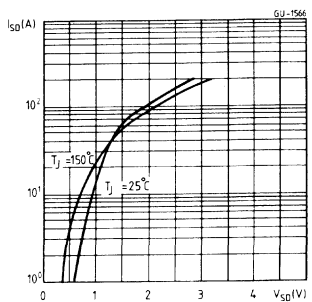
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature

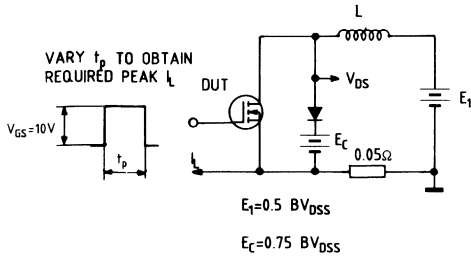


Source-drain diode forward characteristics



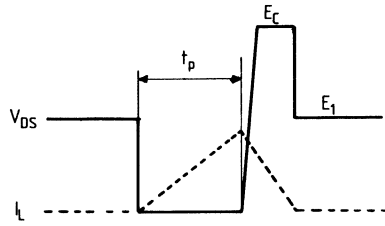


### Clamped inductive test circuit



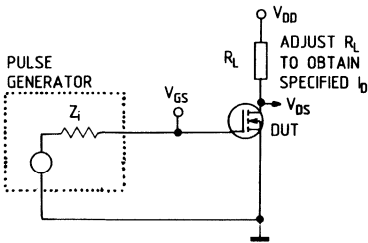
SC-0242

### Clamped inductive waveforms



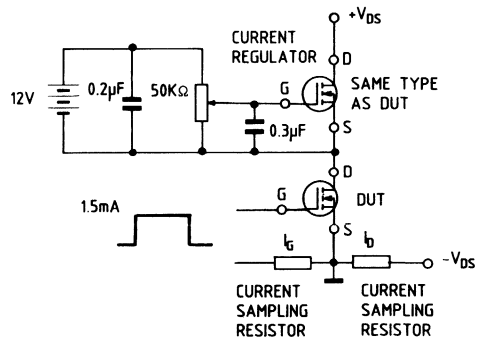
SC-0243

### Switching times test circuit



SC-0246

### Gate charge test circuit



SC-0244



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

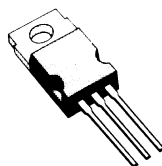
| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> <sup>■</sup> |
|----------|------------------|---------------------|-----------------------------|
| IRF520   | 100 V            | 0.27 Ω              | 9.2 A                       |
| IRF520FI | 100 V            | 0.27 Ω              | 7 A                         |
| IRF521   | 80 V             | 0.27 Ω              | 9.2 A                       |
| IRF521FI | 80 V             | 0.27 Ω              | 7 A                         |
| IRF522   | 100 V            | 0.36 Ω              | 8 A                         |
| IRF522FI | 100 V            | 0.36 Ω              | 6 A                         |
| IRF523   | 80 V             | 0.36 Ω              | 8 A                         |
| IRF523FI | 80 V             | 0.36 Ω              | 6 A                         |

- 80-100 VOLTS - FOR DC/DC CONVERTERS
- HIGH CURRENT
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- ULTRA FAST SWITCHING
- EASY DRIVE- FOR REDUCED COST AND SIZE

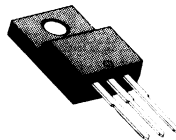
### INDUSTRIAL APPLICATIONS:

- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Applications include DC/DC converters, UPS, battery chargers, secondary regulators, servo control, power-audio amplifiers and robotics.

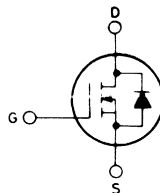


TO-220



ISOWATT220

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                               |                                                 | TO-220<br>ISOWATT220 |  | IRF          |              |              |              |      |
|-------------------------------|-------------------------------------------------|----------------------|--|--------------|--------------|--------------|--------------|------|
|                               |                                                 |                      |  | 520<br>520FI | 521<br>521FI | 522<br>522FI | 523<br>523FI |      |
| V <sub>DS</sub> *             | Drain-source voltage (V <sub>GS</sub> = 0)      |                      |  | 100          | 80           | 100          | 80           | V    |
| V <sub>DGR</sub> *            | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    |                      |  | 100          | 80           | 100          | 80           | V    |
| V <sub>GS</sub>               | Gate-source voltage                             |                      |  | ±20          |              |              |              | V    |
| I <sub>DM</sub> (•)           | Drain current (pulsed)                          |                      |  | 37           | 37           | 32           | 32           | A    |
| I <sub>D</sub>                | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | <b>520</b>   | <b>521</b>   | <b>522</b>   | <b>523</b>   | A    |
| I <sub>D</sub>                | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 9.2          | 9.2          | 8            | 8            | A    |
|                               |                                                 |                      |  | 6.5          | 6.5          | 5.6          | 5.6          | A    |
| I <sub>D</sub> <sup>■</sup>   | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | <b>520FI</b> | <b>521FI</b> | <b>522FI</b> | <b>523FI</b> | A    |
| I <sub>D</sub> <sup>■</sup>   | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 7            | 7            | 6            | 6            | A    |
|                               |                                                 |                      |  | 4            | 4            | 3.5          | 3.5          | A    |
|                               |                                                 |                      |  | TO-220       |              | ISOWATT220   |              |      |
| P <sub>tot</sub> <sup>■</sup> | Total dissipation at T <sub>c</sub> < 25°C      |                      |  | 60           |              | 30           |              | W    |
|                               | Derating factor                                 |                      |  | 0.48         |              | 0.24         |              | W/°C |
| T <sub>stg</sub>              | Storage temperature                             |                      |  | -55 to 150   |              |              |              | °C   |
| T <sub>j</sub>                | Max. operating junction temperature             |                      |  | 150          |              |              |              | °C   |

\* T<sub>j</sub> = 25°C to 125°C

(•) Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT220 on this datasheet.

♦ Introduced in 1988 week 44

## THERMAL DATA \*

TO-220

ISOWATT220

|                  |                                                |     |      |      |      |
|------------------|------------------------------------------------|-----|------|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 2.08 | 4.16 | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.5  |      | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 80   |      | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300  |      | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^\circ\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

## OFF

|                |                                                  |                                                                                     |                           |             |                                |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$<br>for IRF520/522/520FI/522FI<br>for IRF521/523/521FI/523FI | $V_{GS} = 0$              | 100<br>80   | V<br>V                         |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$             | $T_c = 125^\circ\text{C}$ | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                                         |                           | $\pm 500$   | nA                             |

## ON \*\*

|              |                                   |                                                                                                                |                         |          |              |                      |
|--------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------|-------------------------|----------|--------------|----------------------|
| $V_{GS(th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                              | $I_D = 250 \mu\text{A}$ | 2        | 4            | V                    |
| $I_{D(on)}$  | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$<br>for IRF520/521/520FI/521FI<br>for IRF521/523/521FI/523FI | $V_{GS} = 10 \text{ V}$ | 9.2<br>8 |              | A<br>A               |
| $R_{DS(on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$<br>for IRF520/521/520FI/521FI<br>for IRF522/523/522FI/523FI                            | $I_D = 5.6 \text{ A}$   |          | 0.27<br>0.36 | $\Omega$<br>$\Omega$ |

## ENERGY TEST

|           |                                                      |                                                                                                                          |                       |          |  |        |
|-----------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-----------------------|----------|--|--------|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 \text{ V}$<br>starting $T_l = 25^\circ\text{C}$<br>for IRF520/521/520FI/521FI<br>for IRF522/523/522FI/523FI | $L = 100 \mu\text{H}$ | 9.2<br>8 |  | A<br>A |
|-----------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-----------------------|----------|--|--------|

## DYNAMIC

|             |                              |                                                                             |                     |  |                   |                |
|-------------|------------------------------|-----------------------------------------------------------------------------|---------------------|--|-------------------|----------------|
| $g_{fs}$ ** | Forward transconductance     | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$<br>$I_D = 5.6 \text{ A}$ | 2.7                 |  |                   | mho            |
| $C_{iss}$   | Input capacitance            | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$                                     | $f = 1 \text{ MHz}$ |  | 600<br>400<br>100 | pF<br>pF<br>pF |
| $C_{oss}$   | Output capacitance           |                                                                             |                     |  |                   |                |
| $C_{rss}$   | Reverse transfer capacitance |                                                                             |                     |  |                   |                |

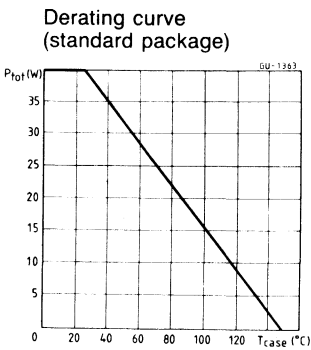
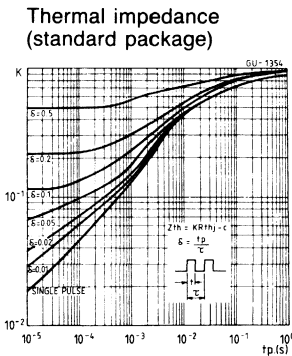
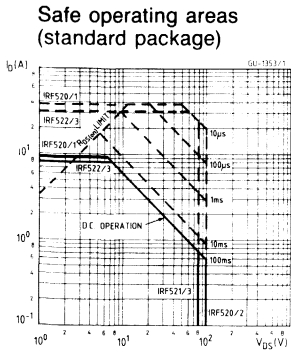
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters   |                     | Test Conditions                                                                                              | Min. | Typ. | Max. | Unit |
|--------------|---------------------|--------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on time        | $V_{DD} = 40\text{ V}$ $I_D = 4.0\text{ A}$<br>$R_I = 50\ \Omega$<br>(see test circuit)                      |      |      | 40   | ns   |
| $t_r$        | Rise time           |                                                                                                              |      |      | 70   | ns   |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                              |      |      | 100  | ns   |
| $t_f$        | Fall time           |                                                                                                              |      |      | 70   | ns   |
| $Q_g$        | Total Gate Charge   | $V_{GS} = 15\text{ V}$ $I_D = 9.2\text{ A}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) |      |      | 15   | nC   |

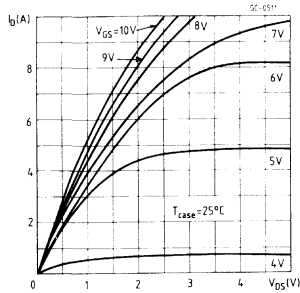
SOURCE DRAIN DIODE

|                 |                               |                                                            |  |     |     |               |
|-----------------|-------------------------------|------------------------------------------------------------|--|-----|-----|---------------|
| $I_{SD}$        | Source-drain current          |                                                            |  |     | 9.2 | A             |
| $I_{SDM}^{(*)}$ | Source-drain current (pulsed) |                                                            |  |     | 37  | A             |
| $V_{SD}^{**}$   | Forward on voltage            | $I_{SD} = 9.2\text{ A}$ $V_{GS} = 0$                       |  |     | 2.5 | V             |
| $t_{rr}$        | Reverse recovery time         | $T_j = 150^\circ\text{C}$                                  |  | 280 |     | ns            |
| $Q_{rr}$        | Reverse recovered charge      | $I_{SD} = 9.2\text{ A}$ $di/dt = 100\text{ A}/\mu\text{s}$ |  | 1.6 |     | $\mu\text{C}$ |

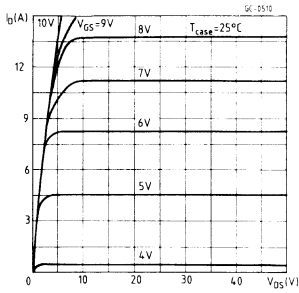
\*\* Pulsed: Pulse duration  $\leq 300\ \mu\text{s}$ , duty cycle  $\leq 1.2\%$   
(\*) Repetitive Rating: Pulse width limited by max junction temperature  
■ See note on ISOWATT220 in this datasheet



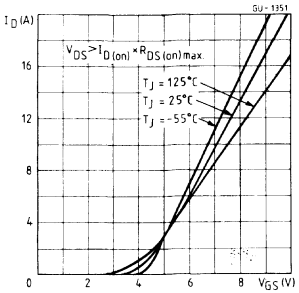
Output characteristics



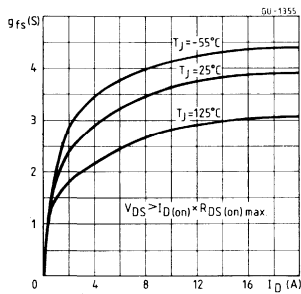
Output characteristics



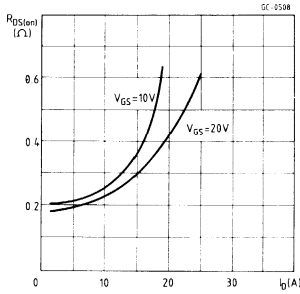
Transfer characteristics



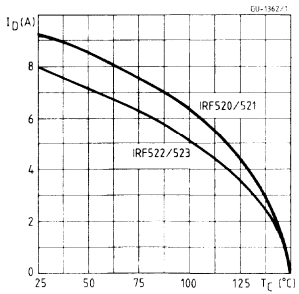
Transconductance



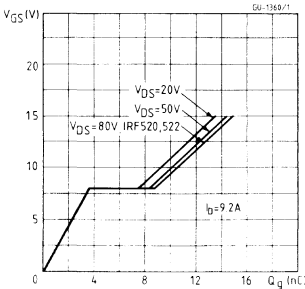
Static drain-source on resistance



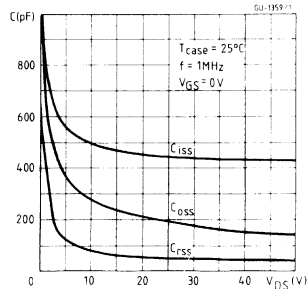
Maximum drain current vs temperature



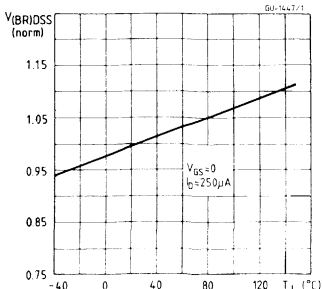
Gate charge vs gate-source voltage



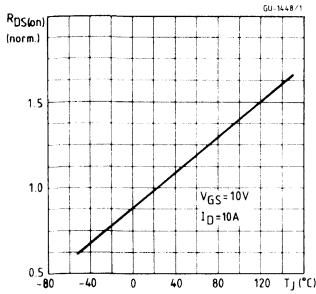
Capacitance variation



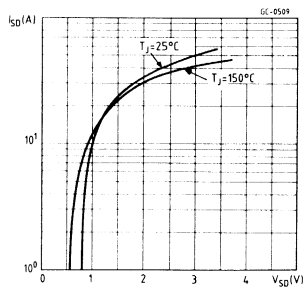
Normalized breakdown voltage vs temperature



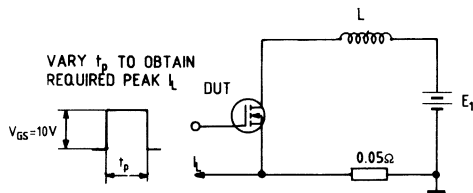
Normalized on resistance  
vs temperature



Source-drain diode forward  
characteristics

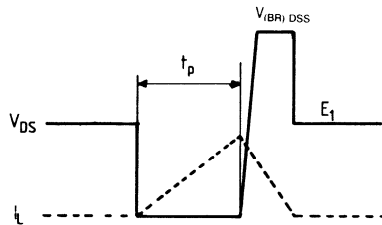


Unclamped inductive test circuit



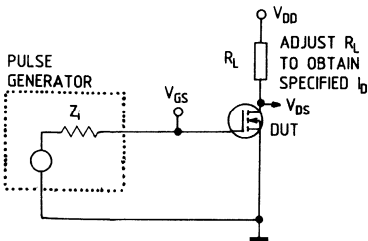
SC-0339

Unclamped inductive waveforms



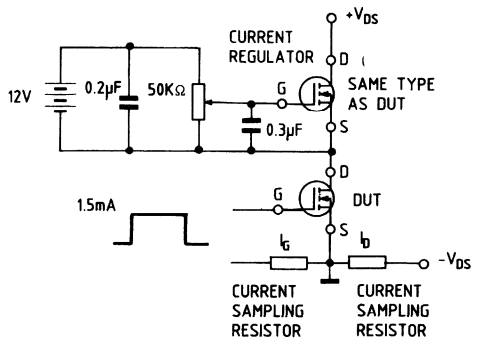
SC-0338

Switching times test circuit



SC-0246

Gate charge test circuit



SC-0244

# **ISOWATT220 PACKAGE CHARACTERISTICS AND APPLICATION.**

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

# **THERMAL IMPEDANCE OF ISOWATT220 PACKAGE**

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th(tot)}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

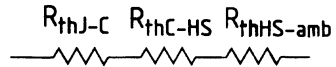
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

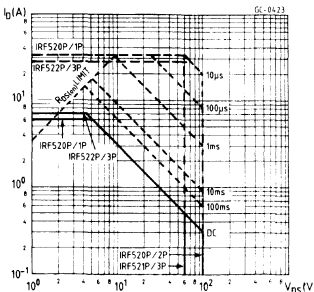
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

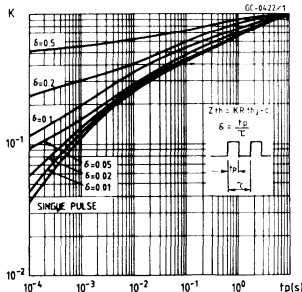


## **ISOWATT DATA**

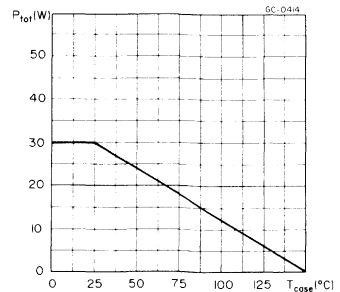
### **Safe operating areas**



### **Thermal impedance**



### **Derating curve**





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

PRELIMINARY DATA

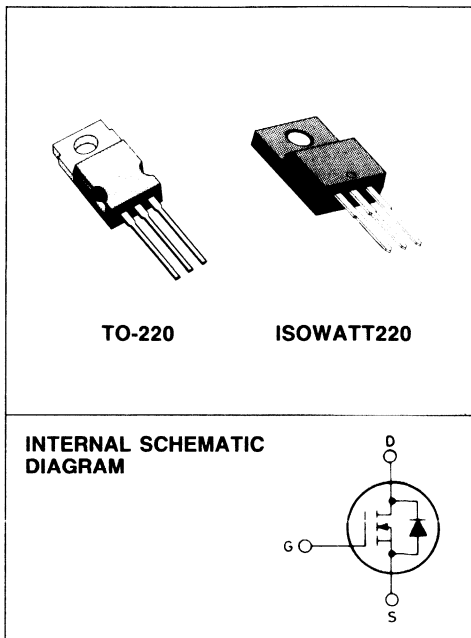
| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> <sup>■</sup> |
|----------|------------------|---------------------|-----------------------------|
| IRF530   | 100 V            | 0.16 Ω              | 14 A                        |
| IRF530FI | 100 V            | 0.16 Ω              | 9 A                         |
| IRF531   | 80 V             | 0.16 Ω              | 14 A                        |
| IRF531FI | 80 V             | 0.16 Ω              | 9 A                         |
| IRF532   | 100 V            | 0.23 Ω              | 12 A                        |
| IRF532FI | 100 V            | 0.23 Ω              | 8 A                         |
| IRF533   | 80 V             | 0.23 Ω              | 12 A                        |
| IRF533FI | 80 V             | 0.23 Ω              | 8 A                         |

- 80-100 VOLTS - FOR DC/DC CONVERTERS
- HIGH CURRENT
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Applications include DC/DC converters, UPS, battery chargers, secondary regulators, servo control, power-audio amplifiers and robotics.



### ABSOLUTE MAXIMUM RATINGS

|                               |                                                 | IRF        |       |       |       |
|-------------------------------|-------------------------------------------------|------------|-------|-------|-------|
|                               |                                                 | 530        | 531   | 532   | 533   |
|                               |                                                 | 530FI      | 531FI | 532FI | 533FI |
| V <sub>DS</sub> *             | Drain-source voltage (V <sub>GS</sub> = 0)      | 100        | 80    | 100   | 80    |
| V <sub>DGR</sub> *            | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 100        | 80    | 100   | 80    |
| V <sub>GS</sub>               | Gate-source voltage                             | ±20        |       |       |       |
| I <sub>DM</sub> (●)           | Drain current (pulsed)                          | 56         | 56    | 48    | 48    |
| I <sub>DLM</sub>              | Drain inductive current, clamped (L = 100 μH)   | 56         | 56    | 48    | 48    |
| I <sub>D</sub>                | Drain current (cont.) at T <sub>c</sub> = 25°C  | 14         | 14    | 12    | 12    |
| I <sub>D</sub>                | Drain current (cont.) at T <sub>c</sub> = 100°C | 9          | 9     | 8     | 8     |
| I <sub>D</sub> <sup>■</sup>   | Drain current (cont.) at T <sub>c</sub> = 25°C  | 530FI      | 531FI | 532FI | 533FI |
| I <sub>D</sub> <sup>■</sup>   | Drain current (cont.) at T <sub>c</sub> = 100°C | 9          | 9     | 8     | 8     |
| P <sub>tot</sub> <sup>■</sup> | Total dissipation at T <sub>c</sub> < 25°C      | 79         | 35    | 35    | 35    |
| T <sub>stg</sub>              | Storage temperature                             | 0.63       | 0.28  | 0.28  | 0.28  |
| T <sub>j</sub>                | Max. operating junction temperature             | -55 to 150 |       |       |       |
|                               |                                                 | 150        |       |       |       |

\* T<sub>j</sub> = 25°C to 125°C

(●) Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT220 on this datasheet.

THERMAL DATA \*

|                  |                                                | TO-220 |      | ISOWATT220 |      |
|------------------|------------------------------------------------|--------|------|------------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max    | 1.58 | 3.57       | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ    |      | 0.5        | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max    |      | 80         | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |        |      | 300        | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                                |  |           |  |                                               |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------|--|-----------|--|-----------------------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$ $V_{GS} = 0$<br>for <b>IRF530/532/530FI/532FI</b><br>for <b>IRF531/533/531FI/533FI</b> |  | 100<br>80 |  | V<br>V                                        |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}\text{C}$            |  |           |  | 250<br>1000<br>$\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                                                                    |  |           |  | $\pm 100$<br>nA                               |

ON \*\*

|               |                                   |                                                                                                                                              |  |          |  |                                      |
|---------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|--|----------|--|--------------------------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 250 \mu\text{A}$                                                                                                    |  | 2        |  | 4<br>V                               |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$ $V_{GS} = 10 \text{ V}$<br>for <b>IRF530/531/530FI/531FI</b><br>for <b>IRF532/533/532FI/533FI</b> |  | 14<br>12 |  | A<br>A                               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ $I_D = 8.3 \text{ A}$<br>for <b>IRF530/531/530FI/531FI</b><br>for <b>IRF532/533/532FI/533FI</b>                      |  |          |  | 0.16<br>0.23<br>$\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                                                   |     |  |                  |                |
|-------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------|-----|--|------------------|----------------|
| $g_{fs}^{**}$                       | Forward transconductance                                                | $V_{DS} > I_{D(on)} \times R_{DS(on)max}$<br>$I_D = 8.3\text{ A}$ | 5.1 |  |                  | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\text{ V}$<br>$V_{GS} = 0$<br>$f = 1\text{ MHz}$      |     |  | 850<br>260<br>50 | pF<br>pF<br>pF |

SWITCHING

|                                                 |                                                               |                                                                                                               |  |  |  |                                              |
|-------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|--|--|--|----------------------------------------------|
| $t_{d (on)}$<br>$t_r$<br>$t_{d (off)}$<br>$t_f$ | Turn-on time<br>Rise time<br>Turn-off delay time<br>Fall time | $V_{DD} = 36 \text{ V}$ $I_D = 8.0 \text{ A}$<br>$R_l = 15 \Omega$<br>(see test circuit)                      |  |  |  | 30<br>75<br>40<br>45<br>ns<br>ns<br>ns<br>ns |
| $Q_g$                                           | Total Gate Charge                                             | $V_{GS} = 10 \text{ V}$ $I_D = 14 \text{ A}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) |  |  |  | 30<br>nC                                     |

ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

SOURCE DRAIN DIODE

|                           |                                                          |                                                              |  |          |               |
|---------------------------|----------------------------------------------------------|--------------------------------------------------------------|--|----------|---------------|
| $I_{SD}$<br>$I_{SDM}$ (*) | Source-drain current<br>Source-drain current<br>(pulsed) |                                                              |  | 14<br>56 | A<br>A        |
| $V_{SD}$ **               | Forward on voltage                                       | $I_{SD} = 14\text{ A}$<br>$V_{GS} = 0$                       |  | 2.5      | V             |
| $t_{rr}$                  | Reverse recovery<br>time                                 | $T_j = 150^\circ\text{C}$                                    |  | 360      | ns            |
| $Q_{rr}$                  | Reverse recovered<br>charge                              | $I_{SD} = 14\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |  | 21       | $\mu\text{C}$ |

\*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$   
(\*) Repetitive Rating: Pulse width limited by max junction temperature  
■ See note on ISOWATT220 in this datasheet

ISOWATT220 PACKAGE  
CHARACTERISTICS AND APPLICATION.

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The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

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$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

THERMAL IMPEDANCE OF  
ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th \text{ (tot)}}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

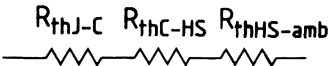
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

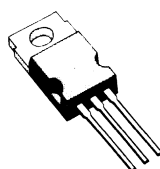
| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> * |
|----------|------------------|---------------------|------------------|
| IRF540   | 100 V            | 0.077 Ω             | 28 A             |
| IRF540FI | 100 V            | 0.077 Ω             | 15 A             |
| IRF541   | 80 V             | 0.077 Ω             | 28 A             |
| IRF541FI | 80 V             | 0.077 Ω             | 15 A             |
| IRF542   | 100 V            | 0.100 Ω             | 25 A             |
| IRF542FI | 100 V            | 0.100 Ω             | 14 A             |
| IRF543   | 80 V             | 0.100 Ω             | 25 A             |
| IRF543FI | 80 V             | 0.100 Ω             | 14 A             |

- 80-100 VOLTS - FOR DC/DC CONVERTERS
- HIGH CURRENT
- ULTRA FAST SWITCHING
- EASY DRIVE- FOR REDUCED COST AND SIZE

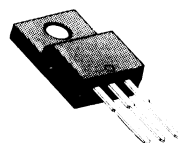
### INDUSTRIAL APPLICATIONS:

- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Applications include DC/DC converters, UPS, battery chargers, secondary regulators, servo control, power-audio amplifiers and robotics.

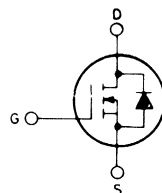


**TO-220**



**ISOWATT220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

| ABSOLUTE MAXIMUM RATINGS |                                                 | IRF                  |  |                |              |              |              |      |
|--------------------------|-------------------------------------------------|----------------------|--|----------------|--------------|--------------|--------------|------|
|                          |                                                 | TO-220<br>ISOWATT220 |  | 540<br>540FI   | 541<br>541FI | 542<br>542FI | 543<br>543FI |      |
| V <sub>DS</sub> *        | Drain-source voltage (V <sub>GS</sub> = 0)      |                      |  | 100            | 80           | 100          | 80           | V    |
| V <sub>DGR</sub> *       | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    |                      |  | 100            | 80           | 100          | 80           | V    |
| V <sub>GS</sub>          | Gate-source voltage                             |                      |  |                |              | ±20          |              | V    |
| I <sub>DM</sub> (•)      | Drain current (pulsed)                          |                      |  | 110            | 110          | 100          | 100          | A    |
| I <sub>DLM</sub>         | Drain inductive current, clamped (L = 100 μH)   |                      |  | 110            | 110          | 100          | 100          | A    |
|                          |                                                 |                      |  | 540            | 541          | 542          | 543          |      |
| I <sub>D</sub>           | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | 28             | 28           | 25           | 25           | A    |
| I <sub>D</sub>           | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 20             | 20           | 17           | 17           | A    |
|                          |                                                 |                      |  | 540FI          | 541FI        | 542FI        | 543FI        |      |
| I <sub>D</sub> ■         | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | 15             | 15           | 14           | 14           | A    |
| I <sub>D</sub> ■         | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 9              | 9            | 8            | 8            | A    |
|                          |                                                 |                      |  | TO-220         |              | ISOWATT220   |              |      |
| P <sub>tot</sub> ■       | Total dissipation at T <sub>c</sub> < 25°C      |                      |  | 125            |              | 40           |              | W    |
| ■                        | Derating factor                                 |                      |  | 1              |              | 0.32         |              | W/°C |
| T <sub>stg</sub>         | Storage temperature                             |                      |  | - 55 to 150 °C |              |              |              |      |
| T <sub>j</sub>           | Max. operating junction temperature             |                      |  | 150 °C         |              |              |              |      |

\* T = 25°C to 125°C

(•) Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT220 on this datasheet.

THERMAL DATA \*

|                  |                                                | TO-220 |     | ISOWATT220 |
|------------------|------------------------------------------------|--------|-----|------------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max    | 1   | 3.12 °C/W  |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ    | 0.5 | °C/W       |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max    | 80  | °C/W       |
| $T_l$            | Maximum lead temperature for soldering purpose |        | 300 | °C         |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                               |                      |           |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------|----------------------|-----------|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for IRF540/542/540FI/542FI<br>for IRF541/543/541FI/543FI | $V_{GS} = 0$         | 100<br>80 |  |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$       | $T_c = 125^{\circ}C$ |           |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                           |                      |           |  | $\pm 500$   | nA                 |

ON \*\*

|               |                                   |                                                                                                        |                   |          |  |                |                      |
|---------------|-----------------------------------|--------------------------------------------------------------------------------------------------------|-------------------|----------|--|----------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                      | $I_D = 250 \mu A$ | 2        |  | 4              | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$<br>for IRF540/541/540FI/541FI<br>for IRF542/543/542FI/543FI | $V_{GS} = 10 V$   | 28<br>25 |  |                | A<br>A               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>for IRF540/541/540FI/541FI<br>for IRF542/543/542FI/543FI                            | $I_D = 17 A$      |          |  | 0.077<br>0.100 | $\Omega$<br>$\Omega$ |

DYNAMIC

|             |                              |                                                            |             |  |  |      |     |
|-------------|------------------------------|------------------------------------------------------------|-------------|--|--|------|-----|
| $g_{fs} **$ | Forward transconductance     | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$<br>$I_D = 17 A$ | 8.7         |  |  |      | mho |
| $C_{iss}$   | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$                            | $f = 1 MHz$ |  |  | 1600 | pF  |
| $C_{oss}$   | Output capacitance           |                                                            |             |  |  | 800  | pF  |
| $C_{rss}$   | Reverse transfer capacitance |                                                            |             |  |  | 300  | pF  |

SWITCHING

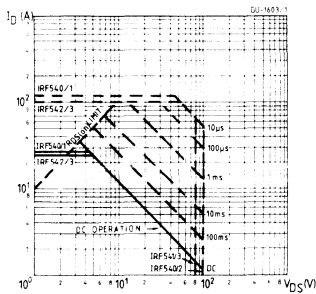
|               |                     |                                                                                  |              |  |  |    |    |
|---------------|---------------------|----------------------------------------------------------------------------------|--------------|--|--|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 30 V$<br>$R_l = 4.7 \Omega$<br>(see test circuit)                      | $I_D = 15 A$ |  |  | 30 | ns |
| $t_r$         | Rise time           |                                                                                  |              |  |  | 60 | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                                                  |              |  |  | 80 | ns |
| $t_f$         | Fall time           |                                                                                  |              |  |  | 30 | ns |
| $Q_g$         | Total Gate Charge   | $V_{GS} = 10 V$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) | $I_D = 28 A$ |  |  | 59 | nC |

# ELECTRICAL CHARACTERISTICS (Continued)

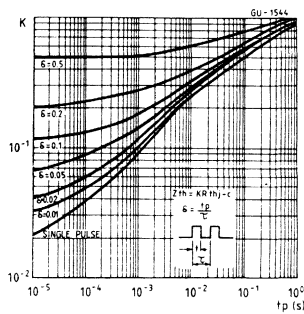
| Parameters                                    | Test Conditions                                           | Min. | Typ. | Max. | Unit          |
|-----------------------------------------------|-----------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$ Source-drain current                 |                                                           |      |      | 28   | A             |
| $I_{SDM}^{(*)}$ Source-drain current (pulsed) |                                                           |      |      | 110  | A             |
| $V_{SD}^{**}$ Forward on voltage              | $I_{SD} = 28\text{ A}$ $V_{GS} = 0$                       |      |      | 2.5  | V             |
| $t_{rr}$ Reverse recovery time                | $T_J = 150^\circ\text{C}$                                 |      | 500  |      | ns            |
| $Q_{rr}$ Reverse recovered charge             | $I_{SD} = 28\text{ A}$ $di/dt = 100\text{ A}/\mu\text{s}$ |      | 2.9  |      | $\mu\text{C}$ |

- \*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 1.5\%$   
 (\*) Repetitive Rating: Pulse width limited by max junction temperature  
 See note on ISOWATT220 in this datasheet

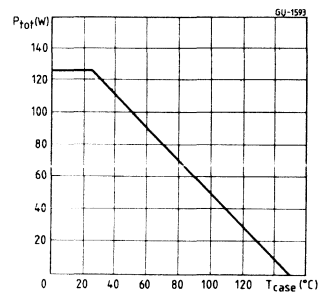
Safe operating areas  
(standard package)



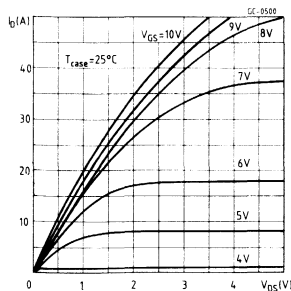
Thermal impedance  
(standard package)



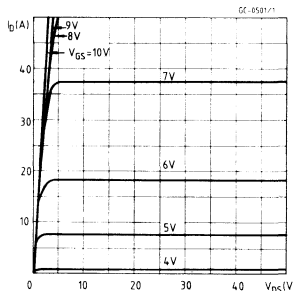
Derating curve  
(standard package)



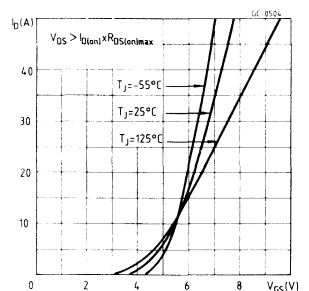
Output characteristics



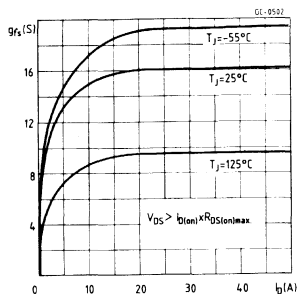
Output characteristics



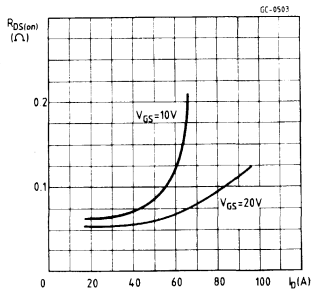
Transfer characteristics



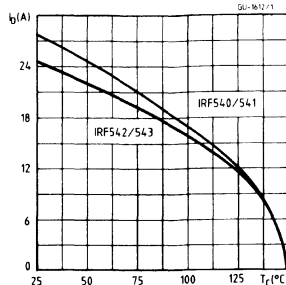
Transconductance



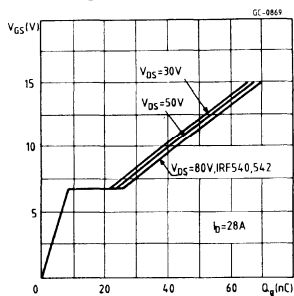
Static drain-source on resistance



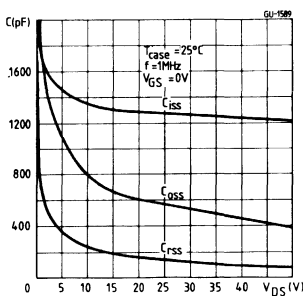
Maximum drain current vs temperature



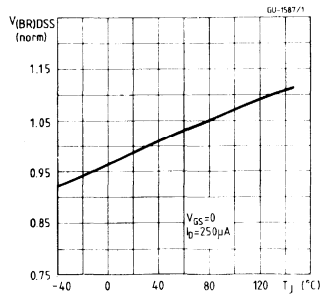
Gate charge vs gate-source voltage



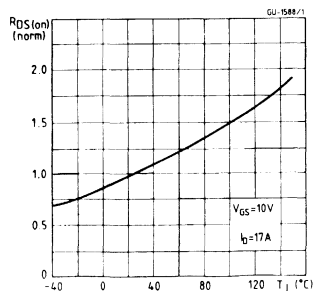
Capacitance variation



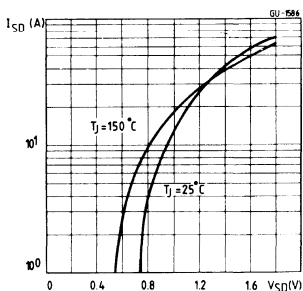
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature

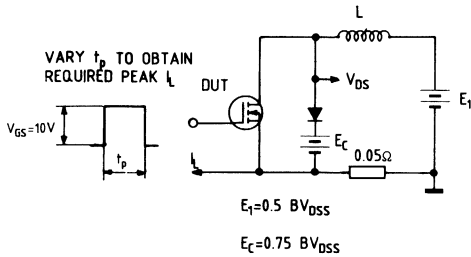


Source-drain diode forward characteristics



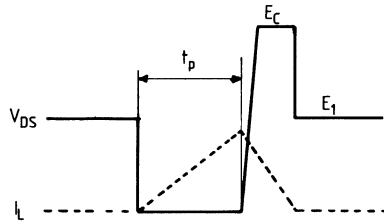


### Clamped inductive test circuit



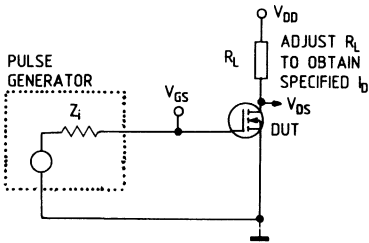
SC-0242

### Clamped inductive waveforms



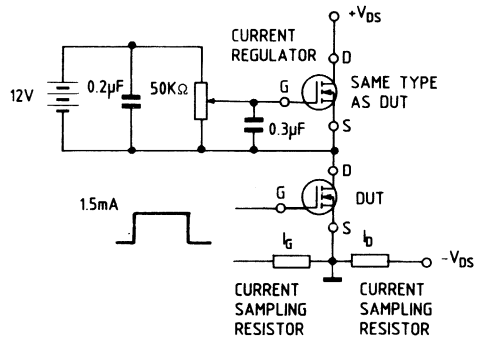
SC-0243

### Switching times test circuit



SC-0246

### Gate charge test circuit



SC-0244

# ISOWATT220 PACKAGE CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

# THERMAL IMPEDANCE OF ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th \text{ (tot)}}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

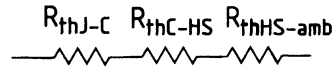
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

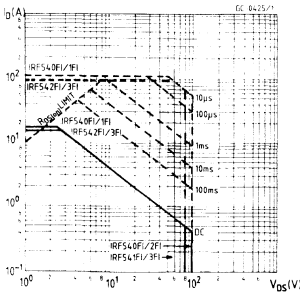
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

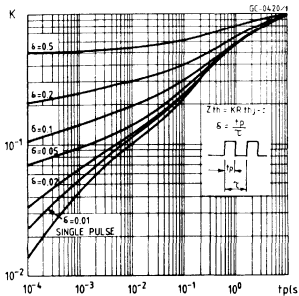


# ISOWATT DATA

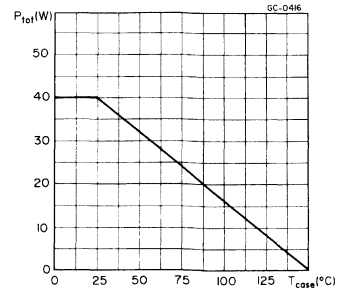
Safe operating areas



Thermal impedance



Derating curve



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

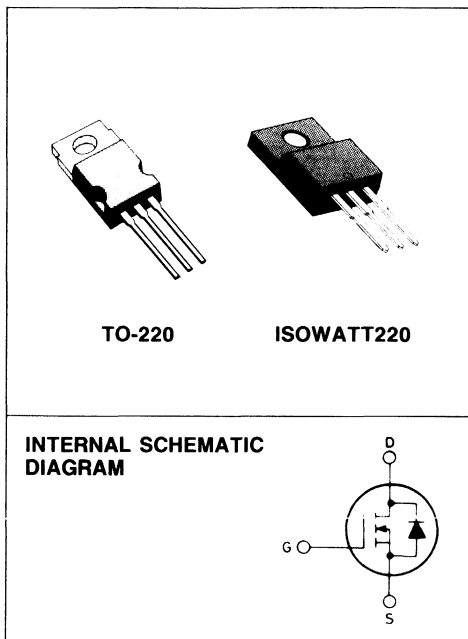
| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> ■ |
|----------|------------------|---------------------|------------------|
| IRF620   | 200 V            | 0.8 Ω               | 5 A              |
| IRF620FI | 200 V            | 0.8 Ω               | 4 A              |
| IRF621   | 150 V            | 0.8 Ω               | 5 A              |
| IRF621FI | 150 V            | 0.8 Ω               | 4 A              |
| IRF622   | 200 V            | 1.2 Ω               | 4 A              |
| IRF622FI | 200 V            | 1.2 Ω               | 3.5 A            |
| IRF623   | 150 V            | 1.2 Ω               | 4 A              |
| IRF623FI | 150 V            | 1.2 Ω               | 3.5 A            |

- 200V FOR TELECOMMUNICATION APPLICATIONS
- ULTRA FAST SWITCHING
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- EASY DRIVE - REDUCES COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCHING MODE POWER SUPPLIES
- DC SWITCH
- ROBOTCS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Typical uses are in telecommunications, robotics, switching power supplies and as a DC switch.



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | TO-220<br>ISOWATT220 |  | IRF          |              |              |              |      |
|---------------------|-------------------------------------------------|----------------------|--|--------------|--------------|--------------|--------------|------|
|                     |                                                 |                      |  | 620<br>620FI | 621<br>621FI | 622<br>622FI | 623<br>623FI |      |
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      |                      |  | 200          | 150          | 200          | 150          | V    |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    |                      |  | 200          | 150          | 200          | 150          | V    |
| V <sub>GS</sub>     | Gate-source voltage                             |                      |  |              |              | ±20          |              | V    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          |                      |  | 20           | 20           | 16           | 16           | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | 5            | 5            | 4            | 4            | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 3            | 3            | 2.5          | 2.5          | A    |
| I <sub>D</sub> ■    | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | 4            | 4            | 3.5          | 3.5          | A    |
| I <sub>D</sub> ■    | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 2.5          | 2.5          | 2            | 2            | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      |                      |  | TO-220       |              | ISOWATT220   |              | W    |
|                     | Derating factor                                 |                      |  | 40           |              | 30           |              | W/°C |
| T <sub>stg</sub>    | Storage temperature                             |                      |  | 0.32         |              | 0.24         |              | W/°C |
| T <sub>j</sub>      | Max. operating junction temperature             |                      |  | -55 to 150   |              | 150          |              | °C   |

\* T<sub>j</sub> = 25°C to 125°C

(\*) Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT220 on this datasheet.

♦ Introduced in 1988 week 44

**THERMAL DATA**

TO-220 | ISOWATT220

|                  |                                                |     |      |      |      |
|------------------|------------------------------------------------|-----|------|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 3.12 | 4.16 | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.5  |      | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 80   |      | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300  |      | °C   |

**ELECTRICAL CHARACTERISTICS** ( $T_{case} = 25^\circ\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                                                     |                           |             |                                |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$<br>for IRF620/622/620FI/622FI<br>for IRF621/623/621FI/623FI | $V_{GS} = 0$              | 200<br>150  | V<br>V                         |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$             | $T_c = 125^\circ\text{C}$ | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                                         |                           | $\pm 500$   | nA                             |

**ON \*\***

|               |                                   |                                                                                                                 |                         |        |            |                      |
|---------------|-----------------------------------|-----------------------------------------------------------------------------------------------------------------|-------------------------|--------|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                               | $I_D = 250 \mu\text{A}$ | 2      | 4          | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D (on)} \times R_{DS(on) \text{ max}}$<br>for IRF620/621/620FI/621FI<br>for IRF622/623/622FI/623FI | $V_{GS} = 10 \text{ V}$ | 5<br>4 |            | A<br>A               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$<br>for IRF620/621/620FI/621FI<br>for IRF622/623/622FI/623FI                             | $I_D = 2.5 \text{ A}$   |        | 0.8<br>1.2 | $\Omega$<br>$\Omega$ |

**ENERGY TEST**

|           |                                                      |                                                                                                                          |                       |        |  |        |
|-----------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-----------------------|--------|--|--------|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 \text{ V}$<br>starting $T_j = 25^\circ\text{C}$<br>for IRF620/621/620FI/621FI<br>for IRF622/623/622FI/623FI | $L = 100 \mu\text{H}$ | 5<br>4 |  | A<br>A |
|-----------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-----------------------|--------|--|--------|

**DYNAMIC**

|             |                              |                                                                               |                     |     |     |     |
|-------------|------------------------------|-------------------------------------------------------------------------------|---------------------|-----|-----|-----|
| $g_{fs} **$ | Forward transconductance     | $V_{DS} > I_{D (on)} \times R_{DS (on) \text{ max}}$<br>$I_D = 2.5 \text{ A}$ |                     | 1.3 |     | mho |
| $C_{iss}$   | Input capacitance            | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$                                       | $f = 1 \text{ MHz}$ |     | 600 | pF  |
| $C_{oss}$   | Output capacitance           |                                                                               |                     |     | 300 | pF  |
| $C_{rss}$   | Reverse transfer capacitance |                                                                               |                     |     | 80  | pF  |

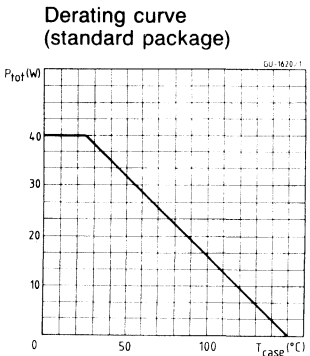
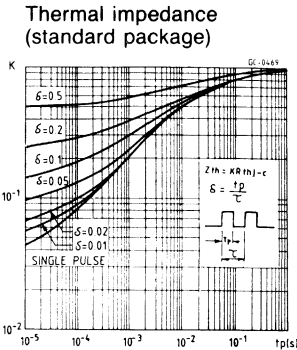
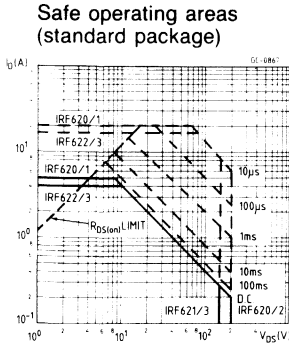
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                    | Test Conditions                                                                                                                                             | Min. | Typ. | Max.                  | Unit                 |
|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-----------------------|----------------------|
| $t_{d(on)}$<br>$t_r$<br>$t_{d(off)}$<br>$t_f$ | Turn-on time<br>Rise time<br>Turn-off delay time<br>Fall time<br>$V_{DD} = 75\text{ V}$<br>$I_D = 2.5\text{ A}$<br>$R_i = 50\ \Omega$<br>(see test circuit) |      |      | 40<br>60<br>100<br>60 | ns<br>ns<br>ns<br>ns |
| $Q_g$                                         | Total Gate Charge<br>$V_{GS} = 10\text{ V}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit)                                                |      |      | 15                    | nC                   |

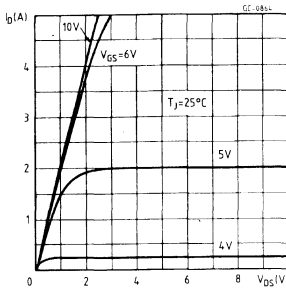
SOURCE DRAIN DIODE

|                           |                                                                                                                                                                  |  |            |            |                     |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------|------------|---------------------|
| $I_{SD}$<br>$I_{SDM} (*)$ | Source-drain current<br>Source-drain current (pulsed)                                                                                                            |  |            | 5<br>20    | A<br>A              |
| $V_{SD}^{**}$             | Forward on voltage<br>for IRF620/621/620FI/621FI<br>$I_{SD} = 5\text{ A}$<br>for IRF622/623/622FI/623FI<br>$I_{SD} = 4\text{ A}$<br>$V_{GS} = 0$<br>$V_{GS} = 0$ |  |            | 1.8<br>1.4 | V<br>V              |
| $t_{rr}$<br>$Q_{rr}$      | Reverse recovery time<br>Reverse recovered charge<br>$I_{SD} = 5\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$                                                 |  | 350<br>2.3 |            | ns<br>$\mu\text{C}$ |

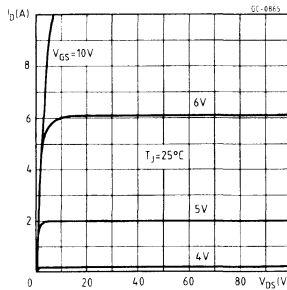
\*\* Pulsed: Pulse duration  $\leq 300\ \mu\text{s}$ , duty cycle  $\leq 1.5\%$   
(\*) Repetitive Rating: Pulse width limited by max junction temperature  
■ See note on ISOWAT F220 In this datasheet



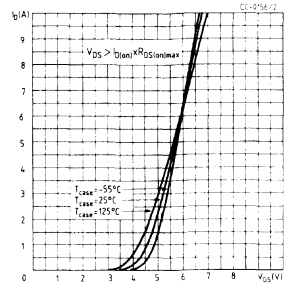
Output characteristics



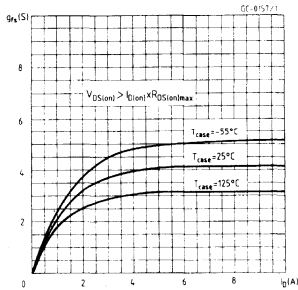
Output characteristics



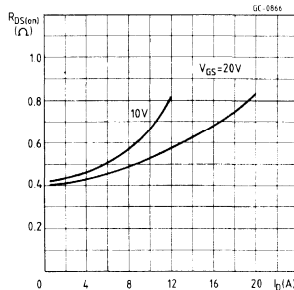
Transfer characteristics



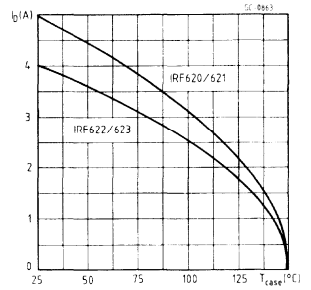
Transconductance



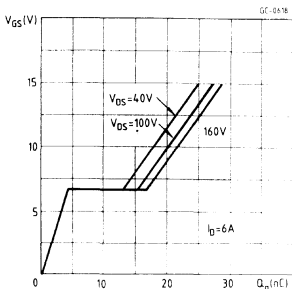
Static drain-source on resistance



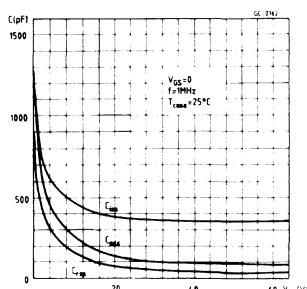
Maximum drain current vs temperature



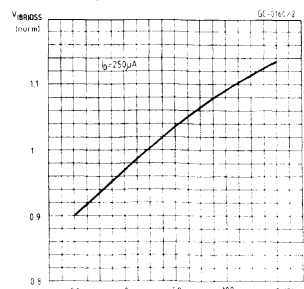
Gate charge vs gate-source voltage



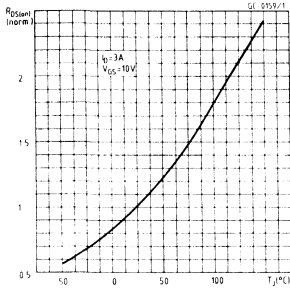
Capacitance variation



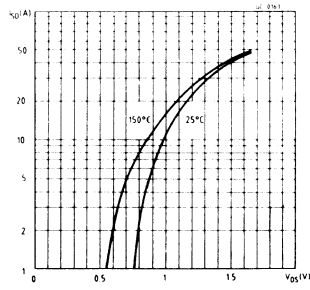
Normalized breakdown voltage vs temperature



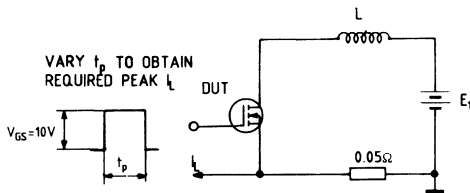
Normalized on resistance vs temperature



Source-drain diode forward characteristics

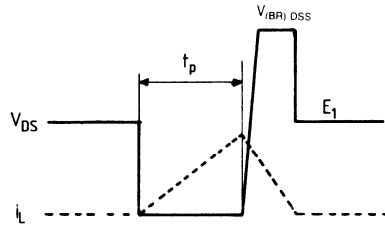


Unclamped inductive test circuit



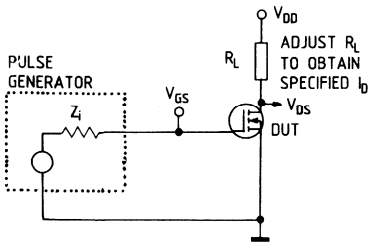
SC-0339

Unclamped inductive waveforms



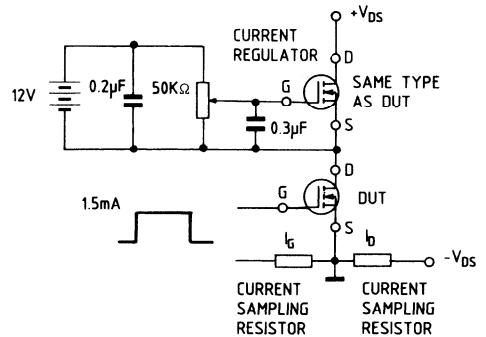
SC-0338

Switching times test circuit



SC-0246

Gate charge test circuit



SC-0244

**ISOWATT220 PACKAGE CHARACTERISTICS AND APPLICATION.**

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation. The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance. ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

**THERMAL IMPEDANCE OF ISOWATT220 PACKAGE**

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package. The total thermal resistance  $R_{th \text{ (tot)}}$  is the sum of each of these elements. The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

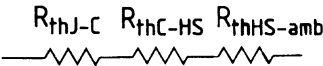
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

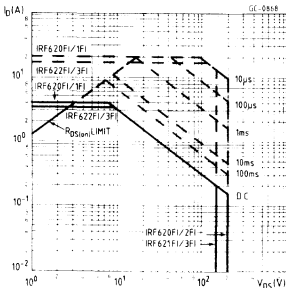
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

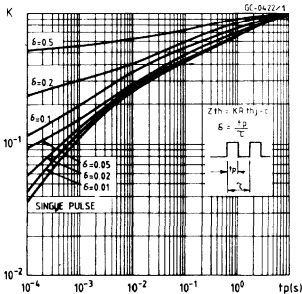


**ISOWATT DATA**

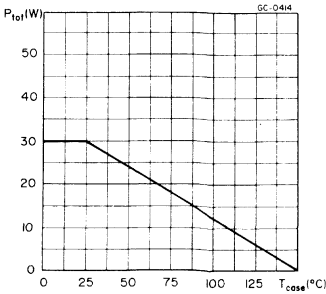
Safe operating areas



Thermal impedance



Derating curve







## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

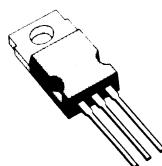
| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> * |
|----------|------------------|---------------------|------------------|
| IRF720   | 400 V            | 1.8 Ω               | 3.3 A            |
| IRF720FI | 400 V            | 1.8 Ω               | 2.5 A            |
| IRF721   | 350 V            | 1.8 Ω               | 3.3 A            |
| IRF721FI | 350 V            | 1.8 Ω               | 2.5 A            |
| IRF722   | 400 V            | 2.5 Ω               | 2.8 A            |
| IRF722FI | 400 V            | 2.5 Ω               | 2.0 A            |
| IRF723   | 350 V            | 2.5 Ω               | 2.8 A            |
| IRF723FI | 350 V            | 2.5 Ω               | 2.0 A            |

- HIGH VOLTAGE - FOR OFF LINE APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

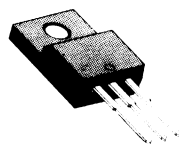
### INDUSTRIAL APPLICATIONS:

- ELECTRONIC LAMP BALLAST
- DC SWITCH

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Applications include off-line use, constant current source, ultrasonic equipment and switching powers supplies start-up circuits.

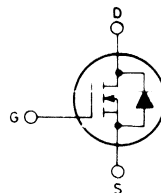


TO-220



ISOWATT220

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

| ABSOLUTE MAXIMUM RATINGS |                                                 | IRF         |       |            |       |
|--------------------------|-------------------------------------------------|-------------|-------|------------|-------|
|                          |                                                 | 720         | 721   | 722        | 723   |
|                          |                                                 | 720FI       | 721FI | 722FI      | 723FI |
| V <sub>DS</sub> *        | Drain-source voltage (V <sub>GS</sub> = 0)      | 400         | 350   | 400        | 350   |
| V <sub>DGR</sub> *       | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 400         | 350   | 400        | 350   |
| V <sub>GS</sub>          | Gate-source voltage                             | ±20         |       |            |       |
| I <sub>DM</sub> (•)      | Drain current (pulsed)                          | 13          | 13    | 11         | 11    |
| I <sub>DLM</sub>         | Drain inductive current, clamped (L = 100 μH)   | 13          | 13    | 11         | 11    |
|                          |                                                 | 720         | 721   | 722        | 723   |
| I <sub>D</sub>           | Drain current (cont.) at T <sub>c</sub> = 25°C  | 3.3         | 3.3   | 2.8        | 2.8   |
| I <sub>D</sub>           | Drain current (cont.) at T <sub>c</sub> = 100°C | 2.1         | 2.1   | 1.8        | 1.8   |
|                          |                                                 | 720FI       | 721FI | 722FI      | 723FI |
| I <sub>D</sub> ■         | Drain current (cont.) at T <sub>c</sub> = 25°C  | 2.5         | 2.5   | 2          | 2     |
| I <sub>D</sub> ■         | Drain current (cont.) at T <sub>c</sub> = 100°C | 1.5         | 1.5   | 1.2        | 1.2   |
|                          |                                                 | TO-220      |       | ISOWATT220 |       |
| P <sub>tot</sub> ■       | Total dissipation at T <sub>c</sub> < 25°C      | 50          |       | 30         |       |
| ■                        | Derating factor                                 | 0.40        |       | 0.24       |       |
| T <sub>stg</sub>         | Storage temperature                             | - 55 to 150 |       |            |       |
| T <sub>i</sub>           | Max. operating junction temperature             | 150         |       |            |       |

\* T<sub>j</sub> = 25°C to 125°C

(•) Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT220 on this datasheet.

THERMAL DATA \*

TO-220 | ISOWATT220

|                  |                                                |     |      |      |      |
|------------------|------------------------------------------------|-----|------|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 2.50 | 4.16 | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.5  |      | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 80   |      | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300  |      | °C   |

ELECTRICAL CHARACTERISTICS (T<sub>case</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                             |                     |             |                    |
|----------------|--------------------------------------------------|---------------------------------------------------------------------------------------------|---------------------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>IRF720/722/720FI/722FI</b><br>for <b>IRF721/723/721FI/723FI</b> | $V_{GS} = 0$        | 400<br>350  | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$                     | $T_c = 125^\circ C$ | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                         |                     | $\pm 500$   | nA                 |

ON \*\*

|               |                                   |                                                                                                                       |                   |            |            |                      |
|---------------|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------|-------------------|------------|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                                     | $I_D = 250 \mu A$ | 2          | 4          | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D (on)} \times R_{DS(on) max}$<br>for <b>IRF720/721/720FI/721FI</b><br>for <b>IRF722/723/722FI/723FI</b> | $V_{GS} = 10 V$   | 3.3<br>2.8 |            | A<br>A               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>for <b>IRF720/721/720FI/721FI</b><br>for <b>IRF722/723/722FI/723FI</b>                             | $I_D = 1.8 A$     |            | 1.8<br>2.5 | $\Omega$<br>$\Omega$ |

DYNAMIC

|             |                              |                                                               |             |  |     |     |
|-------------|------------------------------|---------------------------------------------------------------|-------------|--|-----|-----|
| $g_{fs} **$ | Forward transconductance     | $V_{DS} > I_{D (on)} \times R_{DS (on) max}$<br>$I_D = 1.8 A$ | 1.0         |  |     | mho |
| $C_{iss}$   | Input capacitance            | $V_{DS} = 25 V$                                               | $f = 1 MHz$ |  | 600 | pF  |
| $C_{oss}$   | Output capacitance           | $V_{GS} = 0$                                                  |             |  | 200 | pF  |
| $C_{rss}$   | Reverse transfer capacitance |                                                               |             |  | 40  | pF  |

SWITCHING

|               |                     |                                                                                  |               |  |     |    |
|---------------|---------------------|----------------------------------------------------------------------------------|---------------|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 175 V$                                                                 | $I_D = 1.5 A$ |  | 40  | ns |
| $t_r$         | Rise time           | $R_l = 50 \Omega$                                                                |               |  | 50  | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit)                                                               |               |  | 100 | ns |
| $t_f$         | Fall time           |                                                                                  |               |  | 50  | ns |
| $Q_g$         | Total Gate Charge   | $V_{GS} = 10 V$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) | $I_D = 3.3 A$ |  | 15  | nC |

### ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

## SOURCE DRAIN DIODE

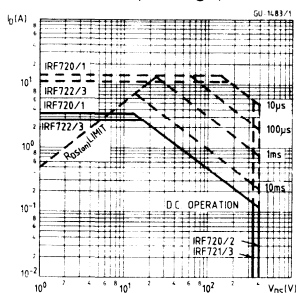
|               |                               |                  |                          |  |     |         |
|---------------|-------------------------------|------------------|--------------------------|--|-----|---------|
| $I_{SD}$      | Source-drain current          |                  |                          |  | 3.3 | A       |
| $I_{SDM}$ (*) | Source-drain current (pulsed) |                  |                          |  | 13  | A       |
| $V_{SD}$      | Forward on voltage            | $I_{SD} = 3.3$ A | $V_{GS} = 0$             |  | 1.6 | V       |
| $t_{rr}$      | Reverse recovery time         |                  |                          |  | 450 | ns      |
| $Q_{rr}$      | Reverse recovered charge      | $I_{SD} = 3.3$ A | $di/dt = 100$ A/ $\mu$ s |  | 3.1 | $\mu$ C |

\*\* Pulsed: Pulse duration  $\leq 300 \mu\text{s}$ , duty cycle  $\leq 1.5\%$

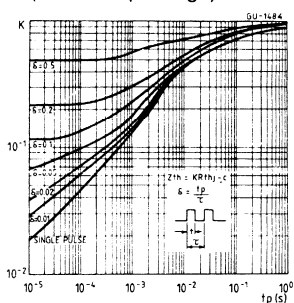
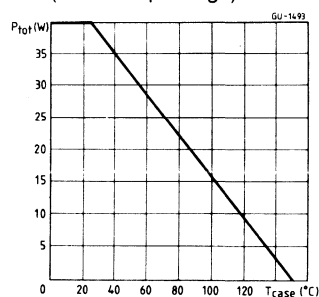
(\*) Repetitive Rating: Pulse width limited by max junction temperature

- See note on ISOWATT220 in this datasheet

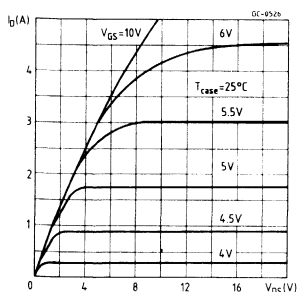
### Safe operating areas (standard package)



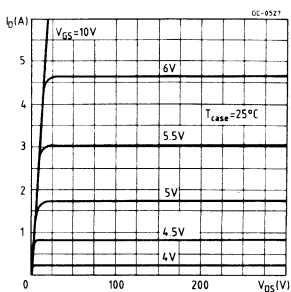
Thermal impedance  
(standard package)

Derating curve  
(standard package)

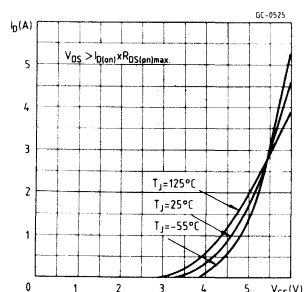
### Output characteristics



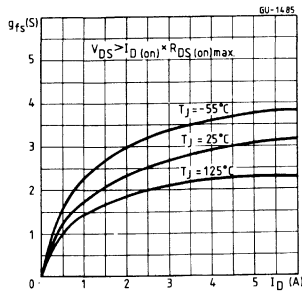
### Output characteristics



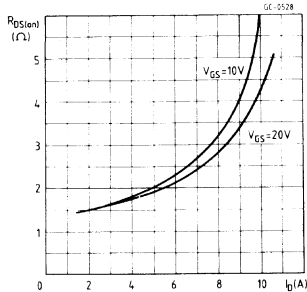
### Transfer characteristics



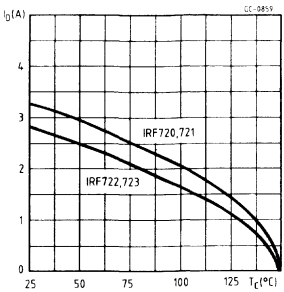
Transconductance



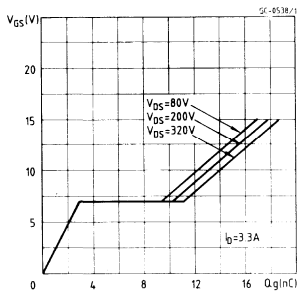
Static drain-source on resistance



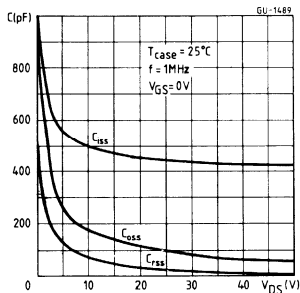
Maximum drain current vs temperature



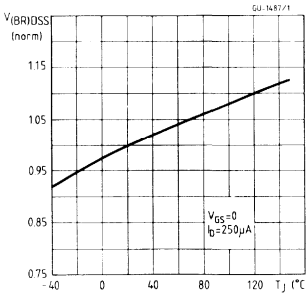
Gate charge vs gate-source voltage



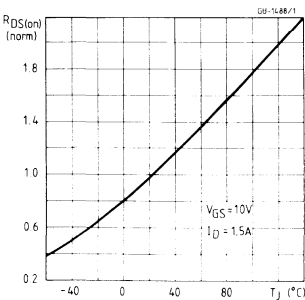
Capacitance variation



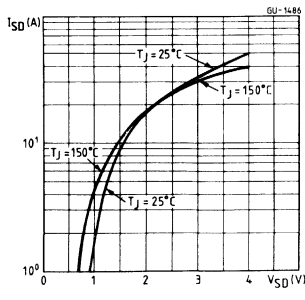
Normalized breakdown voltage vs temperature



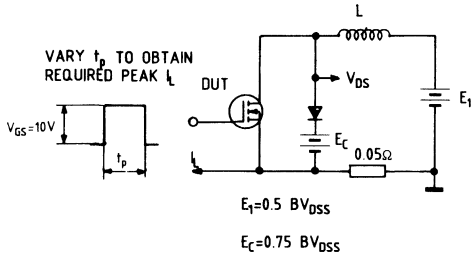
Normalized on resistance vs temperature



Source-drain diode forward characteristics

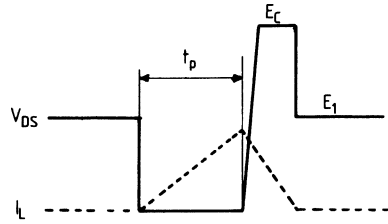


### Clamped inductive test circuit



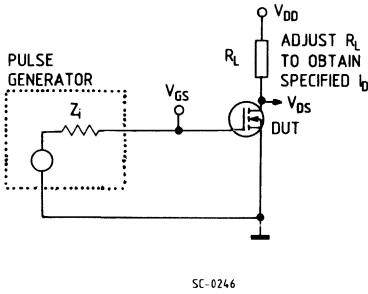
SC-0242

### Clamped inductive waveforms



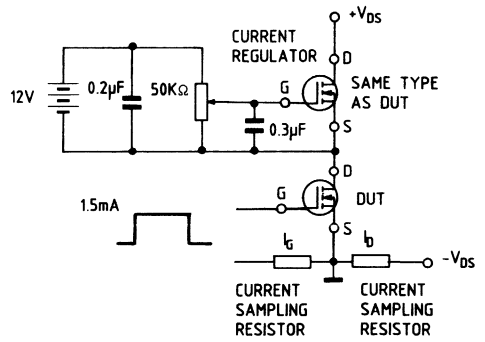
SC-0243

### Switching times test circuit



SC-0246

### Gate charge test circuit



SC-0244

## ISOWATT220 PACKAGE CHARACTERISTICS AND APPLICATION.

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The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

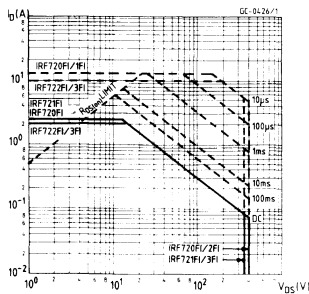
$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

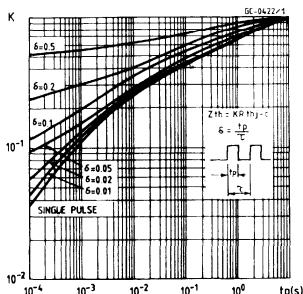
$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

## ISOWATT DATA

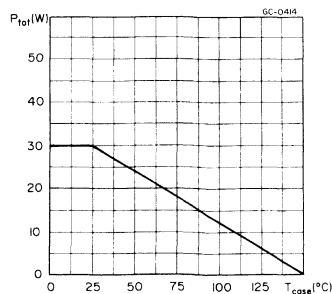
### Safe operating areas



### Thermal impedance



## Derating curve



### THERMAL IMPEDANCE OF ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th(tot)}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1 ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

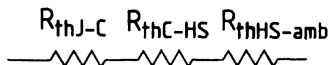
$$Z_{th} = R_{th,J-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> <sup>■</sup> |
|----------|------------------|---------------------|-----------------------------|
| IRF730   | 400 V            | 1.0 Ω               | 5.5 A                       |
| IRF730FI | 400 V            | 1.0 Ω               | 3.5 A                       |
| IRF731   | 350 V            | 1.0 Ω               | 5.5 A                       |
| IRF731FI | 350 V            | 1.0 Ω               | 3.5 A                       |
| IRF732   | 400 V            | 1.5 Ω               | 4.5 A                       |
| IRF732FI | 400 V            | 1.5 Ω               | 3.0 A                       |
| IRF733   | 350 V            | 1.5 Ω               | 4.5 A                       |
| IRF733FI | 350 V            | 1.5 Ω               | 3.0 A                       |

- HIGH VOLTAGE - FOR ELECTRONIC LAMP BALLAST
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- ELECTRONIC LAMP BALLAST
- DC SWITCH

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Applications include DC switch, constant current source, ultrasonic equipment and electronic ballast for fluorescent lamps.

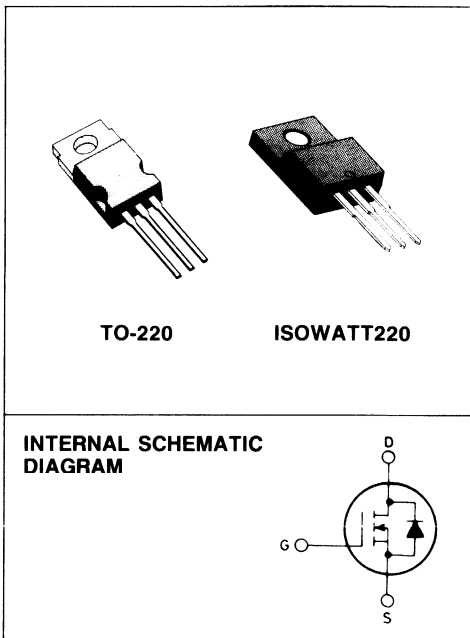
### ABSOLUTE MAXIMUM RATINGS

| ABSOLUTE MAXIMUM RATINGS |                                                 | TO-220<br>ISOWATT220 |              | IRF               |              |      |  |
|--------------------------|-------------------------------------------------|----------------------|--------------|-------------------|--------------|------|--|
|                          |                                                 | 730<br>730FI         | 731<br>731FI | 732<br>732FI      | 733<br>733FI |      |  |
| V <sub>DS</sub> *        | Drain-source voltage (V <sub>GS</sub> = 0)      | 400                  | 350          | 400               | 350          | V    |  |
| V <sub>DGR</sub> *       | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 400                  | 350          | 400               | 350          | V    |  |
| V <sub>GS</sub>          | Gate-source voltage                             |                      |              | ±20               |              | V    |  |
| I <sub>DM</sub> (•)      | Drain current (pulsed)                          | 20                   | 20           | 16                | 16           | A    |  |
| I <sub>DLM</sub>         | Drain inductive current, clamped (L = 100 μH)   | 20                   | 20           | 16                | 16           | A    |  |
|                          |                                                 | <b>730</b>           | <b>731</b>   | <b>732</b>        | <b>733</b>   |      |  |
| I <sub>D</sub>           | Drain current (cont.) at T <sub>c</sub> = 25°C  | 5.5                  | 5.5          | 4.5               | 4.5          | A    |  |
| I <sub>D</sub>           | Drain current (cont.) at T <sub>c</sub> = 100°C | 3.5                  | 3.5          | 3                 | 3            | A    |  |
|                          |                                                 | <b>730FI</b>         | <b>731FI</b> | <b>732FI</b>      | <b>733FI</b> |      |  |
| I <sub>D</sub> ■         | Drain current (cont.) at T <sub>c</sub> = 25°C  | 3.5                  | 3.5          | 3                 | 3            | A    |  |
| I <sub>D</sub> ■         | Drain current (cont.) at T <sub>c</sub> = 100°C | 2                    | 2            | 1.8               | 1.8          | A    |  |
|                          |                                                 | <b>TO-220</b>        |              | <b>ISOWATT220</b> |              |      |  |
| P <sub>tot</sub> ■       | Total dissipation at T <sub>c</sub> < 25°C      | 74                   |              | 35                |              | W    |  |
| ■                        | Derating factor                                 | 0.59                 |              | 0.28              |              | W/°C |  |
| T <sub>stg</sub>         | Storage temperature                             | - 55 to 150          |              |                   |              | °C   |  |
| T <sub>j</sub>           | Max. operating junction temperature             | 150                  |              |                   |              | °C   |  |

\* T<sub>j</sub> = 25°C to 125°C

(•) Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT220 on this datasheet.



THERMAL DATA \*

|                  |                                                |     | TO-220 | ISOWATT220 |      |
|------------------|------------------------------------------------|-----|--------|------------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.69   | 3.57       | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.5    |            | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 80     |            | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300    |            | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                             |                      |             |                    |
|----------------|--------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>IRF730/732/730FI/732FI</b><br>for <b>IRF731/733/731FI/733FI</b> | $V_{GS} = 0$         | 400<br>350  | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$                     | $T_c = 125^{\circ}C$ | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                         |                      | $\pm 500$   | nA                 |

ON \*\*

|               |                                   |                                                                                                                      |                   |            |            |                      |
|---------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------|-------------------|------------|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                                    | $I_D = 250 \mu A$ | 2          | 4          | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$<br>for <b>IRF730/731/730FI/731FI</b><br>for <b>IRF732/733/732FI/733FI</b> | $V_{GS} = 10 V$   | 5.5<br>4.5 |            | A<br>A               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>for <b>IRF730/731/730FI/731FI</b><br>for <b>IRF732/733/732FI/733FI</b>                            | $I_D = 3.0 A$     |            | 1.0<br>1.5 | $\Omega$<br>$\Omega$ |

DYNAMIC

|               |                              |                                                             |             |  |     |     |
|---------------|------------------------------|-------------------------------------------------------------|-------------|--|-----|-----|
| $g_{fs}^{**}$ | Forward transconductance     | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$<br>$I_D = 3.0 A$ | 2.9         |  |     | mho |
| $C_{iss}$     | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$                             | $f = 1 MHz$ |  | 800 | pF  |
| $C_{oss}$     | Output capacitance           |                                                             |             |  | 300 | pF  |
| $C_{rss}$     | Reverse transfer capacitance |                                                             |             |  | 80  | pF  |

SWITCHING

|               |                     |                                                            |               |  |    |    |
|---------------|---------------------|------------------------------------------------------------|---------------|--|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 175 V$                                           | $I_D = 3.0 A$ |  | 30 | ns |
| $t_r$         | Rise time           | $R_i = 15 \Omega$                                          |               |  | 35 | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit)                                         |               |  | 55 | ns |
| $t_f$         | Fall time           |                                                            |               |  | 35 | ns |
| $Q_g$         | Total Gate Charge   | $V_{GS} = 10 V$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $I_D = 5.5 A$ |  | 35 | nC |
|               |                     | (see test circuit)                                         |               |  |    |    |

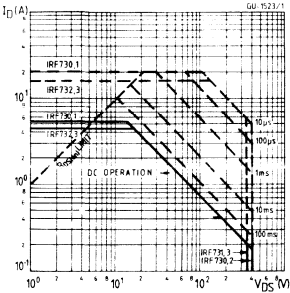


ELECTRICAL CHARACTERISTICS (Continued)

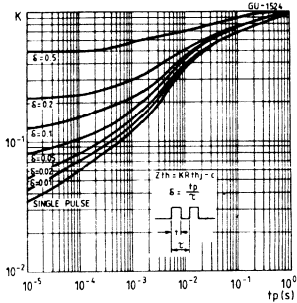
| Parameters                                                                            | Test Conditions                                                 | Min. | Typ. | Max.      | Unit          |
|---------------------------------------------------------------------------------------|-----------------------------------------------------------------|------|------|-----------|---------------|
| $I_{SD}$<br>$I_{SDM}$ (*)<br>Source-drain current<br>Source-drain current<br>(pulsed) |                                                                 |      |      | 5.5<br>20 | A<br>A        |
| $V_{SD}$<br>Forward on voltage                                                        | $I_{SD} = 5.5 \text{ A}$<br>$V_{GS} = 0$                        |      |      | 1.6       | V             |
| $t_{rr}$<br>Reverse recovery<br>time                                                  | $T_J = 150^\circ\text{C}$                                       |      | 600  |           | ns            |
| $Q_{rr}$<br>Reverse recovered<br>charge                                               | $I_{SD} = 5.5 \text{ A}$<br>$di/dt = 100 \text{ A}/\mu\text{s}$ |      | 4    |           | $\mu\text{C}$ |

\*\* Pulsed: Pulse duration  $\leq 300 \mu\text{s}$ , duty cycle  $\leq 1.5\%$   
(\*) Repetitive Rating: Pulse width limited by max junction temperature  
■ See note on ISOWATT220 in this datasheet

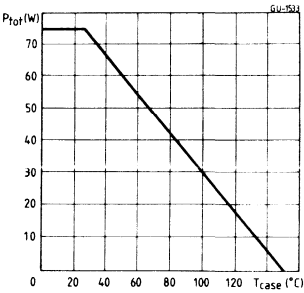
Safe operating areas  
(standard package)



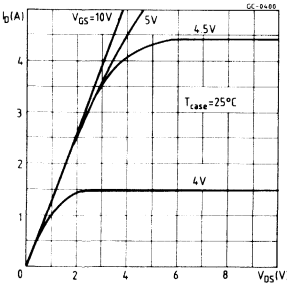
Thermal impedance  
(standard package)



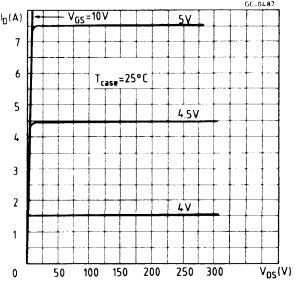
Derating curve  
(standard package)



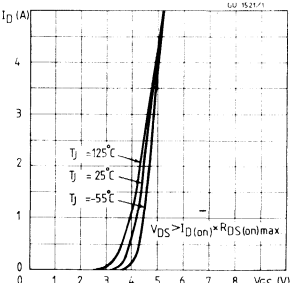
Output characteristics



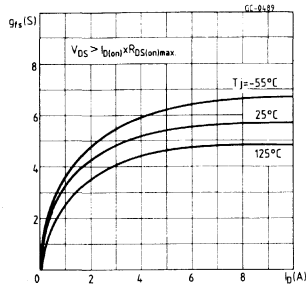
Output characteristics



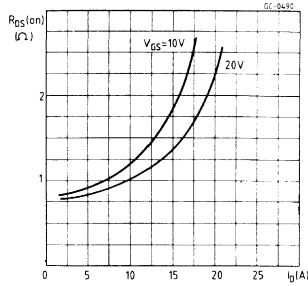
Transfer characteristics



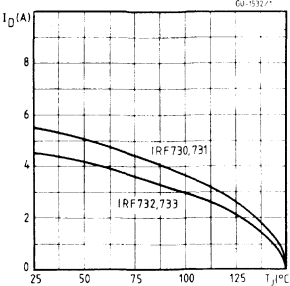
Transconductance



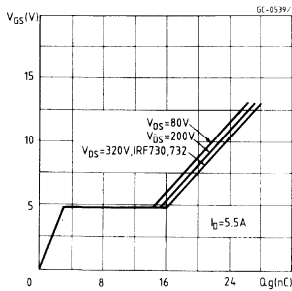
Static drain-source on resistance



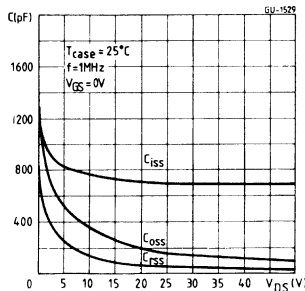
Maximum drain current vs temperature



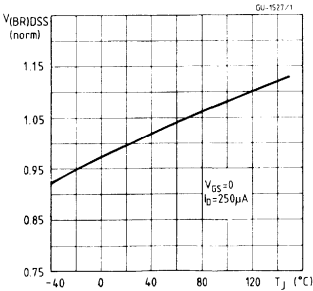
Gate charge vs gate-source voltage



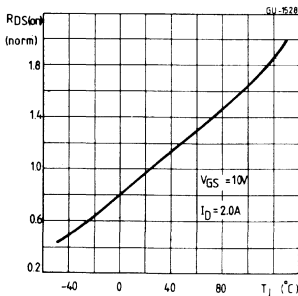
Capacitance variation



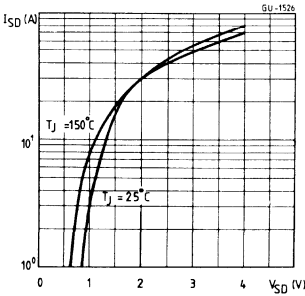
Normalized breakdown voltage vs temperature



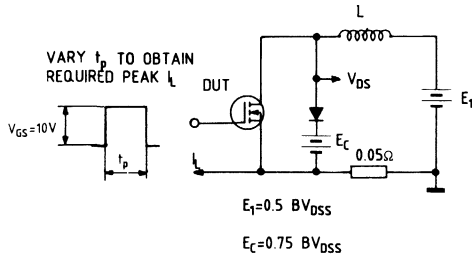
Normalized on resistance vs temperature



Source-drain diode forward characteristics

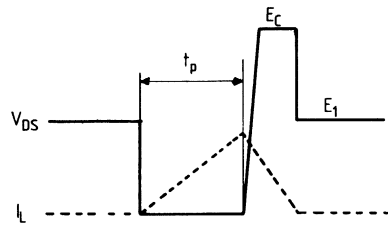


Clamped inductive test circuit



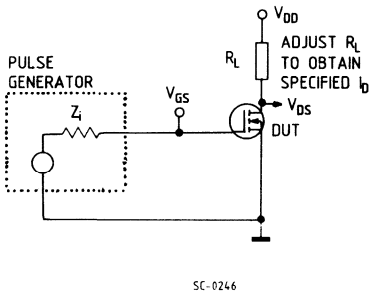
SC-0242

Clamped inductive waveforms



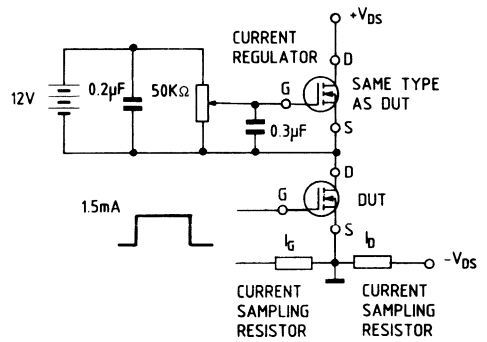
SC-0243

Switching times test circuit



SC-0246

Gate charge test circuit



SC-0244

ISOWATT220 PACKAGE  
CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation. The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance. ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_J - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

THERMAL IMPEDANCE OF  
ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package. The total thermal resistance  $R_{th(tot)}$  is the sum of each of these elements. The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

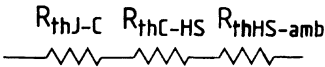
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

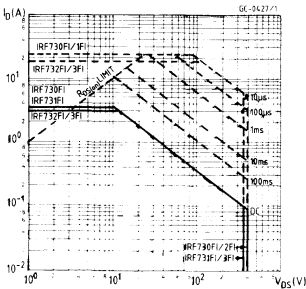
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

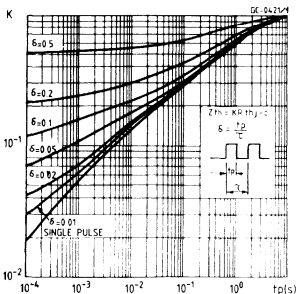


ISOWATT DATA

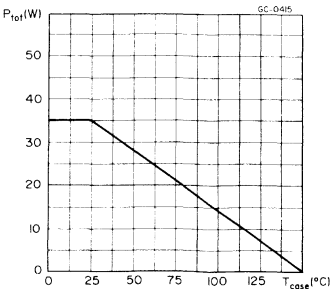
Safe operating areas



Thermal impedance



Derating curve



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> * |
|----------|------------------|---------------------|------------------|
| IRF740   | 400 V            | 0.55 Ω              | 10 A             |
| IRF740FI | 400 V            | 0.55 Ω              | 5.5 A            |
| IRF741   | 350 V            | 0.55 Ω              | 10 A             |
| IRF741FI | 350 V            | 0.55 Ω              | 5.5 A            |
| IRF742   | 400 V            | 0.8 Ω               | 8.3 A            |
| IRF742FI | 400 V            | 0.8 Ω               | 4.5 A            |
| IRF743   | 350 V            | 0.8 Ω               | 8.3 A            |
| IRF743FI | 350 V            | 0.8 Ω               | 4.5 A            |

- HIGH VOLTAGE - FOR SWITCHING POWER SUPPLIES
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCHING POWER SUPPLIES
- DC SWITCH

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Applications include DC switch, switching power supplies, ultrasonic equipment and electronic ballast for fluorescent lamps.

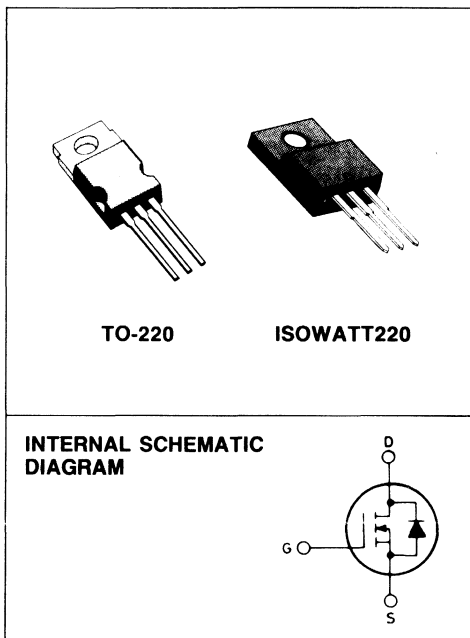
### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | TO-220<br>ISOWATT220 |  | IRF          |              |              |              |      |
|---------------------|-------------------------------------------------|----------------------|--|--------------|--------------|--------------|--------------|------|
|                     |                                                 |                      |  | 740<br>740FI | 741<br>741FI | 742<br>742FI | 743<br>743FI |      |
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      |                      |  | 400          | 350          | 400          | 350          | V    |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    |                      |  | 400          | 350          | 400          | 350          | V    |
| V <sub>GS</sub>     | Gate-source voltage                             |                      |  | ±20          |              |              |              | V    |
| I <sub>DM</sub> (•) | Drain current (pulsed)                          |                      |  | 40           | 40           | 33           | 33           | A    |
| I <sub>DLM</sub>    | Drain inductive current, clamped (L = 100 μH)   |                      |  | 40           | 40           | 33           | 33           | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | 740          | 741          | 742          | 743          |      |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 10           | 10           | 8.3          | 8.3          | A    |
|                     |                                                 |                      |  | 6.3          | 6.3          | 5.2          | 5.2          | A    |
| I <sub>D</sub> ■    | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | 740FI        | 741FI        | 742FI        | 743FI        |      |
| I <sub>D</sub> ■    | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 5.5          | 5.5          | 4.5          | 4.5          | A    |
|                     |                                                 |                      |  | 3            | 3            | 2.5          | 2.5          | A    |
| P <sub>tot</sub> ■  | Total dissipation at T <sub>c</sub> < 25°C      |                      |  | TO-220       |              | ISOWATT220   |              |      |
| ■                   | Derating factor                                 |                      |  | 125          |              | 40           |              | W    |
| T <sub>stg</sub>    | Storage temperature                             |                      |  | 1            |              | 0.32         |              | W/°C |
| T <sub>j</sub>      | Max. operating junction temperature             |                      |  | -55 to 150   |              | 150          |              | °C   |

\* T<sub>j</sub> = 25°C to 125°C

• Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT220 on this datasheet.



**THERMAL DATA \***

TO-220 | ISOWATT220

|                  |                                                |     |     |      |      |
|------------------|------------------------------------------------|-----|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1   | 3.12 | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.5 |      | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 80  |      | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300 |      | °C   |

**ELECTRICAL CHARACTERISTICS** ( $T_{case} = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                                                                                |  |             |                                |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$ $V_{GS} = 0$<br>for <b>IRF740/742/740FI/742FI</b><br>for <b>IRF741/743/741FI/743FI</b> |  | 400<br>350  | V<br>V                         |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}\text{C}$            |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                                                                    |  | $\pm 500$   | nA                             |

**ON \*\***

|               |                                   |                                                                                                                                              |  |           |             |                      |
|---------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|--|-----------|-------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 250 \mu\text{A}$                                                                                                    |  | 2         | 4           | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$ $V_{GS} = 10 \text{ V}$<br>for <b>IRF740/741/740FI/741FI</b><br>for <b>IRF742/743/742FI/743FI</b> |  | 10<br>8.3 |             | A<br>A               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ $I_D = 5.2 \text{ A}$<br>for <b>IRF740/741/740FI/741FI</b><br>for <b>IRF742/743/742FI/743FI</b>                      |  |           | 0.55<br>0.8 | $\Omega$<br>$\Omega$ |

**DYNAMIC**

|             |                              |                                                                     |  |     |      |     |
|-------------|------------------------------|---------------------------------------------------------------------|--|-----|------|-----|
| $g_{fs} **$ | Forward transconductance     | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$<br>$I_D = 5.2 \text{ A}$ |  | 4.0 |      | mho |
| $C_{iss}$   | Input capacitance            | $V_{DS} = 25 \text{ V}$ $f = 1 \text{ MHz}$<br>$V_{GS} = 0$         |  |     | 1600 | pF  |
| $C_{oss}$   | Output capacitance           |                                                                     |  |     | 450  | pF  |
| $C_{rss}$   | Reverse transfer capacitance |                                                                     |  |     | 150  | pF  |

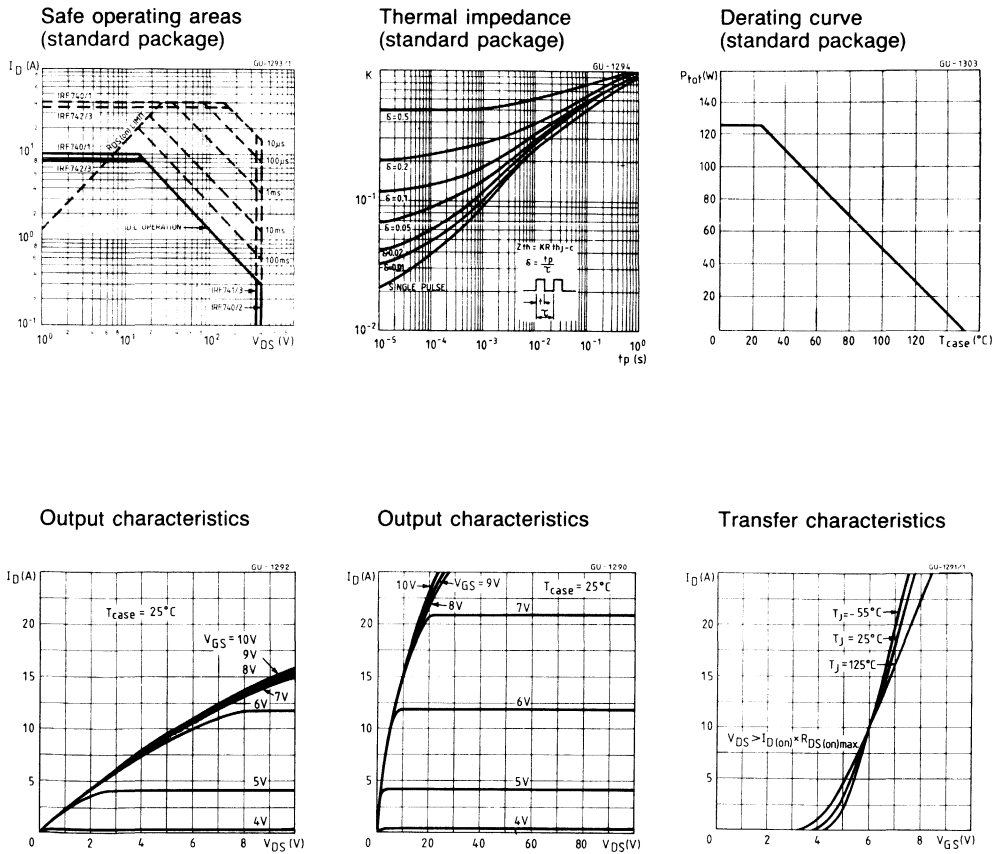
**SWITCHING**

|               |                     |                                                                                                               |  |  |    |    |
|---------------|---------------------|---------------------------------------------------------------------------------------------------------------|--|--|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 175 \text{ V}$ $I_D = 5.0 \text{ A}$                                                                |  |  | 35 | ns |
| $t_r$         | Rise time           | $R_i = 4.7 \Omega$                                                                                            |  |  | 15 | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit)                                                                                            |  |  | 90 | ns |
| $t_f$         | Fall time           |                                                                                                               |  |  | 35 | ns |
| $Q_g$         | Total Gate Charge   | $V_{GS} = 10 \text{ V}$ $I_D = 10 \text{ A}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) |  |  | 63 | nC |

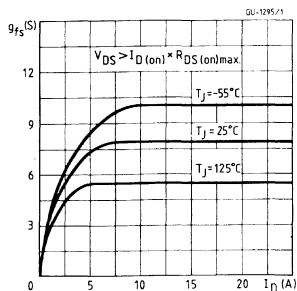
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                                                   | Test Conditions                                           | Min. | Typ. | Max.     | Unit          |
|------------------------------------------------------------------------------|-----------------------------------------------------------|------|------|----------|---------------|
| $I_{SD}$ Source-drain current<br>$I_{SDM}$ (*) Source-drain current (pulsed) |                                                           |      |      | 10<br>40 | A<br>A        |
| $V_{SD}$ Forward on voltage                                                  | $I_{SD} = 10\text{ A}$ $V_{GS} = 0$                       |      |      | 2.0      | V             |
| $t_{rr}$ Reverse recovery time                                               | $T_J = 150^\circ\text{C}$                                 |      | 800  |          | ns            |
| $Q_{rr}$ Reverse recovered charge                                            | $I_{SD} = 10\text{ A}$ $di/dt = 100\text{ A}/\mu\text{s}$ |      | 5.7  |          | $\mu\text{C}$ |

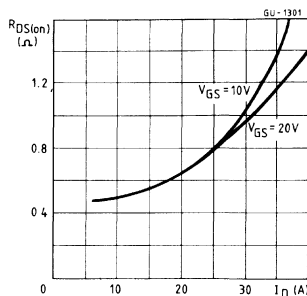
\*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 1.5\%$   
(\*) Repetitive Rating: Pulse width limited by max junction temperature  
■ See note on ISOWATT220 in this datasheet



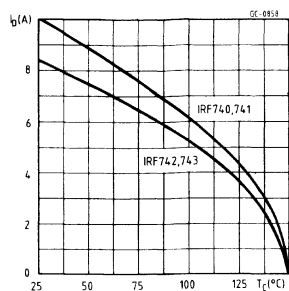
Transconductance



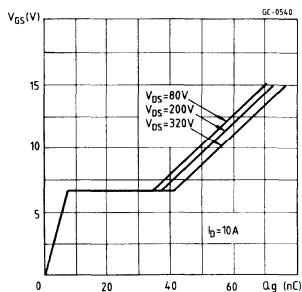
Static drain-source on resistance



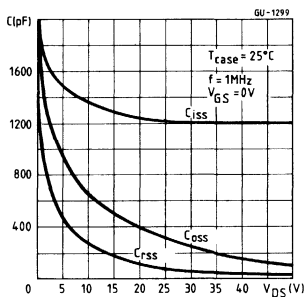
Maximum drain current vs temperature



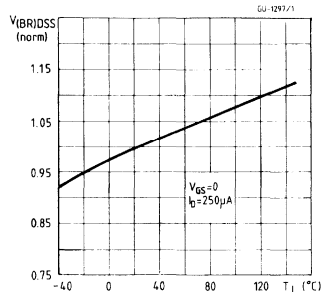
Gate charge vs gate-source voltage



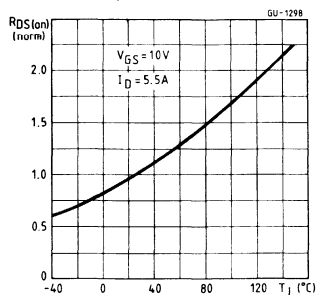
Capacitance variation



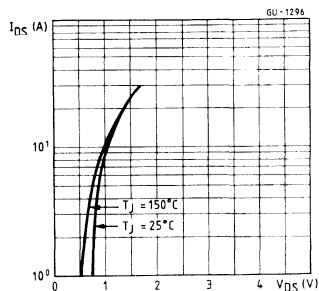
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature

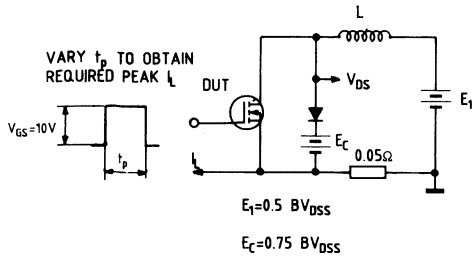


Source-drain diode forward characteristics



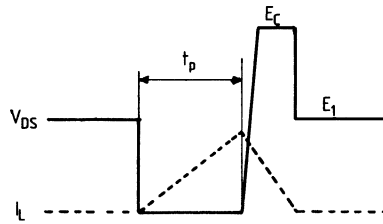


### Clamped inductive test circuit



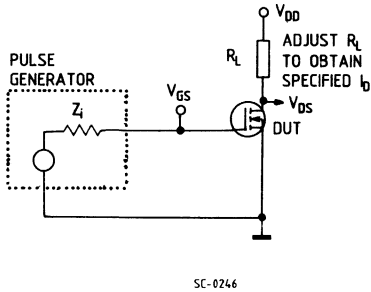
SC-0242

### Clamped inductive waveforms



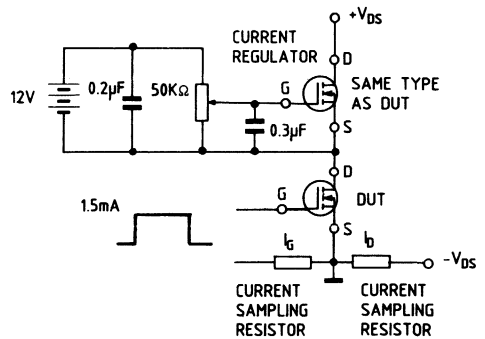
SC-0243

### Switching times test circuit



SC-0246

### Gate charge test circuit



SC-0244

# ISOWATT220 PACKAGE CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

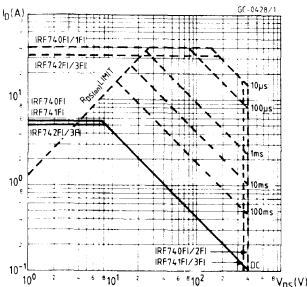
$$P_D = \frac{T_J - T_C}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

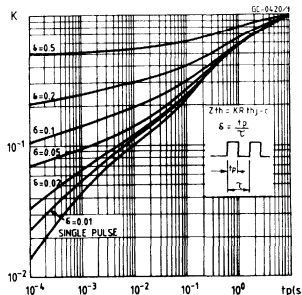
$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

## ISOWATT DATA

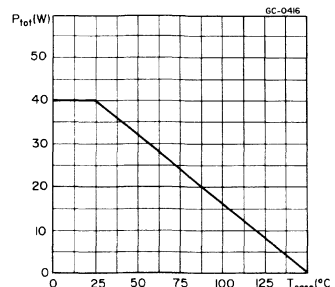
### Safe operating areas



### Thermal impedance



### Derating curve



## THERMAL IMPEDANCE OF ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th (tot)}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

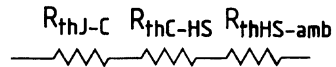
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

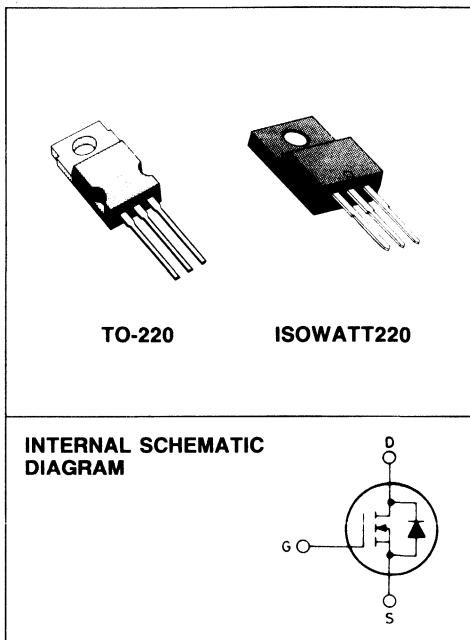
| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> * |
|----------|------------------|---------------------|------------------|
| IRF820   | 500 V            | 3.0 Ω               | 2.5 A            |
| IRF820FI | 500 V            | 3.0 Ω               | 2.0 A            |
| IRF821   | 450 V            | 3.0 Ω               | 2.5 A            |
| IRF821FI | 450 V            | 3.0 Ω               | 2.0 A            |
| IRF822   | 500 V            | 4.0 Ω               | 2.2 A            |
| IRF822FI | 500 V            | 4.0 Ω               | 1.5 A            |
| IRF823   | 450 V            | 4.0 Ω               | 2.2 A            |
| IRF823FI | 450 V            | 4.0 Ω               | 1.5 A            |

- HIGH VOLTAGE - 450 V FOR OFF LINE SMP
- ULTRA FAST SWITCHING - FOR OPERATION AT > KHz
- EASY DRIVE- FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Typical applications include switching power supplies, uninterruptible power supplies and motor speed control.



