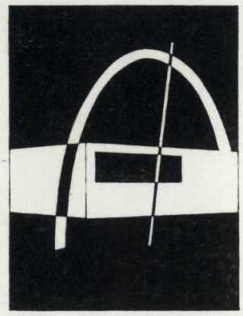
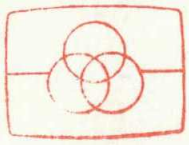
PHILIPS





# Digital dc voltmeter





# PM2441

9447 024 410.1

9499 470 09611 740102/05/..

PHILIPS




# Manual

# Digital dc voltmeter PM2441

9447 024 410.1

PHILIPS

9499 470 09611 740102/05/··

# Contents





PRINTED IN THE NETHERLANDS

# List of Figures

# I. Introduction

## GENERAL



The digital DC Voltmeter PM 2441 is an accurate $4\frac{1}{2}$ digit instrument with a maximum display of 19999.
The instrument measures DC voltages from 20 mV to 1000 V full scale, divided in 6 ranges.
Range switching, polarity-, mV- or V- and decimal point indication is effected either manually by means of push-buttons, or automatically. No matter what the amplitude of the signal, it is measured automatically with the optimum resolution.
In case of overload, the whole display flashes on and off.
The isolated inner housing (Guard) enables floating measurements to be made, which are less affected by common mode voltage.

With the optional PM 9230 (Remote Control) the instrument can be fully "remote controlled". Digital information such as range, polarity, result, overload etc. can be taken from the PM 2441, by application of the optional PM 9231 (Digital Output), to control a printer, a parallel-to-serial converter, etc.

To measure AC voltages, or resistance values, an additional input is available, to which an AC/DC- or OHM/DC- converter can be connected.

On account of its high sensitivity, its great accuracy and its versatility, the PM 2441 is an ideal instrument for research and development purposes, as well as application in automatic systems.

# II. Technical data

Properties expressed in numerical values with tolerances stated are guaranteed by the factory. Numerical values without tolerances serve only for infromation and represent the properties of an average instrument.

## II-1. MEASURING RANGE

### II-1.1. Direct voltage

Measuring range
- 1 µV up to 1000 V divided in 6 ranges

| Ranges | Resolution |
|---|---|
| 20 mV | 1 µV |
| 200 mV | 10 µV |
| 2 V | 100 µV |
| 20 V | 1 mV |
| 200 V | 10 mV |
| 1000 V | 100 mV |

Commutation point
- At the end of each representation unit

Input impedance
- Range 20 mV > 1 GΩ // 500 pF
- Range 200 mV, 2 V and 20 V > 10 GΩ // 500 pF
- Range 200 V and 1000 V 10 MΩ (± 1%) // 500 pF
- Input impedance constant during conversion cycle
- Apparatus non-operative > 10 GΩ
- No kick back from the input
- Impedance during overload 100 kΩ

Impedance:
- Low-Guard - 10 GΩ // 700 pF
- Guard-Ground - 50 GΩ // 1.5 nF
- Low-Ground - 60 GΩ // 700 pF

Input terminals
- Asymetrical
- Floating with respect to ground
- Guarded

Accuracy:
- Accuracy (± ... % of reading ± ... % of range)

| | Range 20 mV | Range 200 mV / 200 V | Range 1000 V |
|---|---|---|---|
| 24 hours, 23°C ± 1°C | 0.005 / 0.010 | 0.005 / 0.005 | 0.005 / 0.010 |
| 24 hours, 23°C ± 5°C | 0.010 / 0.023 | 0.010 / 0.010 | 0.010 / 0.020 |
| 1 month, 23°C ± 5°C | 0.012 / 0.041 | 0.012 / 0.012 | 0.012 / 0.024 |
| 3 month, 23°C ± 5°C | 0.017 / 0.048 | 0.017 / 0.014 | 0.017 / 0.028 |
| 6 month, 23°C ± 5°C | 0.040 / 0.084 | 0.040 / 0.018 | 0.040 / 0.036 |
| 3 month, 0°C - 45°C | 0.034 / 0.093 | 0.034 / 0.031 | 0.034 / 0.062 |
| Temperature coefficient | 0.001 / 0.0025 | 0.001 / 0.001 | 0.001 / 0.002 |

- Zeroing: 20-turn potentiometer accessible after removal of the case

| | |
|---|---|
| Input current | - < 10 pA |
| Drift input current | - < 2 pA / °C ; < 10 pA / month |
| Operating conditions | - According to Usage Group I. IEC359<br>- Temperature:<br>- Ambient temperature (reference value) 23°C ± 1°C<br>- Rated range of use 0 ... 55°C<br>- Limit range of storage and transport -40 ... +70°C<br>- Relative humidity:<br>- Reference range 47 ... 75%<br>- Rated range of use 20 ... 80% excluding condensation |

| Stability of the electrical zero and the output information | Time of test | Ranges 200 mV up to 1000 V | Range 20 mV |
|---|---|---|---|
| - Fluctuation | - | ± 1 digit | ± 1 digit |
| - Short-term drift | 24 hours | ± 1 digit | ± 2 digits |
| - Long-term drift | 3 months | ± 2 digits | ± 4 digits |

- Stability errors are not included in the operating error.

| | |
|---|---|
| Series mode rejection | - > 60 dB at a mains frequency of 50 Hz ± 0.1%<br>- Maximum series mode signal 150% of range (DC + AC peak) |
| Common mode rejection | - > 150 dB for DC signals (unbalance 1 kΩ)<br>- > 120 dB for AC signals at 50 Hz mains frequency<br>- Maximum common mode signal 250 V DC or $AC_{rms}$ |
| Input voltages | |
| High-Low | - 1000 V DC continuously on all ranges* |
| Low-Guard | - 250 V DC or AC |
| Guard-Ground | - 250 V DC or AC |

*for the ranges 20 mV up to 20 V to a maximum of 30 seconds.

## II-2. GENERAL DATA

| | |
|---|---|
| Principle of operation | - Dual Slope |
| Maximum display | - 19999 |
| Number of digits | - $4\frac{1}{2}$ |
| Representation of the result and polarity | - Numerical tubes<br>- Digital Output (optional) |
| Range selection | - Manual<br>- Automatic (max. 600 V DC)<br>- Remote-controlled |
| Automatic range selection | - Up-ranging at 20000<br>Down-ranging at 01800 |
| Overflow indication | - Flashing of the display |
| Conversion rate (intern) | - 4 conv./sec. (Sampling time 100 msec.)<br>- with Remote Control also 20 or 100 conv./sec. |

Conversion command
- Repetitive
- Manual (push-button)
- Electrical: via BNC socket, negative-going pulse
  H = +2.4 – +50 V
  L = -1.5 V – + 1 V
  width: 10 µsec. - 100 msec.

External conversion command - Max. conv./sec.

| Max. conv./sec. | Sampling time |
|---|---|
| 4 | 100 msec. |
| 20 | 20 msec.* |
| 100 | 2 msec.* |

* With Remote Control PM 9230

Power interrupttime -

| | Recovery time |
|---|---|
| within 10 msec. | no influence |
| 10 msec. - 500 msec. | max. 500 msec. |
| over 500 msec. | max. 12 sec. |

Step-responsetime -

| Range | Sampl. time 100 msec. | Sampl. time 20 msec. | Sampl. time 2 msec. |
|---|---|---|---|
| 20 mV | 1.7 sec. | 1.6 sec. | 0.5 sec. |
| 200 mV | 350 msec. | 190 msec. | 55 msec. |
| 2 V-1000 V | 250 msec. | 55 msec. | 10 msec. |

Input-settlingtime -

| Range | Sampl. time 100 msec. | Sampl. time 20 msec. | Sampl. time 2 msec. |
|---|---|---|---|
| 20 mV | 1.5 sec. | 1.5 sec. | 500 msec. |
| 200 mV | 150 msec. | 150 msec. | 50 msec. |
| 2 V-1000 V | 15 msec. | 15 msec. | 5 msec. |

The input-settlingtime can be decreased by removing capacitor C1018 from board U10

- Sampling time 100 msec. and 2 msec.:

| Range | Settling time | Fluctuation |
|---|---|---|
| 20 mV | 50 msec. | ±3 digits |
| 200 mV | 10 msec. | ±1 digit |
| 2 V-1000 V | 5 msec. | ±1 digit |

- Sampling time 20 msec.

| Range | Settling time | Fluctuation |
|---|---|---|
| 20 mV | 50 msec. | ±10 digits |
| 200 mV | 10 msec. | ± 2 digits |
| 2 V-1000 V | 5 msec. | ± 1 digit |

Recovery time after overload - 10 msec.

Calibration - External source
Calibration voltage: 90% of range

Recalibration interval - 6 months

| | |
|---|---|
| Warming-up time | - 60 min. |
| Mains voltage | - 110, 220, 240 V +10%<br>Freq. 50 Hz or 60 Hz +5%<br>(Adaptable by means of internal jumpers) |
| Power consumption | - 25 W |

II-3. MECHANICAL DATA

| | | |
|---|---|---|
| Dimensions | - Height | 145 mm |
| | - Width | 305 mm |
| | - Depth | 270 mm |
| Weight | - 9 kg | |



# III. Accessories

- Measuring cable

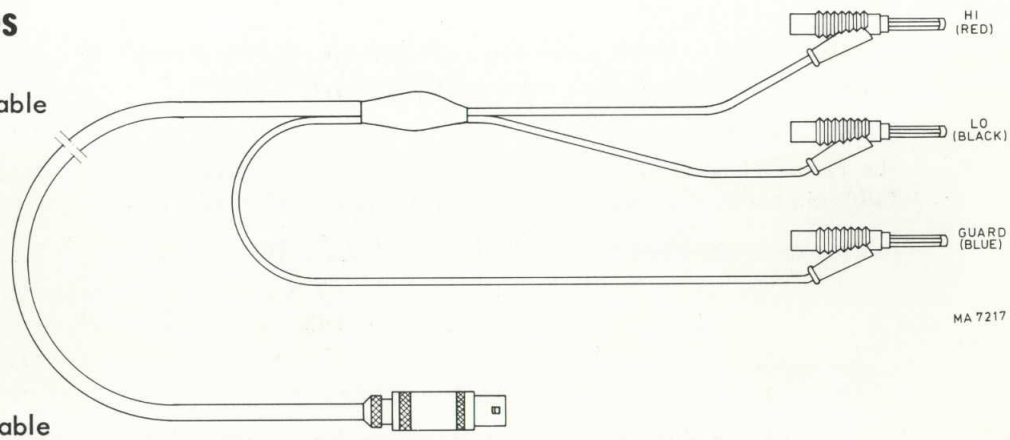



Fig. 1 Measuring cable

- Mains cable
- 4 Fuses: 250 mA + 15 V supply
  2 A + 5 V supply
  315 mA delayed action 220 V and 240 V mains
  630 mA delayed action 110 V mains
- Allen key
- Manual

OPTIONAL AVAILABLE

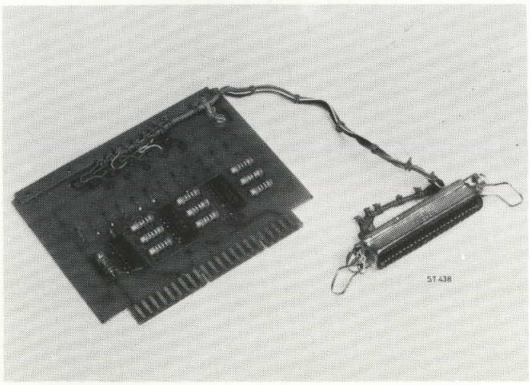


Fig. 2. PM 9230 Remote Control

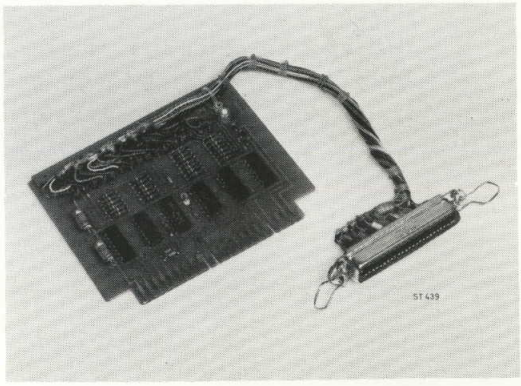


Fig. 3. PM 9231 Digital Output

- Plug-in cabinet PM 9706A

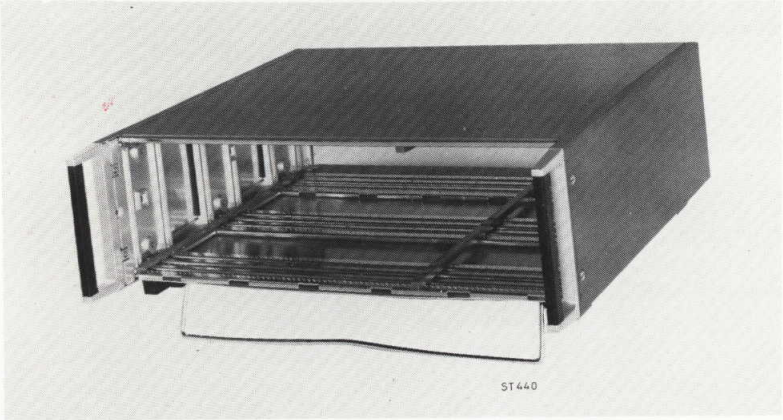



Fig. 4 PM 9706A Plug-in cabinet

The PM 9706A is an universal 3E-cabinet, with a width of 6 modules
It is provided with side panels including handles, feet, tilting bracket, top and bottom plate, guiding strips and a grey plastic cable in which two brackets are located for 19" rack mounting.

- Blank panel PM 9722
  The PM 9722 is a blank panel for a 3E-cabinet, having a width of 2 modules, to fill the blank space when the PM 2441 is mounted in cabinet PM 9706A.

- Blank panel PM 9721
  The PM 9721 is a blank panel for a 3E-cabinet, having a width of 1 module.
  Two panels PM 9721 can be used instead of one PM 9722.

- Interconnection cable PM 9220/01 and PM 9220/10

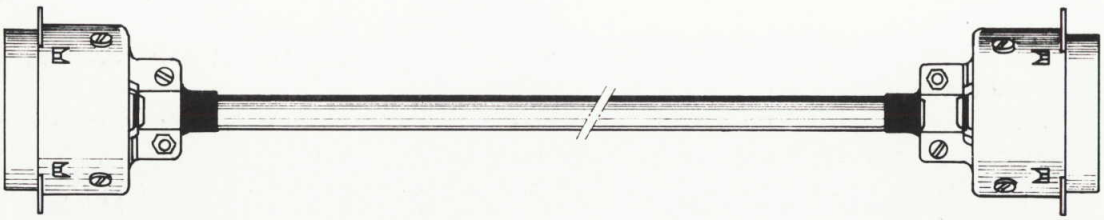


Fig. 5 PM 9220 Interconnection cable MA7161

Interconnection cable PM 9220/01 is a 50-pole cable with a 50-pole Amphenol plug at both sides.
The length is about 0.75 m.
The PM 9220/10 has a length of 1.5 m.

# IV. Description of working



## IV-1. PRINCIPLE OF WORKING

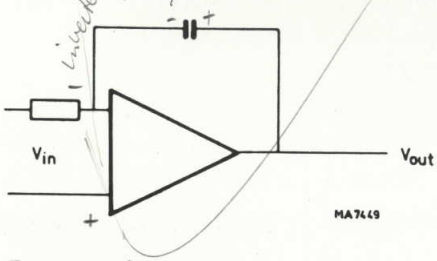



Fig. 6 Integrator

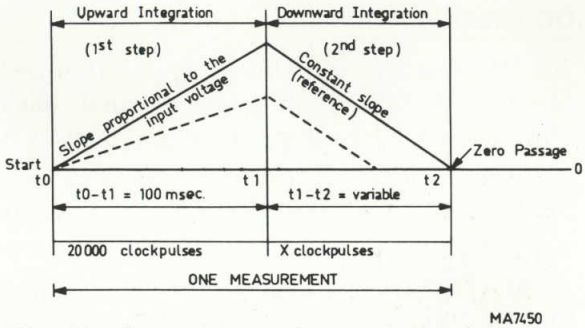



Fig. 7 Integration process

- The conversion principle in the PM 2441 of the analogue signals into digital form is based on the DUAL SLOPE principle.
  The analogue input signal is applied to the integrator (Fig. 6).
  The integrator supplies an output pulse, the width of which is proportional to the measuring value.
  Fig. 7 shows a graphical representation of the voltage as function of time during the charging and discharging cycle.
  During the integration process two main conditions should be distinguished, namely the upward integration (first step) and the downward integration (second step).
  During the first step (start) a current, which is proportional to the input voltage, is applied to the integrator.
  The output voltage of the integrator increases linearly as a function of time: its direction depends on the polarity, and its steepness on the value of the input voltage.
  The integration time is determined by the duration of 20,000 clock pulses. During this interval upward integration is effected and the integration capacitor (Fig. 6) is charged.
  During the second step the integrator is discharged to zero by a constant current. The discharging of the integrator is effected by connecting a reference voltage to the input of the integrator. The polarity of the reference voltage is opposite to the polarity of the input voltage supplied to the integrator. The discharge rate is determined by the discharge current, consequently, by the reference voltage, so that it will be constant.
  The time $t_1 - t_2$ downward integration is measured by counting the number of clock pulses; it is directly proportional to the unknown input voltage applied during the first step.
  As the same integration elements and clock generator are employed for both upward- and downward integration, temperature variations, long-term drift and absolute values will not affect the measuring accuracy.
  The measuring accuracy in the first place depends on the accuracy of the reference voltage.