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | TO-220<br>ISOWATT220 |  | IRF          |              |              |              |      |
|---------------------|-------------------------------------------------|----------------------|--|--------------|--------------|--------------|--------------|------|
|                     |                                                 |                      |  | 820<br>820FI | 821<br>821FI | 822<br>822FI | 823<br>823FI |      |
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      |                      |  | 500          | 450          | 500          | 450          | V    |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    |                      |  | 500          | 450          | 500          | 450          | V    |
| V <sub>GS</sub>     | Gate-source voltage                             |                      |  | ± 20         |              |              |              | V    |
| I <sub>DM</sub> (•) | Drain current (pulsed)                          |                      |  | 8            | 8            | 7            | 7            | A    |
| I <sub>DLM</sub>    | Drain inductive current, clamped (L = 100 μH)   |                      |  | 8            | 8            | 7            | 7            | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | 820          | 821          | 822          | 823          |      |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 2.5          | 2.5          | 2.2          | 2.2          | A    |
|                     |                                                 |                      |  | 1.6          | 1.6          | 1.4          | 1.4          | A    |
|                     |                                                 |                      |  | 820FI        | 821FI        | 822FI        | 823FI        |      |
|                     |                                                 |                      |  | 2            | 2            | 1.5          | 1.5          | A    |
|                     |                                                 |                      |  | 1.2          | 1.2          | 0.9          | 0.9          | A    |
|                     |                                                 |                      |  | TO-220       |              | ISOWATT220   |              |      |
| P <sub>tot</sub> ■  | Total dissipation at T <sub>c</sub> < 25°C      |                      |  | 50           |              | 30           |              | W    |
| ■                   | Derating factor                                 |                      |  | 0.40         |              | 0.24         |              | W/°C |
| T <sub>stg</sub>    | Storage temperature                             |                      |  | - 55 to 150  |              |              |              | °C   |
| T <sub>j</sub>      | Max. operating junction temperature             |                      |  | 150          |              |              |              | °C   |

\* T<sub>j</sub> = 25°C to 125°C

(•) Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT220 on this datasheet.

**THERMAL DATA \***

TO-220 | ISOWATT220

|                  |                                                |     |     |      |      |
|------------------|------------------------------------------------|-----|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 2.5 | 4.16 | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.5 |      | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 80  |      | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300 |      | °C   |

**ELECTRICAL CHARACTERISTICS** ( $T_{case} = 25^\circ\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                                                     |                           |            |             |                                |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------|------------|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$<br>for IRF820/822/820FI/822FI<br>for IRF821/823/821FI/823FI | $V_{GS} = 0$              | 500<br>450 |             | V<br>V                         |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$             | $T_c = 125^\circ\text{C}$ |            | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                                         |                           |            | $\pm 500$   | nA                             |

**ON \*\***

|               |                                   |                                                                                                                |                         |            |  |            |                      |
|---------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------|-------------------------|------------|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                              | $I_D = 250 \mu\text{A}$ | 2          |  | 4          | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$<br>for IRF820/821/820FI/821FI<br>for IRF822/823/821FI/823FI | $V_{GS} = 10 \text{ V}$ | 2.5<br>2.2 |  |            | A<br>A               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$<br>for IRF820/821/820FI/821FI<br>for IRF822/823/822FI/823FI                            | $I_D = 1.4 \text{ A}$   |            |  | 3.0<br>4.0 | $\Omega$<br>$\Omega$ |

**DYNAMIC**

|             |                              |                                                                             |                     |     |  |     |     |
|-------------|------------------------------|-----------------------------------------------------------------------------|---------------------|-----|--|-----|-----|
| $g_{fs} **$ | Forward transconductance     | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$<br>$I_D = 1.4 \text{ A}$ |                     | 1.0 |  |     | mho |
| $C_{iss}$   | Input capacitance            | $V_{DS} = 25 \text{ V}$                                                     | $f = 1 \text{ MHz}$ |     |  | 400 | pF  |
| $C_{oss}$   | Output capacitance           | $V_{GS} = 0$                                                                |                     |     |  | 150 | pF  |
| $C_{rss}$   | Reverse transfer capacitance |                                                                             |                     |     |  | 40  | pF  |

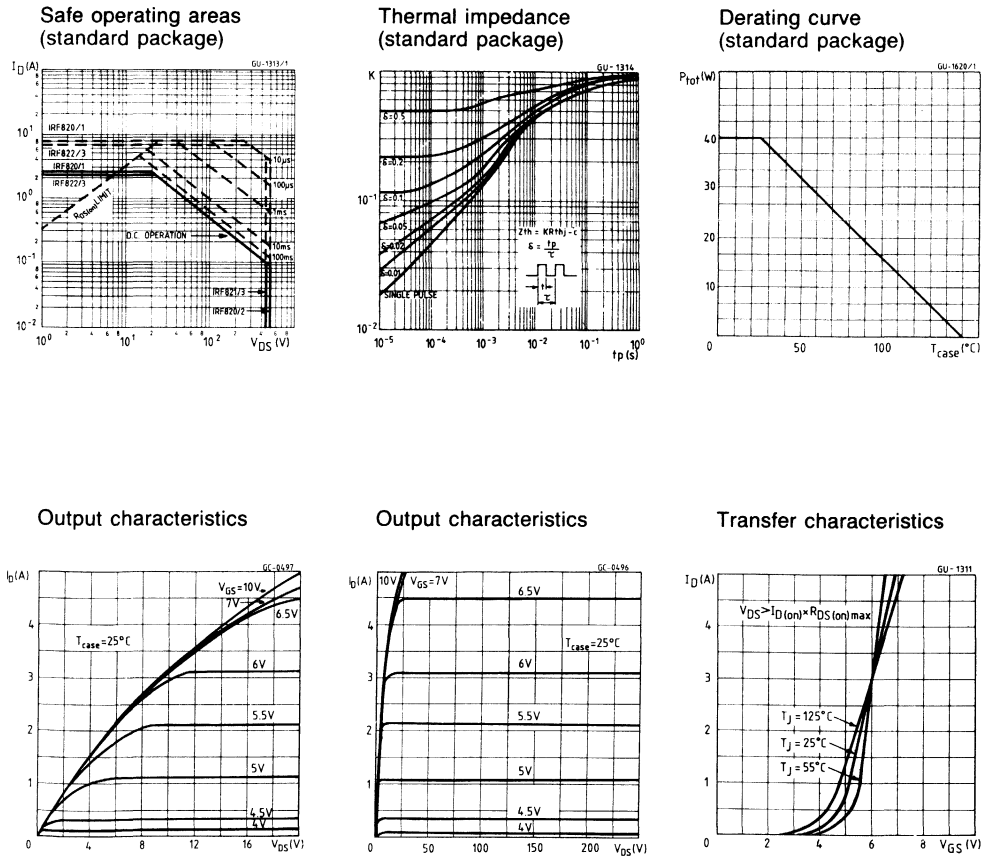
**SWITCHING**

|               |                     |                                                                                          |                       |  |  |    |    |
|---------------|---------------------|------------------------------------------------------------------------------------------|-----------------------|--|--|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 225 \text{ V}$                                                                 | $I_D = 1.0 \text{ A}$ |  |  | 60 | ns |
| $t_r$         | Rise time           | $R_i = 50 \Omega$                                                                        |                       |  |  | 50 | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit)                                                                       |                       |  |  | 60 | ns |
| $t_f$         | Fall time           |                                                                                          |                       |  |  | 30 | ns |
| $Q_g$         | Total Gate Charge   | $V_{GS} = 10 \text{ V}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) | $I_D = 2.5 \text{ A}$ |  |  | 19 | nC |

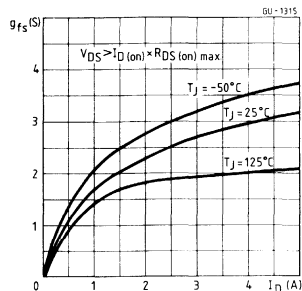
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                | Test Conditions                                          | Min.                                                          | Typ. | Max.      | Unit          |
|---------------------------|----------------------------------------------------------|---------------------------------------------------------------|------|-----------|---------------|
| $I_{SD}$<br>$I_{SDM}$ (*) | Source-drain current<br>Source-drain current<br>(pulsed) |                                                               |      | 2.5<br>10 | A<br>A        |
| $V_{SD}^{**}$             | Forward on voltage.                                      | $I_{SD} = 2.5\text{ A}$<br>$V_{GS} = 0$                       |      | 1.6       | V             |
| $t_{rr}$                  | Reverse recovery<br>time                                 | $T_J = 150^\circ\text{C}$                                     | 600  |           | ns            |
| $Q_{rr}$                  | Reverse recovered<br>charge                              | $I_{SD} = 2.5\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ | 3.5  |           | $\mu\text{C}$ |

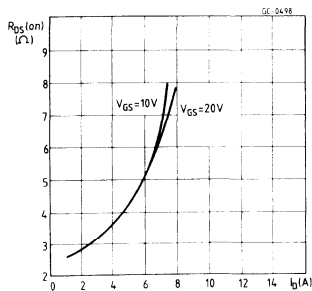
\*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 1.5\%$   
(\*) Repetitive Rating: Pulse width limited by max junction temperature  
■ See note on ISOWATT220 in this datasheet



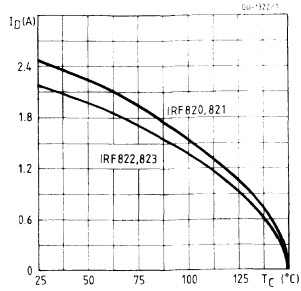
Transconductance



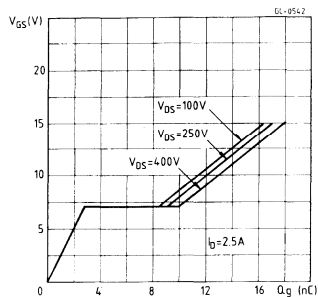
Static drain-source on resistance



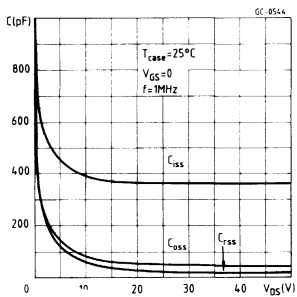
Maximum drain current vs temperature



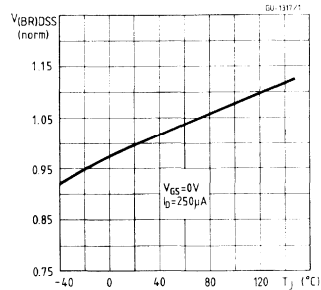
Gate charge vs gate-source voltage



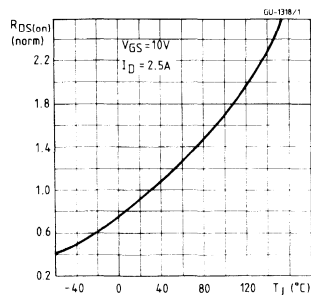
Capacitance variation



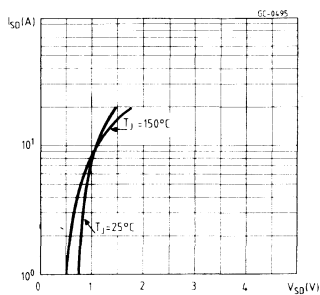
Normalized breakdown voltage vs temperature



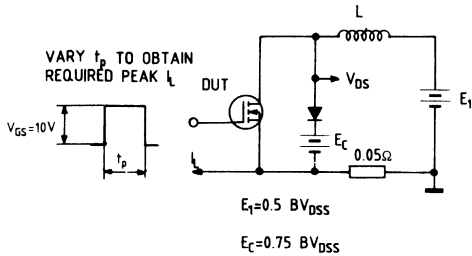
Normalized on resistance vs temperature



Source-drain diode forward characteristics

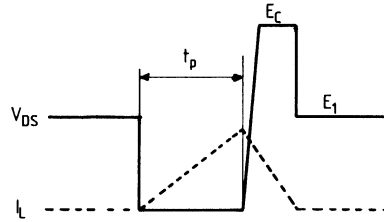


### Clamped inductive test circuit



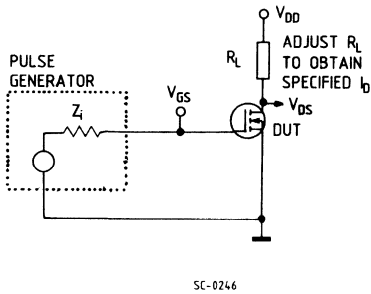
SC-0242

### Clamped inductive waveforms



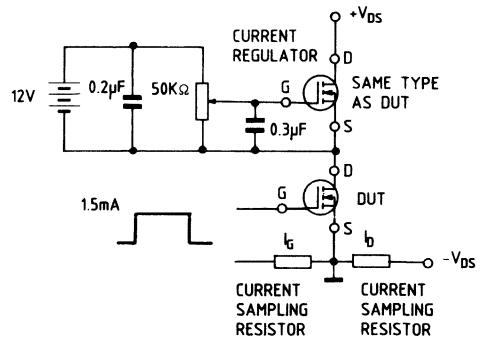
SC-0243

### Switching times test circuit



SC-0246

### Gate charge test circuit



SC-0244

# ISOWATT220 PACKAGE CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

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ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

# THERMAL IMPEDANCE OF ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th \text{ (tot)}}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

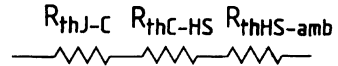
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

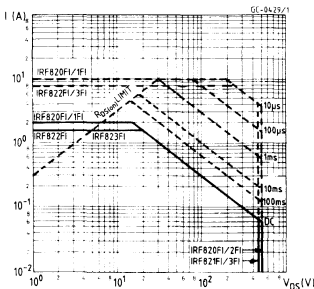
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

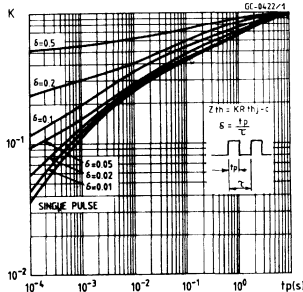


# ISOWATT DATA

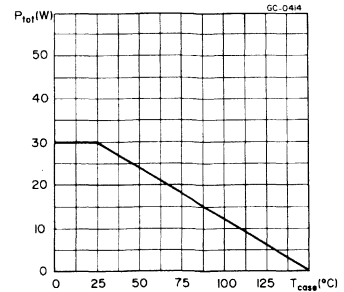
## Safe operating areas



## Thermal impedance



## Derating curve





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

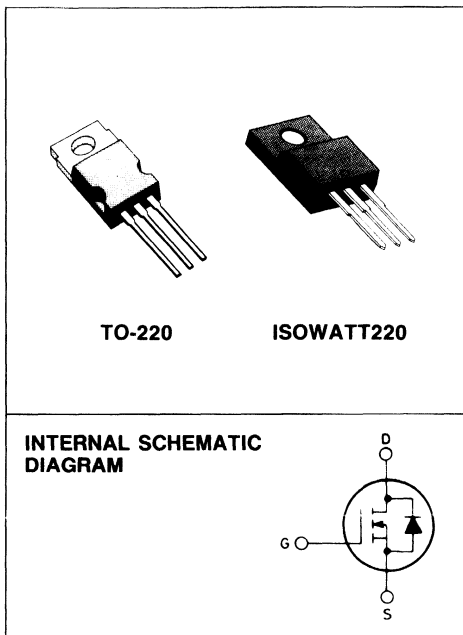
| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> * |
|----------|------------------|---------------------|------------------|
| IRF830   | 500 V            | 1.5 Ω               | 4.5 A            |
| IRF830FI | 500 V            | 1.5 Ω               | 3.0 A            |
| IRF831   | 450 V            | 1.5 Ω               | 4.5 A            |
| IRF831FI | 450 V            | 1.5 Ω               | 3.0 A            |
| IRF832   | 500 V            | 2.0 Ω               | 4.0 A            |
| IRF832FI | 500 V            | 2.0 Ω               | 2.5 A            |
| IRF833   | 450 V            | 2.0 Ω               | 4.0 A            |
| IRF833FI | 450 V            | 2.0 Ω               | 2.5 A            |

- HIGH VOLTAGE - 450 V FOR OFF LINE SMPS
- ULTRA FAST SWITCHING - FOR OPERATION AT > KHz
- EASY DRIVE- FOR REDUCED COST AND SIZE
- COST EFFECTIVE PLASTIC PACKAGE

### INDUSTRIAL APPLICATIONS:

- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Typical uses include SMPS, lamp ballast and motor control.



### ABSOLUTE MAXIMUM RATINGS

| ABSOLUTE MAXIMUM RATINGS |                                                 | IRF          |              |              |              |
|--------------------------|-------------------------------------------------|--------------|--------------|--------------|--------------|
|                          | TO-220<br>ISOWATT220                            | 830<br>830FI | 831<br>831FI | 832<br>832FI | 833<br>833FI |
| V <sub>DS</sub> *        | Drain-source voltage (V <sub>GS</sub> = 0)      | 500          | 450          | 500          | 450          |
| V <sub>DGR</sub> *       | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 500          | 450          | 500          | 450          |
| V <sub>GS</sub>          | Gate-source voltage                             | ±20          |              |              |              |
| I <sub>DM</sub> (•)      | Drain current (pulsed)                          | 15           | 15           | 13           | 13           |
| I <sub>DLM</sub>         | Drain inductive current, clamped (L = 100 μH)   | 15           | 15           | 13           | 13           |
|                          |                                                 | 830          | 831          | 832          | 833          |
| I <sub>D</sub>           | Drain current (cont.) at T <sub>c</sub> = 25°C  | 4.5          | 4.5          | 4            | 4            |
| I <sub>D</sub>           | Drain current (cont.) at T <sub>c</sub> = 100°C | 3            | 3            | 2.5          | 2.5          |
|                          |                                                 | 830FI        | 831FI        | 832FI        | 833FI        |
| I <sub>D</sub> ■         | Drain current (cont.) at T <sub>c</sub> = 25°C  | 3            | 3            | 2.5          | 2.5          |
| I <sub>D</sub> ■         | Drain current (cont.) at T <sub>c</sub> = 100°C | 1.8          | 1.8          | 1.5          | 1.5          |
|                          |                                                 | TO-220       |              | ISOWATT220   |              |
| P <sub>tot</sub> ■       | Total dissipation at T <sub>c</sub> < 25°C      | 74           |              | 35           |              |
| ■                        | Derating factor                                 | 0.59         |              | 0.28         |              |
| T <sub>stg</sub>         | Storage temperature                             | - 55 to 150  |              |              |              |
| T <sub>j</sub>           | Max. operating junction temperature             | 150          |              |              |              |

\* T<sub>j</sub> = 25°C to 125°C

(•) Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT220 on this datasheet.

THERMAL DATA \*

TO-220

ISOWATT220

|                  |                                                |     |      |      |      |
|------------------|------------------------------------------------|-----|------|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.69 | 3.57 | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.5  |      | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 80   |      | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300  |      | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                               |                            |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------|----------------------------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for IRF830/832/830FI/832FI<br>for IRF831/833/831FI/833FI | $V_{GS} = 0$<br>500<br>450 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$       | $T_c = 125^{\circ}C$       | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                           |                            | $\pm 500$   | nA                 |

ON \*\*

|               |                                   |                                                                                                        |                               |   |  |            |                      |
|---------------|-----------------------------------|--------------------------------------------------------------------------------------------------------|-------------------------------|---|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                      | $I_D = 250 \mu A$             | 2 |  | 4          | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$<br>for IRF830/831/830FI/831FI<br>for IRF832/833/832FI/833FI | $V_{GS} = 10 V$<br>4.5<br>4.0 |   |  |            | A<br>A               |
| $R_{DS(on)}$  | Static drain-source on resistance | $V_{GS} = 10 V$<br>for IRF830/831/830FI/831FI<br>for IRF832/833/832FI/833FI                            | $I_D = 2.5 A$                 |   |  | 1.5<br>2.0 | $\Omega$<br>$\Omega$ |

DYNAMIC

|               |                              |                                                             |             |  |  |     |     |
|---------------|------------------------------|-------------------------------------------------------------|-------------|--|--|-----|-----|
| $g_{fs}^{**}$ | Forward transconductance     | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$<br>$I_D = 2.5 A$ | 2.7         |  |  |     | mho |
| $C_{iss}$     | Input capacitance            |                                                             |             |  |  | 800 | pF  |
| $C_{oss}$     | Output capacitance           | $V_{DS} = 25 V$                                             | $f = 1 MHz$ |  |  | 200 | pF  |
| $C_{rss}$     | Reverse transfer capacitance | $V_{GS} = 0$                                                |             |  |  | 60  | pF  |

SWITCHING

|              |                     |                                                                                  |               |  |  |    |    |
|--------------|---------------------|----------------------------------------------------------------------------------|---------------|--|--|----|----|
| $t_{d(on)}$  | Turn-on time        | $V_{DD} = 225 V$                                                                 | $I_D = 2.5 A$ |  |  | 30 | ns |
| $t_r$        | Rise time           | $R_i = 15 \Omega$                                                                |               |  |  | 30 | ns |
| $t_{d(off)}$ | Turn-off delay time | (see test circuit)                                                               |               |  |  | 55 | ns |
| $t_f$        | Fall time           |                                                                                  |               |  |  | 30 | ns |
| $Q_g$        | Total Gate Charge   | $V_{GS} = 10 V$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) | $I_D = 4.5 A$ |  |  | 32 | nC |

\* See note on ISOWATT220 in this datasheet

\*\* Pulsed: Pulse duration  $\leq 300 \mu s$ , duty cycle  $\leq 2\%$

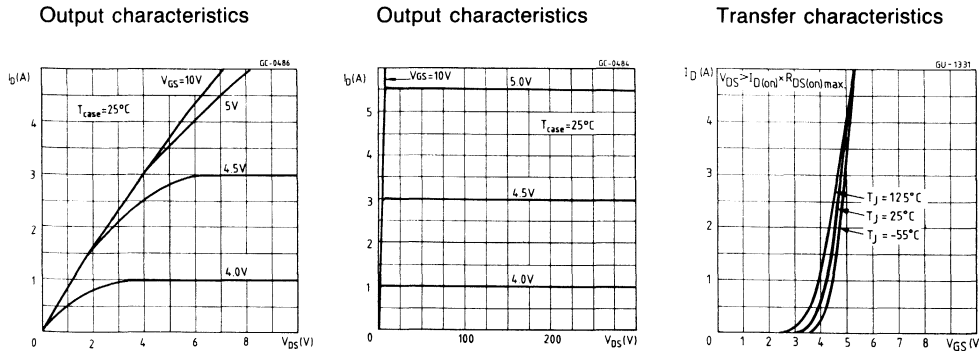
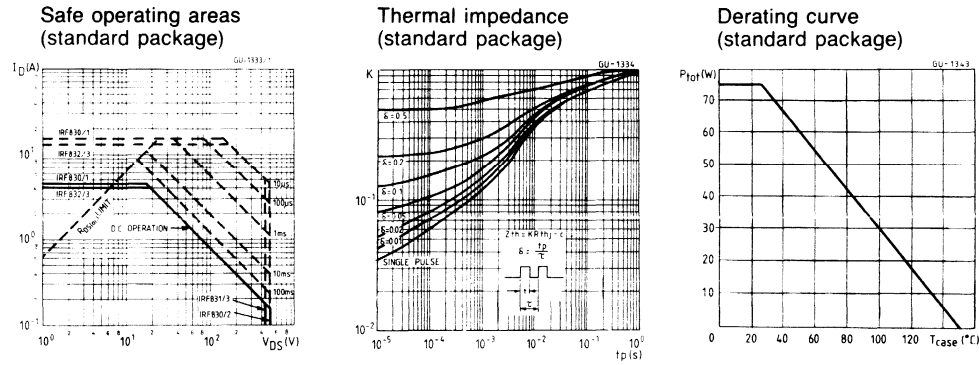
# ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

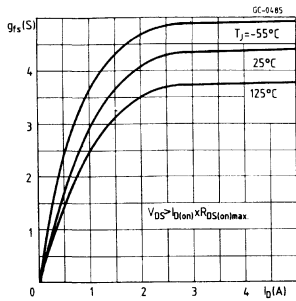
## SOURCE DRAIN DIODE

|                             |                                                          |                                                               |     |           |               |
|-----------------------------|----------------------------------------------------------|---------------------------------------------------------------|-----|-----------|---------------|
| $I_{SD}$<br>$I_{SDM}^{(*)}$ | Source-drain current<br>Source-drain current<br>(pulsed) |                                                               |     | 4.5<br>15 | A<br>A        |
| $V_{SD}^{**}$               | Forward on voltage                                       | $I_{SD} = 4.5\text{ A}$<br>$V_{GS} = 0$                       |     | 1.6       | V             |
| $t_{rr}$                    | Reverse recovery<br>time                                 | $T_j = 150^\circ\text{C}$                                     | 800 |           | ns            |
| $Q_{rr}$                    | Reverse recovered<br>charge                              | $I_{SD} = 4.5\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ | 4.6 |           | $\mu\text{C}$ |

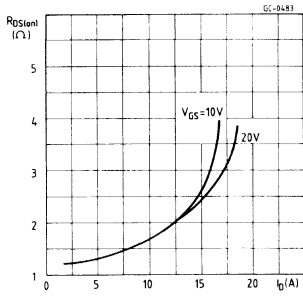
\*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 1.5\%$   
 (\*) Repetive Rating: Pulse width limited by max junction temperature



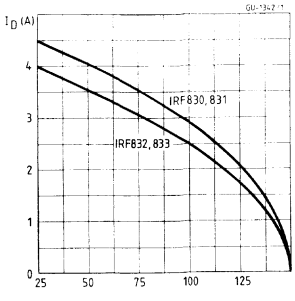
Transconductance



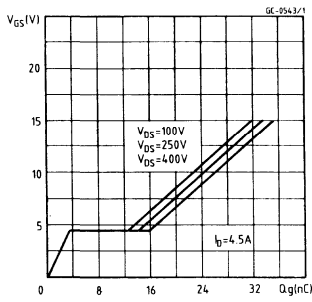
Static drain-source on resistance



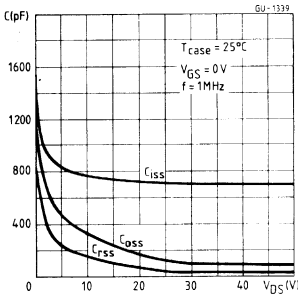
Maximum drain current vs temperature



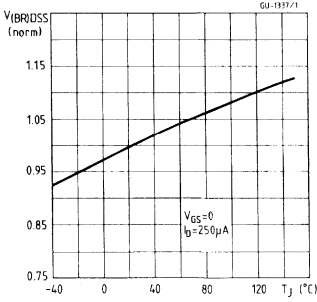
Gate charge vs gate-source voltage



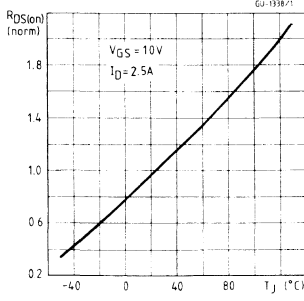
Capacitance variation



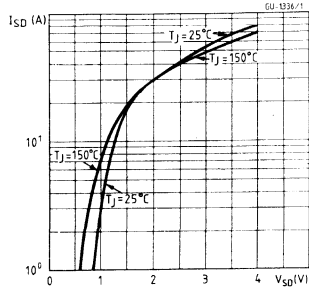
Normalized breakdown voltage vs temperature



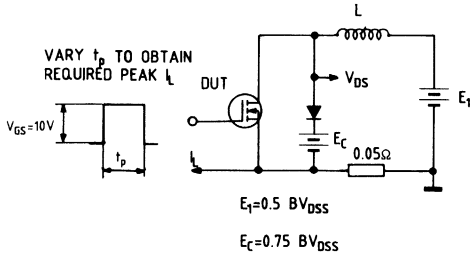
Normalized on resistance vs temperature



Source-drain diode forward characteristics

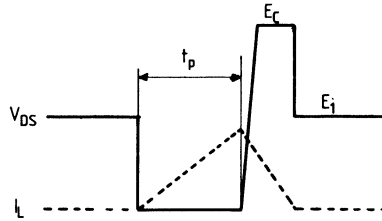


### Clamped inductive test circuit



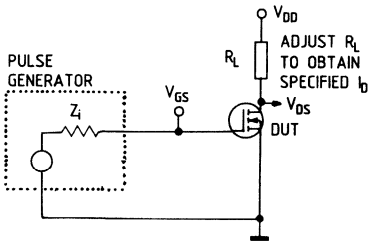
SC-0242

### Clamped inductive waveforms



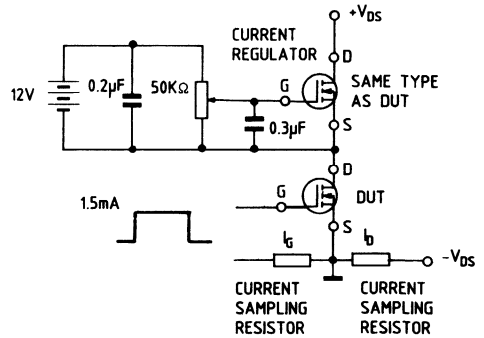
SC-0243

### Switching times test circuit



SC-0246

### Gate charge test circuit



SC-0244

## ISOWATT220 PACKAGE CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

## THERMAL IMPEDANCE OF ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th(tot)}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

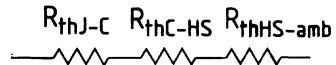
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

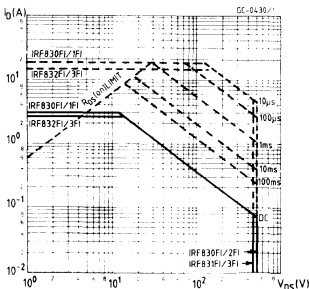
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

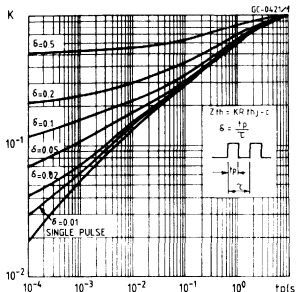


## ISOWATT DATA

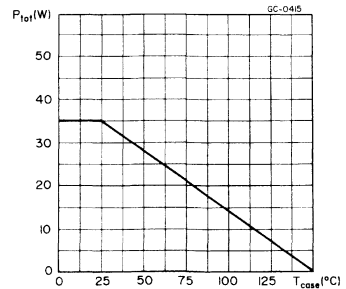
Safe operating areas



Thermal impedance



Derating curve



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

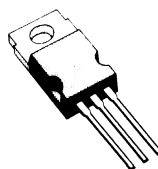
| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> * |
|----------|------------------|---------------------|------------------|
| IRF840   | 500 V            | 0.85 Ω              | 8 A              |
| IRF840FI | 500 V            | 0.85 Ω              | 4.5 A            |
| IRF841   | 450 V            | 0.85 Ω              | 8 A              |
| IRF841FI | 450 V            | 0.85 Ω              | 4.5 A            |
| IRF842   | 500 V            | 1.1 Ω               | 7 A              |
| IRF842FI | 500 V            | 1.1 Ω               | 4 A              |
| IRF843   | 450 V            | 1.1 Ω               | 7 A              |
| IRF843FI | 450 V            | 1.1 Ω               | 4 A              |

- HIGH VOLTAGE - 450 V FOR OFF LINE SMPS
- ULTRA FAST SWITCHING - FOR OPERATION AT > 100KHz
- EASY DRIVE- FOR REDUCED COST AND SIZE
- COST EFFECTIVE PLASTIC PACKAGE

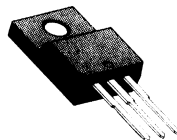
### INDUSTRIAL APPLICATIONS:

- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications.

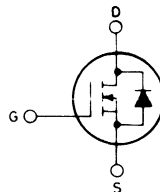


TO-220



ISOWATT220

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | TO-220<br>ISOWATT220 |  | IRF          |              |              |              |      |
|---------------------|-------------------------------------------------|----------------------|--|--------------|--------------|--------------|--------------|------|
|                     |                                                 |                      |  | 840<br>840FI | 841<br>841FI | 842<br>842FI | 843<br>843FI |      |
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      |                      |  | 500          | 450          | 500          | 450          | V    |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    |                      |  | 500          | 450          | 500          | 450          | V    |
| V <sub>GS</sub>     | Gate-source voltage                             |                      |  | ±20          |              |              |              | V    |
| I <sub>DM</sub> (•) | Drain current (pulsed)                          |                      |  | 32           | 32           | 28           | 28           | A    |
| I <sub>DLM</sub>    | Drain inductive current, clamped (L = 100 μH)   |                      |  | 32           | 32           | 28           | 28           | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | 840          | 841          | 842          | 843          |      |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 8            | 8            | 7            | 7            | A    |
|                     |                                                 |                      |  | 5.1          | 5.1          | 4.4          | 4.4          | A    |
|                     |                                                 |                      |  | 840FI        | 841FI        | 842FI        | 843FI        |      |
|                     |                                                 |                      |  | 4.5          | 4.5          | 4            | 4            | A    |
|                     |                                                 |                      |  | 2.8          | 2.8          | 2.5          | 2.5          | A    |
| P <sub>tot</sub> ■  | Total dissipation at T <sub>c</sub> < 25°C      |                      |  | TO-220       |              | ISOWATT220   |              |      |
| ■                   | Derating factor                                 |                      |  | 125          |              | 40           |              | W    |
| T <sub>stg</sub>    | Storage temperature                             |                      |  | 1            |              | 0.32         |              | W/°C |
| T <sub>j</sub>      | Max. operating junction temperature             |                      |  | -55 to 150   |              | 150          |              | °C   |

\* T<sub>j</sub> = 25°C to 125°C

(•) Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT220 on this datasheet.

THERMAL DATA \*

|                  |                                                | TO-220 |     | ISOWATT220 |
|------------------|------------------------------------------------|--------|-----|------------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max    | 1   | 3.12 °C/W  |
| $R_{thc - s}$    | Thermal resistance case-sink                   | typ    | 0.5 | °C/W       |
| $R_{thj - amb}$  | Thermal resistance junction-ambient            | max    | 80  | °C/W       |
| $T_l$            | Maximum lead temperature for soldering purpose |        | 300 | °C         |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                               |                      |            |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------|----------------------|------------|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for IRF840/842/840FI/842FI<br>for IRF841/843/841FI/843FI | $V_{GS} = 0$         | 500<br>450 |  |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$       | $T_c = 125^{\circ}C$ |            |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                           |                      |            |  | $\pm 500$   | nA                 |

ON \*\*

|               |                                   |                                                                                                        |                   |        |  |             |                      |
|---------------|-----------------------------------|--------------------------------------------------------------------------------------------------------|-------------------|--------|--|-------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                      | $I_D = 250 \mu A$ | 2      |  | 4           | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$<br>for IRF840/841/840FI/841FI<br>for IRF842/843/842FI/843FI | $V_{GS} = 10 V$   | 8<br>7 |  |             | A<br>A               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>for IRF840/841/840FI/841FI<br>for IRF842/843/842FI/843FI                            | $I_D = 4.4 A$     |        |  | 0.85<br>1.1 | $\Omega$<br>$\Omega$ |

DYNAMIC

|               |                              |                                                             |             |  |  |      |     |
|---------------|------------------------------|-------------------------------------------------------------|-------------|--|--|------|-----|
| $g_{fs}^{**}$ | Forward transconductance     | $V_{DS} > I_{D(on)} \times R_{DS(on) max}$<br>$I_D = 4.4 A$ | 4.9         |  |  |      | mho |
| $C_{iss}$     | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$                             | $f = 1 MHz$ |  |  | 1600 | pF  |
| $C_{oss}$     | Output capacitance           |                                                             |             |  |  | 350  | pF  |
| $C_{rss}$     | Reverse transfer capacitance |                                                             |             |  |  | 150  | pF  |

SWITCHING

|               |                     |                                                                                  |                    |  |  |    |    |
|---------------|---------------------|----------------------------------------------------------------------------------|--------------------|--|--|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 200 V$                                                                 | $I_D = 4.0 A$      |  |  | 35 | ns |
| $t_r$         | Rise time           | $R_l = 4.7 \Omega$                                                               | (see test circuit) |  |  | 15 | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                                                  |                    |  |  | 90 | ns |
| $t_f$         | Fall time           |                                                                                  |                    |  |  | 30 | ns |
| $Q_g$         | Total Gate Charge   | $V_{GS} = 10 V$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) | $I_D = 8 A$        |  |  | 63 | nC |



# ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

## SOURCE DRAIN DIODE

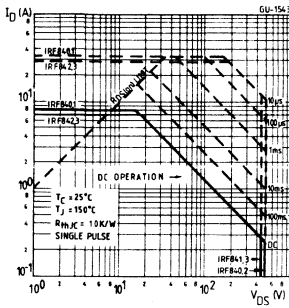
|               |                               |                           |                                     |      |               |
|---------------|-------------------------------|---------------------------|-------------------------------------|------|---------------|
| $I_{SD}$      | Source-drain current          |                           |                                     | 8    | A             |
| $I_{SDM} (*)$ | Source-drain current (pulsed) |                           |                                     | 32   | A             |
| $V_{SD}^{**}$ | Forward on voltage            | $I_{SD} = 8 \text{ A}$    | $V_{GS} = 0$                        | 2    | V             |
| $t_{rr}$      | Reverse recovery time         | $T_j = 150^\circ\text{C}$ |                                     | 1100 | ns            |
| $Q_{rr}$      | Reverse recovered charge      | $I_{SD} = 8.0 \text{ A}$  | $di/dt = 100 \text{ A}/\mu\text{s}$ | 6.4  | $\mu\text{C}$ |

\*\* Pulsed: Pulse duration  $\leq 300 \mu\text{s}$ , duty cycle  $\leq 1.5\%$

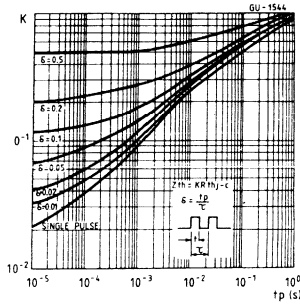
(\*) Repetive Rating: Pulse width limited by max junction temperature

■ See note on ISOWATT220 in this datasheet

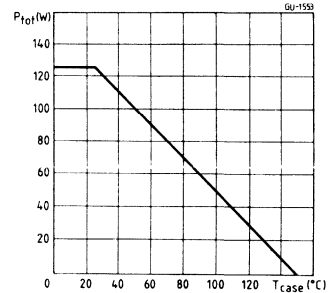
Safe operating areas  
(standard package)



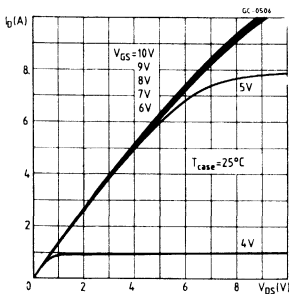
Thermal impedance  
(standard package)



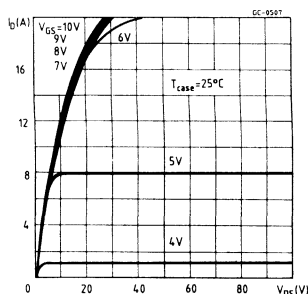
Derating curve  
(standard package)



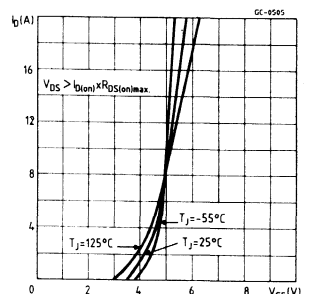
Output characteristics



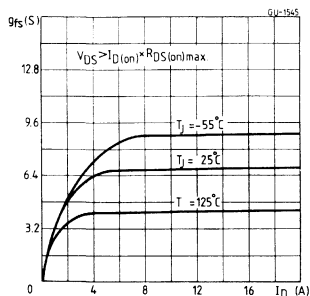
Output characteristics



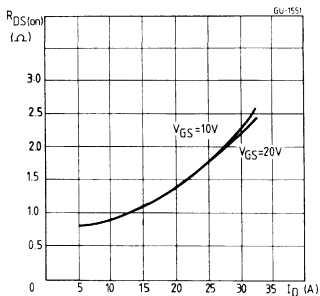
Transfer characteristics



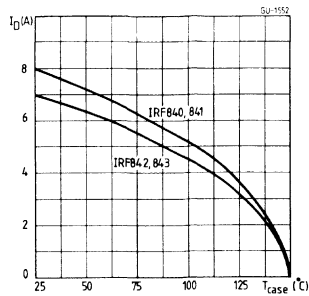
Transconductance



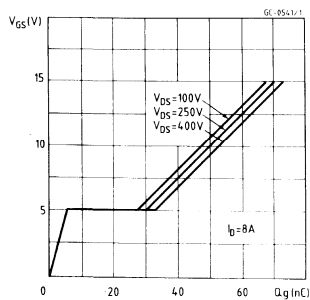
Static drain-source on resistance



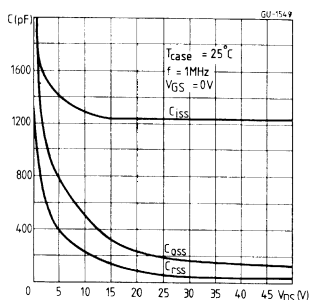
Maximum drain current vs temperature



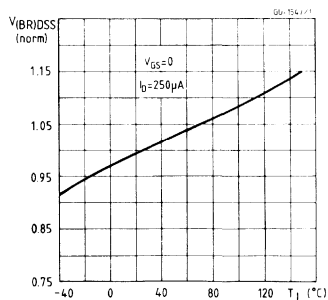
Gate charge vs gate-source voltage



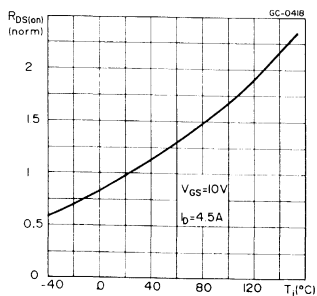
Capacitance variation



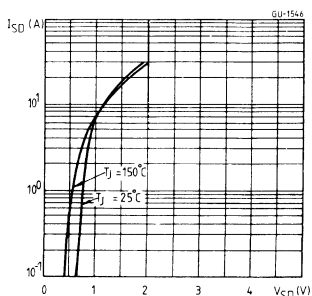
Normalized breakdown voltage vs temperature



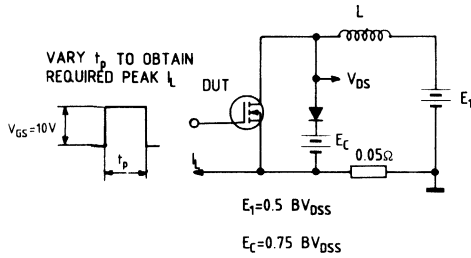
Normalized on resistance vs temperature



Source-drain diode forward characteristics

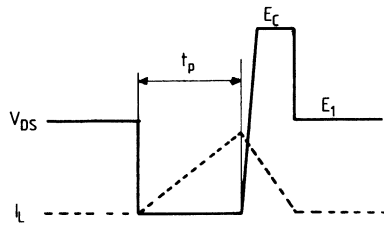


### Clamped inductive test circuit



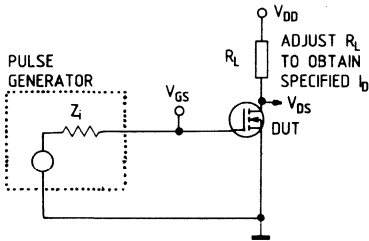
SC-0242

### Clamped inductive waveforms



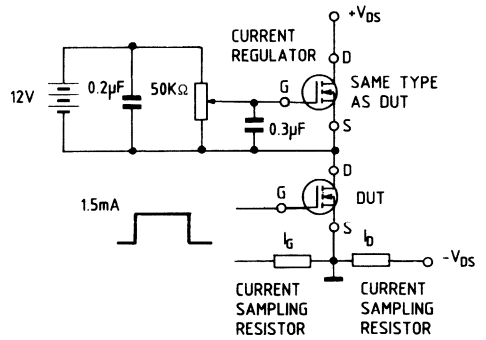
SC-0243

### Switching times test circuit



SC-0246

### Gate charge test circuit



SC-0244

**ISOWATT220 PACKAGE  
CHARACTERISTICS AND APPLICATION.**

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation. The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance. ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

**THERMAL IMPEDANCE OF  
ISOWATT220 PACKAGE**

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package. The total thermal resistance  $R_{th \text{ (tot)}}$  is the sum of each of these elements. The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

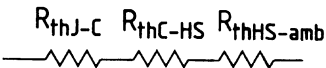
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

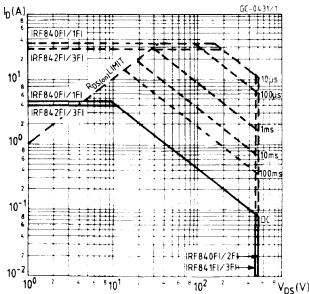
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

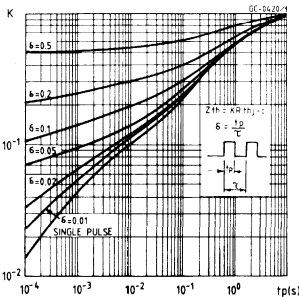


**ISOWATT DATA**

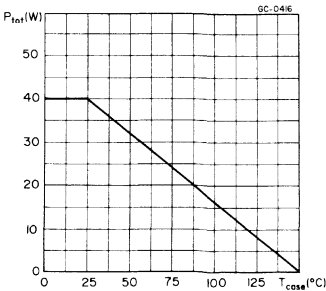
Safe operating areas



Thermal impedance



Derating curve



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

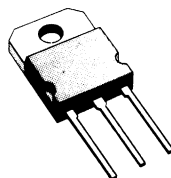
| TYPE      | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> * |
|-----------|------------------|---------------------|------------------|
| IRFP150   | 100 V            | 0.055 Ω             | 40 A             |
| IRFP150FI | 100 V            | 0.055 Ω             | 26 A             |
| IRFP151   | 60 V             | 0.055 Ω             | 40 A             |
| IRFP151FI | 60 V             | 0.055 Ω             | 26 A             |
| IRFP152   | 100 V            | 0.08 Ω              | 34 A             |
| IRFP152FI | 100 V            | 0.08 Ω              | 21 A             |
| IRFP153   | 60 V             | 0.08 Ω              | 34 A             |
| IRFP153FI | 60 V             | 0.08 Ω              | 21 A             |

- 60 - 100 V FOR DC/DC CONVERTERS
- HIGH CURRENT
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- ULTRA FAST SWITCHING
- EASY DRIVE - FOR REDUCES COST AND SIZE

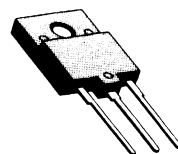
### INDUSTRIAL APPLICATIONS:

- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Applications include DC/DC converters, UPS, battery chargers, secondary regulators, servo control, power audio amplifiers and robotics.

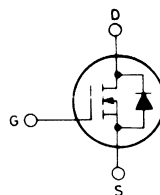


TO-218



ISOWATT218

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | TO-218<br>ISOWATT218 |  | IRFP         |              |              |              |    |
|---------------------|-------------------------------------------------|----------------------|--|--------------|--------------|--------------|--------------|----|
|                     |                                                 |                      |  | 150<br>150FI | 151<br>151FI | 152<br>152FI | 153<br>153FI |    |
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      |                      |  | 100          | 60           | 100          | 60           | V  |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    |                      |  | 100          | 60           | 100          | 60           | V  |
| V <sub>GS</sub>     | Gate-source voltage                             |                      |  | ±20          |              |              |              | V  |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          |                      |  | 160          | 160          | 140          | 140          | A  |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | 150          | 151          | 152          | 153          | A  |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 40           | 40           | 34           | 34           | A  |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 26           | 26           | 22           | 22           | A  |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      |  | 150FI        | 151FI        | 152FI        | 153FI        | A  |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 26           | 26           | 21           | 21           | A  |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C |                      |  | 16           | 16           | 13           | 13           | A  |
| P <sub>tot</sub> ■  | Total dissipation at T <sub>c</sub> < 25°C      |                      |  | TO-218       |              | ISOWATT218   |              | W  |
|                     | Derating factor                                 |                      |  | 150          |              | 65           |              | W  |
| T <sub>stg</sub>    | Storage temperature                             |                      |  | 1.2          |              | 0.52         |              | °C |
| T <sub>j</sub>      | Max. operating junction temperature             |                      |  | -55 to 150   |              | 150          |              | °C |

\* T<sub>j</sub> = 25°C to 125°C

(\*) Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT218 on this datasheet.

♦ Introduced in 1988 week 44

**THERMAL DATA \***

|                  |                                                | TO-218 |      | ISOWATT218 |      |
|------------------|------------------------------------------------|--------|------|------------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max    | 0.83 | 1.92       | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ    | 0.1  |            | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max    | 30   |            | °C/W |
| $T_I$            | Maximum lead temperature for soldering purpose |        | 300  |            | °C   |

**ELECTRICAL CHARACTERISTICS** ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                                                               |                      |             |                    |
|----------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>IRFP150/152/150FI/152FI</b><br>for <b>IRFP151/153/151FI/153FI</b> | $V_{GS} = 0$         | 100<br>60   | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$                       | $T_c = 125^{\circ}C$ | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                           |                      | $\pm 100$   | nA                 |

**ON \*\***

|               |                                   |                                                                                                                                |                   |          |               |                      |
|---------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------|-------------------|----------|---------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                                              | $I_D = 250 \mu A$ | 2        | 4             | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$<br>for <b>IRFP150/151/150FI/151FI</b><br>for <b>IRFP152/153/152FI/153FI</b> | $V_{GS} = 10 V$   | 40<br>34 |               | A<br>A               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>for <b>IRFP150/151/150FI/151FI</b><br>for <b>IRFP152/153/152FI/153FI</b>                                    | $I_D = 22 A$      |          | 0.055<br>0.08 | $\Omega$<br>$\Omega$ |

**ENERGY TEST**

|           |                                                      |                                                                                                                             |                 |          |  |        |
|-----------|------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------------|----------|--|--------|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 V$<br>starting $T_j = 25^{\circ}C$<br>for <b>IRFP150/151/150FI/151FI</b><br>for <b>IRFP152/153/152FI/153FI</b> | $L = 100 \mu H$ | 40<br>34 |  | A<br>A |
|-----------|------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------------|----------|--|--------|

**DYNAMIC**

|             |                              |                                                                    |                     |    |                     |                |
|-------------|------------------------------|--------------------------------------------------------------------|---------------------|----|---------------------|----------------|
| $g_{fs} **$ | Forward transconductance     | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$<br>$I_D = 22 A$ |                     | 13 |                     | mho            |
| $C_{iss}$   | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$                                    | $f = 1 \text{ MHz}$ |    | 3000<br>1500<br>500 | pF<br>pF<br>pF |
| $C_{oss}$   | Output capacitance           |                                                                    |                     |    |                     |                |
| $C_{rss}$   | Reverse transfer capacitance |                                                                    |                     |    |                     |                |

ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

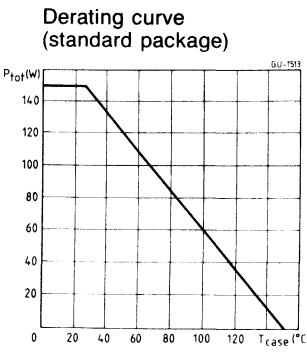
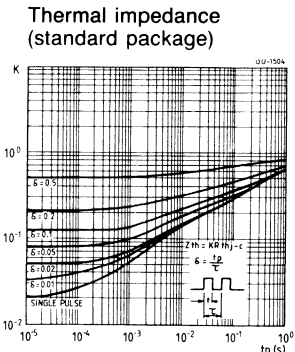
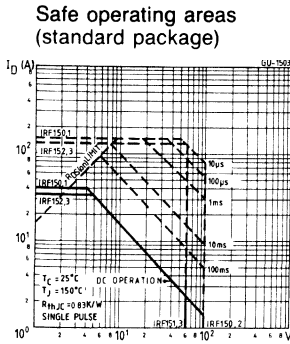
SWITCHING

|                                             |                                                               |                                                                                            |                     |                         |                      |
|---------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------------------------------------------|---------------------|-------------------------|----------------------|
| $t_d$ (on)<br>$t_r$<br>$t_d$ (off)<br>$t_f$ | Turn-on time<br>Rise time<br>Turn-off delay time<br>Fall time | $V_{DD} = 24\text{ V}$<br>$R_i = 4.7\ \Omega$<br>$I_D = 20\text{ A}$<br>(see test circuit) |                     | 35<br>100<br>125<br>100 | ns<br>ns<br>ns<br>ns |
| $Q_g$                                       | Total Gate Charge                                             | $V_{GS} = 10\text{ V}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit)    | $I_D = 50\text{ A}$ | 110                     | nC                   |

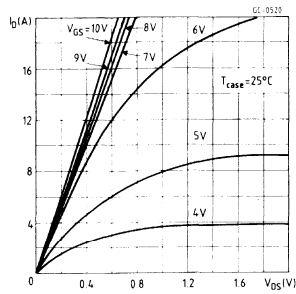
SOURCE DRAIN DIODE

|               |                               |                                                              |  |            |               |
|---------------|-------------------------------|--------------------------------------------------------------|--|------------|---------------|
| $I_{SD}$      | Source-drain current          | for IRFP150/151/150FI/151FI<br>for IRFP152/153/152FI/153FI   |  | 40<br>34   | A<br>A        |
| $I_{SDM}$ (*) | Source-drain current (pulsed) | for IRFP150/151/150FI/151FI<br>for IRFP152/153/152FI/153FI   |  | 160<br>140 | A<br>A        |
| $V_{SD}^{**}$ | Forward on voltage            | $I_{SD} = 40\text{ A}$<br>$V_{GS} = 0$                       |  | 2.5        | V             |
| $t_{rr}$      | Reverse recovery time         | $T_j = 150^\circ\text{C}$                                    |  | 600        | ns            |
| $Q_{rr}$      | Reverse recovered charge      | $I_{SD} = 40\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |  | 3.3        | $\mu\text{C}$ |

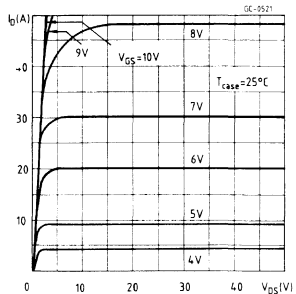
\*\* Pulsed: Pulse duration  $\leq 300\ \mu\text{s}$ , duty cycle  $\leq 1.5\%$   
(\*) Repetitive Rating: Pulse width limited by max junction temperature  
■ See note on ISOWATT220 in this datasheet



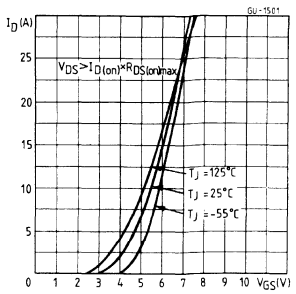
Output characteristics



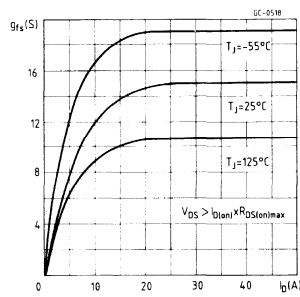
Output characteristics



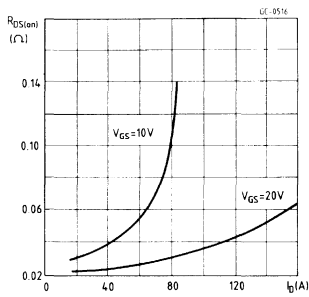
Transfer characteristics



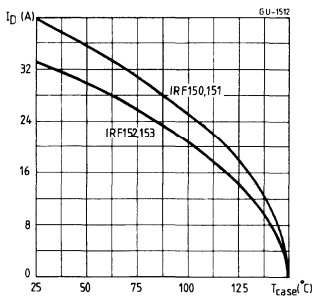
Transconductance



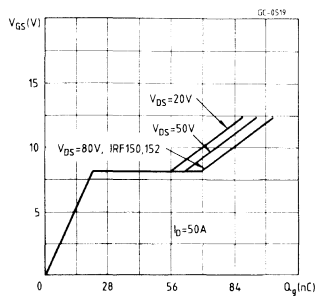
Static drain-source on resistance



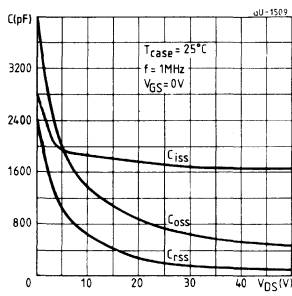
Maximum drain current vs temperature



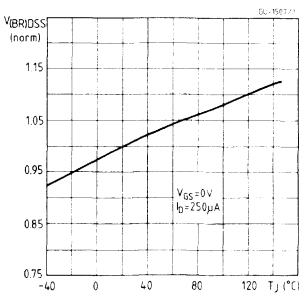
Gate charge vs gate-source voltage



Capacitance variation

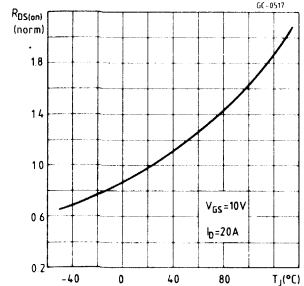


Normalized breakdown voltage vs temperature

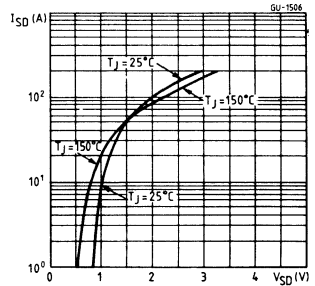




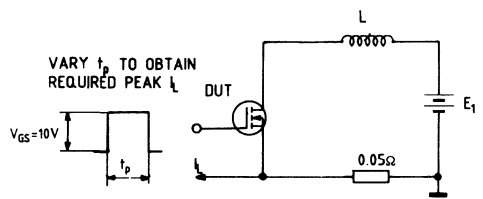
Normalized on resistance vs temperature



Source-drain diode forward characteristics

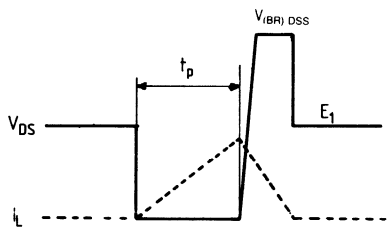


Unclamped inductive test circuit



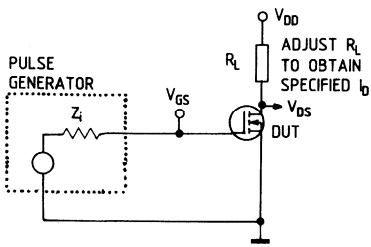
SC-0339

Unclamped inductive waveforms



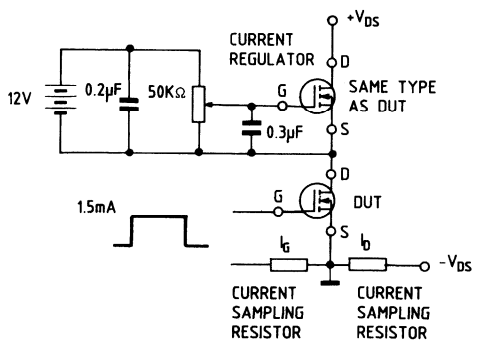
SC-0338

Switching times test circuit



SC-0246

Gate charge test circuit



SC-0244

**ISOWATT218 PACKAGE  
CHARACTERISTICS AND APPLICATION.**

ISOWATT218 is fully isolated to 4000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. These distances are in agreement with VDE and UL creepage and clearance standards. The ISOWATT218 package eliminates the need for external isolation so reducing fixing hardware.

The package is supplied with leads longer than the standard TO-218 to allow easy mounting on pcbs. Accurate moulding techniques used in manufacture assures consistent heat spreader-to-heatsink capacitance

ISOWATT218 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT218 packages is determined by:

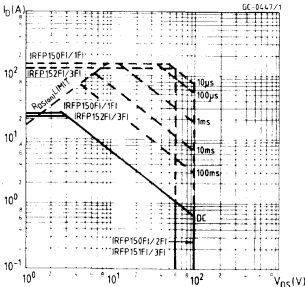
$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

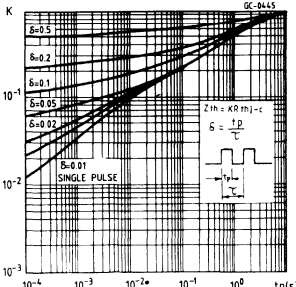
$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

**ISOWATT DATA**

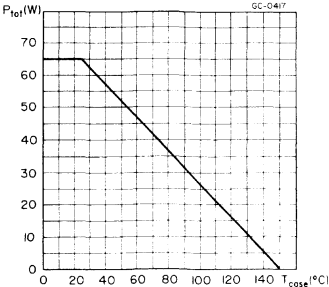
Safe operating areas



Thermal impedance



Derating curve



**THERMAL IMPEDANCE OF  
ISOWATT218 PACKAGE**

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT218 package.

The total thermal resistance  $R_{th \text{ (tot)}}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

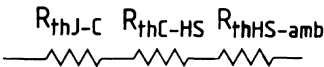
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

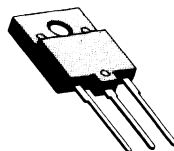
| TYPE      | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-----------|------------------|---------------------|----------------|
| IRFP350FI | 400 V            | 0.3 Ω               | 10 A           |

- HIGH VOLTAGE - FOR OFF-LINE SMPS
- HIGH CURRENT - FOR SMPS UPTO 350W
- ULTRA FAST SWITCHING - FOR OPERATION AT > 100KHz
- EASY DRIVE - REDUCES SIZE AND COST

### INDUSTRIAL APPLICATIONS:

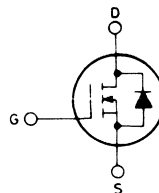
- SWITCHING MODE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Fast switching and easy drive make this POWER MOS transistor ideal for high voltage switching applications include electronic welders, switched mode power supplies and sonar equipment.



**ISOWATT218**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 |             |      |
|---------------------|-------------------------------------------------|-------------|------|
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      | 400         | V    |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 400         | V    |
| V <sub>GS</sub>     | Gate-source voltage                             | ± 20        | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 10          | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 6.3         | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 60          | A    |
| I <sub>DLM</sub>    | Drain inductive current, clamped (L = 100 μH)   | 60          | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      | 70          | W    |
|                     | Derating factor                                 | 0.56        | W/°C |
| T <sub>stg</sub>    | Storage temperature                             | - 55 to 150 | °C   |
| T <sub>j</sub>      | Max. operating junction temperature             | 150         | °C   |

\* T<sub>j</sub> = 25°C to 125°C

(\*) Repetitive Rating: Pulse width limited by max junction temperature

THERMAL DATA

|                  |                                                |     |      |               |
|------------------|------------------------------------------------|-----|------|---------------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.78 | $^{\circ}C/W$ |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.1  | $^{\circ}C/W$ |
| $R_{thj - amb}$  | Thermal resistance junction-ambient            | max | 30   | $^{\circ}C/W$ |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300  | $^{\circ}C$   |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                              |     |  |             |                    |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$ $V_{GS} = 0$                                                               | 400 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_j = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                          |     |  | $\pm 100$   | nA                 |

ON \*\*

|               |                                   |                                                                |    |  |     |          |
|---------------|-----------------------------------|----------------------------------------------------------------|----|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 250 \mu A$                            | 2  |  | 4   | V        |
| $I_{D (on)}$  | On-state drain current            | $V_{DS} > I_{D (on)} \times R_{DS (on) max}$ , $V_{GS} = 10 V$ | 10 |  |     | A        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 8.0 A$                                  |    |  | 0.3 | $\Omega$ |

DYNAMIC

|               |                              |                                                               |     |  |      |     |
|---------------|------------------------------|---------------------------------------------------------------|-----|--|------|-----|
| $g_{fs}^{**}$ | Forward transconductance     | $V_{DS} > I_{D (on)} \times R_{DS (on) max}$<br>$I_D = 8.0 A$ | 8.0 |  |      | mho |
| $C_{iss}$     | Input capacitance            | $V_{DS} = 25 V$ $f = 1 MHz$<br>$V_{GS} = 0$                   |     |  | 3000 | pF  |
| $C_{oss}$     | Output capacitance           |                                                               |     |  | 600  | pF  |
| $C_{rss}$     | Reverse transfer capacitance |                                                               |     |  | 200  | pF  |

SWITCHING

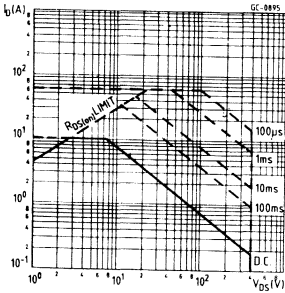
|               |                     |                                                                                               |  |  |     |    |
|---------------|---------------------|-----------------------------------------------------------------------------------------------|--|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 180 V$ $I_D = 8.0 A$<br>$R_l = 4.7 \Omega$<br>(see test circuit)                    |  |  | 35  | ns |
| $t_r$         | Rise time           |                                                                                               |  |  | 65  | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                                                               |  |  | 150 | ns |
| $t_f$         | Fall time           |                                                                                               |  |  | 75  | ns |
| $Q_g$         | Total Gate Charge   | $V_{GS} = 10 V$ $I_D = 18 A$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) |  |  | 120 | nC |

ELECTRICAL CHARACTERISTICS (Continued)

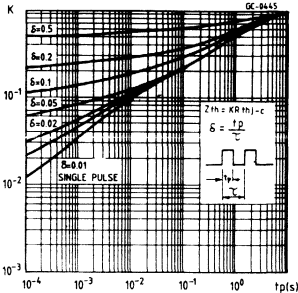
| Parameters                | Test Conditions                                       | Min.                                                                                        | Typ.        | Max.     | Unit                |
|---------------------------|-------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------|----------|---------------------|
| $I_{SD}$<br>$I_{SDM}$ (*) | Source-drain current<br>Source-drain current (pulsed) |                                                                                             |             | 10<br>60 | A<br>A              |
| $V_{SD}^{**}$             | Forward on voltage                                    | $I_{SD} = 15\text{ A}$<br>$V_{GS} = 0$                                                      |             | 1.6      | V                   |
| $t_{rr}$<br>$Q_{rr}$      | Reverse recovery time<br>Reverse recovered charge     | $T_J = 150^{\circ}\text{C}$<br>$I_{SD} = 15\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ | 1000<br>6.6 |          | ns<br>$\mu\text{C}$ |

\*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 1.5\%$   
(\*) Repetitive Rating: Pulse width limited by max junction temperature

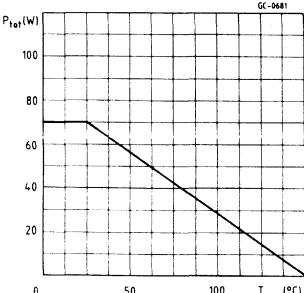
Safe operating areas



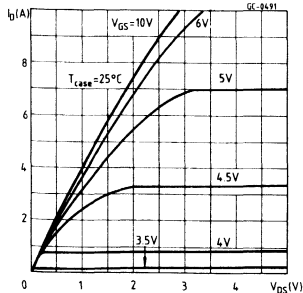
Thermal impedance



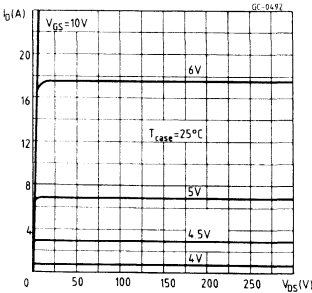
Derating curve



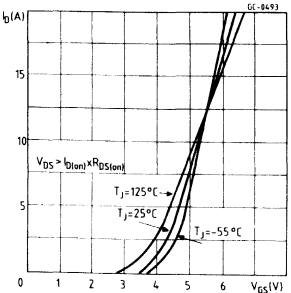
Output characteristics



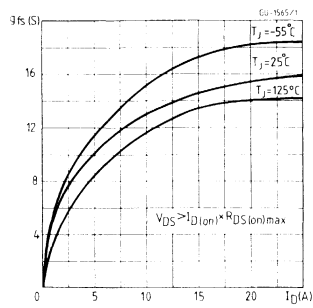
Output characteristics



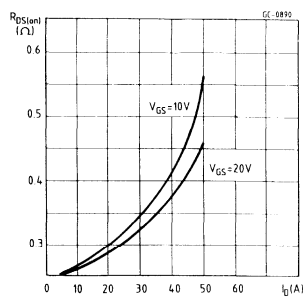
Transfer characteristics



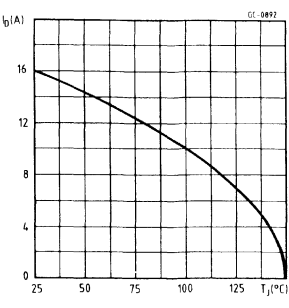
Transconductance



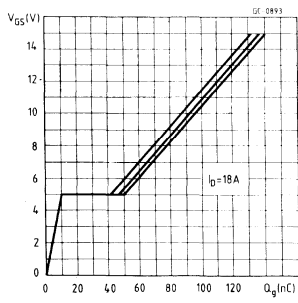
Static drain-source on resistance



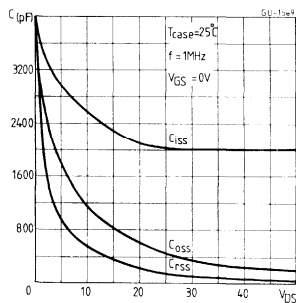
Maximum drain current vs temperature



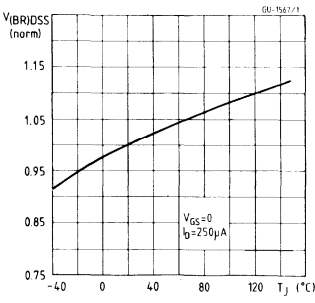
Gate charge vs gate-source voltage



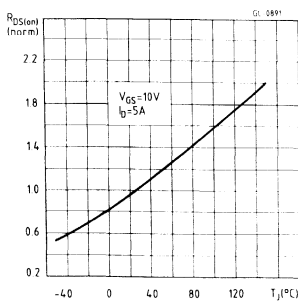
Capacitance variation



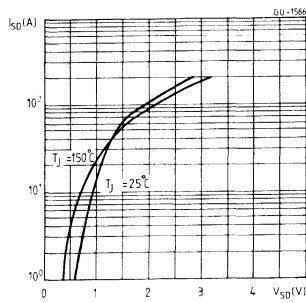
Normalized breakdown voltage vs temperature



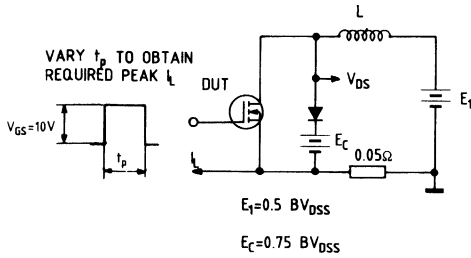
Normalized on resistance vs temperature



Source-drain diode forward characteristics

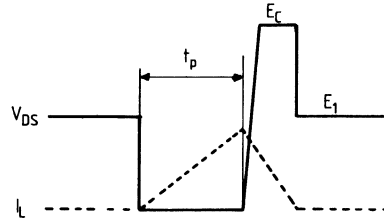


## Clamped inductive test circuit



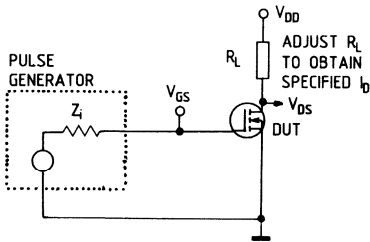
SC-0242

## Clamped inductive waveforms



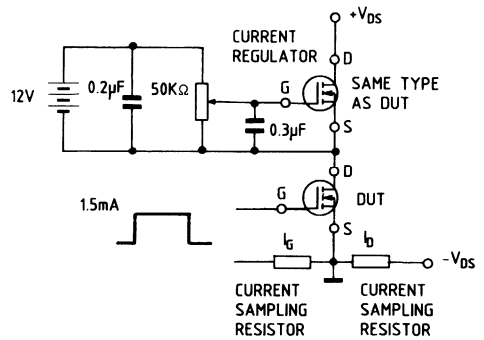
SC-0243

## Switching times test circuit



SC-0246

## Gate charge test circuit



SC-0244

## ISOWATT218 PACKAGE CHARACTERISTICS AND APPLICATION.

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The structure of the case ensures optimum distances between the pins and heatsink. These distances are in agreement with VDE and UL creepage and clearance standards. The ISOWATT218 package eliminates the need for external isolation so reducing fixing hardware.

The package is supplied with leads longer than the standard TO-218 to allow easy mounting on pcbs. Accurate moulding techniques used in manufacture assures consistent heat spreader-to-heatsink capacitance

ISOWATT218 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT218 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

## THERMAL IMPEDANCE OF ISOWATT218 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT218 package.

The total thermal resistance  $R_{th \text{ (tot)}}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

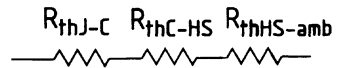
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

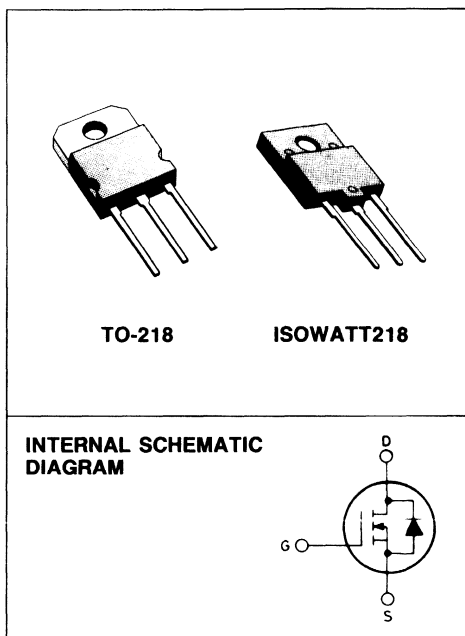
| TYPE      | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> * |
|-----------|------------------|---------------------|------------------|
| IRFP450   | 500 V            | 0.4 Ω               | 14 A             |
| IRFP450FI | 500 V            | 0.4 Ω               | 9 A              |
| IRFP451   | 450 V            | 0.4 Ω               | 14 A             |
| IRFP451FI | 450 V            | 0.4 Ω               | 9 A              |
| IRFP452   | 500 V            | 0.5 Ω               | 12 A             |
| IRFP452FI | 500 V            | 0.5 Ω               | 8 A              |
| IRFP453   | 450 V            | 0.5 Ω               | 12 A             |
| IRFP453FI | 450 V            | 0.5 Ω               | 8 A              |

- HIGH VOLTAGE - 450V FOR OFF LINE SMPS
- HIGH CURRENT - 12A FOR UP TO 350W SMPS
- ULTRA FAST SWITCHING - FOR OPERATION AT > 100 KHz
- EASY DRIVE - REDUCES COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCHING MODE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications.



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | TO-218<br>ISOWATT218 |       | IRFP       |       |  |  |      |
|---------------------|-------------------------------------------------|----------------------|-------|------------|-------|--|--|------|
|                     |                                                 | 450                  | 451   | 452        | 453   |  |  |      |
|                     |                                                 | 450FI                | 451FI | 452FI      | 453FI |  |  |      |
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      | 500                  | 450   | 500        | 450   |  |  | V    |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 500                  | 450   | 500        | 450   |  |  | V    |
| V <sub>GS</sub>     | Gate-source voltage                             | ± 20                 |       |            |       |  |  | V    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 56                   | 56    | 48         | 48    |  |  | A    |
| I <sub>DLM</sub>    | Drain inductive current, clamped (L = 100 μH)   | 56                   | 56    | 48         | 48    |  |  | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 450                  | 451   | 452        | 453   |  |  | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 14                   | 14    | 12         | 12    |  |  | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 8.8                  | 8.8   | 7.9        | 7.9   |  |  | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 450FI                | 451FI | 452FI      | 453FI |  |  | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 9                    | 9     | 8          | 8     |  |  | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 5.6                  | 5.6   | 5          | 5     |  |  | A    |
| P <sub>tot</sub> *  | Total dissipation at T <sub>c</sub> < 25°C      | TO-218               |       | ISOWATT218 |       |  |  | W    |
|                     | Derating factor                                 | 180                  |       | 70         |       |  |  | W/°C |
| T <sub>stg</sub>    | Storage temperature                             | 1.44                 |       | 0.55       |       |  |  | °C   |
| T <sub>j</sub>      | Max. operating junction temperature             | -55 to 150           |       | 150        |       |  |  | °C   |

\* T<sub>j</sub> = 25°C to 125°C

(\*) Repetitive Rating: Pulse width limited by max junction temperature.

■ See note on ISOWATT218 on this datasheet.

**THERMAL DATA \*****TO-218****ISOWATT218**

|                  |                                                |     |      |     |      |
|------------------|------------------------------------------------|-----|------|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.69 | 1.8 | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.1  |     | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 30   |     | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300  |     | °C   |

**ELECTRICAL CHARACTERISTICS** ( $T_{case} = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                                                                                  |  |            |  |             |                                |
|----------------|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------|--|------------|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$ $V_{GS} = 0$<br>for <b>IRFP450/452/450FI/452FI</b><br>for <b>IRFP451/453/451FI/453FI</b> |  | 500<br>450 |  |             | V<br>V                         |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}\text{C}$              |  |            |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                                                                      |  |            |  | $\pm 500$   | nA                             |

**ON \*\***

|               |                                   |                                                                                                                                                        |  |          |  |            |                      |
|---------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|--|----------|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 250 \mu\text{A}$                                                                                                              |  | 2        |  | 4          | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$ $V_{GS} = 10 \text{ V}$<br>for <b>IRFP450/451/450FI/451FI</b><br>for <b>IRFP452/453/452FI/453FI</b> |  | 14<br>12 |  |            | A<br>A               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ $I_D = 7.9 \text{ A}$<br>for <b>IRFP450/451/450FI/451FI</b><br>for <b>IRFP452/453/452FI/453FI</b>                              |  |          |  | 0.4<br>0.5 | $\Omega$<br>$\Omega$ |

**DYNAMIC**

|             |                              |                                                                             |  |     |  |      |     |
|-------------|------------------------------|-----------------------------------------------------------------------------|--|-----|--|------|-----|
| $g_{fs} **$ | Forward transconductance     | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$<br>$I_D = 7.9 \text{ A}$ |  | 9.3 |  |      | mho |
| $C_{iss}$   | Input capacitance            | $V_{DS} = 25 \text{ V}$ $f = 1 \text{ MHz}$<br>$V_{GS} = 0$                 |  |     |  | 3000 | pF  |
| $C_{oss}$   | Output capacitance           |                                                                             |  |     |  | 600  | pF  |
| $C_{rss}$   | Reverse transfer capacitance |                                                                             |  |     |  | 200  | pF  |

**SWITCHING**

|              |                     |                                                                                                               |  |  |  |     |    |
|--------------|---------------------|---------------------------------------------------------------------------------------------------------------|--|--|--|-----|----|
| $t_{d(on)}$  | Turn-on time        | $V_{DD} = 210 \text{ V}$ $I_D = 7.0 \text{ A}$                                                                |  |  |  | 35  | ns |
| $t_r$        | Rise time           | $R_i = 4.7 \Omega$                                                                                            |  |  |  | 50  | ns |
| $t_{d(off)}$ | Turn-off delay time | (see test circuit)                                                                                            |  |  |  | 150 | ns |
| $t_f$        | Fall time           |                                                                                                               |  |  |  | 70  | ns |
| $Q_g$        | Total Gate Charge   | $V_{GS} = 10 \text{ V}$ $I_D = 13 \text{ A}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) |  |  |  | 120 | nC |

ELECTRICAL CHARACTERISTICS (Continued)

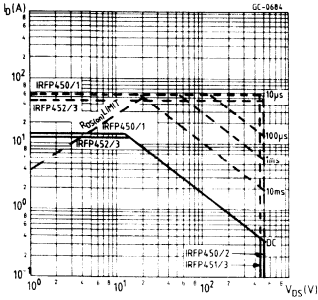
| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

SOURCE DRAIN DIODE

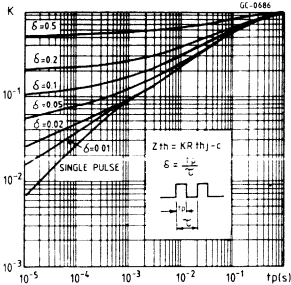
|               |                               |                           |                                    |      |               |
|---------------|-------------------------------|---------------------------|------------------------------------|------|---------------|
| $I_{SD}$      | Source-drain current          |                           |                                    | 14   | A             |
| $I_{SDM}$ (*) | Source-drain current (pulsed) |                           |                                    | 56   | A             |
| $V_{SD}$      | Forward on voltage            | $I_{SD} = 14\text{ A}$    | $V_{GS} = 0$                       | 1.4  | V             |
| $t_{rr}$      | Reverse recovery time         | $T_j = 150^\circ\text{C}$ |                                    | 1300 | ns            |
| $Q_{rr}$      | Reverse recovered charge      | $I_{SD} = 14\text{ A}$    | $di/dt = 100\text{ A}/\mu\text{s}$ | 7.4  | $\mu\text{C}$ |

- \*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 1.5\%$   
(\*) Repetitive Rating: Pulse width limited by max junction temperature  
■ See note on ISOWATT218 in this datasheet.

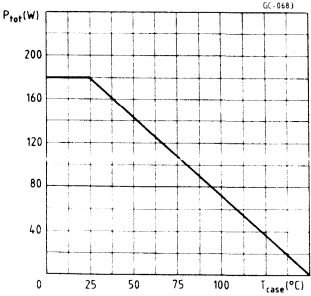
Safe operating areas  
(standard package)



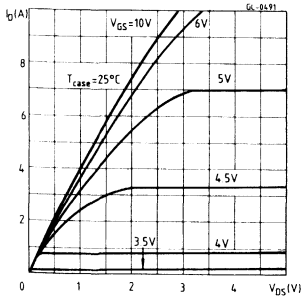
Thermal impedance  
(standard package)



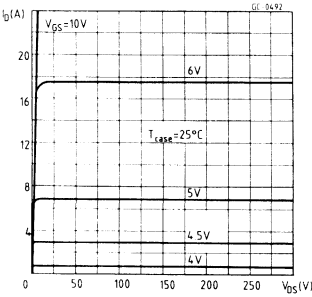
Derating curve  
(standard package)



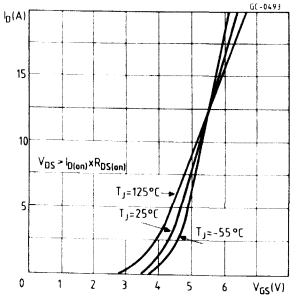
Output characteristics



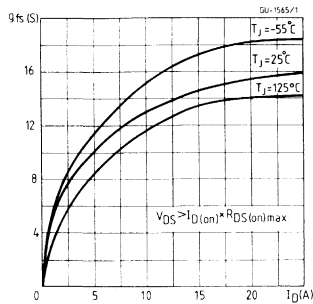
Output characteristics



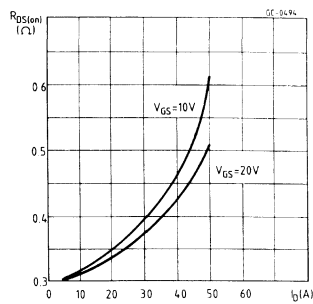
Transfer characteristics



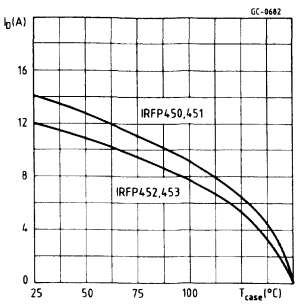
Transconductance



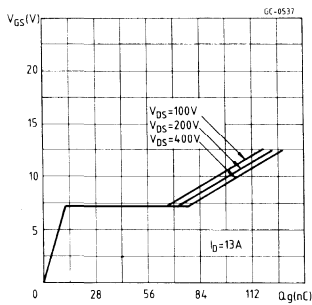
Static drain-source on resistance



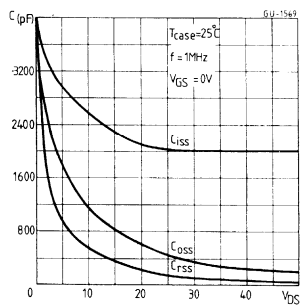
Maximum drain current vs temperature



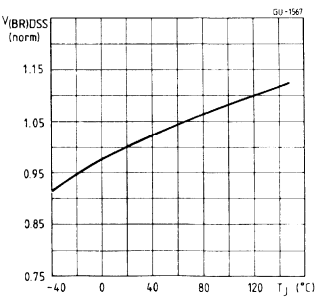
Gate charge vs gate-source voltage



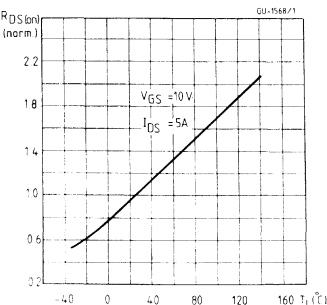
Capacitance variation



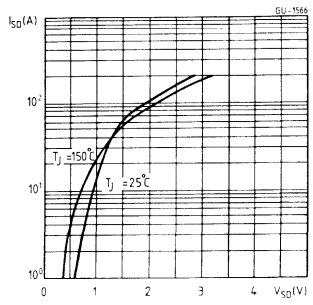
Normalized breakdown voltage vs temperature



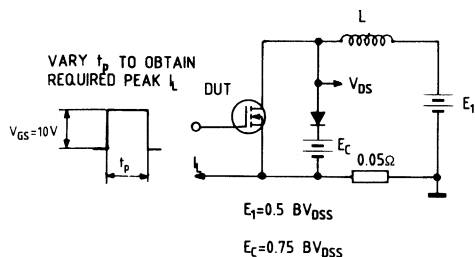
Normalized on resistance vs temperature



Source-drain diode forward characteristics

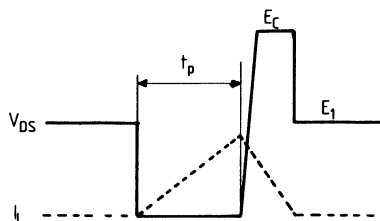


### Clamped inductive test circuit



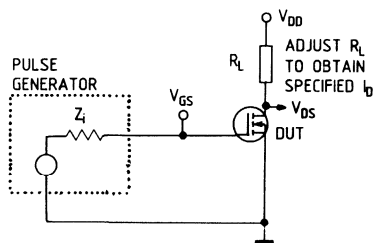
SC-0242

### Clamped inductive waveforms



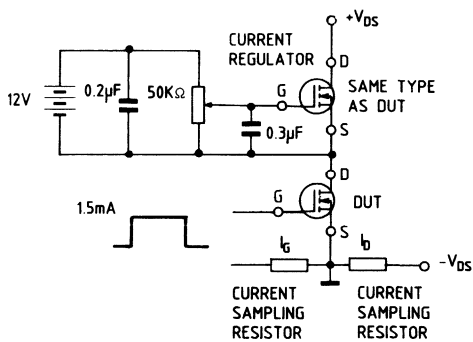
SC-0243

### Switching times test circuit



SC-0246

### Gate charge test circuit



SC-0244

**ISOWATT218 PACKAGE  
CHARACTERISTICS AND APPLICATION.**

ISOWATT218 is fully isolated to 4000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. These distances are in agreement with VDE and UL creepage and clearance standards. The ISOWATT218 package eliminates the need for external isolation so reducing fixing hardware.

The package is supplied with leads longer than the standard TO-218 to allow easy mounting on pcbs. Accurate moulding techniques used in manufacture assures consistent heat spreader-to-heatsink capacitance

ISOWATT218 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT218 packages is determined by:

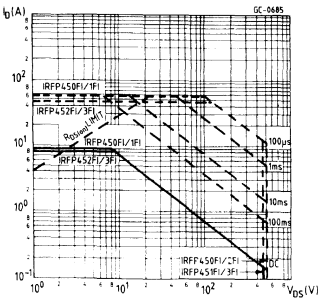
$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

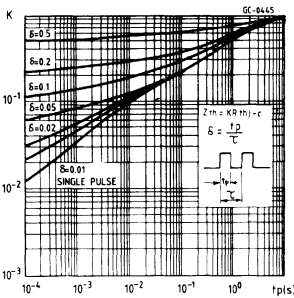
$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

**ISOWATT DATA**

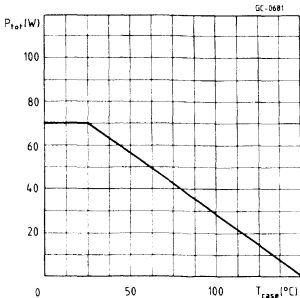
Safe operating areas



Thermal impedance



Derating curve



**THERMAL IMPEDANCE OF  
ISOWATT218 PACKAGE**

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT218 package.

The total thermal resistance  $R_{th(tot)}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

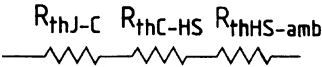
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

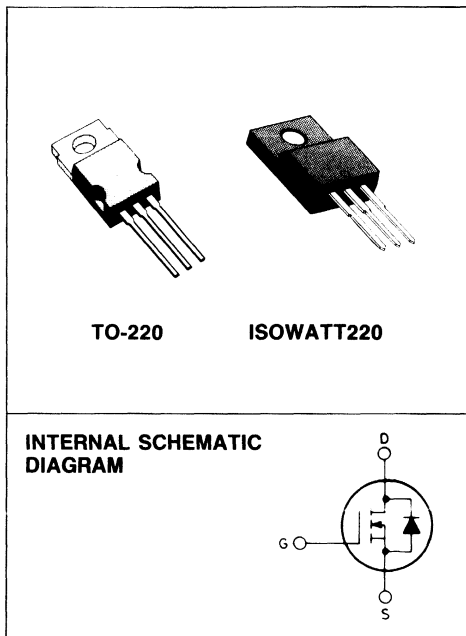
| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|----------|------------------|---------------------|----------------|
| IRFZ20   | 50 V             | 0.1 Ω               | 15 A           |
| IRFZ20FI | 50 V             | 0.1 Ω               | 12.5 A         |
| IRFZ22   | 50 V             | 0.12 Ω              | 14 A           |
| IRFZ20FI | 50 V             | 0.12 Ω              | 12 A           |

- N-CHANNEL POWER MOS TRANSISTORS
- VERY LOW R<sub>DS(on)</sub>
- LOW DRIVE ENERGY FOR EASY DRIVE
- COST EFFECTIVE

### INDUSTRIAL APPLICATIONS:

- AUTOMOTIVE POWER ACTUATORS
- MOTOR CONTROLS
- INVERTERS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching circuits applications such as power actuators driving, motor drive including brushless motors, hydraulic actuator and many other in automotive and automatic guided vehicle applications. They also find use DC/DC converters and uninterruptible power supplies



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | IRF          |              |
|---------------------|-------------------------------------------------|--------------|--------------|
|                     |                                                 | Z20<br>Z20FI | Z22<br>Z22FI |
| V <sub>DS</sub> *   | Drain-source voltage (V <sub>GS</sub> = 0)      | 50           | 50           |
| V <sub>DGR</sub> *  | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 50           | 50           |
| V <sub>GS</sub>     | Gate-source voltage                             | ±20          | ±20          |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 60           | 56           |
| I <sub>DLM</sub>    | Drain inductive current, clamped (L = 100 μH)   | 60           | 56           |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 15           | 14           |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 10           | 9            |
| I <sub>D</sub> ■    | Drain current (cont.) at T <sub>c</sub> = 25°C  | 12.5         | 12           |
| I <sub>D</sub> ■    | Drain current (cont.) at T <sub>c</sub> = 100°C | 7.5          | 7            |
| P <sub>tot</sub> ■  | Total dissipation at T <sub>c</sub> < 25°C      | 40           | 30           |
| T <sub>stg</sub>    | Storage temperature                             | 0.32         | 0.24         |
| T <sub>j</sub>      | Max. operating junction temperature             | 150          | 150          |

\* T<sub>j</sub> = 25°C to 125°C

(\*) Repetitive Rating: Pulse width limited by max junction temperature

■ See note on ISOWATT220 in this datasheet

THERMAL DATA \*

|                  |                                                | TO-220 |      | ISOWATT220 |      |
|------------------|------------------------------------------------|--------|------|------------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max    | 3.12 | 4.16       | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ    | 0.5  |            | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max    | 80   |            | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |        | 300  |            | °C   |

ELECTRICAL CHARACTERISTICS (T<sub>case</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                             |    |  |             |                    |
|----------------|--------------------------------------------------|---------------------------------------------------------------------------------------------|----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$ $V_{GS} = 0$                                                              | 50 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^\circ C$ |    |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                         |    |  | $\pm 500$   | nA                 |

ON \*\*

|               |                                   |                                                                                                           |          |  |              |                      |
|---------------|-----------------------------------|-----------------------------------------------------------------------------------------------------------|----------|--|--------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 250 \mu A$                                                                       | 2        |  | 4            | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D (on)} \times R_{DS(on) max}$ $V_{GS} = 10 V$<br>for IRFZ20/IRFZ20FI<br>for IRFZ22/IRFZ22FI | 15<br>14 |  |              | A<br>A               |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 9.0 A$<br>for IRFZ20/IRFZ20FI<br>for IRFZ22/IRFZ22FI                               |          |  | 0.10<br>0.12 | $\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                                               |   |  |                   |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------|---|--|-------------------|----------------|
| $g_{fs} **$                         | Forward transconductance                                                | $V_{DS} > I_{D (on)} \times R_{DS (on) max}$<br>$I_D = 9.0 A$ | 5 |  |                   | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$ $f = 1 MHz$<br>$V_{GS} = 0$                   |   |  | 850<br>350<br>100 | pF<br>pF<br>pF |

SWITCHING

|                                                 |                                                               |                                                                                               |  |  |                      |                      |
|-------------------------------------------------|---------------------------------------------------------------|-----------------------------------------------------------------------------------------------|--|--|----------------------|----------------------|
| $t_{d (on)}$<br>$t_r$<br>$t_{d (off)}$<br>$t_f$ | Turn-on time<br>Rise time<br>Turn-off delay time<br>Fall time | $V_{DD} = 25 V$ $I_D = 9.0 A$<br>$R_l = 50 \Omega$<br>(see test circuit)                      |  |  | 30<br>90<br>40<br>30 | ns<br>ns<br>ns<br>ns |
| $Q_g$                                           | Total Gate Charge                                             | $V_{GS} = 10 V$ $I_D = 20 A$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) |  |  | 17                   | nC                   |

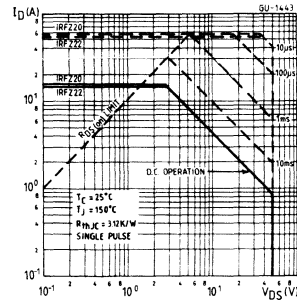


ELECTRICAL CHARACTERISTICS (Continued)

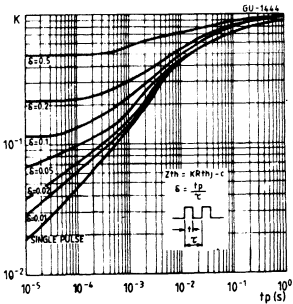
| Parameters                        | Test Conditions                                                                            | Min. | Typ. | Max.                 | Unit               |
|-----------------------------------|--------------------------------------------------------------------------------------------|------|------|----------------------|--------------------|
| $I_{SD}$ Source-drain current     | for IRFZ20/IRFZ20FI<br>for IRFZ22/IRFZ22FI<br>for IRFZ20/IRFZ20FI<br>for IRFZ22/IRFZ22FI   |      |      | 15<br>14<br>60<br>56 | ns<br>ns<br>A<br>A |
| $V_{SD}^{**}$ Forward on voltage  | $V_{GS} = 0$<br>for IRFZ20/IRFZ20FI $I_{SD} = 15$ A<br>for IRFZ22/IRFZ22FI $I_{SD} = 14$ A |      |      | 1.5<br>1.4           | V<br>V             |
| $t_{rr}$ Reverse recovery time    | $T_J = 150^\circ\text{C}$                                                                  |      | 100  |                      | ns                 |
| $Q_{rr}$ Reverse recovered charge | $I_{SD} = 15$ A $di/dt = 100$ A/ $\mu\text{s}$                                             |      | 0.4  |                      | $\mu\text{C}$      |

\*\* Pulsed: Pulse duration  $\leq 300 \mu\text{s}$ , duty cycle  $\leq 1.5\%$   
 (\*) Repetitive Rating: Pulse width limited by max junction temperature  
 ■ See note on ISOWATT220 in this datasheet

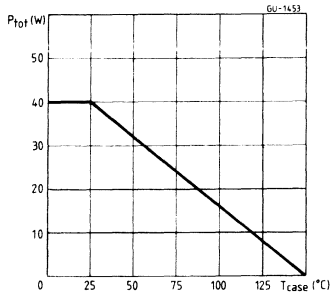
Safe operating areas  
(standard package)



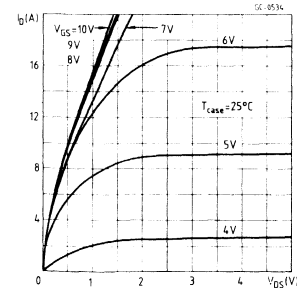
Thermal impedance  
(standard package)



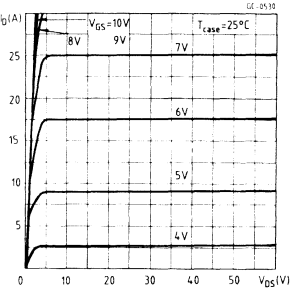
Derating curve  
(standard package)



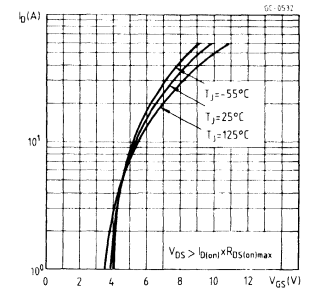
Output characteristics



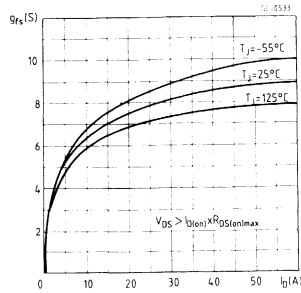
Output characteristics



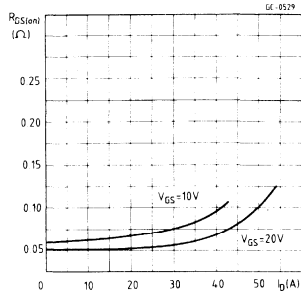
Transfer characteristics



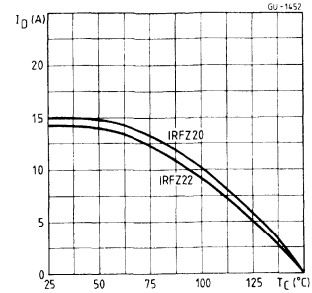
Transconductance



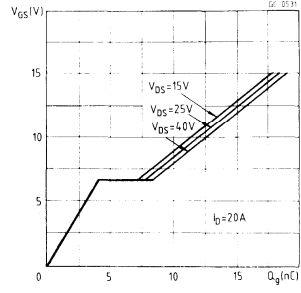
Static drain-source on resistance



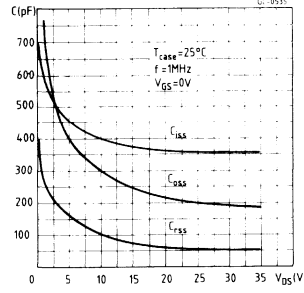
Maximum drain current vs temperature



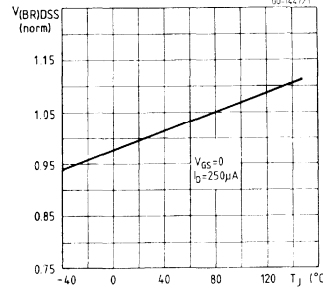
Gate charge vs gate-source voltage



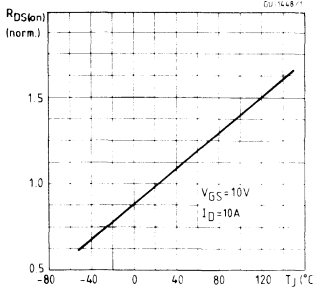
Capacitance variation



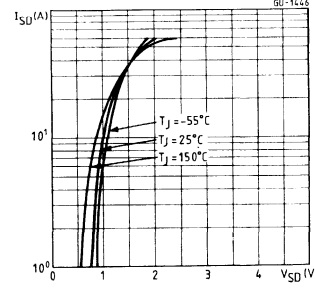
Normalized breakdown voltage vs temperature



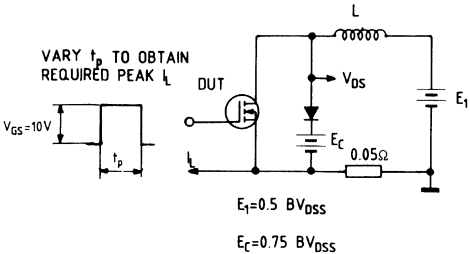
Normalized on resistance vs temperature



Source-drain diode forward characteristics

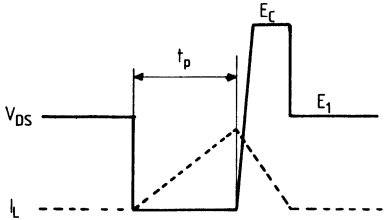


Clamped inductive test circuit



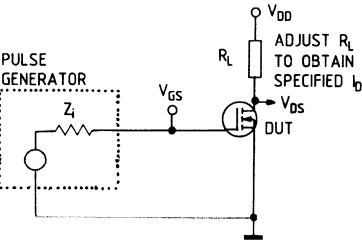
SC-0242

Clamped inductive waveforms



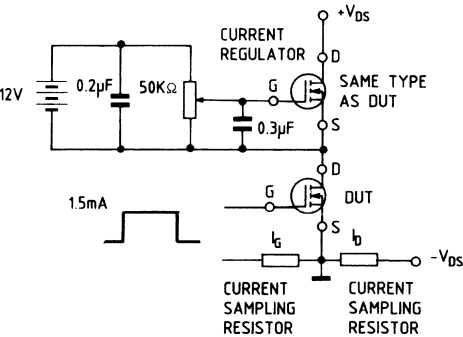
SC-0243

Switching times test circuit



SC-0246

Gate charge test circuit



SC-0244

ISOWATT220 PACKAGE  
CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation. The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance. ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^{\circ}\text{C)}}}$$

THERMAL IMPEDANCE OF  
ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package. The total thermal resistance  $R_{th(tot)}$  is the sum of each of these elements. The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

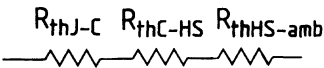
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

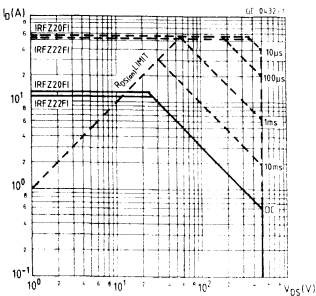
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

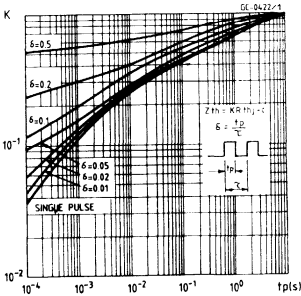


ISOWATT DATA

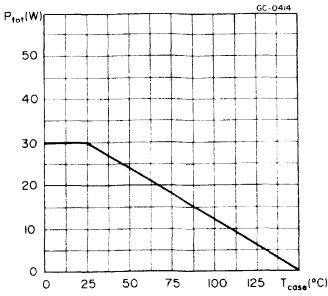
Safe operating areas



Thermal impedance



Derating curve



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

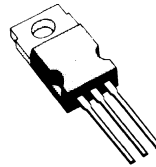
| TYPE   | V <sub>DS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|-----------------|---------------------|----------------|
| IRFZ40 | 50 V            | 0.028 Ω             | 35 A           |
| IRFZ42 | 50 V            | 0.035 Ω             | 35 A           |

- VERY LOW R<sub>DS(on)</sub>
- LOW DRIVE ENERGY FOR EASY DRIVE
- HIGH TRANSCONDUCTANCE /C<sub>rss</sub> RATIO

### INDUSTRIAL APPLICATIONS:

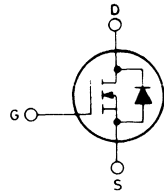
- AUTOMOTIVE POWER ACTUATORS
- MOTOR CONTROLS
- INVERTERS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching circuits applications such as power actuators driving, motor drive including brushless motor, hydraulic actuators and many other in automotive and automatic guided vehicle applications. They also find use DC/DC converters and uninterruptible power supplies



TO-220

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     | IRFZ40     | IRFZ42 |      |
|---------------------|------------|--------|------|
| V <sub>DS</sub> *   |            | 50     | V    |
| V <sub>DGR</sub> *  |            | 50     | V    |
| V <sub>GS</sub>     |            | ± 20   | V    |
| I <sub>D</sub>      | 35         | 35     | A    |
| I <sub>D</sub>      | 32         | 29     | A    |
| I <sub>DM</sub> (*) | 160        | 145    | A    |
| I <sub>DLM</sub>    | 160        | 145    | A    |
| P <sub>tot</sub>    |            | 125    | W    |
|                     |            | 1.2    | W/°C |
| T <sub>stg</sub>    | -55 to 150 |        | °C   |
| T <sub>j</sub>      | 150        |        | °C   |

\* T<sub>j</sub> = 25°C to 125°C

(\*) Repetitive Rating: Pulse width limited by max junction temperature

**THERMAL DATA**

|                  |                                                |     |     |      |
|------------------|------------------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.0 | °C/W |
| $R_{thc-s}$      | Thermal resistance case-sink                   | typ | 0.5 | °C/W |
| $R_{thj-amb}$    | Thermal resistance junction-ambient            | max | 80  | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose |     | 300 | °C   |

**ELECTRICAL CHARACTERISTICS** ( $T_{case} = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                                                                     |    |  |             |                                |
|----------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------|----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$ $V_{GS} = 0$                                                                | 50 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}\text{C}$ |    |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                                                         |    |  | $\pm 500$   | nA                             |

**ON \*\***

|               |                                   |                                                                            |    |  |                |                      |
|---------------|-----------------------------------|----------------------------------------------------------------------------|----|--|----------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 250 \mu\text{A}$                                  | 2  |  | 4              | V                    |
| $I_{D(on)}$   | On-state drain current            | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$ $V_{GS} = 10 \text{ V}$ | 35 |  |                | A                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$<br>for <b>IRFZ40</b><br>for <b>IRFZ42</b>          |    |  | 0.028<br>0.035 | $\Omega$<br>$\Omega$ |

**DYNAMIC**

|                                     |                                                                         |                                                                            |    |  |                     |                |
|-------------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------------|----|--|---------------------|----------------|
| $g_{fs} **$                         | Forward transconductance                                                | $V_{DS} > I_{D(on)} \times R_{DS(on) \text{ max}}$<br>$I_D = 29 \text{ A}$ | 17 |  |                     | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 \text{ V}$ $f = 1 \text{ MHz}$<br>$V_{GS} = 0$                |    |  | 3000<br>1200<br>400 | pF<br>pF<br>pF |

**SWITCHING**

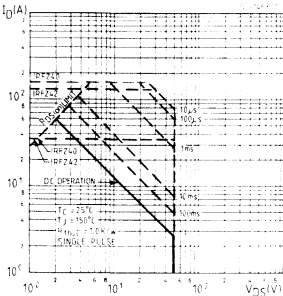
|                                                 |                                                               |                                                                                                               |  |  |                      |                      |
|-------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|--|--|----------------------|----------------------|
| $t_{d (on)}$<br>$t_r$<br>$t_{d (off)}$<br>$t_f$ | Turn-on time<br>Rise time<br>Turn-off delay time<br>Fall time | $V_{DD} = 25 \text{ V}$ $I_D = 29 \text{ A}$<br>$Z_i = 4.7 \Omega$<br>(see test circuit)                      |  |  | 25<br>60<br>70<br>25 | ns<br>ns<br>ns<br>ns |
| $Q_g$                                           | Total gate charge                                             | $V_{GS} = 10 \text{ V}$ $I_D = 64 \text{ A}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>(see test circuit) |  |  | 60                   | nC                   |

ELECTRICAL CHARACTERISTICS (Continued)

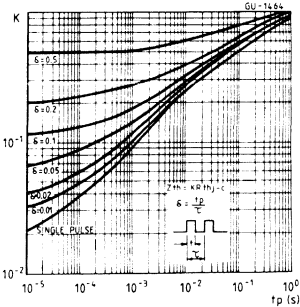
| Parameters                                                                   | Test Conditions                                                                                                | Min. | Typ.       | Max.             | Unit                |
|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|------|------------|------------------|---------------------|
| $I_{SD}$ Source-drain current<br>$I_{SDM}$ (*) Source-drain current (pulsed) | for <b>IRFZ40</b><br>for <b>IRFZ42</b>                                                                         |      |            | 35<br>160<br>145 | A<br>A<br>A         |
| $V_{SD}^{**}$ Forward on voltage                                             | $V_{GS} = 0$<br>for <b>IRFZ40</b><br>for <b>IRFZ42</b><br><br>$I_{SD} = 51\text{ A}$<br>$I_{SD} = 46\text{ A}$ |      |            | 2.5<br>2.2       | V<br>V              |
| $t_{rr}$ Reverse recovery time<br>$Q_{rr}$ Reverse recovered charge          | $T_J = 150^{\circ}\text{C}$<br><br>$I_{SD} = 51\text{ A}$<br><br>$di/dt = 100\text{ A}/\mu\text{s}$            |      | 350<br>2.1 |                  | ns<br>$\mu\text{C}$ |

\*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 1.5\%$   
(\*) Repetitive Rating: Pulse width limited by max junction temperature

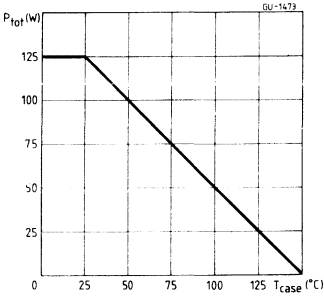
Safe operating areas



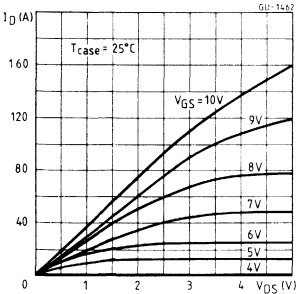
Thermal impedance



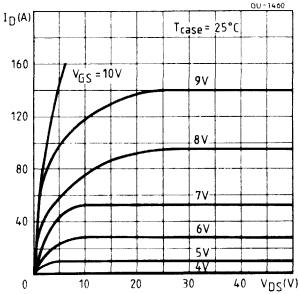
Derating curve



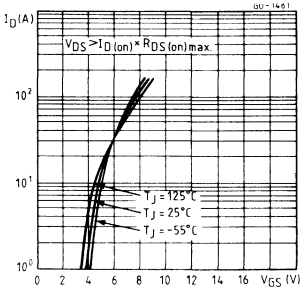
Output characteristics



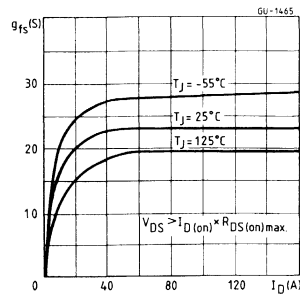
Output characteristics



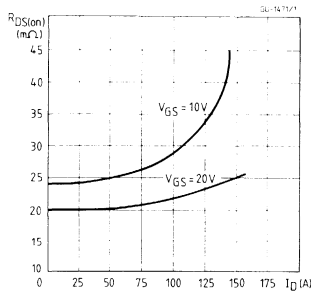
Transfer characteristics



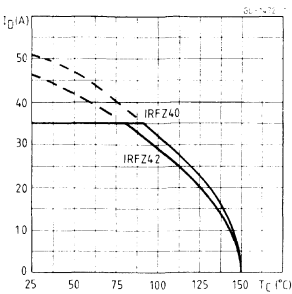
Transconductance



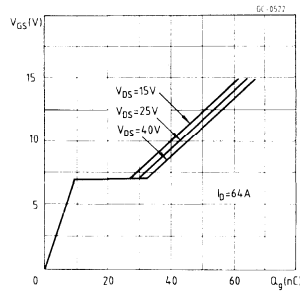
Static drain-source on resistance



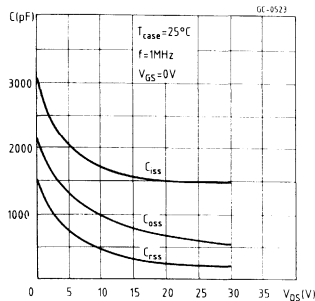
Maximum drain current vs temperature



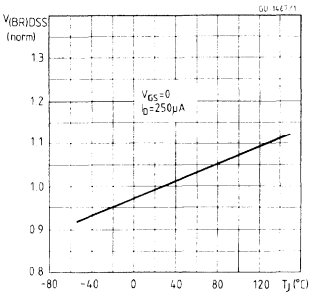
Gate charge vs gate-source voltage



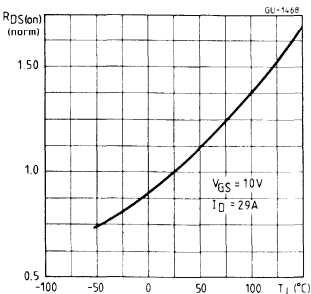
Capacitance variation



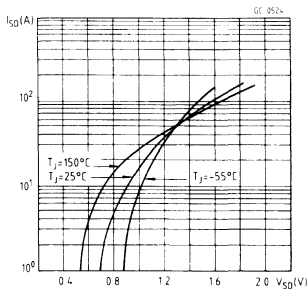
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature

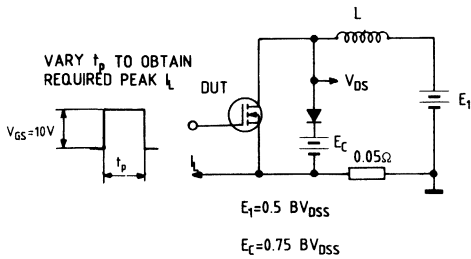


Source-drain diode forward characteristics



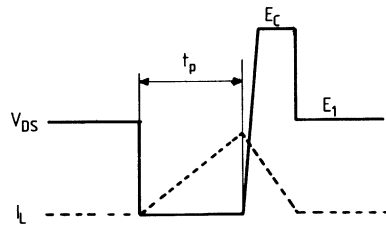


### Clamped inductive test circuit



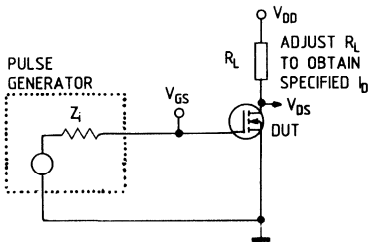
SC-0242

### Clamped inductive waveforms



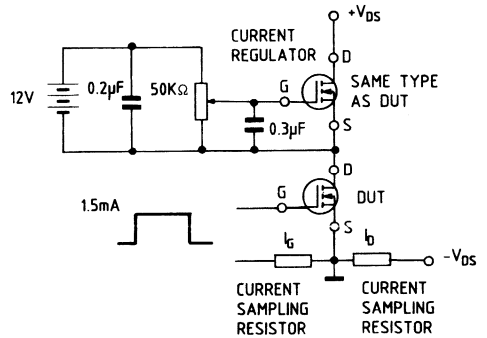
SC-0243

### Switching times test circuit



SC-0246

### Gate charge test circuit



SC-0244



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

PRELIMINARY DATA

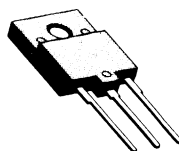
| TYPE      | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-----------|------------------|---------------------|----------------|
| MTH6N60FI | 600 V            | 1.2 Ω               | 3.5 A          |

- HIGH VOLTAGE - 600 V FOR OFF-LINE APPLICATIONS
- ULTRA FAST SWITCHING TIMES FOR OPERATIONS AT > 100KHz
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

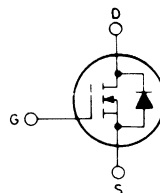
- SWITCHING POWER SUPPLY
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make these POWER MOS ideal for very high speed switching applications. Typical uses include SMPS, uninterruptible power supplies and motor controls.



**ISOWATT218**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                |             |      |
|------------------|------------------------------------------------|-------------|------|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)     | 600         | V    |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)   | 600         | V    |
| V <sub>GS</sub>  | Gate-source voltage                            | ± 20        | V    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> = 25°C | 3.5         | A    |
| I <sub>DM</sub>  | Drain current (pulsed)                         | 14          | A    |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C     | 40          | W    |
|                  | Derating factor                                | 0.32        | W/°C |
| T <sub>stg</sub> | Storage temperature                            | - 65 to 150 | °C   |
| T <sub>j</sub>   | Max. operating junction temperature            | 150         | °C   |

THERMAL DATA

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 3.12 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient |     | 62.5 | °C/W |

ELECTRICAL CHARACTERISTICS
( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                              |     |             |                    |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|-----|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$ $V_{GS} = 0$                                                               | 600 |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}C$ |     | 200<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                          |     | $\pm 500$   | nA                 |

ON

|               |                                   |                                                                                                       |          |  |                    |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------------------------|----------|--|--------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 1 \text{ mA}$<br>$V_{DS} = V_{GS}$ $I_D = 1 \text{ mA}$ $T_c = 100^{\circ}C$ | 2<br>1.5 |  | 4.5<br>4    V<br>V |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 3 A$                                                                           |          |  | 1.2 $\Omega$       |
| $V_{DS(on)}$  | Drain-source on voltage           | $V_{GS} = 10 V$ $I_D = 6 A$<br>$V_{GS} = 10 V$ $I_D = 3 A$ $T_c = 100^{\circ}C$                       |          |  | 8<br>7.2    V<br>V |

DYNAMIC

|           |                              |                                                     |   |  |         |
|-----------|------------------------------|-----------------------------------------------------|---|--|---------|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 10 V$ $I_D = 3 A$                         | 2 |  | mho     |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$ $f = 1 \text{ MHz}$<br>$V_{GS} = 0$ |   |  | 1800 pF |
| $C_{oss}$ | Output capacitance           |                                                     |   |  | 350 pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                     |   |  | 150 pF  |

SWITCHING

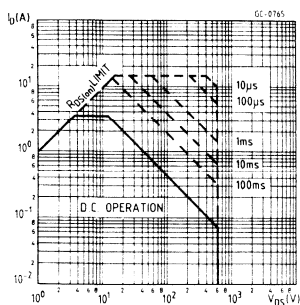
|             |                     |                                                               |  |  |        |
|-------------|---------------------|---------------------------------------------------------------|--|--|--------|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 25 V$ $I_D = 3 A$<br>$R_i = 50 \Omega$ $V_i = 10 V$ |  |  | 60 ns  |
| $t_r$       | Rise time           |                                                               |  |  | 150 ns |
| $t_d (off)$ | Turn-off delay time |                                                               |  |  | 200 ns |
| $t_f$       | Fall time           |                                                               |  |  | 120 ns |

## ELECTRICAL CHARACTERISTICS (Continued)

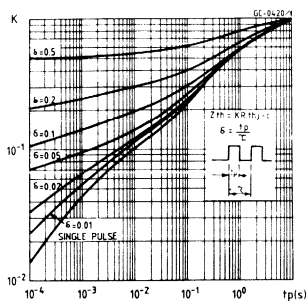
| Parameters                              | Test Conditions                                          | Min. | Typ. | Max. | Unit |
|-----------------------------------------|----------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current           |                                                          |      |      | 3.5  | A    |
| $I_{SDM}$ Source-drain current (pulsed) |                                                          |      |      | 14   | A    |
| $V_{SD}$ Forward on voltage             | $I_{SD} = 6\text{ A}$ $V_{GS} = 0$                       |      | 1.3  |      | V    |
| $t_{rr}$ Reverse recovery time          | $I_{SD} = 6\text{ A}$ $di/dt = 100\text{ A}/\mu\text{s}$ |      | 600  |      | ns   |

## SOURCE DRAIN DIODE

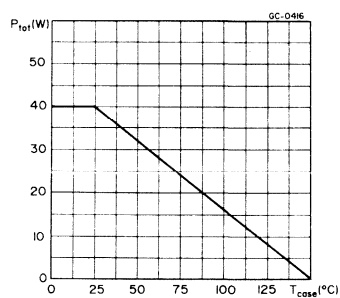
Safe operating areas



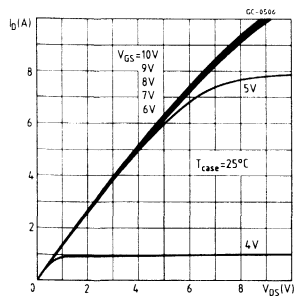
Thermal impedance



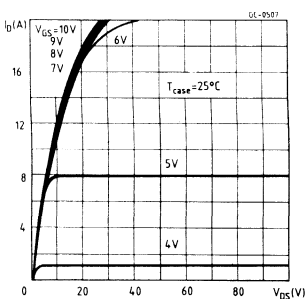
Derating curve



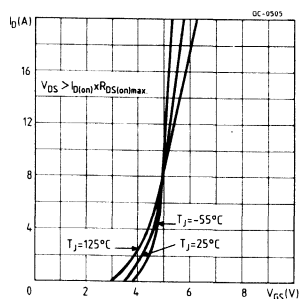
Output characteristics



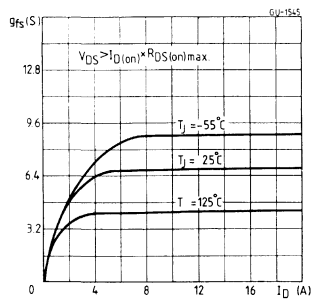
Output characteristics



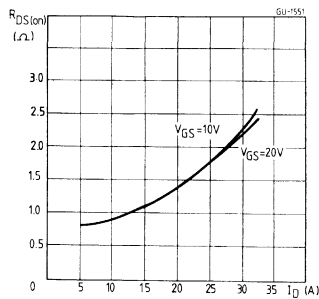
Transfer characteristics



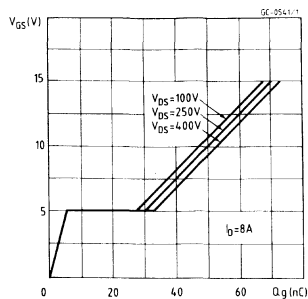
Transconductance



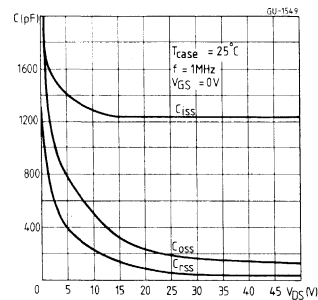
Static drain-source on resistance



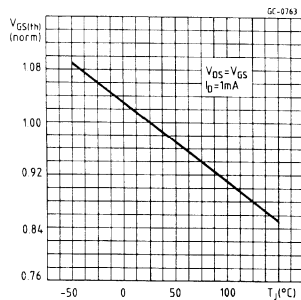
Gate charge vs gate-source voltage



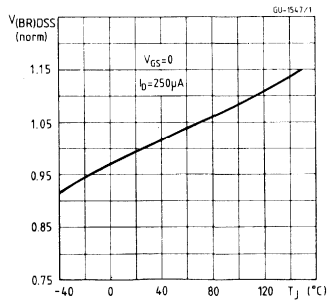
Capacitance variation



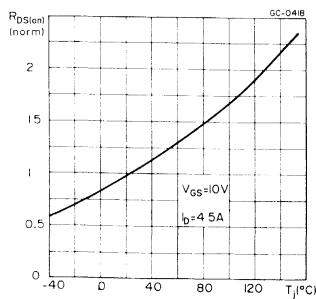
Normalized gate threshold voltage vs temperature



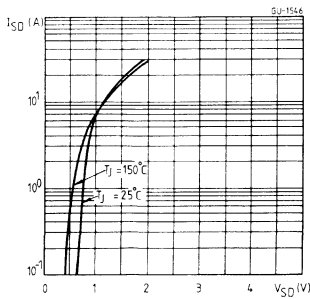
Normalized breakdown voltage vs temperature



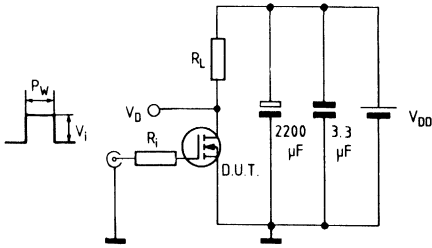
Normalized on resistance vs temperature



Source-drain diode forward characteristics

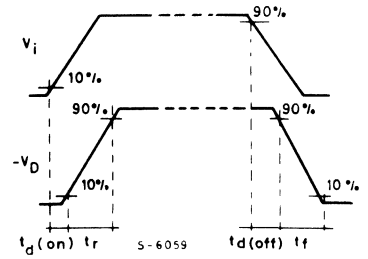


Switching times test circuit for resistive load

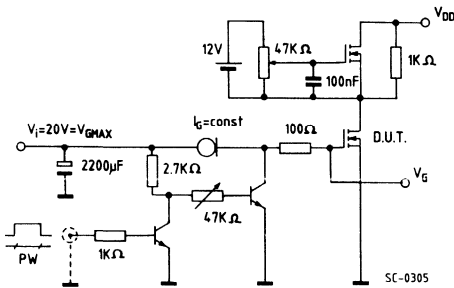


Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

Switching time waveforms for resistive load

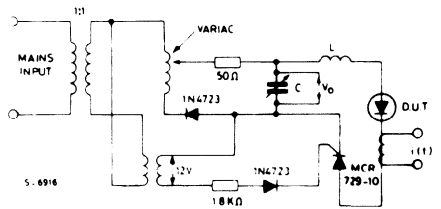


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## ISOWATT218 PACKAGE CHARACTERISTICS AND APPLICATION.

ISOWATT218 is fully isolated to 4000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. These distances are in agreement with VDE and UL creepage and clearance standards. The ISOWATT218 package eliminates the need for external isolation so reducing fixing hardware.

The package is supplied with leads longer than the standard TO-218 to allow easy mounting on pcbs. Accurate moulding techniques used in manufacture assures consistent heat spreader-to-heatsink capacitance

ISOWATT218 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT218 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

## THERMAL IMPEDANCE OF ISOWATT218 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT218 package.

The total thermal resistance  $R_{th \text{ (tot)}}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

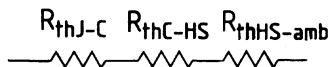
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1





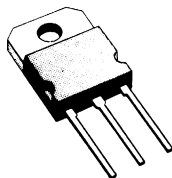
## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

| TYPE       | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|------------|------------------|---------------------|----------------|
| MTH40N06   | 60 V             | 0.028 Ω             | 40 A           |
| MTH40N06FI | 60 V             | 0.028 Ω             | 26 A           |

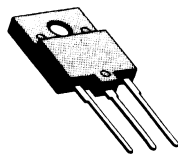
- VERY LOW ON-LOSSES
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- LOW DRIVE ENERGY FOR EASY DRIVE
- HIGH TRANSCONDUCTANCE/C<sub>rss</sub> RATIO

### AUTOMOTIVE POWER APPLICATIONS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching circuit in applications such as power actuator driving, motor drive including brushless motors, hydraulic actuators and many other uses in automotive applications. They also find use in DC/DC converters and uninterruptible power supplies.

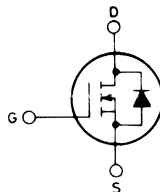


TO-218



ISOWATT218

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

| TO-218<br>ISOWATT218 |                                             | MTH40N06<br>MTH40N06FI |      |
|----------------------|---------------------------------------------|------------------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)  | 60                     | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 1 MΩ) | 60                     | V    |
| V <sub>GS</sub>      | Gate-source voltage                         | ±20                    | V    |
| I <sub>DM</sub>      | Drain current (pulsed)                      | 140                    | A    |
| I <sub>D</sub> ■     | Drain current (cont.) T <sub>c</sub> = 20°C | 40                     | 26   |
| P <sub>tot</sub> ■   | Total dissipation at T <sub>c</sub> < 25°C  | 150                    | 65   |
| ■                    | Derating factor                             | 1.2                    | 0.52 |
| T <sub>stg</sub>     | Storage temperature                         | - 65 to 150 °C         |      |
| T <sub>j</sub>       | Max. operating junction temperature         | 150 °C                 |      |

■ See note on ISOWATT218 in this datasheet

♦ Introduced in 1988 week 44

THERMAL DATA ■

TO-218 | ISOWATT218

|                  |                                                |     |      |      |      |
|------------------|------------------------------------------------|-----|------|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | 1.92 | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose | max | 275  |      | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                           |    |  |             |                    |
|----------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------|----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 100 \mu A$ $V_{GS} = 0$                                                                            | 60 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating} \times 0.85$<br>$V_{DS} = \text{Max Rating} \times 0.85$ $T_c = 100^{\circ}C$ |    |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                                       |    |  | $\pm 100$   | nA                 |

ON \*

|               |                                   |                                                                                                       |          |  |             |          |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------------------------|----------|--|-------------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 1 \text{ mA}$<br>$V_{DS} = V_{GS}$ $I_D = 1 \text{ mA}$ $T_c = 100^{\circ}C$ | 2<br>1.5 |  | 4.5<br>4    | V<br>V   |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 20 A$                                                                          |          |  | 0.028       | $\Omega$ |
| $V_{DS (on)}$ | Drain-source on voltage           | $V_{GS} = 10 V$ $I_D = 40 A$<br>$V_{GS} = 10 V$ $I_D = 20 A$ $T_c = 100^{\circ}C$                     |          |  | 1.4<br>1.12 | V<br>V   |

ENERGY TEST

|           |                                                      |                                                                 |    |  |  |   |
|-----------|------------------------------------------------------|-----------------------------------------------------------------|----|--|--|---|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 V$ $L = 100 \mu H$<br>starting $T_j = 25^{\circ}C$ | 40 |  |  | A |
|-----------|------------------------------------------------------|-----------------------------------------------------------------|----|--|--|---|

DYNAMIC

|                                     |                                                                         |                                                     |    |  |                      |                |
|-------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------|----|--|----------------------|----------------|
| $g_{fs}^*$                          | Forward transconductance                                                | $V_{DS} = 15 V$ $I_D = 20 A$                        | 10 |  |                      | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$ $f = 1 \text{ MHz}$<br>$V_{GS} = 0$ |    |  | 5000<br>2500<br>1000 | pF<br>pF<br>pF |
| $Q_g$                               | Total gate charge                                                       | $V_{DS} = 50 V$ $I_D = 40 A$<br>$V_{GS} = 10 V$     |    |  | 120                  | nC             |

ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

SWITCHING

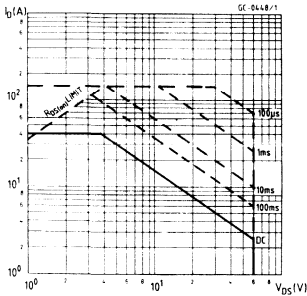
|             |                     |                              |                     |  |     |    |
|-------------|---------------------|------------------------------|---------------------|--|-----|----|
| $t_d$ (on)  | Turn-on time        | $V_{DD} = 25\text{ V}$       | $I_D = 20\text{ A}$ |  | 50  | ns |
| $t_r$       | Rise time           | $R_{gen} = 50\text{ }\Omega$ |                     |  | 300 | ns |
| $t_d$ (off) | Turn-off delay time |                              |                     |  | 150 | ns |
| $t_f$       | Fall time           |                              |                     |  | 100 | ns |

SOURCE DRAIN DIODE

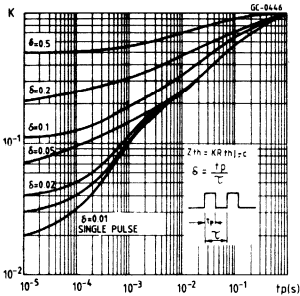
|          |                       |                        |              |  |     |    |
|----------|-----------------------|------------------------|--------------|--|-----|----|
| $V_{SD}$ | Forward on voltage    | $I_{SD} = 40\text{ A}$ | $V_{GS} = 0$ |  | 3   | V  |
| $t_{rr}$ | Reverse recovery time | $I_{SD} = 40\text{ A}$ | $V_{GS} = 0$ |  | 200 | ns |
| $t_{on}$ | Forward turn-on time  |                        |              |  | 150 | ns |

- Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$
- See note on ISOWATT218 in this datasheet

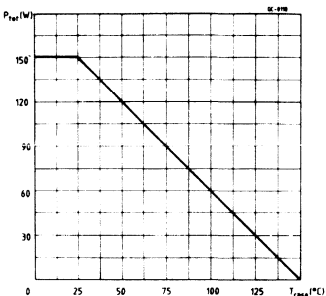
Safe operating areas  
(standard package)



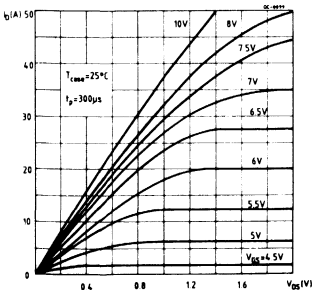
Thermal impedance  
(standard package)



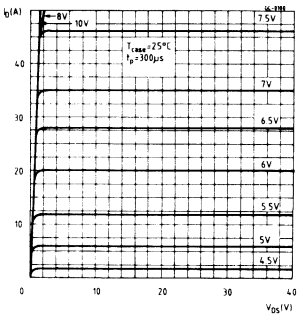
Derating curve  
(standard package)



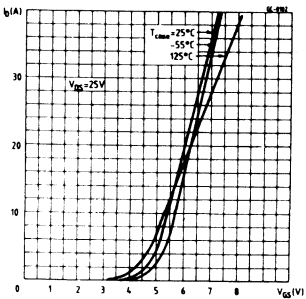
Output characteristics



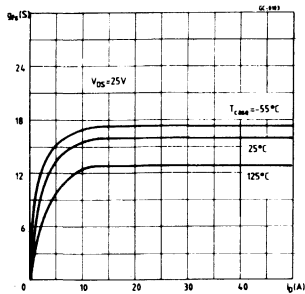
Output characteristics



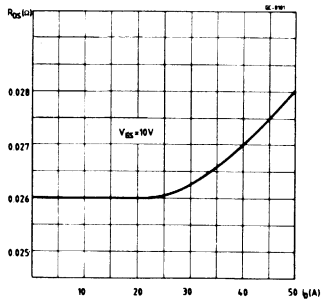
Transfer characteristics



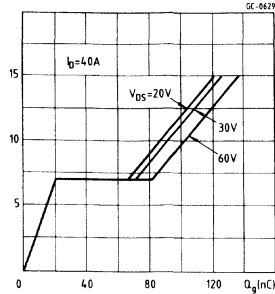
Transconductance



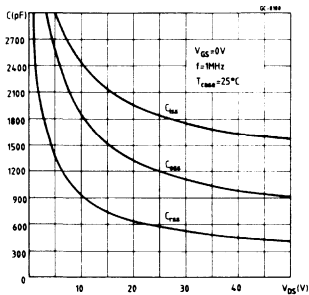
Static drain-source on resistance



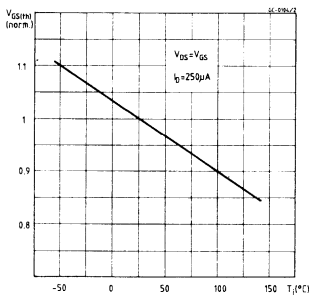
Gate charge vs gate-source voltage



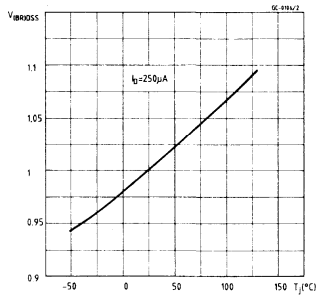
Capacitance variation



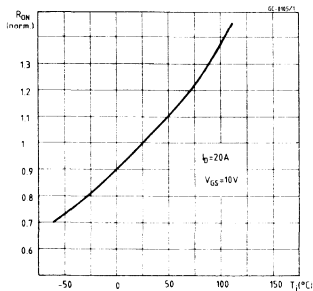
Normalized gate threshold voltage vs temperature



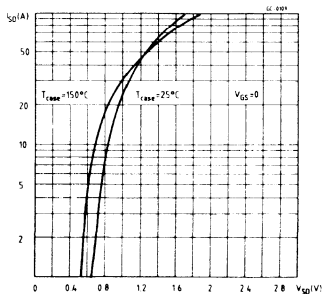
Normalized breakdown voltage vs temperature



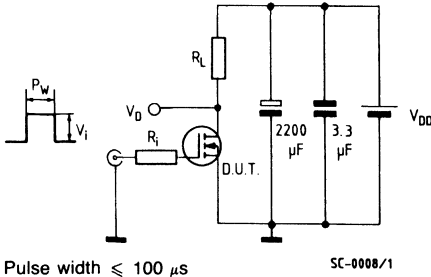
Normalized on resistance vs temperature



Source-drain diode forward characteristics

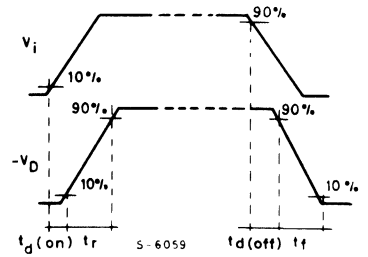


Switching times test circuit for resistive load

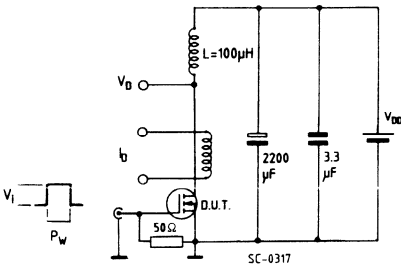


Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

Switching time waveforms for resistive load

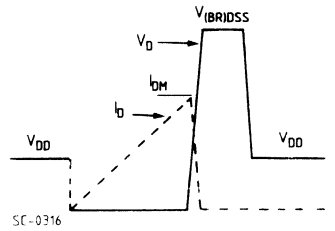


Unclamped inductive load test circuit

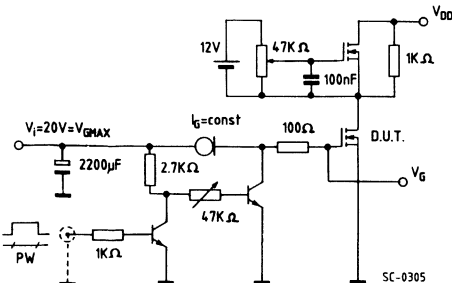


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$

Unclamped inductive waveforms

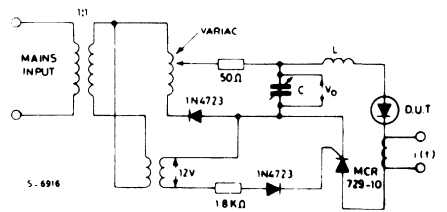


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## ISOWATT218 PACKAGE CHARACTERISTICS AND APPLICATION.

ISOWATT218 is fully isolated to 4000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. These distances are in agreement with VDE and UL creepage and clearance standards. The ISOWATT218 package eliminates the need for external isolation so reducing fixing hardware.

The package is supplied with leads longer than the standard TO-218 to allow easy mounting on pcbs. Accurate moulding techniques used in manufacture assures consistent heat spreader-to-heatsink capacitance

ISOWATT218 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT218 packages is determined by:

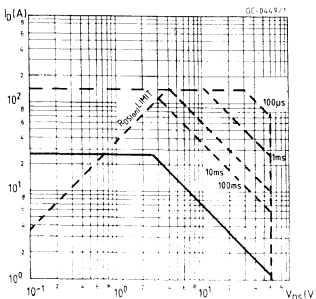
$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

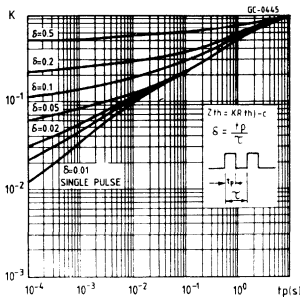
$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

## ISOWATT DATA

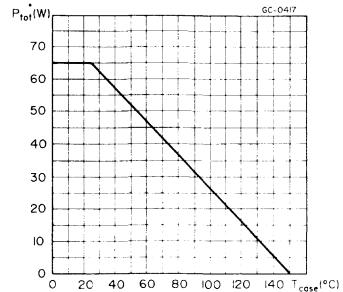
### Safe operating areas



### Thermal impedance



### Derating curve



## THERMAL IMPEDANCE OF ISOWATT218 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT218 package.

The total thermal resistance  $R_{th(tot)}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

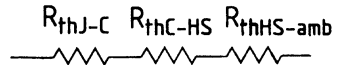
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

PRELIMINARY DATA

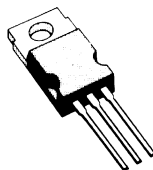
| TYPE      | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-----------|------------------|---------------------|----------------|
| MTP3N60   | 600 V            | 2.5 Ω               | 3 A            |
| MTP3N60FI | 600 V            | 2.5 Ω               | 2.5 A          |

- HIGH VOLTAGE FOR OFF-LINE APPLICATIONS
- ULTRA FAST SWITCHING TIMES FOR OPERATION AT > 100KHz
- EASY DRIVE FOR REDUCED COST AND SIZE

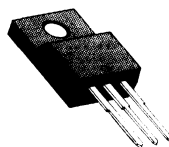
### INDUSTRIAL APPLICATIONS

- SWITCHING POWER SUPPLIES

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and fast switching times make these POWER MOS ideal for very high speed switching applications. Typical uses include SMPS and uninterruptible power supplies.

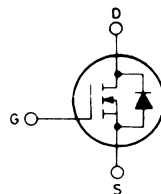


**TO-220**



**ISOWATT220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                |                    |                            |
|------------------|------------------------------------------------|--------------------|----------------------------|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)     | 600                | V                          |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)   | 600                | V                          |
| V <sub>GS</sub>  | Gate-source voltage                            | ± 20               | V                          |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> = 25°C | <b>TO-220</b><br>3 | <b>ISOWATT220</b><br>2.5 A |
| I <sub>DM</sub>  | Drain current (pulsed)                         | 10                 | 10 A                       |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C     | 75                 | 35 W                       |
|                  | Derating factor                                | 0.6                | 0.28 W/°C                  |
| T <sub>stg</sub> | Storage temperature                            | - 65 to 150 °C     |                            |
| T <sub>j</sub>   | Max. operating junction temperature            | 150 °C             |                            |

THERMAL DATA

TO-220 | ISOWATT220

|                  |                                     |     |      |      |               |
|------------------|-------------------------------------|-----|------|------|---------------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.67 | 3.57 | $^{\circ}C/W$ |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 62.5 |      | $^{\circ}C/W$ |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                              |     |  |             |                    |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                            | 600 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}C$ |     |  | 200<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                          |     |  | $\pm 100$   | nA                 |

ON

|               |                                   |                                                                                       |          |  |          |          |
|---------------|-----------------------------------|---------------------------------------------------------------------------------------|----------|--|----------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 1 mA$<br>$V_{DS} = V_{GS}$ $I_D = 1 mA$ $T_c = 100^{\circ}C$ | 2<br>1.5 |  | 4.5<br>4 | V<br>V   |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 1.5 A$                                                         |          |  | 2.5      | $\Omega$ |
| $V_{DS(on)}$  | Drain-source on voltage           | $V_{GS} = 10 V$ $I_D = 3 A$<br>$V_{GS} = 10 V$ $I_D = 1.5 A$ $T_c = 100^{\circ}C$     |          |  | 9<br>7.5 | V<br>V   |

DYNAMIC

|           |                              |                                             |     |  |      |     |
|-----------|------------------------------|---------------------------------------------|-----|--|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 15 V$ $I_D = 1.5 A$               | 1.5 |  |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$ $f = 1 MHz$<br>$V_{GS} = 0$ |     |  | 1000 | pF  |
| $C_{oss}$ | Output capacitance           |                                             |     |  | 300  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                             |     |  | 80   | pF  |

SWITCHING

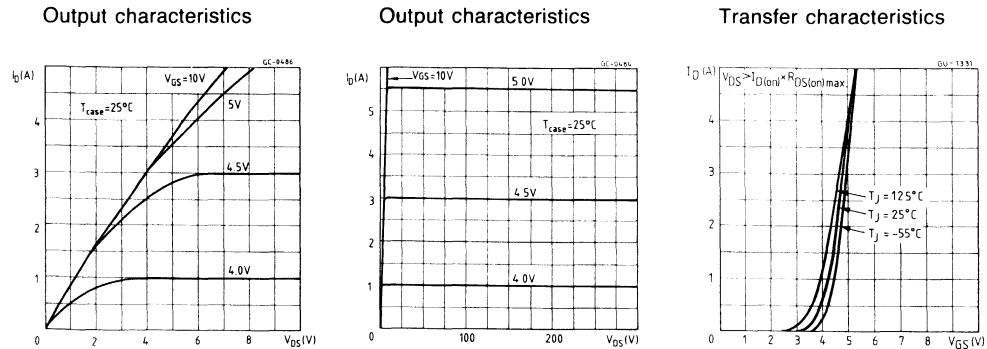
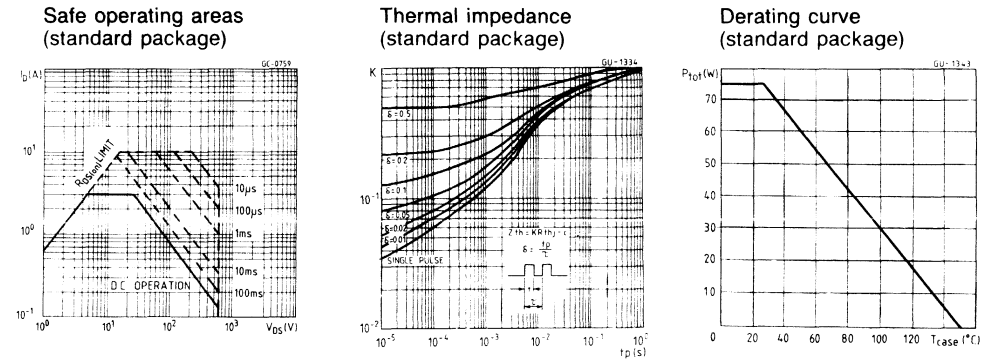
|               |                     |                                                                 |  |  |     |    |
|---------------|---------------------|-----------------------------------------------------------------|--|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 25 V$ $I_D = 1.5 A$<br>$R_i = 50 \Omega$ $V_i = 10 V$ |  |  | 50  | ns |
| $t_r$         | Rise time           |                                                                 |  |  | 100 | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                                 |  |  | 180 | ns |
| $t_f$         | Fall time           |                                                                 |  |  | 80  | ns |



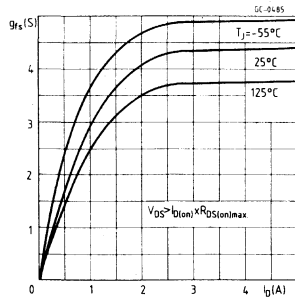
# ELECTRICAL CHARACTERISTICS (Continued)

| Parameters            | Test Conditions                                          | Min.                                                        | Typ. | Max.    | Unit   |
|-----------------------|----------------------------------------------------------|-------------------------------------------------------------|------|---------|--------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) |                                                             |      | 3<br>10 | A<br>A |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 3\text{ A}$<br>$V_{GS} = 0$                       | 1.1  |         | V      |
| $t_{rr}$              | Reverse recovery time                                    | $I_{SD} = 3\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ | 165  |         | ns     |

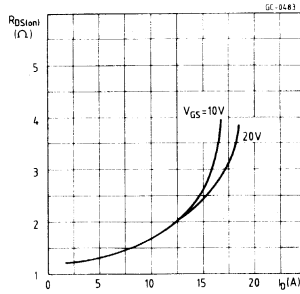
## SOURCE DRAIN DIODE



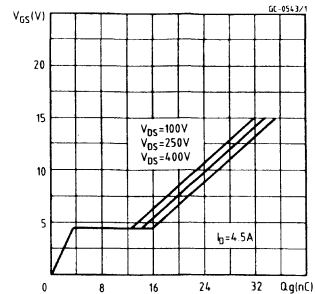
Transconductance



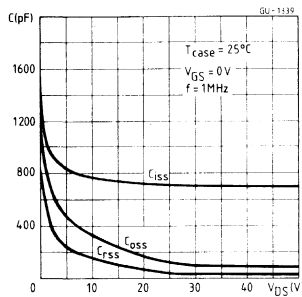
Static drain-source on resistance



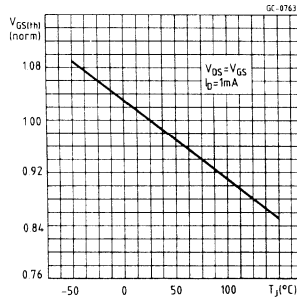
Gate charge vs gate-source voltage



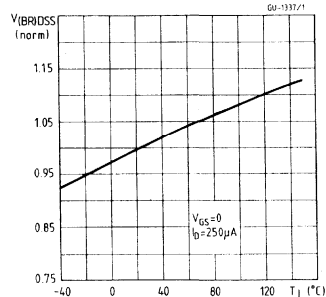
Capacitance variation



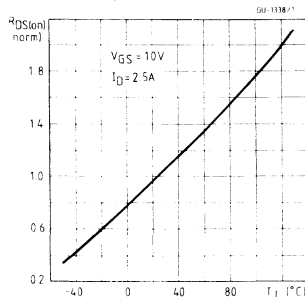
Normalized gate threshold voltage vs temperature



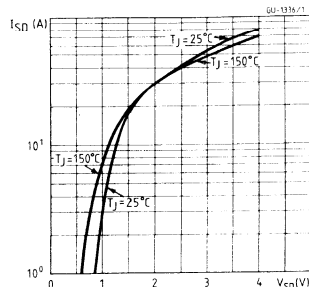
Normalized breakdown voltage vs temperature



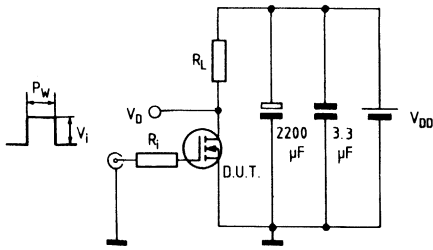
Normalized on resistance vs temperature



Source-drain diode forward characteristics



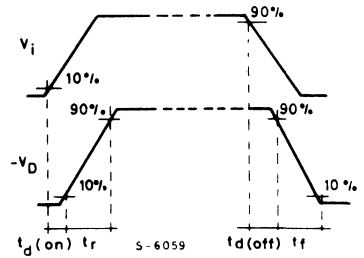
Switching times test circuit for resistive load



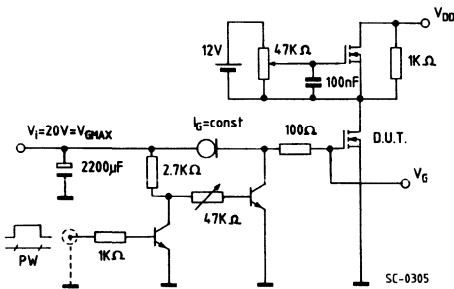
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

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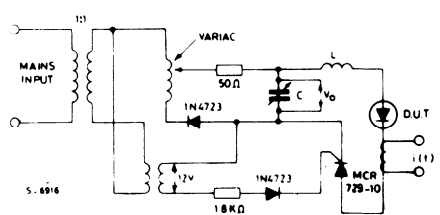
Switching time waveforms for resistive load



Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit


**ISOWATT220 PACKAGE  
CHARACTERISTICS AND APPLICATION.**

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation. The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

**THERMAL IMPEDANCE OF  
ISOWATT220 PACKAGE**

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th \text{ (tot)}}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

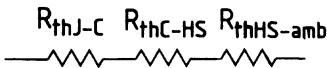
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

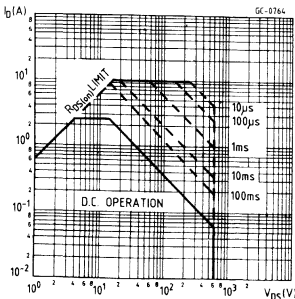
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

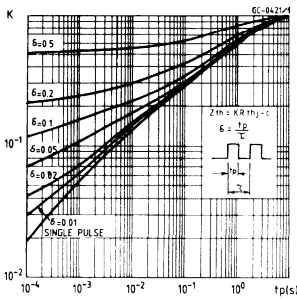


**ISOWATT DATA**

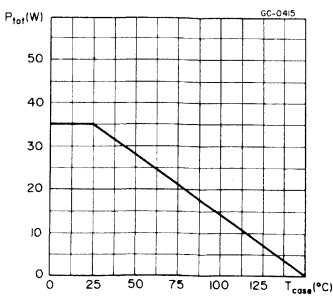
Safe operating areas



Thermal impedance



Derating curve



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

PRELIMINARY DATA

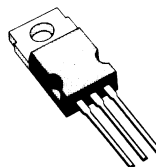
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| MTP6N60 | 600 V            | 1.2 Ω               | 6 A            |

- HIGH VOLTAGE - 600 V FOR OFF-LINE APPLICATIONS
- ULTRA FAST SWITCHING TIMES FOR OPERATIONS AT > 100KHz
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

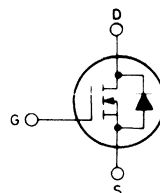
- SWITCHING POWER SUPPLY
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make these POWER MOS ideal for very high speed switching applications. Typical uses include SMPS, uninterruptible power supplies and motor controls.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                |             |      |
|------------------|------------------------------------------------|-------------|------|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)     | 600         | V    |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)   | 600         | V    |
| V <sub>GS</sub>  | Gate-source voltage                            | ± 20        | V    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> = 25°C | 6           | A    |
| I <sub>DM</sub>  | Drain current (pulsed)                         | 30          | A    |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C     | 125         | W    |
|                  | Derating factor                                | 1           | W/°C |
| T <sub>stg</sub> | Storage temperature                            | - 65 to 150 | °C   |
| T <sub>j</sub>   | Max. operating junction temperature            | 150         | °C   |

THERMAL DATA

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1    | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient | max | 62.5 | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                              |     |  |             |                    |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$ $V_{GS} = 0$                                                               | 600 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}C$ |     |  | 200<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                          |     |  | $\pm 500$   | nA                 |

ON

|               |                                   |                                                                                                       |          |  |          |          |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------------------------|----------|--|----------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 1 \text{ mA}$<br>$V_{DS} = V_{GS}$ $I_D = 1 \text{ mA}$ $T_c = 100^{\circ}C$ | 2<br>1.5 |  | 4.5<br>4 | V<br>V   |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 3 A$                                                                           |          |  | 1.2      | $\Omega$ |
| $V_{DS(on)}$  | Drain-source on voltage           | $V_{GS} = 10 V$ $I_D = 6 A$<br>$V_{GS} = 10 V$ $I_D = 3 A$ $T_c = 100^{\circ}C$                       |          |  | 8<br>7.2 | V<br>V   |

DYNAMIC

|                                     |                                                                         |                                                     |   |  |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------|---|--|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 10 V$ $I_D = 3 A$                         | 2 |  |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$ $f = 1 \text{ MHz}$<br>$V_{GS} = 0$ |   |  | 1800<br>350<br>150 | pF<br>pF<br>pF |

SWITCHING

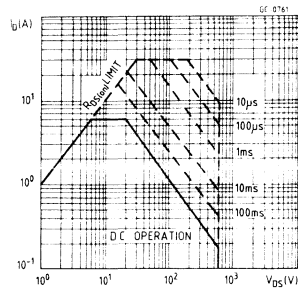
|               |                     |                                |  |  |     |    |
|---------------|---------------------|--------------------------------|--|--|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 25 V$ $I_D = 3 A$    |  |  | 60  | ns |
| $t_r$         | Rise time           | $R_i = 50 \Omega$ $V_i = 10 V$ |  |  | 150 | ns |
| $t_{d (off)}$ | Turn-off delay time |                                |  |  | 200 | ns |
| $t_f$         | Fall time           |                                |  |  | 120 | ns |

ELECTRICAL CHARACTERISTICS (Continued)

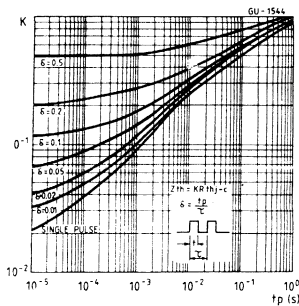
| Parameters            | Test Conditions                                          | Min.                                                        | Typ. | Max.    | Unit   |
|-----------------------|----------------------------------------------------------|-------------------------------------------------------------|------|---------|--------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) |                                                             |      | 6<br>30 | A<br>A |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 6\text{ A}$<br>$V_{GS} = 0$                       | 1.3  |         | V      |
| $t_{rr}$              | Reverse recovery time                                    | $I_{SD} = 6\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ | 600  |         | ns     |

SOURCE DRAIN DIODE

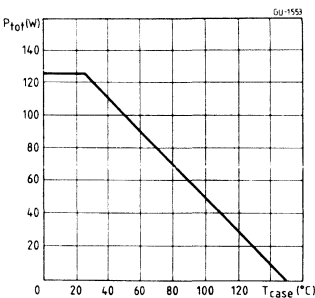
Safe operating areas



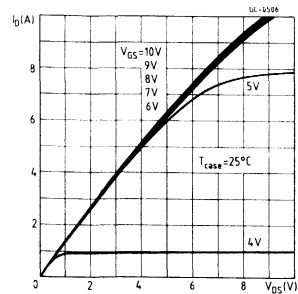
Thermal impedance



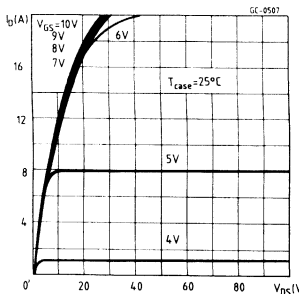
Derating curve



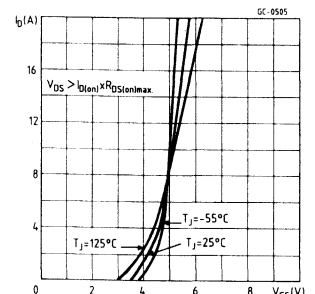
Output characteristics



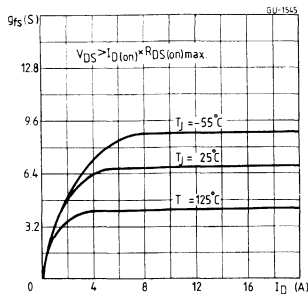
Output characteristics



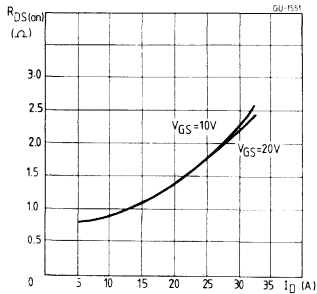
Transfer characteristics



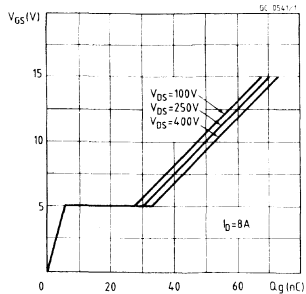
Transconductance



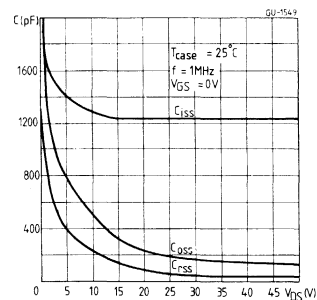
Static drain-source on resistance



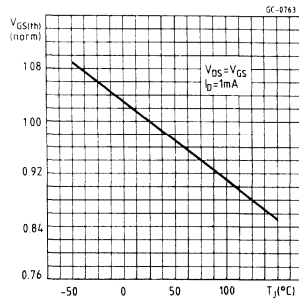
Gate charge vs gate-source voltage



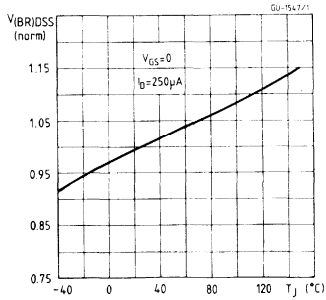
Capacitance variation



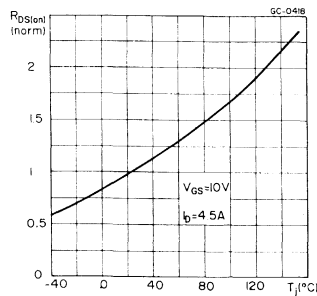
Normalized gate threshold voltage vs temperature



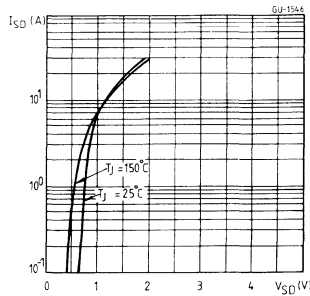
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature

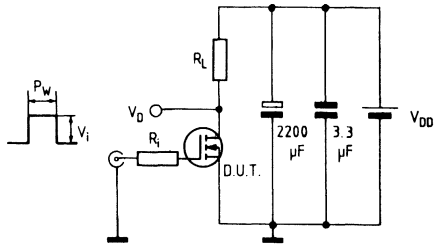


Source-drain diode forward characteristics





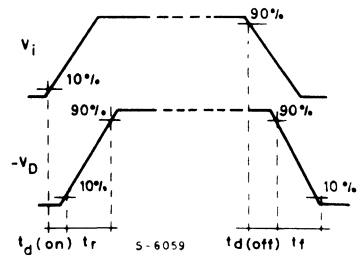
Switching times test circuit for resistive load



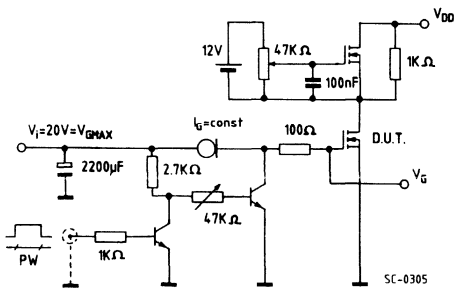
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

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Switching time waveforms for resistive load

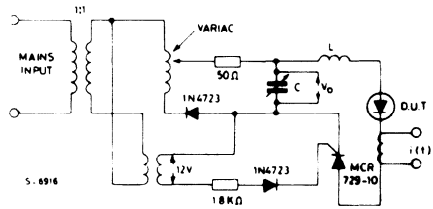


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit





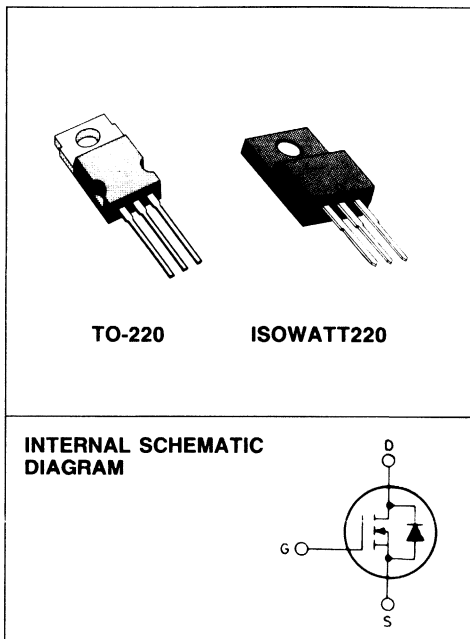
## N - CHANNEL ENHANCEMENT MODE LOW THRESHOLD POWER MOS TRANSISTORS

PRELIMINARY DATA

| TYPE        | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|-------------|------------------|---------------------|----------------|
| MTP15N05L   | 50 V             | 0.15 Ω              | 15 A           |
| MTP15N05LFI | 50 V             | 0.15 Ω              | 10 A           |
| MTP15N06L   | 60 V             | 0.15 Ω              | 15 A           |
| MTP15N06LFI | 60 V             | 0.15 Ω              | 10 A           |

- LOGIC LEVEL (+5V) CMOS/TTL COMPATIBLE INPUT
- HIGH INPUT IMPEDANCE
- ULTRA FAST SWITCHING

N - channel enhancement mode POWER MOS field effect transistors. The low input voltage - logic level - and easy drive make these devices ideal for automotive and industrial applications. Typical uses are in relay and actuator driving in the automotive environment.



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | TO-220<br>ISOWATT220 | MTP15N06L<br>MTP15N06LFI | MTP15N05L<br>MTP15N05LFI |      |
|---------------------|-------------------------------------------------|----------------------|--------------------------|--------------------------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)      |                      | 60                       | 50                       | V    |
| V <sub>DGR</sub>    | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    |                      | 60                       | 50                       | V    |
| V <sub>GS</sub>     | Gate-source voltage                             |                      |                          | ± 15                     | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      | 15                       | 10                       | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C |                      | 9.5                      | 6.3                      | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          |                      | 40                       | 40                       | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      |                      | 75                       | 30                       | W    |
|                     | Derating factor                                 |                      | 0.6                      | 0.24                     | W/°C |
| T <sub>stg</sub>    | Storage temperature                             |                      | - 65 to 150              |                          | °C   |
| T <sub>j</sub>      | Max. operating junction temperature             |                      | 150                      |                          | °C   |

(\*) Pulse width limited by safe operating area

## THERMAL DATA

TO-220 | ISOWATT220

|                  |                                                |     |      |      |      |
|------------------|------------------------------------------------|-----|------|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.67 | 4.16 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient            | max | 62.5 |      | °C   |
| $T_L$            | Maximum lead temperature for soldering purpose | max | 275  |      | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

## OFF

|                |                                                  |                                                                            |                             |          |           |                                |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------|-----------------------------|----------|-----------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 1 \text{ mA}$<br>for <b>MTP15N06L/FI</b><br>for <b>MTP15N05L/FI</b> | $V_{GS} = 0$                | 60<br>50 |           | V<br>V                         |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$               | $T_c = 125^{\circ}\text{C}$ |          | 1<br>50   | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 15 \text{ V}$                                                |                             |          | $\pm 100$ | nA                             |

## ON \*\*

|               |                                   |                                                                                             |                             |           |  |          |          |
|---------------|-----------------------------------|---------------------------------------------------------------------------------------------|-----------------------------|-----------|--|----------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 1 \text{ mA}$<br>$V_{DS} = V_{GS}$ $I_D = 1 \text{ mA}$            | $T_c = 100^{\circ}\text{C}$ | 1<br>0.75 |  | 2<br>1.5 | V<br>V   |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 5 \text{ V}$ $I_D = 7.5 \text{ A}$                                                |                             |           |  | 0.15     | $\Omega$ |
| $V_{DS (on)}$ | Drain-source on voltage           | $V_{GS} = 5 \text{ V}$ $I_D = 15 \text{ A}$<br>$V_{GS} = 5 \text{ V}$ $I_D = 7.5 \text{ A}$ | $T_c = 100^{\circ}\text{C}$ |           |  | 3<br>1.5 | V<br>V   |

## DYNAMIC

|           |                              |                         |                       |   |  |     |     |
|-----------|------------------------------|-------------------------|-----------------------|---|--|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 15 \text{ V}$ | $I_D = 7.5 \text{ A}$ | 5 |  |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$ | $f = 1 \text{ MHz}$   |   |  | 900 | pF  |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$            |                       |   |  | 450 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                         |                       |   |  | 200 | pF  |

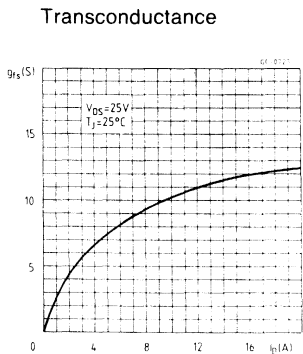
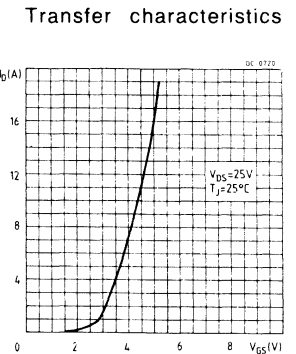
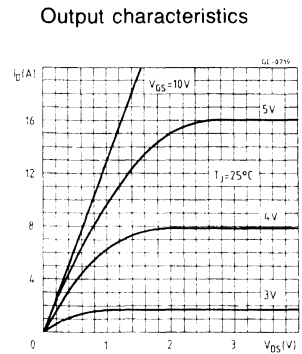
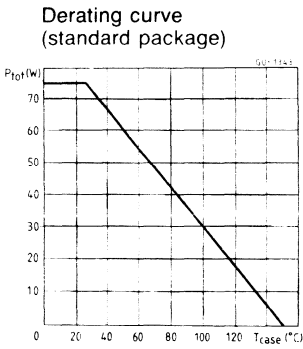
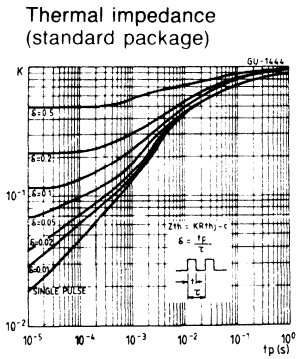
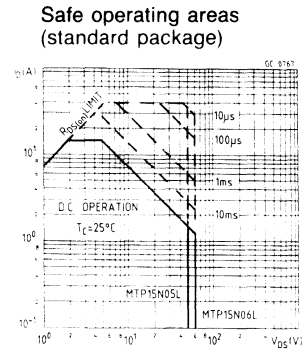
## SWITCHING

|             |                     |                         |                       |  |    |     |    |
|-------------|---------------------|-------------------------|-----------------------|--|----|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 25 \text{ V}$ | $I_D = 7.5 \text{ A}$ |  |    | 40  | ns |
| $t_r$       | Rise time           | $V_i = 5 \text{ V}$     | $R_i = 50 \Omega$     |  |    | 260 | ns |
| $t_d (off)$ | Turn-off delay time |                         |                       |  |    | 200 | ns |
| $t_f$       | Fall time           |                         |                       |  |    | 200 | ns |
| $Q_g$       | Total Gate Charge   | $V_{DD} = 48 \text{ V}$ | $I_D = 15 \text{ A}$  |  | 14 | 22  | nC |
| $Q_{gs}$    | Gate-source charge  | $V_{GS} = 5 \text{ V}$  |                       |  | 7  |     | nC |
| $Q_{gd}$    | Gate-drain charge   |                         |                       |  | 7  |     | nC |

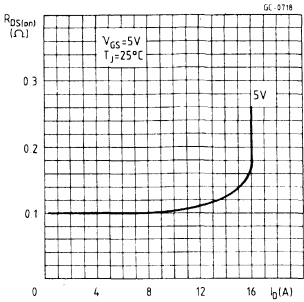
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                  | Test Conditions                                          | Min.                                                        | Typ. | Max.     | Unit   |
|-----------------------------|----------------------------------------------------------|-------------------------------------------------------------|------|----------|--------|
| $I_{SD}$<br>$I_{SDM}^{(*)}$ | Source-drain current<br>Source-drain current<br>(pulsed) |                                                             |      | 15<br>60 | A<br>A |
| $V_{SD}^{**}$               | Forward on voltage                                       | $I_{SD} = 15\text{ A}$<br>$V_{GS} = 0$                      | 1.8  |          | V      |
| $t_{rr}$                    | Reverse recovery<br>time                                 | $I_{SD} = 15\text{ A}$<br>$di/dt = 100\text{A}/\mu\text{s}$ |      | 300      | ns     |

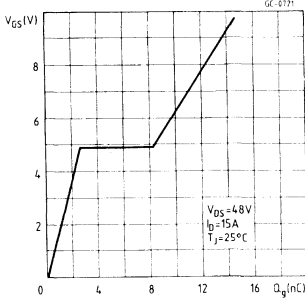
\*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$   
(\*) Pulse width limited by safe operating area



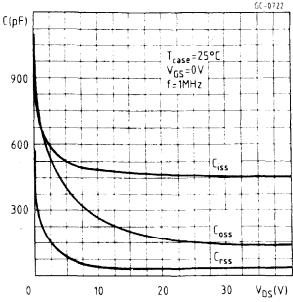
Static drain-source on resistance



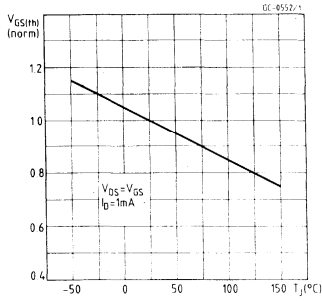
Gate charge vs gate-source voltage



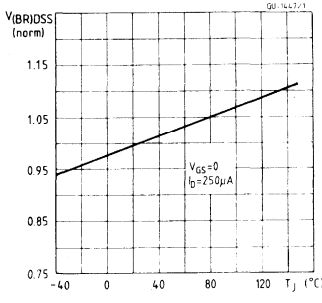
Capacitance variation



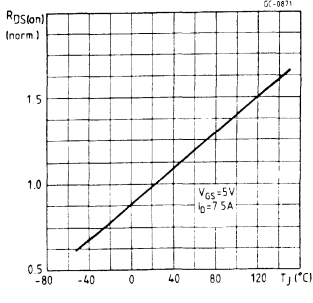
Normalized gate threshold voltage vs temperature



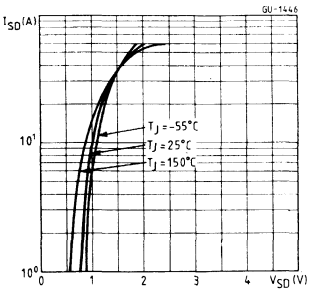
Normalized breakdown voltage vs temperature



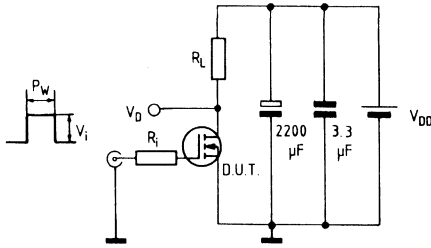
Normalized on resistance vs temperature



Source-drain diode forward characteristics

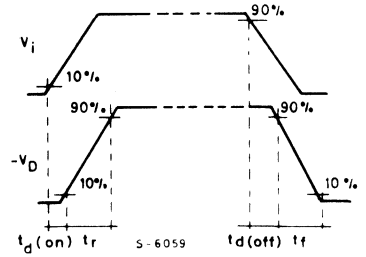


Switching times test circuit for resistive load

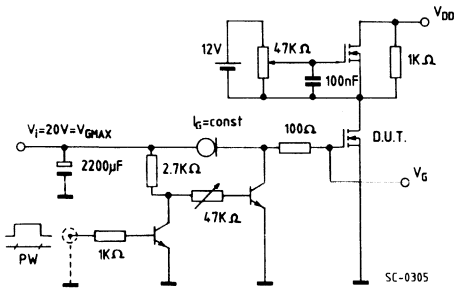


Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

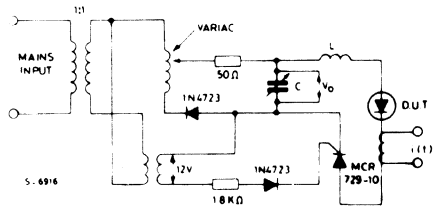
Switching time waveforms for resistive load



Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit


ISOWATT220 PACKAGE  
CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_J - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^{\circ}\text{C)}}}$$

THERMAL IMPEDANCE OF  
ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th \text{ (tot)}}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

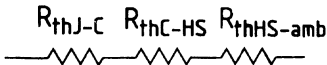
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

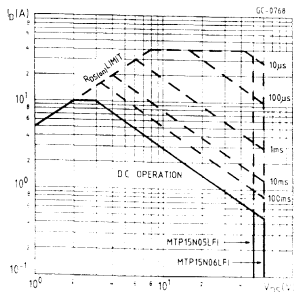
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

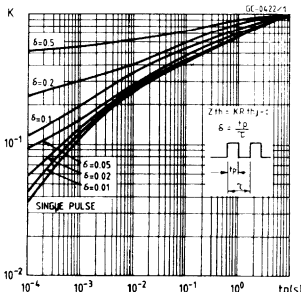


ISOWATT DATA

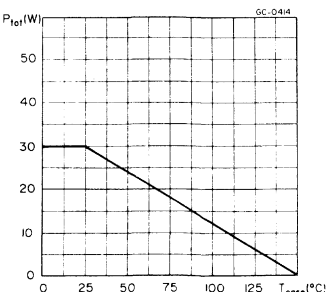
Safe operating areas



Thermal impedance



Derating curve





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

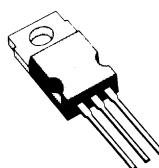
| TYPE       | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> <sup>■</sup> |
|------------|------------------|---------------------|-----------------------------|
| MTP3055A   | 60 V             | 0.15 Ω              | 12 A                        |
| MTP3055AFI | 60 V             | 0.15 Ω              | 10 A                        |

- ULTRA FAST SWITCHING - UP TO > 100KHz
- LOW DRIVE ENERGY FOR EASY DRIVE  
REDUCES SIZE AND COST
- INTEGRAL SOURCE - DRAIN DIODE

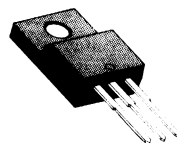
### INDUSTRIAL APPLICATIONS:

- GENERAL PURPOSE SWITCH
- SERIES REGULATOR

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast times make these POWER MOS transistors ideal for high speed switching circuit in applications such as power actuator driving, motor drive including brushless motors, robotics, actuators lamp driving, series regulator and many other uses in industrial control applications. They also find use in DC/DC converters and uninterruptible power supplies.

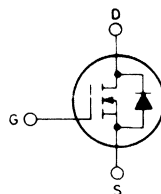


**TO-220**



**ISOWATT220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                               |                                              | TO-220<br>ISOWATT220 |  | MTP3055A<br>MTP3055AFI |    |
|-------------------------------|----------------------------------------------|----------------------|--|------------------------|----|
| V <sub>DS</sub>               | Drain-source voltage (V <sub>GS</sub> = 0)   |                      |  | 60                     | V  |
| V <sub>DGR</sub>              | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ) |                      |  | 60                     | V  |
| V <sub>GS</sub>               | Gate-source voltage                          |                      |  | ± 20                   | V  |
| I <sub>DM</sub>               | Drain current (pulsed)                       |                      |  | 26                     | A  |
| I <sub>GM</sub>               | Gate current (pulsed)                        |                      |  | 1.5                    | A  |
| I <sub>D</sub> <sup>■</sup>   | Drain current (continuous)                   |                      |  |                        |    |
| P <sub>tot</sub> <sup>■</sup> | Total dissipation at T <sub>c</sub> < 25°C   |                      |  |                        |    |
| ■                             | Derating factor                              |                      |  |                        |    |
| T <sub>stg</sub>              | Storage temperature                          |                      |  | - 65 to 150            | °C |
| T <sub>j</sub>                | Max. operating junction temperature          |                      |  | 150                    | °C |

■ See note on ISOWATT220 in this datasheet

THERMAL DATA

TO-220 | ISOWATT220

|                  |                                                |     |      |      |               |
|------------------|------------------------------------------------|-----|------|------|---------------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 3.12 | 4.16 | $^{\circ}C/W$ |
| $T_I$            | Maximum lead temperature for soldering purpose | max | 275  |      | $^{\circ}C$   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                              |    |  |            |                    |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|----|--|------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$ $V_{GS} = 0$                                                               | 60 |  |            | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}C$ |    |  | 50<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                          |    |  | $\pm 100$  | nA                 |

ON \*

|               |                                   |                                                                                                                 |          |      |                   |             |
|---------------|-----------------------------------|-----------------------------------------------------------------------------------------------------------------|----------|------|-------------------|-------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 1 \text{ mA}$<br>$V_{DS} = V_{GS}$ $I_D = 1 \text{ mA}$ $T_c = 100^{\circ}C$           | 2<br>1.5 |      | 4.5<br>4          | V<br>V      |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 6 A$                                                                                     |          | 0.15 | $\Omega$          |             |
| $V_{DS (on)}$ | Drain-source on voltage           | $V_{GS} = 10 V$ $I_D = 12 A$<br>$V_{GS} = 10 V$ $I_D = 6 A$<br>$V_{GS} = 10 V$ $I_D = 6 A$ $T_c = 100^{\circ}C$ |          |      | 2.0<br>0.9<br>1.5 | V<br>V<br>V |

DYNAMIC

|                                     |                                                                         |                                                     |     |  |                   |                |
|-------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------|-----|--|-------------------|----------------|
| $g_{fs}^*$                          | Forward transconductance                                                | $V_{DS} = 10 V$ $I_D = 6 A$                         | 4.5 |  |                   | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$ $f = 1 \text{ MHz}$<br>$V_{GS} = 0$ |     |  | 500<br>200<br>100 | pF<br>pF<br>pF |
| $Q_g$                               | Total gate charge                                                       | $V_{DS} = 48 V$ $I_D = 12 A$<br>$V_{GS} = 10 V$     |     |  | 17                | nC             |

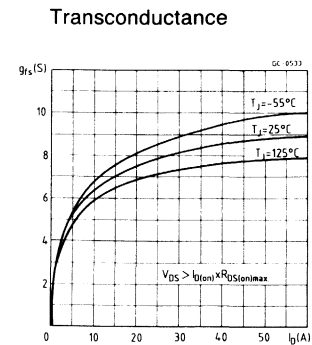
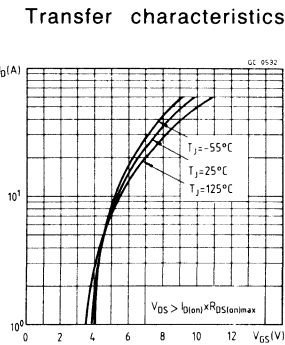
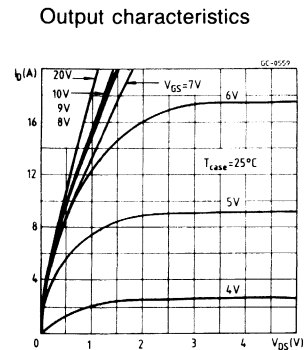
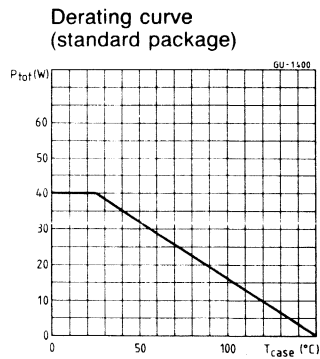
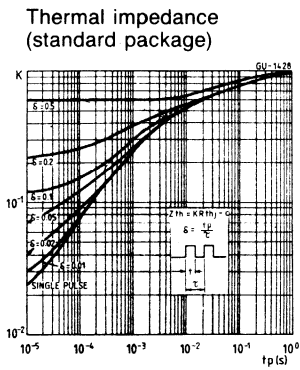
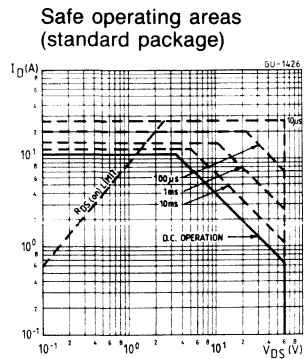
SWITCHING

|             |                     |                             |  |  |    |    |
|-------------|---------------------|-----------------------------|--|--|----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 25 V$ $I_D = 6 A$ |  |  | 20 | ns |
| $t_r$       | Rise time           | $R_{gen} = 50 \Omega$       |  |  | 60 | ns |
| $t_d (off)$ | Turn-off delay time |                             |  |  | 65 | ns |
| $t_f$       | Fall time           |                             |  |  | 65 | ns |

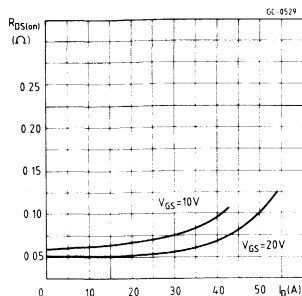
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                     | Test Conditions                     | Min. | Typ. | Max. | Unit |
|--------------------------------|-------------------------------------|------|------|------|------|
| $V_{SD}$ Forward on voltage    | $I_{SD} = 12\text{ A}$ $V_{GS} = 0$ |      |      | 2    | V    |
| $t_{rr}$ Reverse recovery time | $I_{SD} = 12\text{ A}$ $V_{GS} = 0$ |      |      | 75   | ns   |

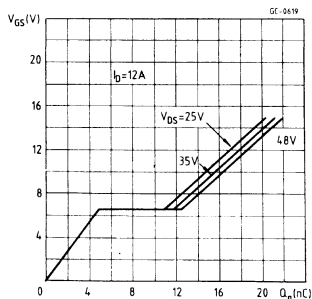
- \* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$
- See note on ISOWATT220 in this datasheet



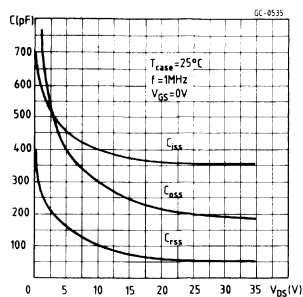
Static drain-source on resistance



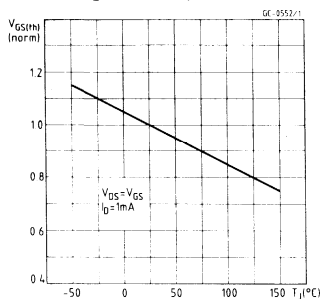
Gate charge vs gate-source voltage



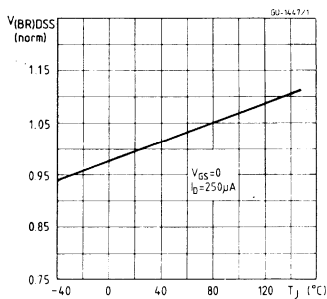
Capacitance variation



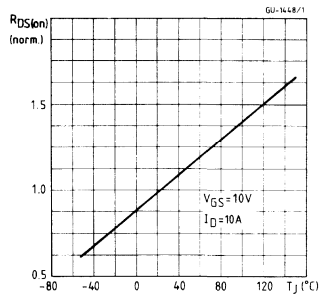
Normalized gate threshold voltage vs temperature



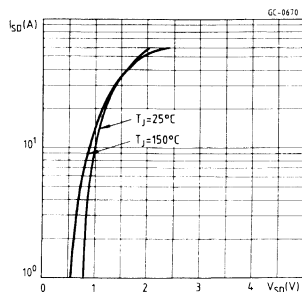
Normalized breakdown voltage vs temperature



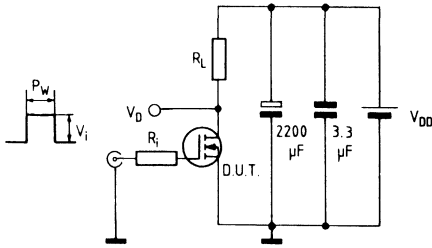
Normalized on resistance vs temperature



Source-drain diode forward characteristics



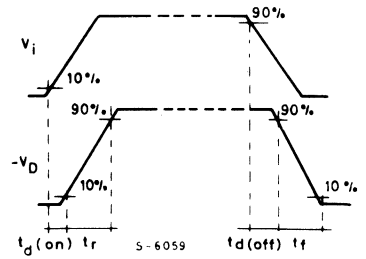
Switching times test circuit for resistive load



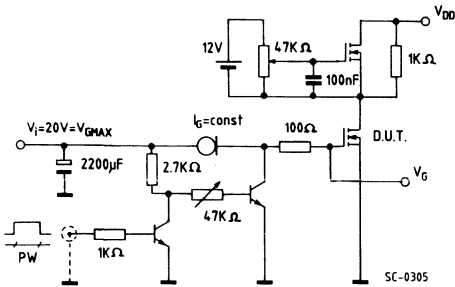
Pulse width  $\leq 100 \mu s$   
Duty cycle  $\leq 2\%$

SC-0008/1

Switching time waveforms for resistive load

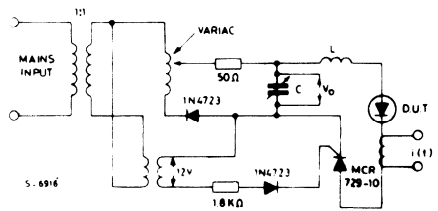


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



**ISOWATT220 PACKAGE  
CHARACTERISTICS AND APPLICATION.**

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^\circ\text{C)}}}$$

**THERMAL IMPEDANCE OF  
ISOWATT220 PACKAGE**

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th(tot)}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

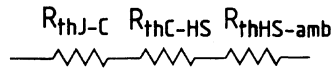
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

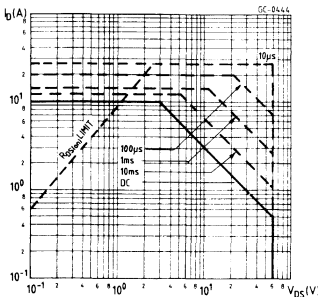
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

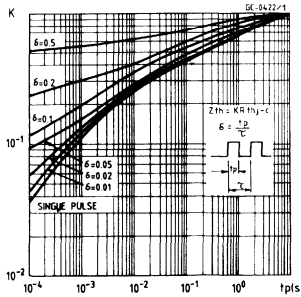


**ISOWATT DATA**

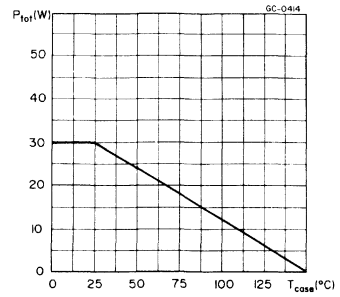
Safe operating areas



Thermal impedance



Derating curve



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

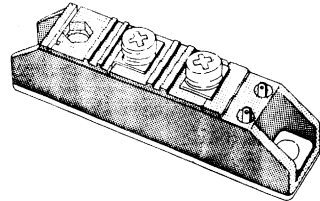
| TYPE         | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------------|------------------|---------------------|----------------|
| SGS30MA050D1 | 500 V            | 0.20 $\Omega$       | 30 A           |

- ISOLATED POWERMOS MODULE
- HIGH POWER
- FAST SWITCHING
- EASY DRIVE
- EASY TO PARALLEL

### INDUSTRIAL APPLICATIONS:

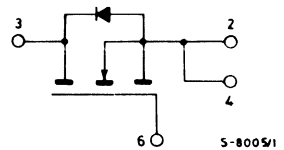
- SWITCHING MODE POWER SUPPLIES
- UNINTERRUPTIBLE POWER SUPPLIES

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and fast switching of this TRANSPACK module make it ideal for high power, high speed switching applications. Typical applications include DC motor control (variable frequency control) switching mode power supplies, uninterruptible power supplies, DC/DC convertors and high frequency welding equipment. The large RBSOA and absence of second breakdown in POWER MOS make this TRANSPACK module very rugged. This, together with the isolated package with its optimised thermal performance, make this module extremely effective in high power applications.