## IV-2. EXPLANATION OF THE BLOCK DIAGRAM

### IV-2.1. Input and Range switches U9

In this part the reed relays are situated in such a way that they supply the voltage to be measured (supplied to BU2 or BU4) to the DC amplifier.
On the ranges 20 mV, 200 mV, 2 V and 20 V the DC voltages are supplied directly to the input of the DC amplifier. On the ranges 200 V and 1000 V the DC voltages are attenuated with an attenuation factor of 100.
The reed relays are controlled by the:

a. Automatic Range (U6/U8)
b. Range push-button switches on the front panel of the PM 2441.

### IV-2.2. DC Amplifier U10

The DC amplifier is an inverting amplifier and gives an output level of 20 V DC at end of range (display 20.000), in all ranges selected, except on the 1000 V range (10 V DC).
This is possible by using various gain factors for the ranges.

### IV-2.3. Analog-to-Digital Converter U11

Unit U11 contains the integrator and the positive and negative reference voltage circuits (Chap. IV-1.). The input voltage (from U10) of the integrator is controlled by the signal $t_0 - t_1$ (upward integration) (Chap. IV-1.).
The $+V_{ref}$ and $-V_{ref}$ are controlled by the signal $t_1$ (start of downward integration).
The signals $t_0 - t_1$ and $t_1 - t_2$ are prepared on the Inguard-Program Unit U12.
The Analog-to-Digital conversion principle employing an integrator is described in chapter IV-1.
The number of clock pulses of the clock oscillator which are counted by the counter during upward integration $t_0 - t_1$ and downward integration $t_1 - t_2$ are supplied to the memory (Chap. IV-1.)

### IV-2.4. Counter / Memory U4

The counter on unit U4 counts the number of clock pulses from the clock oscillator (U5) during the upward- and downward integration.
The number of clock pulses counted during the upward integration is fixed (see Chap. IV-1. and table below).

| Measuring speed | Freq. clock oscill. | Counter | Sampling time | |
|---|---|---|---|---|
| 4 meas./sec. | 200 kHz | 20,000 | 100 msec. | |
| 20 meas./sec. | 1 MHz | 20,000 | 20 msec. | Only via Remote Control Unit U7 |
| 100 meas./sec. | 1 MHz | 2,000 | 2 msec. | Only via Remote Control Unit U7 |

The number of clock pulses counted during the downward integration depends on the voltage that is supplied to the integrator (see Chap. IV-1.)
The output information of the counter is supplied to the memory.
This information is supplied to the display (U1) only when a TRANSFER pulse is given, which is derived from the reset circuit on Unit U5.

### IV-2.5. Start oscillator, Clock oscillator and Reset circuit U5

The start oscillator the measurements (upward- and downward integration). The measuring speed is 4 measurements per second.
The measuring speed can be increased via the Remote Control Unit U7.
At 4 measurements per second the clock oscillator frequency is 200 kHz (see table in IV-2.4.).

The reset circuit generates 3 pulses:
1. transfer pulse to the memory
2. reset counter
3. reset program

The reset circuit is controlled by the program which generates a pulse "zero detect" ($t_2$); the reset circuit reacts to this pulse as soon as the integrator passes zero at the end of the downward integration (Chap. IV-1.).

## IV-2.6. Program U6

The following functions are prepared on the program unit:

- Start ($t_0$)
  As soon as a start pulse is generated by the start oscillator, the program supplies the pulse to the integrator via the inguard program, and the upward integration starts ($t_0$ - $t_1$).
  At the same time the clock pulses of the clock oscillator are supplied to the counter.

- End of upward integration ($t_1$)
  This signal is generated by the counter when the counter position is 20,000 (for the 1000 V range 10,000). The signal $t_1$ is supplied to the integrator via the inguard program U12.

- Zero detect ($t_2$)
  The zero-detect signal is generated when the integrator passes zero during the downward integration (end of downward integration $t_2$), and is supplied to the program.
  Zero-detect is used to prepare the stop counting signal and the transfer- and reset signals on unit U5.

- Up- and down ranging
  When the automatic range is switched on, the automatic range (U6/U8) receives up- and down signals which are generated in the counter.
  Up ranging at counter position 20000.
  Down ranging at counter position 01800.

- Overload
  At a counter position 20, 000, for the 1000 V range 10,000, (manual range switching) the indication will flash on and off; this is the overload state.

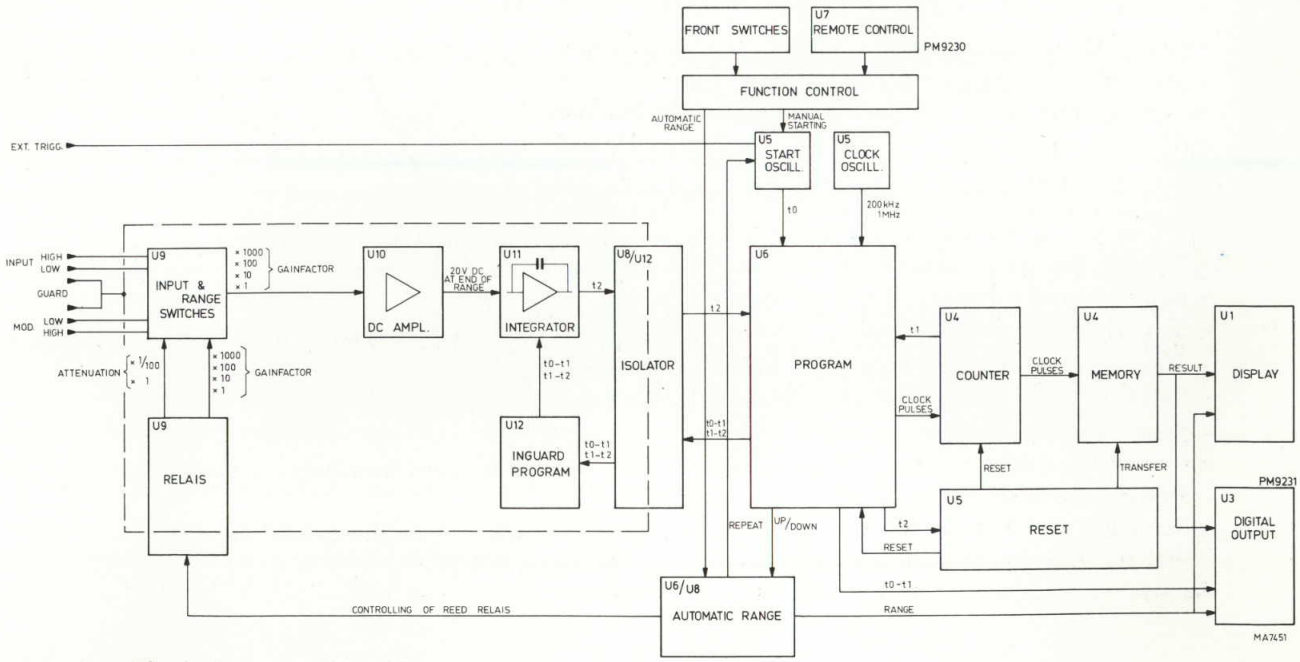



Fig. 8 Block diagram PM 2441

# V. Installation

# DIRECTIONS FOR USE

## V-1. EARTHING

The instrument must be connected to a wall socket with rim earthing via the 3-pole mains cable supplied on delivery.
The housing of the instrument is then earthed via the above-mentioned cable.
If the instrument cannot be earthed via the mains cable, a separate earthing cable should be connected to the earthing socket BU1 at the front of the instrument (see Fig. 14) or with the earthing screw at the rear of the instrument (Fig. 15).
Pay attention to the local safety directions.

## V-2. MAINS SUPPLY

Before connecting the instrument to the mains, check if the position of the mains switch SK5 at the rear of the instrument (Fig. 15) corresponds to the local mains voltage.
The instrument can be used at the following voltages:
110 V +10%, SK5 to 110 V : fuse VL1 630 mA delayed action
220 V +10%, SK5 to 220 V : fuse VL1 315 mA delayed action
240 V +10%, SK5 to 240 V : fuse VL1 315 mA delayed action

Fuse VL1 is mounted at the rear of the instrument (see Fig. 15).

## V-3. CONVERTING THE INSTRUMENT FROM 50 Hz TO 60 Hz MAINS FREQUENCY

Converting the PM 2441 from 50 Hz to 60 Hz mains frequency may be realized by means of an internal jumper on unit U5 and unit U11 (see Chap. VIII-4.4. and 9.4.).

## V-4. COMBINING THE INSTRUMENT WITH OTHER MODULES

The chassis of the PM 2441 may be accomodated in a 6-module cabinet (PM 9706A) instead of the 4-module cabinet. The additional space in this cabinet can then be used for other units of the 3E modular system, being employed in conjunction with a digital voltmeter or independently. This 6-module cabinet is suitable for mounting in 19" racks. When the additional space is not used, it can be closed off by means of a blank pulg-in chassis.

For converting the instrument into the rack mounting version proceed as follows:
- Remove the grey, plastic cable cover from the PM 9706A cabinet and take out the brackets.
- Remove the four screws at the two sides.
- Slightly lift the side plates at the front and remove the plastic plates which are now accessible. The brackets can now be placed in the free space.
- Refit the side plates and secure them with the four screws.
- Remove the four feet.
- Mount the desired number of guide rails to the upper and lower crossbars. The appropriate holes in the crossbars are threaded.
- Slide the PM 2441 out of the 4-module cabinet and slide it into the 6-module cabinet.
- Fill the free space with one unit PM 9722 or two units PM 9721.
- Lock the PM 2441 and the PM 9722.

# VI. Operation

## VI-1. SWITCHING-ON

After having been connected to the mains, the instrument can be switched on by means of switch POWER ON SK1 (Fig. 14). The display lamps then light.
A warming-up period of 60 minutes is necessary before the instrument meets the accurate specifications.

## VI-2. CONTROLS

| Item | Description | Application | Fig. |
|---|---|---|---|
| SK1 | POWER ON | Switches on the instrument | 14 |
| SK2/1...SK2/6 | mV - V | Range switches 20 mV up to 1000 V DC | 14 |
| SK2/7 | AUTO | Switches on the automatic range selection | 14 |
| SK3/1 | DIRECT | The instrument measures the DC voltage supplied to BU2 | 14 |
| SK3/2 | MODULE | The instrument measures the DC voltage supplied to BU5 | 14 |
| SK4/1 | INTERN | Internal starting of the measuring cycle. Measuring speed = 4 measurements/sec. | 14 |
| SK4/2 | MAN / EXT | External starting of the measuring cycle a. Manual (By depressing SK4/2) b. Electrical via BU3 | 14 |
| SK5 | 110 V, 220 V, 240 V | Mains adaptor switch | 15 |
| BU1 | | Earth socket | 14 |
| BU2 | INPUT | DC input (parallel to BU4) | 14 |
| BU3 | START | External starting of the measuring cycle: negative-going pulse, H = +2.4 – +50 V L = - 1.5 – + 1 V width: 10 µsec. - 100 msec. | 15 |
| BU4 | INPUT | DC input (parallel to BU2) | 15 |
| BU5 | MODULE | Input socket (14-pole Amphenol) for and AC/DC or OHM/DC convertor | 15 |
| (BU6) | REMOTE CONTROL | Input of PM 9230 (U7) (Optional available) | 15 |
| (BU7) | DIGITAL OUTPUT | Output of PM 9231 (U3) (Optional available) | 15 |
| BU8 | | Mains input | 15 |
| LA1 | REMOTE CONTROLLED | Remote control indication | 14 |
| VL1 | | Mains fuse | 15 |
| Earth screw | | Earth screw | 15 |

## VI-3. ELECTRICAL ZERO-SETTING AND CALIBRATION (see chap. X-4.)

### VI-3.1. Removing the cabinet

The instrument chassis is constructed as a compact plug-in chassis and is accommodated in a 3-module standard cabinet.
The chassis can be pulled out of the cabinet by means of the two locking devices at the front. When these locking devices cannot be hinged out, the two locking screws at the front should be loosened (do not remove them) by means of the 2.5 mm Allen key, included in the delivery. The chassis then can be pulled out of the cabinet. When the chassis is pulled out of the cabinet the potentiometers for the electrical zero-setting and the calibration are visible.


Fig. 9 Pulling the chassis out of the cabinet

## VI-4. MEASURING

### VI-4.1. Voltage measurements with guard-connection

The digital DC-voltmeter PM 2441 is equipped with a GUARD. This guard is an additional shield between low and ground which increases the low-to-ground leakage impedance.
The resulting higher impedance improves the leakage resistance and the common mode rejection. The guard may be connected to the circuit being measured by means of the guard plug (blue) of the measuring cable. Using the guard properly provides a high rejection of common mode voltages and enables accurate measurements to be performed in the most sensitive range.
In Fig. 10 some examples are given, how to connect the guard to the circuit under test.

The following rules are given for an optimum guard-connection:

A. Connect the voltage source to be measured to the PM 2441 via the screened cable supplied on delivery, so that interference signals do not influence the result of the measurement.
B. Connect the guard to the same potential as the low terminal.
C. Connect the guard so that no common mode current flows through any source resistance.

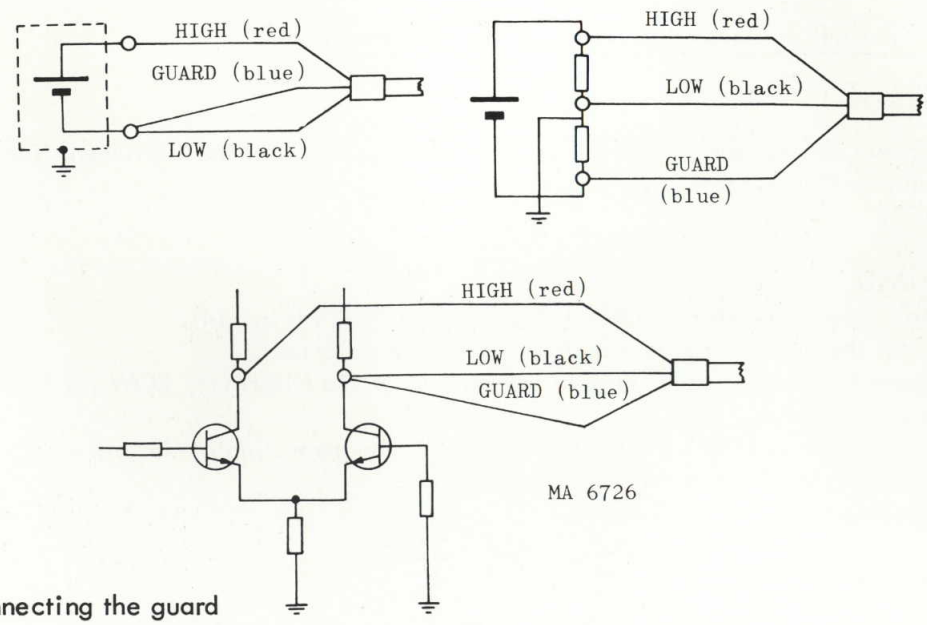



Fig. 10 Connecting the guard

VI-4.2. Measuring DC voltages

a. With manual range selection

- Connect the measuring cable (Fig. 1) at the input BU2 of the instrument (Fig. 14).
  Connect GUARD to LOW.
  HIGH = red
  LOW = black
  GUARD = blue
- Select the correct measuring range with switches SK2/1 to SK2/6 (Fig. 14).
  In mV-ranges the mV-indication is illuminated and in V-ranges the V-indication.
- Depress switches SK3/1 DIRECT and SK4/1 INTERN (see Fig. 14).
- Connect the unknown voltage to the measuring instrument via HIGH (+), LOW (-) GUARD of the measuring cable.
- In case of OVERLOAD all indication lamps flash on and off.
- Positive (+) or negative (-) is indicated automatically if a positive or negative voltage is supplied to input HIGH with respect to input LOW.

b. With automatic range selection

- Connect the measuring cable (Fig. 1) to the input BU2 of the instrument (Fig. 14).
  Connect GUARD to LOW.
  HIGH = red
  LOW = black
  GUARD = blue
- Depress switches SK3/1 DIRECT and SK4/1 INTERN (Fig. 14).
- Depress switch SK2/7 AUTO (Fig. 14).
- Connect the unknown voltage to the measuring instrument via HIGH (+), LOW (-) and GUARD of the measuring cable.
- The range switching-over (20 mV to 1000 V), the polarity indication and mV- or V-indication are obtained automatically. If 20000 is read out, a less sensitive range is selected. If 01800 is read out, a more sensitive range is selected.

c. With internal or external starting of the measurement

- Internal

- Connect the measuring cable (Fig. 1) to the input BU2 of the instrument (Fig. 14).
  Connect GUARD to LOW.
  HIGH = red
  LOW = black
  GUARD = blue
- Depress switches SK3/1 DIRECT and SK4/1 INTERN (Fig. 14).
- Select the mode of range selection (manual or automatic).
- Connect the unknown voltage to the instrument via HIGH (+), LOW (-) and GUARD of the measuring cable.
- Because switch SK4/1 INTERN is depressed, the measuring cycles are internally started.
  Measuring speed = 4 measurements/sec.
  Sampling time = 100 msec.

- External

- Depress switch SK4/2 MAN/EXT instead of switch SK4/1 INTERN (Fig. 14).
  The measurements can now be started in three ways:
  1. By depressing push-button SK4/2 MAN/EXT. 1 x depress = 1 measurement.
  2. Via BNC connector BU3 (Fig. 15) by a negative-going pulse
     H = +2.4 – +50 V
     L = -1.5 – + 1 V
     Width = 10 µsec. - 100 msec.
  3. Via a. REMOTE CONTROL PM 9230
     b. DIGITAL OUTPUT PM 9231

d. - PM 2441 is equipped with a MODULE-input BU5 (Fig. 15), which enables a.c. voltages or resistances to be measured via a converter connected to this input.
- At measurements via MODULE-input switch MODULE SK3/2 (Fig. 14) must be depressed.

e. With the REMOTE CONTROL PM 9230

- See chapter XII.

f. With the DIGITAL OUTPUT PM 9231

- See chapter XIII.