TO-247

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                       |             |      |
|------------------|-------------------------------------------------------|-------------|------|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)            | 500         | V    |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 500         | V    |
| V <sub>GS</sub>  | Gate-source voltage                                   | $\pm 20$    | V    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> = 25°C        | 30          | A    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> = 100°C       | 19          | A    |
| I <sub>DM</sub>  | Drain current (pulsed)                                | 120         | A    |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C            | 400         | W    |
|                  | Derating factor                                       | 3.2         | W/°C |
| T <sub>stg</sub> | Storage temperature                                   | - 65 to 150 | °C   |
| T <sub>j</sub>   | Max. operating junction temperature                   | 150         | °C   |
| V <sub>ISO</sub> | Insulation withstand voltage (AC)                     | 2500        | V    |

THERMAL DATA

|                  |                                  |     |      |      |
|------------------|----------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case | max | 0.31 | °C/W |
| $R_{thc - h}$    | Thermal resistance case-heatsink | max | 0.20 | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |              |     |  |           |                     |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|--------------|-----|--|-----------|---------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 2\text{ mA}$                                                     | $V_{GS} = 0$ | 500 |  |           | V                   |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ |              |     |  | 500<br>2  | $\mu\text{A}$<br>mA |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$                                              |              |     |  | $\pm 400$ | nA                  |

ON\*

|               |                                   |                        |                     |   |  |      |          |
|---------------|-----------------------------------|------------------------|---------------------|---|--|------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$      | $I_D = 2\text{ mA}$ | 2 |  | 4    | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10\text{ V}$ | $I_D = 15\text{ A}$ |   |  | 0.20 | $\Omega$ |

DYNAMIC

|           |                              |                                        |                     |    |  |      |     |
|-----------|------------------------------|----------------------------------------|---------------------|----|--|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25\text{ V}$                 | $I_D = 15\text{ A}$ | 15 |  |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25\text{ V}$<br>$V_{GS} = 0$ | $f = 1\text{ MHz}$  |    |  | 9100 | pF  |
| $C_{oss}$ | Output capacitance           |                                        |                     |    |  | 1200 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                        |                     |    |  | 850  | pF  |

SWITCHING

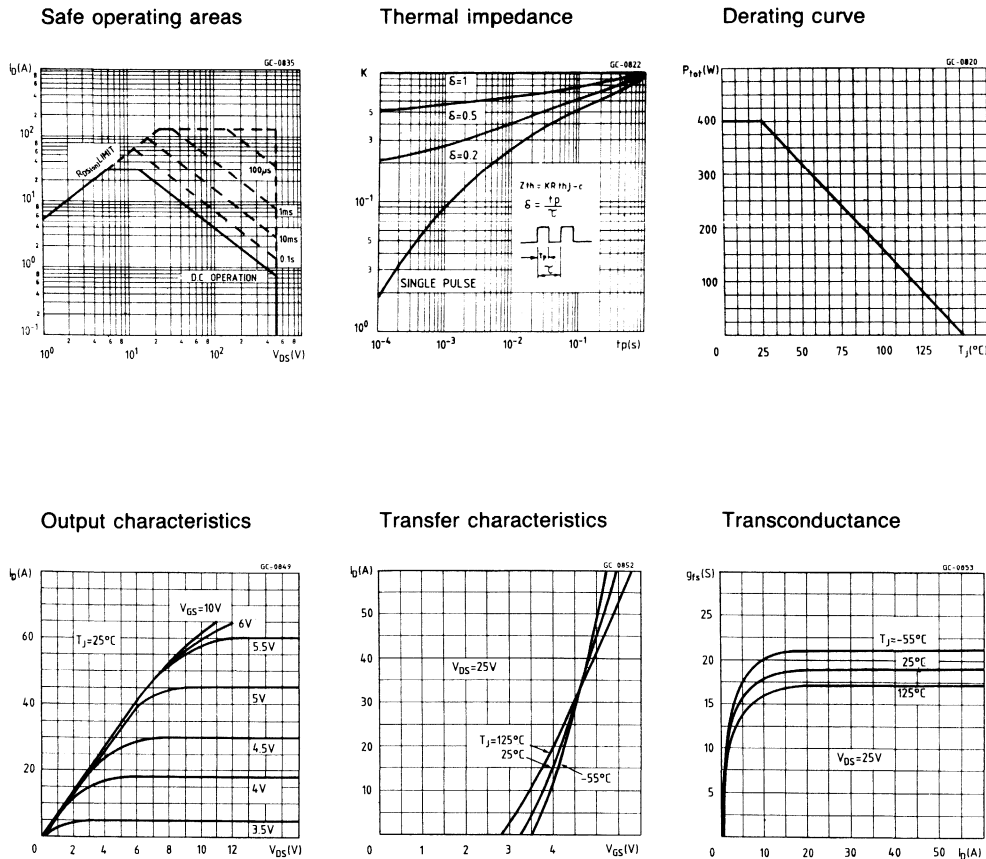
| INDUCTIVE LOAD |                       |                          |                     |  |  |     |                  |
|----------------|-----------------------|--------------------------|---------------------|--|--|-----|------------------|
| $t_{d (on)}$   | Turn-on time          | $V_{DD} = 250\text{ V}$  | $I_D = 15\text{ A}$ |  |  | 120 | ns               |
| $(di/dt)_{on}$ | Turn-on current slope | $R_i = 50\text{ }\Omega$ | $V_i = 10\text{ V}$ |  |  | 100 | A/ $\mu\text{s}$ |
| $t_{d (off)}$  | Turn-off delay time   |                          |                     |  |  | 1.5 | $\mu\text{s}$    |
| $t_f$          | Fall time             |                          |                     |  |  | 300 | ns               |



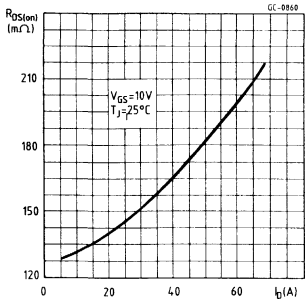
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters |                               | Test Conditions        |                                    | Min. | Typ. | Max. | Unit |
|------------|-------------------------------|------------------------|------------------------------------|------|------|------|------|
| $I_{SD}$   | Source-drain current          |                        |                                    |      |      | 30   | A    |
| $I_{SDM}$  | Source-drain current (pulsed) |                        |                                    |      |      | 120  | A    |
| $V_{SD}$   | Forward on voltage            | $I_{SD} = 30\text{ A}$ | $V_{GS} = 0$                       |      |      | 2    | V    |
| $t_{rr}$   | Reverse recovery time         | $I_{SD} = 30\text{ A}$ | $di/dt = 150\text{ A}/\mu\text{s}$ |      | 600  |      | ns   |

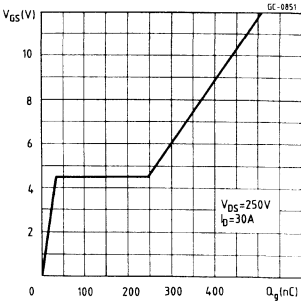
\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$



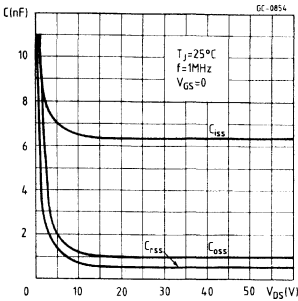
Static drain-source on resistance



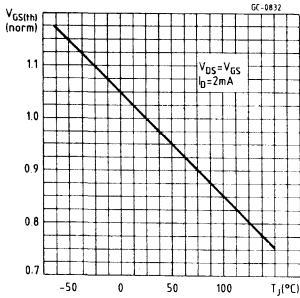
Gate charge vs gate-source voltage



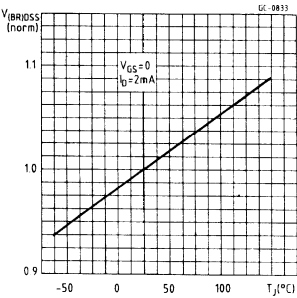
Capacitance variation



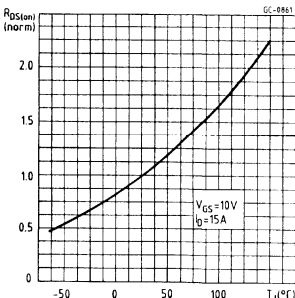
Normalized gate threshold voltage vs temperature



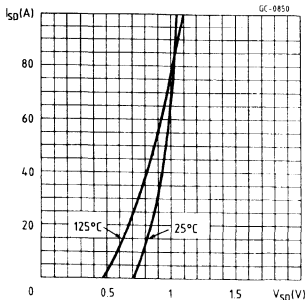
Normalized breakdown voltage vs temperature



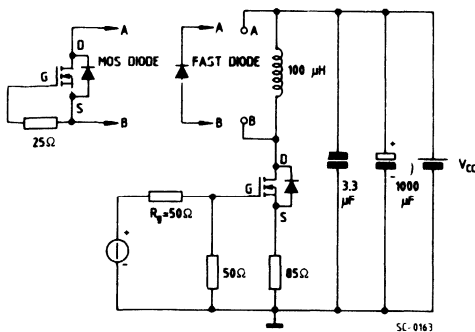
Normalized on resistance vs temperature



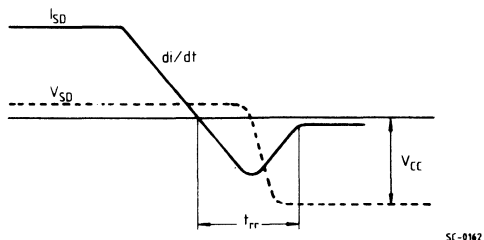
Source-drain diode forward characteristics



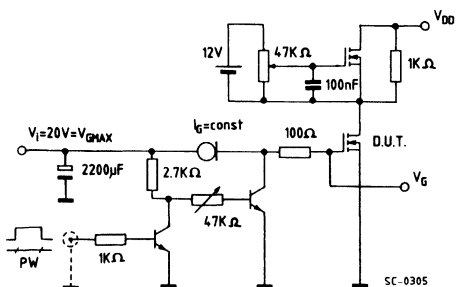
### Test circuit for inductive load switching and diode reverse recovery times



### Diode reverse recovery time waveform



### Gate charge test circuit



PW adjusted to obtain required  $V_G$



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

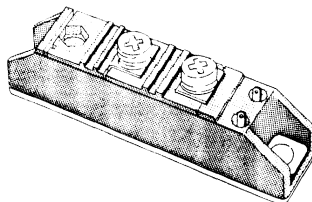
| TYPE         | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------------|------------------|---------------------|----------------|
| SGS35MA050D1 | 500 V            | 0.16 Ω              | 35 A           |

- ISOLATED POWERMOS MODULE
- HIGH POWER
- FAST SWITCHING
- EASY DRIVE
- EASY TO PARALLEL

### INDUSTRIAL APPLICATIONS:

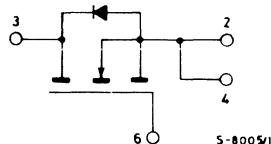
- SWITCHING MODE POWER SUPPLIES
- UNINTERRUPTIBLE POWER SUPPLIES

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and fast switching of this TRANSPACK module make it ideal for high power, high speed switching applications. Typical applications include DC motor control (variable frequency control) switching mode power supplies, uninterruptible power supplies, DC/DC converters and high frequency welding equipment. The large RBSOA and absence of second breakdown in POWER MOS make this TRANSPACK module very rugged. This, together with the isolated package with its optimised thermal performance, make this module extremely effective in high power applications.



**TO-240**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                |             |      |
|------------------|------------------------------------------------|-------------|------|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> =0)      | 500         | V    |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> =20 KΩ)    | 500         | V    |
| V <sub>GS</sub>  | Gate-source voltage                            | ± 20        | V    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> =25°C  | 35          | A    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> =100°C | 22          | A    |
| I <sub>DM</sub>  | Drain current (pulsed)                         | 140         | A    |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C     | 400         | W    |
|                  | Derating factor                                | 3.2         | W/°C |
| T <sub>stg</sub> | Storage temperature                            | - 65 to 150 | °C   |
| T <sub>j</sub>   | Max. operating junction temperature            | 150         | °C   |
| V <sub>ISO</sub> | Insulation withstand voltage (AC)              | 2500        | V    |

THERMAL DATA

|                  |                                  |     |      |      |
|------------------|----------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case | max | 0.31 | °C/W |
| $R_{thc - h}$    | Thermal resistance case-heatsink | max | 0.20 | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                     |     |  |           |                     |
|----------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----|--|-----------|---------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 2\text{ mA}$ $V_{GS} = 0$                                                                    | 500 |  |           | V                   |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_j = 125^{\circ}\text{C}$ |     |  | 500<br>2  | $\mu\text{A}$<br>mA |
| $I_{GS\leq}$   | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$                                                                          |     |  | $\pm 500$ | nA                  |

ON\*

|               |                                   |                                              |   |  |      |          |
|---------------|-----------------------------------|----------------------------------------------|---|--|------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 2\text{ mA}$        | 2 |  | 4    | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10\text{ V}$ $I_D = 17.5\text{ A}$ |   |  | 0.16 | $\Omega$ |

DYNAMIC

|                                     |                                                                         |                                                           |    |  |                       |                |
|-------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------|----|--|-----------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25\text{ V}$ $I_D = 17.5\text{ A}$              | 15 |  |                       | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\text{ V}$ $f = 1\text{ MHz}$<br>$V_{GS} = 0$ |    |  | 12000<br>1500<br>1000 | pF<br>pF<br>pF |

SWITCHING

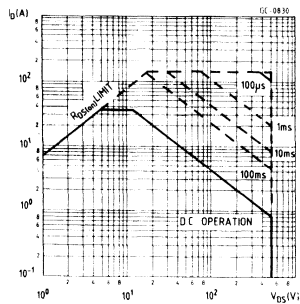
|                |                       |                                               |  |     |  |                  |
|----------------|-----------------------|-----------------------------------------------|--|-----|--|------------------|
| $t_{d (on)}$   | Turn-on time          | $V_{DD} = 250\text{ V}$ $I_D = 17.5\text{ A}$ |  | 120 |  | ns               |
| $(di/dt)_{on}$ | Turn-on current slope | $R_i = 50\ \Omega$ $V_i = 10\text{ V}$        |  | 100 |  | A/ $\mu\text{s}$ |
| $t_{d (off)}$  | Turn-off delay time   |                                               |  | 1.5 |  | $\mu\text{s}$    |
| $t_f$          | Fall time             |                                               |  | 300 |  | ns               |

ELECTRICAL CHARACTERISTICS (Continued)

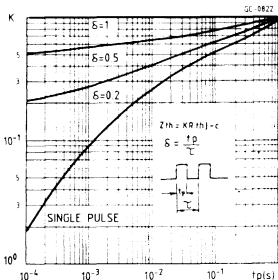
| Parameters            | Test Conditions                                          | Min.                   | Typ.                               | Max.      | Unit   |
|-----------------------|----------------------------------------------------------|------------------------|------------------------------------|-----------|--------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) |                        |                                    | 35<br>140 | A<br>A |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 35\text{ A}$ | $V_{GS} = 0$                       | 2         | V      |
| $t_{rr}$              | Reverse recovery<br>time                                 | $I_{SD} = 35\text{ A}$ | $di/dt = 150\text{ A}/\mu\text{s}$ | 600       | ns     |

\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$

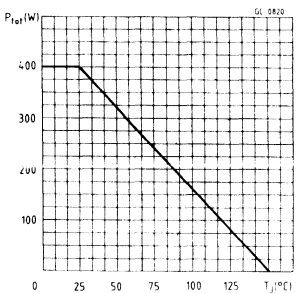
Safe operating areas



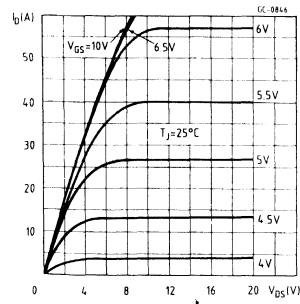
Thermal impedance



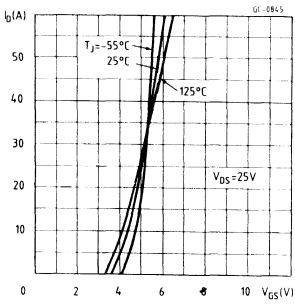
Derating curve



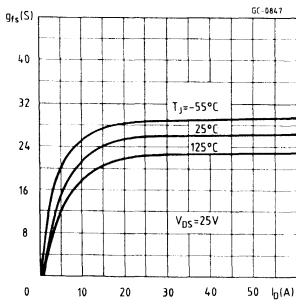
Output characteristics



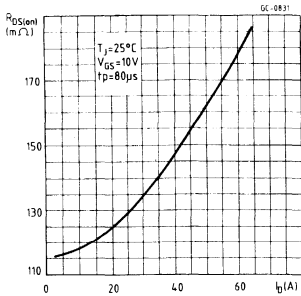
Transfer characteristics



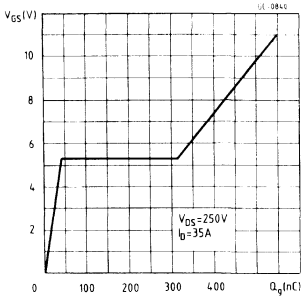
Transconductance



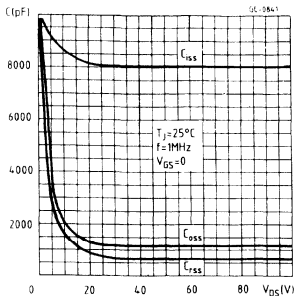
Static drain-source on resistance



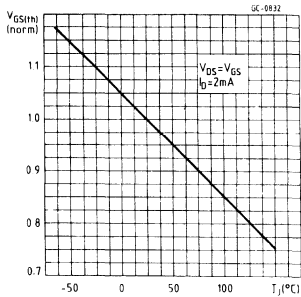
Gate charge vs gate-source voltage



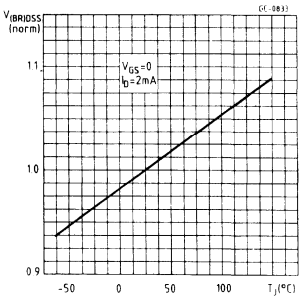
Capacitance variation



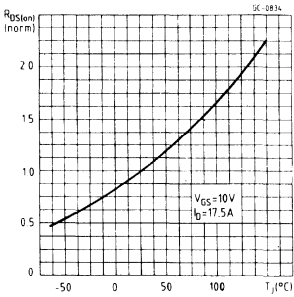
Normalized gate threshold voltage vs temperature



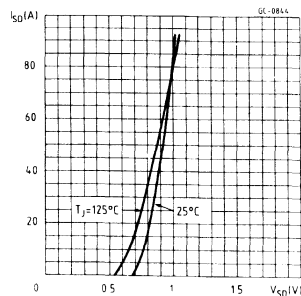
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature



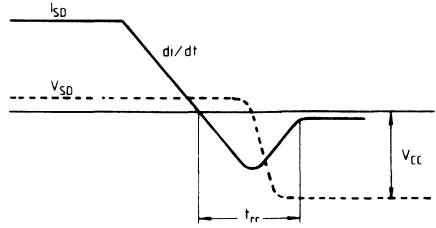
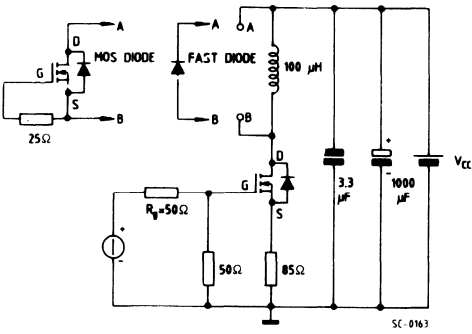
Source-drain diode forward characteristics



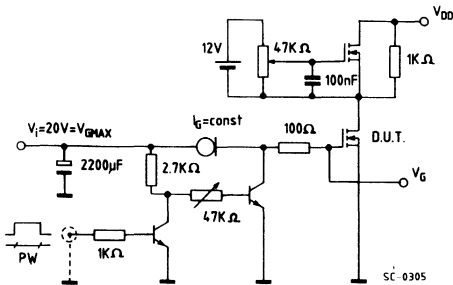


Test circuit for inductive load switching and diode reverse recovery times

Diode reverse recovery time waveform



Gate charge test circuit



PW adjusted to obtain required  $V_G$



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

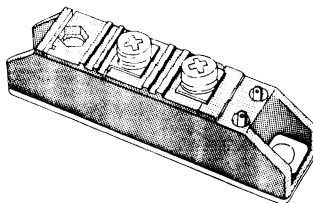
| TYPE          | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------------|------------------|---------------------|----------------|
| SGS100MA010D1 | 100 V            | 0.014 Ω             | 120 A          |

- ISOLATED POWERMOS MODULE
- HIGH POWER
- FAST SWITCHING
- EASY DRIVE
- EASY TO PARALLEL

### INDUSTRIAL APPLICATIONS:

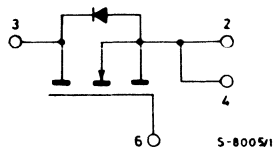
- SWITCHING MODE POWER SUPPLIES
- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS
- INVERTERS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and fast switching of this TRANSPACK module make it ideal for high power, high speed switching applications. Typical applications include DC motor control (variable frequency control) switching mode power supplies, uninterruptible power supplies, DC/DC convertors and high frequency welding equipment. The large RBSOA and absence of second breakdown in POWER MOS make this TRANSPACK module very rugged. This, together with the isolated package with its optimised thermal performance, make this module extremely effective in high power applications.



**TO-240**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                |             |      |
|------------------|------------------------------------------------|-------------|------|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> =0)      | 100         | V    |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> =20 KΩ)    | 100         | V    |
| V <sub>GS</sub>  | Gate-source voltage                            | ± 20        | V    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> =25°C  | 120         | A    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> =100°C | 75          | A    |
| I <sub>DM</sub>  | Drain current (pulsed)                         | 400         | A    |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C     | 400         | W    |
|                  | Derating factor                                | 3.2         | W/°C |
| T <sub>stg</sub> | Storage temperature                            | - 65 to 150 | °C   |
| T <sub>j</sub>   | Max. operating junction temperature            | 150         | °C   |
| V <sub>ISO</sub> | Insulation withstand voltage (AC)              | 2500        | V    |

THERMAL DATA

|                  |                                  |     |      |      |
|------------------|----------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case | max | 0.31 | °C/W |
| $R_{thc - h}$    | Thermal resistance case-heatsink | max | 0.20 | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                              |                             |     |   |           |                     |
|----------------|--------------------------------------------------|--------------------------------------------------------------|-----------------------------|-----|---|-----------|---------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 2\text{ mA}$                                          | $V_{GS} = 0$                | 100 |   |           | V                   |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ | $T_j = 125^{\circ}\text{C}$ |     |   | 500<br>2  | $\mu\text{A}$<br>mA |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$                                   |                             |     | - | $\pm 400$ | nA                  |

ON\*

|               |                                   |                        |                     |   |  |    |            |
|---------------|-----------------------------------|------------------------|---------------------|---|--|----|------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$      | $I_D = 2\text{ mA}$ | 2 |  | 4  | V          |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10\text{ V}$ | $I_D = 50\text{ A}$ |   |  | 14 | m $\Omega$ |

DYNAMIC

|                                     |                                                                         |                                        |                     |    |  |                       |                |
|-------------------------------------|-------------------------------------------------------------------------|----------------------------------------|---------------------|----|--|-----------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25\text{ V}$                 | $I_D = 50\text{ A}$ | 20 |  |                       | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\text{ V}$<br>$V_{GS} = 0$ | $f = 1\text{ MHz}$  |    |  | 11200<br>4200<br>1700 | pF<br>pF<br>pF |

SWITCHING

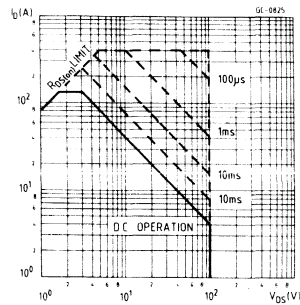
|                |                       |                          |                     |  |     |  |                  |
|----------------|-----------------------|--------------------------|---------------------|--|-----|--|------------------|
| $t_{d (on)}$   | Turn-on time          | $V_{DD} = 50\text{ V}$   | $I_D = 50\text{ A}$ |  | 120 |  | ns               |
| $(di/dt)_{on}$ | Turn-on current slope | $R_i = 50\text{ }\Omega$ | $V_i = 10\text{ V}$ |  | 100 |  | A/ $\mu\text{s}$ |
| $t_{d (off)}$  | Turn-off delay time   |                          |                     |  | 2   |  | $\mu\text{s}$    |
| $t_f$          | Fall time             |                          |                     |  | 300 |  | ns               |

ELECTRICAL CHARACTERISTICS (Continued)

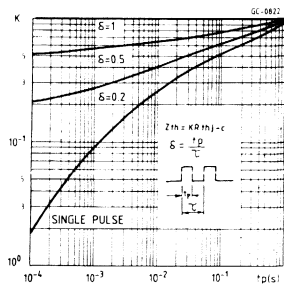
| Parameters            | Test Conditions                                          | Min.                    | Typ.                               | Max.       | Unit   |
|-----------------------|----------------------------------------------------------|-------------------------|------------------------------------|------------|--------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) |                         |                                    | 120<br>400 | A<br>A |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 120\text{ A}$ | $V_{GS} = 0$                       | 2          | V      |
| $t_{rr}$              | Reverse recovery<br>time                                 | $I_{SD} = 120\text{ A}$ | $di/dt = 100\text{ A}/\mu\text{s}$ | 400        | ns     |

\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$

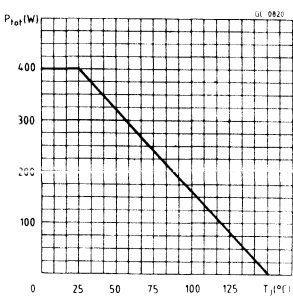
Safe operating areas



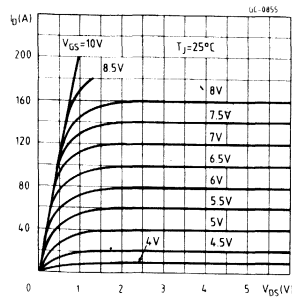
Thermal impedance



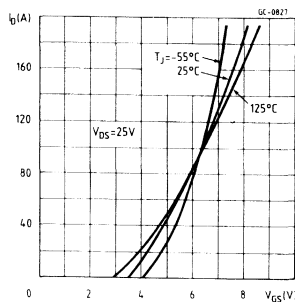
Derating curve



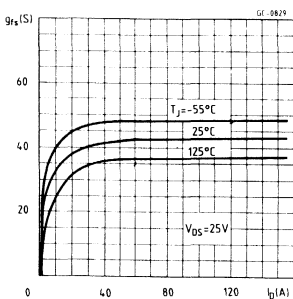
Output characteristics



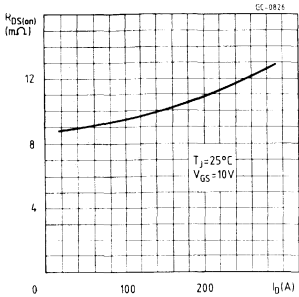
Transfer characteristics



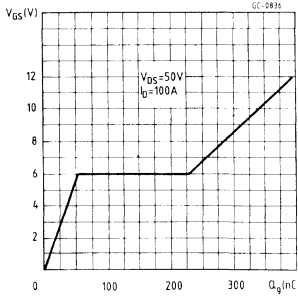
Transconductance



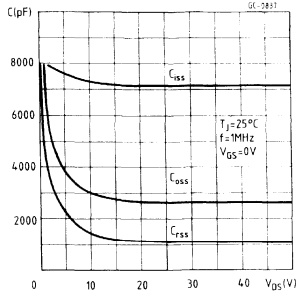
Static drain-source on resistance



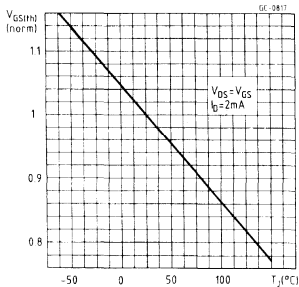
Gate charge vs gate-source voltage



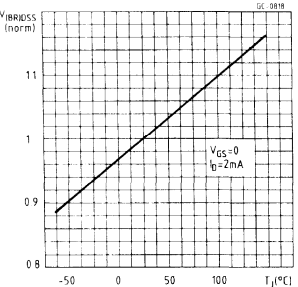
Capacitance variation



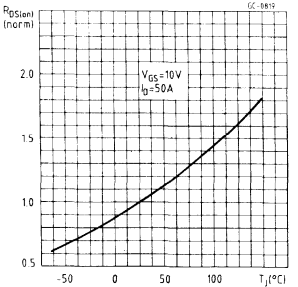
Normalized gate threshold voltage vs temperature



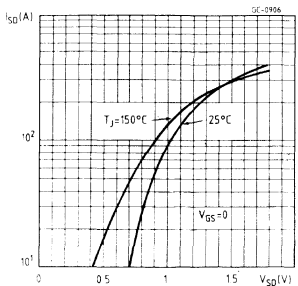
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature



Source-drain diode forward characteristics









## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

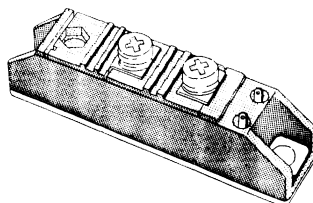
| TYPE          | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------------|------------------|---------------------|----------------|
| SGS150MA010D1 | 100 V            | 0.009 Ω             | 150 A          |

- ISOLATED POWERMOS MODULE
- HIGH POWER
- FAST SWITCHING
- EASY DRIVE
- EASY TO PARALLEL

### INDUSTRIAL APPLICATIONS:

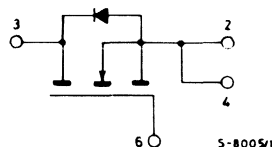
- SWITCHING MODE POWER SUPPLIES
- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS
- INVERTERS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and fast switching of this TRANSPACK module make it ideal for high power, high speed switching applications. Typical applications include DC motor control (variable frequency control) switching mode power supplies, uninterruptible power supplies, DC/DC convertors and high frequency welding equipment. The large RBSOA and absence of second breakdown in POWER MOS make this TRANSPACK module very rugged. This, together with the isolated package with its optimised thermal performance, make this module extremely effective in high power applications.



TO-247

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                 |             |      |
|------------------|-------------------------------------------------|-------------|------|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)      | 100         | V    |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 100         | V    |
| V <sub>GS</sub>  | Gate-source voltage                             | ±20         | V    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> = 25°C  | 150         | A    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> = 100°C | 95          | A    |
| I <sub>DM</sub>  | Drain current (pulsed)                          | 600         | A    |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C      | 400         | W    |
|                  | Derating factor                                 | 3.2         | W/°C |
| T <sub>stg</sub> | Storage temperature                             | - 65 to 150 | °C   |
| T <sub>j</sub>   | Max. operating junction temperature             | 150         | °C   |
| V <sub>ISO</sub> | Insulation withstand voltage (AC)               | 2500        | V    |

THERMAL DATA

|                  |                                  |     |      |      |
|------------------|----------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case | max | 0.33 | °C/W |
| $R_{thc - h}$    | Thermal resistance case-heatsink | max | 0.20 | °C/W |

ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                     |     |  |           |               |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|---------------------|-----|--|-----------|---------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 2 \mu A$                                                         | $V_{GS} = 0$        | 100 |  |           | V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_j = 125^\circ C$ |     |  | 500<br>2  | $\mu A$<br>mA |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                             |                     |     |  | $\pm 500$ | nA            |

ON\*

|               |                                   |                         |                      |   |  |   |    |
|---------------|-----------------------------------|-------------------------|----------------------|---|--|---|----|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$       | $I_D = 2 \text{ mA}$ | 2 |  | 4 | V  |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ | $I_D = 75 \text{ A}$ |   |  | 9 | mΩ |

DYNAMIC

|           |                              |                                         |                      |    |  |       |     |
|-----------|------------------------------|-----------------------------------------|----------------------|----|--|-------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 \text{ V}$                 | $I_D = 75 \text{ A}$ | 20 |  |       | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$  |    |  | 14000 | pF  |
| $C_{oss}$ | Output capacitance           |                                         |                      |    |  | 5300  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                         |                      |    |  | 2200  | pF  |

SWITCHING

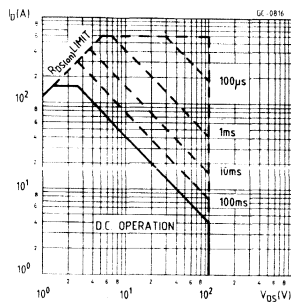
|                |                       |                         |                      |  |     |  |            |
|----------------|-----------------------|-------------------------|----------------------|--|-----|--|------------|
| $t_{d (on)}$   | Turn-on time          | $V_{DD} = 50 \text{ V}$ | $I_D = 75 \text{ A}$ |  | 120 |  | ns         |
| $(di/dt)_{on}$ | Turn-on current slope | $R_i = 50 \Omega$       | $V_i = 10 \text{ V}$ |  | 100 |  | A/ $\mu s$ |
| $t_{d (off)}$  | Turn-off delay time   |                         |                      |  | 2   |  | $\mu s$    |
| $t_f$          | Fall time             |                         |                      |  | 300 |  | ns         |

ELECTRICAL CHARACTERISTICS (Continued)

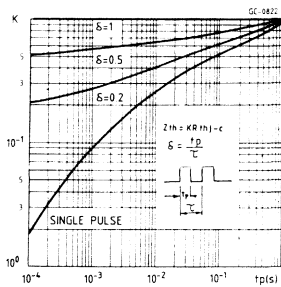
| Parameters            | Test Conditions                                          | Min.                    | Typ.                               | Max.       | Unit   |
|-----------------------|----------------------------------------------------------|-------------------------|------------------------------------|------------|--------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current<br>(pulsed) |                         |                                    | 150<br>600 | A<br>A |
| $V_{SD}$              | Forward on voltage                                       | $I_{SD} = 150\text{ A}$ | $V_{GS} = 0$                       | 2          | V      |
| $t_{rr}$              | Reverse recovery<br>time                                 | $I_{SD} = 150\text{ A}$ | $di/dt = 250\text{ A}/\mu\text{s}$ | 400        | ns     |

\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$

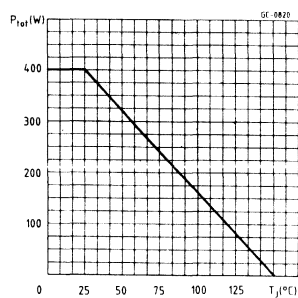
Safe operating areas



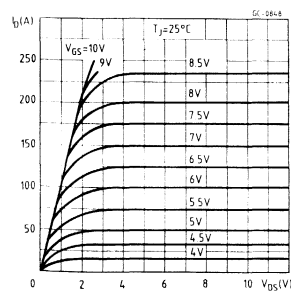
Thermal impedance



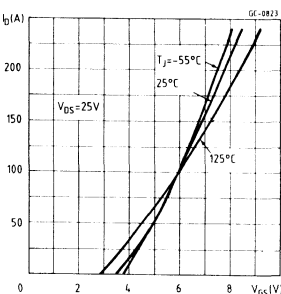
Derating curve



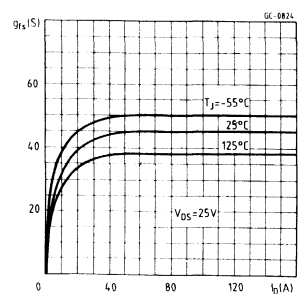
Output characteristics



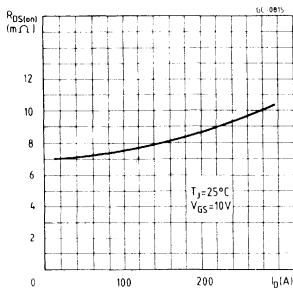
Transfer characteristics



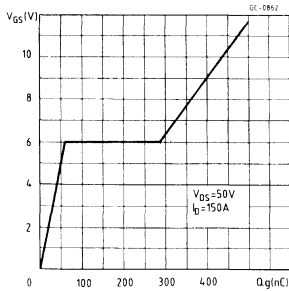
Transconductance



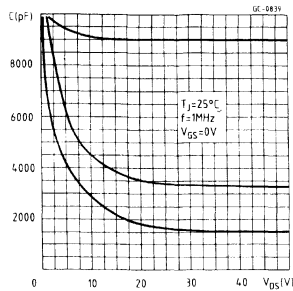
Static drain-source on resistance



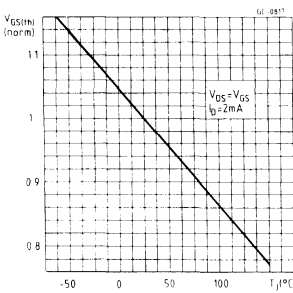
Gate charge vs gate-source voltage



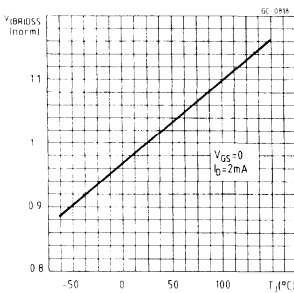
Capacitance variation



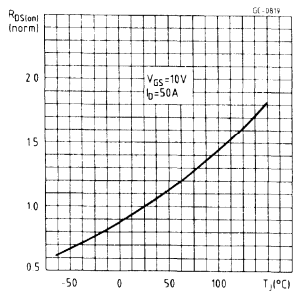
Normalized gate threshold voltage vs temperature



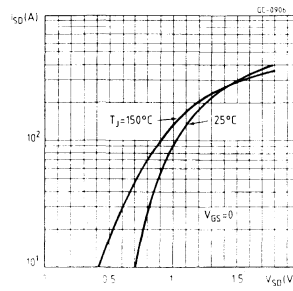
Normalized breakdown voltage vs temperature



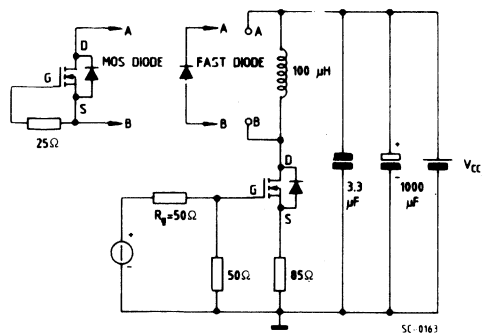
Normalized on resistance vs temperature



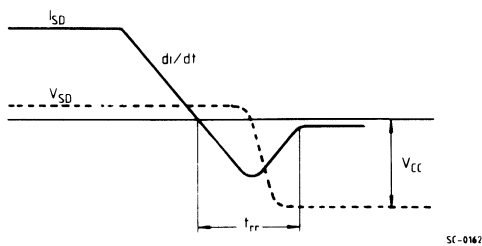
Source-drain diode forward characteristics



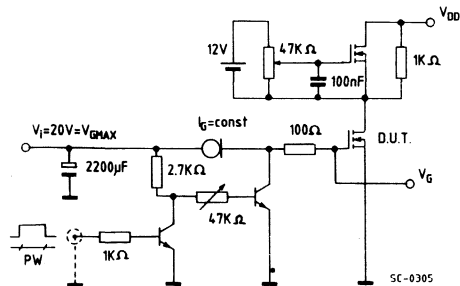
Test circuit for inductive load switching and diode reverse recovery times



Diode reverse recovery time waveform



Gate charge test circuit



PW adjusted to obtain required V<sub>G</sub>



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

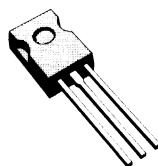
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP201 | 100 V            | 1.4 Ω               | 2.0 A          |

- HIGH SPEED SWITCHING APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

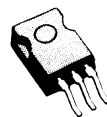
### INDUSTRIAL APPLICATIONS:

- GENERAL PURPOSE SWITCHING

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include general purpose low voltage switching, solenoid driving, motor and lamp control, switching power supplies, and driving, bipolar power switching transistors.

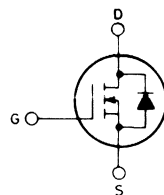


**SOT-82**



**OPTION  
SOT-194**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 |             |      |
|----------------------|-------------------------------------------------|-------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 100         | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 100         | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ± 20        | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 2.0         | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 1.2         | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 6           | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 6           | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 18          | W    |
|                      | Derating factor                                 | 0.144       | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | − 65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |               |
|------------------|------------------------------------------------|-----|------|---------------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 6.95 | $^{\circ}C/W$ |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | $^{\circ}C$   |

ELECTRICAL CHARACTERISTICS
( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                 |     |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                               | 100 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>$T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                             |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                              |   |  |            |                      |
|---------------|-----------------------------------|----------------------------------------------------------------------------------------------|---|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$                                                       | 2 |  | 4          | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$V_{GS} = 10 V$<br>$I_D = 1.2 A$<br>$I_D = 1.2 A$<br>$T_c = 100^{\circ}C$ |   |  | 1.4<br>2.8 | $\Omega$<br>$\Omega$ |

DYNAMIC

|           |                              |                                                        |     |    |     |     |
|-----------|------------------------------|--------------------------------------------------------|-----|----|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$<br>$I_D = 1.2 A$                       | 0.5 |    |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 \text{ MHz}$ |     | 90 | 125 | pF  |
| $C_{oss}$ | Output capacitance           |                                                        |     |    | 45  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                        |     |    | 30  | pF  |

SWITCHING

|             |                     |                                                       |  |                      |    |    |
|-------------|---------------------|-------------------------------------------------------|--|----------------------|----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 50 V$<br>$V_i = 10 V$<br>(see test circuit) |  | 10<br>20<br>15<br>15 | 15 | ns |
| $t_r$       | Rise time           |                                                       |  |                      | 30 | ns |
| $t_d (off)$ | Turn-off delay time |                                                       |  |                      | 20 | ns |
| $t_f$       | Fall time           |                                                       |  |                      | 20 | ns |

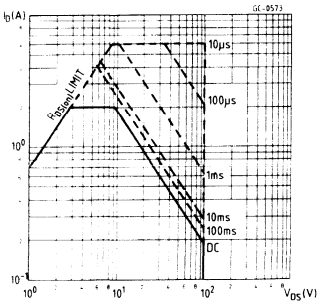


ELECTRICAL CHARACTERISTICS (Continued)

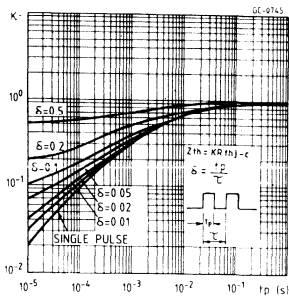
| Parameters                                                                     | Test Conditions                                                           | Min. | Typ. | Max.     | Unit   |
|--------------------------------------------------------------------------------|---------------------------------------------------------------------------|------|------|----------|--------|
| $I_{SD}$ Source-drain current<br>$I_{SDM}^{(*)}$ Source-drain current (pulsed) |                                                                           |      |      | 2.0<br>6 | A<br>A |
| $V_{SD}$ Forward on voltage                                                    | $I_{SD} = 2.0\text{ A}$ $V_{GS} = 0$                                      |      |      | 1.35     | V      |
| $t_{rr}$ Reverse recovery time                                                 | $I_{SD} = 2.0\text{ A}$ $V_{GS} = 0$<br>$di/dt = 25\text{ A}/\mu\text{s}$ |      | 90   |          | ns     |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
(\*) Pulse width limited by safe operating area

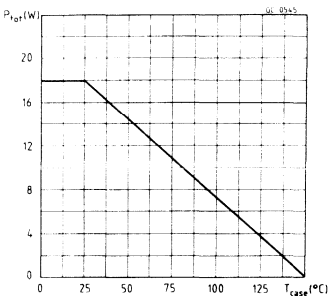
Safe operating areas



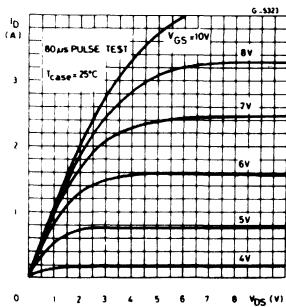
Thermal impedance



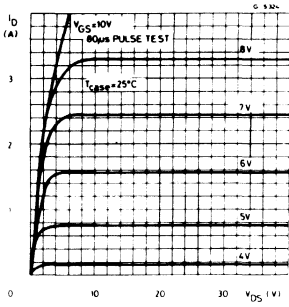
Derating curve



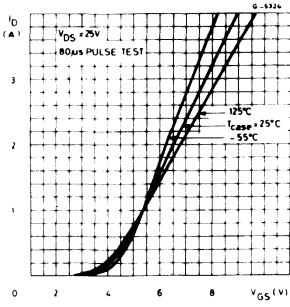
Output characteristics



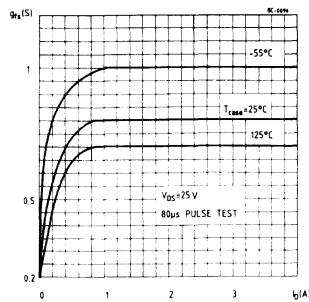
Output characteristics



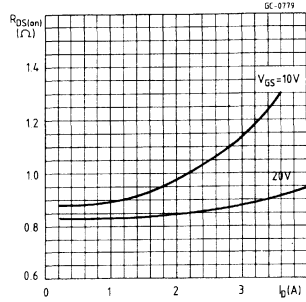
Transfer characteristics



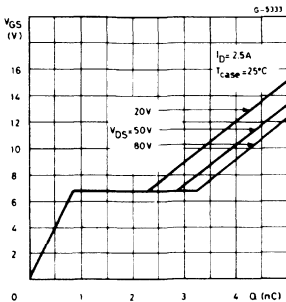
Transconductance



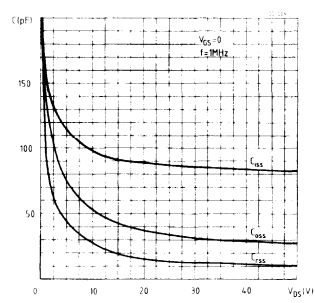
Static drain-source on resistance



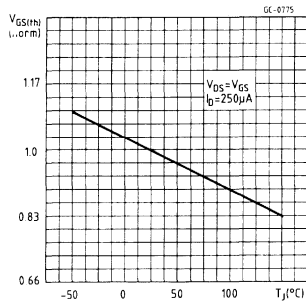
Gate charge vs gate-source voltage



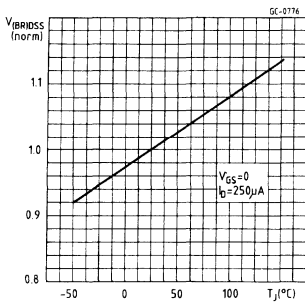
Capacitance variation



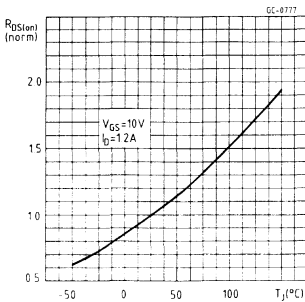
Normalized gate threshold voltage vs temperature



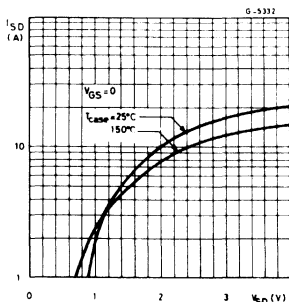
Normalized breakdown voltage vs temperature



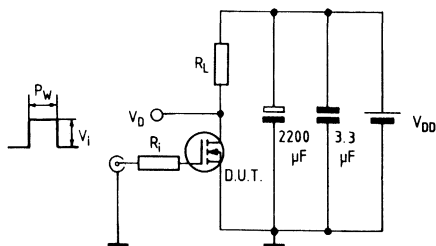
Normalized on resistance vs temperature



Source-drain diode forward characteristics

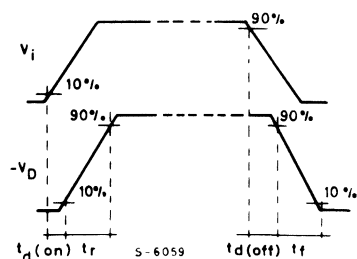


Switching times test circuit for resistive load

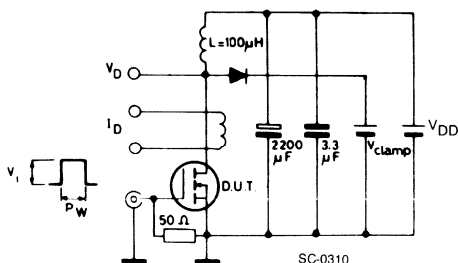
Pulse width  $\leq 100 \mu\text{s}$ Duty cycle  $\leq 2\%$ 

SC-0008/1

Switching time waveforms for resistive load

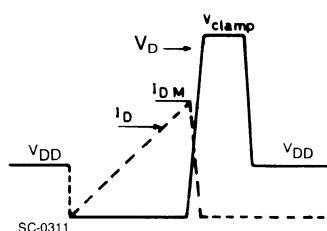


Clamped inductive load test circuit

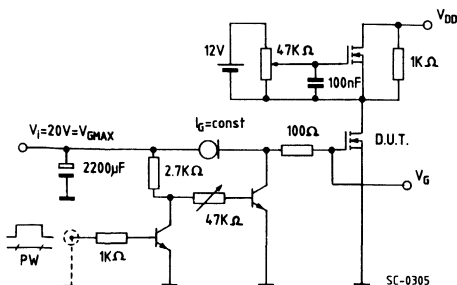
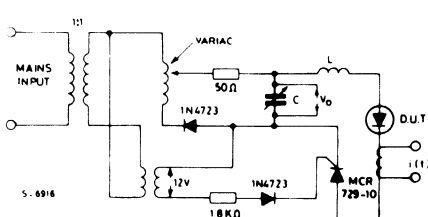


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(BR)} \text{ DSS}$ .

Clamped inductive waveforms



Gate charge test circuit

PW adjusted to obtain required  $V_G$ Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

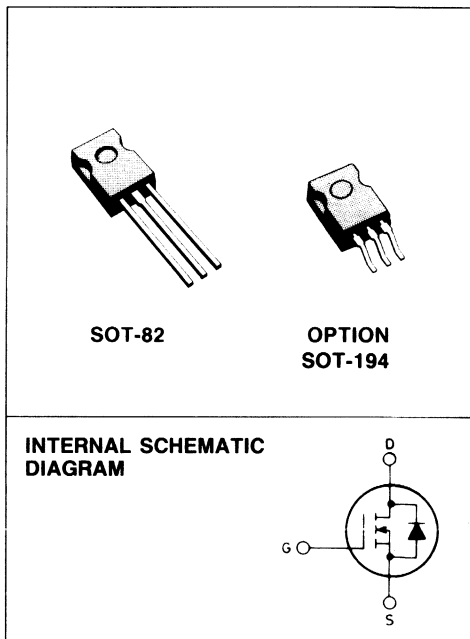
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP222 | 50 V             | 0.13 Ω              | 10 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

**INDUSTRIAL APPLICATIONS:**

- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS.

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Uses include general motor speed control, low voltage DC/DC converters and solenoid driving.


**ABSOLUTE MAXIMUM RATINGS**

|                      |                                                 |             |      |
|----------------------|-------------------------------------------------|-------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 50          | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 50          | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ±20         | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 10          | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 6.3         | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 40          | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 40          | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 50          | W    |
|                      | Derating factor                                 | 0.4         | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | - 65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |     |      |
|------------------|------------------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 2.5 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275 | °C   |

ELECTRICAL CHARACTERISTICS
(T<sub>case</sub> = 25°C unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                     |    |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|---------------------|----|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$                                                       | $V_{GS} = 0$        | 50 |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^\circ C$ |    | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                     |    | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                    |                                                   |   |  |              |                      |
|---------------|-----------------------------------|------------------------------------|---------------------------------------------------|---|--|--------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                  | $I_D = 250 \mu A$                                 | 2 |  | 4            | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$V_{GS} = 10 V$ | $I_D = 5 A$<br>$I_D = 5 A$<br>$T_c = 100^\circ C$ |   |  | 0.13<br>0.26 | $\Omega$<br>$\Omega$ |

DYNAMIC

|           |                              |                                 |                     |   |     |     |     |
|-----------|------------------------------|---------------------------------|---------------------|---|-----|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$                 | $I_D = 5 A$         | 3 |     |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$ |   | 460 | 550 | pF  |
| $C_{oss}$ | Output capacitance           |                                 |                     |   |     | 350 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                 |                     |   |     | 180 | pF  |

SWITCHING

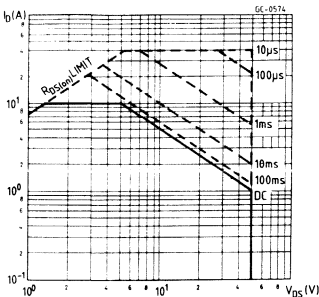
|               |                     |                    |                    |  |    |    |    |
|---------------|---------------------|--------------------|--------------------|--|----|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 25 V$    | $I_D = 5 A$        |  | 15 | 20 | ns |
| $t_r$         | Rise time           | $V_i = 10 V$       | $R_i = 4.7 \Omega$ |  | 40 | 55 | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit) |                    |  | 40 | 55 | ns |
| $t_f$         | Fall time           |                    |                    |  | 20 | 30 | ns |

ELECTRICAL CHARACTERISTICS (Continued)

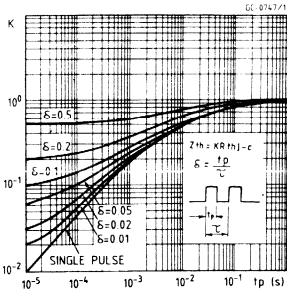
| Parameters                                                                   | Test Conditions                                                          | Min. | Typ. | Max.     | Unit   |
|------------------------------------------------------------------------------|--------------------------------------------------------------------------|------|------|----------|--------|
| $I_{SD}$ Source-drain current<br>$I_{SDM}$ (*) Source-drain current (pulsed) |                                                                          |      |      | 10<br>40 | A<br>A |
| $V_{SD}$ Forward on voltage                                                  | $I_{SD} = 10\text{ A}$ $V_{GS} = 0$                                      |      |      | 1.4      | V      |
| $t_{rr}$ Reverse recovery time                                               | $I_{SD} = 10\text{ A}$ $V_{GS} = 0$<br>$di/dt = 25\text{ A}/\mu\text{s}$ |      | 100  |          | ns     |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
(\*) Pulse width limited by safe operating area

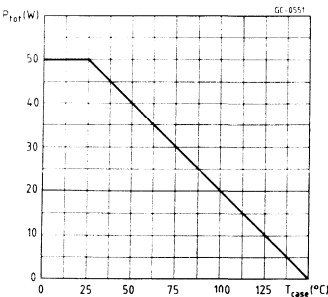
Safe operating areas



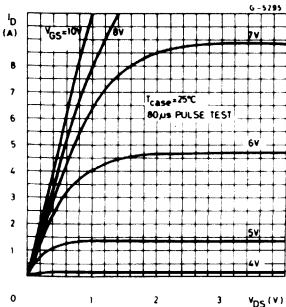
Thermal impedance



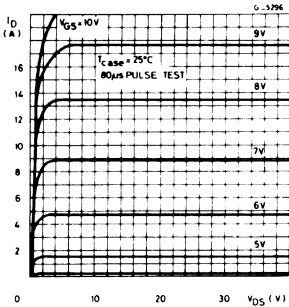
Derating curve



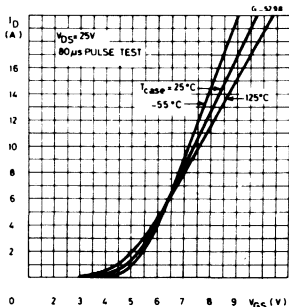
Output characteristics



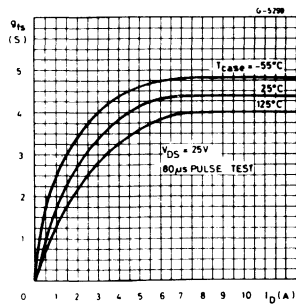
Output characteristics



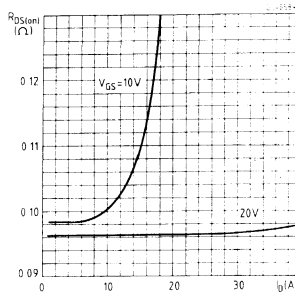
Transfer characteristics



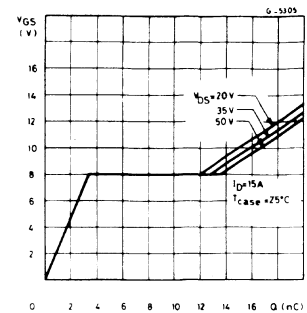
Transconductance



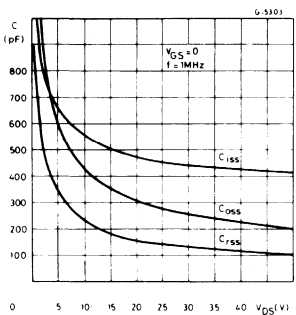
Static drain-source on resistance



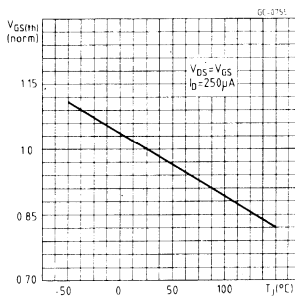
Gate charge vs gate-source voltage



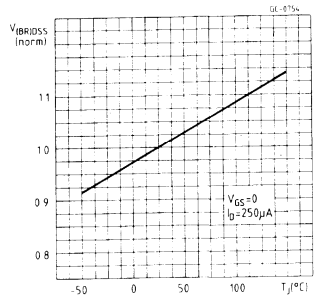
Capacitance variation



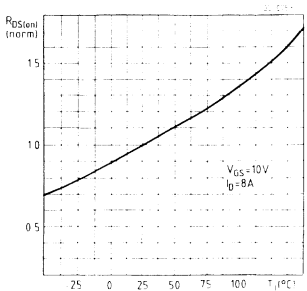
Normalized gate threshold voltage vs temperature



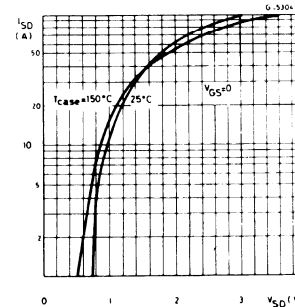
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature

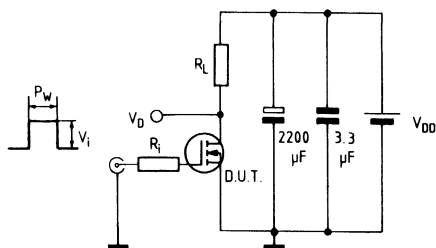


Source-drain diode forward characteristics



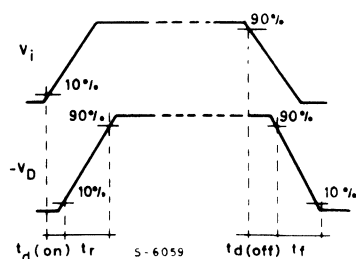


Switching times test circuit for resistive load

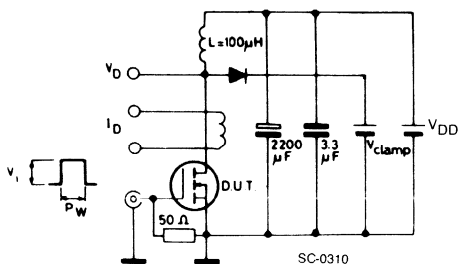
Pulse width  $\leq 100 \mu\text{s}$ Duty cycle  $\leq 2\%$ 

SC-0008/1

Switching time waveforms for resistive load

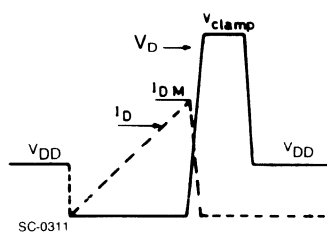


Clamped inductive load test circuit

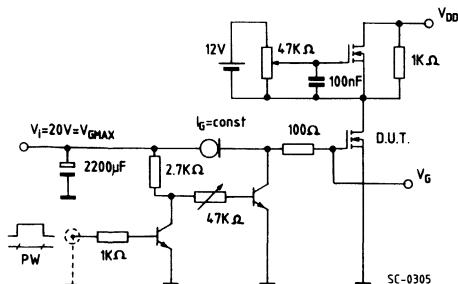
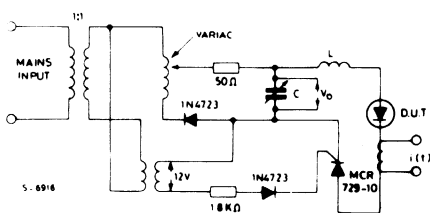


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(BR)} \text{ DSS}$ .

Clamped inductive waveforms



Gate charge test circuit

PW adjusted to obtain required  $V_G$ Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

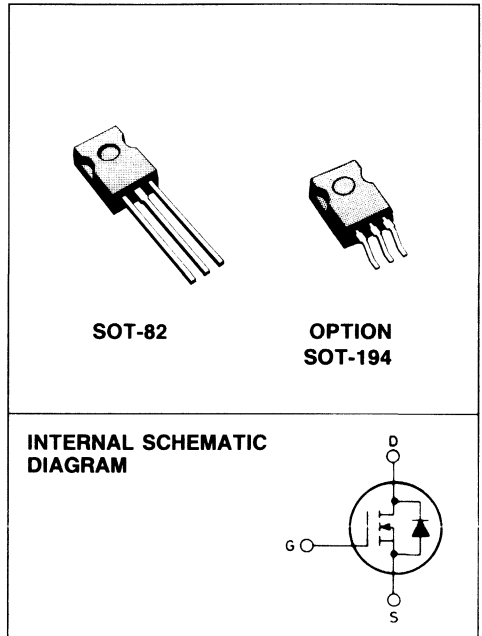
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP230 | 450 V            | 3 Ω                 | 2.5 A          |

- HIGH SPEED SWITCHING APPLICATIONS
- HIGH VOLTAGE - 450V FOR OFF-LINE SMPS
- ULTRA FAST SWITCHING FOR OPERATION AT > 100KHz
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include switching power supplies, uninterruptible power supplies and motor speed control.



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 |             |      |
|----------------------|-------------------------------------------------|-------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 450         | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 450         | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ±20         | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 2.5         | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 1.5         | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 10          | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 10          | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 50          | W    |
|                      | Derating factor                                 | 0.4         | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | - 65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |     |      |
|------------------|------------------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 2.5 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275 | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                 |     |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                               | 450 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>$T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                             |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                     |   |  |        |                      |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------|---|--|--------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$                                              | 2 |  | 4      | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 1.2 A$<br>$V_{GS} = 10 V$ $I_D = 1.2 A$ $T_c = 100^{\circ}C$ |   |  | 3<br>6 | $\Omega$<br>$\Omega$ |

DYNAMIC

|           |                              |                                                |     |     |     |     |
|-----------|------------------------------|------------------------------------------------|-----|-----|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$<br>$I_D = 1.2 A$               | 0.8 |     |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 MHz$ |     | 340 | 450 | pF  |
| $C_{oss}$ | Output capacitance           |                                                |     |     | 95  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                |     |     | 50  | pF  |

SWITCHING

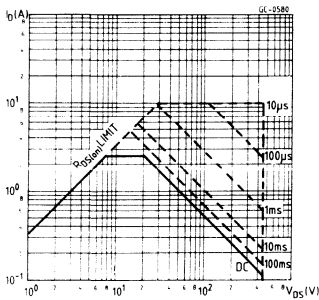
|               |                     |                                                        |                                     |    |    |    |
|---------------|---------------------|--------------------------------------------------------|-------------------------------------|----|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 225 V$<br>$V_i = 10 V$<br>(see test circuit) | $I_D = 1.2 A$<br>$R_i = 4.7 \Omega$ | 10 | 15 | ns |
| $t_r$         | Rise time           |                                                        |                                     | 25 | 35 | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                        |                                     | 55 | 70 | ns |
| $t_f$         | Fall time           |                                                        |                                     | 25 | 35 | ns |

ELECTRICAL CHARACTERISTICS (Continued)

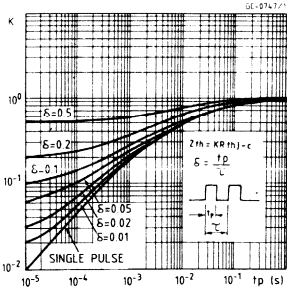
| Parameters                                                                     | Test Conditions                                                            | Min. | Typ. | Max.      | Unit   |
|--------------------------------------------------------------------------------|----------------------------------------------------------------------------|------|------|-----------|--------|
| $I_{SD}$ Source-drain current<br>$I_{SDM}^{(*)}$ Source-drain current (pulsed) |                                                                            |      |      | 2.5<br>10 | A<br>A |
| $V_{SD}$ Forward on voltage                                                    | $I_{SD} = 2.5\text{ A}$ $V_{GS} = 0$                                       |      |      | 1.2       | V      |
| $t_{rr}$ Reverse recovery time                                                 | $I_{SD} = 2.5\text{ A}$ $V_{GS} = 0$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |      | 340  |           | ns     |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
(\*) Pulse width limited by safe operating area

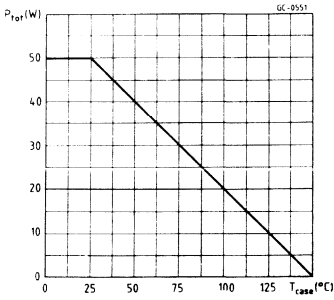
Safe operating areas



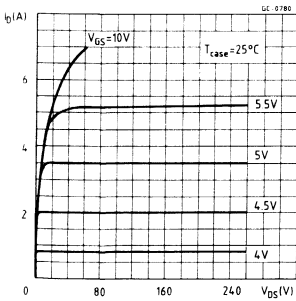
Thermal impedance



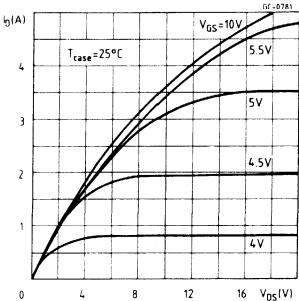
Derating curve



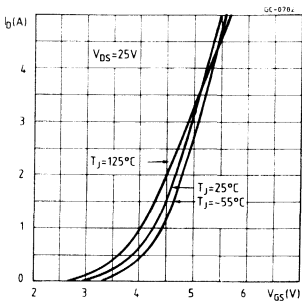
Output characteristics



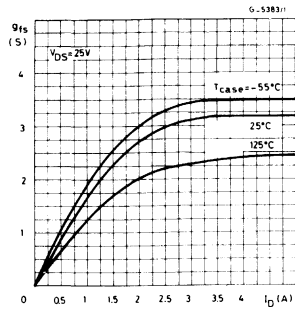
Output characteristics



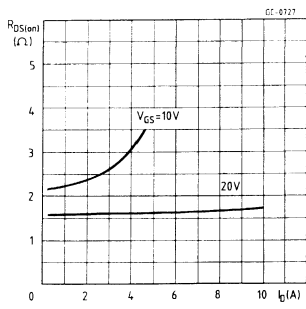
Transfer characteristics



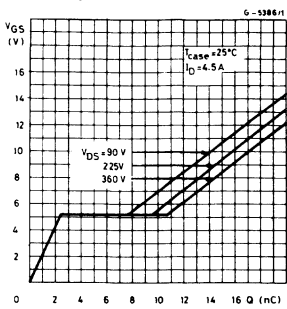
Transconductance



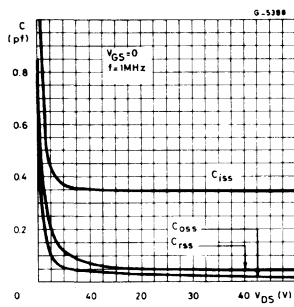
Static drain-source on resistance



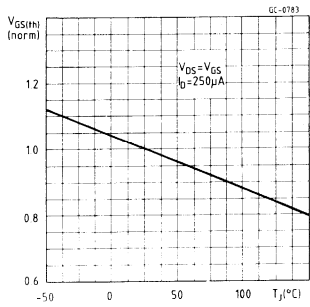
Gate charge vs gate-source voltage



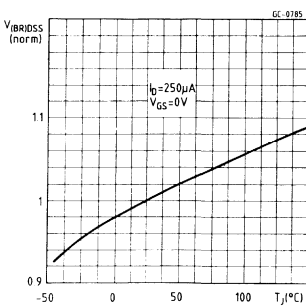
Capacitance variation



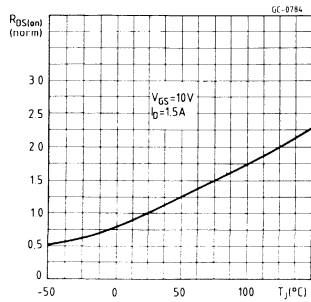
Normalized gate threshold voltage vs temperature



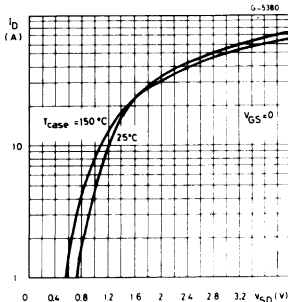
Normalized breakdown voltage vs temperature



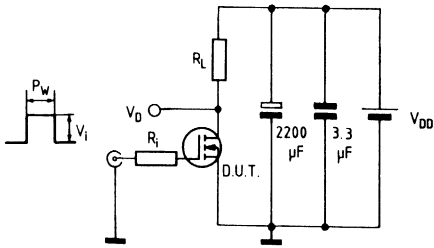
Normalized on resistance vs temperature



Source-drain diode forward characteristics



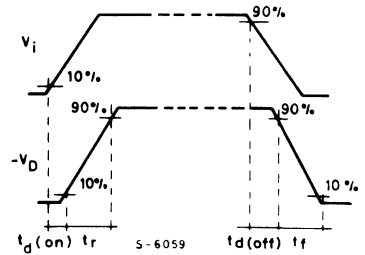
Switching times test circuit for resistive load



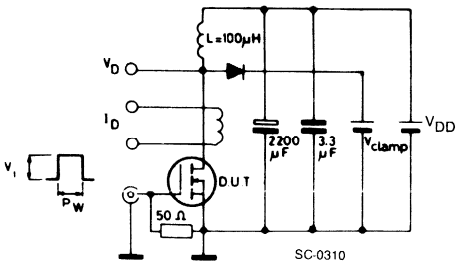
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

SC-0008/1

Switching time waveforms for resistive load



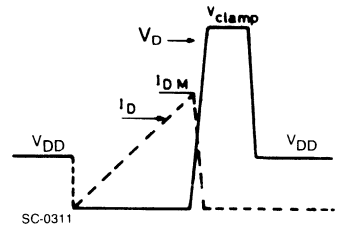
Clamped inductive load test circuit



$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ ,  $V_{clamp} = 0.75 V_{(BR)} \text{ DSS}$ .

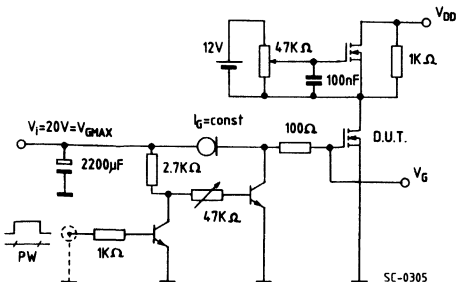
SC-0310

Clamped inductive waveforms



SC-0311

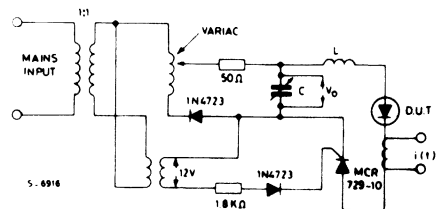
Gate charge test circuit



SC-0305

PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit







## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

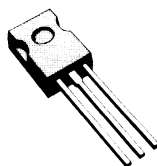
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP239 | 500 V            | 8.5 Ω               | 1.2 A          |

- HIGH SPEED SWITCHING APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

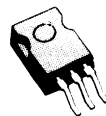
### INDUSTRIAL APPLICATIONS:

- SWITCHING MODE POWER SUPPLIES

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. These include switching power supplies, solenoid drivers and drive circuits for power bipolar transistors.

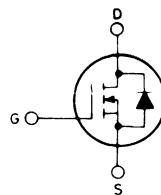


**SOT-82**



**OPTION  
SOT-194**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 |             |      |
|----------------------|-------------------------------------------------|-------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 500         | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 500         | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ± 20        | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 1.2         | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 0.8         | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 4.8         | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 4.8         | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 40          | W    |
|                      | Derating factor                                 | 0.32        | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | - 65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 3.12 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                              |     |  |             |                    |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                            | 500 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                          |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                     |   |  |           |                      |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------|---|--|-----------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$                                              | 2 |  | 4         | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 0.6 A$<br>$V_{GS} = 10 V$ $I_D = 0.6 A$ $T_c = 100^{\circ}C$ |   |  | 8.5<br>17 | $\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                                        |      |     |                 |                |
|-------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------|------|-----|-----------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$<br>$I_D = 0.6 A$                       | 0.65 |     |                 | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 \text{ MHz}$ |      | 260 | 300<br>80<br>40 | pF<br>pF<br>pF |

SWITCHING

|               |                     |                                                                                               |  |                      |                      |                      |
|---------------|---------------------|-----------------------------------------------------------------------------------------------|--|----------------------|----------------------|----------------------|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 250 V$<br>$V_i = 10 V$<br>$I_D = 0.6 A$<br>$R_i = 4.7 \Omega$<br>(see test circuit) |  | 15<br>15<br>30<br>20 | 20<br>30<br>60<br>45 | ns<br>ns<br>ns<br>ns |
| $t_r$         | Rise time           |                                                                                               |  |                      |                      |                      |
| $t_{d (off)}$ | Turn-off delay time |                                                                                               |  |                      |                      |                      |
| $t_f$         | Fall time           |                                                                                               |  |                      |                      |                      |

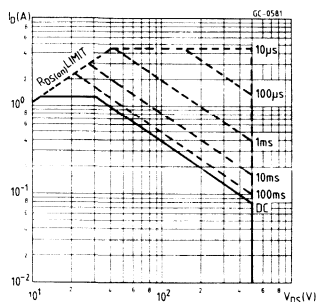
## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                  | Test Conditions                                          | Min. | Typ. | Max. | Unit |
|---------------------------------------------|----------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current               |                                                          |      |      | 1.2  | A    |
| $I_{SDM}$ (*) Source-drain current (pulsed) |                                                          |      |      | 4.8  | A    |
| $V_{SD}$ Forward on voltage                 | $I_{SD} = 1.2$ A $V_{GS} = 0$                            |      |      | 1.15 | V    |
| $t_{rr}$ Reverse recovery time              | $I_{SD} = 1.2$ A $V_{GS} = 0$<br>$di/dt = 25$ A/ $\mu$ s |      | 350  |      | ns   |

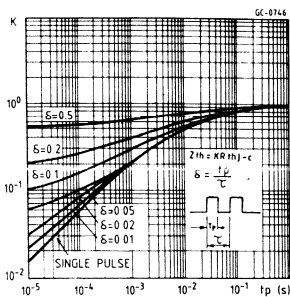
(\*) Pulsed: Pulse duration = 300  $\mu$ s, duty cycle 1.5%

(\*) Pulse width limited by safe operating area

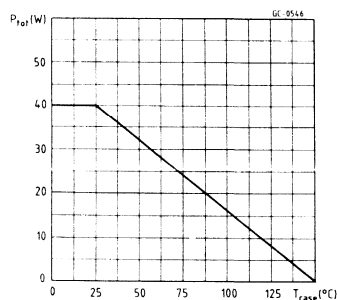
Safe operating areas



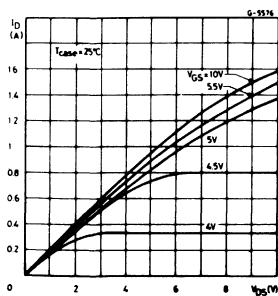
Thermal impedance



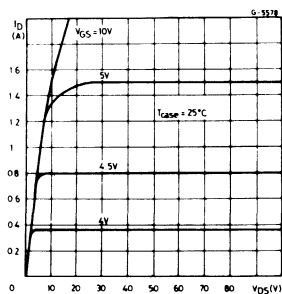
Derating curve



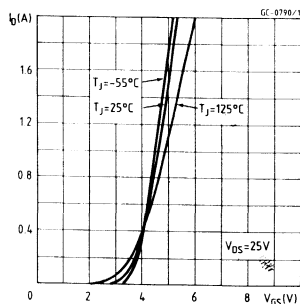
Output characteristics



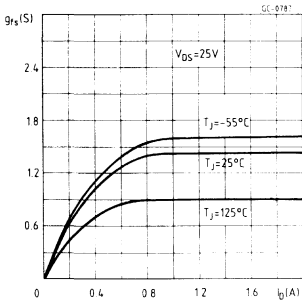
Output characteristics



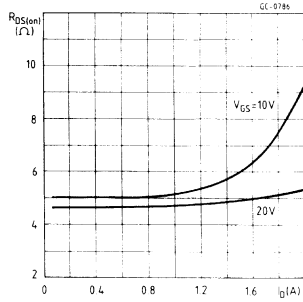
Transfer characteristics



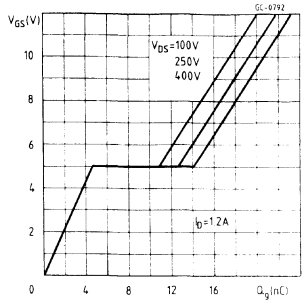
Transconductance



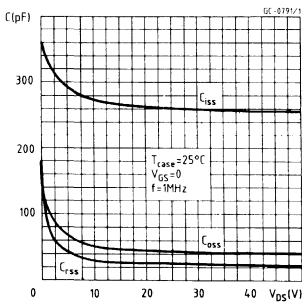
Static drain-source on resistance



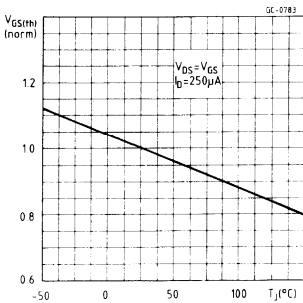
Gate charge vs gate-source voltage



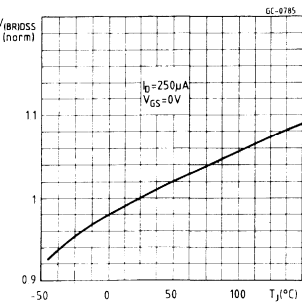
Capacitance variation



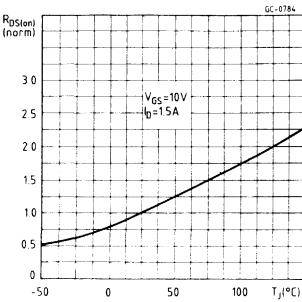
Normalized gate threshold voltage vs temperature



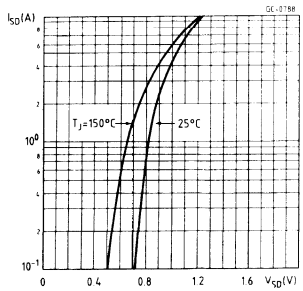
Normalized breakdown voltage vs temperature



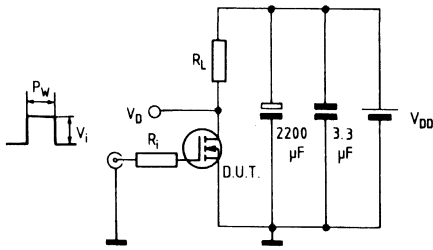
Normalized on resistance vs temperature



Source-drain diode forward characteristics



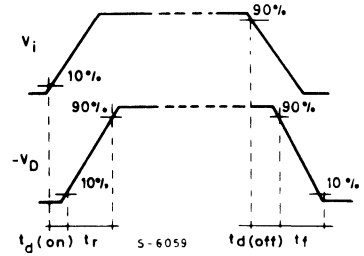
### Switching times test circuit for resistive load



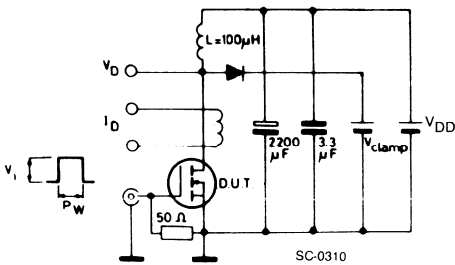
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

SC-0008/1

### Switching time waveforms for resistive load

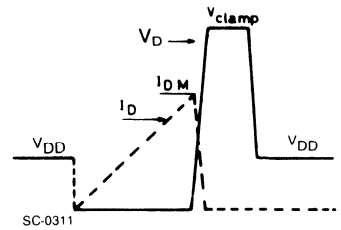


### Clamped inductive load test circuit

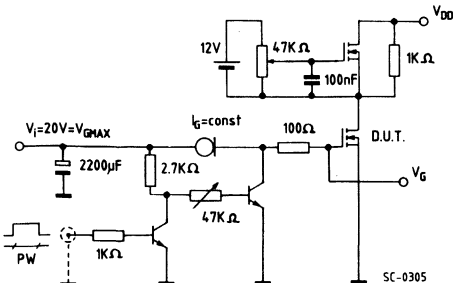


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(\text{BR}) \text{ DSS}}$

### Clamped inductive waveforms

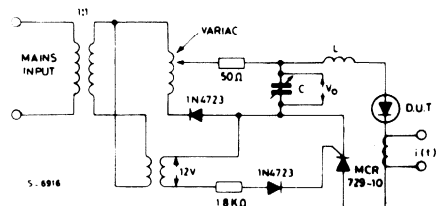


### Gate charge test circuit



PW adjusted to obtain required  $V_G$

### Body-drain diode $t_{rr}$ measurement Jedec test circuit





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

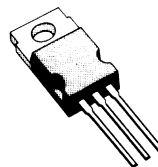
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP301 | 100 V            | 1.4 Ω               | 2.0 A          |

- HIGH SPEED SWITCHING APPLICATIONS
- GENERAL PURPOSE APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

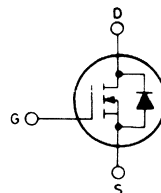
- GENERAL PURPOSE SWITCHING

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include general purpose low voltage switching, solenoid driving, motor and lamp control, switching power supplies, and driving, bipolar power switching transistors.



TO-220

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 |            |      |
|----------------------|-------------------------------------------------|------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 100        | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 100        | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ±20        | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 2.0        | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 1.2        | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 6          | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 6          | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 18         | W    |
|                      | Derating factor                                 | 0.144      | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | -65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150        | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 6.95 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                              |     |  |             |                    |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                            | 100 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                          |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                     |   |  |            |                      |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------|---|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$                                              | 2 |  | 4          | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 1.2 A$<br>$V_{GS} = 10 V$ $I_D = 1.2 A$ $T_c = 100^{\circ}C$ |   |  | 1.4<br>2.8 | $\Omega$<br>$\Omega$ |

DYNAMIC

|           |                              |                                                |     |    |     |     |
|-----------|------------------------------|------------------------------------------------|-----|----|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$<br>$I_D = 1.2 A$               | 0.5 |    |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 MHz$ |     | 90 | 125 | pF  |
| $C_{oss}$ | Output capacitance           |                                                |     |    | 45  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                |     |    | 30  | pF  |

SWITCHING

|               |                     |                                 |                                     |  |          |          |          |
|---------------|---------------------|---------------------------------|-------------------------------------|--|----------|----------|----------|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 50 V$<br>$V_i = 10 V$ | $I_D = 1.2 A$<br>$R_i = 4.7 \Omega$ |  | 10<br>20 | 15<br>30 | ns<br>ns |
| $t_r$         | Rise time           | (see test circuit)              |                                     |  | 15       | 20       | ns       |
| $t_{d (off)}$ | Turn-off delay time |                                 |                                     |  | 15       | 20       | ns       |
| $t_f$         | Fall time           |                                 |                                     |  | 15       | 20       | ns       |

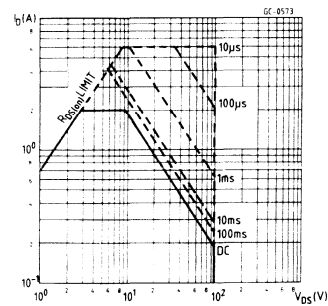


ELECTRICAL CHARACTERISTICS (Continued)

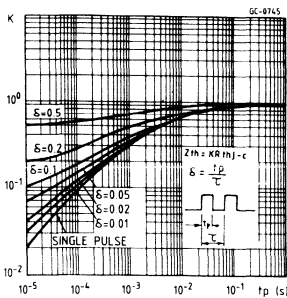
| Parameters                                                                   | Test Conditions                                                           | Min. | Typ. | Max.     | Unit   |
|------------------------------------------------------------------------------|---------------------------------------------------------------------------|------|------|----------|--------|
| $I_{SD}$ Source-drain current<br>$I_{SDM}$ (*) Source-drain current (pulsed) |                                                                           |      |      | 2.0<br>6 | A<br>A |
| $V_{SD}$ Forward on voltage                                                  | $I_{SD} = 2.5\text{ A}$ $V_{GS} = 0$                                      |      |      | 1.35     | V      |
| $t_{rr}$ Reverse recovery time                                               | $I_{SD} = 2.5\text{ A}$ $V_{GS} = 0$<br>$di/dt = 25\text{ A}/\mu\text{s}$ |      | 90   |          | ns     |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
(\*) Pulse width limited by safe operating area

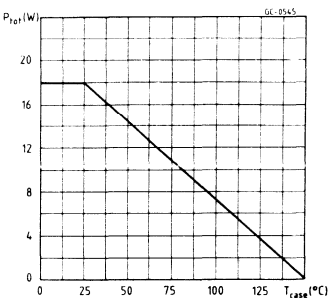
Safe operating areas



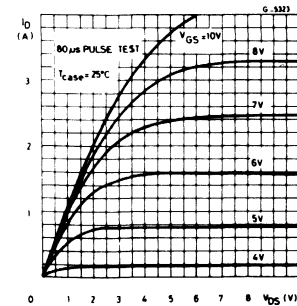
Thermal impedance



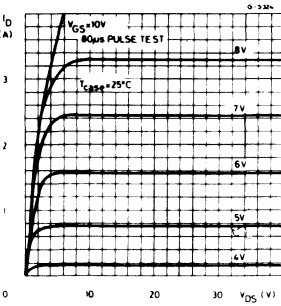
Derating curve



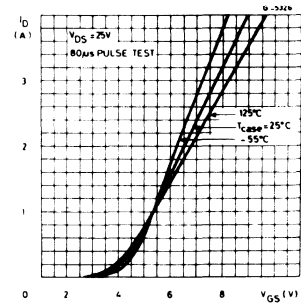
Output characteristics



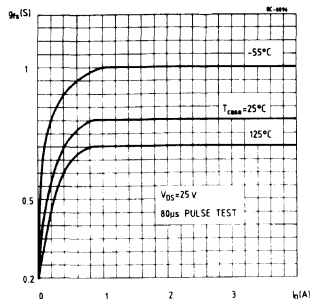
Output characteristics



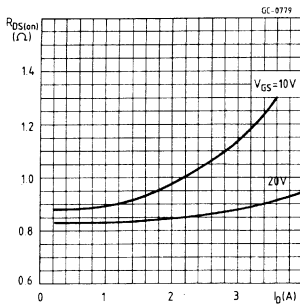
Transfer characteristics



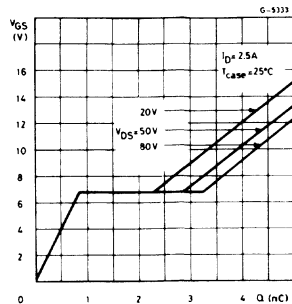
Transconductance



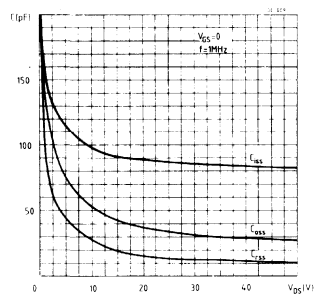
Static drain-source on resistance



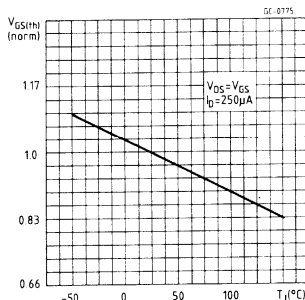
Gate charge vs gate-source voltage



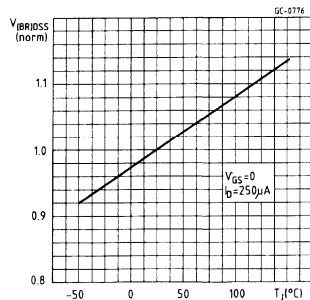
Capacitance variation



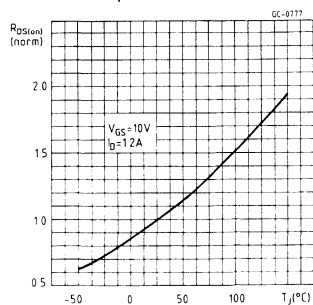
Normalized gate threshold voltage vs temperature



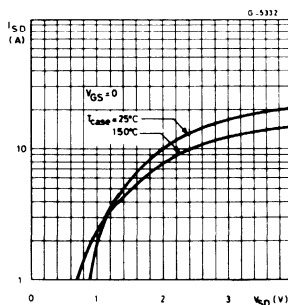
Normalized breakdown voltage vs temperature



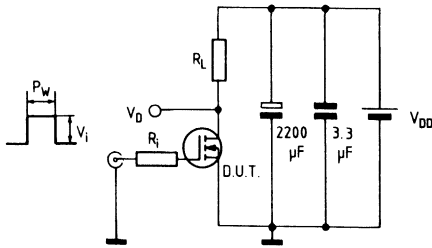
Normalized on resistance vs temperature



Source-drain diode forward characteristics

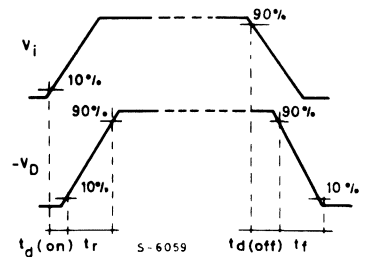


Switching times test circuit for resistive load

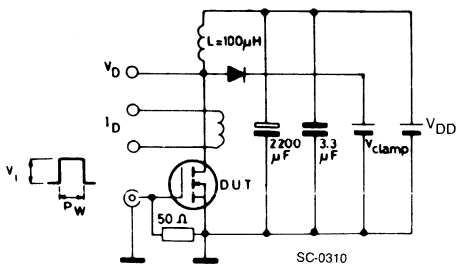


Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

Switching time waveforms for resistive load

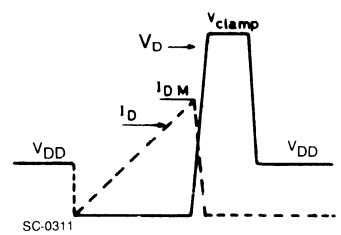


Clamped inductive load test circuit

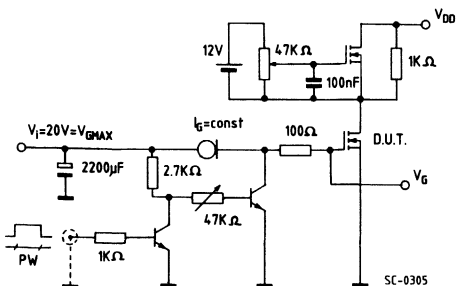


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ ,  $V_{\text{clamp}} = 0.75 V_{(\text{BR}) \text{ DSS}}$

Clamped inductive waveforms

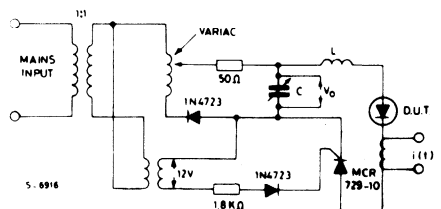


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

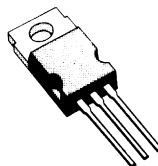
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP311 | 100 V            | 0.3 Ω               | 11 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- 100V FOR DC/DC CONVERTERS
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

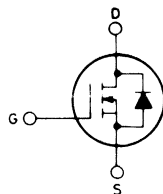
- SWITCHING MODE POWER SUPPLIES
- STEPPER MOTOR CONTROL

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical uses include DC/DC converters, stepper motors and solenoid drives.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 |            |      |
|---------------------|-------------------------------------------------|------------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)      | 100        | V    |
| V <sub>DGR</sub>    | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 100        | V    |
| V <sub>GS</sub>     | Gate-source voltage                             | ±20        | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 11         | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 7          | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 30         | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      | 75         | W    |
|                     | Derating factor                                 | 0.6        | W/°C |
| T <sub>stg</sub>    | Storage temperature                             | -65 to 150 | °C   |
| T <sub>j</sub>      | Max. operating junction temperature             | 150        | °C   |

(\*) Pulse width limited by safe operating area

♦ Introduced in 1989 week 1

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.67 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                              |     |  |             |                    |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$ $V_{GS} = 0$                                                               | 100 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                          |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                     |   |  |            |                      |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------|---|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 250 \mu A$                                                 | 2 |  | 4          | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 5.5 A$<br>$V_{GS} = 10 V$ $I_D = 5.5 A$ $T_c = 100^{\circ}C$ |   |  | 0.3<br>0.6 | $\Omega$<br>$\Omega$ |

ENERGY TEST

|           |                                                      |                                                                 |    |  |  |   |
|-----------|------------------------------------------------------|-----------------------------------------------------------------|----|--|--|---|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 V$<br>starting $T_j = 25^{\circ}C$ $L = 100 \mu H$ | 11 |  |  | A |
|-----------|------------------------------------------------------|-----------------------------------------------------------------|----|--|--|---|

DYNAMIC

|                                     |                                                                         |                                             |   |     |                   |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------------------|---|-----|-------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$ $I_D = 5.5 A$               | 2 |     |                   | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$ $f = 1 MHz$<br>$V_{GS} = 0$ |   | 375 | 480<br>230<br>110 | pF<br>pF<br>pF |

SWITCHING

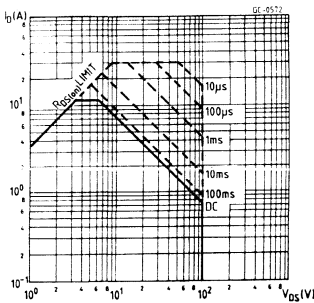
|               |                     |                                 |  |    |    |    |
|---------------|---------------------|---------------------------------|--|----|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 50 V$ $I_D = 5.5 A$   |  | 15 | 20 | ns |
| $t_r$         | Rise time           | $V_i = 10 V$ $R_i = 4.7 \Omega$ |  | 40 | 55 | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit)              |  | 40 | 55 | ns |
| $t_f$         | Fall time           |                                 |  | 20 | 30 | ns |

ELECTRICAL CHARACTERISTICS (Continued)

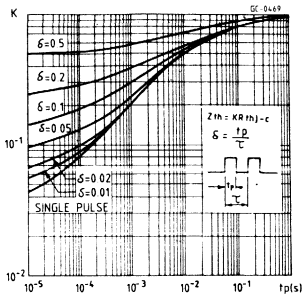
| Parameters                                  | Test Conditions                                                       | Min. | Typ. | Max. | Unit |
|---------------------------------------------|-----------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current               |                                                                       |      |      | 11   | A    |
| $I_{SDM}$ (*) Source-drain current (pulsed) |                                                                       |      |      | 44   | A    |
| $V_{SD}$ Forward on voltage                 | $I_{SD} = 11\text{ A}$ $V_{GS} = 0$                                   |      |      | 1.35 | V    |
| $t_{rr}$ Reverse recovery time              | $I_{SD} = 11\text{ A}$ $dI/dt = 25\text{ A}/\mu\text{s}$ $V_{GS} = 0$ |      | 140  |      | ns   |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
(\*) Pulse width limited by safe operating area