# VII. Survey of connections

In this chapter a short description is given of the Input- and Output sockets of the PM 2441.

## VII-1. DC-INPUT BU2 (BU4)

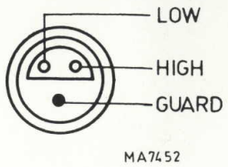



Fig. 11 DC-input socket BU2, BU4

The DC-input of the PM 2441 is a 3-pole socket to which the HIGH, LOW and GUARD are connected.

## VII-2. EXTERNAL "START" SOCKET BU3


Fig. 12 Start-socket BU3

Via the START-Socket BU3 the measurements of the PM 2441 can be started externally by a negative-going pulse

H = +2.4 V ... +50 V
L = -1.5 V ... + 1 V

The width of the pulse is dependent to the SAMPLING TIME of the measurements.
By normal operation the SAMPLING TIME is 100 msec.
By application of the REMOTE CONTROL Unit PM 9230 it is possible to decrease the SAMPLING TIME to 20 msec. or 2 msec. (see table below).

| | | |
|---|---|---|
| 100 msec. | 20 msec. | 2 msec. |
| 4 measm./sec. | 20 measm./sec. | 100 measm./sec. |
| 10 µsec. .. 100 msec. | 10µsec. .. 20 msec. | 10µsec. .. 2 msec. |

## VII-3. MODULE INPUT BU5

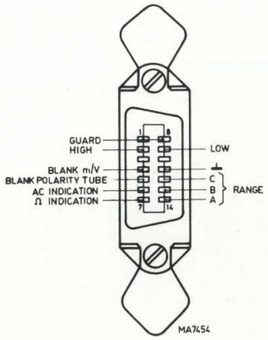



Fig. 13 Module input connector BU5

- By connecting a convertor to the MODULE Input of the PM 2441, it is possible to measure AC voltages or resistance values. On the connector-points of the 14-pole amphenol are situated;
- HIGH, LOW and GUARD,
- Blank the m/V indication,
- Blank B101 (polarity tube),
- AC-indication
- Ω-indication
- Zero
- The range-switching will take place in the convertor. The switching-code is generated in the PM 2441 and is supplied in BCD-code to the convertor.

| RANGE | A | B | C |
|---|---|---|---|
| 20 mV | 1 | 0 | 0 |
| 200 mV | 0 | 1 | 0 |
| 2 V | 1 | 1 | 0 |

| RANGE | A | B | C |
|---|---|---|---|
| 20 V | 0 | 0 | 1 |
| 200 V | 1 | 0 | 1 |
| 1000 V | 0 | 1 | 1 |





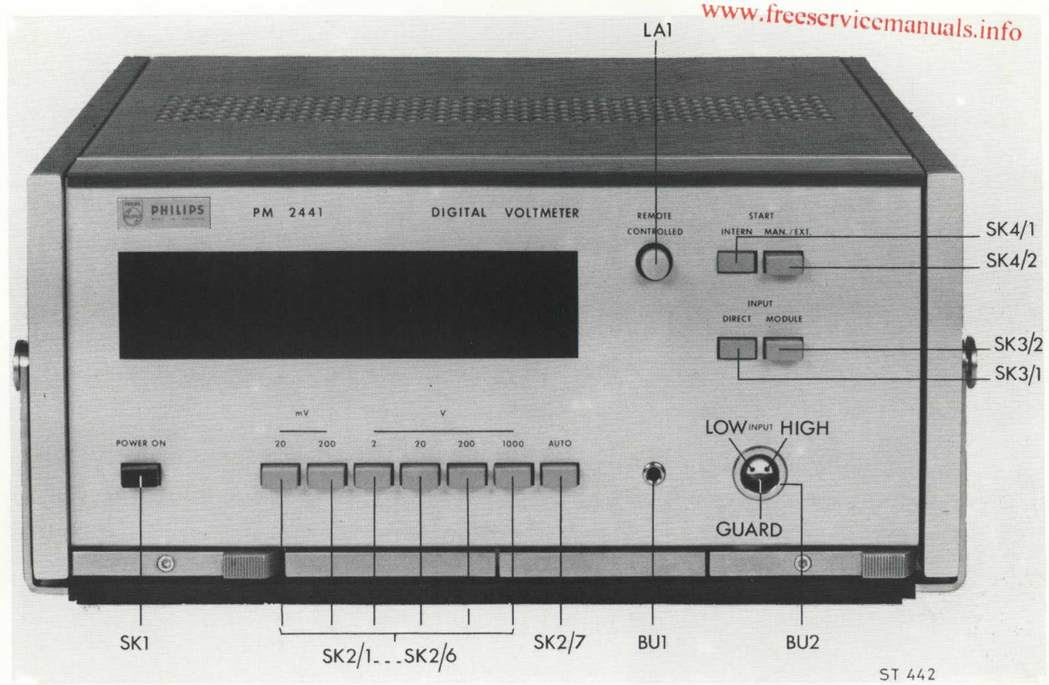



Fig. 14 Front view

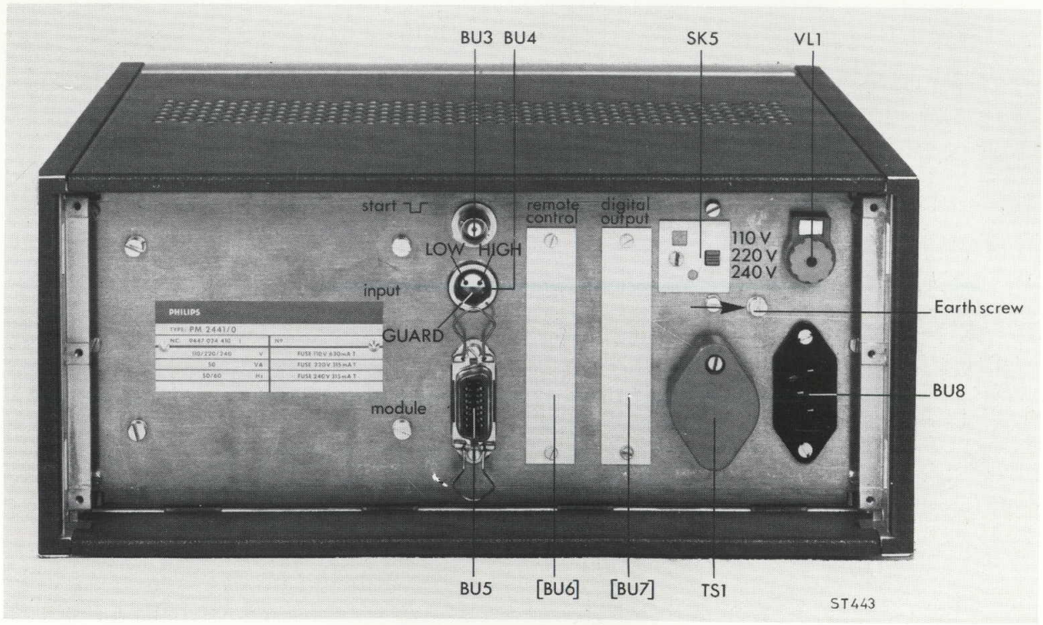



Fig. 15 Rear view

# VIII. Circuit description

# SERVICE DATA

In this chapter a description of the functioning of the PM 2441 is given in the sequence of the units. Where this is necessary for a better understanding, parts of other units will be discussed together with the units in question.

EXPLANATION OF THE EARTH SIGNS AND DIGITAL SIGNALS

Digital signals: OL = active state is logic 1
non-active state is logic 0

$\overline{OL}$ = active state is logic 0
non-active state is logic 1

Earth/zero ⏚ = supply zero/mains earth

⊥ = LOW

⏚ = GUARD

## VIII-1. DISPLAY U1

### 1.1. Indication units (B106), tens (B105), hundreds (B104) and thousands (B103)

This indication is obtained by decoder/drivers IC106, IC105, IC104 and IC103 respectively. These decoder/drivers are controlled by the memory (unit U4) in 8-4-2-1 code. Next function table applies for IC103, IC104, IC105 as well as for IC106.

| Input | | | | Output | Lighting figure |
|---|---|---|---|---|---|
| (8) | (4) | (2) | (1) | | |
| 0 | 0 | 0 | 0 | Q0 (16) = 0 | 0 |
| 0 | 0 | 0 | 1 | Q1 (15) = 0 | 1 |
| 0 | 0 | 1 | 0 | Q2 ( 8) = 0 | 2 |
| 0 | 0 | 1 | 1 | Q3 ( 9) = 0 | 3 |
| 0 | 1 | 0 | 0 | Q4 (13) = 0 | 4 |
| 0 | 1 | 0 | 1 | Q5 (14) = 0 | 5 |
| 0 | 1 | 1 | 0 | Q6 (11) = 0 | 6 |
| 0 | 1 | 1 | 1 | Q7 (10) = 0 | 7 |
| 1 | 0 | 0 | 0 | Q8 ( 1) = 0 | 8 |
| 1 | 0 | 0 | 1 | Q9 ( 2) = 0 | 9 |

NOTE: Only the addressed output is logic 0; the other outputs are logic 1.

1.2. Indication ten-thousands (B102)

This indication is obtained by IC102, which is controlled by the memory (unit U4) in 8-4-2-1 code.

| Input (8) | (4) | (2) | (1) | Output | Lighting figure |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | Q0 (16) = 0 | 0 |
| 0 | 0 | 0 | 1 | Q1 (15) = 0 | 1 |
| 0 | 0 | 1 | 0 | Q2 ( 8) = 0 | 2 |
| 0 | 0 | 1 | 1 | Q3 ( 9) = 0 | 1 |

1.3. Indication +, - and ~ (B101)

The polarity indication, controlled by unit U4, and the a.c. sign, controlled by "MODULE" input BU5, are obtained from IC101.

| Input (8) | (4) | (2) | (1) | Output | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | Q0 (16) = 0 | ~ lights |
| 0 | 0 | 0 | 1 | Q1 (15) = 0 | ~ lights |
| 0 | 0 | 1 | 0 | Q2 ( 8) = 0 | - lights |
| 0 | 0 | 1 | 1 | Q3 ( 9) = 0 | + lights |

1.4. Decimal points

The decimal points are achieved via decoder/driver IC107 which is controlled by the memory, unit U4.

| Input (8) | (4) | (2) | (1) | Output | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | Q0 (16) = 0 | not used |
| 0 | 0 | 0 | 1 | Q1 (15) = 0 | 0.0000, corresponding to range 2 V |
| 0 | 0 | 1 | 0 | Q2 ( 8) = 0 | 00.000, corresponding to range 20 mV or 20 V |
| 0 | 0 | 1 | 1 | Q3 ( 9) = 0 | not used |
| 0 | 1 | 0 | 0 | Q4 (13) = 0 | 000.00, corresponding to range 200 mV or 200 V |
| 0 | 1 | 0 | 1 | Q5 (14) = 0 | not used |
| 0 | 1 | 1 | 0 | Q6 (11) = 0 | not used |
| 0 | 1 | 1 | 1 | Q7 (10) = 0 | not used |
| 1 | 0 | 0 | 0 | Q8 ( 1) = 0 | 0000.0, corresponding to range 1000 V |
| 1 | 0 | 0 | 1 | Q9 ( 2) = 0 | not used |

1.5. Overload

The overload condition is indicated by blinking of all the numerical indicator tubes.
At no overload the signal $\overline{BAT}$ (all tubes blinking) and $\overline{OL}$ (overload) are logic 1 thus:
- TS104 and TS101 are conductive
  +210 V is then supplied to the anodes of the indicators.
- TS107 is conductive so that the blinking oscillator cannot oscillate.

If there is an overload condition, $\overline{OL}$ becomes logic 0, thus allowing the blinking oscillator to produce pulses as long as the overload condition is met.

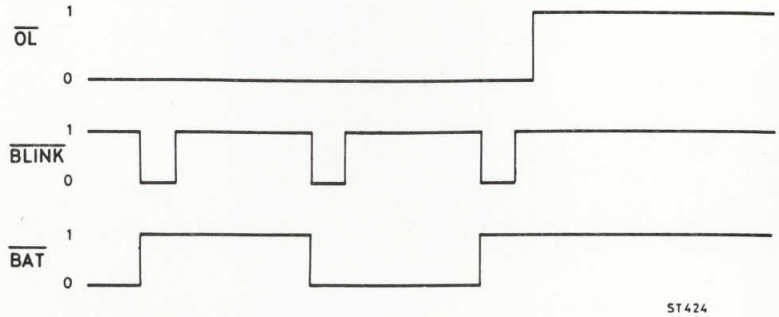



Fig. 16 Pulse diagram blinking oscillator

The frequency is about 1 Hz (BLINK).
These pulses are used as clock pulses to control flip-flop IC804/A (on unit U8).
At every clock pulse the flip-flop reverses.

$\overline{BAT}$ = 0

TS104 is blocked, thus TS101 is blocked, so that the +210 V supply is disconnected from the indicators, which will be extinguished.

$\overline{BAT}$ = 1

The indicator lights.

$\overline{OL}$ is determined by IC601/B on unit U6.

1.6. Blanking indicator B106

The indicator for the units may be blanked via input $\overline{BLT}$ (blanking last tube).

$\overline{BLT}$ = 1 : TS105 and thus TS102 is conductive
Supply voltage +210 V is connected to B106 (except if all tubes are blanked; $\overline{BAT}$ = 0).

$\overline{BLT}$ = 0 : TS105 and thus TS102 is blocked.
+210 V disconnected from B106, which is then extinguished.

$\overline{BLT}$ is determined by the REMOTE CONTROL unit U7.
At "2 msec. SAMPLING TIME" the last indicator ($10^{o}$) is not used and should be extinguished ($\overline{BLT}$ = 0).

1.7. Blanking indicator B101

The indicator for indication of the measuring mode B101 (+,- and ~) may be blanked via input $\overline{BFT}$ (blanking first tube) in the case of e.g. Ω measurements via the MODULE input BU5.
The functioning is the same as given for $\overline{BLT}$ (see 1.6.).

1.8. (m) V indicators (LA101 and LA102)

These indicators indicate the type of measurement, mV or V. They are controlled by IC806/G4/G5 on unit U8 and can be extinguished via the MODULE input BU5 in the case of e.g. Ω measurements.

1.9. Interconnection unit U13

Interconnection unit U13 is situated between the DISPLAY unit U1 and the bottom unit U14.

## VIII-2. POWER SUPPLY U2

### 2.1. Transformer

a. Primary

The primary windings of transformer T1 can be connected as follows:
- S1, S′ and S1" in series (240 V) or
- S1 and S1′ in series (220 V) or
- S1 and S1′ in parallel (110 V)

by means of 3-position slide switch SK5.

b. Secondary

The secondary windings S2, S3 and S4 supply the a.c. voltages for the rectifying circuits. These circuits deliver a non-stabilized voltage of +210 V and two stabilized voltages (+15 V and +5 V). Winding S5 supplies the primary voltage for transformer T2.

### 2.2. Voltage source +210 V

The voltage of +210 V is derived from winding S4 via full-wave rectifier GR201 and is used for the numerical indicator tubes.
C204 is used as a smoothing capacitor.

### 2.3. Voltage source +15 V

The voltage of +15 V is derived from winding S3, It is used for level conversion on units U3 and U4, if necessary, and for driving the relays on unit U9.
The output voltage is stabilized by series stabilization with TS201 and voltage regulator IC201 (TBA281).
This regulator comprises:

- a reference circuit; output 4
- a difference amplifier; input 2 and 3
- an output circuit; output 6
- a limiting circuit; connection 1 and 10.

### 2.4. Voltage source +5 V

The voltage of +5 V is derived from winding S2 and is used for the circuits and integrated circuits on units U1, U3, U4, U5, U6, U7 and U8.
Stabilization is effected by means of TS1, TS202 and voltage regulator IC202.

### 2.5. Earth/Zero

Via resistor R4 the mains earth is connected to the supply zero, creating a treshold for earth potentials when connecting several instruments in parallel with the PM 2441.

The following earth/zero signs are used in the PM 2441:

⏚ = supply zero / mains earth

⊥ = LOW

⊥ = GUARD

## VIII-3. COUNTER/MEMORY U4

### 3.1. Counter

The counter consists of four decade counters IC401, IC403, IC404 and IC405 for the units, tens, hundreds and thousands respectively and a JK flip-flop IC406 for the ten thousands.

Truth table decade counter IC401, IC403, IC404 and IC405

| Count | 11 | 8 | 9 | 12 |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 1 | 0 |
| 3 | 0 | 0 | 1 | 1 |
| 4 | 0 | 1 | 0 | 0 |
| 5 | 0 | 1 | 0 | 1 |
| 6 | 0 | 1 | 1 | 0 |
| 7 | 0 | 1 | 1 | 1 |
| 8 | 1 | 0 | 0 | 0 |
| 9 | 1 | 0 | 0 | 1 |

| Reset | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | 3 | 6 | 7 | | | | |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

The "preset 9" inputs (terminals 6 and 7) of every decade counter are at 0-level, thus have no influence on the counting.
The "reset 0" inputs (terminals 2 and 3) are controlled by signals RESET COUNTER 1 and RESET COUNTER 2. If both are logic 1 the decade counter is set to position $Q_A = 0$, $Q_B = 0$, $Q_C = 0$, $Q_D = 0$. All other combinations mean counting.