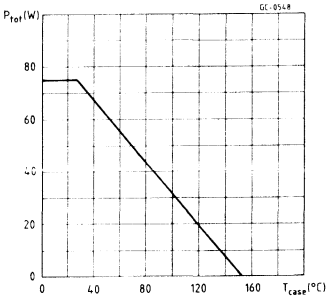
Safe operating areas



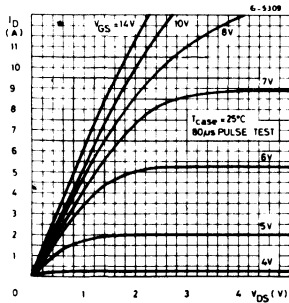
Thermal impedance



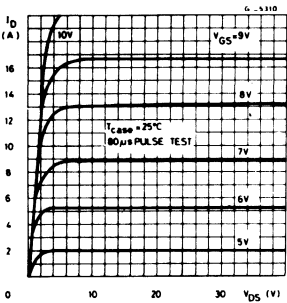
Derating curve



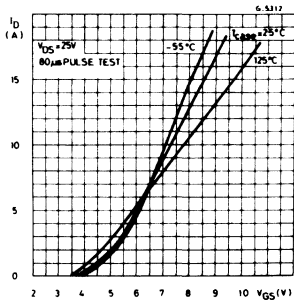
Output characteristics



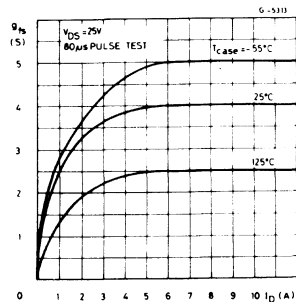
Output characteristics



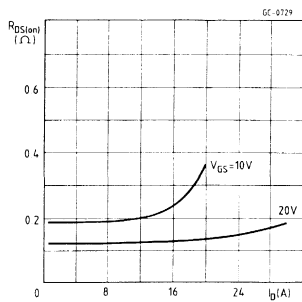
Transfer characteristics



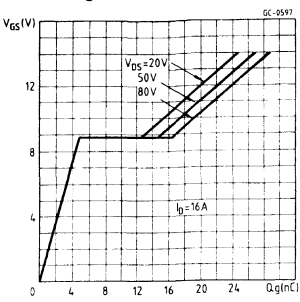
Transconductance



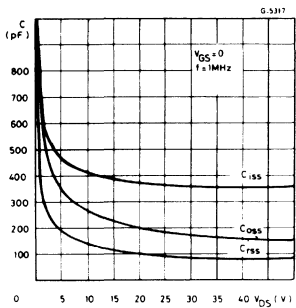
Static drain-source on resistance



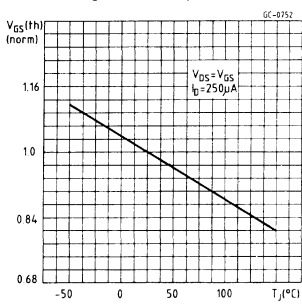
Gate charge vs gate-source voltage



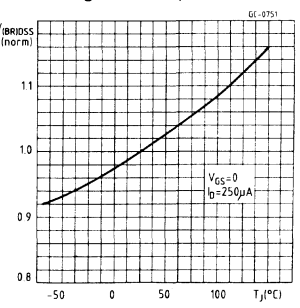
Capacitance variation



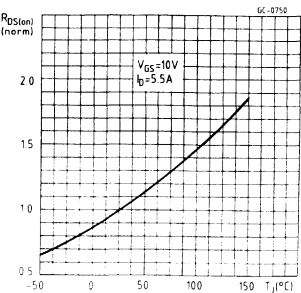
Normalized gate threshold voltage vs temperature



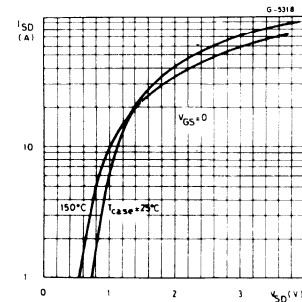
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature

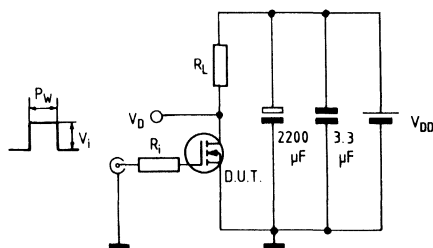


Source-drain diode forward characteristics



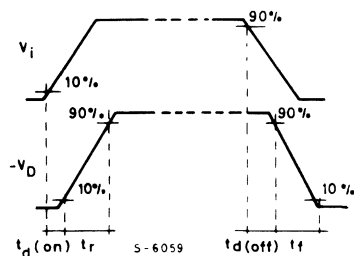


Switching times test circuit for resistive load

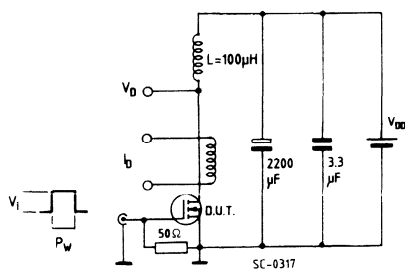


Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

Switching time waveforms for resistive load

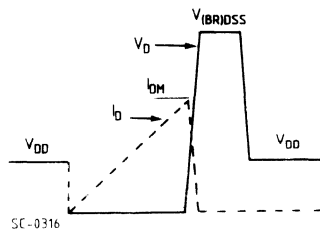


Unclamped inductive load test circuit

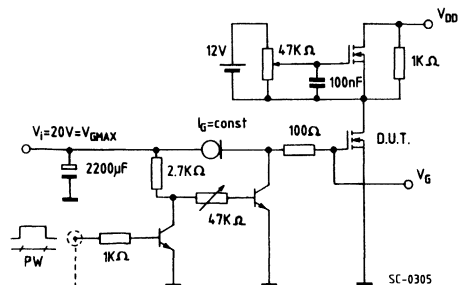


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$

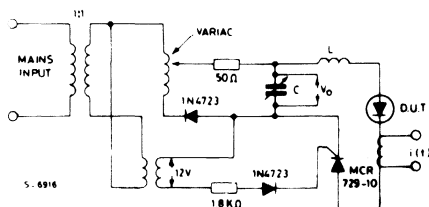
Unclamped inductive waveforms



Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

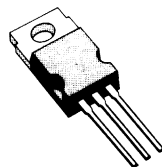
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP316 | 250 V            | 1.2 $\Omega$        | 5 A            |
| SGSP317 | 200 V            | 0.75 $\Omega$       | 6 A            |

- HIGH SPEED SWITCHING APPLICATIONS
- ULTRA FAST SWITCHING
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- EASY DRIVE - REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

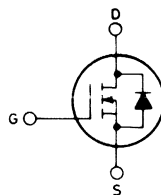
- SWITCHING POWER SUPPLIES
- DC SWITCH

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Typical uses are in telecommunications, switching power supplies and as a DC switch.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                       | SGSP316     | SGSP317 |      |
|---------------------|-------------------------------------------------------|-------------|---------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)            | 250         | 200     | V    |
| V <sub>DGR</sub>    | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 250         | 200     | V    |
| V <sub>GS</sub>     | Gate-source voltage                                   | $\pm 20$    |         | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C        | 5           | 6       | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C       | 3.1         | 3.7     | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                                | 20          | 24      | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C            | 75          |         | W    |
|                     | Derating factor                                       | 0.6         |         | W/°C |
| T <sub>stg</sub>    | Storage temperature                                   | - 65 to 150 |         | °C   |
| T <sub>j</sub>      | Max. operating junction temperature                   | 150         |         | °C   |

(\*) Pulse width limited by safe operating area

♦ Introduced in 1988 week 44

THERMAL DATA

|                  |                                                |     |      |               |
|------------------|------------------------------------------------|-----|------|---------------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.67 | $^{\circ}C/W$ |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | $^{\circ}C$   |

ELECTRICAL CHARACTERISTICS
( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>SGSP316</b><br>for <b>SGSP317</b>           | $V_{GS} = 0$         | 250<br>200  | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                                                                                                                |                      |   |                           |                                              |
|---------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---|---------------------------|----------------------------------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                                                                                              | $I_D = 250 \mu A$    | 2 | 4                         | V                                            |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$I_D = 2.5 A$ for <b>SGSP316</b><br>$I_D = 3 A$ for <b>SGSP317</b><br>$V_{GS} = 10 V$<br>$I_D = 2.5 A$ for <b>SGSP316</b><br>$I_D = 3 A$ for <b>SGSP317</b> | $T_c = 100^{\circ}C$ |   | 1.2<br>0.75<br>2.4<br>1.5 | $\Omega$<br>$\Omega$<br>$\Omega$<br>$\Omega$ |

ENERGY TEST

|           |                                                      |                                                                                             |                 |        |        |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------|--------|--------|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 V$<br>starting $T_j = 25^{\circ}C$<br>for <b>SGSP316</b><br>for <b>SGSP317</b> | $L = 100 \mu H$ | 5<br>6 | A<br>A |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------|--------|--------|

DYNAMIC

|                                     |                                                                         |                                 |             |     |                         |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|-------------|-----|-------------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$                 | $I_D = 3 A$ | 1.5 |                         | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 MHz$ |     | 380<br>500<br>130<br>65 | pF<br>pF<br>pF |

## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

## SWITCHING

|              |                     |                                                                                                                   |    |    |    |
|--------------|---------------------|-------------------------------------------------------------------------------------------------------------------|----|----|----|
| $t_{d(on)}$  | Turn-on time        | $V_{DD} = 100\text{ V}$<br>$V_i = 10\text{ V}$<br>$I_D = 3\text{ A}$<br>$R_i = 4.7\ \Omega$<br>(see test circuit) | 15 | 20 | ns |
| $t_r$        | Rise time           |                                                                                                                   | 30 | 40 | ns |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                                   | 45 | 60 | ns |
| $t_f$        | Fall time           |                                                                                                                   | 15 | 20 | ns |

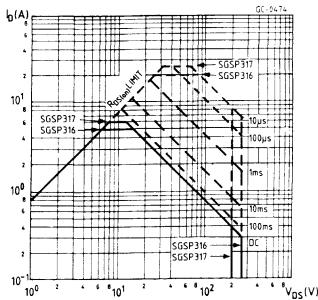
## SOURCE DRAIN DIODE

|                 |                               |                                                                                                      |  |     |            |        |
|-----------------|-------------------------------|------------------------------------------------------------------------------------------------------|--|-----|------------|--------|
| $I_{SD}$        | Source-drain current          | for <b>SGSP316</b><br>for <b>SGSP317</b>                                                             |  |     | 5<br>6     | A<br>A |
| $I_{SDM}^{(*)}$ | Source-drain current (pulsed) | for <b>SGSP316</b><br>for <b>SGSP317</b>                                                             |  |     | 20<br>24   | A<br>A |
| $V_{SD}$        | Forward on voltage            | $V_{GS} = 0$<br>$I_{SD} = 6\text{ A}$ for <b>SGSP316</b><br>$I_{SD} = 5\text{ A}$ for <b>SGSP317</b> |  |     | 1.3<br>1.3 | V<br>V |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 6\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{GS} = 0$                          |  | 180 |            | ns     |

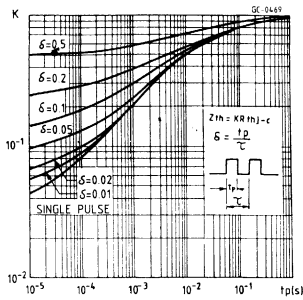
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

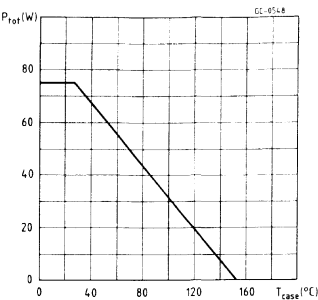
Safe operating areas



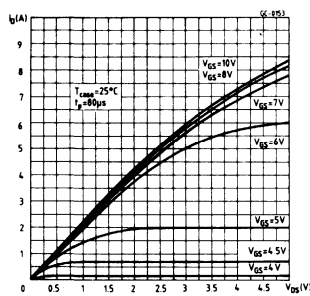
Thermal impedance



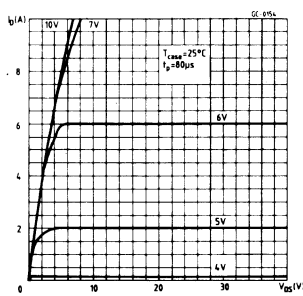
Derating curve



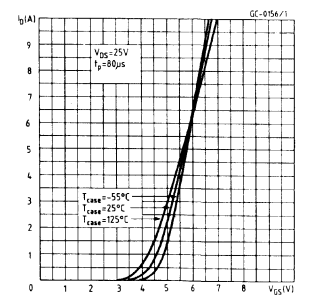
Output characteristics



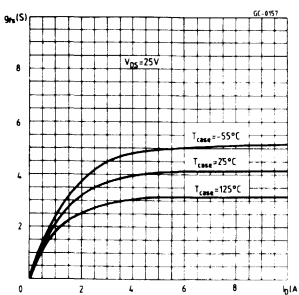
Output characteristics



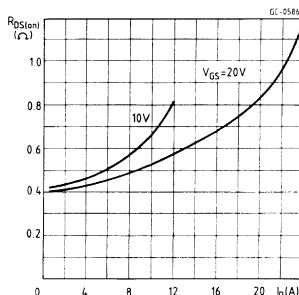
Transfer characteristics



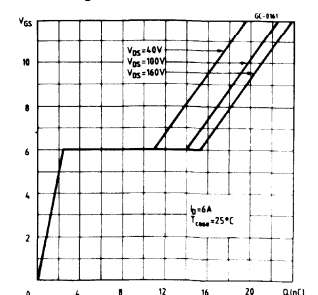
Transconductance



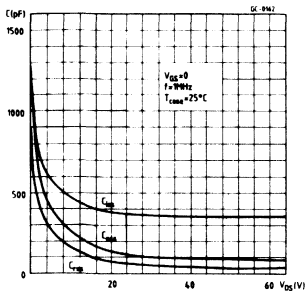
Static drain-source on resistance



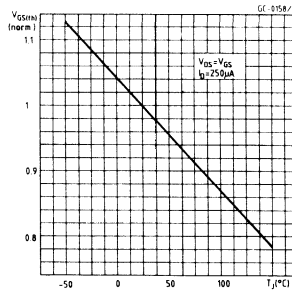
Gate charge vs gate-source voltage



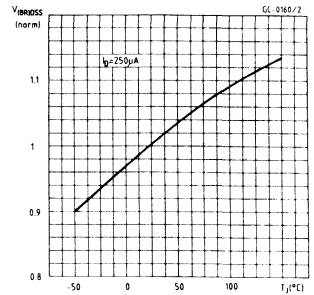
Capacitance variation



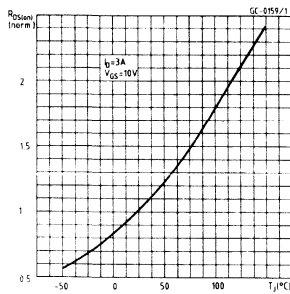
Normalized gate threshold voltage vs temperature



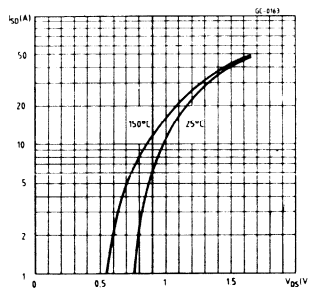
Normalized breakdown voltage vs temperature



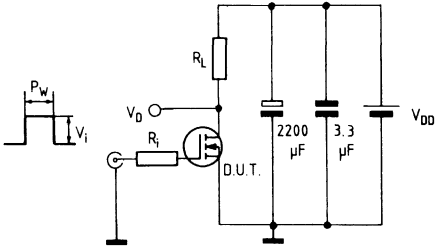
Normalized on resistance vs temperature



Source-drain diode forward characteristics

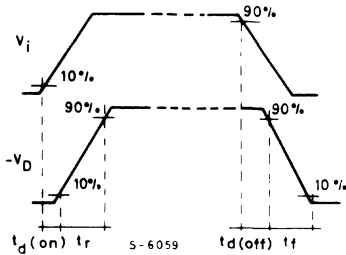


Switching times test circuit for resistive load

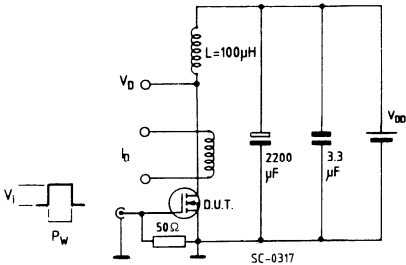


Pulse width  $\leq 100 \mu s$   
Duty cycle  $\leq 2\%$

Switching time waveforms for resistive load

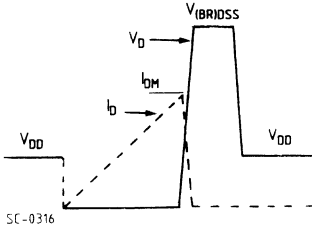


Unclamped inductive load test circuit

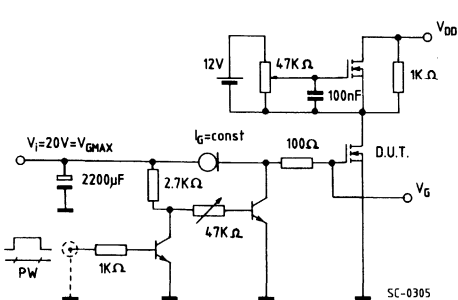


$V_i = 12 V$  - Pulse width: adjusted to obtain specified  $I_{DM}$

Unclamped inductive waveforms

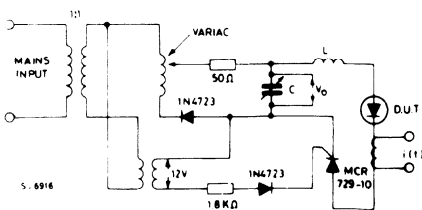


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

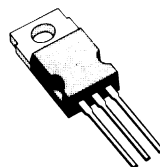
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP319 | 500 V            | 3.8 Ω               | 2.8 A          |

- HIGH SPEED SWITCHING APPLICATIONS
- 500V - HIGH VOLTAGE FOR SMPS
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

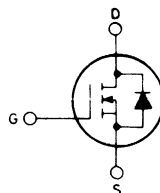
- SWITCHING POWER SUPPLIES

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include switching power supplies, battery chargers, motor speed control and solenoid drivers.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 |            |      |
|----------------------|-------------------------------------------------|------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 500        | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 500        | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ±20        | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 2.8        | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 1.7        | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 11         | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 11         | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 75         | W    |
|                      | Derating factor                                 | 0.6        | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | -65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150        | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.67 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                 |     |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                               | 500 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>$T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                             |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                              |   |  |            |                      |
|---------------|-----------------------------------|----------------------------------------------------------------------------------------------|---|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$                                                       | 2 |  | 4          | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$V_{GS} = 10 V$<br>$I_D = 1.4 A$<br>$I_D = 1.4 A$<br>$T_c = 100^{\circ}C$ |   |  | 3.8<br>7.2 | $\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                                        |     |     |                 |                |
|-------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------|-----|-----|-----------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$<br>$I_D = 1.4 A$                       | 0.8 |     |                 | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 \text{ MHz}$ |     | 340 | 380<br>70<br>50 | pF<br>pF<br>pF |

SWITCHING

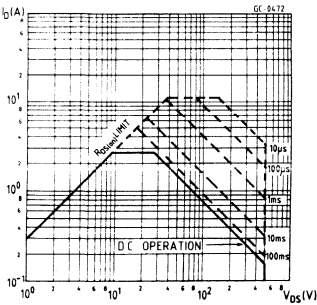
|             |                     |                                    |  |    |    |    |
|-------------|---------------------|------------------------------------|--|----|----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 250 V$<br>$I_D = 1.4 A$  |  | 15 | 20 | ns |
| $t_r$       | Rise time           | $V_i = 10 V$<br>$R_i = 4.7 \Omega$ |  | 25 | 35 | ns |
| $t_d (off)$ | Turn-off delay time | (see test circuit)                 |  | 50 | 65 | ns |
| $t_f$       | Fall time           |                                    |  | 25 | 35 | ns |

ELECTRICAL CHARACTERISTICS (Continued)

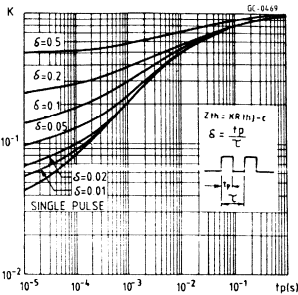
| Parameters                                                                   | Test Conditions                                                            | Min. | Typ. | Max.      | Unit   |
|------------------------------------------------------------------------------|----------------------------------------------------------------------------|------|------|-----------|--------|
| $I_{SD}$ Source-drain current<br>$I_{SDM}$ (*) Source-drain current (pulsed) |                                                                            |      |      | 2.8<br>11 | A<br>A |
| $V_{SD}$ Forward on voltage                                                  | $I_{SD} = 2.8\text{ A}$ $V_{GS} = 0$                                       |      |      | 1.15      | V      |
| $t_{rr}$ Reverse recovery time                                               | $I_{SD} = 2.8\text{ A}$ $V_{GS} = 0$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |      | 360  |           | ns     |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
(\*) Pulse width limited by safe operating area

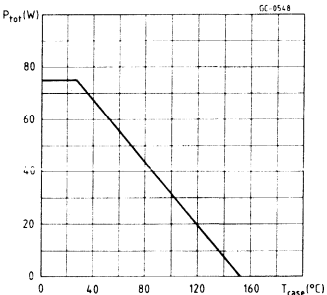
Safe operating areas



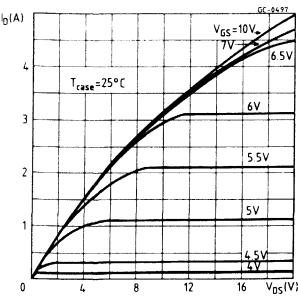
Thermal impedance



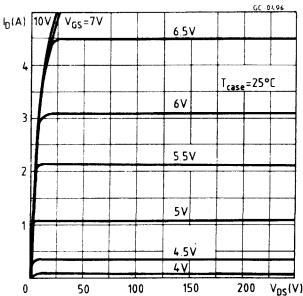
Derating curve



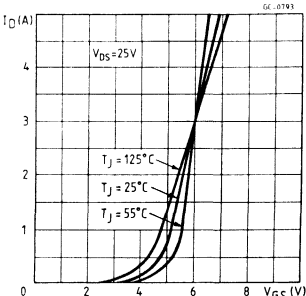
Output characteristics



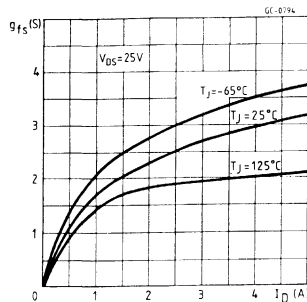
Output characteristics



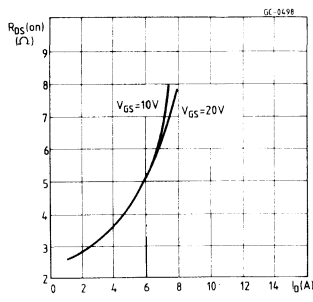
Transfer characteristics



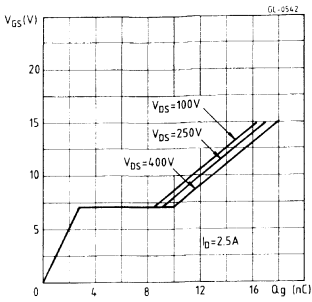
Transconductance



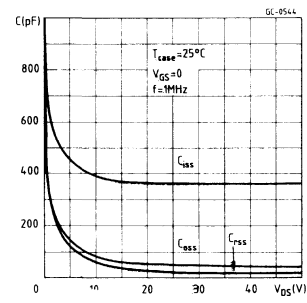
Static drain-source on resistance



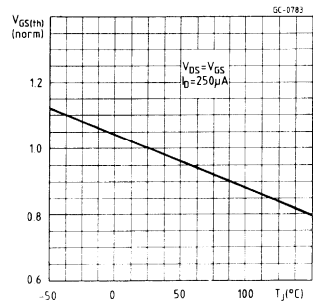
Gate charge vs gate-source voltage



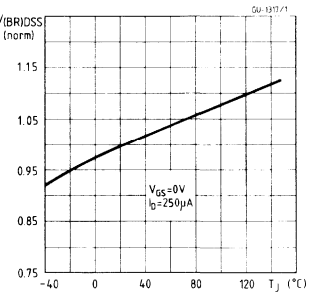
Capacitance variation



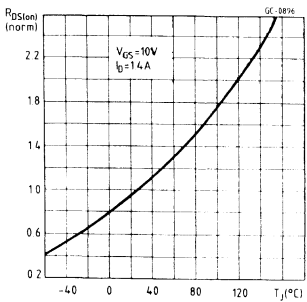
Normalized gate threshold voltage vs temperature



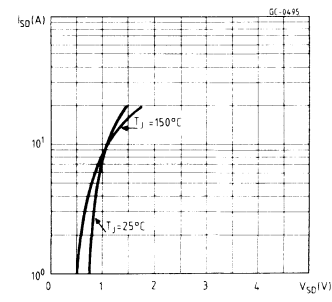
Normalized breakdown voltage vs temperature



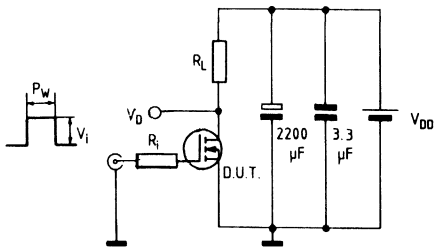
Normalized on resistance vs temperature



Source-drain diode forward characteristics

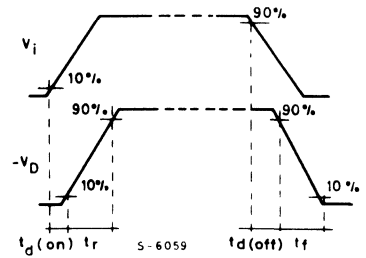


Switching times test circuit for resistive load

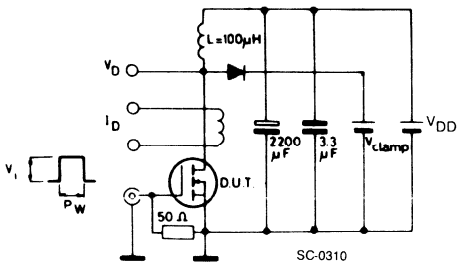


Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

Switching time waveforms for resistive load

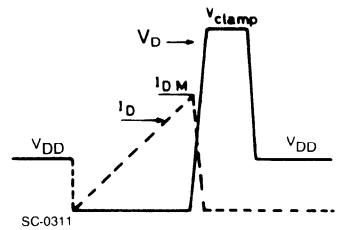


Clamped inductive load test circuit

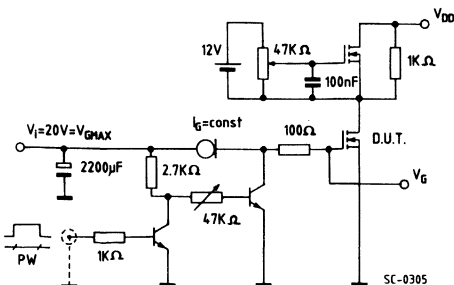


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(BR) \text{ DSS}}$

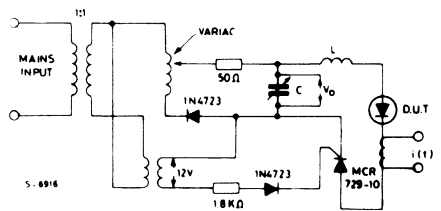
Clamped inductive waveforms



Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

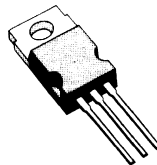
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP321 | 60 V             | 0.13 Ω              | 16 A           |
| SGSP322 | 50 V             | 0.13 Ω              | 16 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- LOW VOLTAGE DC/DC CONVERTERS
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

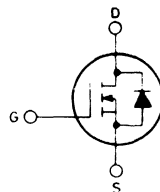
- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Uses include motor speed control, low voltage DC/DC converters and solenoid driving.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 | SGSP321     | SGSP322 |      |
|----------------------|-------------------------------------------------|-------------|---------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 60          | 50      | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 60          | 50      | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ± 20        |         | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 16          |         | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 10          |         | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 40          |         | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 40          |         | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 75          |         | W    |
|                      | Derating factor                                 | 0.6         |         | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | - 65 to 150 |         | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150         |         | °C   |

(\*) Pulse width limited by safe operating area

**THERMAL DATA**

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.67 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

**ELECTRICAL CHARACTERISTICS** ( $T_{case} = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                                         |                             |          |             |                                |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|-----------------------------|----------|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$<br>for <b>SGSP321</b><br>for <b>SGSP322</b>     | $V_{GS} = 0$                | 60<br>50 |             | V<br>V                         |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}\text{C}$ |          | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                             |                             |          | $\pm 100$   | nA                             |

**ON (\*)**

|               |                                   |                                                    |                                                                           |   |  |              |                      |
|---------------|-----------------------------------|----------------------------------------------------|---------------------------------------------------------------------------|---|--|--------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                  | $I_D = 250 \mu\text{A}$                                                   | 2 |  | 4            | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$<br>$V_{GS} = 10 \text{ V}$ | $I_D = 8 \text{ A}$<br>$I_D = 8 \text{ A}$<br>$T_c = 100^{\circ}\text{C}$ |   |  | 0.13<br>0.26 | $\Omega$<br>$\Omega$ |

**DYNAMIC**

|                                     |                                                                         |                                         |                     |   |     |                   |                |
|-------------------------------------|-------------------------------------------------------------------------|-----------------------------------------|---------------------|---|-----|-------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 \text{ V}$                 | $I_D = 8 \text{ A}$ | 3 |     |                   | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$ |   | 460 | 550<br>350<br>180 | pF<br>pF<br>pF |

**SWITCHING**

|             |                     |                         |                     |  |    |    |    |
|-------------|---------------------|-------------------------|---------------------|--|----|----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 25 \text{ V}$ | $I_D = 8 \text{ A}$ |  | 15 | 20 | ns |
| $t_r$       | Rise time           | $V_i = 10 \text{ V}$    | $R_i = 4.7 \Omega$  |  | 45 | 60 | ns |
| $t_d (off)$ | Turn-off delay time | (see test circuit)      |                     |  | 40 | 55 | ns |
| $t_f$       | Fall time           |                         |                     |  | 25 | 35 | ns |

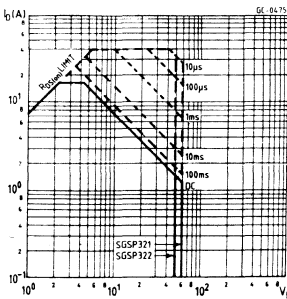


ELECTRICAL CHARACTERISTICS (Continued)

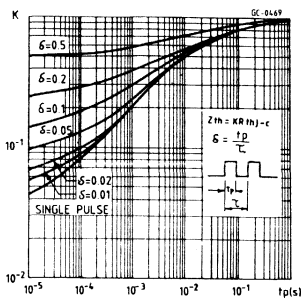
| Parameters                                  | Test Conditions                                                          | Min. | Typ. | Max. | Unit |
|---------------------------------------------|--------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current               |                                                                          |      |      | 16   | A    |
| $I_{SDM}$ (*) Source-drain current (pulsed) |                                                                          |      |      | 40   | A    |
| $V_{SD}$ Forward on voltage                 | $I_{SD} = 16\text{ A}$ $V_{GS} = 0$                                      |      |      | 1.4  | V    |
| $t_{rr}$ Reverse recovery time              | $I_{SD} = 16\text{ A}$ $V_{GS} = 0$<br>$di/dt = 25\text{ A}/\mu\text{s}$ |      | 100  |      | ns   |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
(\*) Pulse width limited by safe operating area

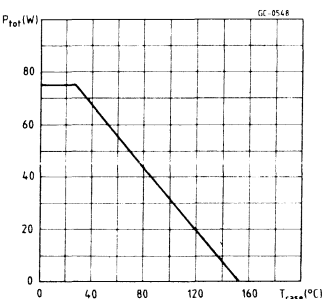
Safe operating areas



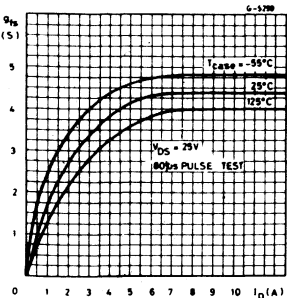
Thermal impedance



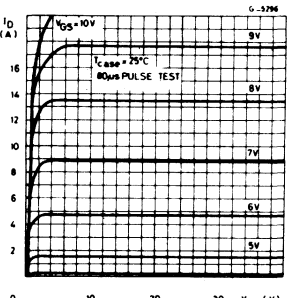
Derating curve



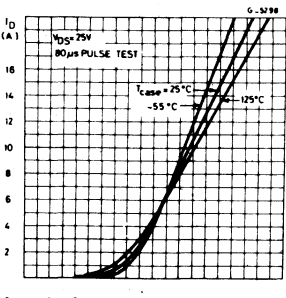
Output characteristics



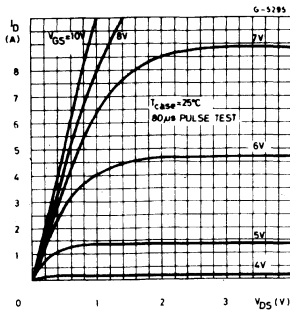
Output characteristics



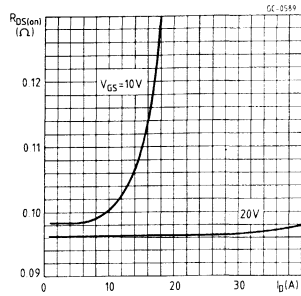
Transfer characteristics



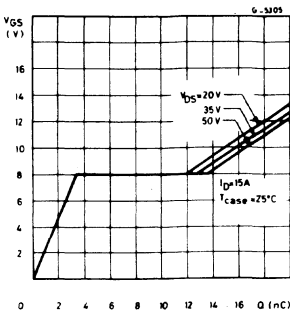
Transconductance



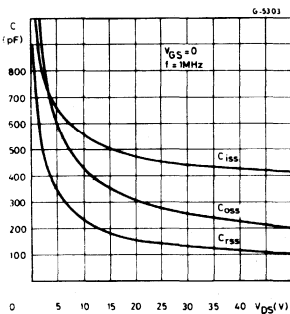
Static drain-source on resistance



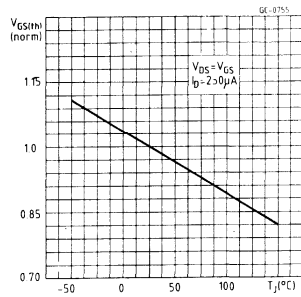
Gate charge vs gate-source voltage



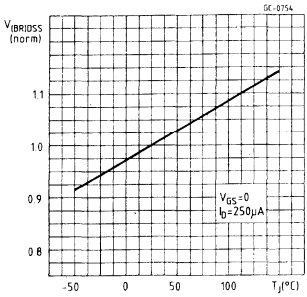
Capacitance variation



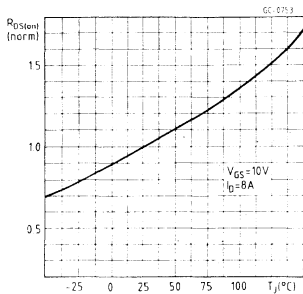
Normalized gate threshold voltage vs temperature



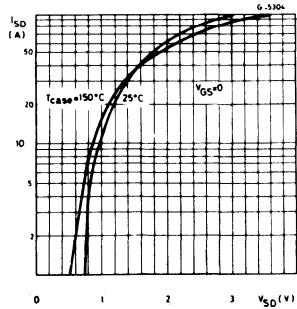
Normalized breakdown voltage vs temperature



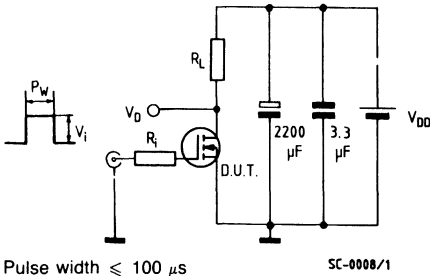
Normalized on resistance vs temperature



Source-drain diode forward characteristics

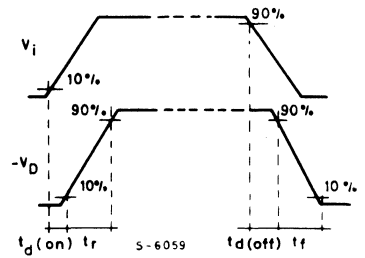


### Switching times test circuit for resistive load

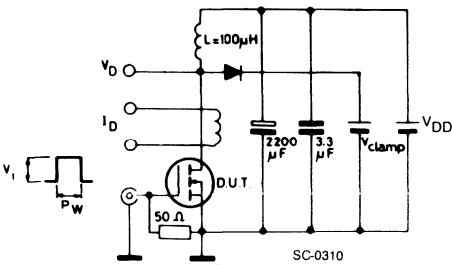


Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

### Switching time waveforms for resistive load

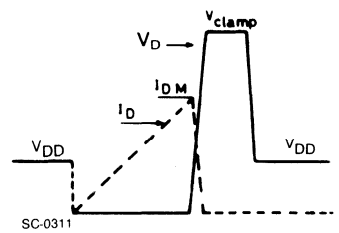


### Clamped inductive load test circuit

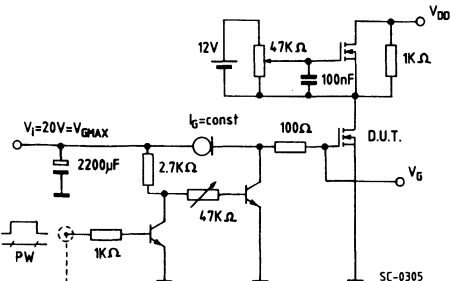


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ ,  $V_{\text{clamp}} = 0.75 V_{(\text{BR}) \text{ DSS}}$

### Clamped inductive waveforms

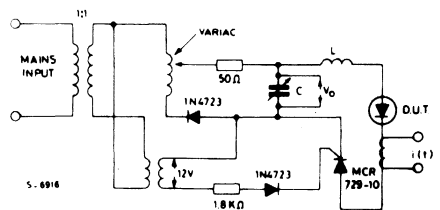


### Gate charge test circuit



PW adjusted to obtain required  $V_G$

### Body-drain diode $t_{rr}$ measurement Jedec test circuit





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

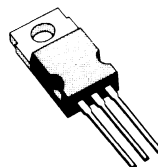
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP330 | 450 V            | 3 Ω                 | 3 A            |

- HIGH SPEED SWITCHING APPLICATIONS
- HIGH VOLTAGE - 450V FOR OFF-LINE SMPS
- ULTRA FAST SWITCHING FOR OPERATION AT > 100KHz
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

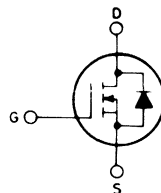
- SWITCHING POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include switching power supplies, uninterruptible power supplies and motor speed control.



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### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 |            |      |
|----------------------|-------------------------------------------------|------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 450        | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 450        | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ±20        | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 3          | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 1.9        | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 12         | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 12         | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 75         | W    |
|                      | Derating factor                                 | 0.6        | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | -65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150        | °C   |

(\*) Pulse width limited by safe operating area

**THERMAL DATA**

|                  |                                                |     |      |                             |
|------------------|------------------------------------------------|-----|------|-----------------------------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.67 | $^{\circ}\text{C}/\text{W}$ |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | $^{\circ}\text{C}$          |

**ELECTRICAL CHARACTERISTICS** ( $T_{case} = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                                                                     |     |  |             |                                |
|----------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$ $V_{GS} = 0$                                                                | 450 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}\text{C}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                                                         |     |  | $\pm 100$   | nA                             |

**ON (\*)**

|               |                                   |                                                                                                                            |   |  |        |                      |
|---------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------|---|--|--------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 250 \mu\text{A}$                                                                                  | 2 |  | 4      | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ $I_D = 1.5 \text{ A}$<br>$V_{GS} = 10 \text{ V}$ $I_D = 1.5 \text{ A}$ $T_c = 100^{\circ}\text{C}$ |   |  | 3<br>6 | $\Omega$<br>$\Omega$ |

**DYNAMIC**

|           |                              |                                                             |     |     |     |     |
|-----------|------------------------------|-------------------------------------------------------------|-----|-----|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 \text{ V}$ $I_D = 1.5 \text{ A}$               | 0.8 |     |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$ $f = 1 \text{ MHz}$<br>$V_{GS} = 0$ |     | 340 | 450 | pF  |
| $C_{oss}$ | Output capacitance           |                                                             |     |     | 95  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                             |     |     | 50  | pF  |

**SWITCHING**

|             |                     |                                                |  |    |    |    |
|-------------|---------------------|------------------------------------------------|--|----|----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 225 \text{ V}$ $I_D = 1.5 \text{ A}$ |  | 10 | 15 | ns |
| $t_r$       | Rise time           | $V_i = 10 \text{ V}$ $R_i = 4.7 \Omega$        |  | 25 | 35 | ns |
| $t_d (off)$ | Turn-off delay time | (see test circuit)                             |  | 55 | 70 | ns |
| $t_f$       | Fall time           |                                                |  | 25 | 35 | ns |

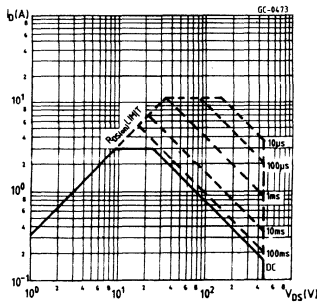
## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                    | Test Conditions                                                          | Min. | Typ. | Max. | Unit |
|-----------------------------------------------|--------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current                 |                                                                          |      |      | 3    | A    |
| $I_{SDM}^{(*)}$ Source-drain current (pulsed) |                                                                          |      |      | 12   | A    |
| $V_{SD}$ Forward on voltage                   | $I_{SD} = 3\text{ A}$ $V_{GS} = 0$                                       |      |      | 1.2  | V    |
| $t_{rr}$ Reverse recovery time                | $I_{SD} = 3\text{ A}$ $V_{GS} = 0$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |      | 360  |      | ns   |

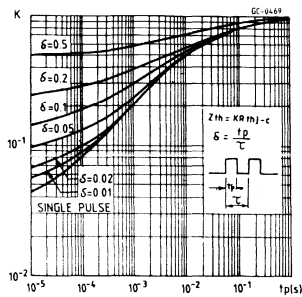
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

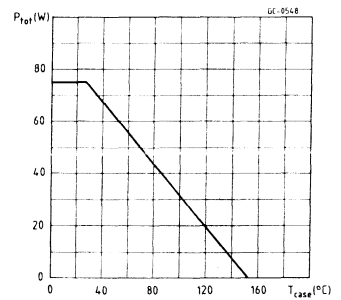
Safe operating areas



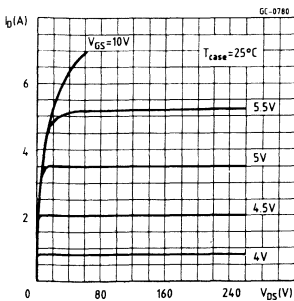
Thermal impedance



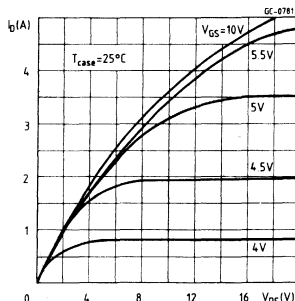
Derating curve



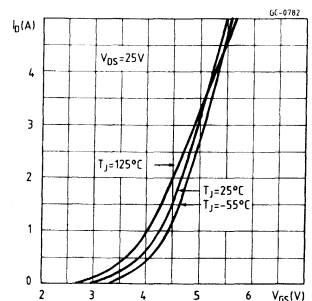
Output characteristics



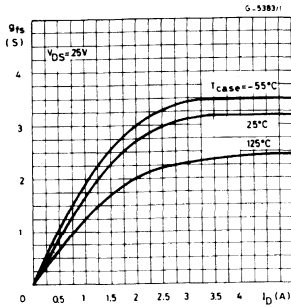
Output characteristics



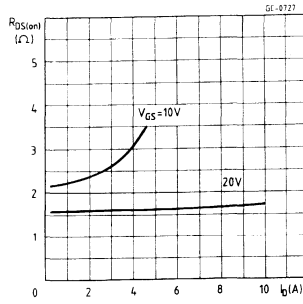
Transfer characteristics



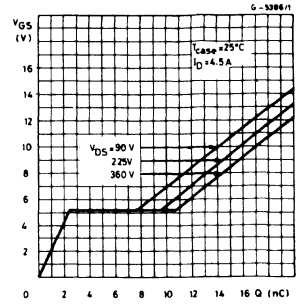
Transconductance



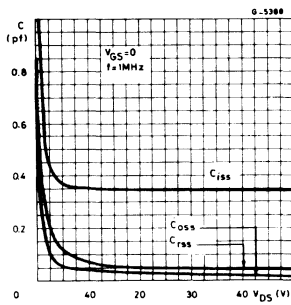
Static drain-source on resistance



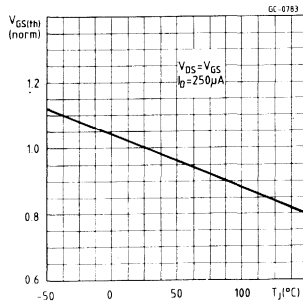
Gate charge vs gate-source voltage



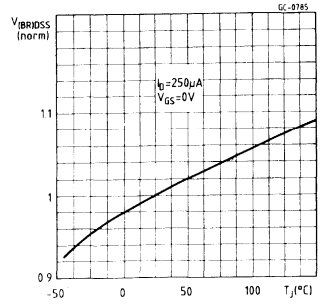
Capacitance variation



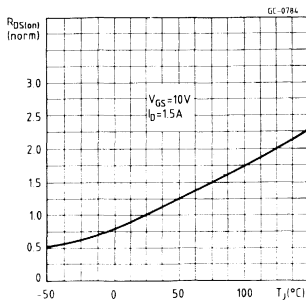
Normalized gate threshold voltage vs temperature



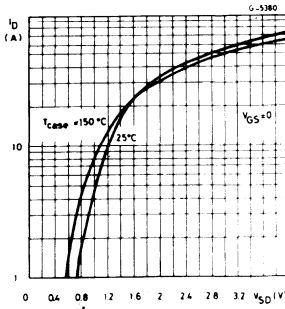
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature

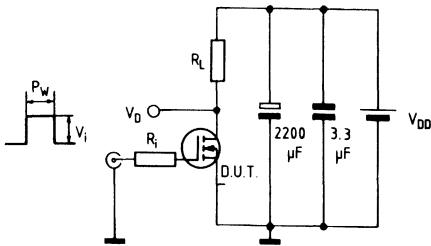


Source-drain diode forward characteristics



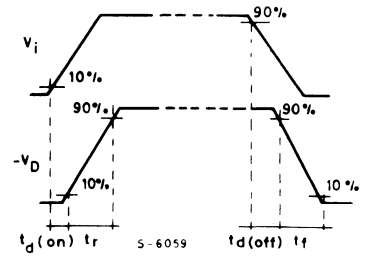


Switching times test circuit for resistive load

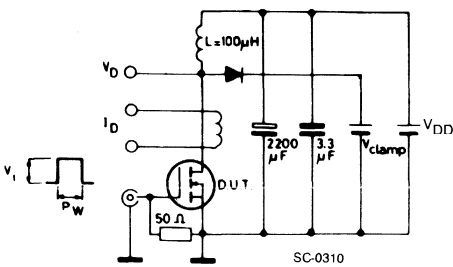
Pulse width  $\leq 100 \mu\text{s}$ Duty cycle  $\leq 2\%$ 

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Switching time waveforms for resistive load

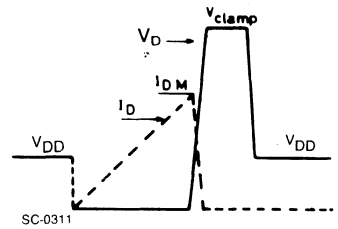


Clamped inductive load test circuit

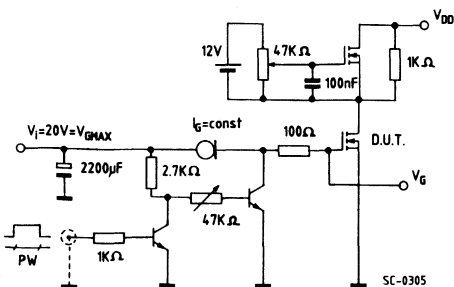
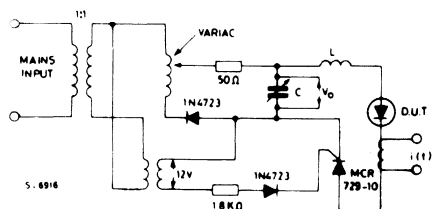


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ ,  $V_{\text{clamp}} = 0.75 V_{(BR)} \text{ DSS}$ .

Clamped inductive waveforms



Gate charge test circuit

PW adjusted to obtain required  $V_G$ Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

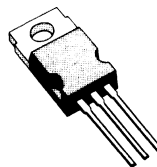
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP341 | 400 V            | 20 $\Omega$         | 0.6 A          |

- HIGH SPEED SWITCHING APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

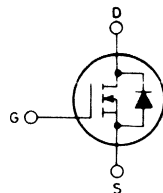
- GENERAL PURPOSE

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include motor starter and drive circuits for power bipolar transistors.



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### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                       |            |      |
|----------------------|-------------------------------------------------------|------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)            | 400        | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 400        | V    |
| V <sub>GS</sub>      | Gate-source voltage                                   | $\pm 20$   | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C        | 0.6        | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C       | 0.4        | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                                | 1.2        | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                      | 1.2        | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C            | 18         | W    |
|                      | Derating factor                                       | 0.14       | W/°C |
| T <sub>stg</sub>     | Storage temperature                                   | -65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature                   | 150        | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |     |      |
|------------------|------------------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 6.8 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275 | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                 |     |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                               | 400 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>$T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                             |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                     |   |  |          |                      |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------|---|--|----------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$                                              | 2 |  | 4        | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 0.3 A$<br>$V_{GS} = 10 V$ $I_D = 0.3 A$ $T_c = 100^{\circ}C$ |   |  | 20<br>40 | $\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                                |     |    |                 |                |
|-------------------------------------|-------------------------------------------------------------------------|------------------------------------------------|-----|----|-----------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$<br>$I_D = 0.3 A$               | 0.1 |    |                 | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 MHz$ |     | 80 | 105<br>20<br>15 | pF<br>pF<br>pF |

SWITCHING

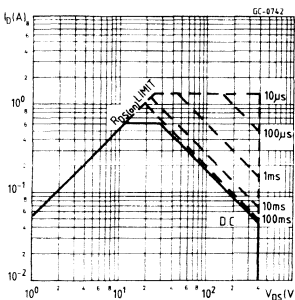
|               |                     |                                    |  |    |    |    |
|---------------|---------------------|------------------------------------|--|----|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 200 V$<br>$I_D = 0.3 A$  |  | 10 | 15 | ns |
| $t_r$         | Rise time           | $V_i = 10 V$<br>$R_i = 4.7 \Omega$ |  | 15 | 20 | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit)                 |  | 25 | 35 | ns |
| $t_f$         | Fall time           |                                    |  | 40 | 55 | ns |

ELECTRICAL CHARACTERISTICS (Continued)

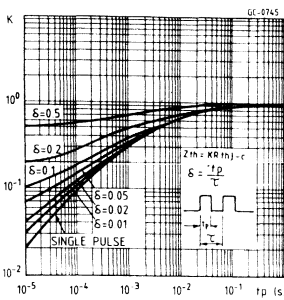
| Parameters                                  | Test Conditions                                                         | Min. | Typ. | Max. | Unit |
|---------------------------------------------|-------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current               |                                                                         |      |      | 0.6  | A    |
| $I_{SDM}$ (*) Source-drain current (pulsed) |                                                                         |      |      | 1.2  | A    |
| $V_{SD}$ Forward on voltage                 | $I_{SD} = 0.6\text{ A}$ $V_{GS} = 0$                                    |      |      | 1.2  | V    |
| $t_{rr}$ Reverse recovery time              | $I_{SD} = 0.6\text{ A}$ $di/dt = 100\text{ A}/\mu\text{s}$ $V_{GS} = 0$ |      | 140  |      | ns   |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
(\*) Pulse width limited by safe operating area

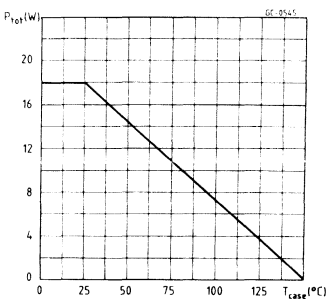
Safe operating areas



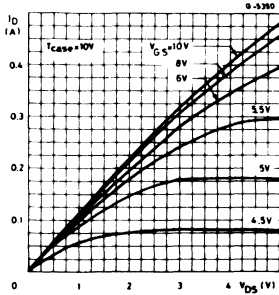
Thermal impedance



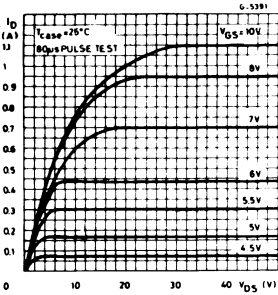
Derating curve



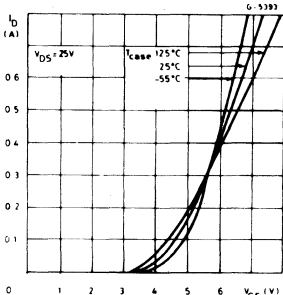
Output characteristics



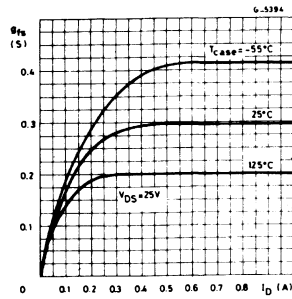
Output characteristics



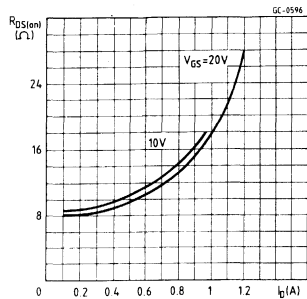
Transfer characteristics



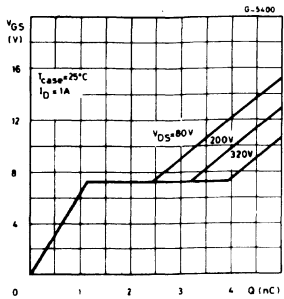
Transconductance



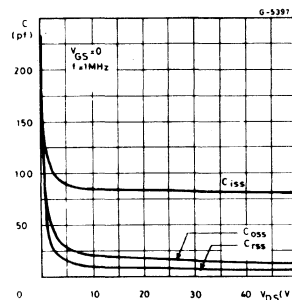
Static drain-source on resistance



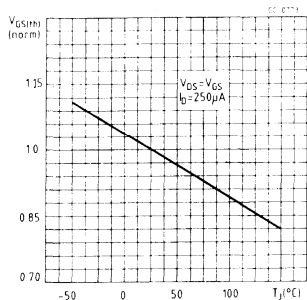
Gate charge vs gate-source voltage



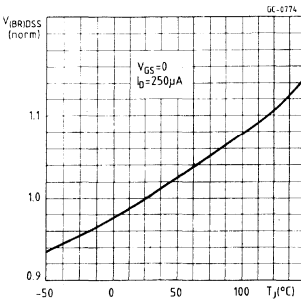
Capacitance variation



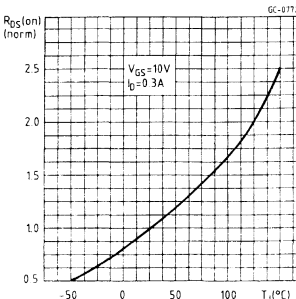
Normalized gate threshold voltage vs temperature



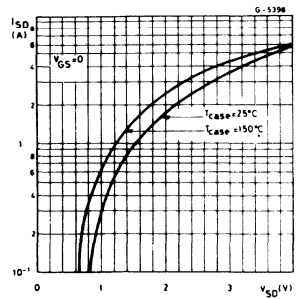
Normalized breakdown voltage vs temperature



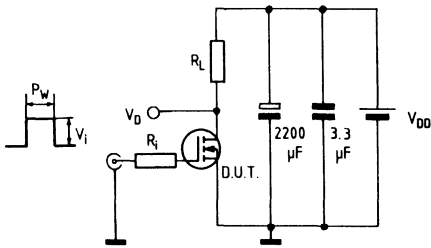
Normalized on resistance vs temperature



Source-drain diode forward characteristics



### Switching times test circuit for resistive load

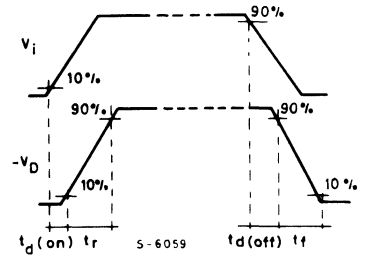


Pulse width  $\leq 100 \mu\text{s}$

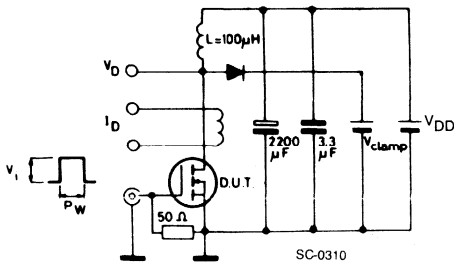
Duty cycle  $\leq 2\%$

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### Switching time waveforms for resistive load



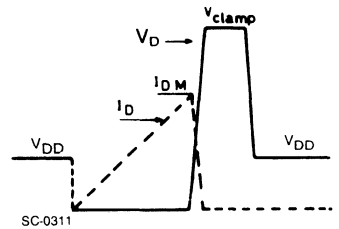
### Clamped inductive load test circuit



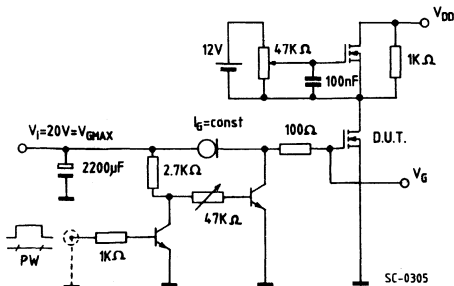
$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(BR)} \text{ DSS}$ .

SC-0310

### Clamped inductive waveforms



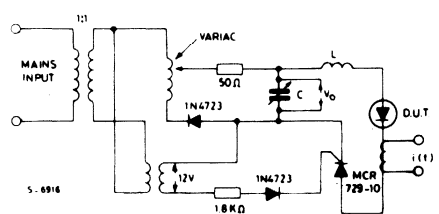
### Gate charge test circuit



PW adjusted to obtain required  $V_G$

SC-0305

### Body-drain diode $t_{rr}$ measurement Jedec test circuit







## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

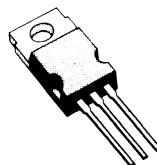
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP351 | 100 V            | 0.6 Ω               | 6 A            |

- HIGH SPEED SWITCHING APPLICATIONS
- DC/DC APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

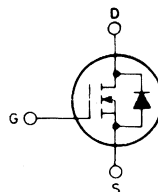
- SWITCHING POWER SUPPLIES
- MOTOR CONTROL

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include stepper motor and printer hammer drives and switching power supplies



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 |             |      |
|----------------------|-------------------------------------------------|-------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 100         | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 100         | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ±20         | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 6           | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 4           | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 24          | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 24          | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 50          | W    |
|                      | Derating factor                                 | 0.4         | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | - 65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |     |      |
|------------------|------------------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 2.5 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275 | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                              |     |  |             |                    |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                            | 100 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                          |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                 |   |  |            |                      |
|---------------|-----------------------------------|---------------------------------------------------------------------------------|---|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 250 \mu A$                                             | 2 |  | 4          | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 3 A$<br>$V_{GS} = 10 V$ $I_D = 3 A$ $T_c = 100^{\circ}C$ |   |  | 0.6<br>1.2 | $\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                             |   |     |                  |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------------------|---|-----|------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$ $I_D = 3 A$                 | 1 |     |                  | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$ $f = 1 MHz$<br>$V_{GS} = 0$ |   | 180 | 250<br>100<br>40 | pF<br>pF<br>pF |

SWITCHING

|               |                     |                                 |  |    |    |    |
|---------------|---------------------|---------------------------------|--|----|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 50 V$ $I_D = 3 A$     |  | 10 | 15 | ns |
| $t_r$         | Rise time           | $V_i = 10 V$ $R_i = 4.7 \Omega$ |  | 25 | 35 | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit)              |  | 25 | 35 | ns |
| $t_f$         | Fall time           |                                 |  | 15 | 20 | ns |

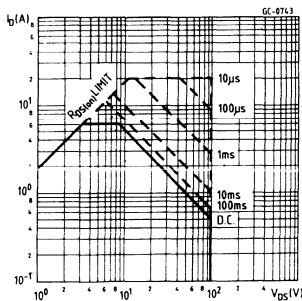
## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                    | Test Conditions                                                         | Min. | Typ. | Max. | Unit |
|-----------------------------------------------|-------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current                 |                                                                         |      |      | 6    | A    |
| $I_{SDM}^{(*)}$ Source-drain current (pulsed) |                                                                         |      |      | 24   | A    |
| $V_{SD}$ Forward on voltage                   | $I_{SD} = 6\text{ A}$ $V_{GS} = 0$                                      |      |      | 1.35 | V    |
| $t_{rr}$ Reverse recovery time                | $I_{SD} = 6\text{ A}$ $V_{GS} = 0$<br>$di/dt = 25\text{ A}/\mu\text{s}$ |      | 120  |      | ns   |

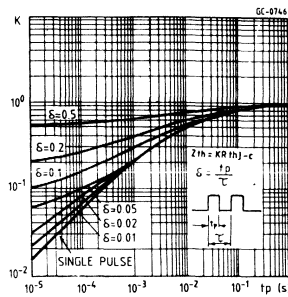
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

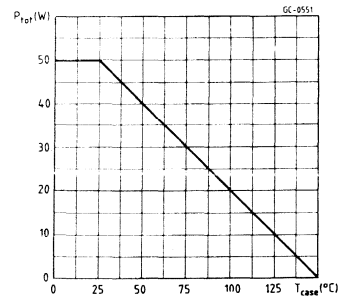
Safe operating areas



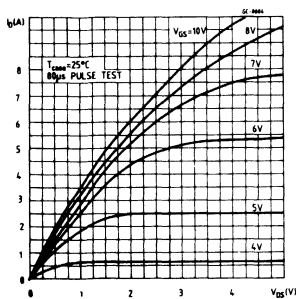
Thermal impedance



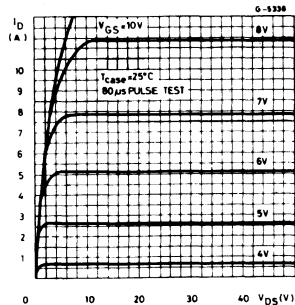
Derating curve



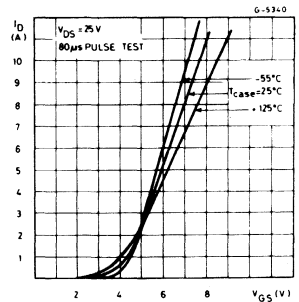
Output characteristics

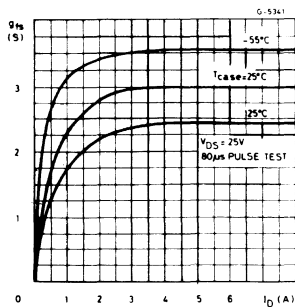
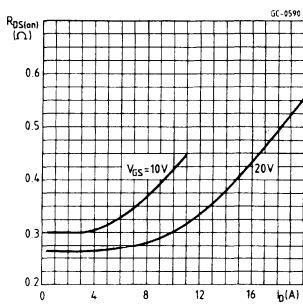
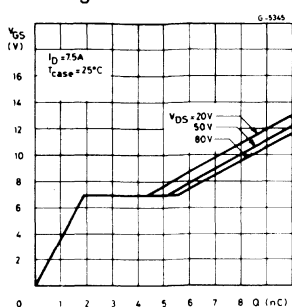
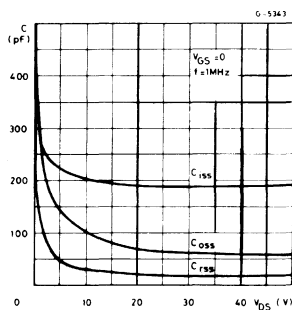
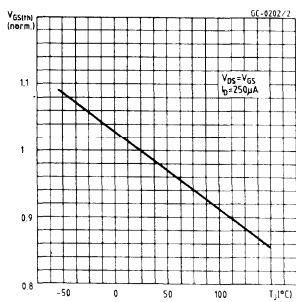
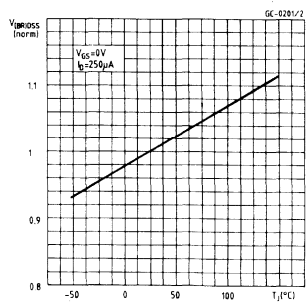
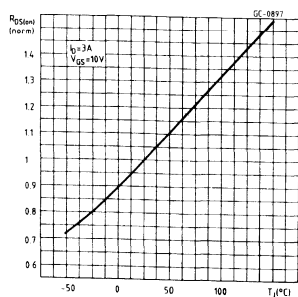
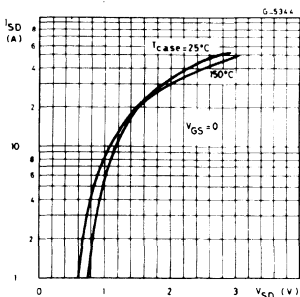


Output characteristics

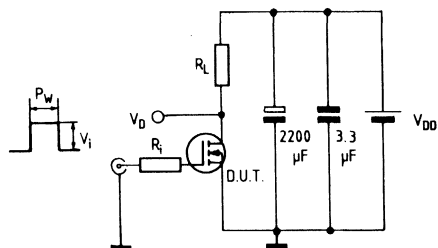


Transfer characteristics



**Transconductance**

**Static drain-source on resistance**

**Gate charge vs gate-source voltage**

**Capacitance variation**

**Normalized gate threshold voltage vs temperature**

**Normalized breakdown voltage vs temperature**

**Normalized on resistance vs temperature**

**Source-drain diode forward characteristics**


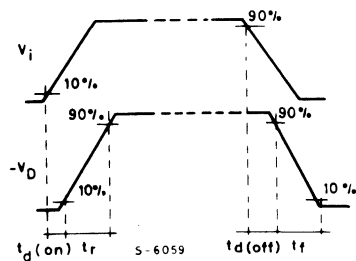
## Switching times test circuit for resistive load



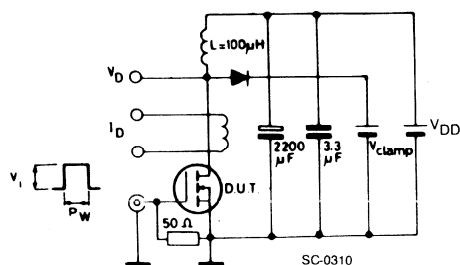
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

SC-0008/1

## Switching time waveforms for resistive load



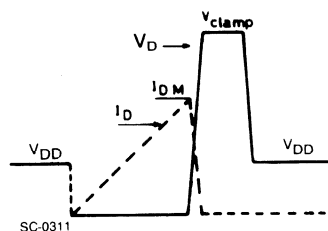
## Clamped inductive load test circuit



$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(BR)}$  DSS.

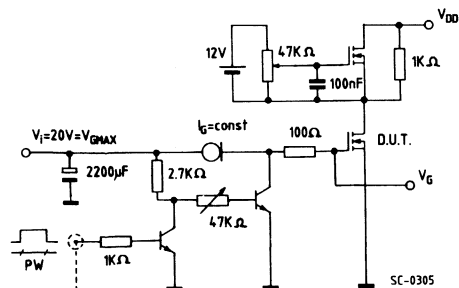
SC-0310

## Clamped inductive waveforms



SC-0311

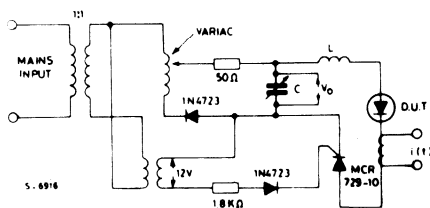
## Gate charge test circuit



PW adjusted to obtain required  $V_G$

SC-0305

## Body-drain diode $t_{rr}$ measurement Jedec test circuit





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

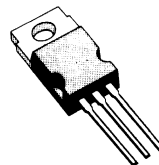
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP358 | 50 V             | 0.3 Ω               | 7 A            |

- HIGH SPEED SWITCHING APPLICATIONS
- GENERAL PURPOSE
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

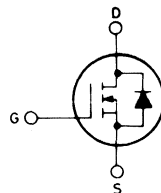
- D.C. SWITCH
- UNINTERRUPTIBLE POWER SUPPLIES

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include DC switching, uninterruptible power supplies and drive circuits for power bipolar transistor.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 |            |      |
|----------------------|-------------------------------------------------|------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 50         | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 50         | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ±20        | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 7          | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 4.4        | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 28         | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 28         | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 50         | W    |
|                      | Derating factor                                 | 0.4        | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | -65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150        | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |     |      |
|------------------|------------------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 2.5 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275 | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                     |    |  |             |                                |
|----------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------|----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$<br>$V_{GS} = 0$                                                             | 50 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}\text{C}$ |    |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                                                         |    |  | $\pm 100$   | nA                             |

ON (\*)

|               |                                   |                                                                                                                            |   |  |            |                      |
|---------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------|---|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu\text{A}$                                                                               | 2 |  | 4          | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ $I_D = 3.5 \text{ A}$<br>$V_{GS} = 10 \text{ V}$ $I_D = 3.5 \text{ A}$ $T_c = 100^{\circ}\text{C}$ |   |  | 0.3<br>0.6 | $\Omega$<br>$\Omega$ |

DYNAMIC

|           |                              |                                                                |     |     |     |     |
|-----------|------------------------------|----------------------------------------------------------------|-----|-----|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 \text{ V}$<br>$I_D = 3.5 \text{ A}$               | 1.5 |     |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$<br>$V_{GS} = 0$<br>$f = 1 \text{ MHz}$ |     | 210 | 270 | pF  |
| $C_{oss}$ | Output capacitance           |                                                                |     |     | 150 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                                |     |     | 70  | pF  |

SWITCHING

|             |                     |                                                 |                                             |  |          |          |          |
|-------------|---------------------|-------------------------------------------------|---------------------------------------------|--|----------|----------|----------|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 25 \text{ V}$<br>$V_i = 10 \text{ V}$ | $I_D = 3.5 \text{ A}$<br>$R_i = 4.7 \Omega$ |  | 10<br>35 | 15<br>45 | ns<br>ns |
| $t_r$       | Rise time           | (see test circuit)                              |                                             |  | 20       | 30       | ns       |
| $t_d (off)$ | Turn-off delay time |                                                 |                                             |  | 15       | 20       | ns       |
| $t_f$       | Fall time           |                                                 |                                             |  |          |          | ns       |

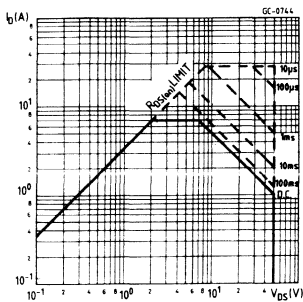


ELECTRICAL CHARACTERISTICS (Continued)

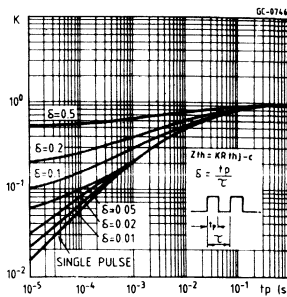
| Parameters                                                                   | Test Conditions                                                         | Min. | Typ. | Max.    | Unit   |
|------------------------------------------------------------------------------|-------------------------------------------------------------------------|------|------|---------|--------|
| $I_{SD}$ Source-drain current<br>$I_{SDM}$ (*) Source-drain current (pulsed) |                                                                         |      |      | 7<br>28 | A<br>A |
| $V_{SD}$ Forward on voltage                                                  | $I_{SD} = 7\text{ A}$ $V_{GS} = 0$                                      |      |      | 1.4     | V      |
| $t_{rr}$ Reverse recovery time                                               | $I_{SD} = 7\text{ A}$ $V_{GS} = 0$<br>$di/dt = 25\text{ A}/\mu\text{s}$ |      | 65   |         | ns     |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
 (\*) Pulse width limited by safe operating area

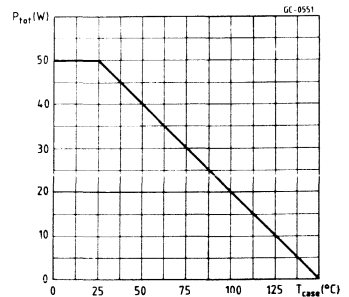
Safe operating areas



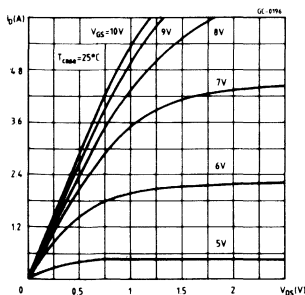
Thermal impedance



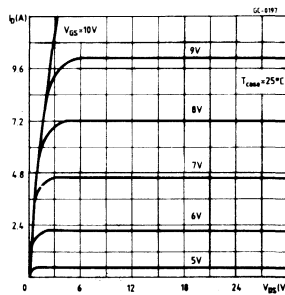
Derating curve



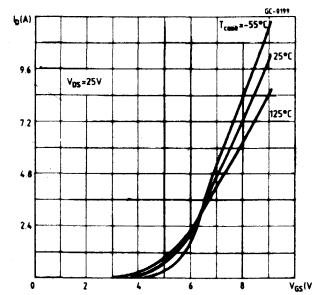
Output characteristics



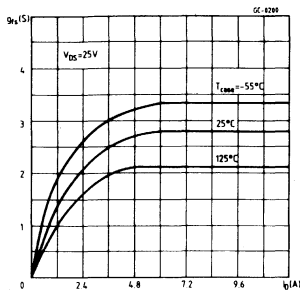
Output characteristics



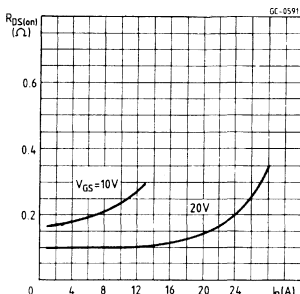
Transfer characteristics



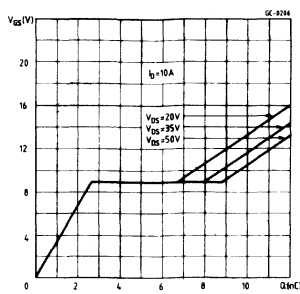
Transconductance



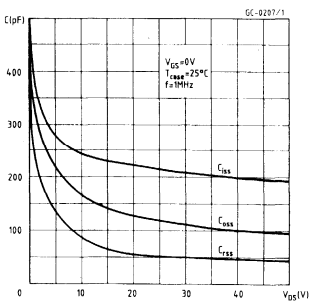
Static drain-source on resistance



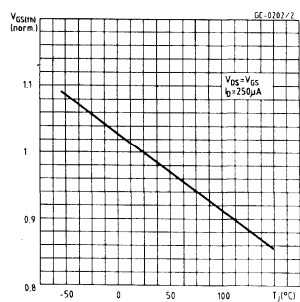
Gate charge vs gate-source voltage



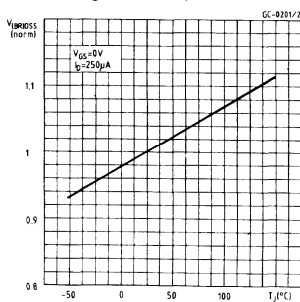
Capacitance variation



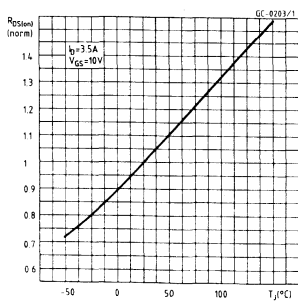
Normalized gate threshold voltage vs temperature



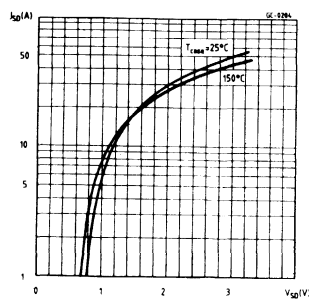
Normalized breakdown voltage vs temperature



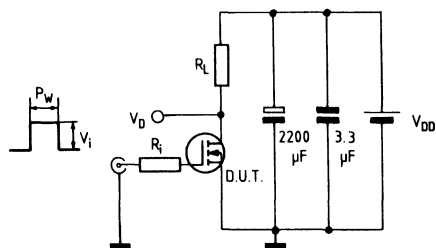
Normalized on resistance vs temperature



Source-drain diode forward characteristics



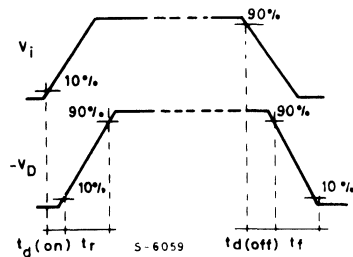
## Switching times test circuit for resistive load



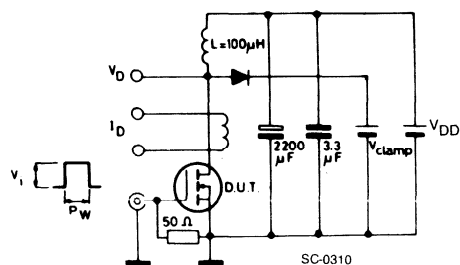
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

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## Switching time waveforms for resistive load

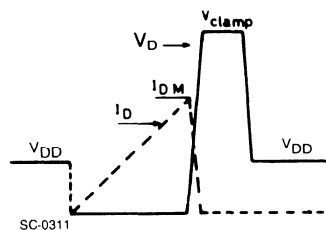


## Clamped inductive load test circuit

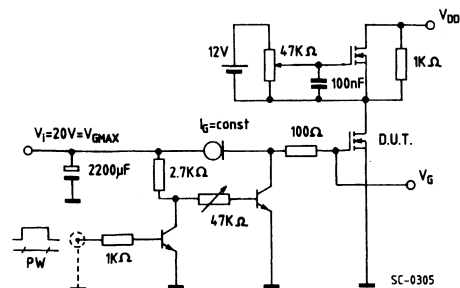


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain  
specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(BR)} \text{ DSS}$ .

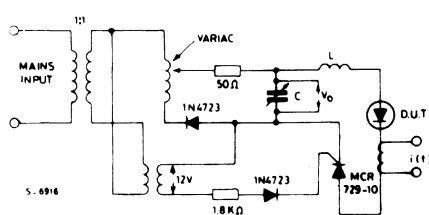
## Clamped inductive waveforms



## Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

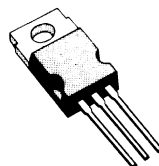
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP361 | 100 V            | 0.15 $\Omega$       | 18 A           |
| SGSP362 | 80 V             | 0.1 $\Omega$        | 22 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- 80 - 100 VOLTS - FOR UPS APPLICATIONS
- ULTRA FAST SWITCHING
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- EASY DRIVE FOR REDUCED SIZE AND COST

### INDUSTRIAL APPLICATIONS:

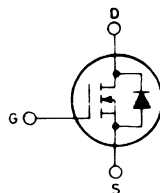
- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include UPS, battery chargers, printer hammer drivers, solenoid drivers and motor control.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                       | SGSP361     | SGSP362  |      |
|---------------------|-------------------------------------------------------|-------------|----------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)            | 100         | 80       | V    |
| V <sub>DGR</sub>    | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 100         | 80       | V    |
| V <sub>GS</sub>     | Gate-source voltage                                   |             | $\pm 20$ | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C        | 18          | 22       | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C       | 11          | 14       | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                                | 72          | 88       | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C            |             | 100      | W    |
|                     | Derating factor                                       |             | 0.8      | W/°C |
| T <sub>stg</sub>    | Storage temperature                                   | - 65 to 150 |          | °C   |
| T <sub>j</sub>      | Max. operating junction temperature                   | 150         |          | °C   |

(\*) Pulse width limited by safe operating area

♦ Introduced in 1988 week 44

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.25 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |           |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|-----------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>SGSP361</b><br>for <b>SGSP362</b>           | $V_{GS} = 0$         | 100<br>80 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |           | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      |           | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                                                                                                              |                      |   |  |                           |                                              |
|---------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---|--|---------------------------|----------------------------------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                                                                                            | $I_D = 250 \mu A$    | 2 |  | 4                         | V                                            |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$I_D = 9 A$ for <b>SGSP361</b><br>$I_D = 11 A$ for <b>SGSP362</b><br>$V_{GS} = 10 V$<br>$I_D = 9 A$ for <b>SGSP361</b><br>$I_D = 11 A$ for <b>SGSP362</b> | $T_c = 100^{\circ}C$ |   |  | 0.15<br>0.1<br>0.3<br>0.2 | $\Omega$<br>$\Omega$<br>$\Omega$<br>$\Omega$ |

ENERGY TEST

|           |                                                      |                                                                                             |                 |          |  |  |        |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------|----------|--|--|--------|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 V$<br>starting $T_j = 25^{\circ}C$<br>for <b>SGSP361</b><br>for <b>SGSP362</b> | $L = 100 \mu H$ | 18<br>22 |  |  | A<br>A |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------|----------|--|--|--------|

DYNAMIC

|                                     |                                                                         |                                 |             |     |     |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|-------------|-----|-----|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$                 | $I_D = 9 A$ | 4.5 |     |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 MHz$ |     | 950 | 1200<br>480<br>230 | pF<br>pF<br>pF |

**ELECTRICAL CHARACTERISTICS** (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**SWITCHING**

|              |                     |                                                                                                                   |    |    |    |
|--------------|---------------------|-------------------------------------------------------------------------------------------------------------------|----|----|----|
| $t_{d(on)}$  | Turn-on time        | $V_{DD} = 50\text{ V}$<br>$V_i = 10\text{ V}$<br>$I_D = 11\text{ A}$<br>$R_i = 4.7\ \Omega$<br>(see test circuit) | 20 | 30 | ns |
| $t_r$        | Rise time           |                                                                                                                   | 50 | 65 | ns |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                                   | 65 | 85 | ns |
| $t_f$        | Fall time           |                                                                                                                   | 25 | 35 | ns |

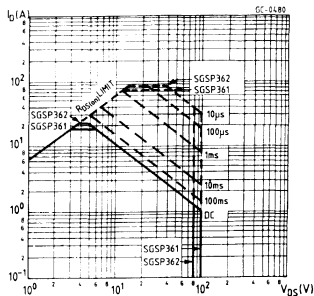
**SOURCE DRAIN DIODE**

|               |                                  |                                                                                                        |  |     |              |        |
|---------------|----------------------------------|--------------------------------------------------------------------------------------------------------|--|-----|--------------|--------|
| $I_{SD}$      | Source-drain current             | for <b>SGSP361</b><br>for <b>SGSP362</b>                                                               |  |     | 18<br>22     | A<br>A |
| $I_{SDM} (*)$ | Source-drain current<br>(pulsed) | for <b>SGSP361</b><br>for <b>SGSP362</b>                                                               |  |     | 72<br>88     | A<br>A |
| $V_{SD}$      | Forward on voltage               | $V_{GS} = 0$<br>$I_{SD} = 18\text{ A}$ for <b>SGSP361</b><br>$I_{SD} = 22\text{ A}$ for <b>SGSP362</b> |  |     | 1.35<br>1.35 | V<br>V |
| $t_{rr}$      | Reverse recovery<br>time         | $I_{SD} = 22\text{ A}$<br>$di/dt = 25\text{ A}/\mu\text{s}$<br>$V_{GS} = 0$                            |  | 180 |              | ns     |

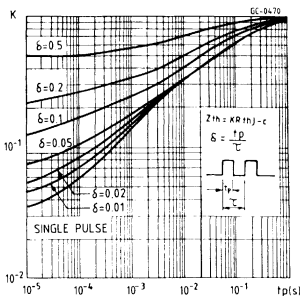
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

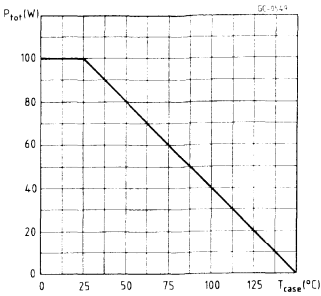
Safe operating areas



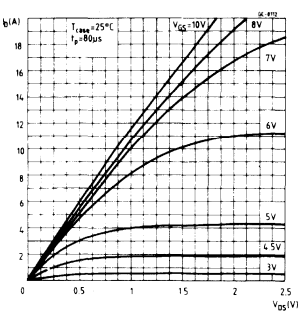
Thermal impedance



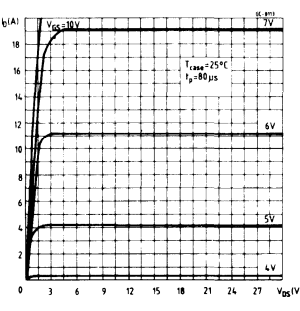
Derating curve



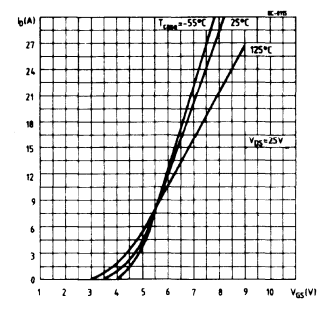
Output characteristics



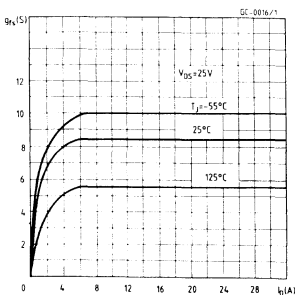
Output characteristics



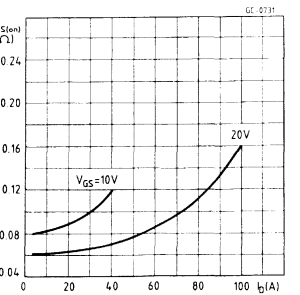
Transfer characteristics



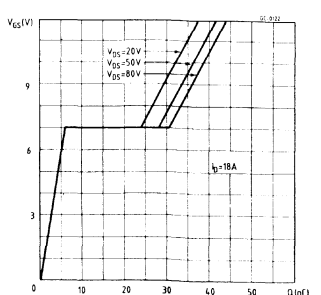
Transconductance



Static drain-source on resistance

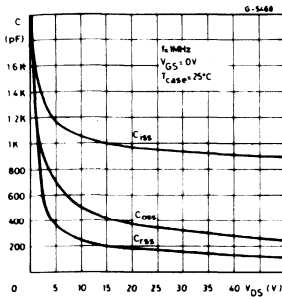


Gate charge vs gate-source voltage

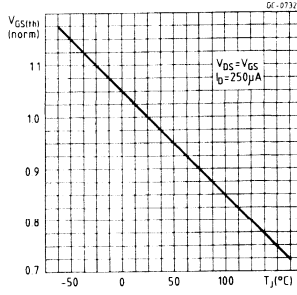




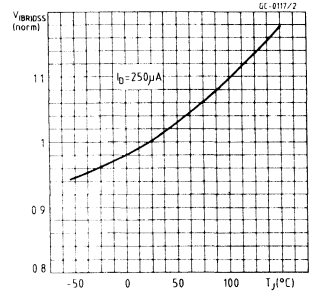
Capacitance variation



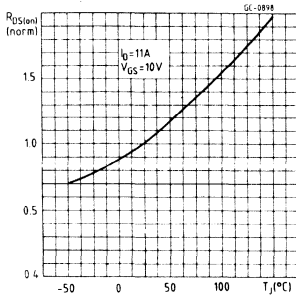
Normalized gate threshold voltage vs temperature



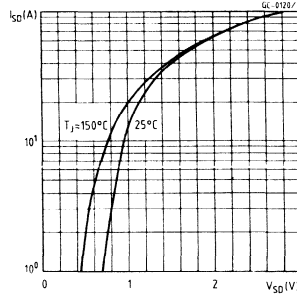
Normalized breakdown voltage vs temperature



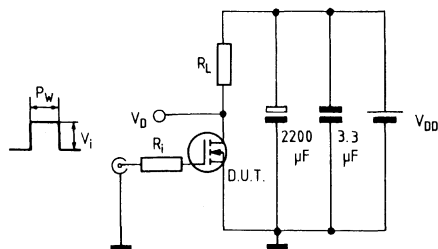
Normalized on resistance vs temperature



Source-drain diode forward characteristics



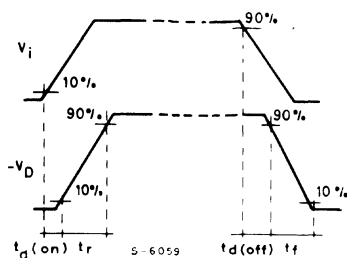
Switching times test circuit for resistive load



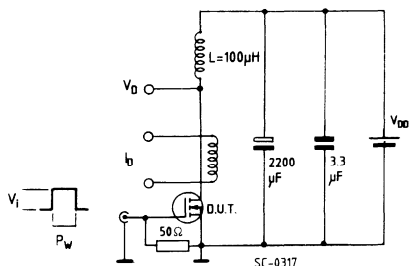
Pulse width  $\leq 100 \mu s$   
Duty cycle  $\leq 2\%$

SC-0008/1

Switching time waveforms for resistive load



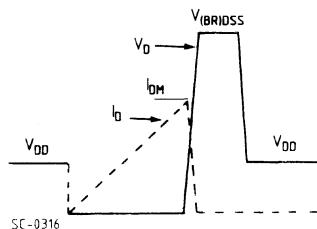
Unclamped inductive load test circuit



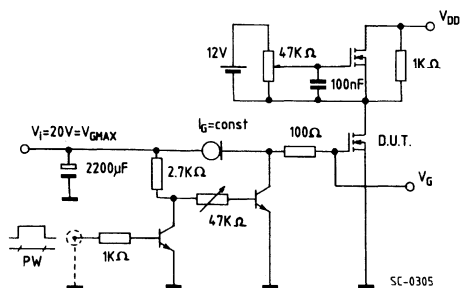
$V_i = 12 V$  - Pulse width: adjusted to obtain specified  $I_{DM}$

SC-0317

Unclamped inductive waveforms



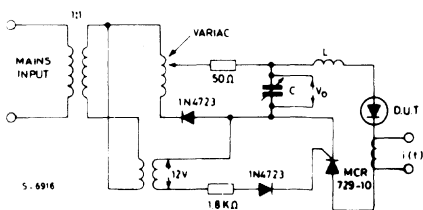
Gate charge test circuit



PW adjusted to obtain required  $V_G$

SC-0305

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

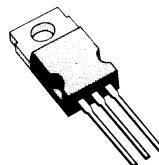
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP363 | 250 V            | 0.45 $\Omega$       | 10 A           |
| SGSP367 | 200 V            | 0.33 $\Omega$       | 12 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- TELECOMMUNICATION APPLICATIONS
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

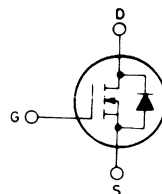
- ROBOTICS
- SWITCHING POWER SUPPLIES

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include robotics, uninterruptible power supplies, motor control and solenoid drives.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                       | SGSP363     | SGSP367  |      |
|---------------------|-------------------------------------------------------|-------------|----------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)            | 250         | 200      | V    |
| V <sub>DGR</sub>    | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 250         | 200      | V    |
| V <sub>GS</sub>     | Gate-source voltage                                   |             | $\pm 20$ | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C        | 10          | 12       | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C       | 6.3         | 7.5      | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                                | 40          | 48       | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C            |             | 100      | W    |
|                     | Derating factor                                       |             | 0.8      | W/°C |
| T <sub>stg</sub>    | Storage temperature                                   | - 65 to 150 |          | °C   |
| T <sub>j</sub>      | Max. operating junction temperature                   | 150         |          | °C   |

(\*) Pulse width limited by safe operating area

♦ Introduced in 1989 week 1

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.25 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |            |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|------------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>SGSP363</b><br>for <b>SGSP367</b>           | $V_{GS} = 0$         | 250<br>200 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |            | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      |            | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                                                                                                            |                      |   |  |                             |                                              |
|---------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---|--|-----------------------------|----------------------------------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                                                                                          | $I_D = 250 \mu A$    | 2 |  | 4                           | V                                            |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$I_D = 5 A$ for <b>SGSP363</b><br>$I_D = 6 A$ for <b>SGSP367</b><br>$V_{GS} = 10 V$<br>$I_D = 5 A$ for <b>SGSP363</b><br>$I_D = 6 A$ for <b>SGSP367</b> | $T_c = 100^{\circ}C$ |   |  | 0.45<br>0.33<br>0.9<br>0.66 | $\Omega$<br>$\Omega$<br>$\Omega$<br>$\Omega$ |

ENERGY TEST

|           |                                                      |                                                                                             |                 |          |  |  |        |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------|----------|--|--|--------|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 V$<br>starting $T_j = 25^{\circ}C$<br>for <b>SGSP363</b><br>for <b>SGSP367</b> | $L = 100 \mu H$ | 10<br>12 |  |  | A<br>A |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------|----------|--|--|--------|

DYNAMIC

|                                     |                                                                         |                                 |             |   |     |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|-------------|---|-----|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$                 | $I_D = 6 A$ | 3 |     |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 MHz$ |   | 980 | 1200<br>260<br>100 | pF<br>pF<br>pF |

**ELECTRICAL CHARACTERISTICS** (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**SWITCHING**

|              |                     |                                                                                                                   |    |    |    |
|--------------|---------------------|-------------------------------------------------------------------------------------------------------------------|----|----|----|
| $t_{d(on)}$  | Turn-on time        | $V_{DD} = 100\text{ V}$<br>$V_i = 10\text{ V}$<br>$I_D = 6\text{ A}$<br>$R_i = 4.7\ \Omega$<br>(see test circuit) | 20 | 30 | ns |
| $t_r$        | Rise time           |                                                                                                                   | 40 | 55 | ns |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                                   | 65 | 85 | ns |
| $t_f$        | Fall time           |                                                                                                                   | 20 | 30 | ns |

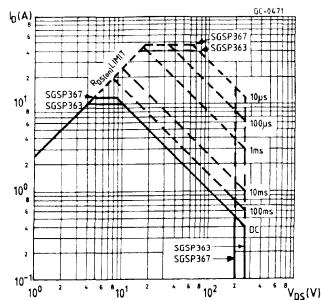
**SOURCE DRAIN DIODE**

|                      |                               |                                                                                                        |  |     |            |        |
|----------------------|-------------------------------|--------------------------------------------------------------------------------------------------------|--|-----|------------|--------|
| $I_{SD}$             | Source-drain current          | for <b>SGSP363</b><br>for <b>SGSP367</b>                                                               |  |     | 10<br>12   | A<br>A |
| $I_{SDM} (^{\circ})$ | Source-drain current (pulsed) | for <b>SGSP363</b><br>for <b>SGSP367</b>                                                               |  |     | 40<br>48   | A<br>A |
| $V_{SD}$             | Forward on voltage            | $V_{GS} = 0$<br>$I_{SD} = 10\text{ A}$ for <b>SGSP363</b><br>$I_{SD} = 12\text{ A}$ for <b>SGSP367</b> |  |     | 1.3<br>1.3 | V<br>V |
| $t_{rr}$             | Reverse recovery time         | $I_{SD} = 12\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{GS} = 0$                           |  | 250 |            | ns     |

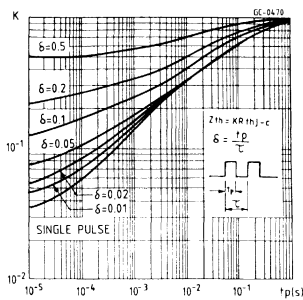
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

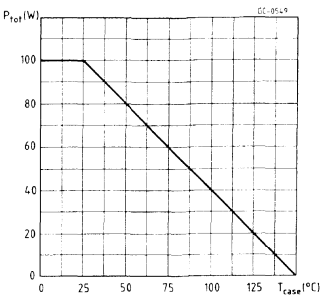
Safe operating areas



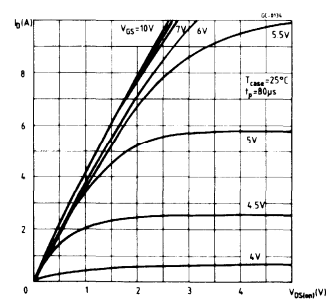
Thermal impedance



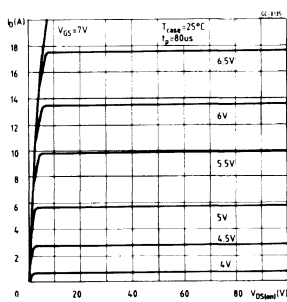
Derating curve



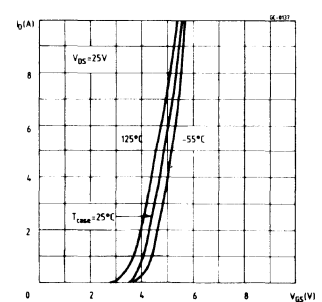
Output characteristics



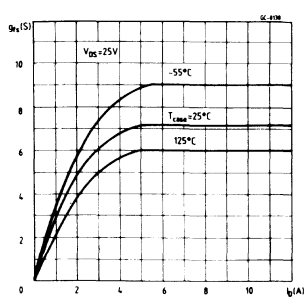
Output characteristics



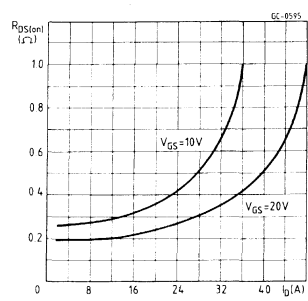
Transfer characteristics



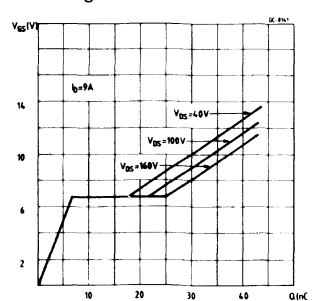
Transconductance



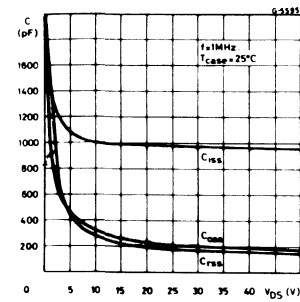
Static drain-source on resistance



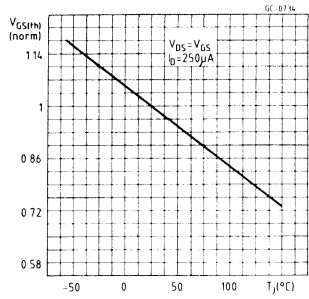
Gate charge vs gate-source voltage



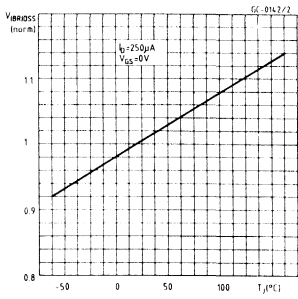
Capacitance variation



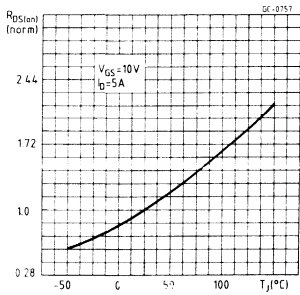
Normalized gate threshold voltage vs temperature



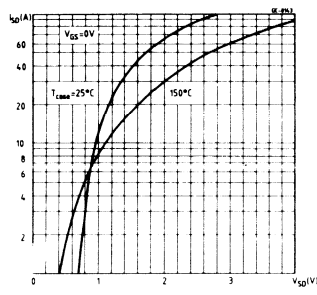
Normalized breakdown voltage vs temperature



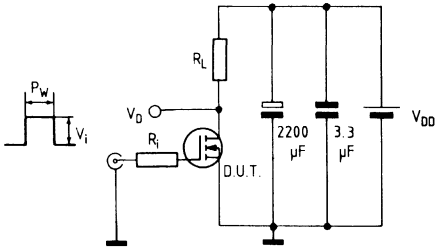
Normalized on resistance vs temperature



Source-drain diode forward characteristics



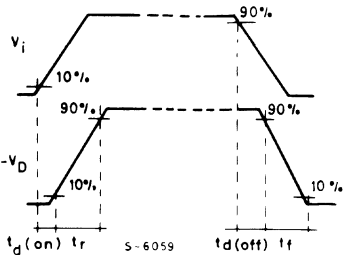
Switching times test circuit for resistive load



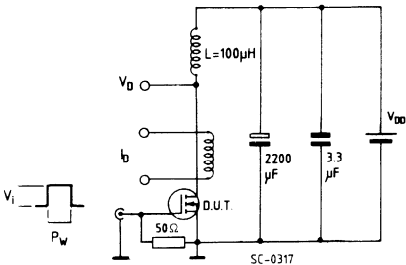
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

SC-0008/1

Switching time waveforms for resistive load



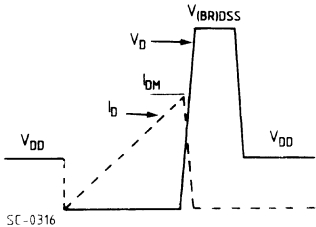
Unclamped inductive load test circuit



$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$

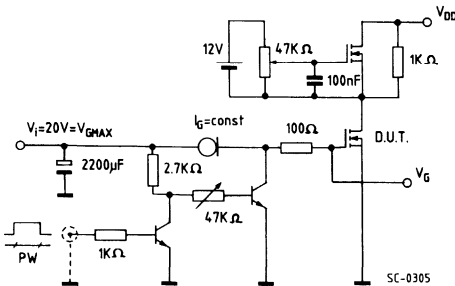
SC-0317

Unclamped inductive waveforms



SC-0316

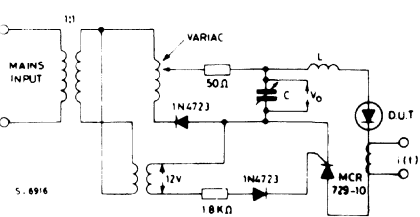
Gate charge test circuit



PW adjusted to obtain required  $V_G$

SC-0305

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

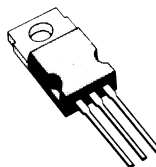
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP364 | 450 V            | 1.5 Ω               | 5 A            |
| SGSP369 | 500 V            | 1.5 Ω               | 5 A            |

- HIGH SPEED SWITCHING APPLICATIONS
- HIGH VOLTAGE - FOR ELECTRONIC LAMP BALLAST
- ULTRA FAST SWITCHING
- EASY DRIVE - REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

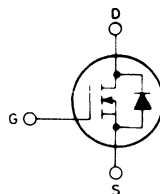
- ELECTRONIC LAMP BALLAST
- DC SWITCH

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Applications include DC switch, constant current source, ultrasonic equipment and electronic ballast for fluorescent lamps.