The "reset 0" input 2 and 3 of IC401 are controlled in another way.
Signal "SAMPLING TIME 2 msec." is logic 1 (except if this signal is programmed via the REMOTE CONTROL input BU6) and if RESET COUNTER 3 is logic 0, the counter is reset. IC401 can count if IC402 supplies a 0-signal. If a logic 0 is applied to input 12 of IC402/G4 ("SAMPLING TIME 2 msec." is 0), counter IC401 is reset continously; IC401 does not count. IC403 is now the first decade at this increased measuring speed.
Because of this the tube that indicates the units is blanked.
The clock pulses are supplied to unit U6 via the circuit shown in Fig. 17.

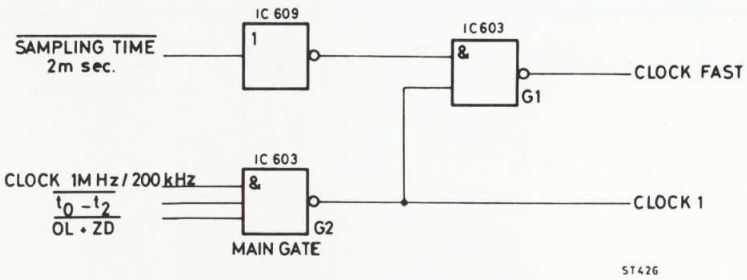



Fig. 17 Applying clock pulses to the counter

If signals $\overline{t_0 - t_2}$ and $\overline{OL + ZD}$, which are determined by the program, are logic 1, the main-gate the clock pulses are supplied to the counter-input of IC401.
IC609 has an open input (signal "SAMPLING TIME 2 msec." is not given via the REMOTE CONTROL input BU6, thus supplying a logic 1 to the input of IC609), so that IC603/G1 is blocked.
If signal "SAMPLING TIME 2 msec." is given by a logic 0, gate IC603/G1 is opened and the clock pulses are supplied to IC402/G1.
At the same time IC401 is reset continuously, because the output of IC402/G4 is logic 1; terminal 11 of IC401 is then logic 0.
The output of IC402/G3 becomes logic 1 and the clock pulses are supplied to the clock-input of IC403 via IC402/G1.
This mode is used at increased measuring speed (see table).

| SAMPLING-TIME | Freq. CLOCK OSCILL. | COUNTER | Number of measurements per second |
|---|---|---|---|
| 100 msec. | 200 kHz | 20,000 | 4 |
| 20 msec. | 1 MHz | 20,000 | 20 |
| 2 msec. | 1 MHz | 2,000 | 100 |

The measuring speed is increased by increasing the clock oscillator frequency and/or decreasing the counter capacity.
The preceding decade counter IC405 delivers at output 11 a carry-pulse for triggering flip-flop IC406.

## 3.2. Memory

The output information of the counter is supplied to the memory.
This information is only supplied to the decoder/drivers (on U1) as soon as $\overline{TRANSFER}$ and UP and DOWN are both logic 0.
Also the polarity information and the information of the decimal points are transferred to the decoder/drivers, as soon as both pulses are logic 0.

## 3.3. Program control signals

Three signals "10 000", "01 800" and "19 990" are derived from the counter (see diagram below).
- Signal "10 000" is used to set the program is such a position that the next higher measuring range can be selected.
- Signal "01 800" supplies the information to the program that a lower range should be selected.
- Signal "19 990" determines the timing of the polarity indication, the timing of down-integration and the timing of zero detection.

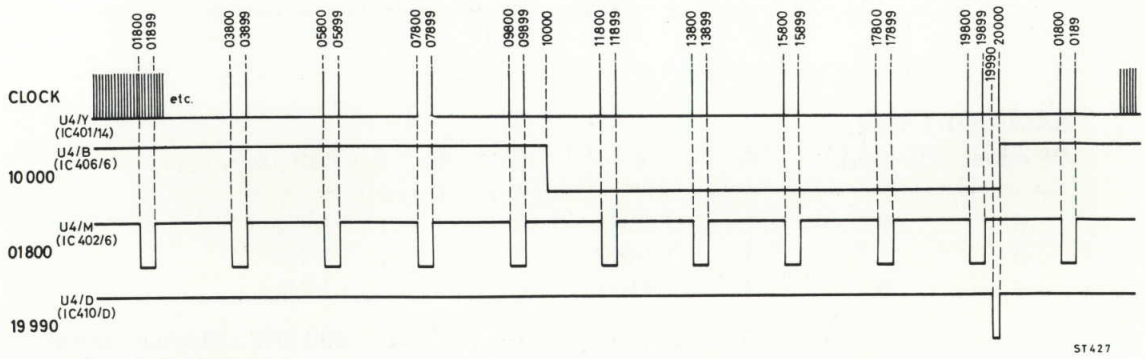



Fig. 18 Output signals unit U4

## VIII-4. OSCILLATOR U5

Unit U5 consists of the following circuits:
- Clock circuit
- Start circuit
- Reset circuit

### 4.1. Clock circuit

The clock for the counter is derived from a crystal-oscillator with a frequency of 6 MHz. The crystal-oscillator is followed by a ring-counter with a switchable division ratio by means of jumper 50 Hz/60 Hz.
- for 50 Hz the division ratio is 6
- for 60 Hz the division ratio is 5

In this way the function tables below are achieved.

Scaler-of-six (50 Hz)

| Count | $Q_C$ | $Q_B$ | $Q_A$ |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 |
| 2 | 0 | 1 | 0 |
| 3 | 0 | 1 | 1 |
| 4 | 1 | 0 | 0 |
| 5 | 1 | 0 | 1 |
| 0 | 0 | 0 | 0 |

Scaler-of-five (60 Hz)

| Count | $Q_C$ | $Q_B$ | $Q_A$ |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 |
| 2 | 0 | 1 | 0 |
| 3 | 0 | 1 | 1 |
| 4 | 1 | 0 | 0 |
| 0 | 0 | 0 | 0 |

The output frequency obtained is 1 MHz for 50 Hz or 1.2 MHz for 60 Hz. By means of IC504 the frequency is again divided by a factor 5.

The circuit of Fig. 19 determines which frequency is supplied to the counter.

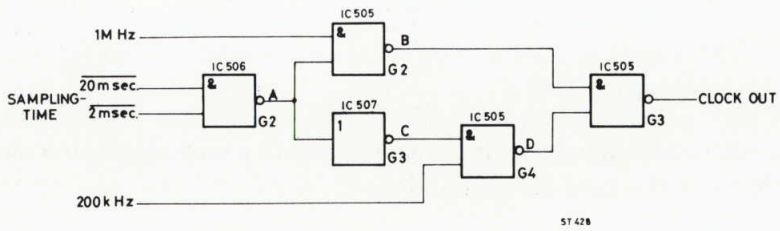



Fig. 19 1 MHz/200 kHz clock pulses determination

SAMPLING TIME

| 20 msec. | 2 msec. | A | B | C | D | Clock out |
|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 1 MHz | 0 | 1 | 1 MHz |
| 0 | 1 | 1 | 1 MHz | 0 | 1 | 1 MHz |
| 1 | 0 | 1 | 1 MHz | 0 | 1 | 1 MHz |
| 1 | 1 | 0 | 1 | 1 | 200 kHz | 200 kHz : Normal operation without REMOTE CONTROL unit U7 |

Remark: - Signal "SAMPLING TIME 20 msec." is supplied by the REMOTE CONTROL unit U7; "SAMPLING TIME 20 msec." is 0 if the instruction "SAMPLING TIME 20 msec." is given; if not, the signal is logic 1.
If no REMOTE CONTROL unit U7 is used, this represents a logic 1 for "SAMPLING TIME 20 msec.".
- For signal "SAMPLING TIME 2 msec." the same applies as given for signal "SAMPLING TIME 20 msec.".

## 4.2. Start circuit

The instrument can be started in the following ways:

a. Internal (button START INTERN (SK4/1) depressed)

The SAMPLING TIME is: - 100 msec.
- 20 msec., if this is programmed via REMOTE CONTROL unit U7.
- 2 msec., if this is programmed via REMOTE CONTROL unit U7.

b. External

- via BNC connector BU3, START : negative-going pulse
H = +2.4 V ... +50 V
L = -1.5 V ... + 1 V
Width = 10 µsec. ... 100 msec. (see table)

- via REMOTE CONTROL unit U7 PM 9230 : negative-going pulse
H = +2.4 V ... +50 V
L = -1.5 V ... + 1 V
Width = 10 µsec. ... 100 msec. (see table)

- via BCD output U3 PM 9237 : negative-going pulse
H = +2.4 V ... +50 V
L = -1.5 V ... + 1 V
Width = 10 µsec. ... 100 msec. (see table)

| | | | |
|---|---|---|---|
| SAMPLING TIME | 100 msec. | 20 msec. | 2 msec. |
| MAX. MEASURING SPEED | 4 measm./sec. | 20 measm./sec. | 100 measm./sec. |
| PULSE WIDTH | 10 µsec. .. 100 msec. | 10 µsec. .. 20 msec. | 10 µsec. .. 2 msec. |

c. Manual by depressing button MAN/EXT SK4/2

The starting circuit consists of a starting oscillator, 1 scaler-of-five and a start flip-flop. The starting oscillator, consisting of TS501 and TS502, is free running as soon as the output of Nand gate IC506/G4 is logic 1.
IC506 is logic 1, if one or both inputs are logic 0.

This means that: - switch SK4/1 START INTERN is depressed; the output of IC609/G4 is then logic 0, for no signal "REMOTE" has been programmed, or
- signal "REPEAT", which is determined by flip-flop IC601 on unit U6, is logic 1.

The starting oscillator supplies pulses with a frequency of 20 Hz.
These pulses are divided one time by five by IC508 and IC509 (provided that the "preset 9" inputs 6 and 7 are logic 0). At the output of IC501/G1, pulses with a frequency of 4 Hz are available. These pulses are supplied to start flip-flop IC503/B.

By making logic 1 the "preset 9" inputs 6 and 7 of IC509, the corresponding divider is preset to $Q_D = 1$, thus do not function as a scaler-of-five.

The next table is a survey of the possible starting speeds.

| SAMPLING TIME | | IC506 | | | | IC501 | IC509 | IC501 |
|---|---|---|---|---|---|---|---|---|
| 20 msec. | 2 msec. | 11 | 6 | 8 | 3 | 6 | 6 and 7 | 2 |
| 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 20 Hz signal |
| 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 20 Hz signal |
| 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 20 Hz signal |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 4 Hz signal |

Normal operation without REMOTE CONTROL unit U7

1 means corresponding divider is "preset to $Q_D = 1$"

0 means that the corresponding divider functions as a scaler-of-five

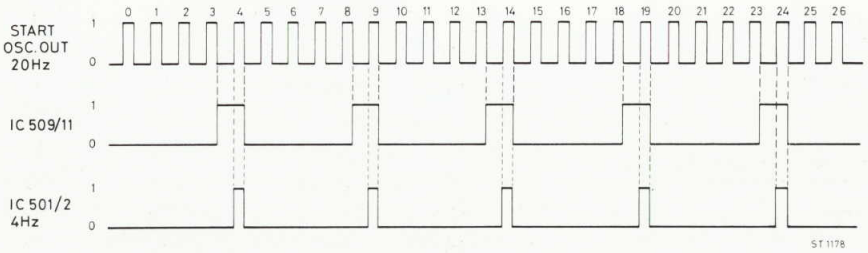



Fig. 20 Start-oscillator frequency

As soon as flip-flop IC503/B receives a starting command (logic 1 at its J input) output Q4 reverses from logic 1 to 0. IC503/B is reset again via its reset input 6 signal $t_0 - t_2$ (logic 0). A manual or external start command is directly supplied via IC507/G3, IC507/G1 and IC501/G1 to the J input of IC503/B, because the scaler-of-five (IC509) is preset (outputs $Q_D$ are then logic 1). This is achieved by making the output of IC506/G4 logic 0 (SK4/1 released and signal "$\overline{\text{REPEAT}}$" logic 1).

## 4.3. Reset circuit

The reset circuit consists of both flip-flops IC510/A and IC510/B, which determine successively the signals: transfer, reset counter and reset program.
They appear as soon as the program supplies the zero detect (ZD) command.

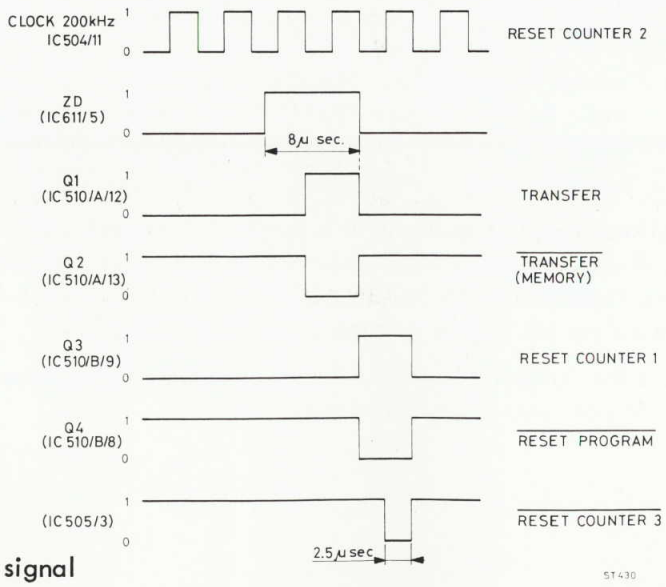



Fig. 21 Reset signal

4.4. Converting the PM 2441 from 50 Hz to 60 Hz mains frequency

The instrument can be converted to 50 Hz or 60 Hz mains frequency by means of the jumper on unit U5 (Fig. 45 and Fig. 46) and that on unit U11 (Fig. 55 and Fig. 56).

## VIII-5. PROGRAM U6

The program determines the timing of the instrument ($t_0$, $t_1$ -$t_3$, zero detect, polarity and the up- or down ranging).

The datum position is set by the reset inputs of any flip-flop. Any $\overline{Q}$ output (IC612/A/6, IC612/B/8, IC604/A/13, IC604/B/8, IC606/B/8, IC606/A/6, IC611/A/6 and IC611/B/8) is then logic 1. The MAIN GATE (IC603/G2) is blocked by a logic 0 level at input 4. Thus the "CLOCK" signal at input 3 is blocked.

Start ($t_0$)

As soon as start command (logic 0) is given by the start flip-flop on U5, flip-flop IC612/A is set (output 5 supplies a logic 1 and output 6 a logic 0). The main gate is then opened and the start flip-flop is reset again. The "CLOCK" signal is supplied to the counter, as the MAINS GATE is open.

End of upward integration ($t_1$)

Upon completion of the upward-integration ($t_1$ at a counter position of 20,000) flip-flops IC612/A, IC612/B and IC604/B are triggered via their clock input by the positive edge of signal "10,000/20,000" by which output IC612/A/5 becomes logic 0 and IC612/B/9 logic 1. IC604/B, however, does not change state because its $J_G$ input is logic 0.

Down-integration ($t_1$ - $t_2$)

As output IC612/B/9 has become logic 1 at the start of the down-integration, the next functions are prepared:

5.1. Down ranging

Preparatory input $J_G$ of IC604/A is logic 1.
This flip-flop is triggered at the negative edge of signal "01800" from counter U4.

a. Correct range

This means that the indication will be higher than 01800 and smaller than 20,000. As soon as signal "01800" becomes 0 (counter position 01800) IC604/A is triggered. Output IC604/A/12 becomes logic 1 and via IC605/G2 prevents that IC606/B is triggered by signal $\overline{ZD}$ ($\overline{ZERO\ DETECT}$) supplied by IC611/A/6 at zero passage of the integrator.
Thus a "down" pulse will be prevented.

b. Selected range too high

This means that the indication will be smaller than 01800. As signal "01800" is not supplied flip-flop IC604/A will not be triggered. As soon as signal $\overline{ZD}$ becomes logic 0 (see 5.3) flip-flop IC606/B is triggered and output IC606/B/9 becomes logic 1, thus delivering a "down"-pulse.
Only if the lowest range (20 mV) is selected, no "down" pulse is delivered as flip-flop IC606/B is blocked via its J input (signal "$\overline{RANGE\ 20\ mV}$" is logic 0).

## 5.2. Up ranging

Preparatory input $J_G$ of IC604/B is logic 1. Flip-flop IC604/B is triggered at the positive edge of signal "10,000/20,000" from the counter and determines up-ranging and the overload condition. The trigger pulse is supplied via IC609/G1, -/G2 and IC610.
This circuit determines at which counter position overload the condition must be signalized.

a. at position 20,000 for ranges 20 mV up to 200 V, IC604/B triggered at positive edge of signal 10,000/20,000
b. at position 10,000 for range 1000 V, IC604/B triggered at negative edge of signal 10,000/20,000 (Fig. 22).

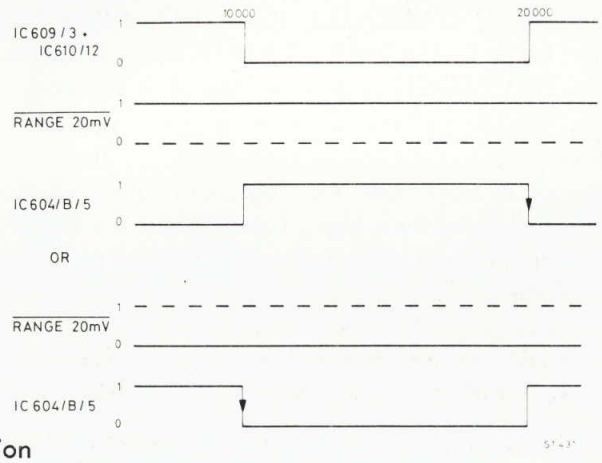



Fig. 22 Signalizing overload condition

Note: If button MODULE is depressed, the overload condition in range 1000 V is also signalized at 20,000.

a. Correct range

This means that the indication will be smaller than 20,000. Flip-flop IC604/B is not triggered as no trigger pulse is generated; the condition of this flip-flop is then maintained (output 9 = 0, output 8 = 1). (see 5.1.a.)

b. Selected range too low

This means that the indication would be higher than 20,000. However, IC604/B is triggered by the positive edge at 20,000, thus IC604/B/9 becomes logic 1 ("up" pulse) and IC604/B/8 becomes logic 0 (Fig. 22).

## 5.3. ZD (Zero detect $t_2$)

This function is determined by flip-flops IC606/A and IC611/A. During up-integration the J input of IC606/A becomes logic 1 at counter position 19990, thus preparing zero detection.
As soon as the integrator output passes zero level during down-integration, a "Set ZD" (see 6.4.) signal is supplied which triggeres flip-flop IC606/A. Output IC606/A/6 becomes logic 0. As input 2 of IC605/G1 is also logic 0 after $t_1$, a trigger pulse is supplied to IC611/A; because of this:

- IC611/A/5 becomes logic 1; signal "ZD" is logic 1.
  Signal ZD is used: a. to prepare the reset signals and the transfer pulse on unit U5
  b. to reset flip-flop IC804, which supplies signal "PREPARE ZD"
  c. to close MAIN GATE IC603/G2 via NOR gate IC605/G4
  d. to trigger polarity flip-flop IC611/B.
- IC611/A/6 becomes logic 0; signal "ZD" is logic 1.
  This signal triggers IC606/B, except if it is blocked by a logic 1 at input 5 of IC605/G2.

## 5.4. Polarity determination

The polarity is determined by flip-flop IC611/B.

- Polarity: At a negative polarity a short negative pulse is supplied to the J input of IC611/B. As the trigger pulse is generated within this pulse, it has no influence on the state of the flip-flop. Output IC611/B/9 remains logic 0.

+ Polarity: At a positive polarity a logic 1 is supplied to the J input of IC611/B. As soon as the flip-flop is triggered, the output (IC611/B/9) becomes logic 1.

Thus: signal "+ POL." = 0; the polarity of the input voltage is negative.
signal "+ POL." = 1; the polarity is positive.

## 5.5. UP-DOWN counter

Determination of the selected range is made with the aid of up-down counter IC608.
This up-down counter offers two possibilities:

a. Manual range selection

Manual range selection is performed by push-buttons SK2/1 up to SK2/6 at the front. Counter IC608 is thus controlled via the preset inputs GD (IC608/15, -/1, -/10 and -/9. However, input G (IC608/11) should be logic 0. This 0 level is achieved via gate IC607/G1 and IC609/G5 and derived from signal Z (see Fig. 23).
By selecting a measuring range a 8-4-2-1 code is supplied to the output via preset inputs GD.

The circuiting of the range push-button is shown in Fig. 23.
Signal REM is logic 0 if no remote control signal is applied.

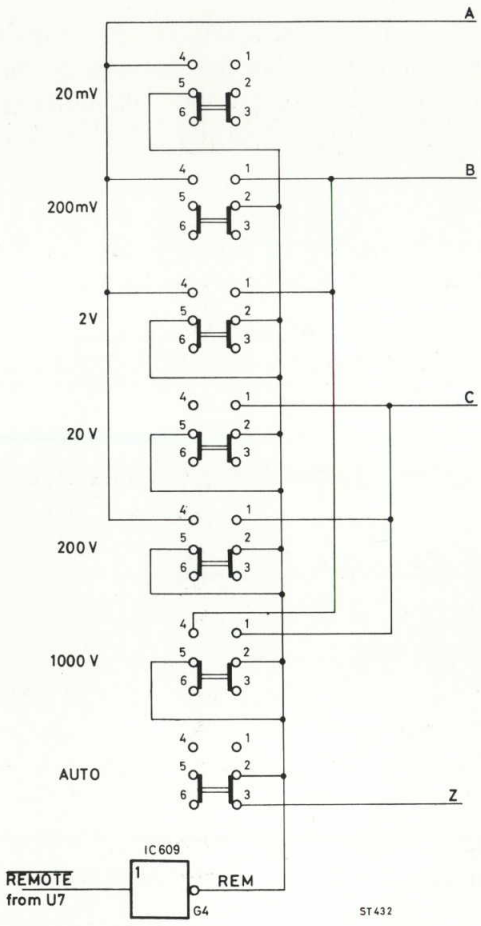





Fig. 23 Range selection circuitry

Function table range selection

| Range | REM | Z | C | B | A | IC608 9 | IC608 10 | IC608 1 | IC608 15 |
|---|---|---|---|---|---|---|---|---|---|
| 20 mV | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 200 mV | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 2 V | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 20 V | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 200 V | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| 1000 V | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| AUTO | 0 | 1 | x | x | x | 0 | 0 | 0 | 0 |

"x" may be logic 1 or 0.
Signals A, B and C are inverted by IC607/G2, -/G3 and G4 thus supplying a real 8-4-2-1 code to the preset inputs (GD). Output IC609/10 is logic 0 by which also the signal "UP" or "DOWN" are blocked.

b. Automatic range selection

By depressing button AUTO output IC609/10 becomes logic 1, so that
- Input G of IC608 becomes logic 1; the counter functions independently of the information at preset inputs GD.
- "UP" or "DOWN" pulses, if available, can pass IC603/G3 or IC602/G2 respectively.

Up-ranging

As soon as an "UP" pulse is supplied by IC604/B (see 5.1.) all three inputs of IC603/G3 are logic 1, the output becomes logic 0, so that the contents of the counter is increased by one via input +1. When IC603/G3 input 11 is logic 0 the "UP" pulse is blocked.
Logical 0 at input 11 of IC603/G3 means that the 1000 RANGE is switched on.

Down-ranging

As soon as a "DOWN" pulse is supplied by IC606/B (see 5.1.) both inputs of IC602/G2 are logic1, the input becomes logic 0 so that the contents of the counter is decreased by one via input -1.

The signal "UP" or "DOWN" is obtained via IC602/G3 and used:
- to reset the counter
- to prepare flip-flop IC601/A.

During up- or down-ranging the output of IC602/G3/8 is logic 1.

Function table up-down counter (input G is logic 1)

| Count +1 (5) | Count -1 (4) | Output (7) | Output (6) | Output (2) | Output (3) | |
|---|---|---|---|---|---|---|
| - | | x | 0 | 0 | 1 | |
| 1 | | x | 0 | 1 | 0 | |
| 2 | | x | 0 | 1 | 1 | |
| 3 | | x | 1 | 0 | 0 | up-ranging |
| 4 | | x | 1 | 0 | 1 | |
| 5 | | x | 1 | 1 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| - | x | 1 | 1 | 0 | |
| 1 | x | 1 | 0 | 1 | |
| 2 | x | 1 | 0 | 0 | down-ranging |
| 3 | x | 0 | 1 | 1 | |
| 4 | x | 0 | 1 | 0 | |
| 5 | x | 0 | 0 | 1 | |

"x" may be logic 1 or 0.

Up- or down-ranging may start at every arbitrary position.

## 5.7. Overload

The overload condition can be estabilished from blinking of the indication tubes and is memorized by flip-flop IC601/B. Its J input is logic 1 if

1. SK2/7, (AUTO) is not depressed (thus manual range selection)
2. range 1000 V has been switched on.

As soon as "up" pulse is supplied (indication would be >2000) the flip-flop is triggered and output IC601/B/8 ($\overline{OL}$) becomes logic 0.

## 5.8. Repeat

After a start (manual or external) the instrument should not be stopped after one range, but the measurement should be completed until the correct range is selected.
For this reason, signal "$\overline{REPEAT}$" is formed by IC601/A.

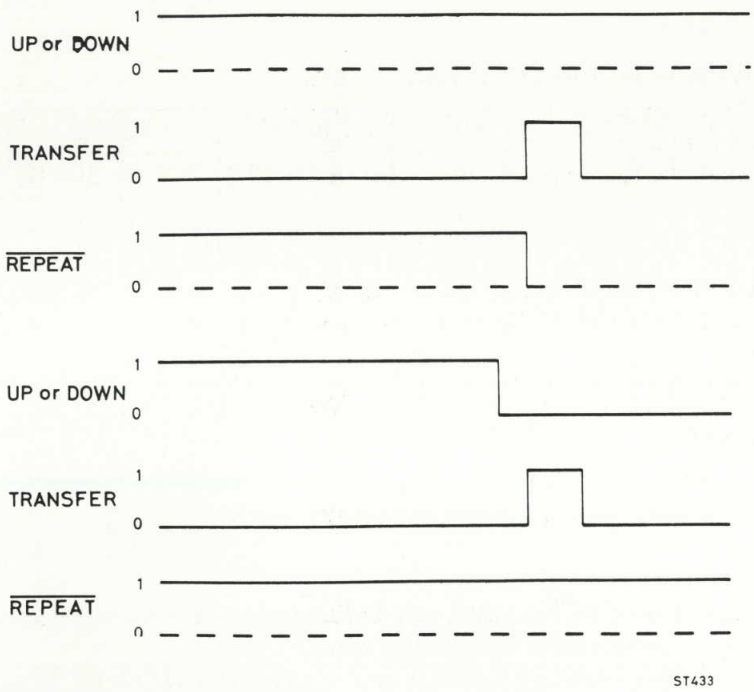



**Fig. 24 Repeat signal**

If, after the transfer pulse, signal "$\overline{REPEAT}$" is logic 0, a new start can be given.

## VIII-6. RELAY DRIVER U8

### 6.1. Decimal points and ranges

The place of the decimal points and the amplification factors for the various ranges are determined by IC807 which is controlled by Up-Down counter IC608 on unit U6.

IC807

| Range | Input | | | | Output | | | | | | Dec. point | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 11 (12) | 12 (13) | 13 (14) | 14 (15) | Q1 (2) | Q2 (3) | Q3 (4) | Q4 (5) | Q5 (6) | Q6 (7) | D | C | B | A |
| 20 mV | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 |
| 200 mV | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| 2 V | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| 20 V | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| 200 V | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 1000 V | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |

Via gates IC802/G1, IC802/G2, IC808/G3 and IC808/G5 the output of IC807 is decoded and delivers signals A, B, C and D for controlling the decimal points.

Signals at the output of IC807 are used to control:
- the input relays (RE909 and L901 + RE907)
- the relays used to determine the gain of the d.c. amplifier (RE901, RE902 and RE903)
- the mV indication

For more details, refer to the table below.

| Range | IC807 | | | | | | IC801 | | IC802 | | IC803 | | | | IC805 | | | | IC806 | | | | | IC808 | | IC809 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 6 | 3 | 8 | 11 | 1 | 4 | 10 | 13 | 1 | 4 | 10 | 13 | 2 | 4 | 8 | 10 | 12 | 2 | 10 | 2 | 4 | 6 | 8 | 10 | 12 |
| 20 mV | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| 200 mV | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| 2 V | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| 20 V | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| 200 V | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 1000 V | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| | | | | | | | | | | | | | | | | | | | see 6.1.b. | see 6.1.d. | see 6.1.c. | | see 6.1.f. | | | see 6.1.e. | | see 6.1.a. | | see 6.1.b. | |

Note: The data, mentioned in the table, are determined under normal operating conditions which means: SAMPLING TIME = 100 msec.
No Remote Control programmed (signal $\overline{\text{MODULE REM.}}$) = 1.

a. Direct or attenuated input

The d.c. input signal is supplied to the d.c. amplifier (U10) directly or via an attenuator. Direct or attenuated input is determined by the output state of IC809/6 and IC809/8. Output IC809/6 controls reed-relay RE909, which determines the direct input, while IC809/8 controls reed-relays L901 + RE907 which determine the attenuated input.
A logic 0 energizes the relevant relay, while at logic 1 the relay is not energized.

b. Gain d.c. amplifier

The gain for the various measuring ranges is controlled by reed-relays RE901, RE902 and RE903 which are driven via IC809/10, IC809/12 and IC806/2 respectively.
A logic 0 energizes the corresponding relay, while at logic 1 the relay is not energized.

c. mV Indication

The outputs of IC806/8 and IC806/10 control directly pilot lamps LA101 (m) and LA102 (V) indicating mV and V respectively. If the outputs is logic 0, the relevant pilot lamp(s) light(s). Signal "BLANK m/V INDICATION", which may be supplied via the MODULE input BU5, must be logic 1.

d. Module

MODULE input BU5 is selected via IC806/4 which controls reed-relay RE906. If the relay is energized, the MODULE input is connected to the input of the d.c. amplifier.
To energize relay RE906 or both inputs of Nand-gate IC802/G3 should be logic 0. This is possible by depressing button SK3/2 MODULE, SK3/1 INTERN releases, or by making signal MODULE REMOTE logic 0.

e. Sampling-time

The sampling-time is controlled via IC809/2 or IC809/4 respectively for signals "SAMPLING TIME 2 msec." or "SAMPLING TIME 20 msec." by REMOTE CONTROL unit U7 (PM 9230).

f. Remote

As soon as the remote control unit is used, pilot lamp LA1 (REMOTE) lights, provided control signal REMOTE is logic 1. This signal is programmed via REMOTE CONTROL unit U7 (PM9230).

6.2. Relays energized

| RANGE | RE909 DIRECT INPUT | L901, RE907 ATTN. 100x | RE901 GAIN 10x | RE902 GAIN 100x | RE903 GAIN 1000x | LA101 m | LA102 V |
|---|---|---|---|---|---|---|---|
| 20 mV | x | | | | x | x | x |
| 200 mV | x | | | x | | x | x |
| 2 V | x | | x | | | | x |
| 20 V | x | | | | | | x |
| 200 V | | x | x | | | | x |
| 1000 V | | x | | | | | x |

| SAMPLING TIME | RE904 | RE905 |
|---|---|---|
| 100 msec. | | |
| 20 msec. | x | |
| 2 msec. | | x |

| REMOTE CONTROL INDICATION | LA1 REMOTE |
|---|---|
| REMOTE U7 | x |

## 6.3. Inguard control

Via pulse transformer T801 the information "start", "19 990" and "zero detect" (ZD) are supplied to the inguard program (see pulse diagram Fig. 25).

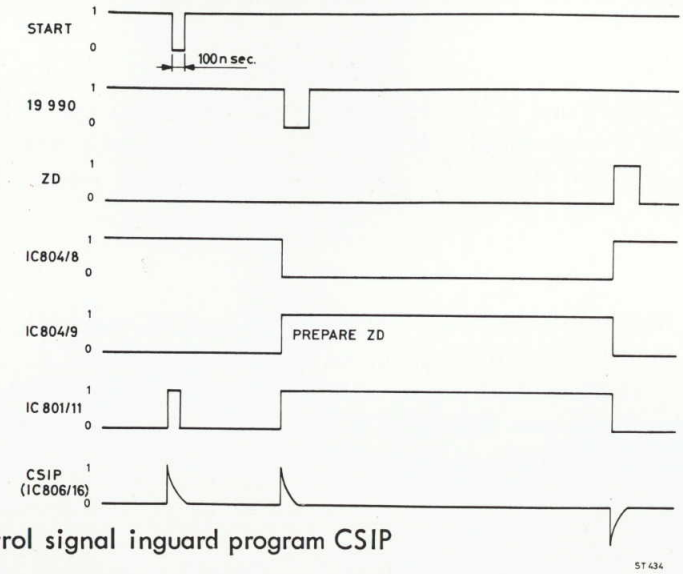



Fig. 25 Control signal inguard program CSIP

## 6.4. Control inguard program

Via pulse transformer T802 the zero detect from the integrator (ZD INT.) is supplied to PROGRAM unit U6, and determines the polarity information and "ZERO DETECT" (ZD) (see pulse diagram Fig. 26).

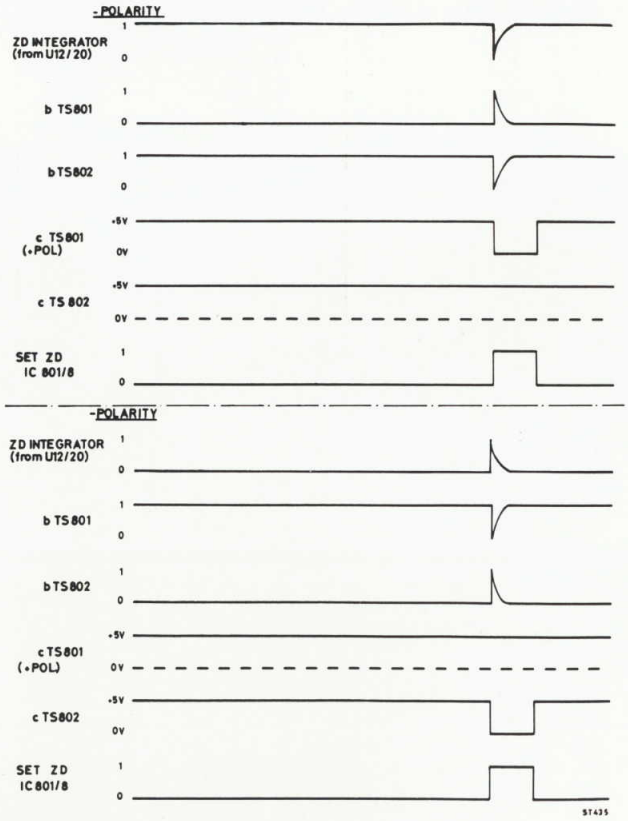



Fig. 26. Polarity determination

Signal "+ POL." is a short negative pulse at negative polarity, and a logic 1 level at positive polarity. For both polarities, however, "SET ZD" is a short positive pulse as soon as the integrator output passes zero.