TO-220

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 | SGSP364    | SGSP369 |      |
|----------------------|-------------------------------------------------|------------|---------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 450        | 500     | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 450        | 500     | V    |
| V <sub>GS</sub>      | Gate-source voltage                             |            | ±20     | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 5          |         | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 3          |         | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 20         |         | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 20         |         | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 100        |         | W    |
|                      | Derating factor                                 | 0.8        |         | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | -65 to 150 |         | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150        |         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.25 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |            |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|------------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>SGSP364</b><br>for <b>SGSP369</b>           | $V_{GS} = 0$         | 450<br>500 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |            | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      |            | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                    |                                                        |   |  |          |                      |
|---------------|-----------------------------------|------------------------------------|--------------------------------------------------------|---|--|----------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                  | $I_D = 250 \mu A$                                      | 2 |  | 4        | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$V_{GS} = 10 V$ | $I_D = 2.5 A$<br>$I_D = 2.5 A$<br>$T_c = 100^{\circ}C$ |   |  | 1.5<br>3 | $\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                 |               |   |     |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|---------------|---|-----|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$                 | $I_D = 2.5 A$ | 3 |     |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 MHz$   |   | 780 | 1000<br>200<br>130 | pF<br>pF<br>pF |

SWITCHING

|             |                     |                    |                    |  |    |     |    |
|-------------|---------------------|--------------------|--------------------|--|----|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 250 V$   | $I_D = 2.5 A$      |  | 20 | 30  | ns |
| $t_r$       | Rise time           | $V_i = 10 V$       | $R_i = 4.7 \Omega$ |  | 30 | 40  | ns |
| $t_d (off)$ | Turn-off delay time | (see test circuit) |                    |  | 85 | 110 | ns |
| $t_f$       | Fall time           |                    |                    |  | 25 | 35  | ns |

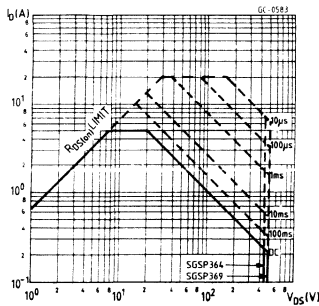
# ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                    | Test Conditions                                                       | Min. | Typ. | Max. | Unit |
|-----------------------------------------------|-----------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current                 |                                                                       |      |      | 5    | A    |
| $I_{SDM}^{(*)}$ Source-drain current (pulsed) |                                                                       |      |      | 20   | A    |
| $V_{SD}$ Forward on voltage                   | $I_{SD} = 5\text{ A}$ $V_{GS} = 0$                                    |      |      | 1.2  | V    |
| $t_{rr}$ Reverse recovery time                | $I_{SD} = 5\text{ A}$ $V_{GS} = 0$ $di/dt = 100\text{ A}/\mu\text{s}$ |      | 470  |      | ns   |

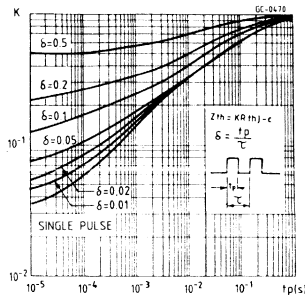
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

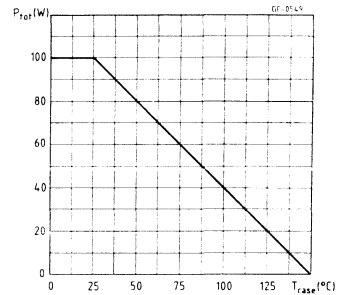
## Safe operating areas



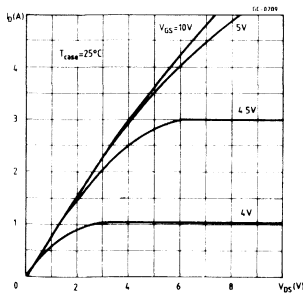
## Thermal impedance



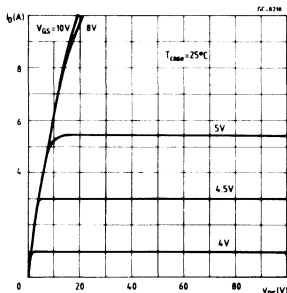
## Derating curve



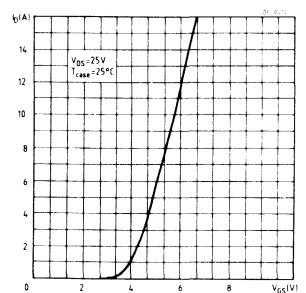
## Output characteristics



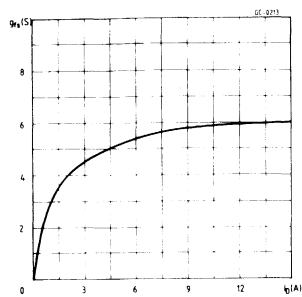
## Output characteristics



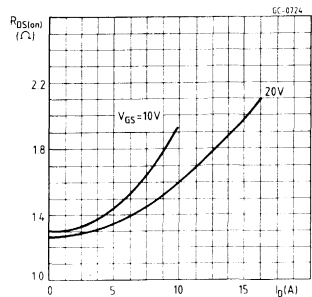
## Transfer characteristics



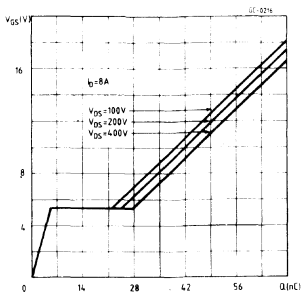
Transconductance



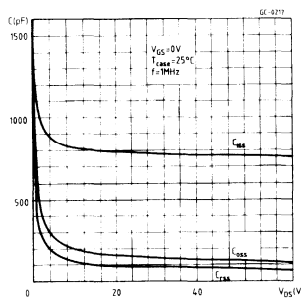
Static drain-source on resistance



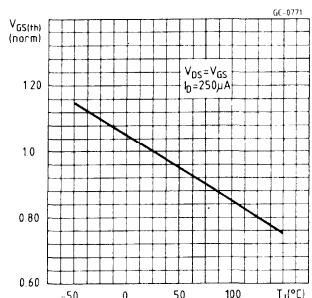
Gate charge vs gate-source voltage



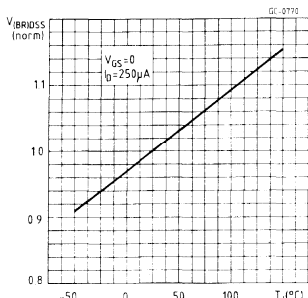
Capacitance variation



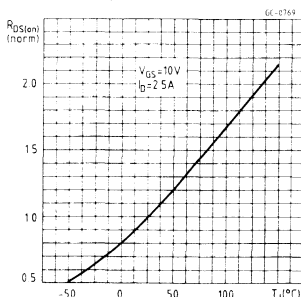
Normalized gate threshold voltage vs temperature



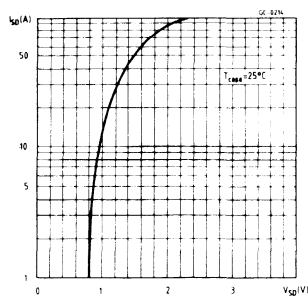
Normalized breakdown voltage vs temperature



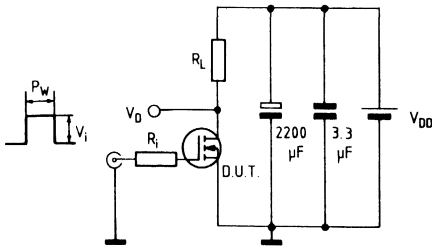
Normalized on resistance vs temperature



Source-drain diode forward characteristics

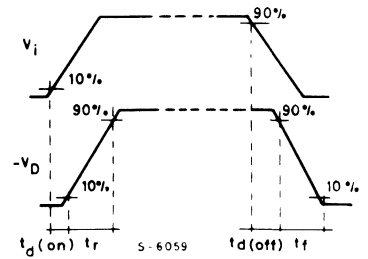


Switching times test circuit for resistive load

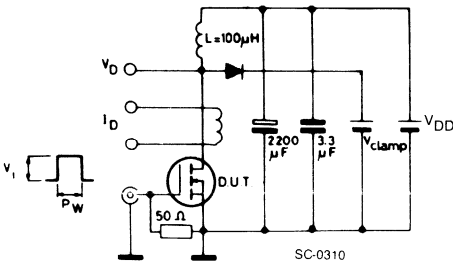


Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

Switching time waveforms for resistive load

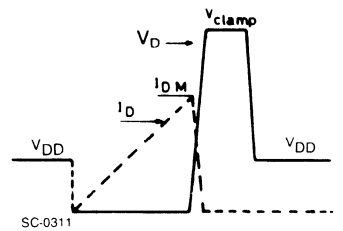


Clamped inductive load test circuit

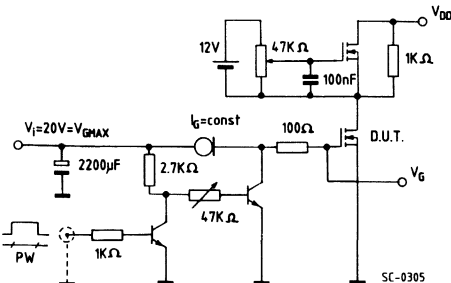


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ ,  $V_{clamp} = 0.75 V_{(BR)}$  DSS

Clamped inductive waveforms

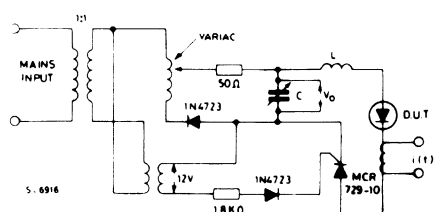


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

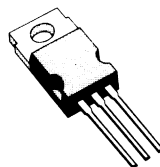
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP381 | 60 V             | 0.06 Ω              | 28 A           |
| SGSP382 | 50 V             | 0.06 Ω              | 28 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- 60 VOLTS - DC/DC AND UPS APPLICATIONS
- HIGH CURRENT
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

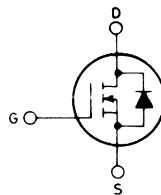
- DC/DC CONVERTERS AND UPS
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Typical uses include UPS, battery chargers, printer mechanism drives and motor speed control



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 |
|----------------------|-------------------------------------------------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    |
| V <sub>GS</sub>      | Gate-source voltage                             |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      |
|                      | Derating factor                                 |
| T <sub>stg</sub>     | Storage temperature                             |
| T <sub>j</sub>       | Max. operating junction temperature             |

### SGSP381

### SGSP382

|             |    |      |
|-------------|----|------|
| 60          | 50 | V    |
| 60          | 50 | V    |
| ± 20        |    | V    |
| 28          |    | A    |
| 17          |    | A    |
| 112         |    | A    |
| 112         |    | A    |
| 100         |    | W    |
| 0.8         |    | W/°C |
| - 65 to 150 |    | °C   |
| 150         |    | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.25 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |          |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|----------|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>SGSP381</b><br>for <b>SGSP382</b>           | $V_{GS} = 0$         | 60<br>50 |  |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |          |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      |          |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                    |                                                      |   |  |              |                      |
|---------------|-----------------------------------|------------------------------------|------------------------------------------------------|---|--|--------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                  | $I_D = 250 \mu A$                                    | 2 |  | 4            | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$V_{GS} = 10 V$ | $I_D = 14 A$<br>$I_D = 14 A$<br>$T_c = 100^{\circ}C$ |   |  | 0.06<br>0.12 | $\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                 |              |   |      |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|--------------|---|------|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$                 | $I_D = 14 A$ | 5 |      |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 MHz$  |   | 1100 | 1400<br>800<br>400 | pF<br>pF<br>pF |

SWITCHING

|               |                     |                    |                    |  |    |     |    |
|---------------|---------------------|--------------------|--------------------|--|----|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 25 V$    | $I_D = 14 A$       |  | 25 | 35  | ns |
| $t_r$         | Rise time           | $V_i = 10 V$       | $R_i = 4.7 \Omega$ |  | 75 | 100 | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit) |                    |  | 50 | 65  | ns |
| $t_f$         | Fall time           |                    |                    |  | 40 | 55  | ns |



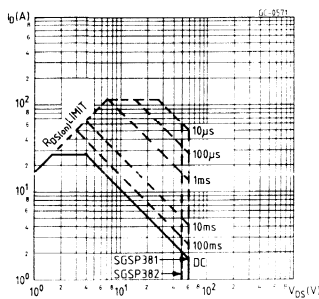
## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                                                   | Test Conditions                                                          | Min. | Typ. | Max.      | Unit   |
|------------------------------------------------------------------------------|--------------------------------------------------------------------------|------|------|-----------|--------|
| $I_{SD}$ Source-drain current<br>$I_{SDM} (*)$ Source-drain current (pulsed) |                                                                          |      |      | 28<br>112 | A<br>A |
| $V_{SD}$ Forward on voltage                                                  | $I_{SD} = 28\text{ A}$ $V_{GS} = 0$                                      |      |      | 1.4       | V      |
| $t_{rr}$ Reverse recovery time                                               | $I_{SD} = 28\text{ A}$<br>$di/dt = 25\text{ A}/\mu\text{s}$ $V_{GS} = 0$ |      | 125  |           | ns     |

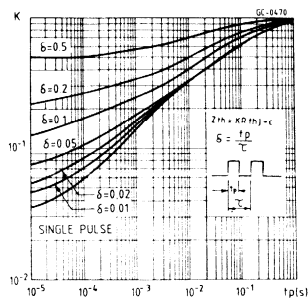
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

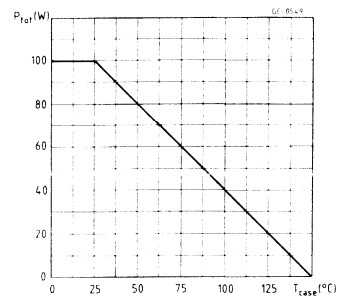
Safe operating areas



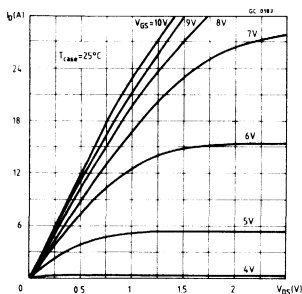
Thermal impedance



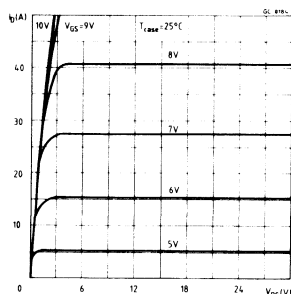
Derating curve



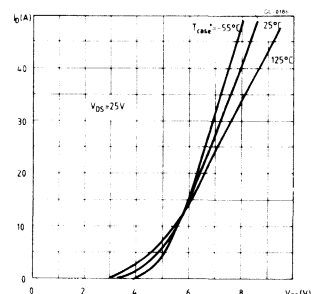
Output characteristics



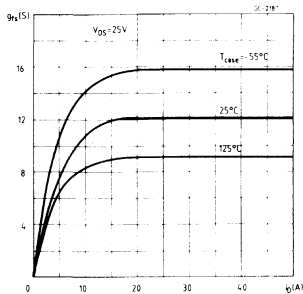
Output characteristics



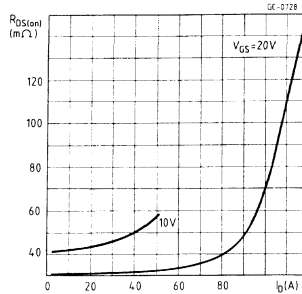
Transfer characteristics



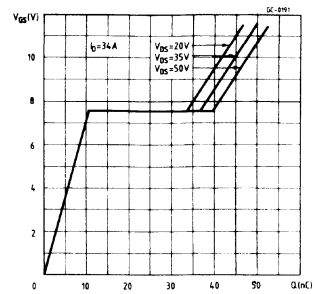
Transconductance



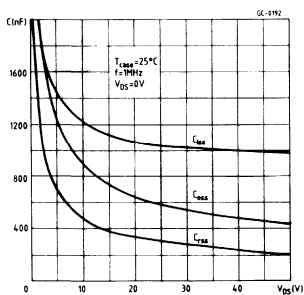
Static drain-source on resistance



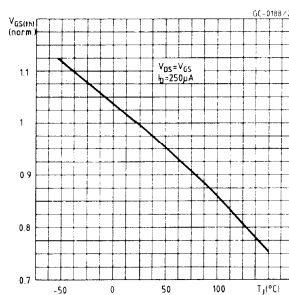
Gate charge vs gate-source voltage



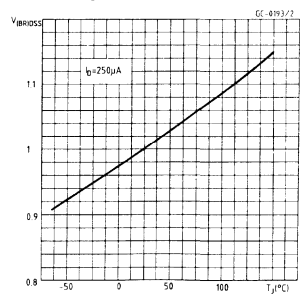
Capacitance variation



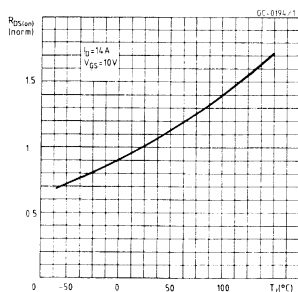
Normalized gate threshold voltage vs temperature



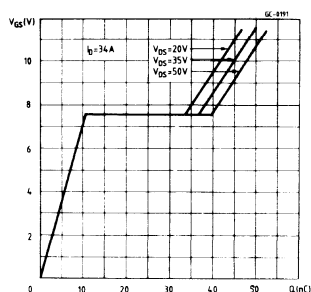
Normalized breakdown voltage vs temperature



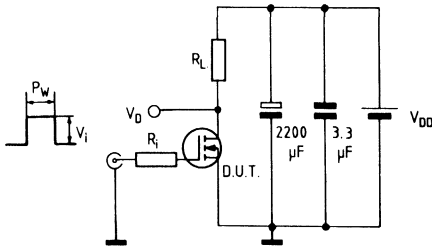
Normalized on resistance vs temperature



Source-drain diode forward characteristics



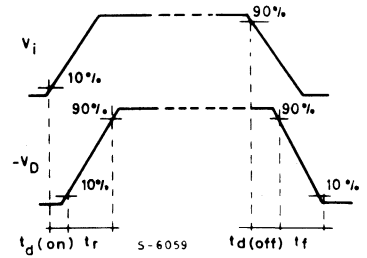
Switching times test circuit for resistive load



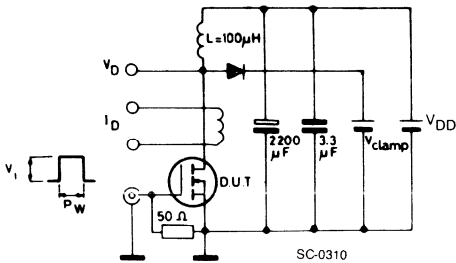
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

SC-0008/1

Switching time waveforms for resistive load



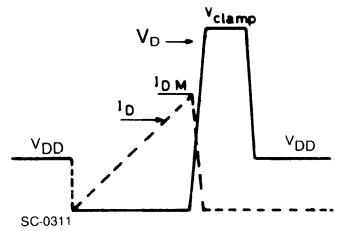
Clamped inductive load test circuit



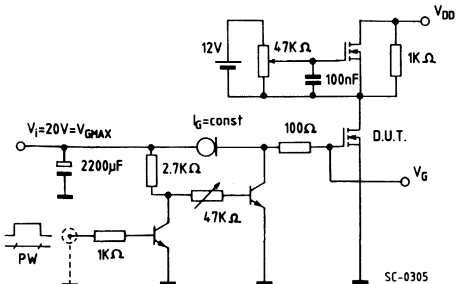
$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ ,  $V_{\text{clamp}} = 0.75 V_{(BR) \text{ DSS}}$

SC-0310

Clamped inductive waveforms

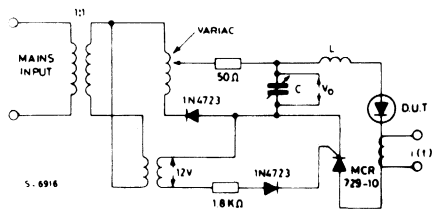


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

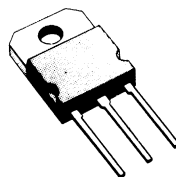
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP461 | 100 V            | 0.15 $\Omega$       | 20 A           |
| SGSP462 | 80 V             | 0.1 $\Omega$        | 25 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- 80 - 100 VOLTS - FOR UPS APPLICATIONS
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

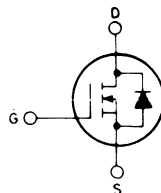
- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Typical applications include UPS, battery chargers, printer hammer drivers, solenoid drivers and motor control.



**TO-218**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                       | SGSP461     | SGSP462 |      |
|---------------------|-------------------------------------------------------|-------------|---------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)            | 100         | 80      | V    |
| V <sub>DGR</sub>    | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 100         | 80      | V    |
| V <sub>GS</sub>     | Gate-source voltage                                   | $\pm 20$    |         | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C        | 20          | 25      | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C       | 13          | 16      | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                                | 80          | 100     | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C            | 125         |         | W    |
|                     | Derating factor                                       | 1           |         | W/°C |
| T <sub>stg</sub>    | Storage temperature                                   | - 65 to 150 |         | °C   |
| T <sub>j</sub>      | Max. operating junction temperature                   | 150         |         | °C   |

(\*) Pulse width limited by safe operating area

♦ Introduced in 1988 week 44

THERMAL DATA

|                  |                                                |     |     |      |
|------------------|------------------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1   | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275 | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |           |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|-----------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>SGSP461</b><br>for <b>SGSP462</b>           | $V_{GS} = 0$         | 100<br>80 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |           | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      |           | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                                                                                                                    |                      |   |  |                           |                                              |
|---------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---|--|---------------------------|----------------------------------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                                                                                                  | $I_D = 250 \mu A$    | 2 |  | 4                         | V                                            |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$I_D = 10 A$ for <b>SGSP461</b><br>$I_D = 12.5 A$ for <b>SGSP462</b><br>$V_{GS} = 10 V$<br>$I_D = 10 A$ for <b>SGSP461</b><br>$I_D = 12.5 A$ for <b>SGSP462</b> | $T_c = 100^{\circ}C$ |   |  | 0.15<br>0.1<br>0.3<br>0.2 | $\Omega$<br>$\Omega$<br>$\Omega$<br>$\Omega$ |

ENERGY TEST

|           |                                                      |                                                                                             |                 |          |  |  |        |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------|----------|--|--|--------|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 V$<br>starting $T_j = 25^{\circ}C$<br>for <b>SGSP461</b><br>for <b>SGSP462</b> | $L = 100 \mu H$ | 20<br>25 |  |  | A<br>A |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------|----------|--|--|--------|

DYNAMIC

|                                     |                                                                         |                                 |                |     |     |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|----------------|-----|-----|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$                 | $I_D = 12.5 A$ | 4.5 |     |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 MHz$    |     | 950 | 1200<br>480<br>230 | pF<br>pF<br>pF |

ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

SWITCHING

|              |                     |                                                                     |                                                    |  |    |    |    |
|--------------|---------------------|---------------------------------------------------------------------|----------------------------------------------------|--|----|----|----|
| $t_{d(on)}$  | Turn-on time        | $V_{DD} = 50\text{ V}$<br>$V_i = 10\text{ V}$<br>(see test circuit) | $I_D = 12.5\text{ A}$<br>$R_i = 4.7\text{ }\Omega$ |  | 20 | 30 | ns |
| $t_r$        | Rise time           |                                                                     |                                                    |  | 60 | 80 | ns |
| $t_{d(off)}$ | Turn-off delay time |                                                                     |                                                    |  | 65 | 85 | ns |
| $t_f$        | Fall time           |                                                                     |                                                    |  | 25 | 35 | ns |

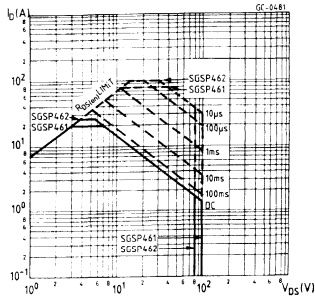
SOURCE DRAIN DIODE

|               |                               |                                                                                                        |              |  |      |    |
|---------------|-------------------------------|--------------------------------------------------------------------------------------------------------|--------------|--|------|----|
| $I_{SD}$      | Source-drain current          | for <b>SGSP461</b><br>for <b>SGSP462</b>                                                               |              |  | 20   | A  |
| $I_{SDM} (*)$ | Source-drain current (pulsed) |                                                                                                        |              |  | 25   | A  |
|               |                               | for <b>SGSP461</b>                                                                                     |              |  | 80   | A  |
|               |                               | for <b>SGSP462</b>                                                                                     |              |  | 100  | A  |
| $V_{SD}$      | Forward on voltage            | $V_{GS} = 0$<br>$I_{SD} = 20\text{ A}$ for <b>SGSP461</b><br>$I_{SD} = 25\text{ A}$ for <b>SGSP462</b> |              |  | 1.35 | V  |
|               |                               |                                                                                                        |              |  | 1.35 | V  |
| $t_{rr}$      | Reverse recovery time         | $I_{SD} = 25\text{ A}$<br>$di/dt = 25\text{ A}/\mu\text{s}$                                            | $V_{GS} = 0$ |  | 190  | ns |

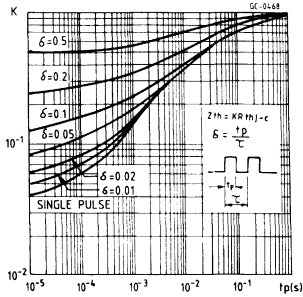
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

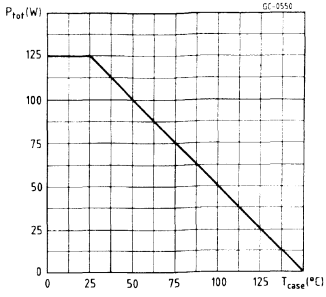
Safe operating areas



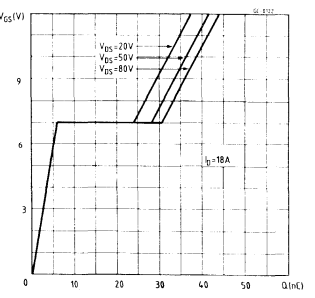
Thermal impedance



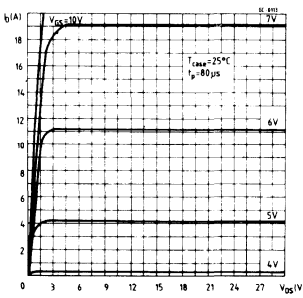
Derating curve



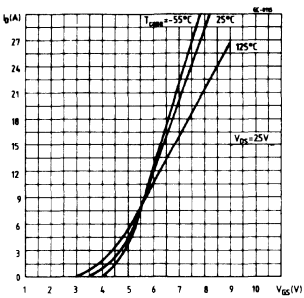
Output characteristics



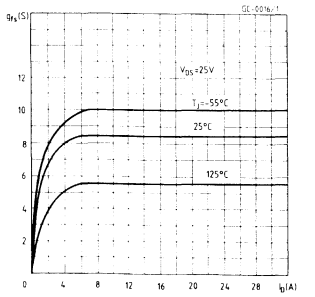
Output characteristics



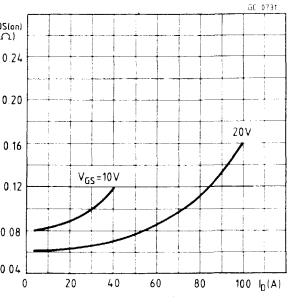
Transfer characteristics



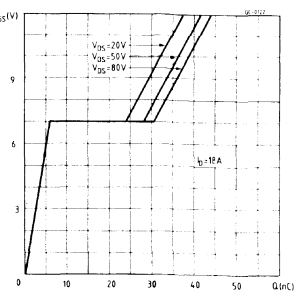
Transconductance



Static drain-source on resistance

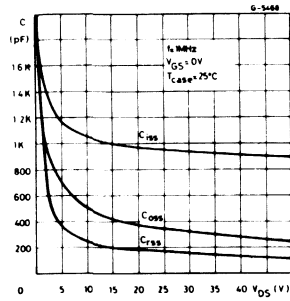


Gate charge vs gate-source voltage

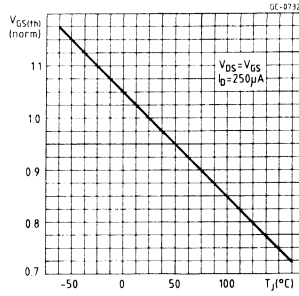




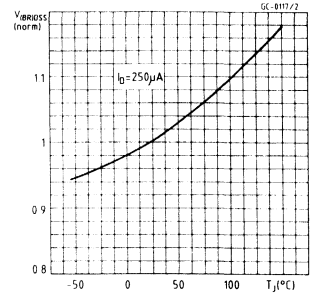
Capacitance variation



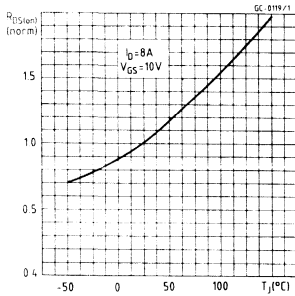
Normalized gate threshold voltage vs temperature



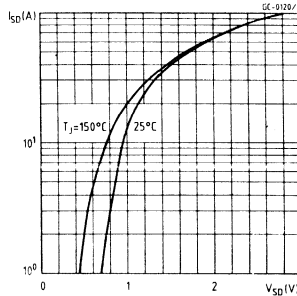
Normalized breakdown voltage vs temperature



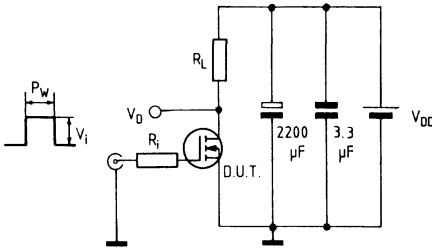
Normalized on resistance vs temperature



Source-drain diode forward characteristics

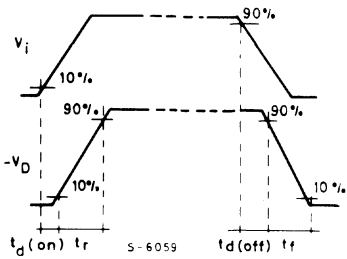


Switching times test circuit for resistive load

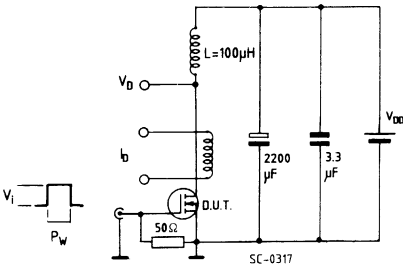


Pulse width  $\leq 100 \mu s$   
Duty cycle  $\leq 2\%$

Switching time waveforms for resistive load

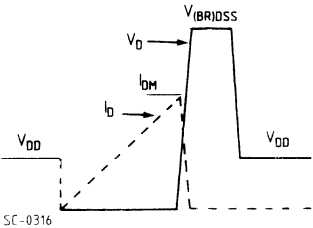


Unclamped inductive load test circuit

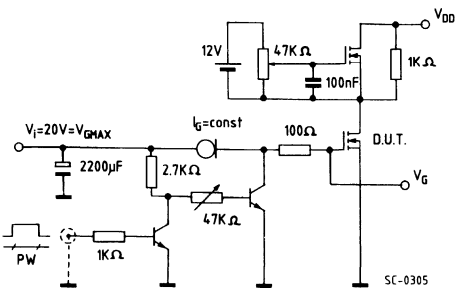


$V_i = 12 V$  - Pulse width: adjusted to obtain specified  $I_{DM}$

Unclamped inductive waveforms

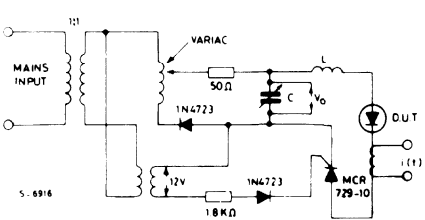


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

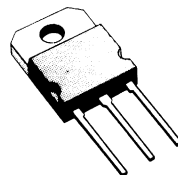
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP471 | 100 V            | 0.075 $\Omega$      | 30 A           |
| SGSP472 | 80 V             | 0.05 $\Omega$       | 35 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- 80 - 100 VOLTS - FOR DC/DC CONVERTERS
- HIGH CURRENT > 1V DROP AT 20A
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED SIZE AND COST

### INDUSTRIAL APPLICATIONS:

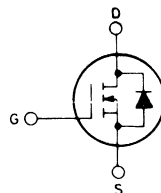
- UNINTERRUPTIBLE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Applications include DC/DC converters, UPS, battery chargers, secondary regulators, servo control, power audio amplifiers and robotics.



TO-218

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                       | SGSP471     | SGSP472 |      |
|---------------------|-------------------------------------------------------|-------------|---------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)            | 100         | 80      | V    |
| V <sub>DGR</sub>    | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 100         | 80      | V    |
| V <sub>GS</sub>     | Gate-source voltage                                   | $\pm 20$    |         | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>C</sub> = 25°C        | 30          | 35      | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>C</sub> = 100°C       | 19          | 22      | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                                | 120         | 140     | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>C</sub> < 25°C            | 150         |         | W    |
|                     | Derating factor                                       | 1.2         |         | W/°C |
| T <sub>stg</sub>    | Storage temperature                                   | - 65 to 150 |         | °C   |
| T <sub>j</sub>      | Max. operating junction temperature                   | 150         |         | °C   |

(\*) Pulse width limited by safe operating area

♦ Introduced in 1988 week 44

THERMAL DATA

|                    |                                                |     |      |      |
|--------------------|------------------------------------------------|-----|------|------|
| $R_{th(j) - case}$ | Thermal resistance junction-case               | max | 0.83 | °C/W |
| $T_L$              | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |           |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|-----------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>SGSP471</b><br>for <b>SGSP472</b>           | $V_{GS} = 0$         | 100<br>80 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |           | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      |           | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                                                                                                                    |                      |   |                              |                                              |
|---------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---|------------------------------|----------------------------------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                                                                                                  | $I_D = 250 \mu A$    | 2 |                              | 4<br>V                                       |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$I_D = 15 A$ for <b>SGSP471</b><br>$I_D = 17.5 A$ for <b>SGSP472</b><br>$V_{GS} = 10 V$<br>$I_D = 15 A$ for <b>SGSP471</b><br>$I_D = 17.5 A$ for <b>SGSP472</b> | $T_c = 100^{\circ}C$ |   | 0.075<br>0.05<br>0.15<br>0.1 | $\Omega$<br>$\Omega$<br>$\Omega$<br>$\Omega$ |

ENERGY TEST

|           |                                                      |                                                                                             |                 |          |  |        |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------|----------|--|--------|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 V$<br>starting $T_j = 25^{\circ}C$<br>for <b>SGSP471</b><br>for <b>SGSP472</b> | $L = 100 \mu H$ | 30<br>35 |  | A<br>A |
|-----------|------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------|----------|--|--------|

DYNAMIC

|                                     |                                                                         |                                 |                |   |                            |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|----------------|---|----------------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$                 | $I_D = 17.5 A$ | 9 |                            | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 MHz$    |   | 1800<br>2200<br>810<br>375 | pF<br>pF<br>pF |

ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

SWITCHING

|              |                     |                                                                                                                           |  |     |     |    |
|--------------|---------------------|---------------------------------------------------------------------------------------------------------------------------|--|-----|-----|----|
| $t_{d(on)}$  | Turn-on time        | $V_{DD} = 50\text{ V}$<br>$V_i = 10\text{ V}$<br>$I_D = 17.5\text{ A}$<br>$R_i = 4.7\text{ }\Omega$<br>(see test circuit) |  | 30  | 40  | ns |
| $t_r$        | Rise time           |                                                                                                                           |  | 85  | 110 | ns |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                                           |  | 100 | 130 | ns |
| $t_f$        | Fall time           |                                                                                                                           |  | 40  | 55  | ns |

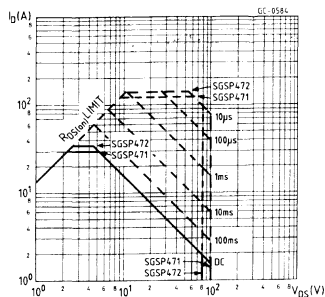
SOURCE DRAIN DIODE

|               |                               |                                                                                                        |  |     |              |        |
|---------------|-------------------------------|--------------------------------------------------------------------------------------------------------|--|-----|--------------|--------|
| $I_{SD}$      | Source-drain current          | for <b>SGSP471</b><br>for <b>SGSP472</b>                                                               |  |     | 30<br>35     | A<br>A |
| $I_{SDM} (*)$ | Source-drain current (pulsed) | for <b>SGSP471</b><br>for <b>SGSP472</b>                                                               |  |     | 120<br>140   | A<br>A |
| $V_{SD}$      | Forward on voltage            | $V_{GS} = 0$<br>$I_{SD} = 30\text{ A}$ for <b>SGSP471</b><br>$I_{SD} = 35\text{ A}$ for <b>SGSP472</b> |  |     | 1.35<br>1.35 | V<br>V |
| $t_{rr}$      | Reverse recovery time         | $I_{SD} = 35\text{ A}$<br>$di/dt = 25\text{ A}/\mu\text{s}$<br>$V_{GS} = 0$                            |  | 190 |              | ns     |

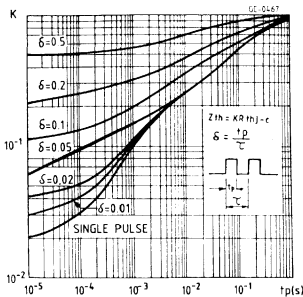
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

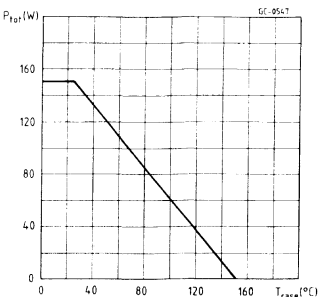
Safe operating areas



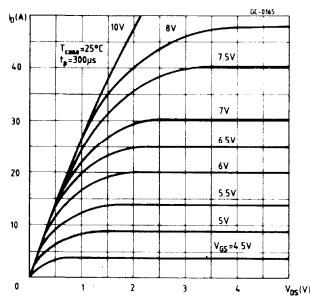
Thermal impedance



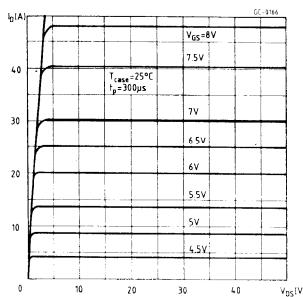
Derating curve



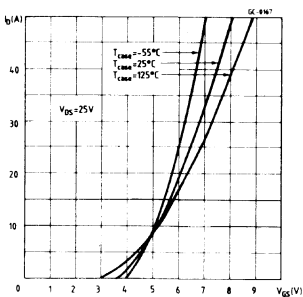
Output characteristics



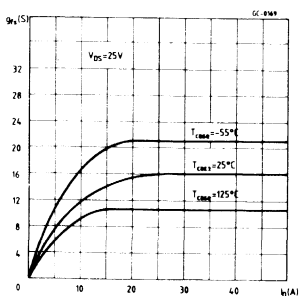
Output characteristics



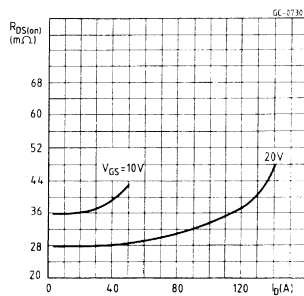
Transfer characteristics



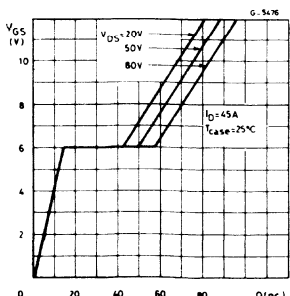
Transconductance



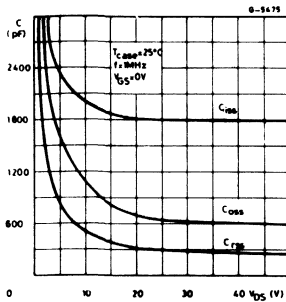
Static drain-source on resistance



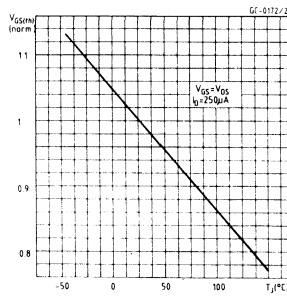
Gate charge vs gate-source voltage



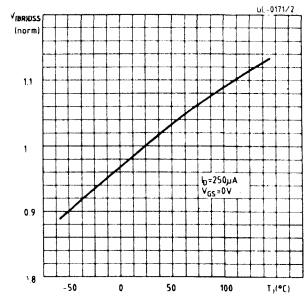
Capacitance variation



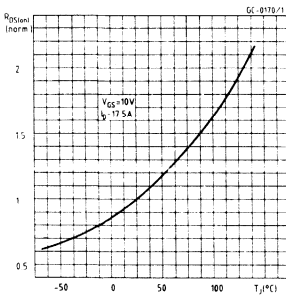
Normalized gate threshold voltage vs temperature



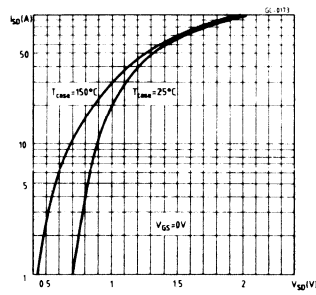
Normalized breakdown voltage vs temperature



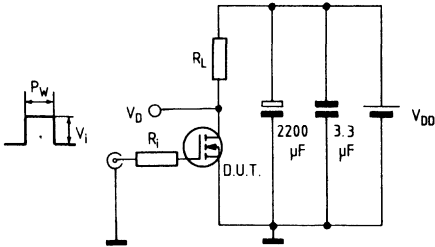
Normalized on resistance vs temperature



Source-drain diode forward characteristics

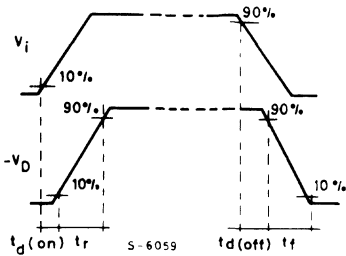


Switching times test circuit for resistive load

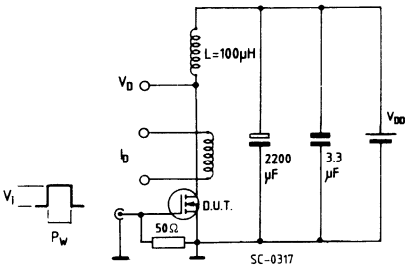


Pulse width  $\leq 100 \mu s$   
Duty cycle  $\leq 2\%$

Switching time waveforms for resistive load

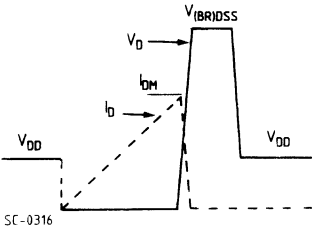


Unclamped inductive load test circuit

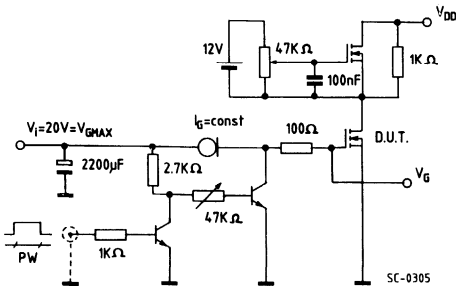


$V_i = 12 V$  - Pulse width: adjusted to obtain specified  $I_{DM}$

Unclamped inductive waveforms

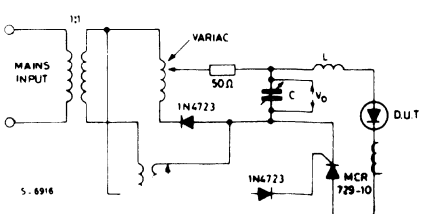


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

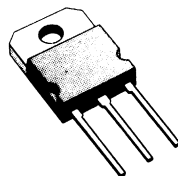
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP474 | 450 V            | 0.7 Ω               | 9 A            |
| SGSP475 | 400 V            | 0.55 Ω              | 10 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- HIGH VOLTAGE - FOR OFF-LINE SMPS
- HIGH CURRENT - FOR SMPS UP TO 350W
- ULTRA FAST SWITCHING - FOR OPERATION AT > 100kHz
- EASY DRIVE FOR REDUCED SIZE AND COST

### INDUSTRIAL APPLICATIONS:

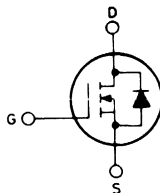
- SWITCHING MODE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Fast switching and easy drive make these POWER MOS transistors ideal for high voltage switching applications. These applications include electronic welders, switched mode power supplies and sonar equipment.



**TO-218**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 | SGSP474     | SGSP475 |      |
|----------------------|-------------------------------------------------|-------------|---------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 450         | 400     | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 450         | 400     | V    |
| V <sub>GS</sub>      | Gate-source voltage                             |             | ±20     | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 9           | 10      | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 5.6         | 6.3     | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 40          | 40      | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 40          | 40      | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      |             | 150     | W    |
|                      | Derating factor                                 |             | 1.2     | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | - 65 to 150 |         | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150         |         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |            |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|------------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>SGSP474</b><br>for <b>SGSP475</b>           | $V_{GS} = 0$         | 450<br>400 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |            | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      |            | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                                                                                                                |                      |   |  |                           |                                              |
|---------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---|--|---------------------------|----------------------------------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                                                                                              | $I_D = 250 \mu A$    | 2 |  | 4                         | V                                            |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$I_D = 4.5 A$ for <b>SGSP474</b><br>$I_D = 5 A$ for <b>SGSP475</b><br>$V_{GS} = 10 V$<br>$I_D = 4.5 A$ for <b>SGSP474</b><br>$I_D = 5 A$ for <b>SGSP475</b> | $T_c = 100^{\circ}C$ |   |  | 0.7<br>0.55<br>1.4<br>1.1 | $\Omega$<br>$\Omega$<br>$\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                 |             |   |      |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|-------------|---|------|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$                 | $I_D = 5 A$ | 6 |      |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 MHz$ |   | 1600 | 2100<br>390<br>260 | pF<br>pF<br>pF |

SWITCHING

|               |                     |                    |                    |  |     |     |    |
|---------------|---------------------|--------------------|--------------------|--|-----|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 225 V$   | $I_D = 5 A$        |  | 30  | 40  | ns |
| $t_r$         | Rise time           | $V_i = 10 V$       | $R_i = 4.7 \Omega$ |  | 45  | 60  | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit) |                    |  | 125 | 165 | ns |
| $t_f$         | Fall time           |                    |                    |  | 30  | 40  | ns |

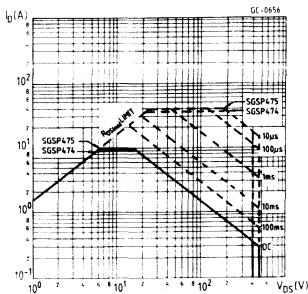
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                  | Test Conditions                                                                                       | Min. | Typ. | Max.          | Unit        |
|---------------------------------------------|-------------------------------------------------------------------------------------------------------|------|------|---------------|-------------|
| $I_{SD}$ Source-drain current               | for <b>SGSP474</b><br>for <b>SGSP475</b>                                                              |      |      | 9<br>10<br>40 | A<br>A<br>A |
| $I_{SDM}$ (*) Source-drain current (pulsed) |                                                                                                       |      |      |               |             |
| $V_{SD}$ Forward on voltage                 | $V_{GS} = 0$<br>$I_{SD} = 9\text{ A}$ for <b>SGSP474</b><br>$I_{SD} = 10\text{ A}$ for <b>SGSP475</b> |      |      | 1.2<br>1.2    | V<br>V      |
| $t_{rr}$ Reverse recovery time              | $I_{SD} = 10\text{ A}$ $V_{GS} = 0$<br>$di/dt = 100\text{ A}/\mu\text{s}$                             |      | 420  |               | ns          |

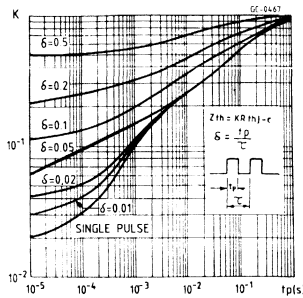
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

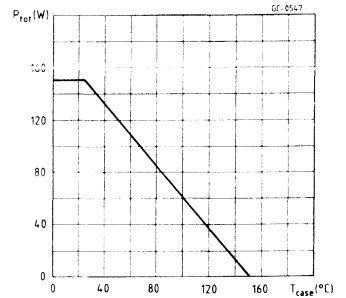
Safe operating areas



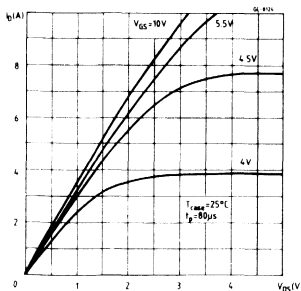
Thermal impedance



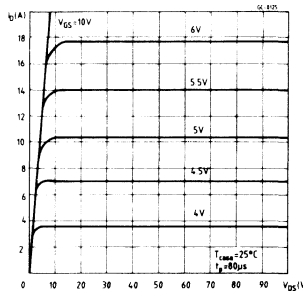
Derating curve



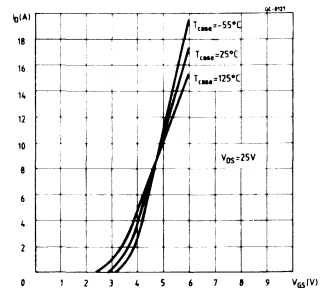
Output characteristics



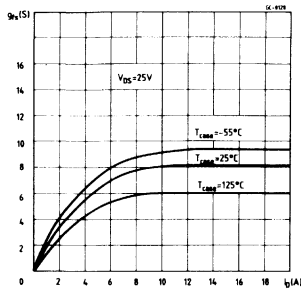
Output characteristics



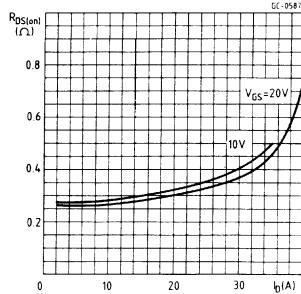
Transfer characteristics



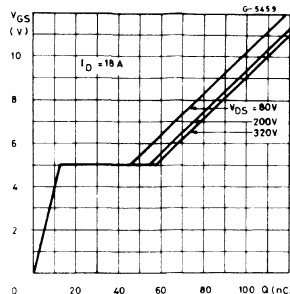
Transconductance



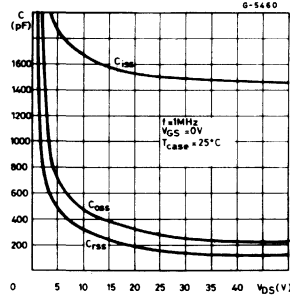
Static drain-source on resistance



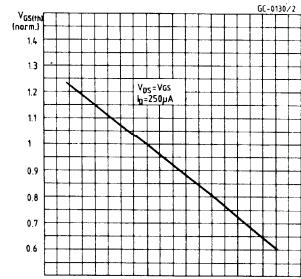
Gate charge vs gate-source voltage



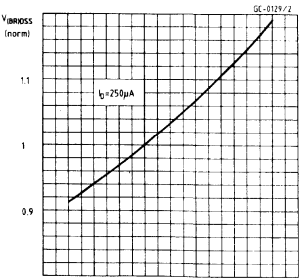
Capacitance variation



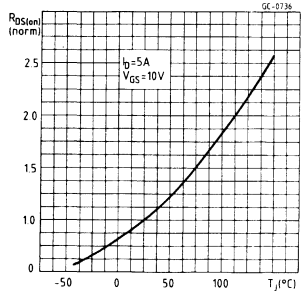
Normalized gate threshold voltage vs temperature



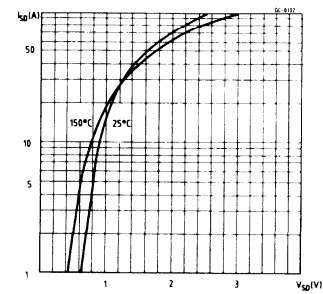
Normalized breakdown voltage vs temperature



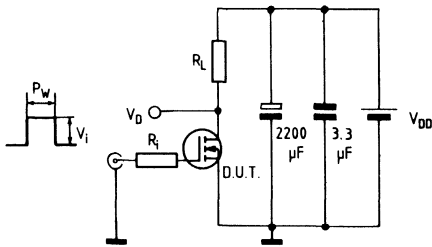
Normalized on resistance vs temperature



Source-drain diode forward characteristics



Switching times test circuit for resistive load

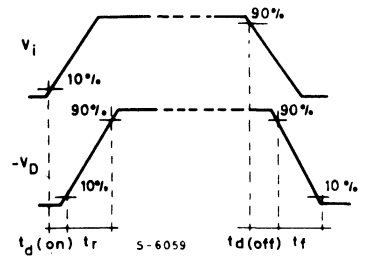


Pulse width  $\leq 100 \mu\text{s}$

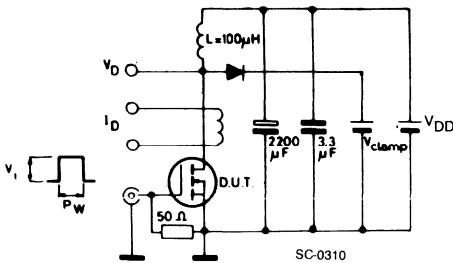
Duty cycle  $\leq 2\%$

SC-0008/1

Switching time waveforms for resistive load



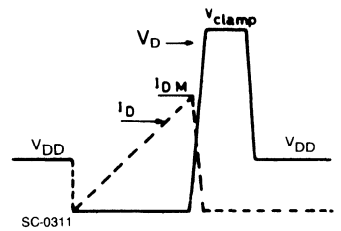
Clamped inductive load test circuit



$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(BR)} \text{ DSS}$ .

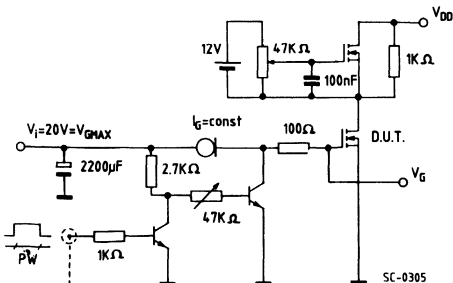
SC-0310

Clamped inductive waveforms



SC-0311

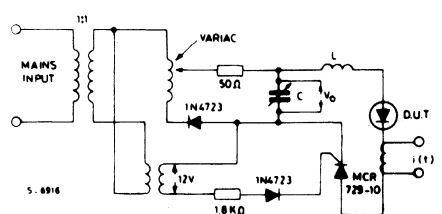
Gate charge test circuit



PW adjusted to obtain required  $V_G$

SC-0305

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



S. 0016



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

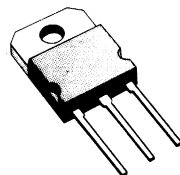
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP477 | 200 V            | 0.17 $\Omega$       | 20 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- HIGH CURRENT - FOR TELECOMM POWER SUPPLIES
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

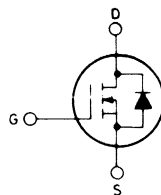
- SWITCHING MODE POWER SUPPLIES
- MOTOR CONTROLS FOR ROBOTICS.

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include robotics, laser diode drives, UPS, SMPS and DC/DC converters, electric vehicle drives and a DC switch for telecommunications.



**TO-218**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                       |            |      |
|----------------------|-------------------------------------------------------|------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)            | 200        | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 200        | V    |
| V <sub>GS</sub>      | Gate-source voltage                                   | $\pm 20$   | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C        | 20         | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C       | 13         | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                                | 80         | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                      | 80         | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C            | 150        | W    |
|                      | Derating factor                                       | 1.2        | W/°C |
| T <sub>stg</sub>     | Storage temperature                                   | -55 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature                   | 150        | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                 |     |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                               | 200 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>$T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                             |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                   |   |  |              |                      |
|---------------|-----------------------------------|-----------------------------------------------------------------------------------|---|--|--------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$                                            | 2 |  | 4            | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 10 A$<br>$V_{GS} = 10 V$ $I_D = 10 A$ $T_c = 100^{\circ}C$ |   |  | 0.17<br>0.34 | $\Omega$<br>$\Omega$ |

DYNAMIC

|           |                              |                                                        |   |      |      |     |
|-----------|------------------------------|--------------------------------------------------------|---|------|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$<br>$I_D = 10 A$                        | 8 |      |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 \text{ MHz}$ |   | 1900 | 2200 | pF  |
| $C_{oss}$ | Output capacitance           |                                                        |   |      | 550  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                        |   |      | 260  | pF  |

SWITCHING

|               |                     |                                                                                              |  |     |     |    |
|---------------|---------------------|----------------------------------------------------------------------------------------------|--|-----|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 100 V$<br>$V_i = 10 V$<br>$I_D = 10 A$<br>$R_i = 4.7 \Omega$<br>(see test circuit) |  | 30  | 40  | ns |
| $t_r$         | Rise time           |                                                                                              |  | 50  | 65  | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                                                              |  | 110 | 145 | ns |
| $t_f$         | Fall time           |                                                                                              |  | 35  | 45  | ns |

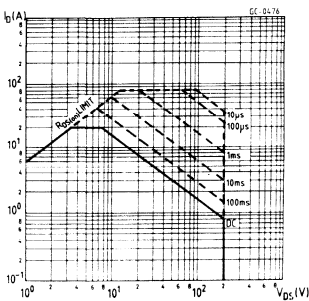


ELECTRICAL CHARACTERISTICS (Continued)

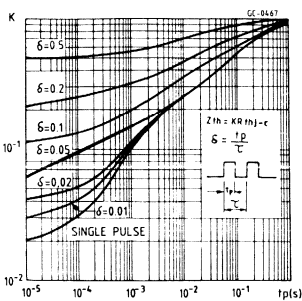
| Parameters                                                                   | Test Conditions                                                           | Min. | Typ. | Max.     | Unit   |
|------------------------------------------------------------------------------|---------------------------------------------------------------------------|------|------|----------|--------|
| $I_{SD}$ Source-drain current<br>$I_{SDM} (*)$ Source-drain current (pulsed) |                                                                           |      |      | 20<br>80 | A<br>A |
| $V_{SD}$ Forward on voltage                                                  | $I_{SD} = 20\text{ A}$ $V_{GS} = 0$                                       |      |      | 1.3      | V      |
| $t_{rr}$ Reverse recovery time                                               | $I_{SD} = 20\text{ A}$ $V_{GS} = 0$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |      | 320  |          | ns     |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
(\*) Pulse width limited by safe operating area

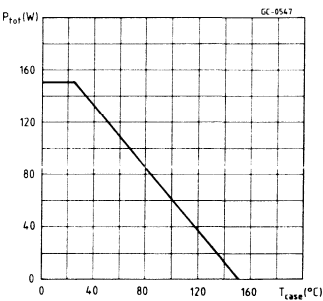
Safe operating areas



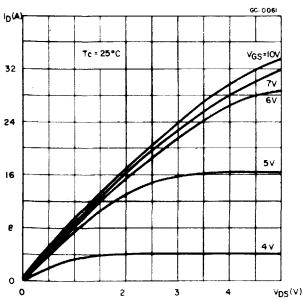
Thermal impedance



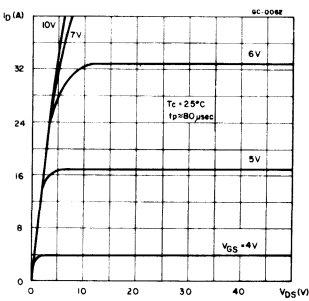
Derating curve



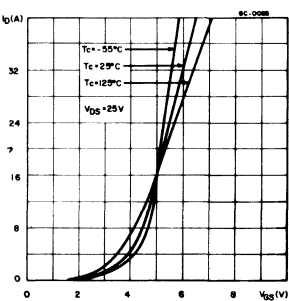
Output characteristics



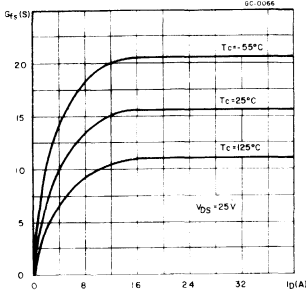
Output characteristics



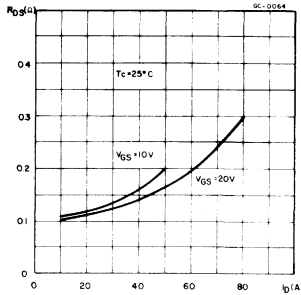
Transfer characteristics



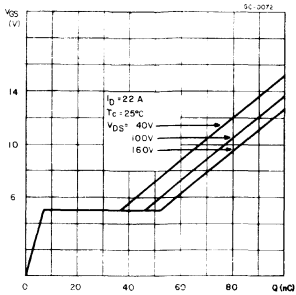
Transconductance



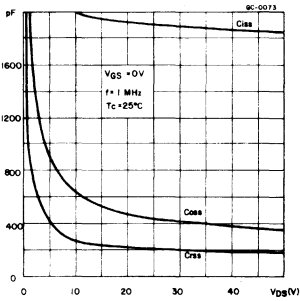
Static drain-source on resistance



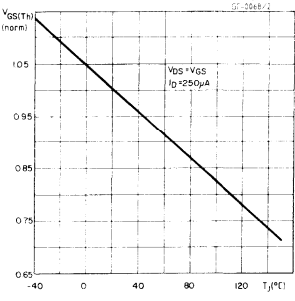
Gate charge vs gate-source voltage



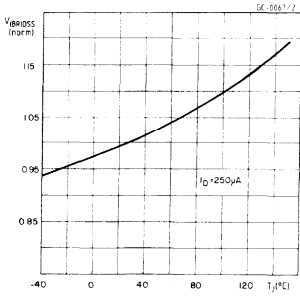
Capacitance variation



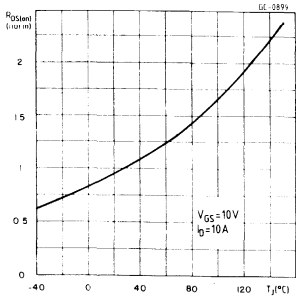
Normalized gate threshold voltage vs temperature



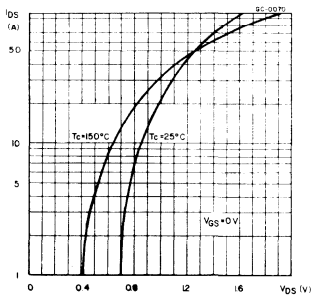
Normalized breakdown voltage vs temperature



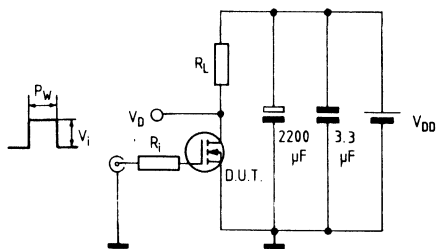
Normalized on resistance vs temperature



Source-drain diode forward characteristics

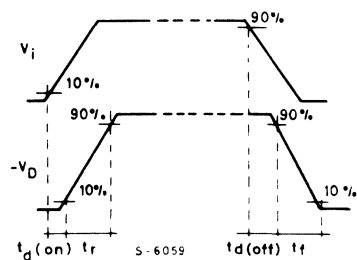


Switching times test circuit for resistive load

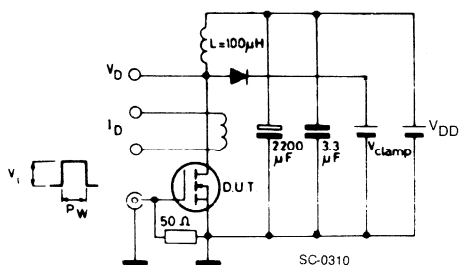
Pulse width  $\leq 100 \mu\text{s}$ Duty cycle  $\leq 2\%$ 

SC-0008/1

Switching time waveforms for resistive load



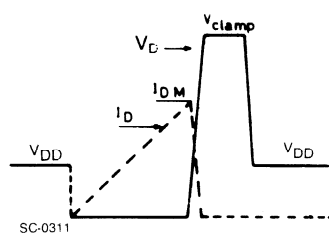
Clamped inductive load test circuit



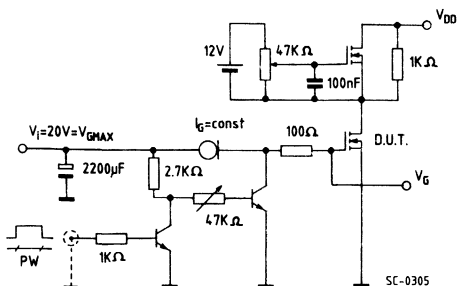
$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(BR) \text{ DSS}}$ .

SC-0310

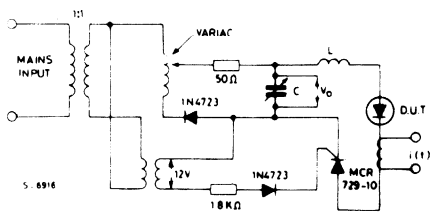
Clamped inductive waveforms



Gate charge test circuit

PW adjusted to obtain required  $V_G$ 

SC-0305

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

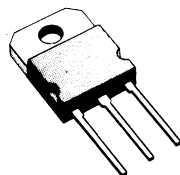
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP479 | 500 V            | 0.7 Ω               | 9 A            |

- HIGH SPEED SWITCHING APPLICATIONS
- HIGH VOLTAGE - 500V FOR OFF-LINE SMPS
- HIGH VOLTAGE - 9A FOR UP TO 350W SMPS
- ULTRA FAST SWITCHING - FOR OPERATION AT > 100KHz
- EASY DRIVE - REDUCES COST AND SIZE

### INDUSTRIAL APPLICATIONS:

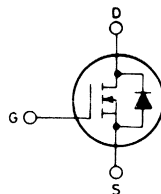
- SWITCHING MODE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include switching mode power supplies, uninterruptible power supplies and motor speed control.



**TO-218**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 |             |      |
|----------------------|-------------------------------------------------|-------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 500         | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 500         | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ± 20        | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 9           | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 5.6         | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 36          | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 36          | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 150         | W    |
|                      | Derating factor                                 | 1.2         | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | - 65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                              |     |  |             |                    |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                            | 500 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                          |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                     |   |  |            |                      |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------|---|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$                                              | 2 |  | 4          | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 4.5 A$<br>$V_{GS} = 10 V$ $I_D = 4.5 A$ $T_c = 100^{\circ}C$ |   |  | 0.7<br>1.4 | $\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                                        |   |      |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------|---|------|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$<br>$I_D = 4.5 A$                       | 5 |      |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 \text{ MHz}$ |   | 1600 | 1900<br>280<br>170 | pF<br>pF<br>pF |

SWITCHING

|             |                     |                                                                                               |  |     |     |    |
|-------------|---------------------|-----------------------------------------------------------------------------------------------|--|-----|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 250 V$<br>$V_i = 10 V$<br>$I_D = 4.5 A$<br>$R_i = 4.7 \Omega$<br>(see test circuit) |  | 30  | 40  | ns |
| $t_r$       | Rise time           |                                                                                               |  | 40  | 60  | ns |
| $t_d (off)$ | Turn-off delay time |                                                                                               |  | 130 | 170 | ns |
| $t_f$       | Fall time           |                                                                                               |  | 30  | 40  | ns |

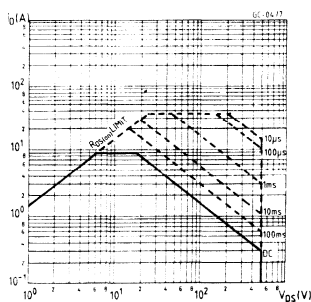
### ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                |                                                          | Test Conditions                                             |              | Min. | Typ. | Max.    | Unit   |
|---------------------------|----------------------------------------------------------|-------------------------------------------------------------|--------------|------|------|---------|--------|
| <b>SOURCE DRAIN DIODE</b> |                                                          |                                                             |              |      |      |         |        |
| $I_{SD}$<br>$I_{SDM}$ (*) | Source-drain current<br>Source-drain current<br>(pulsed) |                                                             |              |      |      | 9<br>36 | A<br>A |
| $V_{SD}$                  | Forward on voltage                                       | $I_{SD} = 9\text{ A}$                                       | $V_{GS} = 0$ |      |      | 1.15    | V      |
| $t_{rr}$                  | Reverse recovery<br>time                                 | $I_{SD} = 9\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ | $V_{GS} = 0$ |      | 420  |         | ns     |

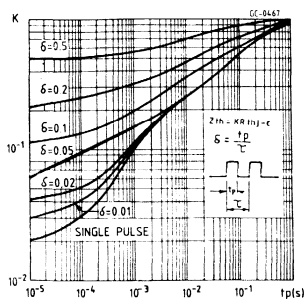
(\*) Pulsed: Pulse duration = 300  $\mu$ s, duty cycle 1.5%

(\*) Pulse width limited by safe operating area

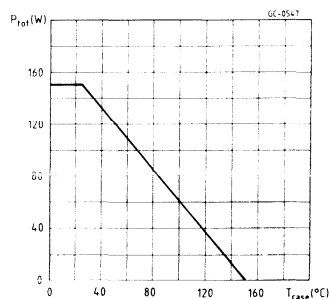
### Safe operating areas



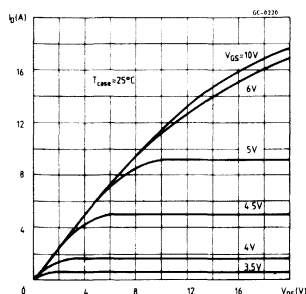
### Thermal impedance



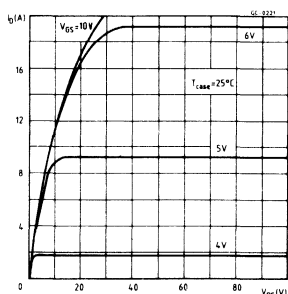
### Derating curve



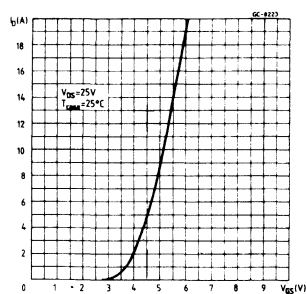
### Output characteristics



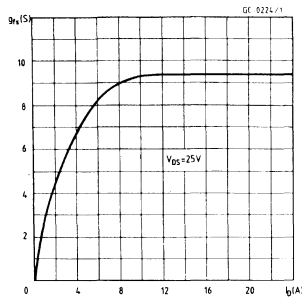
### Output characteristics



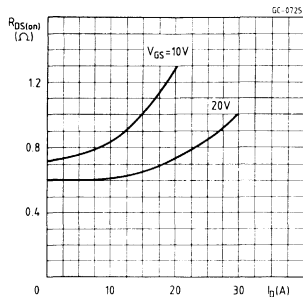
### Transfer characteristics



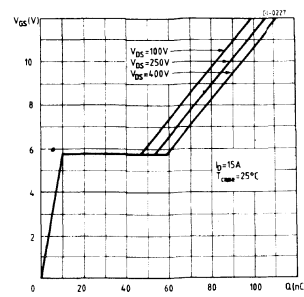
Transconductance



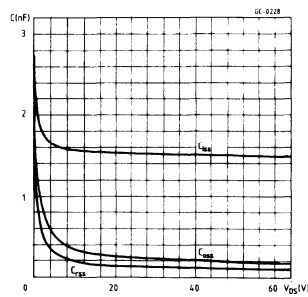
Static drain-source on resistance



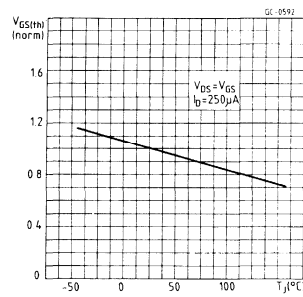
Gate charge vs gate-source voltage



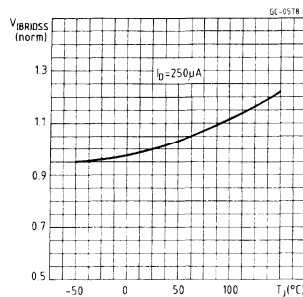
Capacitance variation



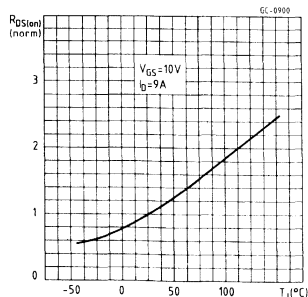
Normalized gate threshold voltage vs temperature



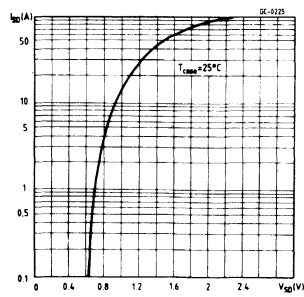
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature

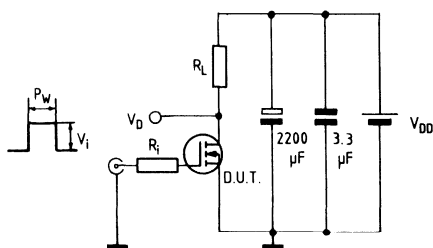


Source-drain diode forward characteristics



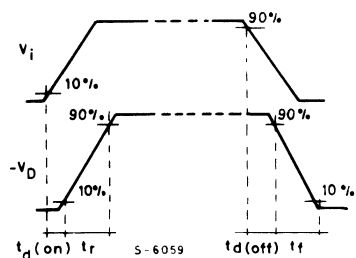


Switching times test circuit for resistive load

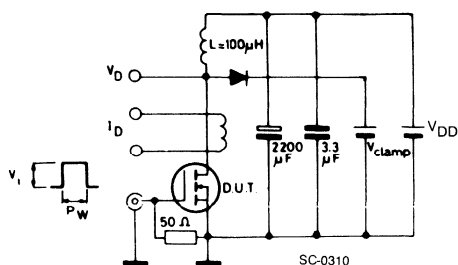
Pulse width  $\leq 100 \mu\text{s}$ Duty cycle  $\leq 2\%$ 

SC-0008/1

Switching time waveforms for resistive load



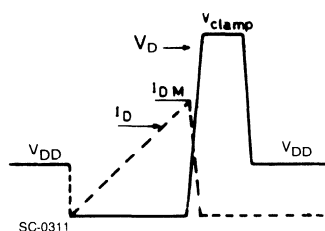
Clamped inductive load test circuit



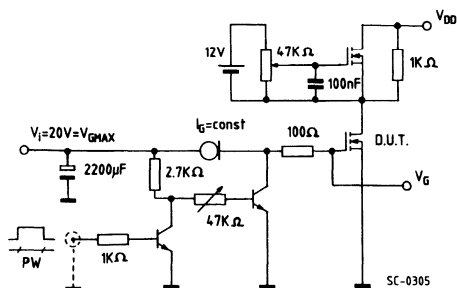
$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain  
specified  $I_{DM}$ ,  $V_{\text{clamp}} = 0.75 V_{(\text{BR}) \text{ DSS}}$

SC-0310

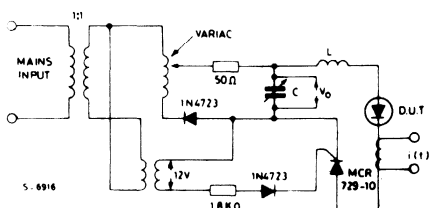
Clamped inductive waveforms



Gate charge test circuit

PW adjusted to obtain required  $V_G$ 

SC-0305

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

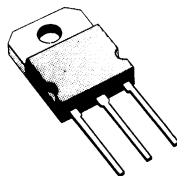
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP481 | 60 V             | 0.06 Ω              | 30 A           |
| SGSP482 | 50 V             | 0.06 Ω              | 30 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- 60 VOLTS - DC/DC AND UPS APPLICATIONS
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

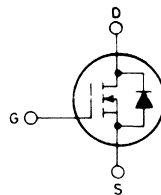
- DC/DC CONVERTERS AND UPS
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Typical uses include UPS, battery chargers, printer mechanism drives and motor speed control.



**TO-218**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 | SGSP481     | SGSP482 |      |
|----------------------|-------------------------------------------------|-------------|---------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 60          | 50      | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 60          | 50      | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ± 20        |         | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 30          |         | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 19          |         | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 120         |         | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 120         |         | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 125         |         | W    |
|                      | Derating factor                                 | 1           |         | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | - 65 to 150 |         | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150         |         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |     |      |
|------------------|------------------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1   | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275 | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |          |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|----------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>SGSP481</b><br>for <b>SGSP482</b>           | $V_{GS} = 0$         | 60<br>50 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |          | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      |          | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                    |                              |   |  |              |                      |
|---------------|-----------------------------------|------------------------------------|------------------------------|---|--|--------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                  | $I_D = 250 \mu A$            | 2 |  | 4            | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$V_{GS} = 10 V$ | $I_D = 15 A$<br>$I_D = 15 A$ |   |  | 0.06<br>0.12 | $\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                 |                     |   |      |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|---------------------|---|------|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$                 | $I_D = 15 A$        | 5 |      |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 \text{ MHz}$ |   | 1100 | 1400<br>800<br>400 | pF<br>pF<br>pF |

SWITCHING

|             |                     |                    |                    |  |    |     |    |
|-------------|---------------------|--------------------|--------------------|--|----|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 25 V$    | $I_D = 15 A$       |  | 25 | 35  | ns |
| $t_r$       | Rise time           | $V_i = 10 V$       | $R_i = 4.7 \Omega$ |  | 75 | 100 | ns |
| $t_d (off)$ | Turn-off delay time | (see test circuit) |                    |  | 50 | 65  | ns |
| $t_f$       | Fall time           |                    |                    |  | 40 | 55  | ns |

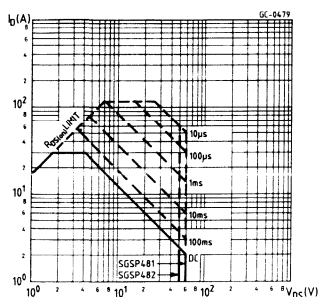
## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                  | Test Conditions                                                           | Min. | Typ. | Max. | Unit |
|---------------------------------------------|---------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current               |                                                                           |      |      | 30   | A    |
| $I_{SDM}$ (*) Source-drain current (pulsed) |                                                                           |      |      | 120  | A    |
| $V_{SD}$ Forward on voltage                 | $I_{SD} = 30\text{ A}$ $V_{GS} = 0$                                       |      |      | 1.4  | V    |
| $t_{rr}$ Reverse recovery time              | $I_{SD} = 30\text{ A}$ $V_{GS} = 0$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |      | 125  |      | ns   |

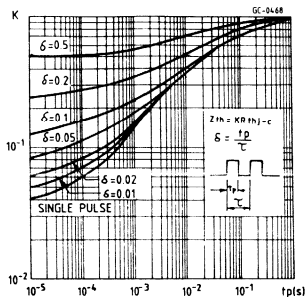
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

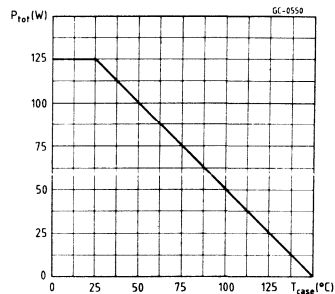
Safe operating areas



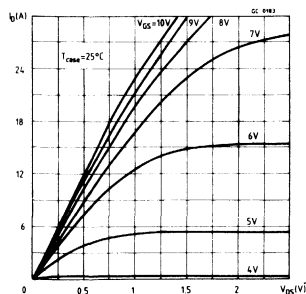
Thermal impedance



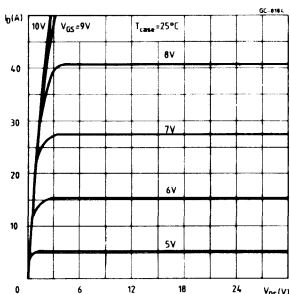
Derating curve



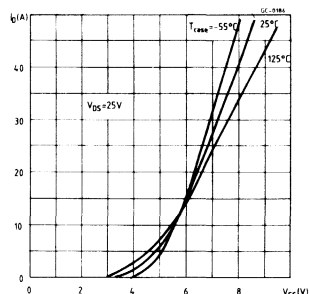
Output characteristics



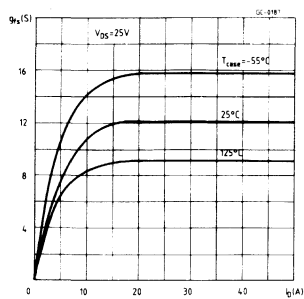
Output characteristics



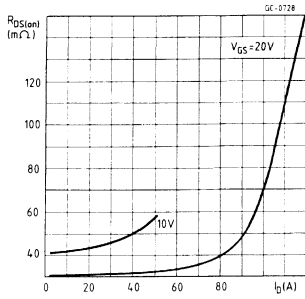
Transfer characteristics



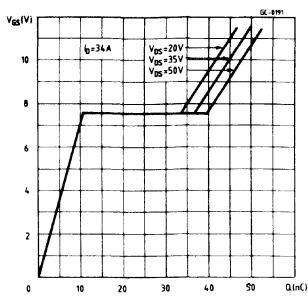
Transconductance



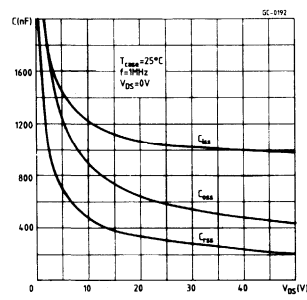
Static drain-source on resistance



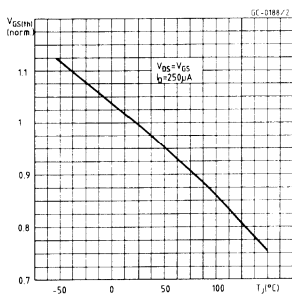
Gate charge vs gate-source voltage



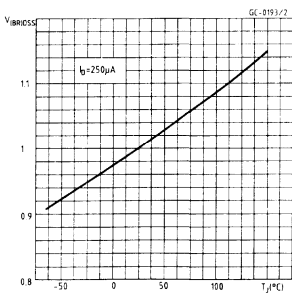
Capacitance variation



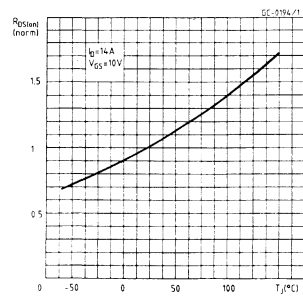
Normalized gate threshold voltage vs temperature



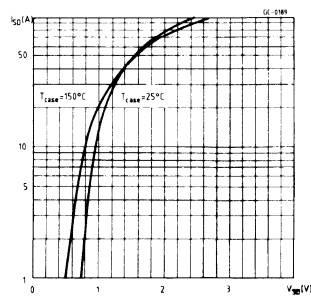
Normalized breakdown voltage vs temperature



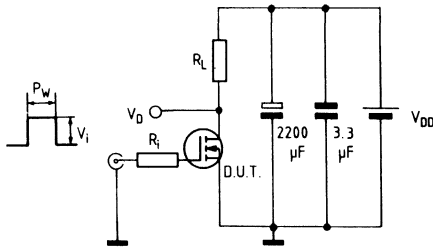
Normalized on resistance vs temperature



Source-drain diode forward characteristics



Switching times test circuit for resistive load

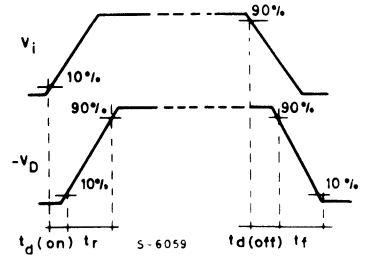


Pulse width  $\leq 100 \mu\text{s}$

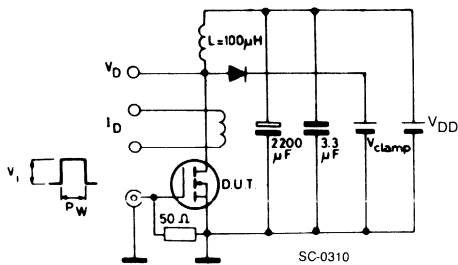
Duty cycle  $\leq 2\%$

SC-0008/1

Switching time waveforms for resistive load

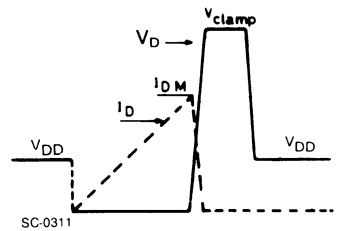


Clamped inductive load test circuit

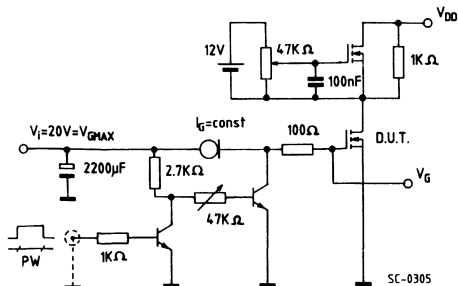


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(BR) DSS}$

Clamped inductive waveforms

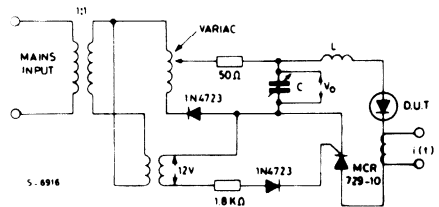


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit







## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

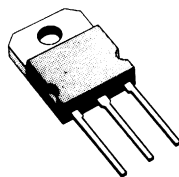
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP491 | 60 V             | 0.033 Ω             | 40 A           |
| SGSP492 | 50 V             | 0.033 Ω             | 40 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- 50 - 60 VOLTS FOR INVERTER AND UPS
- HIGH CURRENT - V<sub>DS(on)</sub> ≤ 1V at 20A
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- EASY DRIVE - REDUCED SIZE AND COST

### INDUSTRIAL APPLICATIONS:

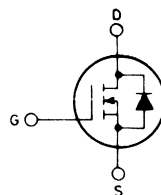
- DC/DC CONVERTERS
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications such as DC/DC converters, UPS, inverters, battery chargers and solar power converters.



**TO-218**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | SGSP491     | SGSP492 |      |
|---------------------|-------------------------------------------------|-------------|---------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)      | 60          | 50      | V    |
| V <sub>DGR</sub>    | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 60          | 50      | V    |
| V <sub>GS</sub>     | Gate-source voltage                             | ± 20        |         | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 40          |         | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 25          |         | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 160         |         | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      | 150         |         | W    |
|                     | Derating factor                                 | 1.2         |         | W/°C |
| T <sub>stg</sub>    | Storage temperature                             | - 65 to 150 |         | °C   |
| T <sub>j</sub>      | Max. operating junction temperature             | 150         |         | °C   |

(\*) Pulse width limited by safe operating area

♦ Introduced in 1988 week 44

**THERMAL DATA**

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

**ELECTRICAL CHARACTERISTICS** ( $T_{case} = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                                         |                             |          |             |                                |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|-----------------------------|----------|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$<br>for <b>SGSP491</b><br>for <b>SGSP492</b>     | $V_{GS} = 0$                | 60<br>50 |             | V<br>V                         |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}\text{C}$ |          | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 \text{ V}$                                             |                             |          | $\pm 100$   | nA                             |

**ON (\*)**

|               |                                   |                                                                                              |                             |   |          |                          |
|---------------|-----------------------------------|----------------------------------------------------------------------------------------------|-----------------------------|---|----------|--------------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                            | $I_D = 250 \mu\text{A}$     | 2 |          | 4<br>V                   |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ $I_D = 20 \text{ A}$<br>$V_{GS} = 10 \text{ V}$ $I_D = 20 \text{ A}$ | $T_c = 100^{\circ}\text{C}$ |   | 33<br>66 | m $\Omega$<br>m $\Omega$ |

**ENERGY TEST**

|           |                                                      |                                                                |                       |    |  |   |
|-----------|------------------------------------------------------|----------------------------------------------------------------|-----------------------|----|--|---|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 \text{ V}$<br>starting $T_j = 25^{\circ}\text{C}$ | $L = 100 \mu\text{H}$ | 40 |  | A |
|-----------|------------------------------------------------------|----------------------------------------------------------------|-----------------------|----|--|---|

**DYNAMIC**

|           |                              |                         |                      |    |      |         |
|-----------|------------------------------|-------------------------|----------------------|----|------|---------|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 \text{ V}$ | $I_D = 20 \text{ A}$ | 10 |      | mho     |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$ | $f = 1 \text{ MHz}$  |    | 1900 | 2800 pF |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$            |                      |    | 1500 | pF      |
| $C_{rss}$ | Reverse transfer capacitance |                         |                      |    | 850  | pF      |

**SWITCHING**

|             |                     |                         |                      |  |     |     |    |
|-------------|---------------------|-------------------------|----------------------|--|-----|-----|----|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 25 \text{ V}$ | $I_D = 20 \text{ A}$ |  | 35  | 45  | ns |
| $t_r$       | Rise time           | $V_i = 10 \text{ V}$    | $R_i = 4.7 \Omega$   |  | 110 | 145 | ns |
| $t_d (off)$ | Turn-off delay time | (see test circuit)      |                      |  | 90  | 120 | ns |
| $t_f$       | Fall time           |                         |                      |  | 55  | 70  | ns |

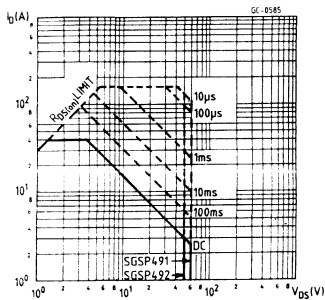
# ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                    | Test Conditions                                                             | Min. | Typ. | Max. | Unit |
|-----------------------------------------------|-----------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current                 |                                                                             |      |      | 40   | A    |
| $I_{SDM}^{(*)}$ Source-drain current (pulsed) |                                                                             |      |      | 160  | A    |
| $V_{SD}$ Forward on voltage                   | $I_{SD} = 40\text{ A}$<br>$V_{GS} = 0$                                      |      |      | 1.4  | V    |
| $t_{rr}$ Reverse recovery time                | $I_{SD} = 40\text{ A}$<br>$di/dt = 25\text{ A}/\mu\text{s}$<br>$V_{GS} = 0$ |      | 140  |      | ns   |

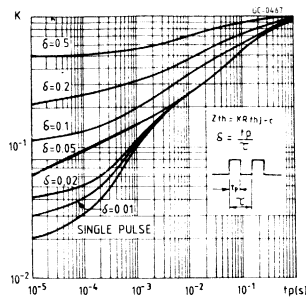
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

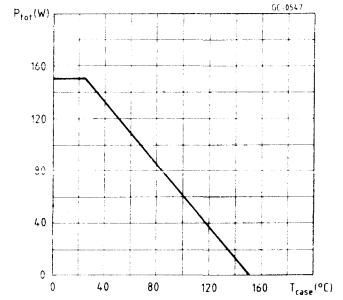
## Safe operating areas



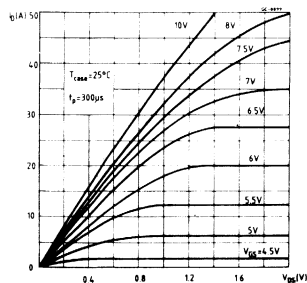
## Thermal impedance



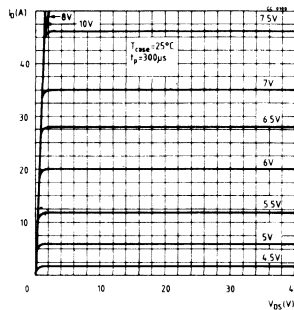
## Derating curve



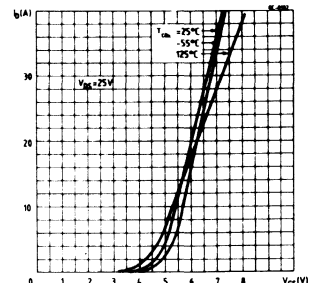
## Output characteristics



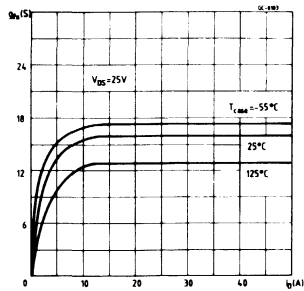
## Output characteristics



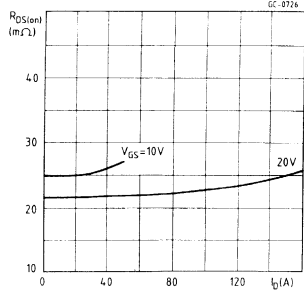
## Transfer characteristics



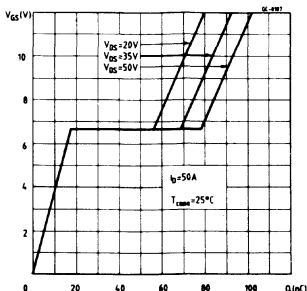
Transconductance



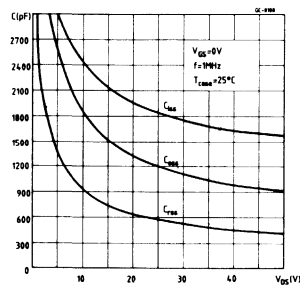
Static drain-source on resistance



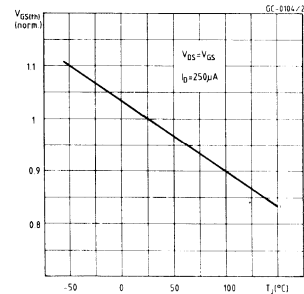
Gate charge vs gate-source voltage



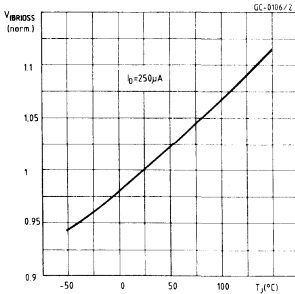
Capacitance variation



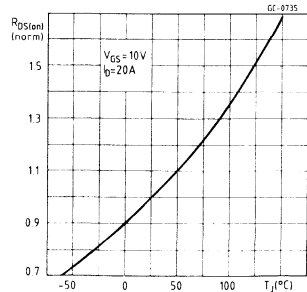
Normalized gate threshold voltage vs temperature



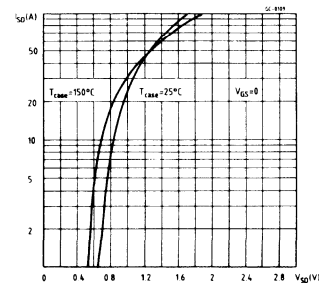
Normalized breakdown voltage vs temperature



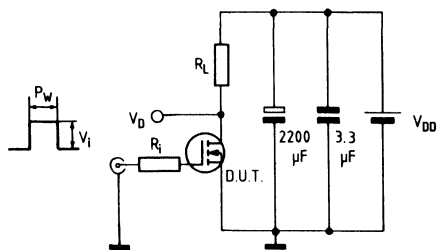
Normalized on resistance vs temperature



Source-drain diode forward characteristics



### Switching times test circuit for resistive load

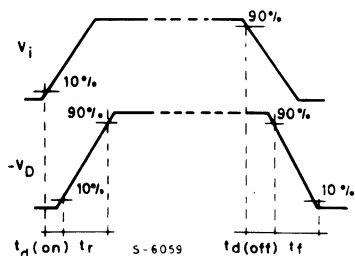


Pulse width  $\leq 100 \mu s$

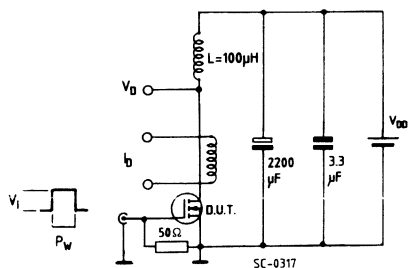
Duty cycle  $\leq 2\%$

SC-0008/1

### Switching time waveforms for resistive load



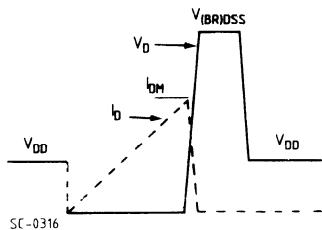
### Unclamped inductive load test circuit



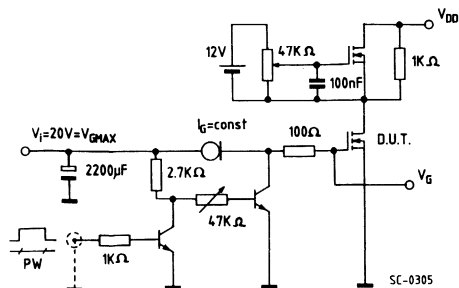
$V_i = 12 V$  - Pulse width: adjusted to obtain specified  $I_{DM}$

SC-0317

### Unclamped inductive waveforms



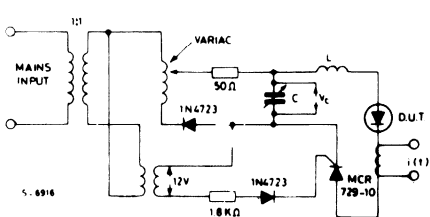
### Gate charge test circuit



PW adjusted to obtain required  $V_G$

SC-0305

### Body-drain diode $t_{rr}$ measurement Jedec test circuit





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

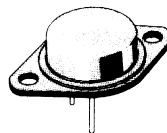
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP574 | 450 V            | 0.7 $\Omega$        | 9 A            |
| SGSP575 | 400 V            | 0.55 $\Omega$       | 10 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- HIGH VOLTAGE - FOR OFF-LINE SMPS
- HIGH CURRENT - FOR SMPS UP TO 350W
- ULTRA FAST SWITCHING - FOR OPERATION AT > 100kHz
- EASY DRIVE FOR REDUCED SIZE AND COST

### INDUSTRIAL APPLICATIONS:

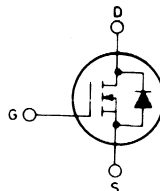
- SWITCHING MODE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Fast switching and easy drive make these POWER MOS transistors ideal for high voltage switching applications. These applications include electronic welders, switched mode power supplies and sonar equipment.