6.5. Blinking all tubes ($\overline{BAT}$)

As soon as the overload condition is signalized, "$\overline{BLINK}$" pulses are supplied with a repetition frequency of 1 Hz to the trigger input of IC804/A. These pulses are derived from the blinking oscillator on unit U1. Thus, at output Q2 (IC804/A/13) a square wave is obtained ($\overline{BAT}$) which controls TS104 on unit 1 (see also 1.5.)
Signal "RESET BLINK" is energized by IC602/G4/11 and appears when there is no overload condition.



VIII-7. RELAY SWITCHES U9

This unit contains the relays for the next functions

| | | | |
|---|---|---|---|
| RE901 | : gain 10x | RE906 | : MODULE |
| RE902 | : gain 100x | RE907 | : attenuation 1 : 100 |
| RE903 | : gain 1000x | RE908 | : attenuation 1 : 100 |
| RE904 | : 2 msec. SAMPLING TIME | L901 | : attenuation 1 : 100 |
| RE905 | : 20 msec. SAMPLING TIME | RE909 | : direct input |

All the relays are controlled by the RELAY DRIVE unit U8 (see table).

Relays energized

| RANGE | RE909 DIRECT INPUT | L901, RE907 ATTN. 100x | RE901 GAIN 10x | RE902 GAIN 100x | RE903 GAIN 1000x | LA101 m | LA102 V |
|---|---|---|---|---|---|---|---|
| 20 mV | x | | | | x | x | x |
| 200 mV | x | | | x | | x | x |
| 2 V | x | | x | | | | x |
| 20 V | x | | | | | | x |
| 200 V | | x | x | | | | x |
| 1000 V | | x | | | | | x |

| SAMPLING TIME | RE904 | RE905 |
|---|---|---|
| 100 msec. | | |
| 20 msec. | x | |
| 2 msec. | | x |

| REMOTE CONTROL INDICATION | LA1 REMOTE |
|---|---|
| REMOTE U7 | x |

## VIII-8.D.C. AMPLIFIER U10

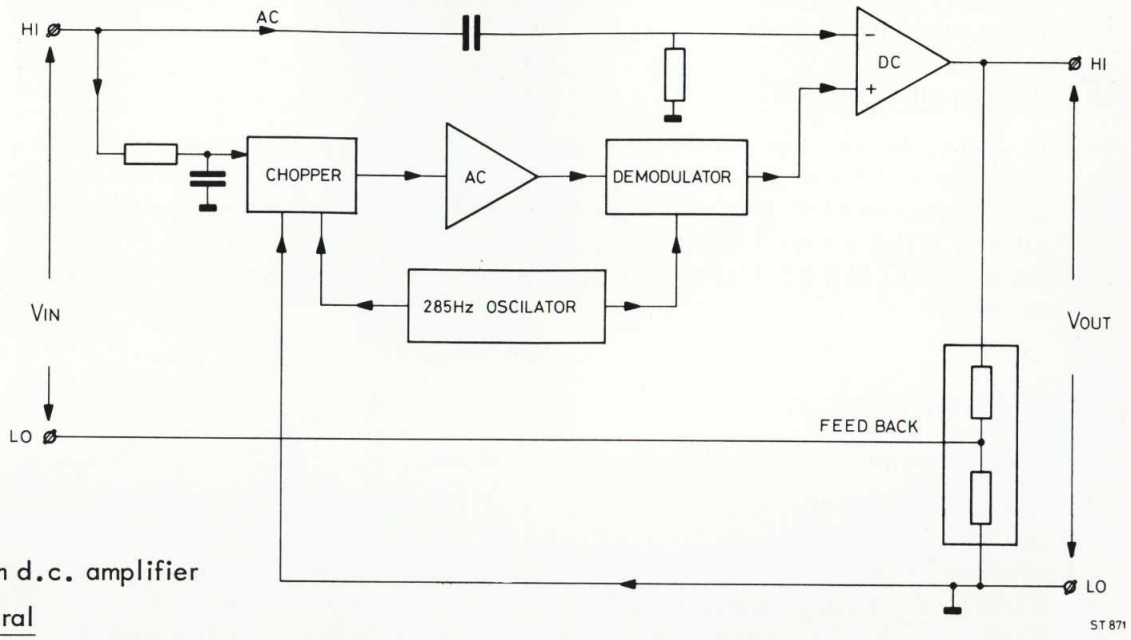



Fig. 27
Blockdiagram d.c. amplifier

### 8.1. General

- The d.c. amplifier is built up out of a chopper amplifier consisting of a chopper, an a.c. amplifier, a demodulator and a chopper drive, and d.c. output amplifier.
  The d.c. amplifier is an inverting amplifier.
- In the new d.c. amplifier, the d.c. input signal is separated in an a.c. - and a d.c. part. The d.c. part is supplied to the chopper amplifier and chopped into a square wave signal by a MOST chopper. The square wave signal is amplified by an a.c. amplifier and demodulated in a d.c. signal again. This d.c. signal is added with the a.c. part and offered to the output amplifier. The output of this amplifier is fed back to the input of the d.c. amplifier.
- The d.c. amplifier gives an output level of 20 V d.c. at the end-of-range (display 20.000) in all ranges selected, except for the 1000 V range (10 V d.c.).
  This is possible by using various gain factors.

### 8.2. Principle of operation

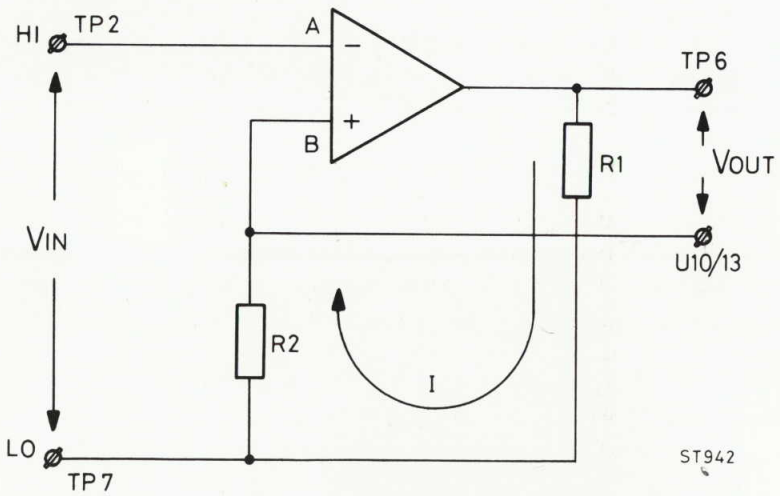



Fig. 28 Principle of operation

When a d.c. voltage is supplied to the input of the d.c. amplifier, the d.c. amplifier will get in balance. By this the +input (B) of the d.c. amplifier will have near the same potential with respect to the LO-input as the voltage on the HI input (input voltage) and a feedback current will flow through the feedback resistors R1 and R2. Due to the high input resistance of the d.c. amplifier, the feedback current will not flow to the LO-input.

By this the input voltage (HI-LO) equals: $V_{in} = I.R2$ (I = feedback current)

The output voltage of the inverting d.c. amplifier equals: $-V_{out} = I\,(R1 + R2)$

The gainfactor is: $$\frac{-V_{out}}{V_{in}} = \frac{I\,(R2+R1)}{I.R2} = \frac{R2+R1}{R2} = \frac{R1}{R2} + 1$$

In the different ranges the gainfactors are constant (see table).

| Range | Gainfactor | Attenuation (on unit U9) |
|---|---|---|
| 20 mV | 1000 | 1 |
| 200 mV | 100 | 1 |
| 2 V | 10 | 1 |
| 20 V | 1 | 1 |
| 200 V | 10 | 100 |
| 1000 V | 1 | 100 |

A gainfactor of 1 is obtained by making the value of resistance R2 infinite, which means open relay contacts.
The different gainfactors for the ranges are determined by changing the resistance of R2.
At the end of range the output of the d.c. amplifier is 20 V.
The open loopgain of the d.c. amplifier is $20.10^6$.
By this the input voltage between point A and B of the amplifier at end of range (maximum input voltage) is: $$\frac{20\ V}{20.10^6} = 1\ \mu V$$

Note: The LO-input is separated from the low of the output.

## 8.3. Circuit description

- d.c. amplifier

The input voltage, connected to the D.C. INPUT of the PM 2441, is supplied via an attenuator (x1 and x100) on unit U9 to the input of the d.c. amplifier unit U10 (TP2 is HI and TP7 is LO).
At end of range the output voltage of the d.c. amplifier is 20 V d.c. (Its polarity is opposite the polarity of the input voltage).
By this the voltage between testpoints TP1 and TP2 is 1 μV (see 8.1. and Fig. 54.)

This d.c. voltage of 1 μV is chopped into a square wave voltage by a MOST FET TS1001. (Fig. 54, diagram B). The FET TS1001 is controlled by a square wave voltage of 285 Hz from the chopper drive circuit TS1003 up to TS1005. The chopped input voltage is uncoupled by capacitor C1005 (Fig. 54, diagram C) and amplified ≈10x by the FET circuitry TS1002 (Fig. 54, diagram D). The d.c. level is 6 V.
IC1001 amplifies the square wave voltage ≈300x (Fig. 54, diagram E) to 3 mV.
By capacitor C1014 the square wave voltage is uncoupled (Fig. 54, diagram F).
The square wave voltage is demodulated and converted into a direct voltage by FET TS1006 (Fig. 54, diagram G and H).
The direct voltage is supplied to one input of the output amplifier (TS1011).

The other input of the difference amplifier (TS1011) is connected to zero by the high-pass filter C1009/R1046. Only when a quick switching input signal is supplied to the input of the d.c. amplifier, it will pass the high-pass filter. (Fig. 29).

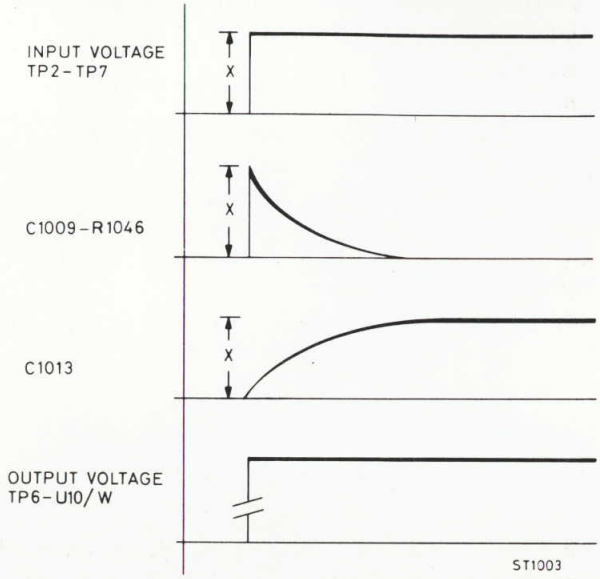



Fig. 29 A.C. path

The output amplifier consists of a difference amplifier and a power output stage.
At end of range the output voltage of the d.c. amplifier at testpoint TP6 is 20 V D.C. .
Via a resistor 100 kΩ (R1048) and the feed back resistors, which are controlling the gain the output is fed back to the input of the d.c. amplifier (testpoint TP1).

- Chopper drive

The modulator and demodulator are driven by a a-stable multivibrator.
The multivibrator frequency is 285 Hz and may be adjusted by resistor R1008.

- Protection

The output of the d.c. amplifier is protected by the circuitry of the diodes GR1006/GR1007 and GR1011 up to GR1015 for 28.4 V.
The input is protected by the circuitry of the diodes GR1014 up to GR1017 and GR1020 for 39 V.

- Supply

The supply voltages for the d.c. amplifier are:

+36 V and -36 V; supply output amplifier
+15 V and -15 V; supply input stage and chopper drive

- Minimum spike adjustment

As there is a capacitive coupling between the gate and drain of the MOST FET TS1001 spikes will appear on the drain of the MOST FET TS1001. These spikes are caused by the square wave signal of the chopper drive.
To suppress these spikes, an inverted chopper signal is supplied to the drain of the MOST FET TS1001. This may be adjusted by the resistors R1010 and R1012.

- Decreasing the input-settling time

The input-settling time may be decreased by removing capacitor C1018.
For data refer to chapter II.

## VIII-9. INTEGRATOR U11

9.1. Unit U11 consists of next circuits:
- $+V_{REF}$ and $-V_{REF}$
- Input circuit
- Amplifiers IC1103 and IC1104
- Integrator
- Comparator

### 9.1. $+V_{REF}$ and $-V_{REF}$

The reference voltage for the integrator is +10 V and -10 V and it is obtained from zener diode GR1101. The zener-voltage of this diode (about 6.3 V) is amplified up to +10 V by IC1106. The gain can be adjusted exactly by R1139.
The +10 V voltage is inverted via IC1105. The gain of this stage is 1x, so that the reference voltage delivered amounts to -10 V.

### 9.2. Input circuit

Three voltages can be connected to the integrator input, via summing amplifier IC1104, viz. the input voltage, $+V_{REF}$ and $-V_{REF}$.
Which voltage is connected to the integrator input is determined by FETs TS1104 and TS1108, TS1105 and TS1109, TS1106 and TS1110 which are controlled by signals $t_0 - t_1$ upward integration, $(t_1 - t_2)$ $+V_{ref}$ and $(t_1 - t_2)$ $-V_{ref}$ (downward integration) respectively.
The signals are formed by the INGUARD PROGRAM (U12).
The FETs are conductive if their gate is 0 V and blocked if the gate is -15 V.
During the upward-integration period, signal $t_0 - t_1$ is 0 V, thus blocking TS1104 and TS1108. The input voltage is connected to the integrator.
Signals $(t_1 - t_2)$ $+V_{ref}$ and $(t_1 - t_2)$ $-V_{ref}$ are -15 V, so that the reference voltages (+10 V and -V) are connected to 0 V via a series resistor.
During downward-integration, $t_0 - t_1$ is -15 V. The input voltage is then connected to 0 V via R1127 and R1128. Depending on the polarity of the input voltage the positive or the negative reference voltage is connected to the integrator input by making the corresponding control signal 0 V.

Remark: To make the offset voltage across TS1104, TS1109 and TS1110 as small as possible the voltage across TS1108, TS1105 and TS1106 is again divided by the voltage divider consisting of R1126, R1135 or R1134 and the offset resistance of the FET.

### 9.3. Amplifiers IC1103 and IC1104

Amplifier IC1103 has a gain of $\frac{R1108 + R1105}{R1111}$ and is about $3.33 \times 10^{-4}$.

Moreover, the input voltage is inverted. In this way the input of the comparator is slightly lower or higher than zero level, so that the zero indication of the instrument is not influenced by hum.
IC1104 acts as a separating amplifier between the input circuit and the integrator input.

## 9.4. Integrator

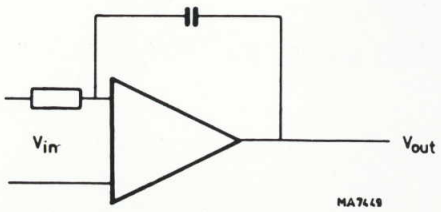



Fig. 30 Integrator

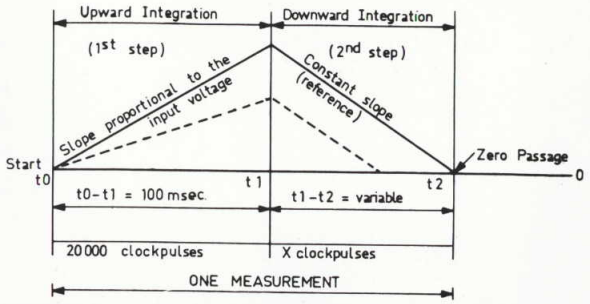



Fig. 31 Integration process

The dual-slope system used comprises an integrator.
During the upward integration, which starts at $t_0$ and ends at $t_1$, the integrating capacitor C1104//C1105 is charged with a constant current which is determined by the input voltage and R1112.
The output voltage, which meets the formula

$$V_{out} = \frac{1}{RC} \int_0^t V_{in}\, dt + V_0 = \frac{I \cdot t}{C},$$ is proportional to the input voltage.

Time t is a fixed time, determined by counting 20 000 clock pulses, and is 100 msec. (SAMPLING TIME) +0.1% at 4 measurements per second (thus under normal operation conditions).
At 20 msec. SAMPLING TIME the charging current is raised by circuiting resistor R1113 in parallel to R1112. Time is 20 msec.
At 2 msec. SAMPLING TIME resistor R1114 is circuited in parallel to R1112. Time is determined by counting 2000 clock pulses; this corresponds with 2 msec.

During the downward integration, starting at $t_1$ the integrating capacitor will be discharged by a constant current which is determined by the reference voltage ($+V_{REF}$ or $-V_{REF}$) and R1112.
The supplied reference voltage, however, is always opposite to the charged voltage.
Thus, the integrator output becomes zero level. The slope during the downward integration period is constant.
As soon as the output level passes zero level the integrating capacitor is short-circuited by making transistor TS1107 conductive (pulse $t_0 - t_2$ is 0).
Converting the PM 2441 from the 50 Hz to the 60 Hz mains frequency version must be performed by unsoldering the jumper which connects C1101 in parallel with the integrator capacitor C1104.

## 9.5. Comparator

Comparator IC1101 compares the output signal of the integrator with the output level of IC1103, which is nearly 0 level.
The comparator supplies signal ZD INT. which is logic 1 (>3.5 V) for a negative d.c. voltage at the instrument input and logic 0 (<0.4 V) for a positive d.c. voltage at the instrument input. (See 10.1., Fig. 32.)