**TO-3**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                       | SGSP574     | SGSP575  |      |
|----------------------|-------------------------------------------------------|-------------|----------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)            | 450         | 400      | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 450         | 400      | V    |
| V <sub>GS</sub>      | Gate-source voltage                                   |             | $\pm 20$ | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C        | 9           | 10       | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C       | 5.6         | 6.3      | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                                | 40          | 40       | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                      | 40          | 40       | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C            |             | 150      | W    |
|                      | Derating factor                                       |             | 1.2      | W/°C |
| T <sub>stg</sub>     | Storage temperature                                   | - 65 to 150 |          | °C   |
| T <sub>j</sub>       | Max. operating junction temperature                   | 150         |          | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |            |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|------------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>SGSP574</b><br>for <b>SGSP575</b>           | $V_{GS} = 0$         | 450<br>400 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |            | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      |            | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                                                                                                                |                      |   |  |                           |                                              |
|---------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---|--|---------------------------|----------------------------------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                                                                                                                                                              | $I_D = 250 \mu A$    | 2 |  | 4                         | V                                            |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$I_D = 4.5 A$ for <b>SGSP574</b><br>$I_D = 5 A$ for <b>SGSP575</b><br>$V_{GS} = 10 V$<br>$I_D = 4.5 A$ for <b>SGSP574</b><br>$I_D = 5 A$ for <b>SGSP575</b> | $T_c = 100^{\circ}C$ |   |  | 0.7<br>0.55<br>1.4<br>1.1 | $\Omega$<br>$\Omega$<br>$\Omega$<br>$\Omega$ |

DYNAMIC

|           |                              |                 |             |   |      |      |     |
|-----------|------------------------------|-----------------|-------------|---|------|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$ | $I_D = 5 A$ | 6 |      |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$ | $f = 1 MHz$ |   | 1600 | 2100 | pF  |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$    |             |   |      | 390  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                 |             |   |      | 260  | pF  |

SWITCHING

|               |                     |                    |                    |  |     |     |    |
|---------------|---------------------|--------------------|--------------------|--|-----|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 225 V$   | $I_D = 5 A$        |  | 30  | 40  | ns |
| $t_r$         | Rise time           | $V_i = 10 V$       | $R_i = 4.7 \Omega$ |  | 45  | 60  | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit) |                    |  | 125 | 165 | ns |
| $t_f$         | Fall time           |                    |                    |  | 30  | 40  | ns |

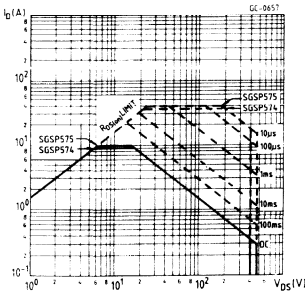


ELECTRICAL CHARACTERISTICS (Continued)

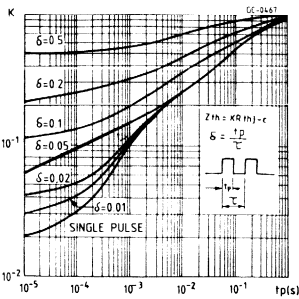
| Parameters                                  | Test Conditions                                                                                       | Min. | Typ. | Max.          | Unit        |
|---------------------------------------------|-------------------------------------------------------------------------------------------------------|------|------|---------------|-------------|
| $I_{SD}$ Source-drain current               | for <b>SGSP574</b><br>for <b>SGSP575</b>                                                              |      |      | 9<br>10<br>40 | A<br>A<br>A |
| $I_{SDM}$ (*) Source-drain current (pulsed) |                                                                                                       |      |      |               |             |
| $V_{SD}$ Forward on voltage                 | $V_{GS} = 0$<br>$I_{SD} = 9\text{ A}$ for <b>SGSP574</b><br>$I_{SD} = 10\text{ A}$ for <b>SGSP575</b> |      |      | 1.2<br>1.2    | V<br>V      |
| $t_{rr}$ Reverse recovery time              | $I_{SD} = 10\text{ A}$ $V_{GS} = 0$<br>$di/dt = 100\text{ A}/\mu\text{s}$                             |      | 420  |               | ns          |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
(\*) Pulse width limited by safe operating area

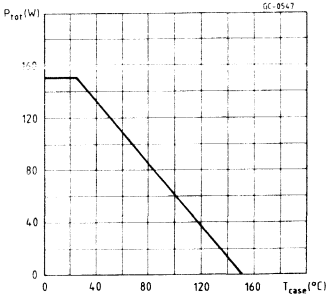
Safe operating areas



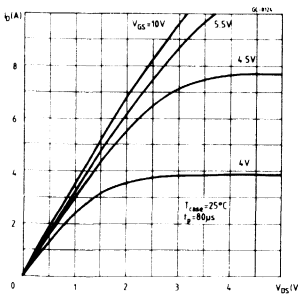
Thermal impedance



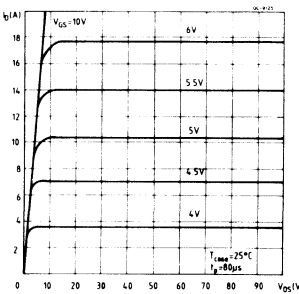
Derating curve



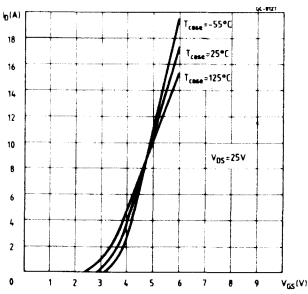
Output characteristics



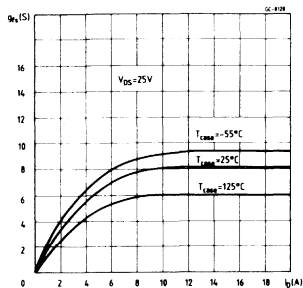
Output characteristics



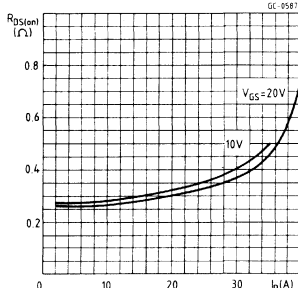
Transfer characteristics



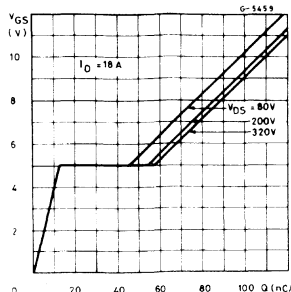
Transconductance



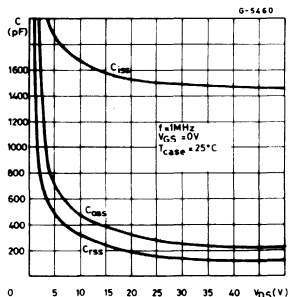
Static drain-source on resistance



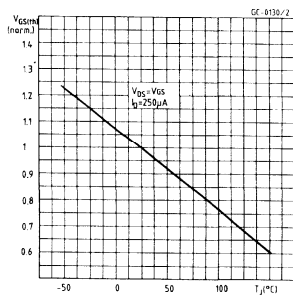
Gate charge vs gate-source voltage



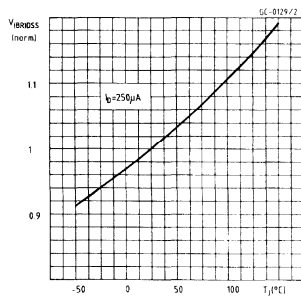
Capacitance variation



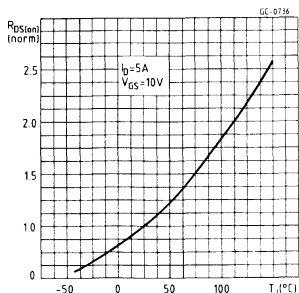
Normalized gate threshold voltage vs temperature



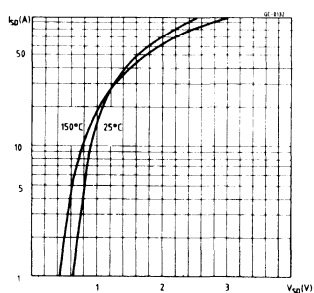
Normalized breakdown voltage vs temperature



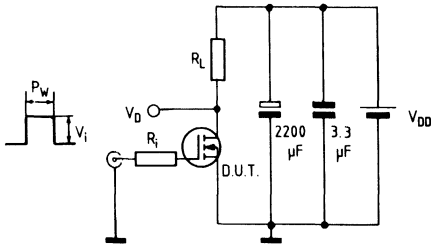
Normalized on resistance vs temperature



Source-drain diode forward characteristics



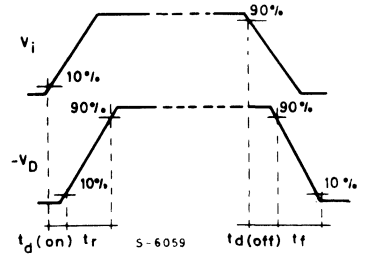
Switching times test circuit for resistive load



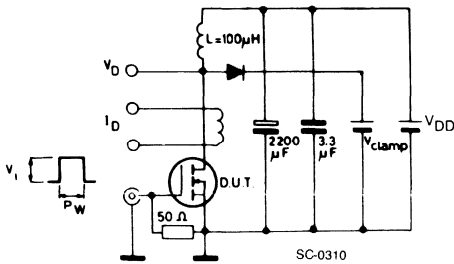
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

SC-0008/1

Switching time waveforms for resistive load

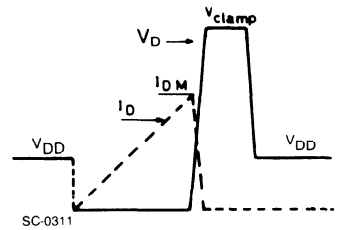


Clamped inductive load test circuit

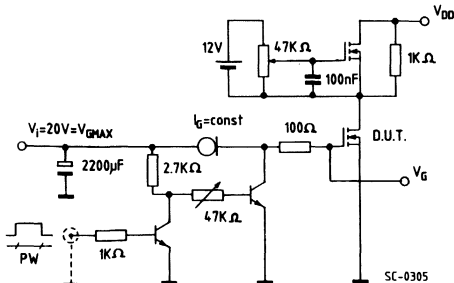


$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(BR)} \text{ DSS}$ .

Clamped inductive waveforms

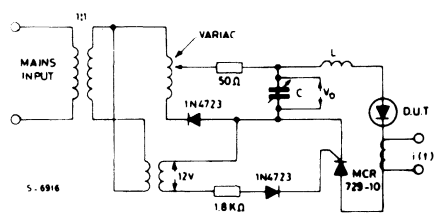


Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit





## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

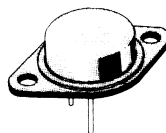
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP577 | 200 V            | 0.17 $\Omega$       | 20 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- HIGH CURRENT - FOR TELECOMM POWER SUPPLIES
- ULTRA FAST SWITCHING
- EASY DRIVE FOR REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

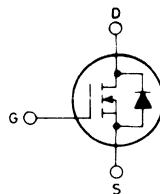
- SWITCHING MODE POWER SUPPLIES
- MOTOR CONTROLS FOR ROBOTICS.

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include robotics, UPS, SMPS and DC/DC converters, electric vehicle drives and a DC switch for telecommunications.



**TO-3**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                       |             |      |
|----------------------|-------------------------------------------------------|-------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)            | 200         | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 K $\Omega$ ) | 200         | V    |
| V <sub>GS</sub>      | Gate-source voltage                                   | $\pm 20$    | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C        | 20          | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C       | 13          | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                                | 80          | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                      | 80          | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C            | 150         | W    |
|                      | Derating factor                                       | 1.2         | W/°C |
| T <sub>stg</sub>     | Storage temperature                                   | - 65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature                   | 150         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                              |     |  |             |                    |
|----------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                            | 200 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                          |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                   |   |  |              |                      |
|---------------|-----------------------------------|-----------------------------------------------------------------------------------|---|--|--------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$                                            | 2 |  | 4            | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 10 A$<br>$V_{GS} = 10 V$ $I_D = 10 A$ $T_c = 100^{\circ}C$ |   |  | 0.17<br>0.34 | $\Omega$<br>$\Omega$ |

DYNAMIC

|                                     |                                                                         |                                                |   |      |                    |                |
|-------------------------------------|-------------------------------------------------------------------------|------------------------------------------------|---|------|--------------------|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$<br>$I_D = 10 A$                | 8 |      |                    | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 MHz$ |   | 1900 | 2200<br>550<br>260 | pF<br>pF<br>pF |

SWITCHING

|             |                     |                                  |                                    |  |          |          |          |
|-------------|---------------------|----------------------------------|------------------------------------|--|----------|----------|----------|
| $t_d (on)$  | Turn-on time        | $V_{DD} = 100 V$<br>$V_i = 10 V$ | $I_D = 10 A$<br>$R_i = 4.7 \Omega$ |  | 30<br>50 | 40<br>65 | ns<br>ns |
| $t_r$       | Rise time           | (see test circuit)               |                                    |  | 110      | 145      | ns       |
| $t_d (off)$ | Turn-off delay time |                                  |                                    |  | 35       | 45       | ns       |
| $t_f$       | Fall time           |                                  |                                    |  |          |          | ns       |

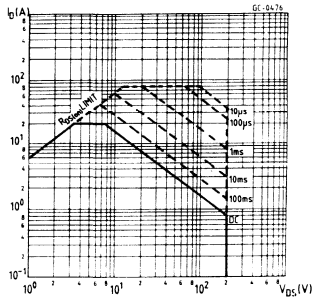
## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                  | Test Conditions                                                           | Min. | Typ. | Max. | Unit |
|---------------------------------------------|---------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current               |                                                                           |      |      | 20   | A    |
| $I_{SDM}$ (*) Source-drain current (pulsed) |                                                                           |      |      | 80   | A    |
| $V_{SD}$ Forward on voltage                 | $I_{SD} = 20\text{ A}$ $V_{GS} = 0$                                       |      |      | 1.3  | V    |
| $t_{rr}$ Reverse recovery time              | $I_{SD} = 20\text{ A}$ $V_{GS} = 0$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |      | 320  |      | ns   |

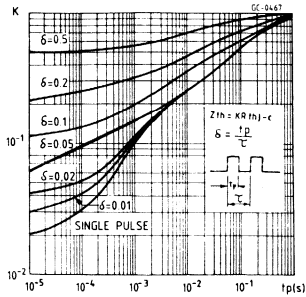
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

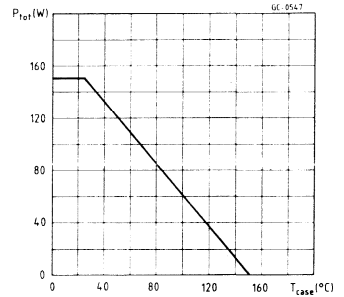
Safe operating areas



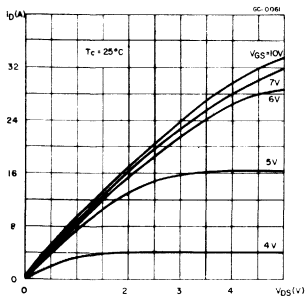
Thermal impedance



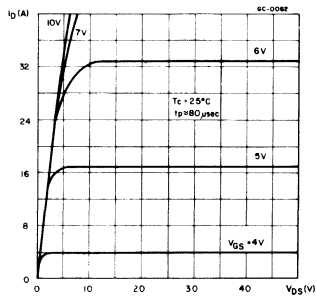
Derating curve



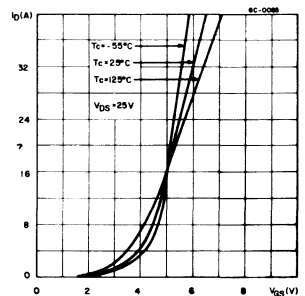
Output characteristics



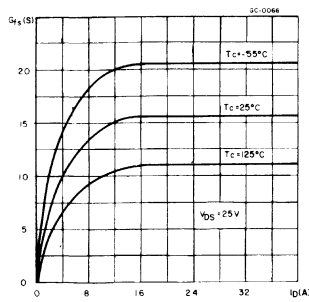
Output characteristics



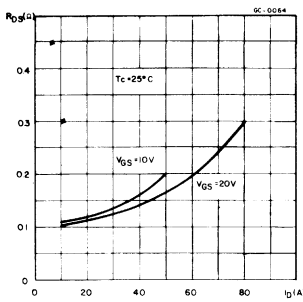
Transfer characteristics



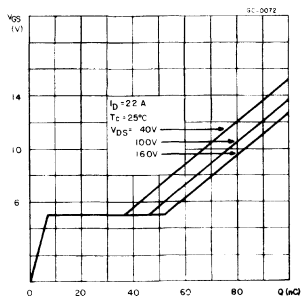
Transconductance



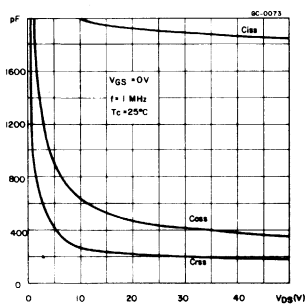
Static drain-source on resistance



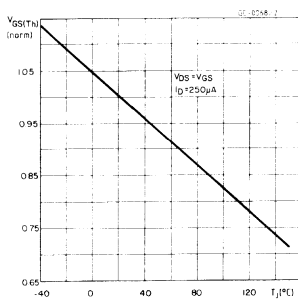
Gate charge vs gate-source voltage



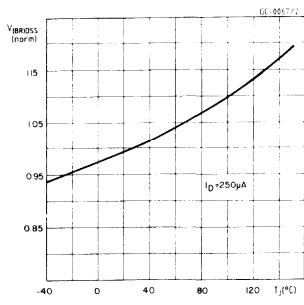
Capacitance variation



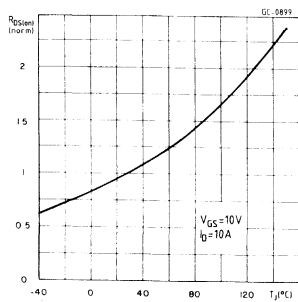
Normalized gate threshold voltage vs temperature



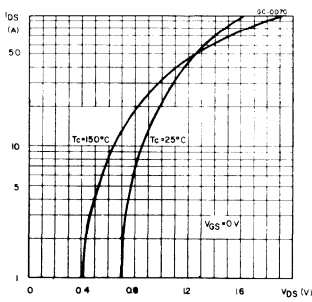
Normalized breakdown voltage vs temperature



Normalized on resistance vs temperature

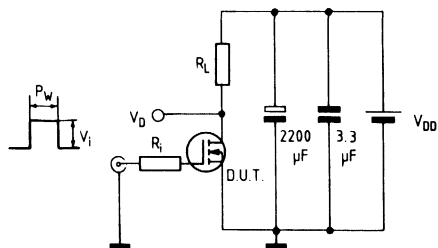


Source-drain diode forward characteristics



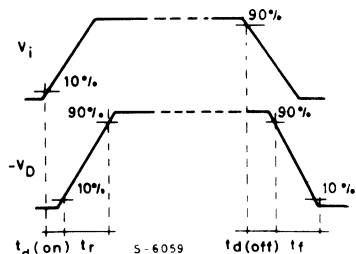


Switching times test circuit for resistive load

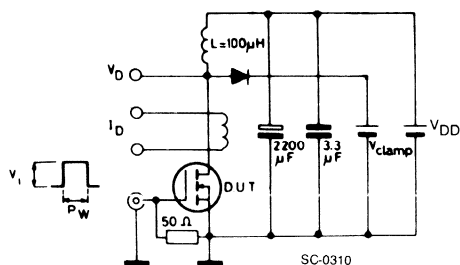
Pulse width  $\leq 100 \mu\text{s}$ Duty cycle  $\leq 2\%$  $V_i = 10 \text{ V}$ 

SC-0008/1

Switching time waveforms for resistive load



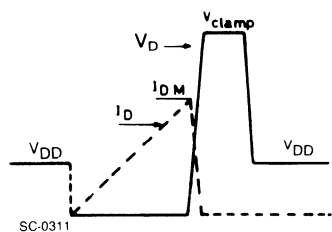
Clamped inductive load test circuit



$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ .  $V_{\text{clamp}} = 0.75 V_{(BR) \text{ DSS}}$ .

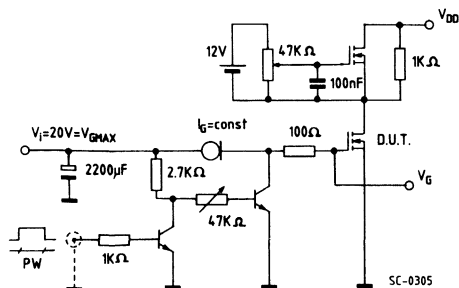
SC-0310

Clamped inductive waveforms

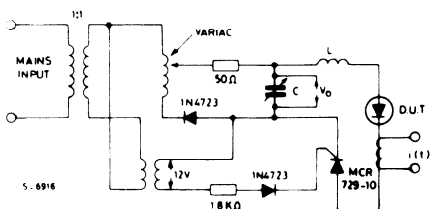


SC-0311

Gate charge test circuit

PW adjusted to obtain required  $V_G$ 

SC-0305

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

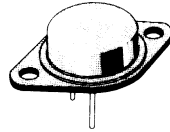
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP579 | 500 V            | 0.7 Ω               | 9 A            |

- HIGH SPEED SWITCHING APPLICATIONS
- HIGH VOLTAGE - 9A FOR UP TO 350W SMPS
- ULTRA FAST SWITCHING - FOR OPERATION AT > 100KHz
- EASY DRIVE - REDUCED COST AND SIZE

### INDUSTRIAL APPLICATIONS:

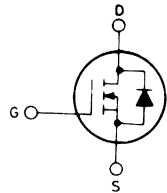
- SWITCHING MODE POWER SUPPLIES
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS transistor ideal for high speed switching applications. Typical applications include switching mode power supplies, uninterruptible power supplies and motor speed control.



**TO-3**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                      |                                                 |             |      |
|----------------------|-------------------------------------------------|-------------|------|
| V <sub>DS</sub>      | Drain-source voltage (V <sub>GS</sub> = 0)      | 500         | V    |
| V <sub>DGR</sub>     | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 500         | V    |
| V <sub>GS</sub>      | Gate-source voltage                             | ± 20        | V    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 25°C  | 9           | A    |
| I <sub>D</sub>       | Drain current (cont.) at T <sub>c</sub> = 100°C | 5.6         | A    |
| I <sub>DM</sub> (*)  | Drain current (pulsed)                          | 36          | A    |
| I <sub>DLM</sub> (*) | Drain inductive current, clamped                | 36          | A    |
| P <sub>tot</sub>     | Total dissipation at T <sub>c</sub> < 25°C      | 150         | W    |
|                      | Derating factor                                 | 1.2         | W/°C |
| T <sub>stg</sub>     | Storage temperature                             | - 65 to 150 | °C   |
| T <sub>j</sub>       | Max. operating junction temperature             | 150         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                 |     |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                               | 500 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>$T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                             |     |  | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                                                                     |   |  |            |                      |
|---------------|-----------------------------------|-------------------------------------------------------------------------------------|---|--|------------|----------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$                                              | 2 |  | 4          | V                    |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$ $I_D = 4.5 A$<br>$V_{GS} = 10 V$ $I_D = 4.5 A$ $T_c = 100^{\circ}C$ |   |  | 0.7<br>1.4 | $\Omega$<br>$\Omega$ |

DYNAMIC

|           |                              |                                                |   |      |      |     |
|-----------|------------------------------|------------------------------------------------|---|------|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$<br>$I_D = 4.5 A$               | 5 |      |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 MHz$ |   | 1600 | 1900 | pF  |
| $C_{oss}$ | Output capacitance           |                                                |   |      | 280  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                |   |      | 170  | pF  |

SWITCHING

|               |                     |                                                        |  |                       |     |    |
|---------------|---------------------|--------------------------------------------------------|--|-----------------------|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 250 V$<br>$V_i = 10 V$<br>(see test circuit) |  | 30<br>40<br>130<br>30 | 40  | ns |
| $t_r$         | Rise time           |                                                        |  |                       | 60  | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                        |  |                       | 170 | ns |
| $t_f$         | Fall time           |                                                        |  |                       | 40  | ns |

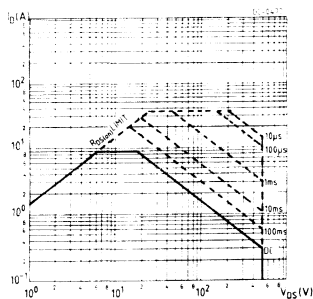
## ELECTRICAL CHARACTERISTICS (Continued)

| Parameters                                    | Test Conditions                                                          | Min. | Typ. | Max. | Unit |
|-----------------------------------------------|--------------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current                 |                                                                          |      |      | 9    | A    |
| $I_{SDM}^{(*)}$ Source-drain current (pulsed) |                                                                          |      |      | 36   | A    |
| $V_{SD}$ Forward on voltage                   | $I_{SD} = 9\text{ A}$ $V_{GS} = 0$                                       |      |      | 1.15 | V    |
| $t_{rr}$ Reverse recovery time                | $I_{SD} = 9\text{ A}$ $V_{GS} = 0$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |      | 420  |      | ns   |

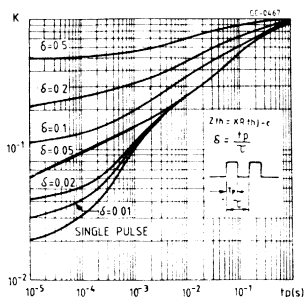
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

(\*) Pulse width limited by safe operating area

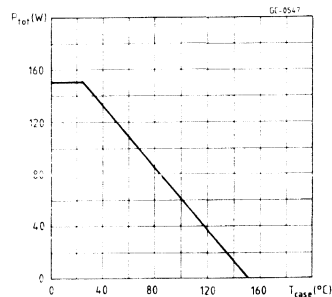
Safe operating areas



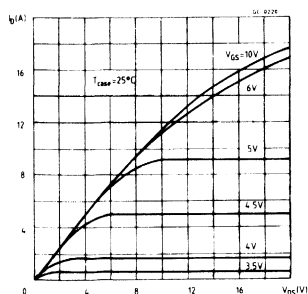
Thermal impedance



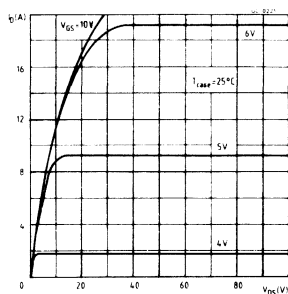
Derating curve



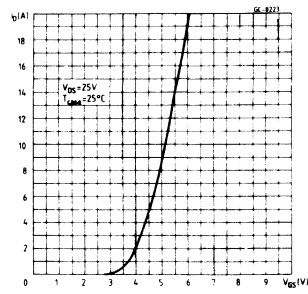
Output characteristics



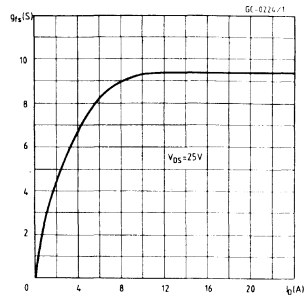
Output characteristics



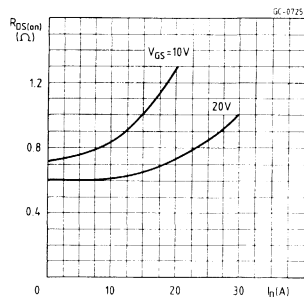
Transfer characteristics



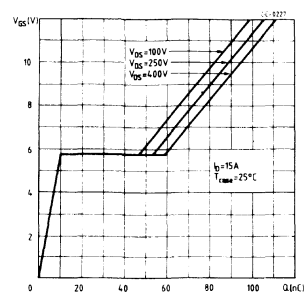
Transconductance



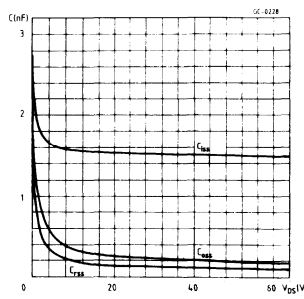
Static drain-source on resistance



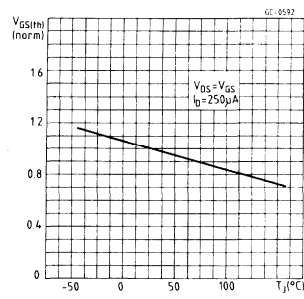
Gate charge vs gate-source voltage



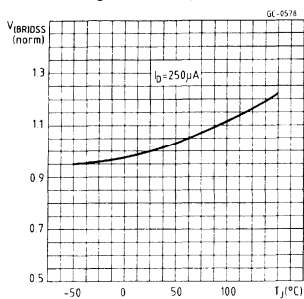
Capacitance variation



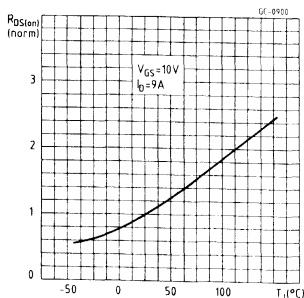
Normalized gate threshold voltage vs temperature



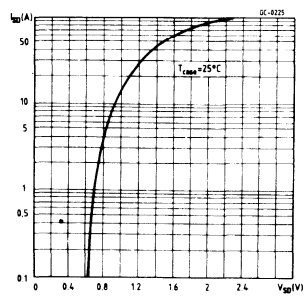
Normalized breakdown voltage vs temperature



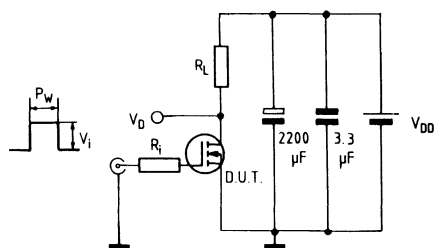
Normalized on resistance vs temperature



Source-drain diode forward characteristics



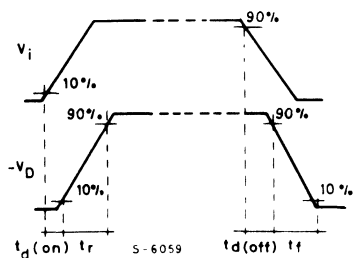
### Switching times test circuit for resistive load

Pulse width  $\leq 100 \mu\text{s}$ 

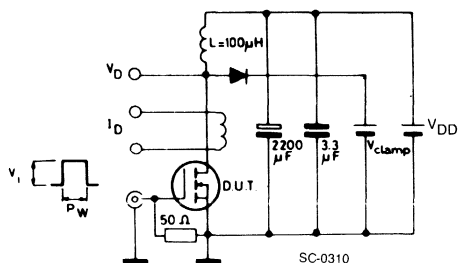
Duty cycle  $\leq 2\%$

SC-0008/1

### Switching time waveforms for resistive load

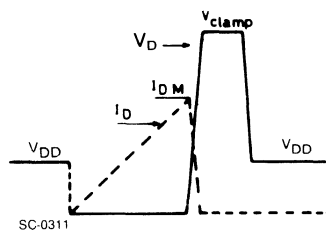


### Clamped inductive load test circuit

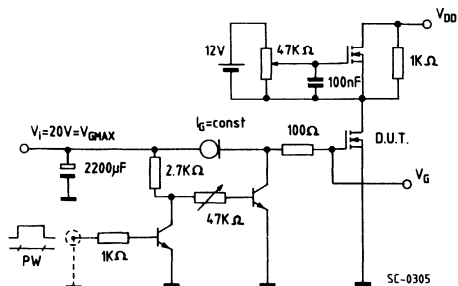


$V_i = 12\text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ ,  $V_{\text{clamp}} = 0.75 V_{(BR)} \text{ DSS}$ .

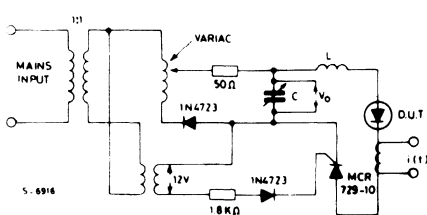
### Clamped inductive waveforms



### Gate charge test circuit

PW adjusted to obtain required  $V_G$ 

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit







## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS

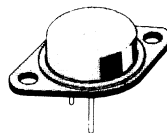
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| SGSP591 | 60 V             | 0.033 Ω             | 40 A           |
| SGSP592 | 50 V             | 0.033 Ω             | 40 A           |

- HIGH SPEED SWITCHING APPLICATIONS
- 50 - 60 VOLTS FOR INVERTERS AND UPS
- HIGH CURRENT - V<sub>DS(on)</sub> ≤ 1V at 20A
- RATED FOR UNCLAMPED INDUCTIVE SWITCHING (ENERGY TEST) ♦
- EASY DRIVE - REDUCES SIZE AND COST

### INDUSTRIAL APPLICATIONS:

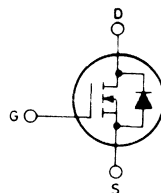
- DC/DC CONVERTERS
- MOTOR CONTROLS

N - channel enhancement mode POWER MOS field effect transistors. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching circuits applications such as DC/DC converters, UPS, inverters, battery chargers and solar power converters.



**TO-3**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | SGSP591     | SGSP592 |      |
|---------------------|-------------------------------------------------|-------------|---------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)      | 60          | 50      | V    |
| V <sub>DGR</sub>    | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 60          | 50      | V    |
| V <sub>GS</sub>     | Gate-source voltage                             | ± 20        |         | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 40          |         | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 25          |         | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 160         |         | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      | 150         |         | W    |
|                     | Derating factor                                 | 1.2         |         | W/°C |
| T <sub>stg</sub>    | Storage temperature                             | - 65 to 150 |         | °C   |
| T <sub>j</sub>      | Max. operating junction temperature             | 150         |         | °C   |

(\*) Pulse width limited by safe operating area

♦ Introduced in 1988 week 44

THERMAL DATA

|                  |                                                |     |      |      |
|------------------|------------------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 0.83 | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275  | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |          |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|----------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>SGSP591</b><br>for <b>SGSP592</b>           | $V_{GS} = 0$         | 60<br>50 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |          | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      |          | $\pm 100$   | nA                 |

ON (\*)

|               |                                   |                                    |                                                      |   |  |          |                          |
|---------------|-----------------------------------|------------------------------------|------------------------------------------------------|---|--|----------|--------------------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$                  | $I_D = 250 \mu A$                                    | 2 |  | 4        | V                        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$V_{GS} = 10 V$ | $I_D = 20 A$<br>$I_D = 20 A$<br>$T_c = 100^{\circ}C$ |   |  | 33<br>66 | m $\Omega$<br>m $\Omega$ |

ENERGY TEST

|           |                                                      |                                                 |                 |    |  |  |   |
|-----------|------------------------------------------------------|-------------------------------------------------|-----------------|----|--|--|---|
| $I_{UIS}$ | Unclamped inductive switching current (single pulse) | $V_{DD} = 30 V$<br>starting $T_j = 25^{\circ}C$ | $L = 100 \mu H$ | 40 |  |  | A |
|-----------|------------------------------------------------------|-------------------------------------------------|-----------------|----|--|--|---|

DYNAMIC

|           |                              |                                 |              |    |      |      |     |
|-----------|------------------------------|---------------------------------|--------------|----|------|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$                 | $I_D = 20 A$ | 10 |      |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$ | $f = 1 MHz$  |    | 1900 | 2800 | pF  |
| $C_{oss}$ | Output capacitance           |                                 |              |    |      | 1500 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                 |              |    |      | 850  | pF  |

SWITCHING

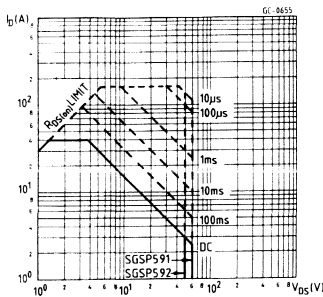
|               |                     |                    |                    |  |     |     |    |
|---------------|---------------------|--------------------|--------------------|--|-----|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 25 V$    | $I_D = 20 A$       |  | 35  | 45  | ns |
| $t_r$         | Rise time           | $V_i = 10 V$       | $R_i = 4.7 \Omega$ |  | 110 | 145 | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit) |                    |  | 90  | 120 | ns |
| $t_f$         | Fall time           |                    |                    |  | 55  | 70  | ns |

# ELECTRICAL CHARACTERISTICS (Continued)

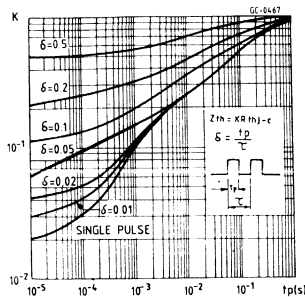
| Parameters                                  | Test Conditions                                                       | Min. | Typ. | Max. | Unit |
|---------------------------------------------|-----------------------------------------------------------------------|------|------|------|------|
| $I_{SD}$ Source-drain current               |                                                                       |      |      | 40   | A    |
| $I_{SDM}$ (*) Source-drain current (pulsed) |                                                                       |      |      | 160  | A    |
| $V_{SD}$ Forward on voltage                 | $I_{SD} = 40\text{ A}$ $V_{GS} = 0$                                   |      |      | 1.4  | V    |
| $t_{rr}$ Reverse recovery time              | $I_{SD} = 40\text{ A}$ $V_{GS} = 0$ $di/dt = 25\text{ A}/\mu\text{s}$ |      | 140  |      | ns   |

- (\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
 (\*) Pulse width limited by safe operating area

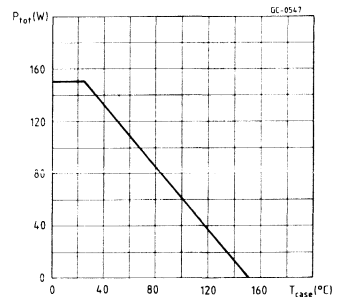
Safe operating areas



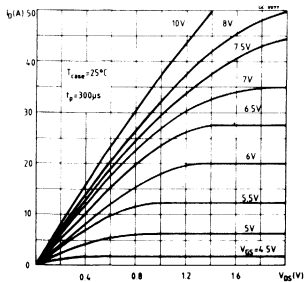
Thermal impedance



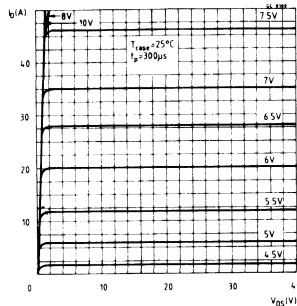
Derating curve



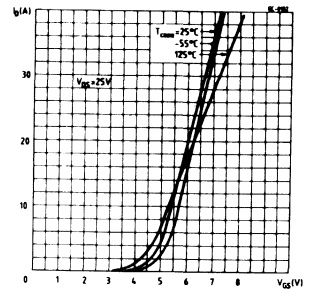
Output characteristics



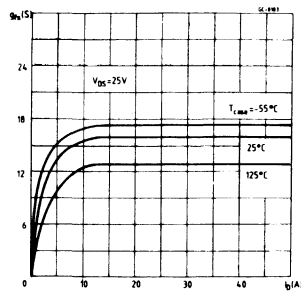
Output characteristics



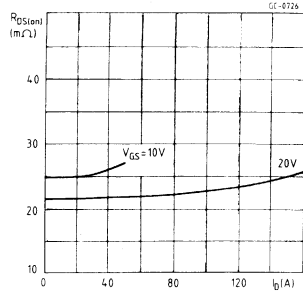
Transfer characteristics



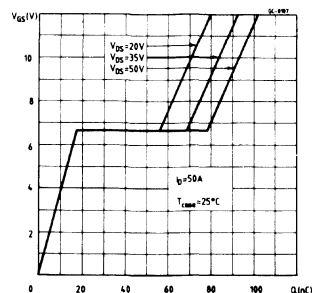
Transconductance



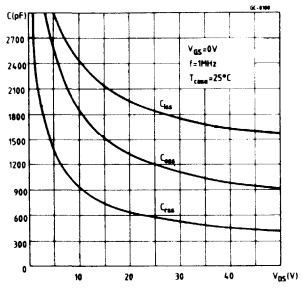
Static drain-source on resistance



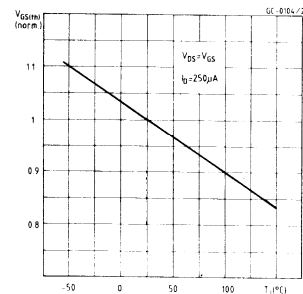
Gate charge vs gate-source voltage



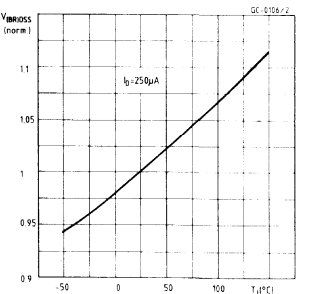
Capacitance variation



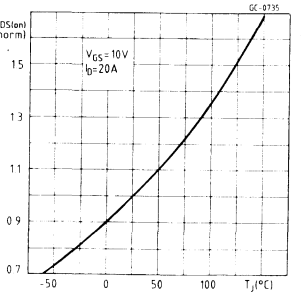
Normalized gate threshold voltage vs temperature



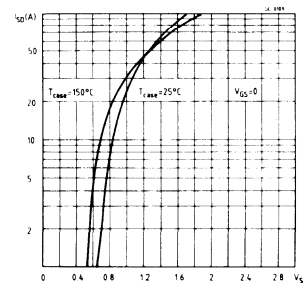
Normalized breakdown voltage vs temperature



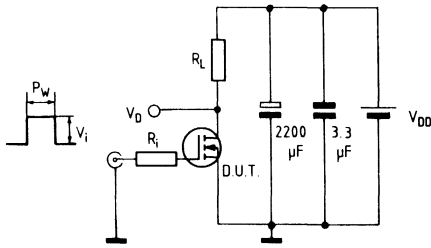
Normalized on resistance vs temperature



Source-drain diode forward characteristics



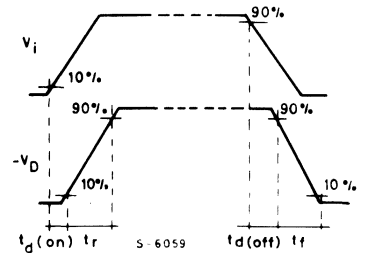
Switching times test circuit for resistive load



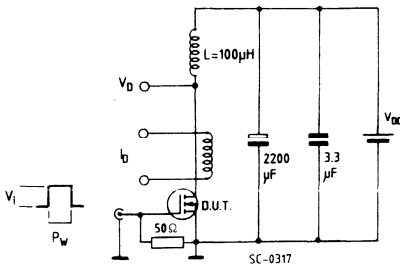
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

SC-0008/1

Switching time waveforms for resistive load



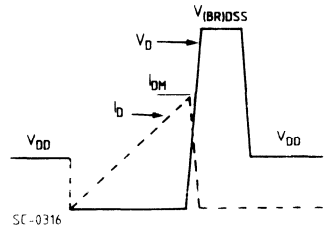
Unclamped inductive load test circuit



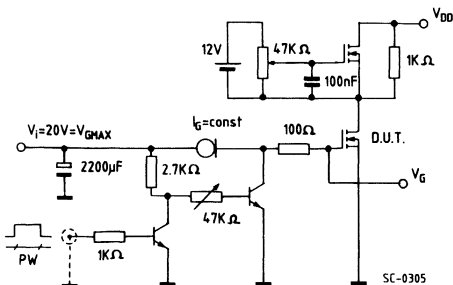
$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$

SC-0317

Unclamped inductive waveforms



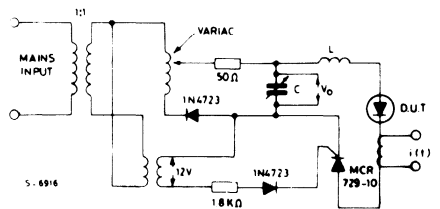
Gate charge test circuit



PW adjusted to obtain required  $V_G$

SC-0305

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit



S-6916



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

ADVANCE DATA

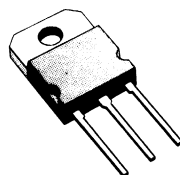
| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| STHV82 | 800 V            | 2 Ω                 | 5.5 A          |

- 800 V - HIGH VOLTAGE FOR OFF-LINE APPLICATIONS
- ULTRA FAST SWITCHING FOR OPERATION AT 100 KHz
- EASY DRIVE FOR REDUCED COST AND SIZE

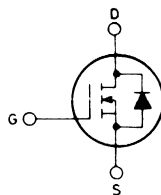
**INDUSTRIAL APPLICATIONS:**

- SWITCHING POWER SUPPLIES

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for very high speed switching applications. It is ideal for off-line SMPS where a high breakdown voltage POWER MOS is required, particularly in single switch design such as flyback and forward converters.



TO-218

**INTERNAL SCHEMATIC  
DIAGRAM**

**ABSOLUTE MAXIMUM RATINGS**

|                  |                                                     |            |      |
|------------------|-----------------------------------------------------|------------|------|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)          | 800        | V    |
| V <sub>GS</sub>  | Gate-source voltage                                 | ±20        | V    |
| I <sub>D</sub>   | Drain current (continuous) at T <sub>c</sub> = 25°C | 5.5        | A    |
| I <sub>DM</sub>  | Drain current (pulsed)                              | 16         | A    |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C          | 125        | W    |
|                  | Derating factor                                     | 1          | W/°C |
| T <sub>stg</sub> | Storage temperature                                 | -65 to 150 | °C   |
| T <sub>j</sub>   | Max. operating junction temperature                 | 150        | °C   |

THERMAL DATA

|                  |                                  |     |   |      |
|------------------|----------------------------------|-----|---|------|
| $R_{thj - case}$ | Thermal resistance junction-case | max | 1 | °C/W |
|------------------|----------------------------------|-----|---|------|

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                 |     |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------|-----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                               | 800 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>$T_c = 125^{\circ}C$ |     |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                             |     |  | $\pm 100$   | nA                 |

ON

|               |                                   |                                        |   |  |   |          |
|---------------|-----------------------------------|----------------------------------------|---|--|---|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$ | 2 |  | 4 | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$I_D = 2.5 A$       |   |  | 2 | $\Omega$ |

DYNAMIC

|                                     |                                                                         |                                                        |   |                   |  |                |
|-------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------|---|-------------------|--|----------------|
| $g_{fs}$                            | Forward transconductance                                                | $V_{DS} = 25 V$<br>$I_D = 2 A$                         | 2 |                   |  | mho            |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 \text{ MHz}$ |   | 1000<br>150<br>90 |  | pF<br>pF<br>pF |

SWITCHING

|                                                 |                                                               |                                                                            |  |                         |  |                      |
|-------------------------------------------------|---------------------------------------------------------------|----------------------------------------------------------------------------|--|-------------------------|--|----------------------|
| $t_{d (on)}$<br>$t_r$<br>$t_{d (off)}$<br>$t_f$ | Turn-on time<br>Rise time<br>Turn-off delay time<br>Fall time | $V_{DD} = 400 V$<br>$R_{GS} = 50 \Omega$<br>$I_D = 2 A$<br>$V_{GS} = 10 V$ |  | 40<br>100<br>300<br>100 |  | ns<br>ns<br>ns<br>ns |
| $Q_g$                                           | Total Gate Charge                                             | $V_{DD} = 500 V$<br>$V_{GS} = 10 V$<br>$I_D = 6 A$                         |  | 70                      |  | nC                   |



ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

SOURCE DRAIN DIODE

|           |                               |                         |                                    |      |               |
|-----------|-------------------------------|-------------------------|------------------------------------|------|---------------|
| $I_{SD}$  | Source-drain current          |                         |                                    | 5.5  | A             |
| $I_{SDM}$ | Source-drain current (pulsed) |                         |                                    | 16   | A             |
| $V_{SD}$  | Forward on voltage            | $I_{SD} = 5.5\text{ A}$ | $V_{GS} = 0$                       | 1.4  | V             |
| $t_{rr}$  | Reverse recovery time         |                         |                                    | 1000 | ns            |
| $Q_{rr}$  | Reverse recovery charge       | $I_{SD} = 5.5\text{ A}$ | $di/dt = 100\text{ A}/\mu\text{s}$ | 15   | $\mu\text{C}$ |



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

PRELIMINARY DATA

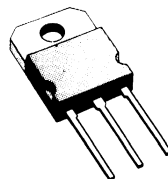
| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| STHV102 | 1000 V           | 3.5 Ω               | 4.2 A          |

- 1000 V - VERY HIGH VOLTAGE FOR SMPS
- EASY DRIVE - REDUCED COST AND SIZE
- ULTRA FAST SWITCHING
- HIGH RESOLUTION CTV DEFLECTION

### INDUSTRIAL APPLICATIONS:

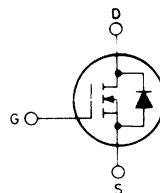
- SINGLE TRANSISTOR HIGH VOLTAGE SWITCH
- SWITCHING POWER SUPPLIES

N - channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make these POWER MOS transistors ideal for high speed switching applications. Typical uses include single transistor forward and flyback converters and lamp ballast. They are also used in high voltage CTV EHT supplies, interfaces to thyristor and power transistors operating from 380V and 440V A.C. supplies and resonant converters operating up to 500kHz.



TO-218

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 |             |      |
|---------------------|-------------------------------------------------|-------------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)      | 1000        | V    |
| V <sub>GS</sub>     | Gate-source voltage                             | ± 20        | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 4.2         | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C | 2.6         | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 16          | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      | 125         | W    |
|                     | Derating factor                                 | 1           | W/°C |
| T <sub>stg</sub>    | Storage temperature                             | - 65 to 150 | °C   |
| T <sub>j</sub>      | Max. operating junction temperature             | 150         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |     |      |
|------------------|------------------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1   | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275 | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                 |      |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------|------|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>$V_{GS} = 0$                                                               | 1000 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>$T_c = 125^{\circ}C$ |      |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                                             |      |  | 100         | nA                 |

ON (\*)

|               |                                   |                                        |   |  |     |          |
|---------------|-----------------------------------|----------------------------------------|---|--|-----|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$<br>$I_D = 250 \mu A$ | 2 |  | 4   | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$<br>$I_D = 2 A$         |   |  | 3.5 | $\Omega$ |

DYNAMIC

|           |                              |                                                        |   |     |      |     |
|-----------|------------------------------|--------------------------------------------------------|---|-----|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$<br>$I_D = 2 A$                         | 2 |     |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$<br>$V_{GS} = 0$<br>$f = 1 \text{ MHz}$ |   | 900 | 1200 | pF  |
| $C_{oss}$ | Output capacitance           |                                                        |   | 150 | 250  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                        |   | 90  | 110  | pF  |

SWITCHING

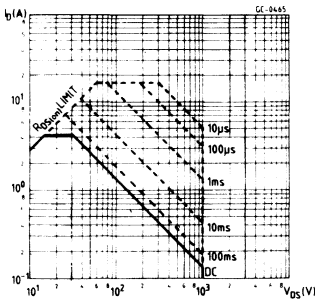
|               |                     |                                                                                            |  |     |    |    |
|---------------|---------------------|--------------------------------------------------------------------------------------------|--|-----|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 400 V$<br>$V_i = 10 V$<br>$I_D = 2 A$<br>$R_i = 50 \Omega$<br>(see test circuit) |  | 40  |    | ns |
| $t_r$         | Rise time           |                                                                                            |  | 100 |    | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                                                            |  | 300 |    | ns |
| $t_f$         | Fall time           |                                                                                            |  | 100 |    | ns |
| $Q_g$         | Total gate Charge   | $V_{DD} = 500 V$<br>$V_{GS} = 10 V$<br>$I_D = 6 A$                                         |  |     | 70 | nC |

ELECTRICAL CHARACTERISTICS (Continued)

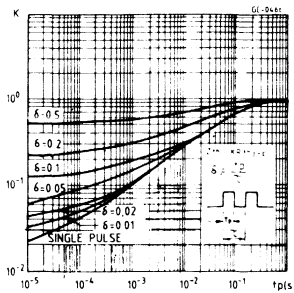
| Parameters                                                                   | Test Conditions                                                            | Min. | Typ.       | Max.      | Unit                |
|------------------------------------------------------------------------------|----------------------------------------------------------------------------|------|------------|-----------|---------------------|
| $I_{SD}$ Source-drain current<br>$I_{SDM}$ (*) Source-drain current (pulsed) |                                                                            |      |            | 4.2<br>16 | A<br>A              |
| $V_{SD}$ Forward on voltage                                                  | $I_{SD} = 4.2\text{ A}$ $V_{GS} = 0$                                       |      |            | 2.5       | V                   |
| $t_{rr}$ Reverse recovery time<br>$Q_{rr}$ Reverse recovery charge           | $I_{SD} = 4.2\text{ A}$ $V_{GS} = 0$<br>$di/dt = 100\text{ A}/\mu\text{s}$ |      | 1000<br>15 |           | ns<br>$\mu\text{C}$ |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%  
(\*) Pulse width limited by safe operating area

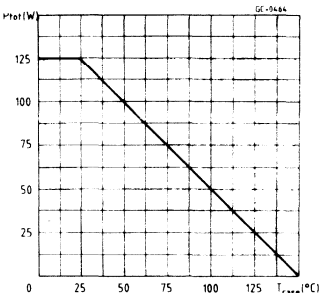
Safe operating areas



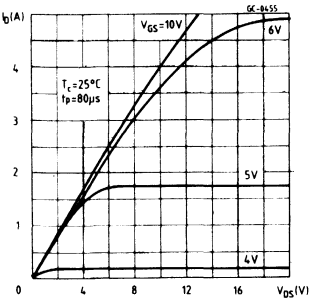
Thermal impedance



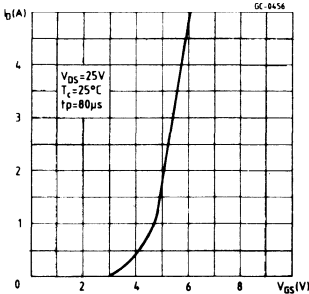
Derating curve



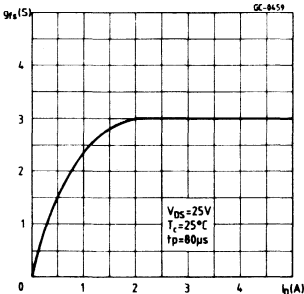
Output characteristics



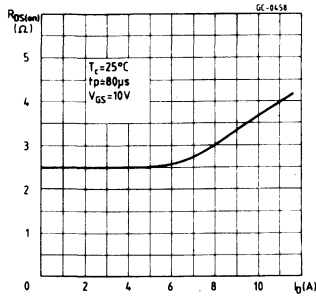
Transfer characteristic



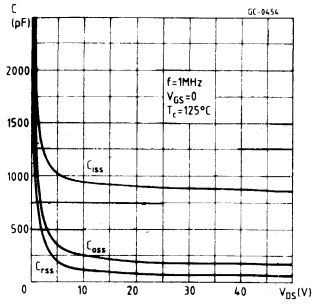
Transconductance



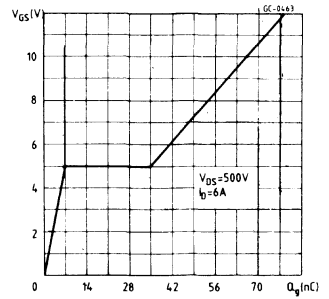
Static drain-source on resistance



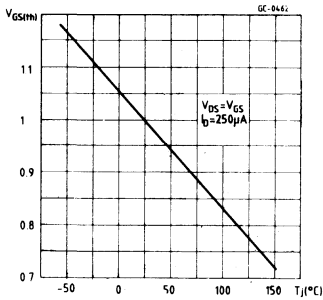
Capacitance variation



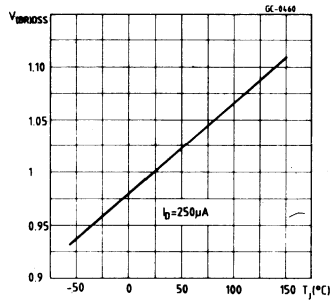
Gate charge vs gate-source voltage



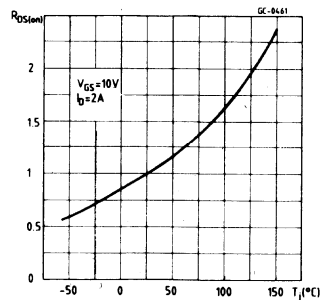
Normalized gate threshold voltage vs temperature



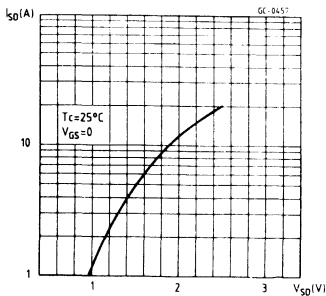
Normalized breakdown voltage vs temperature



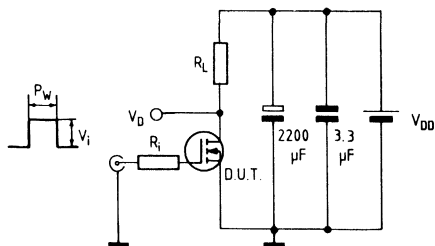
Normalized on resistance vs temperature



Static drain diode forward characteristic



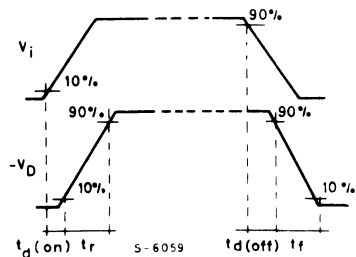
Switching times test circuit for resistive load


Pulse width  $\leq 100 \mu\text{s}$ 

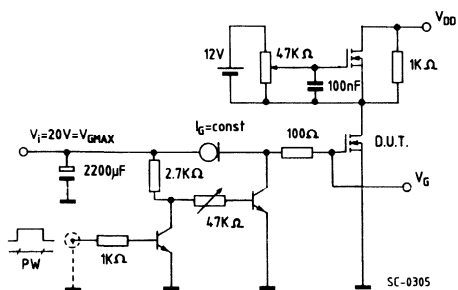
Duty cycle  $\leq 2\%$ 

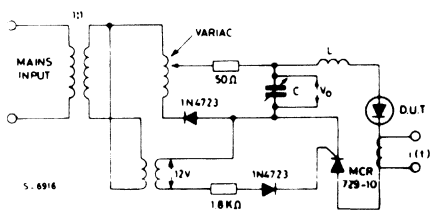
SC-0008/1

Switching time waveforms for resistive load



Gate charge test circuit


PW adjusted to obtain required  $V_G$ 

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit






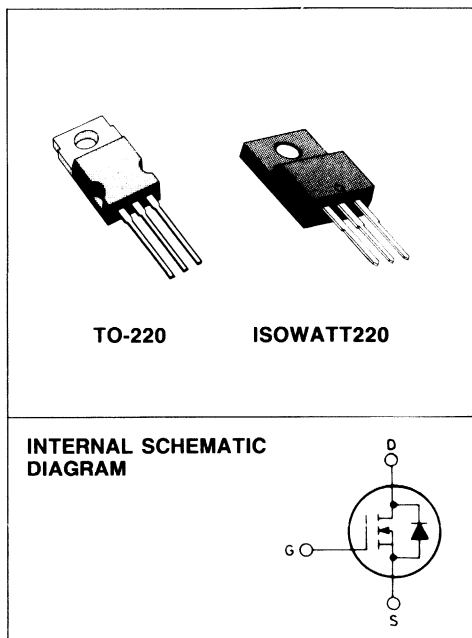
## N - CHANNEL ENHANCEMENT MODE LOW THRESHOLD POWER MOS TRANSISTORS

PRELIMINARY DATA

| TYPE     | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|----------|------------------|---------------------|----------------|
| STLT20   | 60 V             | 0.15 Ω              | 15 A           |
| STLT20FI | 60 V             | 0.15 Ω              | 10 A           |
| STLT19   | 50 V             | 0.15 Ω              | 15 A           |
| STLT19FI | 50 V             | 0.15 Ω              | 10 A           |

- LOGIC LEVEL (+5V) CMOS/TTL COMPATIBLE INPUT
- HIGH INPUT IMPEDANCE
- ULTRA FAST SWITCHING

N - channel enhancement mode POWER MOS field effect transistors. The low input voltage - logic level - and easy drive make these devices ideal for automotive and industrial applications. Typical uses are in relay and actuator driving in the automotive environment.



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 | TO-220<br>ISOWATT220 | STLT20<br>STLT20FI | STLT19<br>STLT19FI |      |
|---------------------|-------------------------------------------------|----------------------|--------------------|--------------------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)      |                      | 60                 | 50                 | V    |
| V <sub>DGR</sub>    | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    |                      | 60                 | 50                 | V    |
| V <sub>GS</sub>     | Gate-source voltage                             |                      |                    | ± 15               | V    |
|                     |                                                 |                      | <b>TO-220</b>      | <b>ISOWATT220</b>  |      |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  |                      | 15                 | 10                 | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 100°C |                      | 9.5                | 6.3                | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          |                      | 40                 | 40                 | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      |                      | 75                 | 30                 | W    |
|                     | Derating factor                                 |                      | 0.6                | 0.24               | W/°C |
| T <sub>stg</sub>    | Storage temperature                             |                      | - 65 to 150        |                    | °C   |
| T <sub>j</sub>      | Max. operating junction temperature             |                      | 150                |                    | °C   |

(\*) Pulse width limited by safe operating area

**THERMAL DATA****TO-220 | ISOWATT220**

|                  |                                                |     |      |      |      |
|------------------|------------------------------------------------|-----|------|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1.67 | 4.16 | °C/W |
| $T_l$            | Maximum lead temperature for soldering purpose | max | 275  |      | °C   |

**ELECTRICAL CHARACTERISTICS** ( $T_{case} = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

**OFF**

|                |                                                  |                                                                         |                             |          |  |             |                                |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|-----------------------------|----------|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu\text{A}$<br>for <b>STLT20/FI</b><br>for <b>STLT19/FI</b> | $V_{GS} = 0$                | 60<br>50 |  |             | V<br>V                         |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}\text{C}$ |          |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 15 \text{ V}$                                             |                             |          |  | $\pm 100$   | nA                             |

**ON \*\***

|               |                                   |                        |                         |   |  |      |          |
|---------------|-----------------------------------|------------------------|-------------------------|---|--|------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$      | $I_D = 250 \mu\text{A}$ | 1 |  | 2.5  | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 5 \text{ V}$ | $I_D = 7.5 \text{ A}$   |   |  | 0.15 | $\Omega$ |

**DYNAMIC**

|           |                              |                         |                       |   |     |  |     |
|-----------|------------------------------|-------------------------|-----------------------|---|-----|--|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 15 \text{ V}$ | $I_D = 7.5 \text{ A}$ | 5 |     |  | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 \text{ V}$ | $f = 1 \text{ MHz}$   |   | 480 |  | pF  |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$            |                       |   | 170 |  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                         |                       |   | 40  |  | pF  |

**SWITCHING**

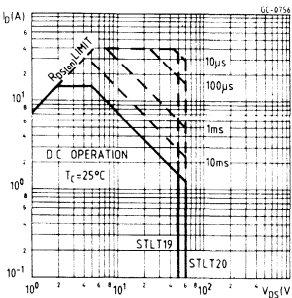
|               |                     |                                                   |                       |  |    |    |    |
|---------------|---------------------|---------------------------------------------------|-----------------------|--|----|----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 25 \text{ V}$                           | $I_D = 7.5 \text{ A}$ |  | 10 |    | ns |
| $t_r$         | Rise time           | $V_i = 5 \text{ V}$                               | $R_i = 50 \Omega$     |  | 70 |    | ns |
| $t_{d (off)}$ | Turn-off delay time |                                                   |                       |  | 35 |    | ns |
| $t_f$         | Fall time           |                                                   |                       |  | 40 |    | ns |
| $Q_g$         | Total Gate Charge   | $V_{DD} = 48 \text{ V}$<br>$V_{GS} = 5 \text{ V}$ | $I_D = 15 \text{ A}$  |  | 8  | 13 | nC |

ELECTRICAL CHARACTERISTICS (Continued)

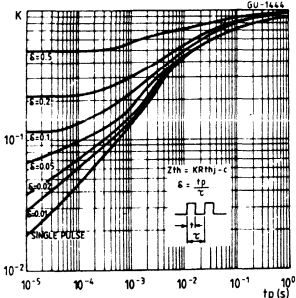
| Parameters                                    | Test Conditions                                           | Min. | Typ. | Max. | Unit          |
|-----------------------------------------------|-----------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$ Source-drain current                 |                                                           |      |      | 15   | A             |
| $I_{SDM}^{(*)}$ Source-drain current (pulsed) |                                                           |      |      | 60   | A             |
| $V_{SD}^{**}$ Forward on voltage              | $I_{SD} = 15\text{ A}$ $V_{GS} = 0$                       |      |      | 1.25 | V             |
| $t_{rr}$ Reverse recovery time                |                                                           |      | 80   |      | ns            |
| $Q_{rr}$ Reverse recovered charge             | $I_{SD} = 15\text{ A}$ $di/dt = 100\text{ A}/\mu\text{s}$ |      | 0.15 |      | $\mu\text{C}$ |

\*\* Pulsed: Pulse duration  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$   
(\*) Pulse width limited by safe operating area

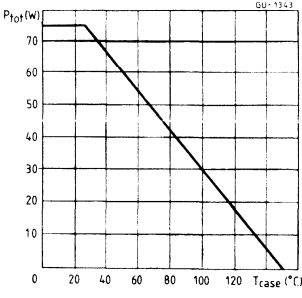
Safe operating areas (standard package)



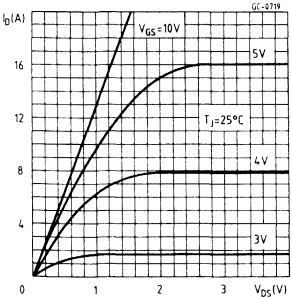
Thermal impedance (standard package)



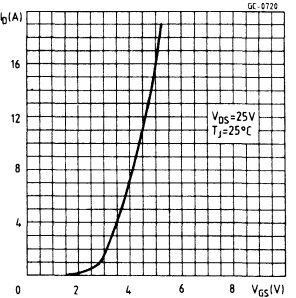
Derating curve (standard package)



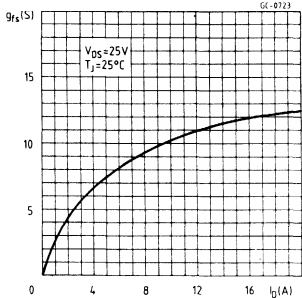
Output characteristics



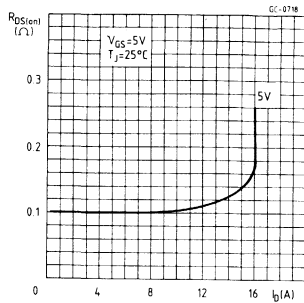
Transfer characteristics



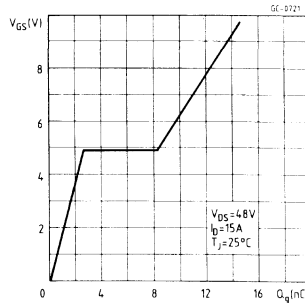
Transconductance



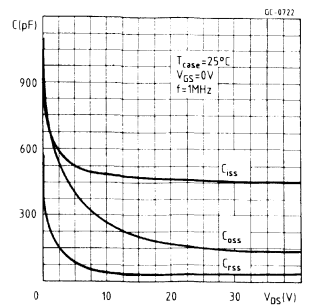
Static drain-source on resistance



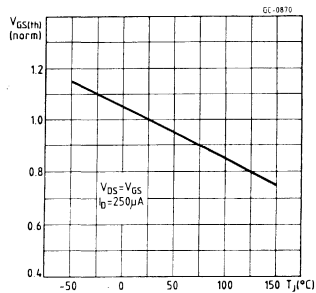
Gate charge vs gate-source voltage



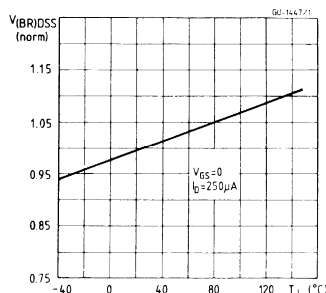
Capacitance variation



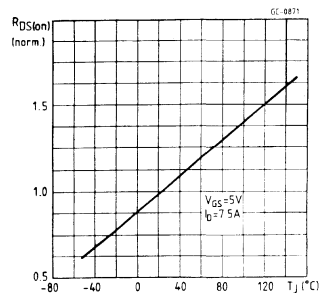
Normalized gate threshold voltage vs temperature



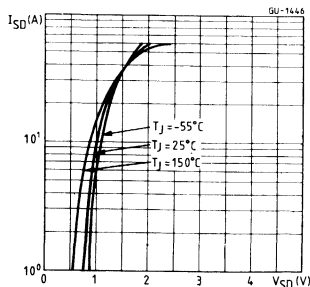
Normalized breakdown voltage vs temperature



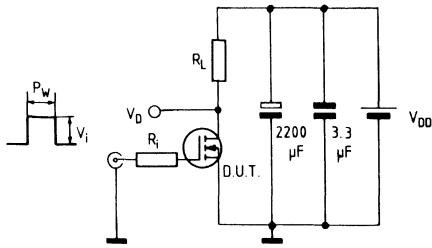
Normalized on resistance vs temperature



Source-drain diode forward characteristics



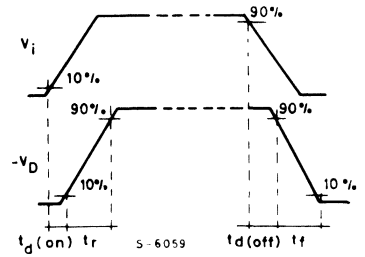
Switching times test circuit for resistive load



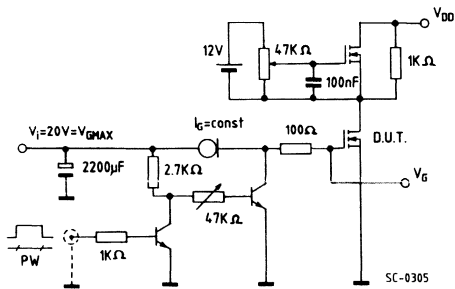
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

SC-0008/1

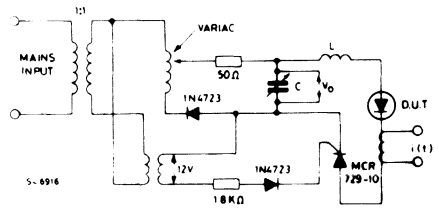
Switching time waveforms for resistive load



Gate charge test circuit



PW adjusted to obtain required  $V_G$

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit

ISOWATT220 PACKAGE  
CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

from this  $I_{Dmax}$  for the POWER MOS can be calculated:

$$I_{Dmax} \leq \sqrt{\frac{P_D}{R_{DS(on)} \text{ (at } 150^{\circ}\text{C)}}}$$

THERMAL IMPEDANCE OF  
ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th(tot)}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

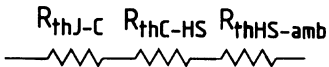
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

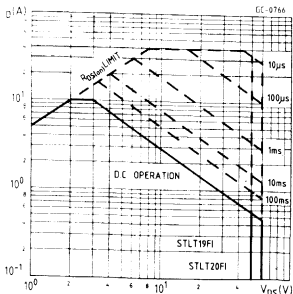
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

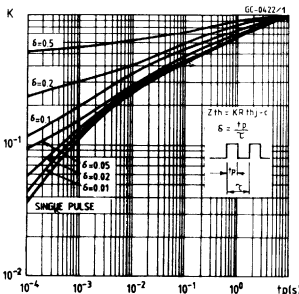


ISOWATT DATA

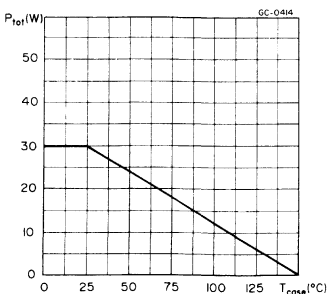
Safe operating areas



Thermal impedance



Derating curve



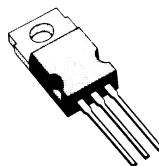
## N - CHANNEL ENHANCEMENT MODE LOW THRESHOLD POWER MOS TRANSISTORS

### ADVANCE DATA

| TYPE   | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------|------------------|---------------------|----------------|
| STLT30 | 60 V             | 0.08 Ω              | 25 A           |
| STLT29 | 50 V             | 0.08 Ω              | 25 A           |

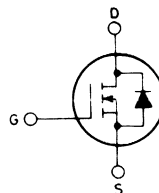
- LOGICAL LEVEL (+5V) CMOS/TTL COMPATIBLE INPUT
- HIGH INPUT IMPEDANCE
- ULTRA FAST SWITCHING

N - channel enhancement mode POWER MOS field effect transistors. The low input voltage - logic level - and easy drive make these devices ideal for automotive and industrial applications. Typical uses are in relay and actuator driving in the automotive environment.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                  |                                                 | STLT30      | STLT29 |      |
|------------------|-------------------------------------------------|-------------|--------|------|
| V <sub>DS</sub>  | Drain-source voltage (V <sub>GS</sub> = 0)      | 60          | 50     | V    |
| V <sub>DGR</sub> | Drain-gate voltage (R <sub>GS</sub> = 20 KΩ)    | 60          | 50     | V    |
| V <sub>GS</sub>  | Gate-source voltage                             | ± 15        |        | V    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> = 25°C  | 25          |        | A    |
| I <sub>D</sub>   | Drain current (cont.) at T <sub>c</sub> = 100°C | 15.7        |        | A    |
| I <sub>DM</sub>  | Drain current (pulsed)                          | 80          |        | A    |
| P <sub>tot</sub> | Total dissipation at T <sub>c</sub> < 25°C      | 100         |        | W    |
|                  | Derating factor                                 | 0.8         |        | W/°C |
| T <sub>stg</sub> | Storage temperature                             | - 65 to 150 |        | °C   |
| T <sub>j</sub>   | Max. operating junction temperature             | 150         |        | °C   |

THERMAL DATA

|                  |                                     |     |      |      |
|------------------|-------------------------------------|-----|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case    | max | 1.25 | °C/W |
| $R_{thj - amb}$  | Thermal resistance junction-ambient |     | 75   | °C/W |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |          |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|----------|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$<br>for <b>STLT30</b><br>for <b>STLT29</b>             | $V_{GS} = 0$         | 60<br>50 |             | V<br>V             |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |          | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 15 V$                                                     |                      |          | $\pm 100$   | nA                 |

ON

|               |                                   |                   |                   |   |  |      |          |
|---------------|-----------------------------------|-------------------|-------------------|---|--|------|----------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ | $I_D = 250 \mu A$ | 1 |  | 2.5  | V        |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 5V$     | $I_D = 12.5 A$    |   |  | 0.08 | $\Omega$ |

DYNAMIC

|           |                              |                 |                |   |     |      |     |
|-----------|------------------------------|-----------------|----------------|---|-----|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 15 V$ | $I_D = 12.5 A$ | 9 |     |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$ | $f = 1 MHz$    |   | 930 | 1200 | pF  |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$    |                |   |     | 600  | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                 |                |   |     | 130  | pF  |

SWITCHING

|               |                     |                                   |                |  |     |  |    |
|---------------|---------------------|-----------------------------------|----------------|--|-----|--|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 25 V$                   | $I_D = 12.5 A$ |  | 25  |  | ns |
| $t_r$         | Rise time           | $R_{GS} = 50 \Omega$              | $V_{GS} = 5 V$ |  | 210 |  | ns |
| $t_{d (off)}$ | Turn-off delay time |                                   |                |  | 55  |  | ns |
| $t_f$         | Fall time           |                                   |                |  | 75  |  | ns |
| $Q_g$         | Total Gate Charge   | $V_{DS} = 25 V$<br>$V_{GS} = 5 V$ | $I_D = 25 A$   |  | 19  |  | nC |



ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

SOURCE DRAIN DIODE

|                       |                                                       |                                                             |  |            |                     |
|-----------------------|-------------------------------------------------------|-------------------------------------------------------------|--|------------|---------------------|
| $I_{SD}$<br>$I_{SDM}$ | Source-drain current<br>Source-drain current (pulsed) |                                                             |  | 25<br>80   | A<br>A              |
| $V_{SD}$              | Forward on voltage                                    | $I_{SD} = 25\text{ A}$<br>$V_{GS} = 0$                      |  | 1.5        | V                   |
| $t_{rr}$<br>$Q_{rr}$  | Reverse recovery time<br>Reverse recovery charge      | $I_{SD} = 25\text{ A}$<br>$di/dt = 100\text{A}/\mu\text{s}$ |  | 300<br>0.3 | ns<br>$\mu\text{C}$ |



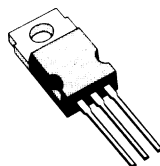
## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR

PRELIMINARY DATA

| TYPE    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|---------|------------------|---------------------|----------------|
| STVHD90 | 50 V             | 0.023 Ω             | 52 A           |

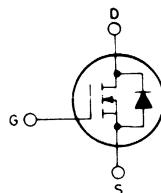
- VERY HIGH DENSITY
- VERY LOW R<sub>DS(on)</sub>
- VERY HIGH CURRENT
- HIGH TRANSCONDUCTANCE/C<sub>rss</sub> RATIO
- LOW DRIVE ENERGY
- ULTRA FAST SWITCHING

N-channel enhancement mode very high density POWER MOS transistors. Easy drive and low on voltage make this device ideal for automotive and industrial applications requiring high current and low on-losses. Typical uses are actuators lamp and motor control in the automotive and industrial environments. It can also be used in DC/DC converters.



**TO-220**

### INTERNAL SCHEMATIC DIAGRAM



### ABSOLUTE MAXIMUM RATINGS

|                     |                                                 |             |      |
|---------------------|-------------------------------------------------|-------------|------|
| V <sub>DS</sub>     | Drain-source voltage (V <sub>GS</sub> = 0)      | 50          | V    |
| V <sub>GS</sub>     | Gate-source voltage                             | ± 20        | V    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 25°C  | 52          | A    |
| I <sub>D</sub>      | Drain current (cont.) at T <sub>c</sub> = 125°C | 32          | A    |
| I <sub>DM</sub> (*) | Drain current (pulsed)                          | 200         | A    |
| I <sub>DLM</sub>    | Drain inductive current clamped                 | 200         | A    |
| P <sub>tot</sub>    | Total dissipation at T <sub>c</sub> < 25°C      | 125         | W    |
|                     | Derating factor                                 | 1           | W/°C |
| T <sub>stg</sub>    | Storage temperature                             | − 65 to 150 | °C   |
| T <sub>j</sub>      | Max. operating junction temperature             | 150         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA

|                  |                                                |     |     |      |
|------------------|------------------------------------------------|-----|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case               | max | 1   | °C/W |
| $T_L$            | Maximum lead temperature for soldering purpose |     | 275 | °C   |

ELECTRICAL CHARACTERISTICS ( $T_{case} = 25^{\circ}C$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                         |                      |    |  |             |                    |
|----------------|--------------------------------------------------|-------------------------------------------------------------------------|----------------------|----|--|-------------|--------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250 \mu A$                                                       | $V_{GS} = 0$         | 50 |  |             | V                  |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ | $T_c = 125^{\circ}C$ |    |  | 250<br>1000 | $\mu A$<br>$\mu A$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20 V$                                                     |                      |    |  | 100         | nA                 |

ON (\*)

|               |                                   |                   |                   |   |  |    |            |
|---------------|-----------------------------------|-------------------|-------------------|---|--|----|------------|
| $V_{GS (th)}$ | Gate threshold voltage            | $V_{DS} = V_{GS}$ | $I_D = 250 \mu A$ | 2 |  | 4  | V          |
| $R_{DS (on)}$ | Static drain-source on resistance | $V_{GS} = 10 V$   | $I_D = 30 A$      |   |  | 23 | m $\Omega$ |

DYNAMIC

|           |                              |                 |              |  |      |      |     |
|-----------|------------------------------|-----------------|--------------|--|------|------|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 25 V$ | $I_D = 30 A$ |  | 30   |      | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25 V$ | $f = 1 MHz$  |  | 2500 | 3000 | pF  |
| $C_{oss}$ | Output capacitance           | $V_{GS} = 0$    |              |  | 850  | 1000 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                 |              |  | 120  | 150  | pF  |

SWITCHING

|               |                     |                                    |                   |  |    |     |    |
|---------------|---------------------|------------------------------------|-------------------|--|----|-----|----|
| $t_{d (on)}$  | Turn-on time        | $V_{DD} = 40 V$                    | $I_D = 25 A$      |  |    | 40  | ns |
| $t_r$         | Rise time           | $V_i = 50 V$                       | $R_f = 50 \Omega$ |  |    | 100 | ns |
| $t_{d (off)}$ | Turn-off delay time | (see test circuit)                 |                   |  |    | 250 | ns |
| $t_f$         | Fall time           |                                    |                   |  |    | 170 | ns |
| $Q_g$         | Total Gate Charge   | $V_{DD} = 25 V$<br>$V_{GS} = 10 V$ | $I_D = 30 A$      |  | 56 |     | nC |

## ELECTRICAL CHARACTERISTICS (Continued)

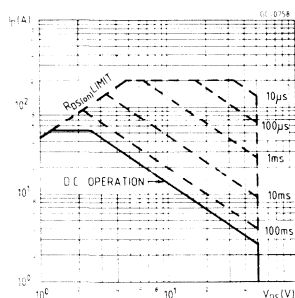
| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

## SOURCE DRAIN DIODE

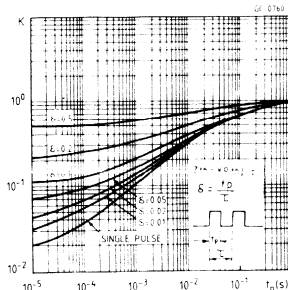
|                 |                               |                                                              |              |     |               |
|-----------------|-------------------------------|--------------------------------------------------------------|--------------|-----|---------------|
| $I_{SD}$        | Source-drain current          |                                                              |              | 52  | A             |
| $I_{SDM}^{(*)}$ | Source-drain current (pulsed) |                                                              |              | 200 | A             |
| $V_{SD}$        | Forward on voltage            | $I_{SD} = 52\text{ A}$                                       | $V_{GS} = 0$ | 1.5 | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 52\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ | $V_{GS} = 0$ | 70  | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                              |              | 110 | $\mu\text{C}$ |

(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

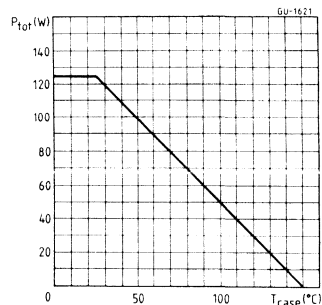
Safe operating areas



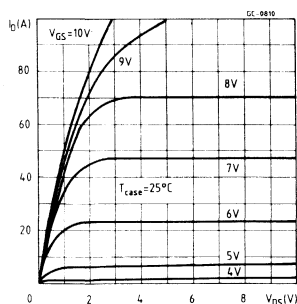
Thermal impedance



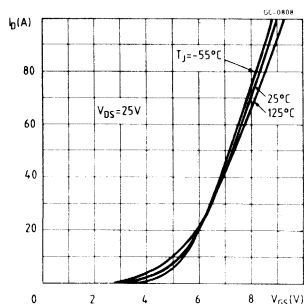
Derating curve



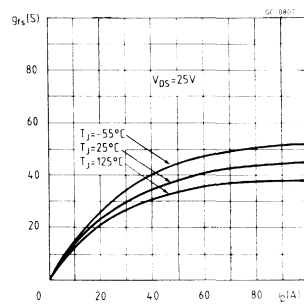
Output characteristics



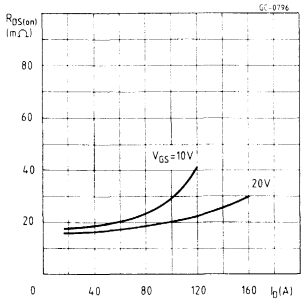
Transfer characteristics



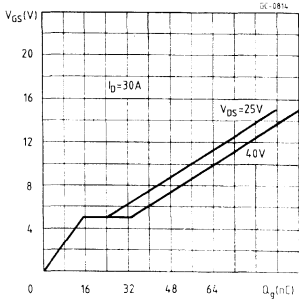
Transconductance



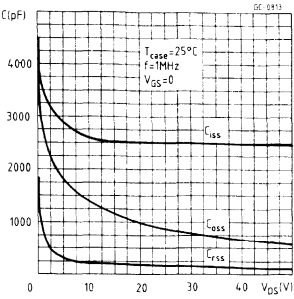
Static drain-source on resistance



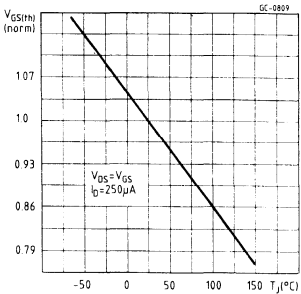
Gate charge vs gate-source voltage



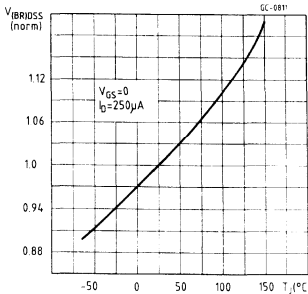
Capacitance variation



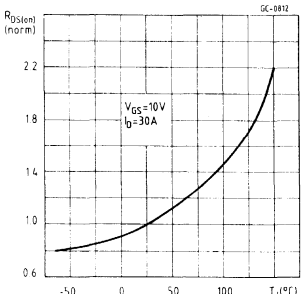
Normalized gate threshold voltage vs temperature



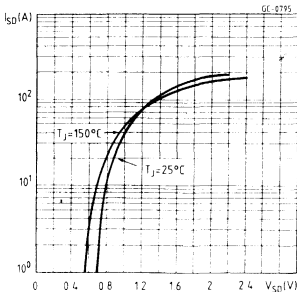
Normalized breakdown voltage vs temperature



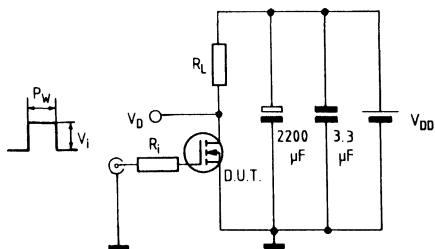
Normalized on resistance vs temperature



Static drain diode forward characteristics



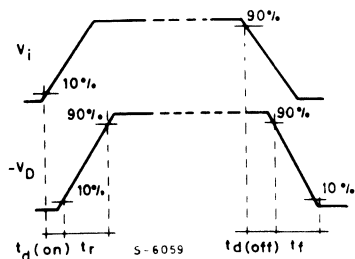
Switching times test circuit for resistive load



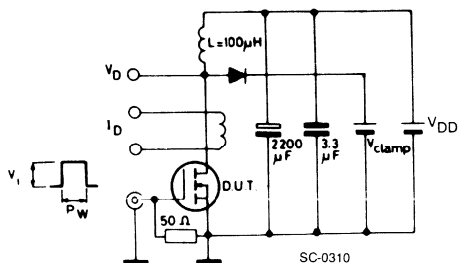
Pulse width  $\leq 100 \mu\text{s}$   
Duty cycle  $\leq 2\%$

SC-0008/1

Switching time waveforms for resistive load



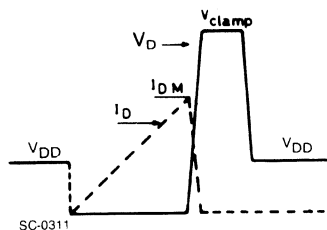
Clamped inductive load test circuit



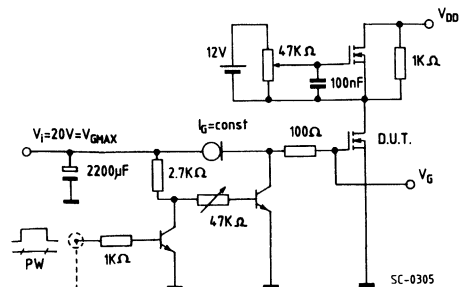
$V_i = 12 \text{ V}$  - Pulse width: adjusted to obtain specified  $I_{DM}$ ,  $V_{\text{clamp}} = 0.75 V_{(BR)} \text{ DSS}$

SC-0310

Clamped inductive waveforms

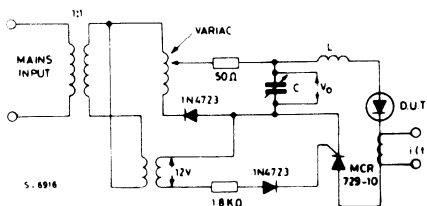


Gate charge test circuit



PW adjusted to obtain required  $V_G$

SC-0305

Body-drain diode  $t_{rr}$  measurement  
Jedec test circuit





# HIGH INJECTION N-CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS (IGBT)

PRELIMINARY DATA

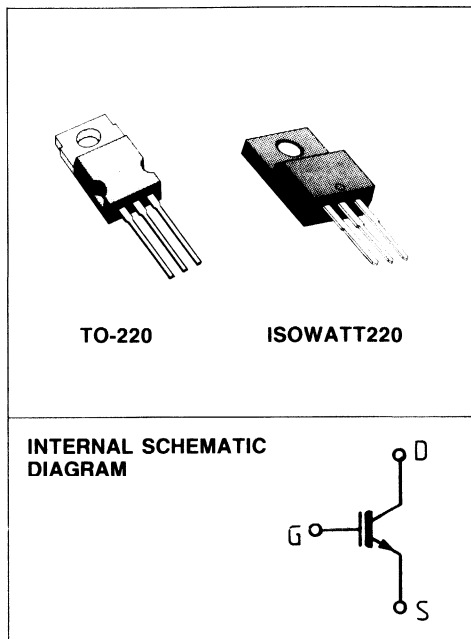
| TYPE        | V <sub>DSS</sub> | I <sub>D</sub> |
|-------------|------------------|----------------|
| STH107N50   | 500 V            | 7 A            |
| STH107N50FI | 500 V            | 7 A            |

- HIGH INPUT IMPEDANCE
- LOW ON-VOLTAGE
- HIGH CURRENT CAPABILITY

**APPLICATIONS:**

- AUTOMOTIVE IGNITION
- DRIVERS FOR SOLENOIDS AND RELAYS

N - channel High Injection POWER MOS transistors (IGBT) which features a high impedance insulated gate input and a low on-resistance characteristic of bipolar transistors. This low resistance is achieved by conductivity modulation of the drain. These devices are particularly suited to automotive ignition switching. They can also be used as drivers for solenoids and relays.