## VIII-10. INGUARD-PROGRAM AND SUPPLY U12

### 10.1. Inguard-program

The inguard-program determines which input "switch" in the input of the integrator circuit is opened or closed, thus which phase (up or down integration) is passed.
The inguard-program consits of flip-flops IC1201/A, IC1201/B and Nand-gate IC1202.
The circuit is controlled by pulse "CSIP" from unit U8 (control signal inguard-program) via pulse transformer T1201 and transistors TS1201 and TS1202.
The functioning of the circuit can easily be derived from pulse diagram Fig. 32.
Via pulse transformer T1202 information "ZD INT" (zero detect integrator) is supplied from the inguard circuit to the main program.

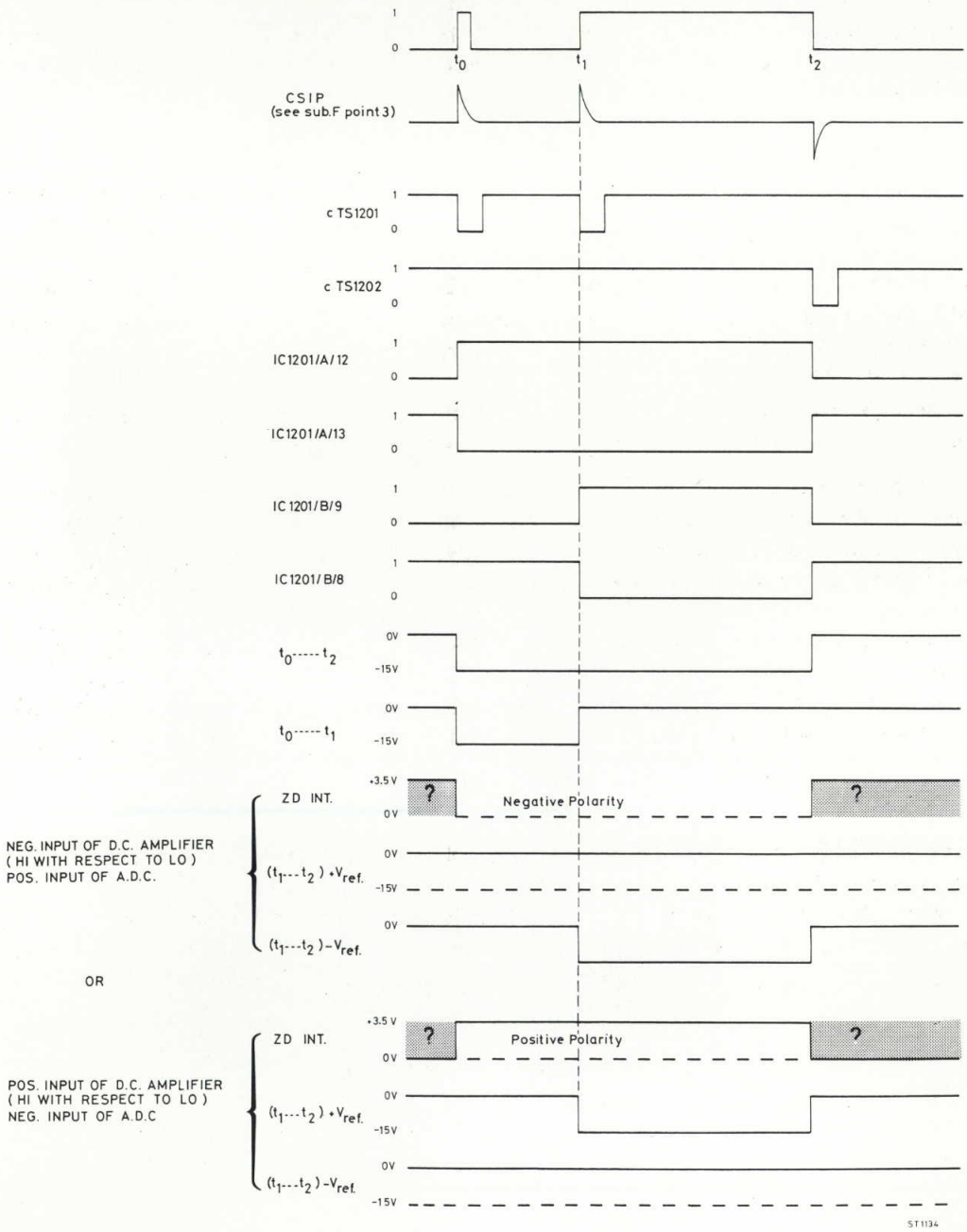



Fig. 32 V-reference determination

## 10.2. Inguard-supply

The secundary voltage of winding S5 of mains transformer T1 is also the primary voltage of transformer T2 which supplies the a.c. voltages for the inguard-supply; last delivers five stabilized voltages.

a. +36 V and -36 V supply

These voltages are derived from windings S2 and S2′ via full-wave rectifier GR1205. The circuit has current-stabilization (TS1210 or TS1211) and voltage-stabilization with zener-diodes GR1206 and GR1207. The +36 V and -36 V supply are used for the d.c. amplifier U10.

b. +15 V and -15 V supply

These voltages are derived from windings S3 and S3′ via full-wave rectifier GR1204. Stabilization is achieved by a series-stabilization circuit consisting of TS1208 and voltage regulator IC1204 for the +15 V supply and TS1207 and IC1203 for the -15 V supply. The reference voltage +5 V is derived from the +36 V supply. The +15 V and -15 V are used for the d.c. amplifier (U10), the integrator (U11) and the inguard-program (U12).

c. +5 V supply

The voltage source is derived from winding S4 via full-wave rectifier GR1203. Stabilization is achieved via series-stabilization circuit TS1209 and voltage regulator IC1205.
The +5 V supply is used for the integrated circuits on units U10 and U12.

d. +4.0 V supply

This supply is derived from the +5 V and is used for supplying the comparator IC1101 on unit U11.

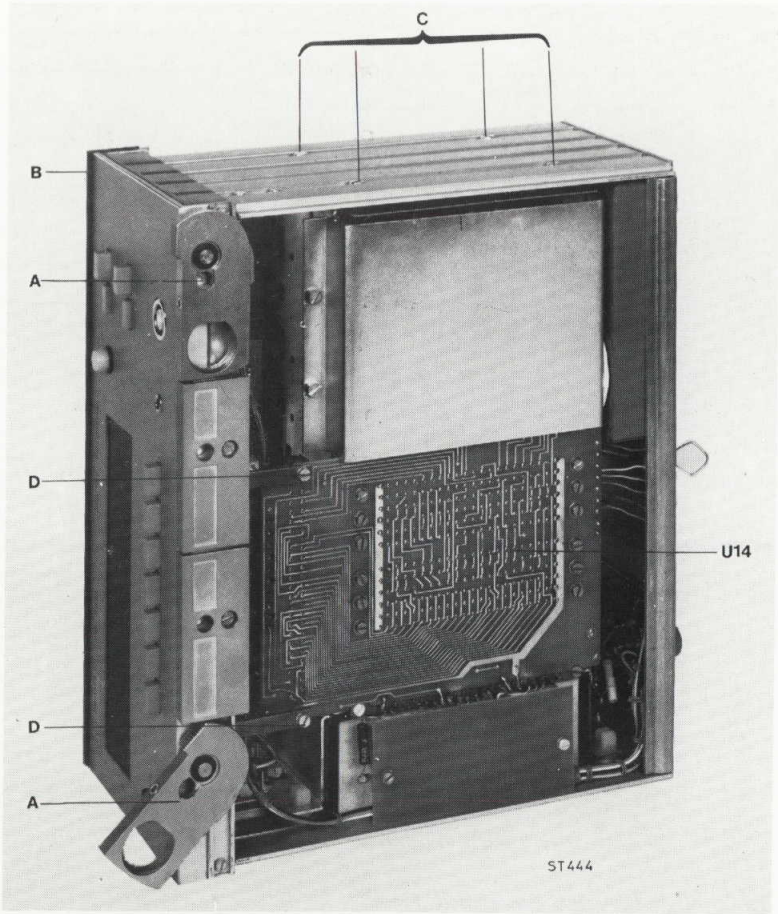



Fig. 33 Bottom view

# IX. Access

## IX-1. REMOVING THE CABINET

The PM 2441 is built-up as a plug-in chassis and accommodated in a 3-module standard cabinet. The chassis can be pulled out of the cabinet by means of the two locking devices at the front (See chap. VI-3.1).
If these locking devices cannot be hinged out, the two locking screws at the front should be loosened (do not remove them) by means of the 2.5 mm Allen key, included upon delivery.
The chassis can then be pulled out of the cabinet.

## IX-2. REMOVING UNITS U1 UP TO U12

When the chassis is pulled out of the cabinet, units U2 up to U8 can be pulled directly out of the cabinet (Fig. 36).
To pull units U9 up to U12 out of the chassis the adjusting cap should be removed first.

Note: When pulling units U9, U10 and U12 out of the chassis the wires should be removed first.

## IX-3. REMOVING UNITS U1 AND U13

Remove the text plate and the front panel.
This may be done by removing screws A, ornamental strip B and the four screws under the text plate (Fig. 33).
Units U1 and U13 can then be pulled out of the connector on U14.

## IX-4. REMOVING THE BOTTOM UNIT U14

Remove all the units (U1 up to U13).
Remove all the wires of the bottom unit U14.
Remove the four screws C (Fig. 33) out of the side plates.
Remove the two screws D (Fig. 33).
Unit U14 together with the guard case can be pulled out of the chassis.

# X. Checking and adjusting

## X-1. GENERAL

The tolerances stated in this chapter correspond to the factory data, which only apply for a complete readjusted instrument.
The tolerances may deviate from those mentioned in the technical data.

When adjusting the PM 2441 the following rules should be taken into account:

- Adjusting the PM 2441, only reference voltages and measuring equipment with the required accuracy should be applied.
- When individual components such as semi-conductors or integrated circuits are replaced, the relevant units should be completely readjusted.
- Always use the measuring cable of the PM 2441 so that the measurement cannot be affected by external influences.
  When an input voltage needs to be supplied, always interconnect the LOW- and GUARD plug of the measuring cable.
  HIGH = red
  LOW = black
  GUARD = blue
- The warming-up time (30 min.) and the reference conditions (relative humidity and temperature) should be taken into account.
- When adjustments are made, always carry out the calibration and the electrical zero-setting procedure again.
- It is advisable to carry out the adjustments with the aid of an extension board (code number 5322 263 70059).

## X-2. SURVEY OF ADJUSTING ELEMENTS

The following table gives a survey of all adjustments of the PM 2441.
For a complete adjustment adhere to the sequence of point 3 and 4 of this chapter.

| Adjustment No. | Adjustment | Adjusting element |
|---|---|---|
| 3.1 | Start oscillator frequency | R505 |
| 3.2.1 | Chopper frequency | R1008 |
| 3.2.2 | Drain voltage TS1002 | R1031 |
| 3.2.3 | Minimum spike | R1012 |
| 3.2.4 | Gain IC1001 | R1024 |
| 3.2.5 | Zero current offset correction | R1030 |
| 3.3.1 | Zener current of GR1101 | R1148 |
| 3.3.2a | +V-reference | R1139 |
| 3.3.3 | Zeroing of IC1104 | R1120 |
| 3.3.4 | +, - Calibration | R1121 |
| 3.3.5 | Coarse adjustment "20 V CAL" | R1127 |

| Adjustment No. | Adjustment | Adjusting element |
|---|---|---|
| 3.3.6 | Zeroing IC1102 | R1104 |
| 3.3.7 | Offset correction IC1101 | R1103 |
| 3.3.8 | Dead band zero | R1105 |
| 3.4.1 | +5 V supply | R1227 |
| 3.5.1 | Hum voltage | R3 |
| 4.1.1 | 20 V Zero | R1103 |
| 4.1.2 | µV Zero | R1023 |
| 4.1.3 | +, - Calibration | R1121 |
| 4.1.4 | 20 V Calibration | R1119 |
| 4.1.5 | 20 mV Calibration | R1067 |
| 4.1.6 | 200 mV Calibration | R1066 |
| 4.1.7 | 2 V Calibration | R1065 |
| 4.1.8 | 20 V Cailbration | Check |
| 4.1.9 | 200 V Calibration | R909 |
| 4.1.10 | 1000 V Calibration | Check |

## X-3. ADJUSTING PROCEDURE

- The sequence given in this adjusting survey should be followed, when adjusting the units concerned.
- Before adjusting, pull the chassis out of the cabinet (Chap. IX) and place the unit concerned on the extension board (code number 5322 263 70059).

| ADJ. NO | ADJUSTMENT | ADJUSTING ELEMENT | UNIT | PREPARATIONS | MEASURING POINTS | ADJUSTMENT DATA |
|---|---|---|---|---|---|---|
| 1 | Start oscillator frequency | R505 (Adjusting resistor MR25 1%, 20 k - 100 k) | U5 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/4 "20V Range" | U5/4<br>U5/22 = 0 V | 4 Hz ±0.2 Hz |
| 2.1 | Chopper frequency | R1008 (Adjusting resistor MR25 1 k - 100 k) | U10 | Depress: SK4/1 "INTERN<br>SK3/1 "DIRECT"<br>SK2/4 "20V Range" | TS1004 collector<br>U10/13 = zero | 285 Hz ±2 Hz |
| 2.2 | Drain voltage TS1002 | R1031 (Adjusting resistor MR25) | U10 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/4 "20V Range" | Testpoint TP4<br>U10/13 = zero | 6 V +0.5 V |
| 2.3 | Minimum spike adj. | R1012 "FINE" (potentiometer) | U10 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/4 "20V Range" | Testpoint TP8<br>Signal ground,<br>SG (TP1) = zero | |
| 2.4 | Gain adjustment IC1001 | R1024 (Adjusting resistor MR25 1%) | U10 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/4 "20V Range"<br>Remove transistors TS1009 and TS1012. (placed on foot)<br>Supply: 1 mV d.c. to TP1 (LO) and TP2 (HI) | Testpoint TP5<br>U10/13 = zero | |

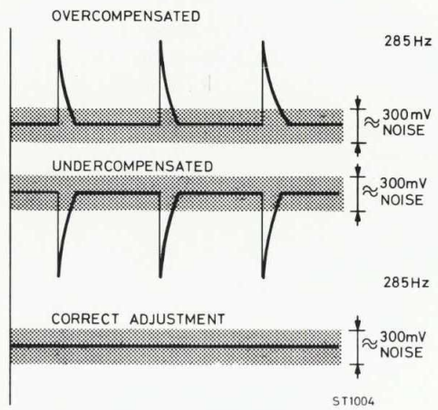



Fig. 34 Spike adjustment

This signal should be measured by oscilloscope. When the adjustment cannot be made, the next procedure should be followed:

a. Place potentiometer R1012 in its mid position.
b. Adjust minimumspikes by means of adjusting resistor R1010 "MINIMUM SPIKE ADJUSTMENT COARSE"
c. Adjust minimum spikes by means of potentiometer R1012 "MINIMUM SPIKE ADJUSTMENT FINE"

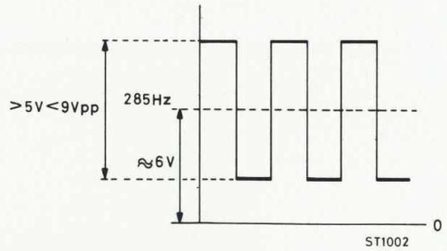



Fig. 35 Gain adjustment

The signal should be measured by oscilloscope.