**ABSOLUTE MAXIMUM RATINGS**

|                    |                                                  |      |   |
|--------------------|--------------------------------------------------|------|---|
| V <sub>DS</sub>    | Drain-source voltage (V <sub>GS</sub> = 0)       | 500  | V |
| V <sub>GS</sub>    | Gate-source voltage                              | ± 20 | V |
| I <sub>D</sub> (*) | Drain current (contin.) at T <sub>c</sub> = 25°C | 7    | A |
| I <sub>DM</sub>    | Drain current (pulsed)                           | 20   | A |
| P <sub>tot</sub>   | Total dissipation at T <sub>c</sub> < 25°C       |      |   |
|                    | Derating factor                                  |      |   |
| T <sub>stg</sub>   | Storage temperature                              |      |   |
| T <sub>j</sub>     | Max. operating junction temperature              |      |   |

**STH107N50**
**STH107N50FI**

100

35

W

0.8

0.28

W/°C

- 65 to 150

°C

150

°C

(\*) Pulse width limited by safe operating area

THERMAL DATA ■

TO-220 | ISOWATT220

|                  |                                  |     |      |     |      |
|------------------|----------------------------------|-----|------|-----|------|
| $R_{thj - case}$ | Thermal resistance junction-case | max | 1.25 | 3.6 | °C/W |
|------------------|----------------------------------|-----|------|-----|------|

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                        |     |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------------------------------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$<br>$V_{GS} = 0$                                                               | 500 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>$T_j = 125^{\circ}\text{C}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\ \text{V}$                                                                            |     |  | $\pm 100$   | nA                             |

ON (\*)

|               |                        |                                                |   |  |     |   |
|---------------|------------------------|------------------------------------------------|---|--|-----|---|
| $V_{GS (th)}$ | Gate threshold voltage | $V_{DS} = V_{GS}$<br>$I_D = 250\ \mu\text{A}$  | 2 |  | 4   | V |
| $V_{DS (on)}$ | Drain-source voltage   | $V_{GS} = 10\ \text{V}$<br>$I_D = 7\ \text{A}$ |   |  | 2.7 | V |

DYNAMIC

|           |                              |                                                                |     |     |     |     |
|-----------|------------------------------|----------------------------------------------------------------|-----|-----|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 20\ \text{V}$<br>$I_D = 7\ \text{A}$                 | 2.5 |     |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25\ \text{V}$<br>$V_{GS} = 0$<br>$f = 1\ \text{MHz}$ |     | 850 | 950 | pF  |
| $C_{oss}$ | Output capacitance           |                                                                |     | 90  | 140 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                                |     | 40  | 80  | pF  |

SWITCHING

| RESISTIVE LOAD |                     | $V_{DD} = 400\ \text{V}$<br>$V_g = 10\ \text{V}$ | $I_D = 10\ \text{A}$<br>$R_g = 100\ \Omega$ |     |      |    |
|----------------|---------------------|--------------------------------------------------|---------------------------------------------|-----|------|----|
| $t_{d (on)}$   | Turn-on delay time  |                                                  |                                             | 100 | 150  | ns |
| $t_r$          | Rise time           |                                                  |                                             | 700 | 1000 | ns |
| $t_{d (off)}$  | Turn-off delay time |                                                  |                                             | 500 | 700  | ns |
| $t_f$          | Fall time           |                                                  |                                             | 800 | 1500 | ns |

# ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

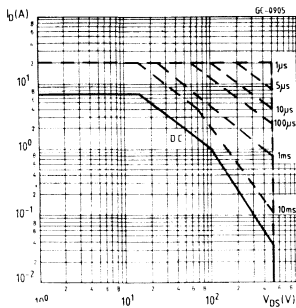
## SWITCHING (continued)

|                |                     |                                                                                                                |                                                                        |     |               |
|----------------|---------------------|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|-----|---------------|
| INDUCTIVE LOAD |                     |                                                                                                                |                                                                        |     |               |
| $t_{d(off)}$   | Turn-off delay time | $V_{DD} = 12\text{ V}$<br>$V_{DS\text{ clamp}} = 350\text{ V}$<br>$V_{GS} = 10\text{ V}$<br>$L = 10\text{ mH}$ | $I_D = 7\text{ A}$<br>$R_g = 100\ \Omega$<br>$T_j = 100^\circ\text{C}$ | 1   | $\mu\text{S}$ |
| $t_f$          | Fall time           |                                                                                                                |                                                                        | 1.1 | $\mu\text{S}$ |
| USE TEST       |                     | $V_{CC} = 14\text{ V}$<br>$L = 7\text{ mH}$                                                                    | $V_{DS\text{ clamp}} = 400\text{ V}$                                   | 6   | A             |

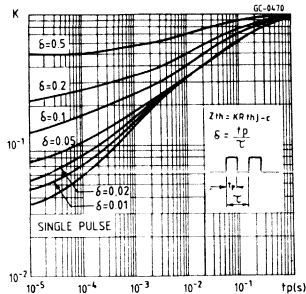
(\*) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1,5%

■ See note on ISOWATT220 or this datasheet

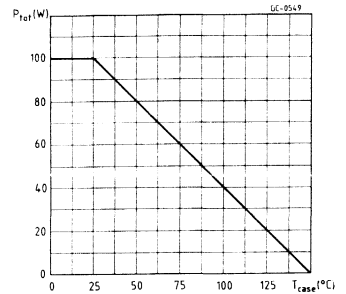
Safe operating areas  
(standard package)



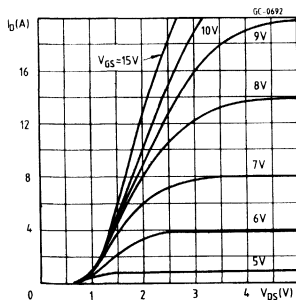
Thermal impedance  
(standard package)



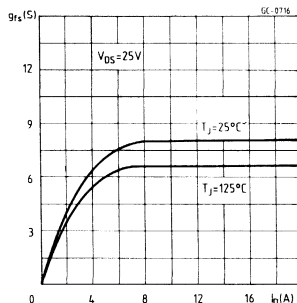
Derating curve  
(standard package)



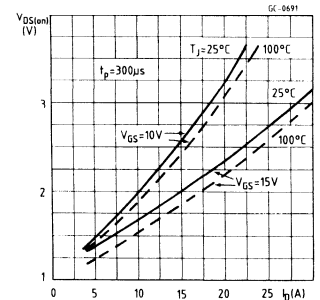
Output characteristics



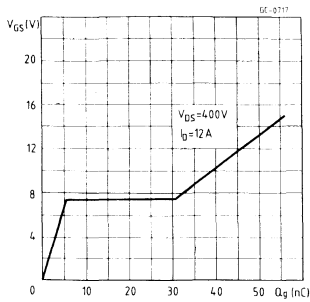
Transconductance



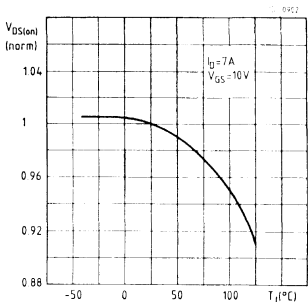
Static drain-source on  
voltage



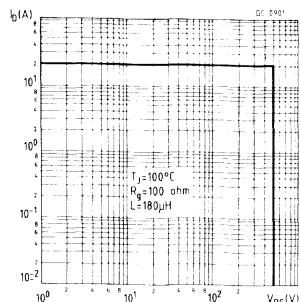
Gate charge vs gate-source voltage



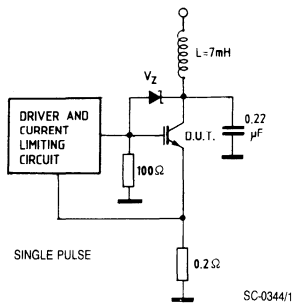
Normalized on voltage vs temperature



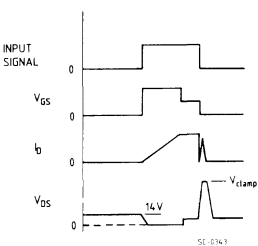
Reverse biased SOA



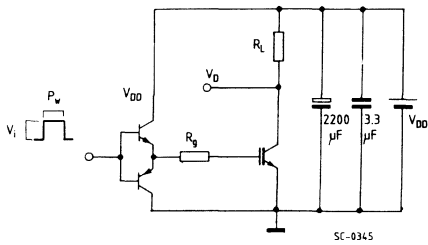
Functional test circuit



Functional test waveforms

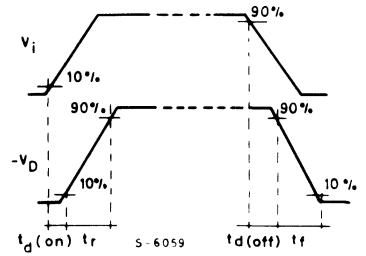


Switching times test circuit for resistive load

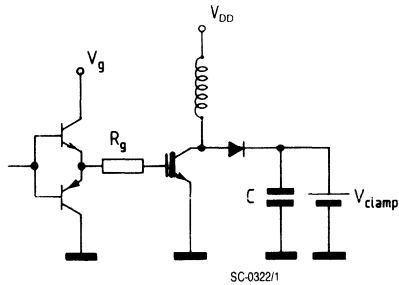


Pulse width  $\leq 100 \mu s$   
Duty cycle  $\leq 2\%$

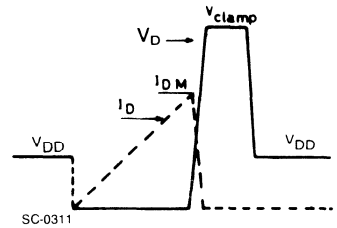
Switching time waveforms for resistive load



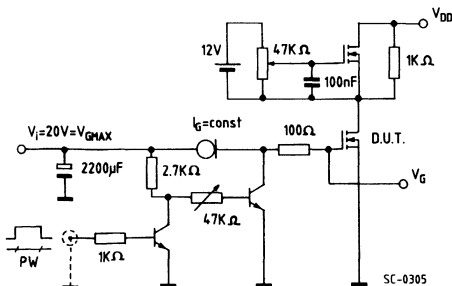
Clamped inductive load and RBSOA test circuit



Clamped inductive waveforms



Gate charge test circuit



PW adjusted to obtain required  $V_G$

ISOWATT220 PACKAGE  
CHARACTERISTICS AND APPLICATION.

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation. The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance. ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

THERMAL IMPEDANCE OF  
ISOWATT220 PACKAGE

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package. The total thermal resistance  $R_{th (tot)}$  is the sum of each of these elements. The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

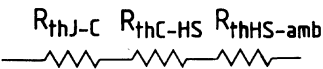
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

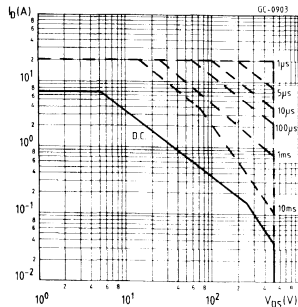
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

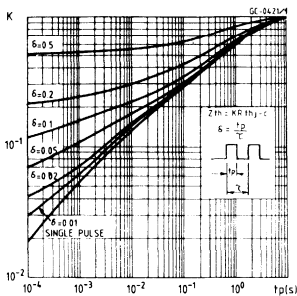


ISOWATT DATA

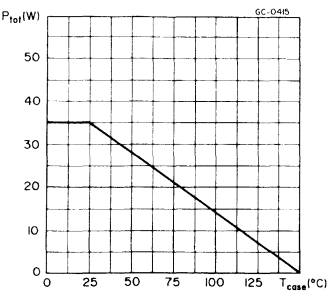
Safe operating areas



Thermal impedance



Derating curve



## HIGH INJECTION N-CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTORS (IGBT)

PRELIMINARY DATA

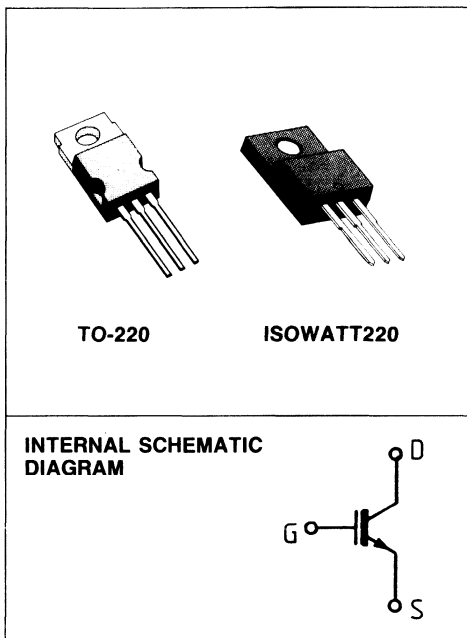
| TYPE       | V <sub>DSS</sub> | I <sub>D</sub> |
|------------|------------------|----------------|
| STH10N50   | 500 V            | 10 A           |
| STH10N50FI | 500 V            | 10 A           |

- HIGH INPUT IMPEDANCE
- LOW ON-VOLTAGE
- HIGH CURRENT CAPABILITY
- FAST TURN-OFF:  $t_f < 1.5 \mu s$

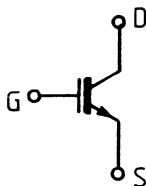
### APPLICATIONS:

- MOTOR CONTROL

N - channel High Injection POWER MOS transistors (IGBT) which feature a high impedance insulated gate input and a low on-resistance characteristic of bipolar transistors. This low resistance is achieved by conductivity modulation of the drain. These devices are particularly suited to switching motor control applications in consumer equipment such as washing machines and tumble dryers and industrial equipment motor control.



**INTERNAL SCHEMATIC  
DIAGRAM**



### ABSOLUTE MAXIMUM RATINGS

|                    |                                                  |             |      |
|--------------------|--------------------------------------------------|-------------|------|
| V <sub>DS</sub>    | Drain-source voltage (V <sub>GS</sub> = 0)       | 500         | V    |
| V <sub>GS</sub>    | Gate-source voltage                              | ± 20        | V    |
| I <sub>D</sub> (*) | Drain current (contin.) at T <sub>c</sub> = 25°C | 10          | A    |
| I <sub>DM</sub>    | Drain current (pulsed)                           | 30          | A    |
| P <sub>tot</sub>   | Total dissipation at T <sub>c</sub> < 25°C       | 100         | W    |
|                    | Derating factor                                  | 0.8         | W/°C |
| T <sub>stg</sub>   | Storage temperature                              | - 65 to 150 | °C   |
| T <sub>j</sub>     | Max. operating junction temperature              | 150         | °C   |

(\*) Pulse width limited by safe operating area

THERMAL DATA ■

TO-220 | ISOWATT220

|                  |                                  |     |      |      |      |
|------------------|----------------------------------|-----|------|------|------|
| $R_{thj - case}$ | Thermal resistance junction-case | max | 1.25 | 3.57 | °C/W |
|------------------|----------------------------------|-----|------|------|------|

ELECTRICAL CHARACTERISTICS ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

OFF

|                |                                                  |                                                                                                        |     |  |             |                                |
|----------------|--------------------------------------------------|--------------------------------------------------------------------------------------------------------|-----|--|-------------|--------------------------------|
| $V_{(BR) DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$<br>$V_{GS} = 0$                                                               | 500 |  |             | V                              |
| $I_{DSS}$      | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$<br>$T_j = 125^{\circ}\text{C}$ |     |  | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$      | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\ \text{V}$                                                                            |     |  | $\pm 100$   | nA                             |

ON (\*)

|               |                        |                                                                                                                          |   |  |            |        |
|---------------|------------------------|--------------------------------------------------------------------------------------------------------------------------|---|--|------------|--------|
| $V_{GS (th)}$ | Gate threshold voltage | $V_{DS} = V_{GS}$<br>$I_D = 250\ \mu\text{A}$                                                                            | 2 |  | 4          | V      |
| $V_{DS (on)}$ | Drain-source voltage   | $V_{GS} = 15\ \text{V}$ $I_D = 10\ \text{A}$<br>$V_{GS} = 15\ \text{V}$ $I_D = 10\ \text{A}$ $T_j = 100^{\circ}\text{C}$ |   |  | 2.7<br>2.7 | V<br>V |

DYNAMIC

|           |                              |                                                                |     |     |     |     |
|-----------|------------------------------|----------------------------------------------------------------|-----|-----|-----|-----|
| $g_{fs}$  | Forward transconductance     | $V_{DS} = 20\ \text{V}$<br>$I_D = 10\ \text{A}$                | 2.5 |     |     | mho |
| $C_{iss}$ | Input capacitance            | $V_{DS} = 25\ \text{V}$<br>$V_{GS} = 0$<br>$f = 1\ \text{MHz}$ |     | 850 | 950 | pF  |
| $C_{oss}$ | Output capacitance           |                                                                |     | 90  | 140 | pF  |
| $C_{rss}$ | Reverse transfer capacitance |                                                                |     | 40  | 80  | pF  |

SWITCHING

| RESISTIVE LOAD |                     | $V_{DD} = 400\ \text{V}$<br>$V_g = 15\ \text{V}$ | $I_D = 10\ \text{A}$<br>$R_g = 100\ \Omega$ |     |      |    |
|----------------|---------------------|--------------------------------------------------|---------------------------------------------|-----|------|----|
| $t_{d (on)}$   | Turn-on delay time  |                                                  |                                             | 100 | 150  | ns |
| $t_r$          | Rise time           |                                                  |                                             | 700 | 1000 | ns |
| $t_{d (off)}$  | Turn-off delay time |                                                  |                                             | 500 | 700  | ns |
| $t_f$          | Fall time           |                                                  |                                             | 800 | 1500 | ns |



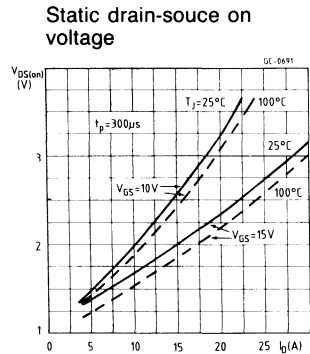
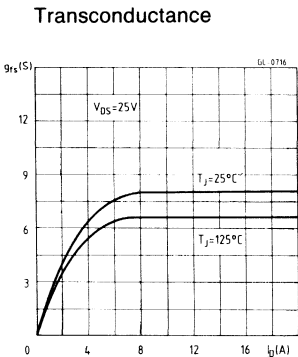
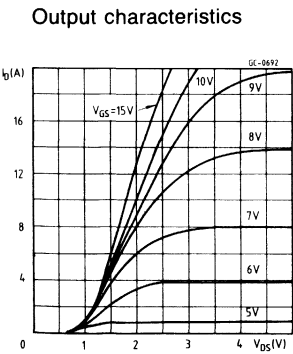
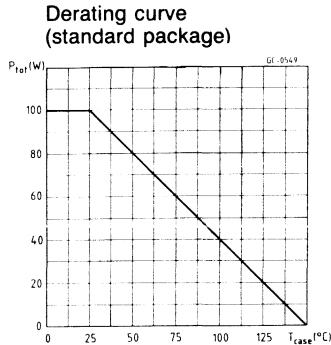
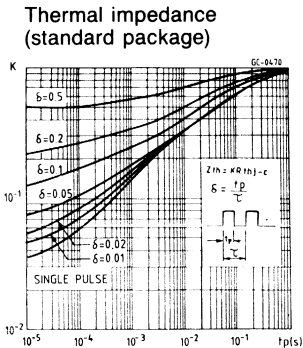
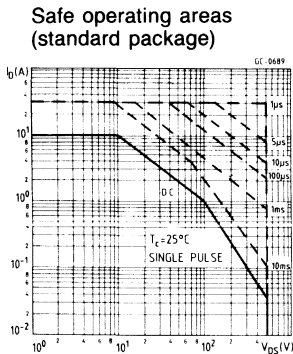
ELECTRICAL CHARACTERISTICS (Continued)

| Parameters | Test Conditions | Min. | Typ. | Max. | Unit |
|------------|-----------------|------|------|------|------|
|------------|-----------------|------|------|------|------|

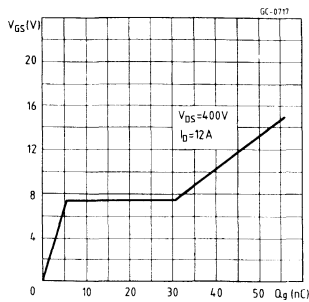
SWITCHING (continued)

| INDUCTIVE LOAD |                     |                                                               |                                                             |     |         |
|----------------|---------------------|---------------------------------------------------------------|-------------------------------------------------------------|-----|---------|
| $t_d$ (off)    | Turn-off delay time | $V_{DS\ clamp} = 350\ V$<br>$V_g = 15\ V$<br>$L = 180\ \mu H$ | $I_D = 10\ A$<br>$R_g = 100\ \Omega$<br>$T_j = 100^\circ C$ | 0.7 | $\mu s$ |
| $t_f$          | Fall time           |                                                               |                                                             | 1.1 | $\mu s$ |
| $t_{cross}$    | Crossover time      |                                                               |                                                             | 1.7 | $\mu s$ |
| $E_{off}$      | Turn-off losses     |                                                               |                                                             | 4   | mJ      |

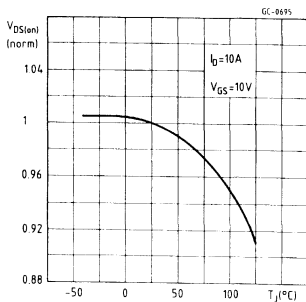
(\*) Pulsed: Pulse duration = 300  $\mu s$ , duty cycle 1,5%  
(■) See note on ISOWATT220 in this datasheet



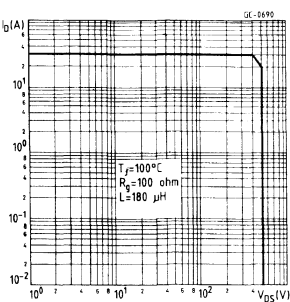
Gate charge vs gate-source voltage



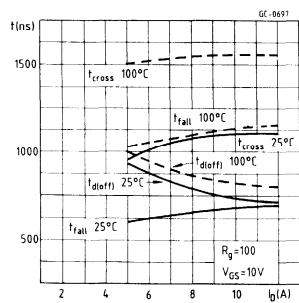
Normalized on voltage vs temperature



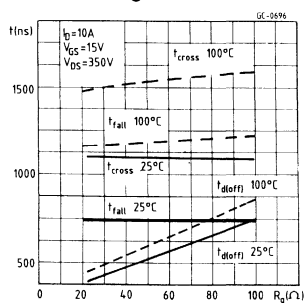
Reverse biased SOA



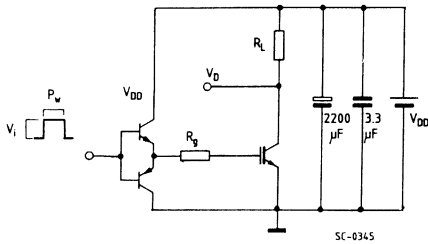
Switching times inductive load vs drain current



Switching times inductive load vs Rg

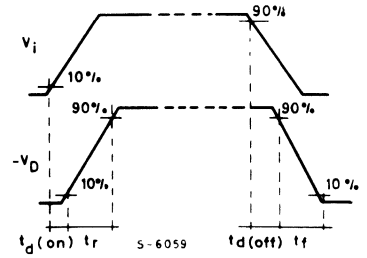


Switching times test circuit for resistive load

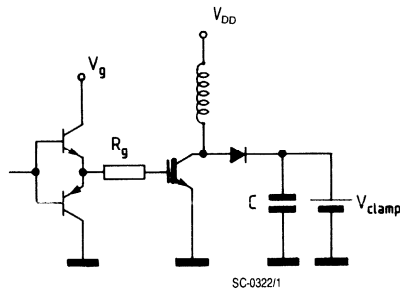


Pulse width  $\leq 100 \mu s$   
Duty cycle  $\leq 2\%$

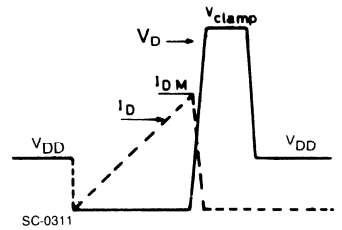
Switching time waveforms for resistive load



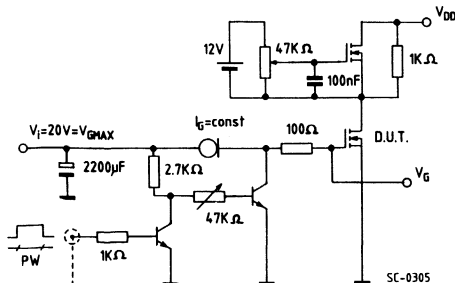
Clamped inductive load and RBSOA test circuit



Clamped inductive waveforms



Gate charge test circuit



PW adjusted to obtain required  $V_G$

**ISOWATT220 PACKAGE  
CHARACTERISTICS AND APPLICATION.**

ISOWATT220 is fully isolated to 2000V dc. Its thermal impedance, given in the data sheet, is optimised to give efficient thermal conduction together with excellent electrical isolation.

The structure of the case ensures optimum distances between the pins and heatsink. The ISOWATT220 package eliminates the need for external isolation so reducing fixing hardware. Accurate moulding techniques used in manufacture assure consistent heat spreader-to-heatsink capacitance.

ISOWATT220 thermal performance is better than that of the standard part, mounted with a 0.1mm mica washer. The thermally conductive plastic has a higher breakdown rating and is less fragile than mica or plastic sheets. Power derating for ISOWATT220 packages is determined by:

$$P_D = \frac{T_j - T_c}{R_{th}}$$

**THERMAL IMPEDANCE OF  
ISOWATT220 PACKAGE**

Fig. 1 illustrates the elements contributing to the thermal resistance of transistor heatsink assembly, using ISOWATT220 package.

The total thermal resistance  $R_{th (tot)}$  is the sum of each of these elements.

The transient thermal impedance,  $Z_{th}$  for different pulse durations can be estimated as follows:

1 - for a short duration power pulse less than 1ms;

$$Z_{th} < R_{thJ-C}$$

2 - for an intermediate power pulse of 5ms to 50ms:

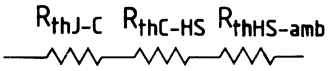
$$Z_{th} = R_{thJ-C}$$

3 - for long power pulses of the order of 500ms or greater:

$$Z_{th} = R_{thJ-C} + R_{thC-HS} + R_{thHS-amb}$$

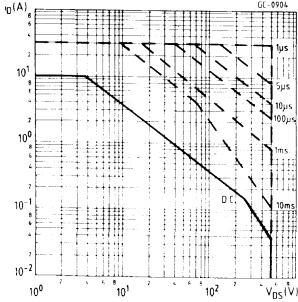
It is often possible to discern these areas on transient thermal impedance curves.

Fig. 1

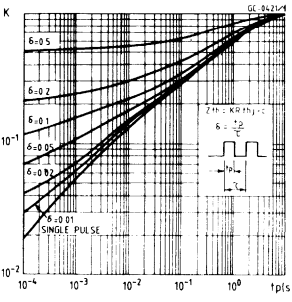


**ISOWATT DATA**

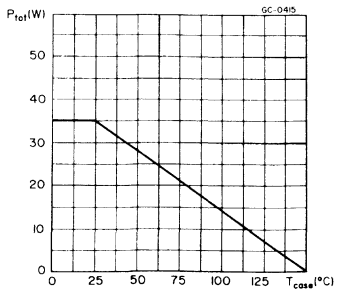
Safe operating areas



Thermal impedance



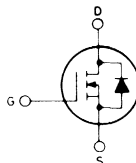
Derating curve



## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR IN DIE FORM

- **DIE SIZE:** 170 × 170 mils
- **METALLIZATION:**
  - Top Al
  - Back Au/Cr/Ni/Au
- **BACKSIDE THICKNESS:** 6100 Å
- **DIE THICKNESS:** 16 ± 2 mils
- **PASSIVATION:** P-Vapox
- **BONDING PAD SIZE:**
  - Source 47 × 51 mils
  - Gate 15 × 18 mils
- **RECOMMENDED WIRE BONDING:**
  - Source Al - max 20 mils
  - Gate Al - max 5 mils

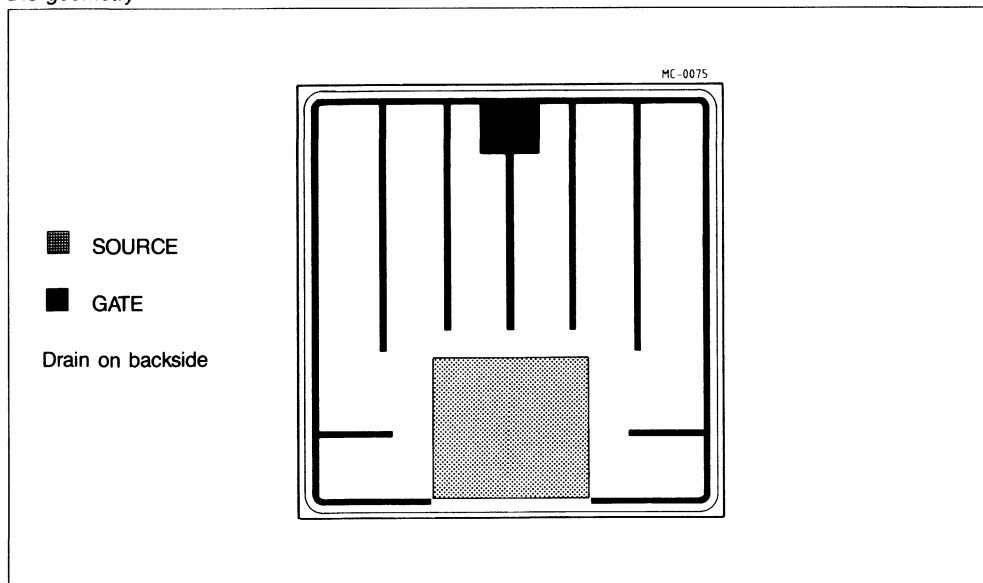
### SCHEMATIC DIAGRAM



| $V_{DS}$ | $R_{DS(on)}$  | $I_D^*$ |
|----------|---------------|---------|
| 50 V     | 0.04 $\Omega$ | 30 A    |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

### Die geometry



\* With  $R_{thjc}$  max. 1.67°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

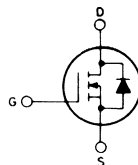
| Parameters            |                                   | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit       |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|------------|
| V <sub>(BR) DSS</sub> | Drain-source breakdown voltage    | I <sub>D</sub> = 250 µA      V <sub>GS</sub> = 0                                             | 50   |      |             | V          |
| I <sub>DSS</sub>      | Zero gate voltage drain current   | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | µ A<br>µ A |
| I <sub>GSS</sub>      | Gate-body leakage current         | V <sub>GS</sub> = ± 20 V                                                                     |      |      | 100         | nA         |
| V <sub>GS (th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 1 mA                                      | 2.1  |      | 4           | V          |
| R <sub>DS (on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 0.04        | Ω          |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 µs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- DIE SIZE: 156 × 156 mils
- METALLIZATION:
  - Top Al
  - Back Au/Cr/Ni/Au
- BACKSIDE THICKNESS: 6100 Å
- DIE THICKNESS: 16 ± 2 mils
- PASSIVATION: P-Vapox
- BONDING PAD SIZE:
  - Source 40 × 34 mils
  - Gate 15 × 19 mils
- RECOMMENDED WIRE BONDING:
  - Source Al - max 15 mils
  - Gate Al - max 7 mils

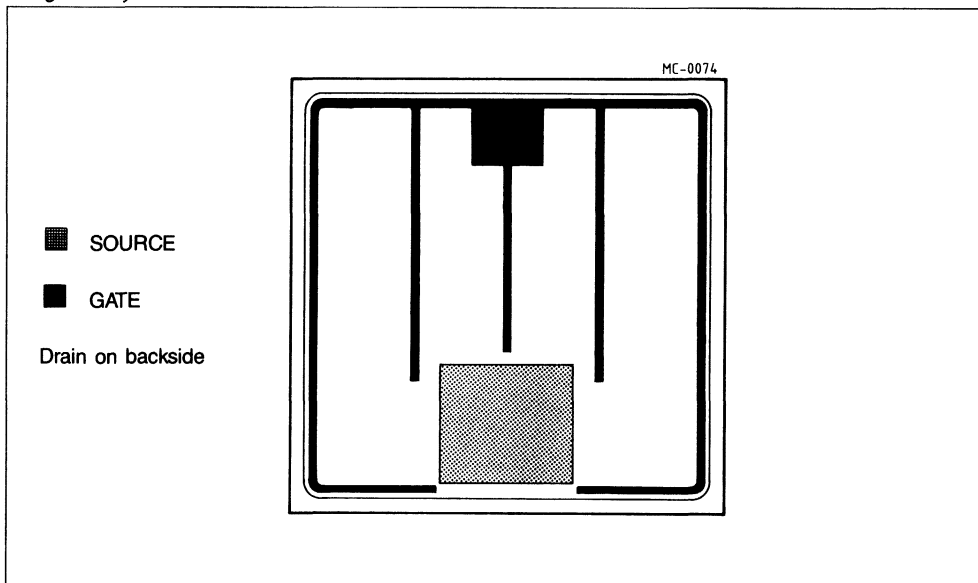
**SCHEMATIC DIAGRAM**



| $V_{DS}$ | $R_{DS(on)}$  | $I_D^*$ |
|----------|---------------|---------|
| 50 V     | 0.06 $\Omega$ | 25 A    |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thjc}$  max. 1.67°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

| Parameters            |                                   | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> | Drain-source breakdown voltage    | I <sub>D</sub> = 250 µA      V <sub>GS</sub> = 0                                             | 50   |      |             | V        |
| I <sub>DSS</sub>      | Zero gate voltage drain current   | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | µA<br>µA |
| I <sub>GSS</sub>      | Gate-body leakage current         | V <sub>GS</sub> = ± 20 V                                                                     |      |      | 100         | nA       |
| V <sub>GS (th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 1 mA                                      | 2.1  |      | 4           | V        |
| R <sub>DS (on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 60          | mΩ       |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width < 300 µs, duty cycle < 2%

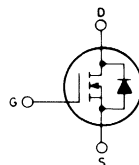
2 - For detailed device characteristics please refer to the discrete device datasheet



**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- DIE SIZE: 156 × 156 mils
- METALLIZATION:
  - Top Al
  - Back Au/Cr/Ni/Au
- BACKSIDE THICKNESS: 6100 Å
- DIE THICKNESS: 16 ± 2 mils
- PASSIVATION: P-Vapox
- BONDING PAD SIZE:
  - Source 40 × 34 mils
  - Gate 15 × 19 mils
- RECOMMENDED WIRE BONDING:
  - Source Al - max 15 mils
  - Gate Al - max 7 mils

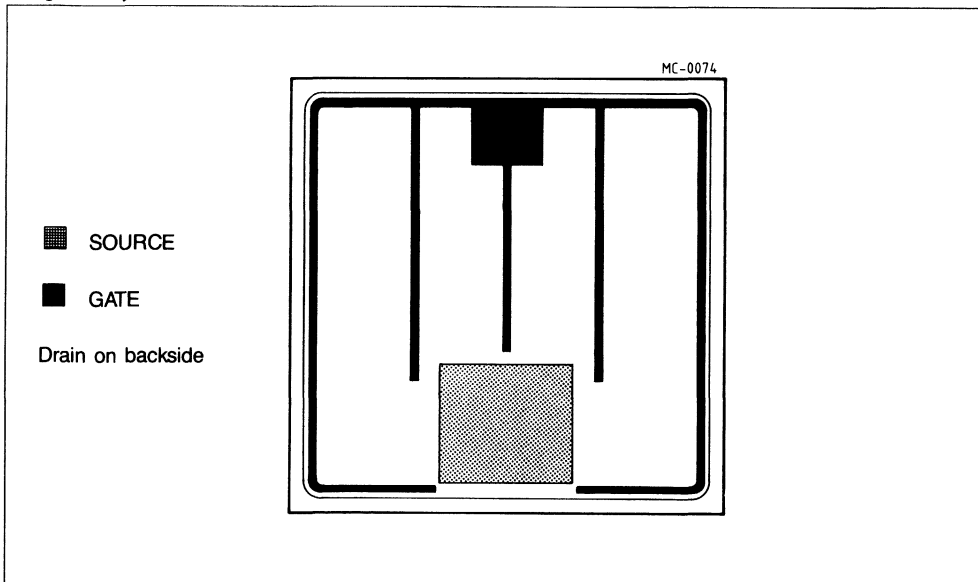
**SCHEMATIC DIAGRAM**



| $V_{DS}$ | $R_{DS(on)}$ | $I_D^*$ |
|----------|--------------|---------|
| 100 V    | 0.1 $\Omega$ | 19 A    |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thj-c}$  max. 1.67°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

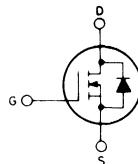
| Parameters            |                                   | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> | Drain-source breakdown voltage    | I <sub>D</sub> = 250 μA      V <sub>GS</sub> = 0                                             | 100  |      |             | V        |
| I <sub>DSS</sub>      | Zero gate voltage drain current   | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | μA<br>μA |
| I <sub>GSS</sub>      | Gate-body leakage current         | V <sub>GS</sub> = ±20 V                                                                      |      |      | 100         | nA       |
| V <sub>GS (th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 1 mA                                      | 2.1  |      | 4           | V        |
| R <sub>DS (on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 0.1         | Ω        |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 μs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- **DIE SIZE:** 156 × 156 mils
- **METALLIZATION:**
  - Top Al
  - Back Au/Cr/Ni/Au
- **BACKSIDE THICKNESS:** 6100 Å
- **DIE THICKNESS:** 16 ± 2 mils
- **PASSIVATION:** P-Vapox
- **BONDING PAD SIZE:**
  - Source 40 × 34 mils
  - Gate 15 × 19 mils
- **RECOMMENDED WIRE BONDING:**
  - Source Al - max 10 mils
  - Gate Al - max 7 mils

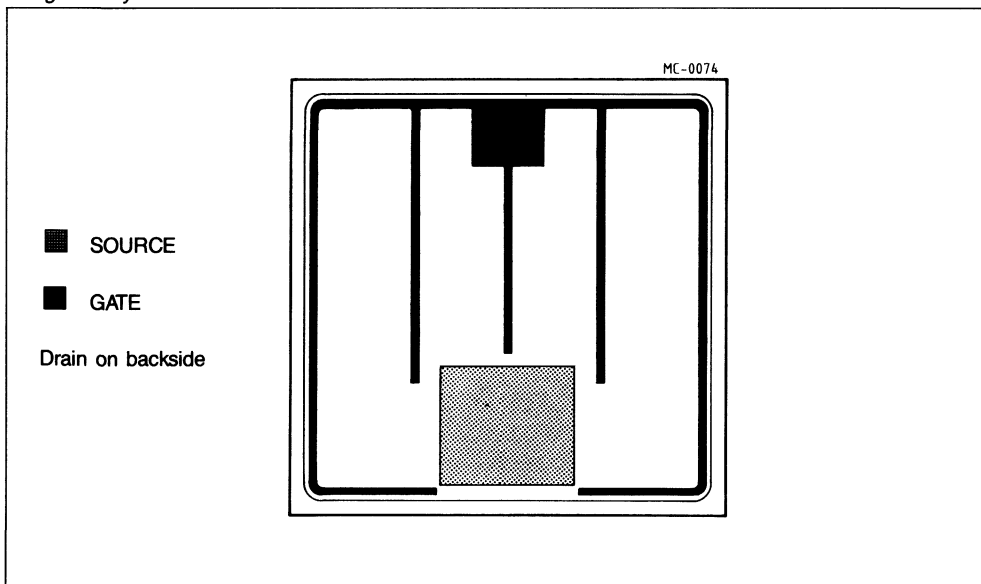
**SCHEMATIC DIAGRAM**



| $V_{DSS}$ | $R_{DS(on)}$ | $I_D^*$ |
|-----------|--------------|---------|
| 200 V     | 0.4 $\Omega$ | 9.5 A   |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thjc}$  max. 1.67°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

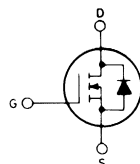
| Parameters            |                                   | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> | Drain-source breakdown voltage    | I <sub>D</sub> = 250 μA      V <sub>GS</sub> = 0                                             | 200  |      |             | V        |
| I <sub>DSS</sub>      | Zero gate voltage drain current   | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | μA<br>μA |
| I <sub>GSS</sub>      | Gate-body leakage current         | V <sub>GS</sub> = ±20 V                                                                      |      |      | 100         | nA       |
| V <sub>GS (th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 1 mA                                      | 2.1  |      | 4           | V        |
| R <sub>DS (on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 0.4         | Ω        |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 μs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- DIE SIZE: 95 × 95 mils
- METALLIZATION:
  - Top Al
  - Back Au/Cr/Ni/Au
- BACKSIDE THICKNESS: 6100 Å
- DIE THICKNESS: 16 ± 2 mils
- PASSIVATION: P-Vapox
- BONDING PAD SIZE:
  - Source 28 × 30 mils
  - Gate 16 × 18 mils
- RECOMMENDED WIRE BONDING:
  - Source Al - max 10 mils
  - Gate Al - max 5 mils

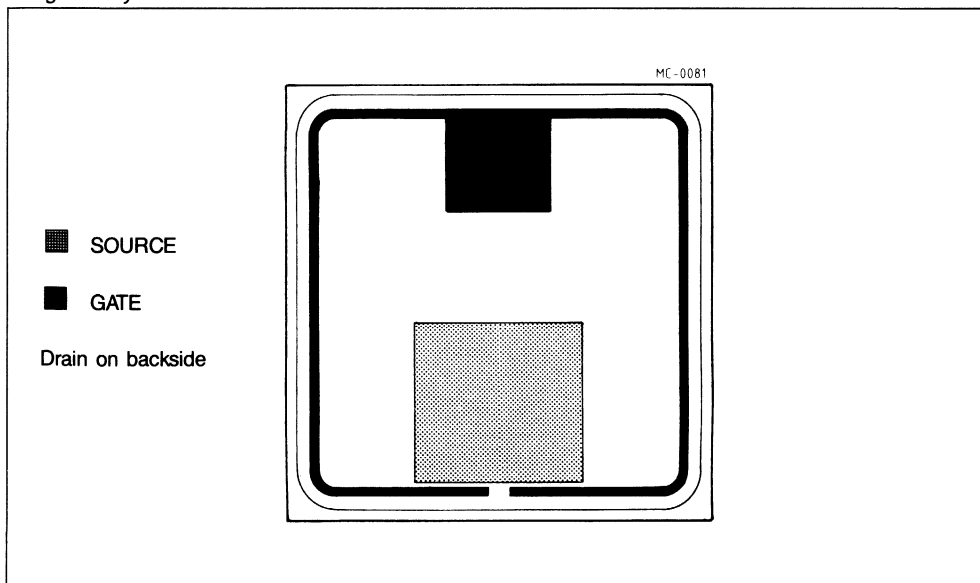
**SCHEMATIC DIAGRAM**



| $V_{DSS}$ | $R_{DS(on)}$ | $I_D^*$ |
|-----------|--------------|---------|
| 50 V      | 0.1 $\Omega$ | 14 A    |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thjc}$  max. 3.1°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

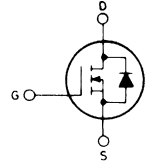
| Parameters            |                                   | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit       |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|------------|
| V <sub>(BR) DSS</sub> | Drain-source breakdown voltage    | I <sub>D</sub> = 250 μA      V <sub>GS</sub> = 0                                             | 50   |      |             | V          |
| I <sub>DSS</sub>      | Zero gate voltage drain current   | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | μ A<br>μ A |
| I <sub>GSS</sub>      | Gate-body leakage current         | V <sub>GS</sub> = ± 20 V                                                                     |      |      | 100         | nA         |
| V <sub>GS (th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 1 mA                                      | 2.1  |      | 4           | V          |
| R <sub>DS (on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 0.1         | Ω          |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width < 300 μs, duty cycle < 2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- **DIE SIZE:** 221 × 221 mils
- **METALLIZATION:**
  - Top Al
  - Back Au/Cr/Ni/Au
- **BACKSIDE THICKNESS:** 6100 Å
- **DIE THICKNESS:** 16 ± 2 mils
- **PASSIVATION:** P-Vapox
- **BONDING PAD SIZE:**
  - Source 56 × 43 mils
  - Gate 18 × 18 mils
- **RECOMMENDED WIRE BONDING:**
  - Source Al - max 20 mils
  - Gate Al - max 7 mils

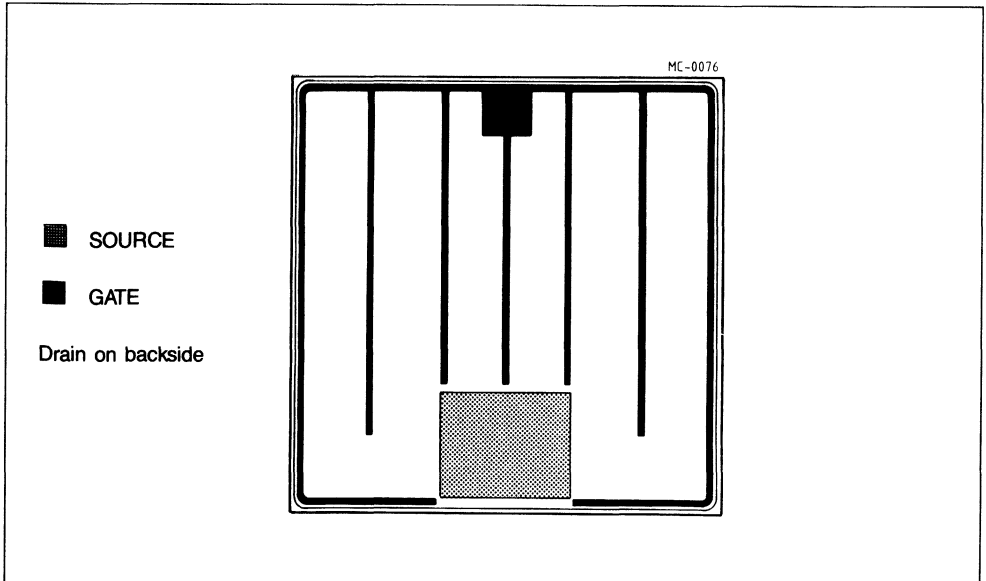
**SCHEMATIC DIAGRAM**



| $V_{DSS}$ | $R_{DS(on)}$   | $I_D^*$ |
|-----------|----------------|---------|
| 60 V      | 0.055 $\Omega$ | 40 A    |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thjc}$  max. 0.83°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

| Parameters                                             | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|--------------------------------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> Drain-source breakdown voltage   | I <sub>D</sub> = 250 μA      V <sub>GS</sub> = 0                                             | 60   |      |             | V        |
| I <sub>DSS</sub> Zero gate voltage drain current       | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | μA<br>μA |
| I <sub>GSS</sub> Gate-body leakage current             | V <sub>GS</sub> = ±20 V                                                                      |      |      | 100         | nA       |
| V <sub>GS (th)</sub> Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 250 μA                                    | 2    |      | 4           | V        |
| R <sub>DS (on)</sub> Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 55          | mΩ       |

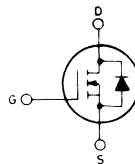
NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 μs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet



**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- DIE SIZE: 95 × 95 mils
- METALLIZATION:
  - Top Al
  - Back Au/Cr/Ni/Au
- BACKSIDE THICKNESS: 6100 Å
- DIE THICKNESS: 16 ± 2 mils
- PASSIVATION: P-Vapox
- BONDING PAD SIZE:
  - Source 28 × 30 mils
  - Gate 16 × 18 mils
- RECOMMENDED WIRE BONDING:
  - Source Al - max 10 mils
  - Gate Al - max 5 mils

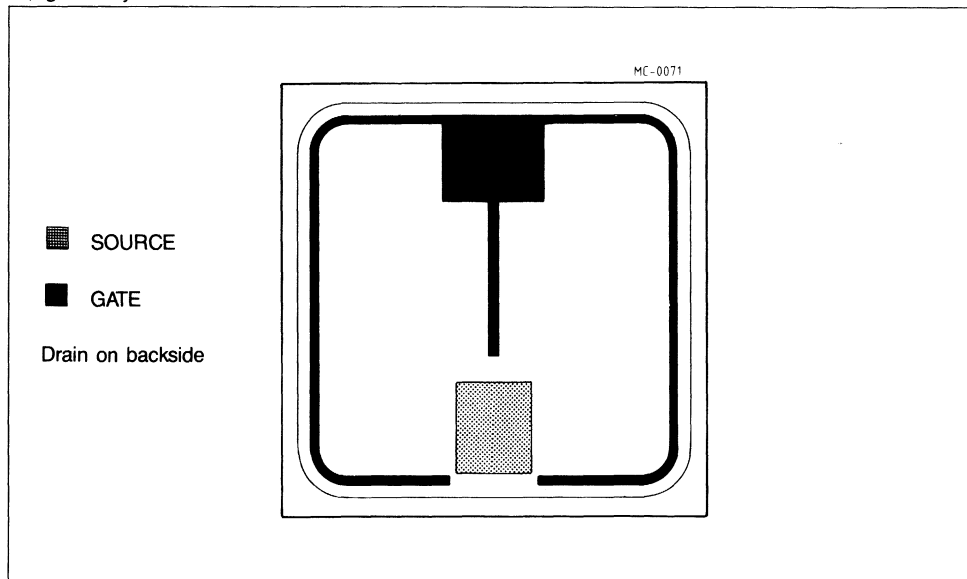
**SCHEMATIC DIAGRAM**



| $V_{DS}$ | $R_{DS(on)}$  | $I_D^*$ |
|----------|---------------|---------|
| 100 V    | 0.27 $\Omega$ | 9.2 A   |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thj-c}$  max. 3.12°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

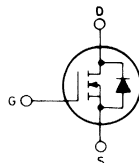
| Parameters                                             | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|--------------------------------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> Drain-source breakdown voltage   | I <sub>D</sub> = 250 μA      V <sub>GS</sub> = 0                                             | 100  |      |             | V        |
| I <sub>DSS</sub> Zero gate voltage drain current       | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | μA<br>μA |
| I <sub>GSS</sub> Gate-body leakage current             | V <sub>GS</sub> = ±20 V                                                                      |      |      | 100         | nA       |
| V <sub>GS (th)</sub> Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 250 μA                                    | 2    |      | 4           | V        |
| R <sub>DS (on)</sub> Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 0.27        | Ω        |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width < 300 μs, duty cycle < 2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- **DIE SIZE:** 170 × 170 mils
- **METALLIZATION:**
  - Top Al
  - Back Au/Cr/Ni/Au
- **BACKSIDE THICKNESS:** 6100 Å
- **DIE THICKNESS:** 16 ± 2 mils
- **PASSIVATION:** P-Vapox
- **BONDING PAD SIZE:**
  - Source 47 × 51 mils
  - Gate 15 × 18 mils
- **RECOMMENDED WIRE BONDING:**
  - Source Al - max 20 mils
  - Gate Al - max 5 mils

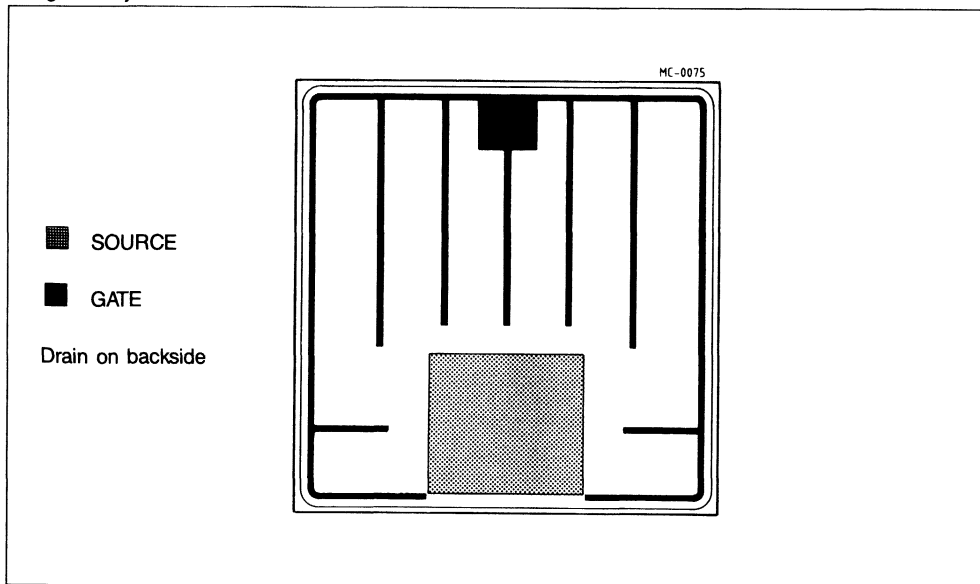
**SCHEMATIC DIAGRAM**



| $V_{DS}$ | $R_{DS(on)}$   | $I_D^*$ |
|----------|----------------|---------|
| 100 V    | 0.077 $\Omega$ | 28 A    |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thjc}$  max. 1°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

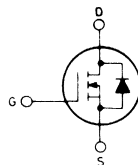
| Parameters                                             | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|--------------------------------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> Drain-source breakdown voltage   | I <sub>D</sub> = 250 μA      V <sub>GS</sub> = 0                                             | 100  |      |             | V        |
| I <sub>DSS</sub> Zero gate voltage drain current       | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | μA<br>μA |
| I <sub>GSS</sub> Gate-body leakage current             | V <sub>GS</sub> = ±20 V                                                                      |      |      | 100         | nA       |
| V <sub>GS (th)</sub> Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 250 μA                                    | 2    |      | 4           | V        |
| R <sub>DS (on)</sub> Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 77          | mΩ       |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 μs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR IN DIE FORM

- DIE SIZE: 110 × 110 mils
- METALLIZATION:
  - Top Al
  - Back Au/Cr/Ni/Au
- BACKSIDE THICKNESS: 6100 Å
- DIE THICKNESS: 16 ± 2 mils
- PASSIVATION: P-Vapox
- BONDING PAD SIZE:
  - Source 19 × 27 mils
  - Gate 30 × 20 mils
- RECOMMENDED WIRE BONDING:
  - Source Al - max 7 mils
  - Gate Al - max 7 mils

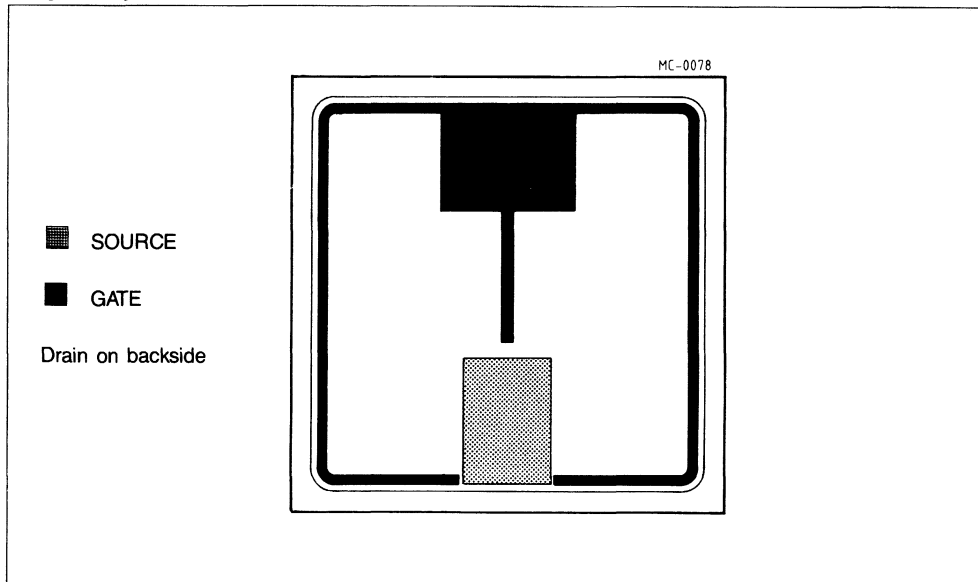
### SCHEMATIC DIAGRAM



| $V_{DS}$ | $R_{DS(on)}$ | $I_D^*$ |
|----------|--------------|---------|
| 200 V    | 0.8 $\Omega$ | 5 A     |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

### Die geometry



\* With  $R_{\theta j-c}$  max. 3.12°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

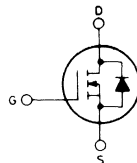
| Parameters                                             | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|--------------------------------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> Drain-source breakdown voltage   | I <sub>D</sub> = 250 μA      V <sub>GS</sub> = 0                                             | 200  |      |             | V        |
| I <sub>DSS</sub> Zero gate voltage drain current       | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | μA<br>μA |
| I <sub>GSS</sub> Gate-body leakage current             | V <sub>GS</sub> = ±20 V                                                                      |      |      | 100         | nA       |
| V <sub>GS (th)</sub> Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 250 μA                                    | 2    |      | 4           | V        |
| R <sub>DS (on)</sub> Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 0.8         | Ω        |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 μs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- DIE SIZE: 110 × 110 mils
- METALLIZATION:
  - Top Al
  - Back Au/Cr/Ni/Au
- BACKSIDE THICKNESS: 6100 Å
- DIE THICKNESS: 16 ± 2 mils
- PASSIVATION: P-Vapox
- BONDING PAD SIZE:
  - Source 16 × 21 mils
  - Gate 22 × 15 mils
- RECOMMENDED WIRE BONDING:
  - Source Al - max 7 mils
  - Gate Al - max 7 mils

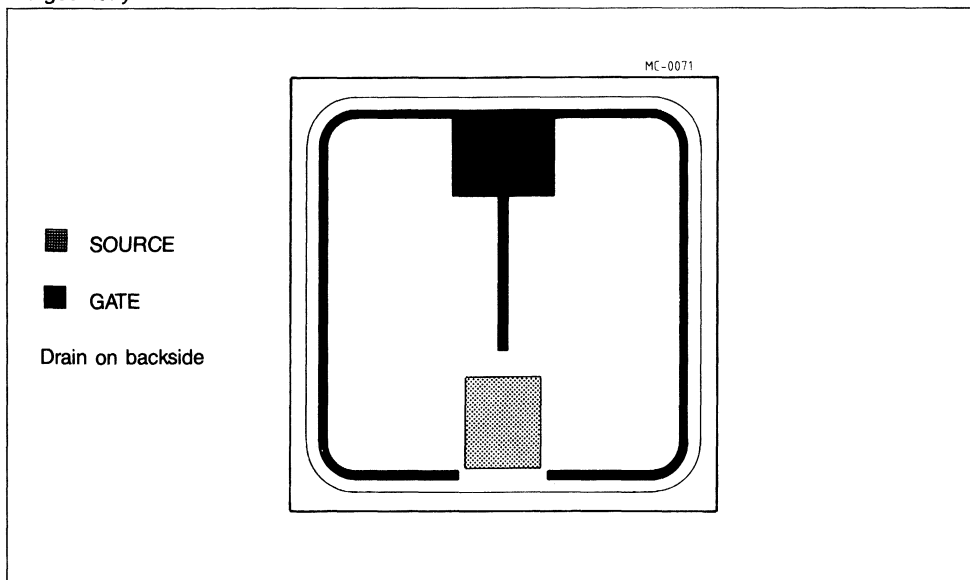
**SCHEMATIC DIAGRAM**



| $V_{DS}$ | $R_{DS(on)}$ | $I_D^*$ |
|----------|--------------|---------|
| 400 V    | 1.8 $\Omega$ | 3.3 A   |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thjc}$  max. 3.12°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub>= 25°C, Note 1)

| Parameters            |                                   | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> | Drain-source breakdown voltage    | I <sub>D</sub> = 250 μA      V <sub>GS</sub> = 0                                             | 400  |      |             | V        |
| I <sub>DSS</sub>      | Zero gate voltage drain current   | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | μA<br>μA |
| I <sub>GSS</sub>      | Gate-body leakage current         | V <sub>GS</sub> = ± 20 V                                                                     |      |      | 100         | nA       |
| V <sub>GS (th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 250 μA                                    | 2    |      | 4           | V        |
| R <sub>DS (on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 1.8         | Ω        |

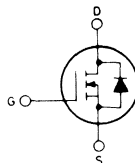
NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width < 300 μs, duty cycle < 2%  
2 - For detailed device characteristics please refer to the discrete device datasheet



**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- DIE SIZE: 156 × 156 mils
- METALLIZATION:
  - Top Al
  - Back Au / Cr / Ni / Au
- BACKSIDE THICKNESS: 6100 Å
- DIE THICKNESS: 16 ± 2 mils
- PASSIVATION: P-Vapox
- BONDING PAD SIZE:
  - Source 30 × 24 mils
  - Gate 20 × 16 mils
- RECOMMENDED WIRE BONDING:
  - Source Al - max 10 mils
  - Gate Al - max 7 mils

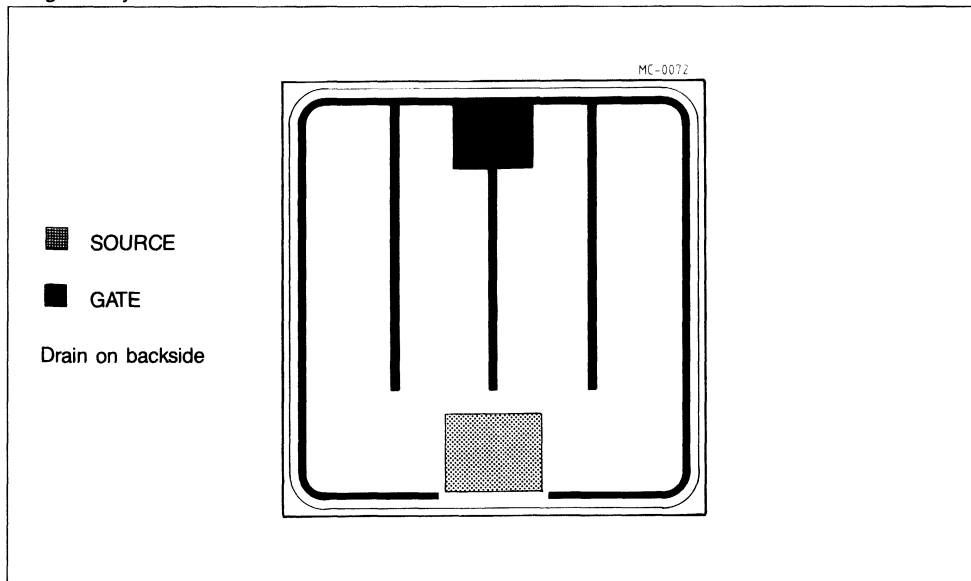
**SCHEMATIC DIAGRAM**



| $V_{DS}$ | $R_{DS(on)}$ | $I_D^*$ |
|----------|--------------|---------|
| 400 V    | 1 $\Omega$   | 5.5 A   |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thjc}$  max. 1.67°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

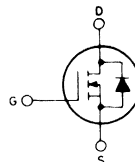
| Parameters            |                                   | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> | Drain-source breakdown voltage    | I <sub>D</sub> = 250 µA      V <sub>GS</sub> = 0                                             | 400  |      |             | V        |
| I <sub>DSS</sub>      | Zero gate voltage drain current   | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | µA<br>µA |
| I <sub>GSS</sub>      | Gate-body leakage current         | V <sub>GS</sub> = ±20 V                                                                      |      |      | 100         | nA       |
| V <sub>GS (th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 250 µA                                    | 2    |      | 4           | V        |
| R <sub>DS (on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 1           | Ω        |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 µs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- DIE SIZE: 180 × 220 mils
- METALLIZATION:
  - Top Al
  - Back Au / Cr / Ni / Au
- BACKSIDE THICKNESS: 6100 Å
- DIE THICKNESS: 16 ± 2 mils
- PASSIVATION: P-Vapox
- BONDING PAD SIZE:
  - Source 29 × 23 mils
  - Gate 20 × 16 mils
- RECOMMENDED WIRE BONDING:
  - Source Al - max 10 mils
  - Gate Al - max 6 mils

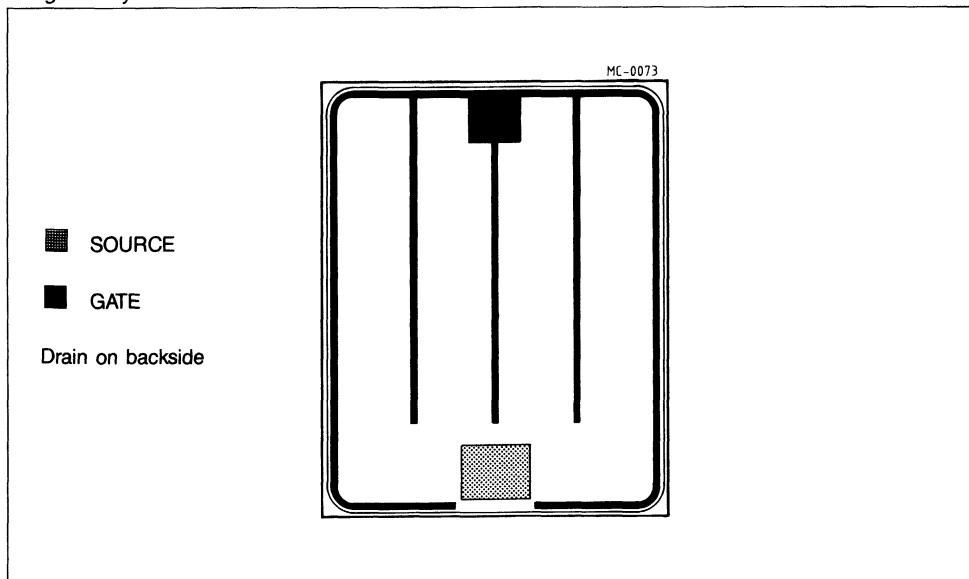
**SCHEMATIC DIAGRAM**



| $V_{DSS}$ | $R_{DS(on)}$  | $I_D^*$ |
|-----------|---------------|---------|
| 400 V     | 0.55 $\Omega$ | 10 A    |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thjc}$  max. 1°C/W

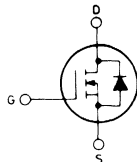
GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

| Parameters                                             | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|--------------------------------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> Drain-source breakdown voltage   | I <sub>D</sub> = 250 μA      V <sub>GS</sub> = 0                                             | 400  |      |             | V        |
| I <sub>DSS</sub> Zero gate voltage drain current       | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>J</sub> = 125°C |      |      | 250<br>1000 | μA<br>μA |
| I <sub>GSS</sub> Gate-body leakage current             | V <sub>GS</sub> = ±20 V                                                                      |      |      | 100         | nA       |
| V <sub>GS (th)</sub> Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 250 μA                                    | 2    |      | 4           | V        |
| R <sub>DS (on)</sub> Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 0.55        | Ω        |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 μs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR IN DIE FORM

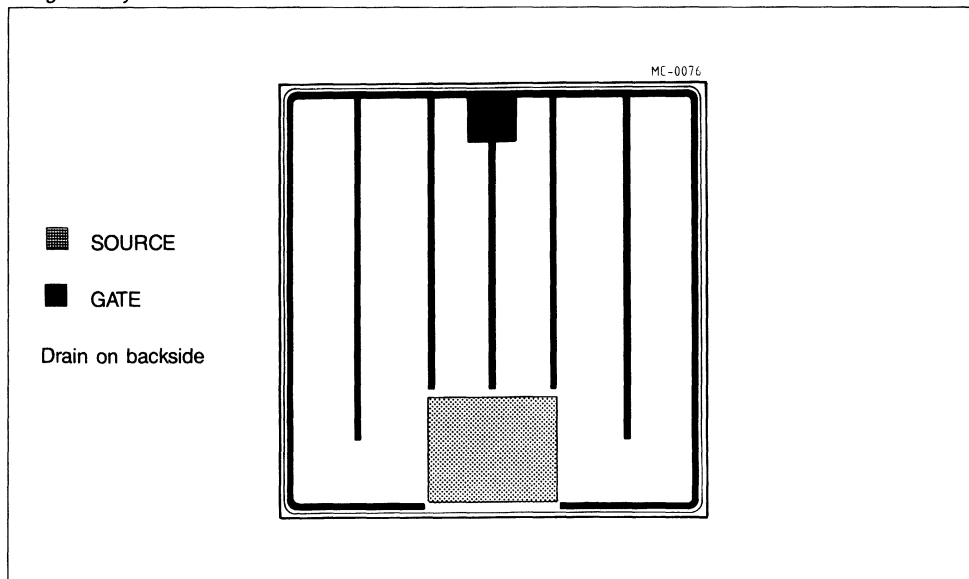
- DIE SIZE: 221 × 221 mils
- METALLIZATION:
  - Top Al
  - Back Au / Cr / Ni / Au
- BACKSIDE THICKNESS: 6100 Å
- DIE THICKNESS: 16 ± 2 mils
- PASSIVATION: P-Vapox
- BONDING PAD SIZE:
  - Source 56 × 43 mils
  - Gate 18 × 18 mils
- RECOMMENDED WIRE BONDING:
  - Source Al - max 20 mils
  - Gate Al - max 7 mils

**SCHEMATIC DIAGRAM**


| $V_{DS}$ | $R_{DS(on)}$   | $I_D^*$ |
|----------|----------------|---------|
| 60 V     | 0.028 $\Omega$ | 40 A    |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

### Die geometry



\* With  $R_{thjc}$  max. 0.83°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS ( $T_j = 25^\circ\text{C}$ , Note 1)

| Parameters                                      | Test Conditions                                                                                   | Min. | Typ. | Max.        | Unit                           |
|-------------------------------------------------|---------------------------------------------------------------------------------------------------|------|------|-------------|--------------------------------|
| $V_{(BR) DSS}$ Drain-source breakdown voltage   | $I_D = 250 \mu\text{A}$ $V_{GS} = 0$                                                              | 60   |      |             | V                              |
| $I_{DSS}$ Zero gate voltage drain current       | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating} \times 0.8$ $T_j = 125^\circ\text{C}$ |      |      | 250<br>1000 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$ Gate-body leakage current             | $V_{GS} = \pm 20 \text{ V}$                                                                       |      |      | 100         | nA                             |
| $V_{GS (th)}$ Gate threshold voltage            | $V_{DS} = V_{GS}$ $I_D = 1 \text{ mA}$                                                            | 2    |      | 4.5         | V                              |
| $R_{DS (on)}$ Static drain-source on resistance | $V_{GS} = 10 \text{ V}$ $I_D = 1 \text{ A}$                                                       |      |      | 28          | $\text{m}\Omega$               |

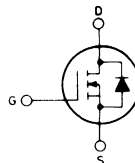
NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width  $< 300 \mu\text{s}$ , duty cycle  $< 2\%$

2 - For detailed device characteristics please refer to the discrete device datasheet

**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- **DIE SIZE:** 52 x 53 mils
- **METALLIZATION:**
  - Top Al
  - Back Au/Cr/Ni/Au
- **BACKSIDE THICKNESS:** 6100 Å
- **DIE THICKNESS:** 16 ± 2 mils
- **PASSIVATION:** P-Vapox
- **BONDING PAD SIZE:**
  - Source 4.4 x 6.5 mils
  - Gate 4.4 x 6.5 mils
- **RECOMMENDED WIRE BONDING:**
  - Source Au - max 2 mils
  - Gate Au - max 2 mils

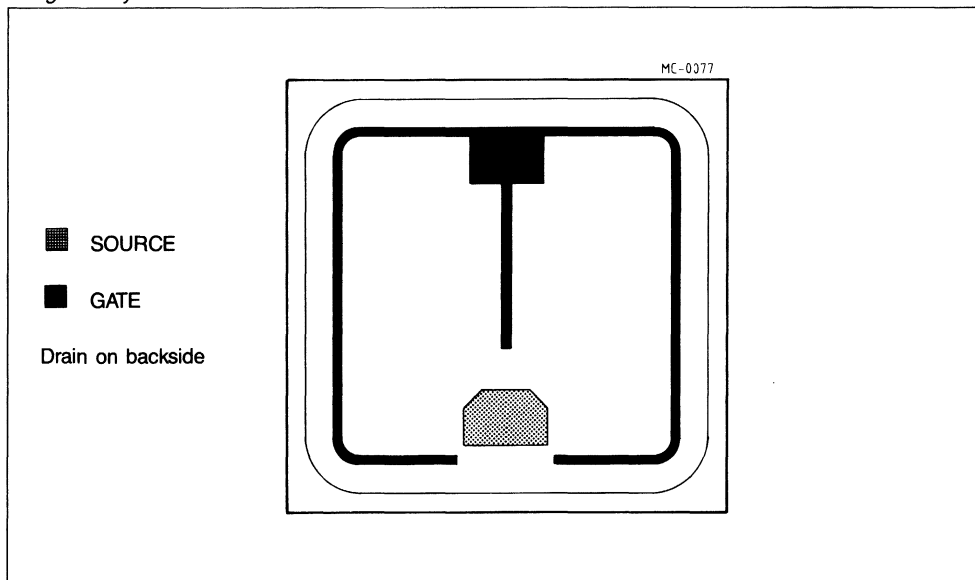
**SCHEMATIC DIAGRAM**



| $V_{DS}$ | $R_{DS(on)}$ | $I_D^*$ |
|----------|--------------|---------|
| 100 V    | 1.4 $\Omega$ | 2.0 A   |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thj-c}$  max. 6.95°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

| Parameters            |                                   | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> | Drain-source breakdown voltage    | I <sub>D</sub> = 250 µA      V <sub>GS</sub> = 0                                             | 100  |      |             | V        |
| I <sub>DSS</sub>      | Zero gate voltage drain current   | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | µA<br>µA |
| I <sub>GSS</sub>      | Gate-body leakage current         | V <sub>GS</sub> = ±20 V                                                                      |      |      | ± 100       | nA       |
| V <sub>GS (th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 250 µA                                    | 2    |      | 4           | V        |
| R <sub>DS (on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 1.4         | Ω        |

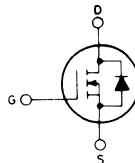
NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 µs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet



**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- DIE SIZE: 52 x 53 mils
- METALLIZATION:
  - Top Al
  - Back Au/Cr/Ni/Au
- BACKSIDE THICKNESS: 6100 Å
- DIE THICKNESS: 16 ± 2 mils
- PASSIVATION: P-Vapox
- BONDING PAD SIZE:
  - Source 10 x 5 mils
  - Gate 5 x 6 mils
- RECOMMENDED WIRE BONDING:
  - Source Au - max 2 mils
  - Gate Au - max 2 mils

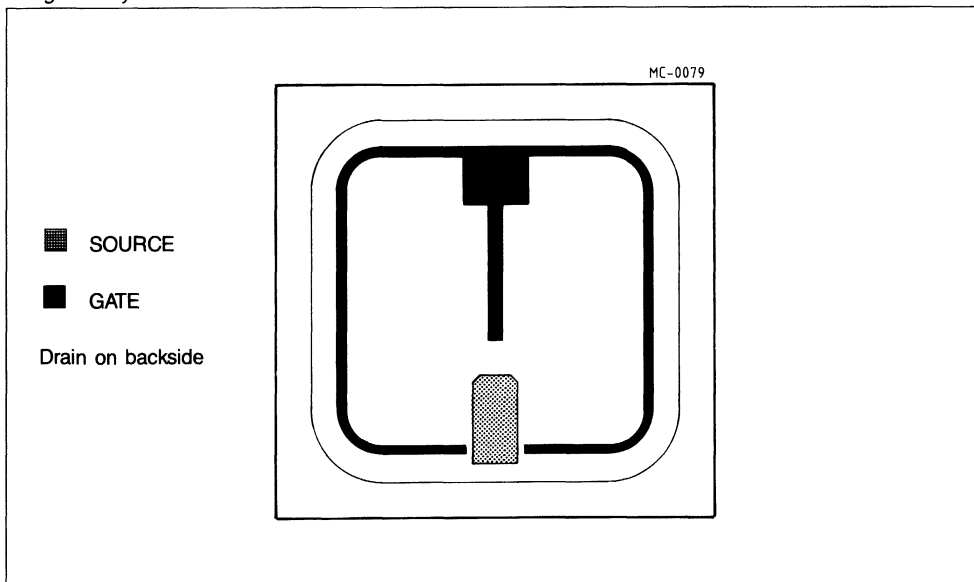
**SCHEMATIC DIAGRAM**



| $V_{DS}$ | $R_{DS(on)}$ | $I_D^*$ |
|----------|--------------|---------|
| 400 V    | 20 $\Omega$  | 0.6 A   |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thjc}$  max. 6.8°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

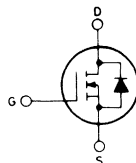
| Parameters            |                                   | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> | Drain-source breakdown voltage    | I <sub>D</sub> = 250 µA      V <sub>GS</sub> = 0                                             | 400  |      |             | V        |
| I <sub>DSS</sub>      | Zero gate voltage drain current   | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | µA<br>µA |
| I <sub>GSS</sub>      | Gate-body leakage current         | V <sub>GS</sub> = ±20 V                                                                      |      |      | ± 100       | nA       |
| V <sub>GS (th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 250 µA                                    | 2    |      | 4           | V        |
| R <sub>DS (on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 0.3 A                                           |      |      | 20          | Ω        |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 µs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

**N - CHANNEL ENHANCEMENT MODE  
POWER MOS TRANSISTOR IN DIE FORM**

- DIE SIZE: 77 × 77 mils
- METALLIZATION:
  - Top Al
  - Back Au / Cr / Ni / Au
- BACKSIDE THICKNESS: 6100 Å
- DIE THICKNESS: 16 ± 2 mils
- PASSIVATION: P-Vapox
- BONDING PAD SIZE:
  - Source 15 × 15 mils
  - Gate 17 × 19 mils
- RECOMMENDED WIRE BONDING:
  - Source Au - max 5 mils
  - Gate Au - max 2 mils

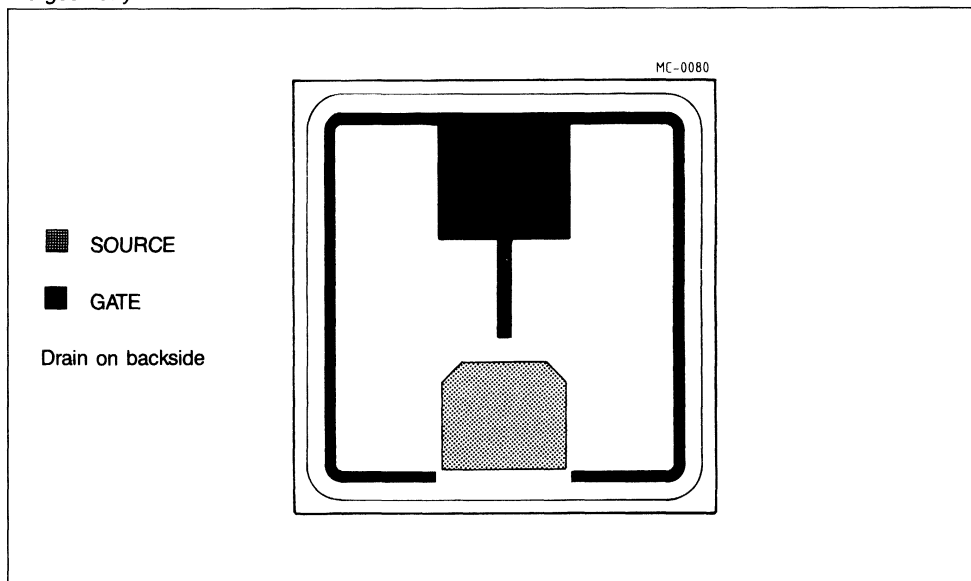
**SCHEMATIC DIAGRAM**



| $V_{DS}$ | $R_{DS(on)}$ | $I_D^*$ |
|----------|--------------|---------|
| 50 V     | 0.3 $\Omega$ | 7 A     |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

*Die geometry*



\* With  $R_{thj-c}$  max. 2.5°C/W

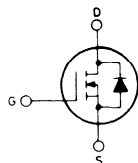
GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

| Parameters            |                                   | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> | Drain-source breakdown voltage    | I <sub>D</sub> = 250 µA      V <sub>GS</sub> = 0                                             | 50   |      |             | V        |
| I <sub>DSS</sub>      | Zero gate voltage drain current   | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | µA<br>µA |
| I <sub>GSS</sub>      | Gate-body leakage current         | V <sub>GS</sub> = ±20 V                                                                      |      |      | 100         | nA       |
| V <sub>GS (th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 250 µA                                    | 2    |      | 4           | V        |
| R <sub>DS (on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 0.3         | Ω        |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 µs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

## N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR IN DIE FORM

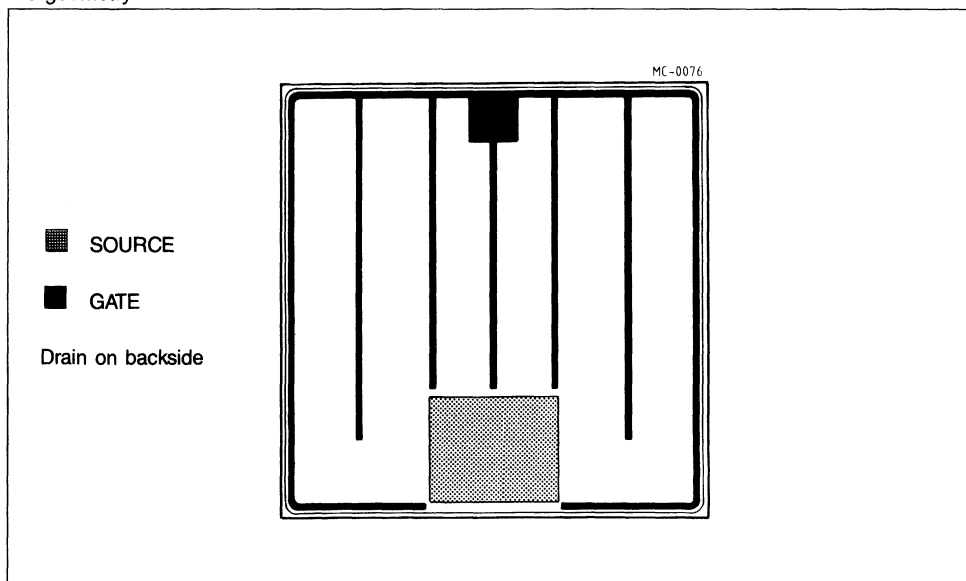
- **DIE SIZE:** 221 × 221 mils
- **METALLIZATION:**
  - Top Al
  - Back Au/Cr/Ni/Au
- **BACKSIDE THICKNESS:** 6100 Å
- **DIE THICKNESS:** 16 ± 2 mils
- **PASSIVATION:** P-Vapox
- **BONDING PAD SIZE:**
  - Source 56 × 43 mils
  - Gate 18 × 18 mils
- **RECOMMENDED WIRE BONDING:**
  - Source Al - max 20 mils
  - Gate Al - max 7 mils

**SCHEMATIC DIAGRAM**


| $V_{DS}$ | $R_{DS(on)}$  | $I_D^*$ |
|----------|---------------|---------|
| 200 V    | 0.17 $\Omega$ | 20 A    |

N-channel enhancement mode POWER MOS field effect transistor. Easy drive and very fast switching times make this POWER MOS ideal for high speed switching applications.

### Die geometry



\* With  $R_{thjc}$  max. 0.83°C/W

GUARANTEED PROBED ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C, Note 1)

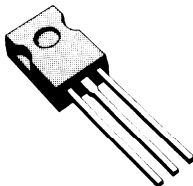
| Parameters            |                                   | Test Conditions                                                                              | Min. | Typ. | Max.        | Unit     |
|-----------------------|-----------------------------------|----------------------------------------------------------------------------------------------|------|------|-------------|----------|
| V <sub>(BR) DSS</sub> | Drain-source breakdown voltage    | I <sub>D</sub> = 250 μA      V <sub>GS</sub> = 0                                             | 200  |      |             | V        |
| I <sub>DSS</sub>      | Zero gate voltage drain current   | V <sub>DS</sub> = Max Rating<br>V <sub>DS</sub> = Max Rating × 0.8    T <sub>j</sub> = 125°C |      |      | 250<br>1000 | μA<br>μA |
| I <sub>GSS</sub>      | Gate-body leakage current         | V <sub>GS</sub> = ±20 V                                                                      |      |      | 100         | nA       |
| V <sub>GS (th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> I <sub>D</sub> = 250 μA                                    | 2    |      | 4           | V        |
| R <sub>DS (on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V      I <sub>D</sub> = 1 A                                             |      |      | 0.17        | Ω        |

NOTES: 1 - Due to probe testing limitations dc parameters only are tested. They are measured using pulse techniques: pulse width <300 μs, duty cycle <2%  
2 - For detailed device characteristics please refer to the discrete device datasheet

# PACKAGES

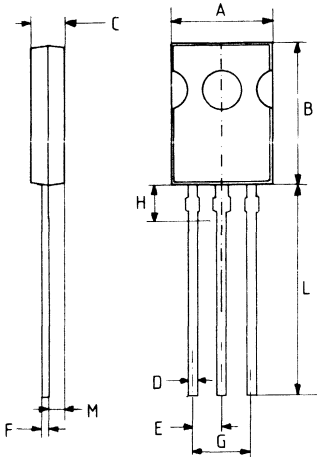






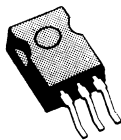
**MINIATURE PACKAGE  
WITH SAME PINOUT  
AS TO-220 IDEAL FOR  
MOUNTING WITH CLIPS**

**MECHANICAL DATA**



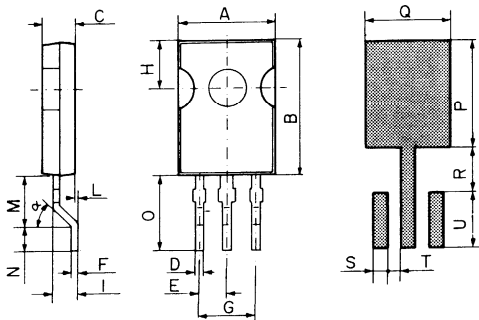
PC-0303

|   | DIMENSIONS |      |            |       |
|---|------------|------|------------|-------|
|   | mm         |      | inches     |       |
|   | min        | max  | min        | max   |
| A | 7.4        | 7.8  | 0.295      | 0.307 |
| B | 10.5       | 10.8 | 0.413      | 0.425 |
| C | 2.4        | 2.7  | 0.094      | 0.106 |
| D | 0.7        | 0.9  | 0.027      | 0.035 |
| E | 2.2 typ.   |      | 0.087 typ. |       |
| F | 0.49       | 0.75 | 0.019      | 0.029 |
| G | 4.4 typ.   |      | 0.173 typ. |       |
| H | 2.54 typ.  |      | 0.100 typ. |       |
| L | 15.7 typ.  |      | 0.618 typ. |       |
| M | 1.2 typ.   |      | 0.047 typ. |       |



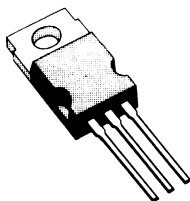
LEAD FORMED  
SOT-82 FOR SURFACE  
MOUNTING ASSEMBLY

MECHANICAL DATA

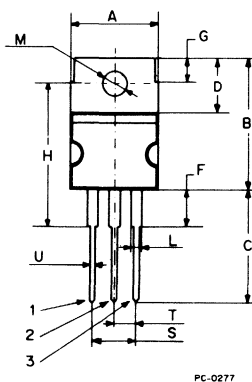


PC-0276

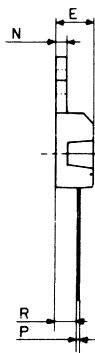
|   | DIMENSIONS |      |            |       |
|---|------------|------|------------|-------|
|   | mm         |      | inches     |       |
|   | min        | max  | min        | max   |
| A | 7.4        | 7.8  | 0.295      | 0.307 |
| B | 10.5       | 10.8 | 0.413      | 0.425 |
| C | 2.4        | 2.7  | 0.094      | 0.106 |
| D | 0.7        | 0.9  | 0.027      | 0.035 |
| E | 2.2 typ.   |      | 0.087 typ. |       |
| F | 0.45       | 0.65 | 0.017      | 0.026 |
| G | 4.4 typ.   |      | 0.173 typ. |       |
| H | 3.8 typ.   |      | 0.149 typ. |       |
| I | 1.8 typ.   |      | 0.070 typ. |       |
| L | 0.1 typ.   |      | 0.004 typ. |       |
| M | 3.8        | 4.2  | 0.149      | 0.165 |
| N | 2 typ.     |      | 0.078 typ. |       |
| O | 6 typ.     |      | 0.236 typ. |       |
| α | 45°        |      | 45°        |       |
| P | 8.5 typ.   |      | 0.334 typ. |       |
| Q | 6.7 typ.   |      | 0.263 typ. |       |
| R | 3.5 typ.   |      | 0.137 typ. |       |
| S | 1.2 typ.   |      | 0.047 typ. |       |
| T | 1 typ.     |      | 0.039 typ. |       |
| U | 4.5 typ.   |      | 0.177 typ. |       |



## MECHANICAL DATA

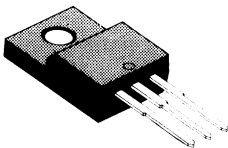


PC-0277



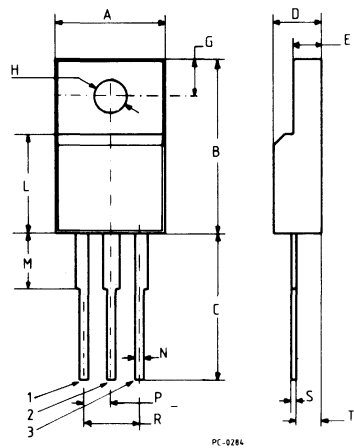
|   | DIMENSIONS |      |            |       |
|---|------------|------|------------|-------|
|   | mm         |      | inches     |       |
|   | min        | max  | min        | max   |
| A | 10         | 10.4 | 0.393      | 0.409 |
| B | 15.2       | 15.9 | 0.598      | 0.626 |
| C | 12.7       | 13.7 | 0.500      | 0.539 |
| D | 6.2        | 6.6  | 0.244      | 0.260 |
| E | 4.4        | 4.6  | 0.173      | 0.181 |
| F | 3.5        | 5.5  | 0.137      | 0.216 |
| G | 2.65       | 2.95 | 0.104      | 0.116 |
| H | 17.6 typ.  |      | 0.692 typ. |       |
| L | 1.14       | 1.7  | 0.044      | 0.067 |
| M | 3.75       | 3.85 | 0.147      | 0.151 |
| N | 1.23       | 1.32 | 0.048      | 0.051 |
| P | 0.41       | 0.64 | 0.016      | 0.025 |
| R | 2.4        | 2.72 | 0.094      | 0.107 |
| S | 4.95       | 5.15 | 0.194      | 0.203 |
| T | 2.4        | 2.7  | 0.094      | 0.106 |
| U | 0.61       | 0.94 | 0.024      | 0.037 |

pin 1: GATE - pin 2: DRAIN - pin 3: SOURCE



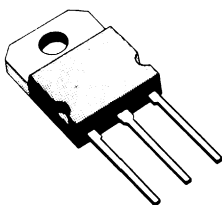
2000V DC FULLY ISOLATED VERSION  
OF THE TO-220 PACKAGE

MECHANICAL DATA

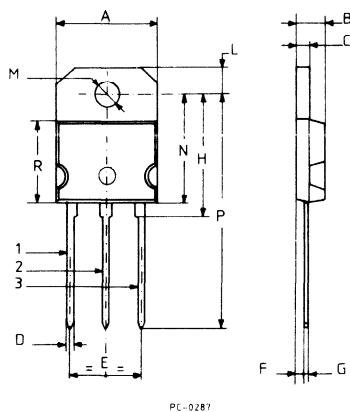


|   | DIMENSIONS |      |        |       |
|---|------------|------|--------|-------|
|   | mm         |      | inches |       |
|   | min        | max  | min    | max   |
| A | 9.8        | 10.6 | 0.386  | 0.417 |
| B | 15.7       | 16.5 | 0.618  | 0.649 |
| C | 12.7       | 14.1 | 0.500  | 0.555 |
| D | 4.18       | 4.82 | 0.164  | 0.189 |
| E | 2.3        | 2.9  | 0.090  | 0.114 |
| G | 3          | 3.8  | 0.118  | 0.149 |
| H | 3          | 3.2  | 0.118  | 0.126 |
| L | 9          | 9.4  | 0.354  | 0.370 |
| M | —          | 6.35 | —      | 0.250 |
| N | 0.63       | 1    | 0.024  | 0.039 |
| P | 2.29       | 2.79 | 0.090  | 0.109 |
| R | 4.83       | 5.33 | 0.190  | 0.209 |
| S | 0.33       | 0.66 | 0.013  | 0.026 |
| T | 2.28       | 2.9  | 0.089  | 0.114 |

pin 1: GATE - pin 2: DRAIN - pin 3: SOURCE

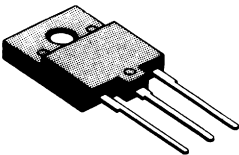


## MECHANICAL DATA



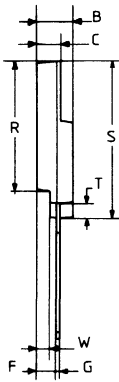
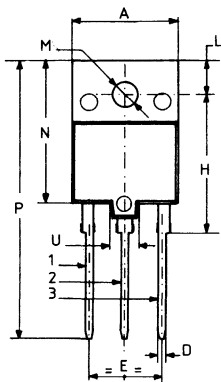
|   | DIMENSIONS |      |           |       |
|---|------------|------|-----------|-------|
|   | mm         |      | inches    |       |
|   | min        | max  | min       | max   |
| A | 14.7       | 15.2 | 0.578     | 0.598 |
| B | 4.7        | 4.9  | 0.185     | 0.193 |
| C | 1.9        | 2.1  | 0.075     | 0.082 |
| D | 1.1        | 1.3  | 0.043     | 0.051 |
| E | 10.8       | 11.1 | 0.425     | 0.437 |
| F | 2.5 typ    |      | 0.098 typ |       |
| G | 0.5        | 0.78 | 0.019     | 0.030 |
| H | 18 typ     |      | 0.708 typ |       |
| L | 3.95       | 4.15 | 0.155     | 0.163 |
| M | 4          | 4.1  | 0.157     | 0.161 |
| N | —          | 16.2 | —         | 0.637 |
| P | 31 typ     |      | 1.220 typ |       |
| R | —          | 12.2 | —         | 0.480 |

pin 1: GATE - pin 2: DRAIN - pin 3: SOURCE



4000V DC FULLY ISOLATED  
VERSION OF THE TO-218  
PACKAGE CONFORMS TO UL AND  
VDE SAFETY STANDARDS

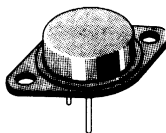
MECHANICAL DATA



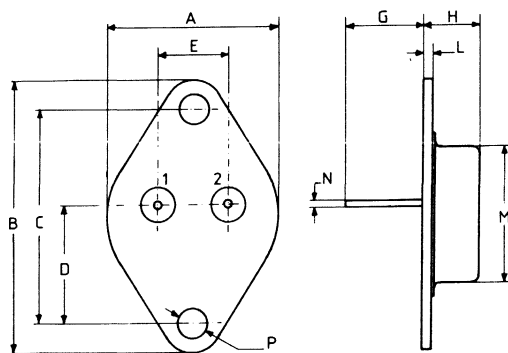
PC-0288

|   | DIMENSIONS |       |            |       |
|---|------------|-------|------------|-------|
|   | mm         |       | inches     |       |
|   | min        | max   | min        | max   |
| A | 15.8       | 16.2  | 0.622      | 0.637 |
| B | 5.35       | 5.65  | 0.210      | 0.222 |
| C | 3.3        | 3.8   | 0.130      | 0.149 |
| D | 1.05       | 1.25  | 0.041      | 0.049 |
| E | 10.8       | 11.2  | 0.425      | 0.441 |
| F | 2.9        | 3.1   | 0.114      | 0.122 |
| G | 0.45       | 1     | 0.017      | 0.039 |
| H | 20.25      | 20.75 | 0.797      | 0.817 |
| L | 4.85       | 5.25  | 0.190      | 0.206 |
| M | 3.5        | 3.7   | 0.137      | 0.145 |
| N | 20.8       | 21.2  | 0.818      | 0.834 |
| P | 40.5       | 42.5  | 1.594      | 1.673 |
| R | 19.1       | 19.9  | 0.752      | 0.783 |
| S | 22.8       | 23.6  | 0.897      | 0.929 |
| T | 2.1        | 2.3   | 0.082      | 0.090 |
| U | 4.6 typ.   |       | 0.181 typ. |       |
| W | 1.88       | 2.08  | 0.074      | 0.081 |

pin 1: GATE - pin 2: DRAIN - pin 3: SOURCE



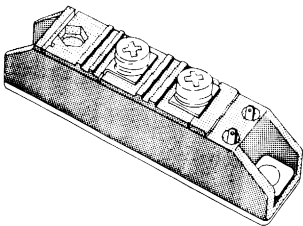
## MECHANICAL DATA



PC-4295A

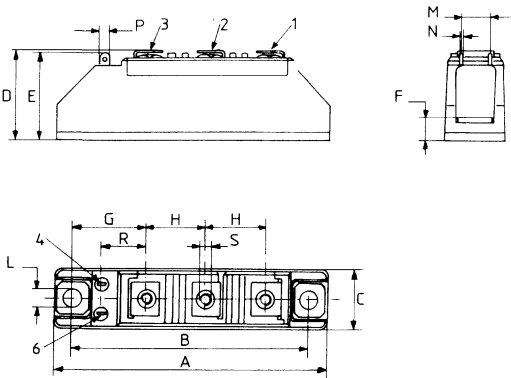
|   | DIMENSIONS |      |        |       |
|---|------------|------|--------|-------|
|   | mm         |      | inches |       |
|   | min        | max  | min    | max   |
| A | 25         | 26   | 0.984  | 1.023 |
| B | 38.5       | 39.3 | 1.515  | 1.547 |
| C | 30         | 30.3 | 1.181  | 1.193 |
| D | 16.5       | 17.2 | 0.649  | 0.677 |
| E | 10.7       | 11.1 | 0.421  | 0.437 |
| G | 11         | 13.1 | 0.433  | 0.515 |
| H | 8.32       | 8.92 | 0.327  | 0.351 |
| L | 1.5        | 1.65 | 0.059  | 0.065 |
| M | 19         | 20   | 0.748  | 0.787 |
| N | 0.97       | 1.15 | 0.038  | 0.045 |
| P | 4          | 4.09 | 0.157  | 0.161 |

pin 1: GATE - pin 2: DRAIN - pin 3: SOURCE



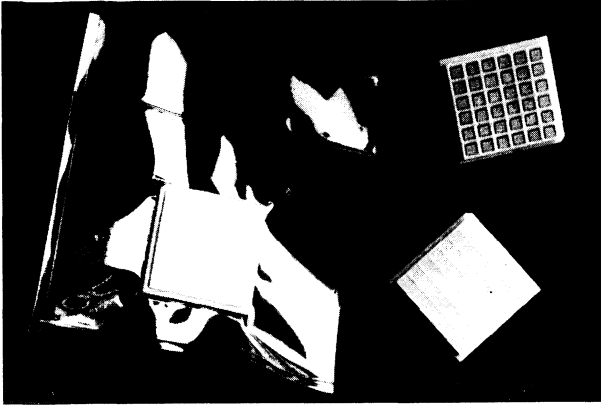
4000V DC  
FULLY ISOLATED  
INDUSTRY STANDARD MODULE  
MEETS UL AND VDE  
SAFETY STANDARDS

MECHANICAL DATA

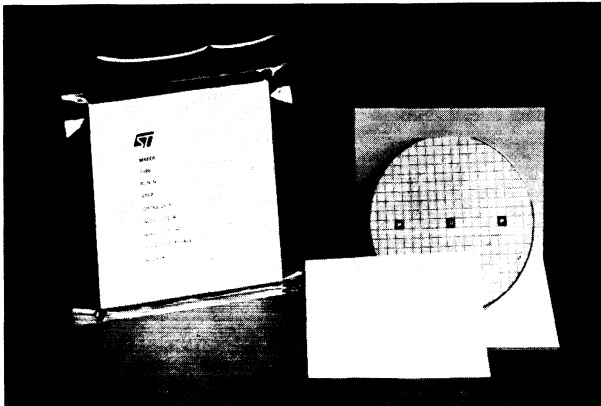


|   | DIMENSIONS |       |            |       |
|---|------------|-------|------------|-------|
|   | mm         |       | inches     |       |
|   | min        | max   | min        | max   |
| A | 91.5       | 92.5  | 3.602      | 3.641 |
| B | 79.75      | 80.25 | 3.140      | 3.160 |
| C | 19.5       | 20.55 | 0.767      | 0.809 |
| D | 29.00      | 31.00 | 1.141      | 1.220 |
| E | 28.8       | 30    | 1.134      | 1.181 |
| F | 8.5 typ.   |       | 0.334 typ. |       |
| G | 24.4 typ.  |       | 0.960 typ. |       |
| H | 19.5       | 20.5  | 0.767      | 0.807 |
| L | 6.2 typ.   |       | 0.244 typ. |       |
| M | 8.95       | 11.05 | 0.352      | 0.435 |
| N | 0.78       | 0.84  | 0.030      | 0.033 |
| P | 2.72       | 2.87  | 0.107      | 0.113 |
| R | 14         | —     | 0.551      | —     |
| S | M5         |       |            |       |





**Waffle pack (cavity plate)**  
Suffix D2: dice in cavity plate



**Wafer pack**  
Suffix D1: wafer tested and inked  
Suffix D3: wafer tested, inked and scribed at 70%



**Circle pack**  
Suffix D4: wafer tested inked and scribed at 100%





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