| ADJ. NO | ADJUSTMENT | ADJUSTING ELEMENT | UNIT | PREPARATIONS | MEASURING POINTS | ADJUSTMENT DATA |
|---|---|---|---|---|---|---|
| 2.5 | ZERO current offset correction | R1030 (potentiometer) | U10 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/4 "20 mV Range"<br>Connect: Interconnect LO- and GUARD plug to earth (BU1) Connect between the HI and LO/GUARD/earth a resistor of 1000 MΩ ±20% | Visible at display | 00.000 mV +5 digits<br>1 digit = 1 mV≙ 1 pA<br>Note: The zero current offset adjustment and µV zeroing are influencing each other. Therefore these adjustments should be repeated when adjusting one or both. |
| 3.1 | Zener current of GR1101 | R1148 (Adjusting resistor MR25 1%, 0Ω - 10 k) | U11 | Depress: SK4/2 "MAN/EXT"<br>SK3/1 "DIRECT"<br>SK2/4 "20 V Range" | mA meter in series with R1148 | 7.5 mA ±0.1 mA<br>Note: The internal resistance of the mA-meter must be taken into account. |
| 3.2a | + V reference | R1139 (Adjusting resistor MR25 1%, 10 Ω - 10 k) | U11 | Depress: SK4/2 "MAN/EXT"<br>SK3/1 "DIRECT"<br>SK2/4 "20 V Range" | IC1106/6<br>U11/L = 0 V | +10 V ±25 mV |
| 3.2b | - V reference (CHECK) | | U11 | Depress: SK4/2 "MAN/EXT"<br>SK3/1 "DIRECT"<br>SK 2/4 "20 V Range" | IC1105/6<br>U11/L = 0 V | - 10 V ±25 mV |
| 3.2c | CHECK 3.1 and 3.2a, and if necessary repeat the adjustments. | | U11 | | | |
| 3.3 | Zeroing of IC1104 | R1120 (potentiometer) | U11 | Depress: SK4/2 "MAN/EXT"<br>SK3/1 "DIRECT"<br>SK2/4 "20 V Range" | IC1104/6<br>U11/L = 0 V | 0 V ±0.2 mV |
| 3.4 | +, - Calibration | R1121 "+ - CAL" (potentiometer) | U11 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/4 "20 V Range"<br>Supply: Alternately +18 V ±0.5 mV and -18 V ±0.5 mV to the DC-input BU2 via the measuring cable | Visible at the display | The same value at + and - polarity. If necessary resistor R1137 or R1138 may be short-circuited. |
| 3.5 | Rough adjustment "20 V CAL" | R1127 (Adjusting resistor MR25 1%, 0 Ω - 1 k) | U11 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/4 "20 V Range"<br>Supply: +18 V ±0.5 mV to the DC-input BU2 via the measuring cable | Visible at the display | 00.000 V ±5 digits |
| 3.6 | Zeroing IC1102 | R1104 (potentiometer) | U11 | Depress: SK4/2 "MAN/EXT"<br>SK3/1 "DIRECT"<br>SK2/4 "20 V Range" | Soldering pin 2<br>U11/L = 0 V | 0 V ±0.2 mV |
| 3.7 | Offset correction IC1101 | R1103 (potentiometer) | U11 | Depress: SK4/2 "MAN/EXT"<br>SK3/1 "DIRECT"<br>SK2/4 "20 V Range" | U11/T<br>U11/L = 0 V | U11/T must switch approximately between 0 V and +3.5 V |

| ADJ. NO | ADJUSTMENT | ADJUSTING ELEMENT | UNIT | PREPARATIONS | MEASURING POINTS | ADJUSTMENT DATA |
|---|---|---|---|---|---|---|
| 3.8 | Dead band zero. This adjustment only must be carried out when the electrical zero setting and the calibration procedure have been performed. | R1105 (potentiometer) | U11 | Depress: SK4/2 "MAN/EXT"<br>SK3/1 "DIRECT"<br>SK2/4 "20 V Range"<br>Supply: Alternately +10 mV ±0.3 mV, 0 V (by interconnecting the HIGH, LOW and GUARD plugs of the measuring cable) and - 10 mV ±0.3 mV. | IC1103/6<br>U11/L = 0 V | a. +10 mV ±0.5 mV<br>b. ±0 mV<br>c. - 10 mV ±0.5 mV |
| 4.1 | +5 V supply | R1227 (Adjusting resistor MR25) | | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/4 "20 V Range" | U12/6 (+5 V)<br>U12/L = 0 V | +5 V ±0.25 V |
| 5.1 | Hum voltage | R3 (Adjusting resistor MR25 1%, 10 Ω - 2 k) | T1 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/4 "20 V Range"<br>Connect the measuring cable to the PM 2441 and interconnect the HIGH, LOW and GUARD plugs. | A.C. voltmeter between instrument housing and the HIGH, LOW and GUARD plugs. | <20 mA A.C. |

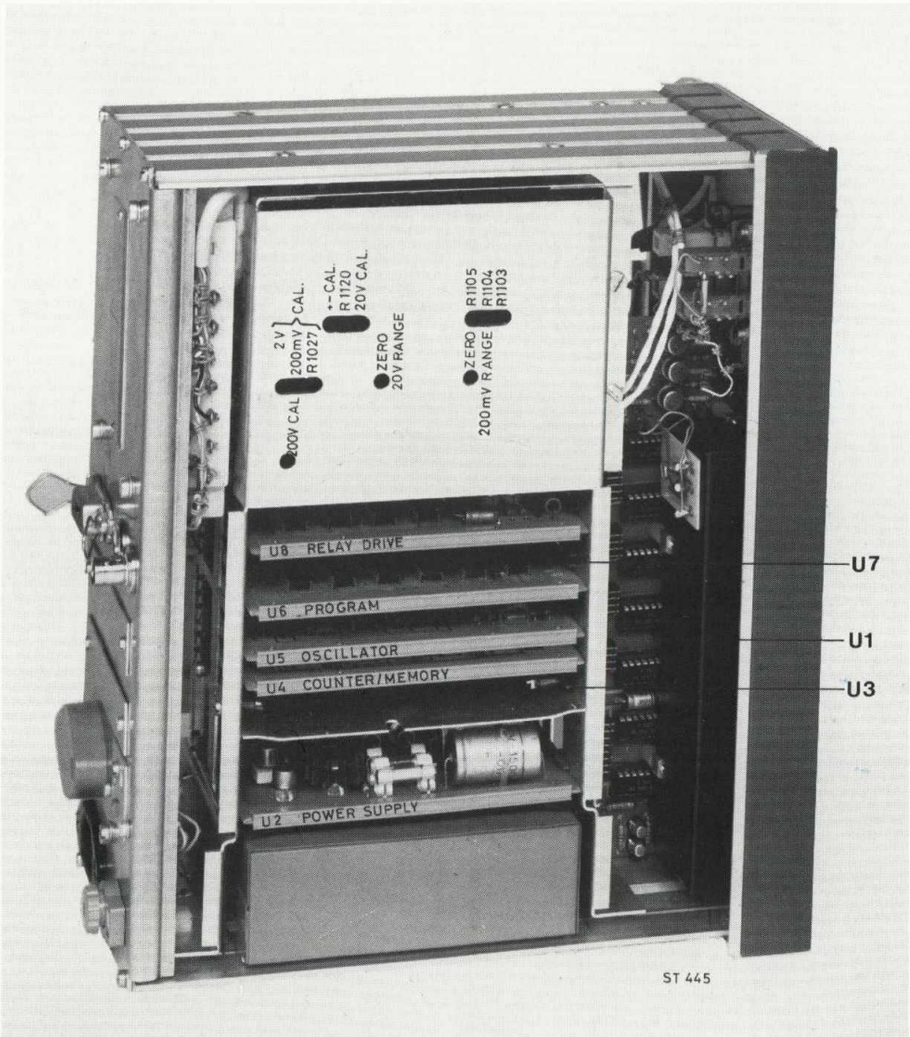



Fig. 36 Calibration elements

## X-4. ELECTRICAL ZERO SETTING AND CALIBRATION PROCEDURE

- The sequence given in the survey should be followed, when calibrating the PM 2441.
- Before calibrating, pull the chassis out of the cabinet (chap. VI-3.1.).
  When the chassis is pulled out of the cabinet, the potentiometers for the electrical zero setting and calibration are visible.
- Because of the high sensitivity of the PM 2441, especially in the 20 mV and 200 mV ranges, the chassis should be kept as short as possible out of the cabinet, so that no temperature variations can influence the accuracy of the adjusting measurements.
- Because of the noise level of a DC-standard, it is advisable to obtain the calibration voltages of +18 mV, +1 μV and +180 mV +20 μV via an accurate voltage divider from the DC-standard.

## 2. Electrical zero setting and calibration procedure

On page 50 of the PM 2441 manual the electrical zerosetting and calibration procedure is given. For zeroing and calibrating the PM 2441 with the new d.c. amplifier, page 51 and 52 should be substituted by the procedure mentioned below.

| ADJUST. NO. | ADJUSTMENT | ADJUSTING ELEMENT | UNIT | PREPARATIONS | MEASURING POINTS | ADJUSTMENT DATA |
|---|---|---|---|---|---|---|
| 1.1 | 20 V ZERO | R1103 "20 V ZERO (potentiometer) | U11 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/4 "20 V Range"<br>Interconnect: The HI, LO and GUARD plugs of the measuring cable. | Visible at display | 00.000 V<br>Note: The offset correction of IC1101 with resistor R1103 (page 47, adjustment no 3.7 of the PM 2441 manual) is cancelled. |
| 1.2 | µV ZERO | R1023 (potentiometer) | U10 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/1 "20 mV Range<br>Interconnect: The HI, LO and GUARD plugs of the measuring cable. | Visible at display | 00.000 mV<br>Note: The zero current offset adjustment and µV zeroing are influencing each other. Therefore these adjustments should be repeated when adjusting one or both. |
| 1.3 | +,- Calibration | R1121 "+ - CAL" (potentiometer) | U11 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/7 "AUTO"<br>Supply: Alternately + 18 V ±200 µV and -18 V ±200 µV to the DC-input BU2, via the measuring cable | Visible at display | The same value at + and - polarity |
| 1.4 | 20 V Calibration | R1119 "20 V CAL" (potentiometer) | U11 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/7 "AUTO"<br>Supply: +18 V ±200 µV to the DC-input BU2, via the measuring cable | Visible at display | + 18.000 V ± 1 digit |
| 1.5 | 20 mV Calibration | R1067 "20 mV CAL" (potentiometer) | U10 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/7 "AUTO"<br>Supply: +18 mV ±1 µV to the DC-input BU2, via the measuring cable | Visible at display | + 18.000 mV ± 1 digit<br>If the calibration cannot be carried out, adjusting resitor R1058 (MR25, 1%) may be changed in value. |
| 1.6 | 200 mV Calibration | R1066 "200 mV CAL" (potentiometer) | U10 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/7 "AUTO"<br>Supply: +180 mV ±2 µV to the DC-input BU2, via the measuring cable | Visible at display | +180.00 mV ± 1 digit<br>If the calibration cannot be carried out, adjusting resistor R1056 (MR25, 1%) may be changed in value. |
| 1.7 | 2 V Calibration | R1065 "2 V CAL" (potentiometer) | U10 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/7 "AUTO"<br>Supply: +1.8 V ±20 µV to the DC-input BU2, via the measuring cable | Visible at display | +1.8000 V ± 1 digit<br>If the calibration cannot be carried out, adjusting resistor R1054 (MR25, 1%) may be changed in value. |
| 1.8 | 20 V Calibration | CHECK | U11 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/7 "AUTO"<br>Supply: +18 V ±200 µV to the DC-input BU2, via the measuring cable | Visible at display | + 18.000 V ± 1 digit<br>if necessary repeat adjustments 2.2 up to 2.5. |
| 1.9 | 200 V Calibration | R909 "200 V CAL" (potentiometer) | U9 | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/7 "AUTO"<br>Supply: +180 mV ±2 mV to the DC-input BU2, via the measuring cable | Visible at display | + 180.00 V ± 1 digit |
| 1.10 | 1000 V Calibration | CHECK | - | Depress: SK4/1 "INTERN"<br>SK3/1 "DIRECT"<br>SK2/7 "AUTO"<br>Supply: +900 V ±10 mV to the DC-input BU2, via the measuring cable | Visible at display | + 0900.0 V ± 1 digit |

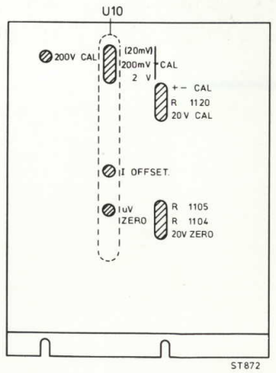



Fig. 37 Adjusting cover

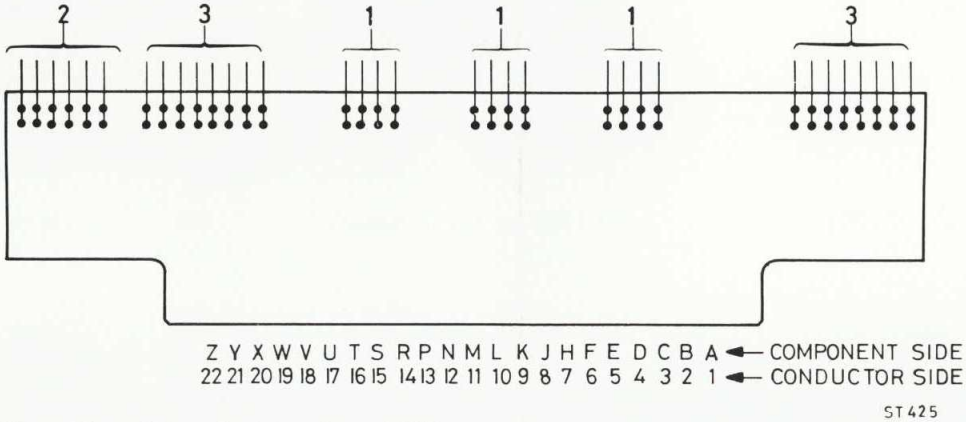



Fig. 38 Printed wiring board U13

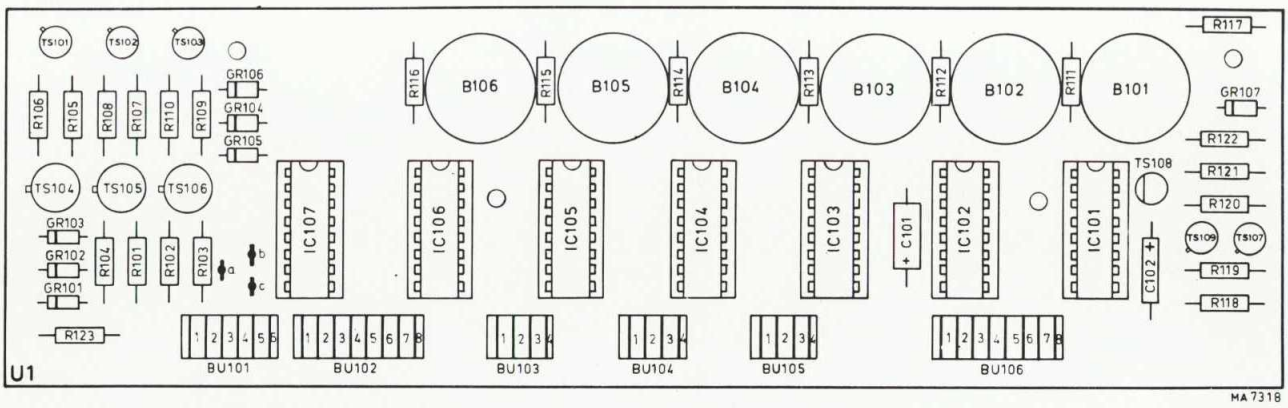



Fig. 39 Printed wiring board U1

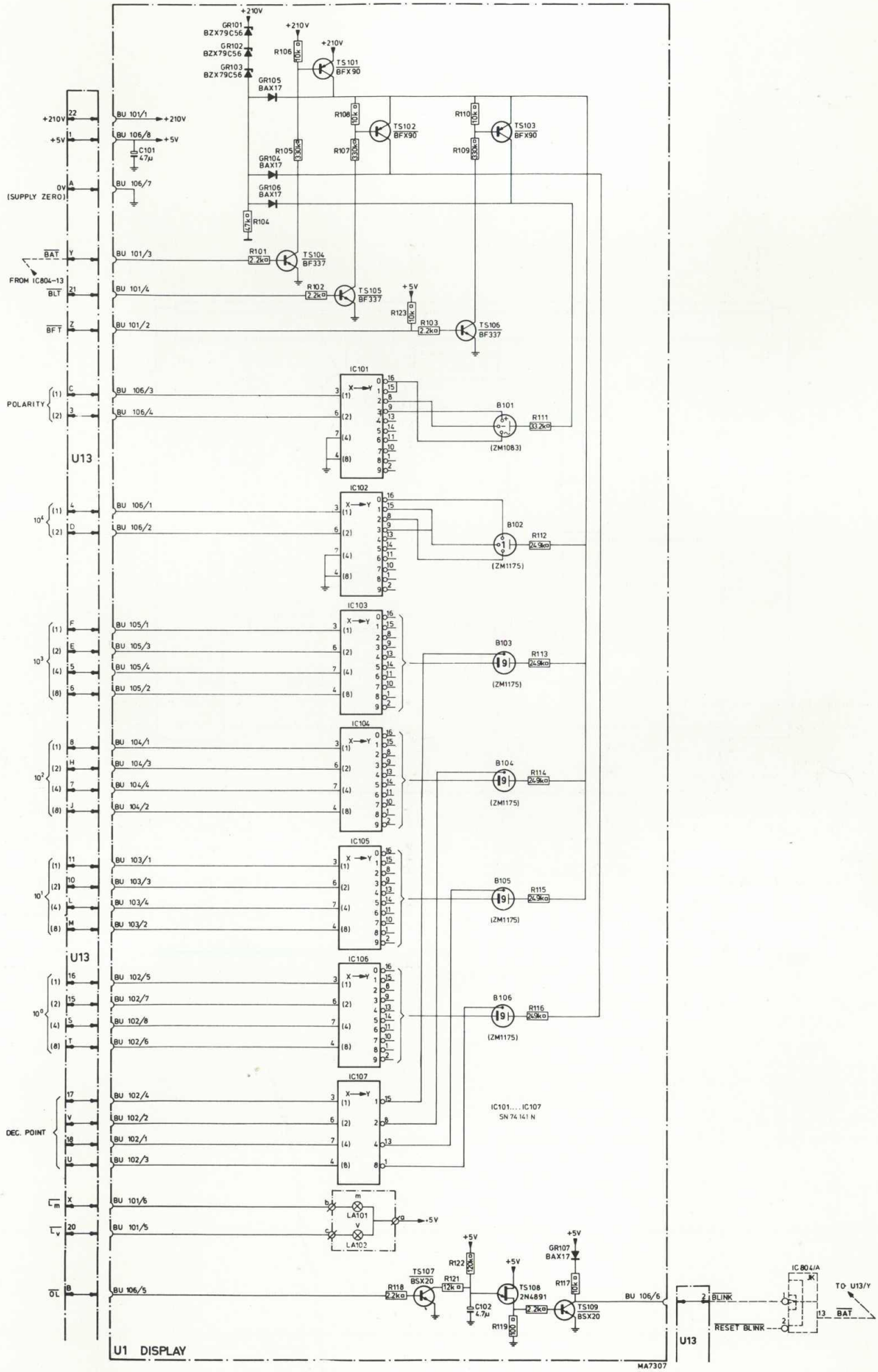



Fig. 40 Circuit diagram DISPLAY unit U1

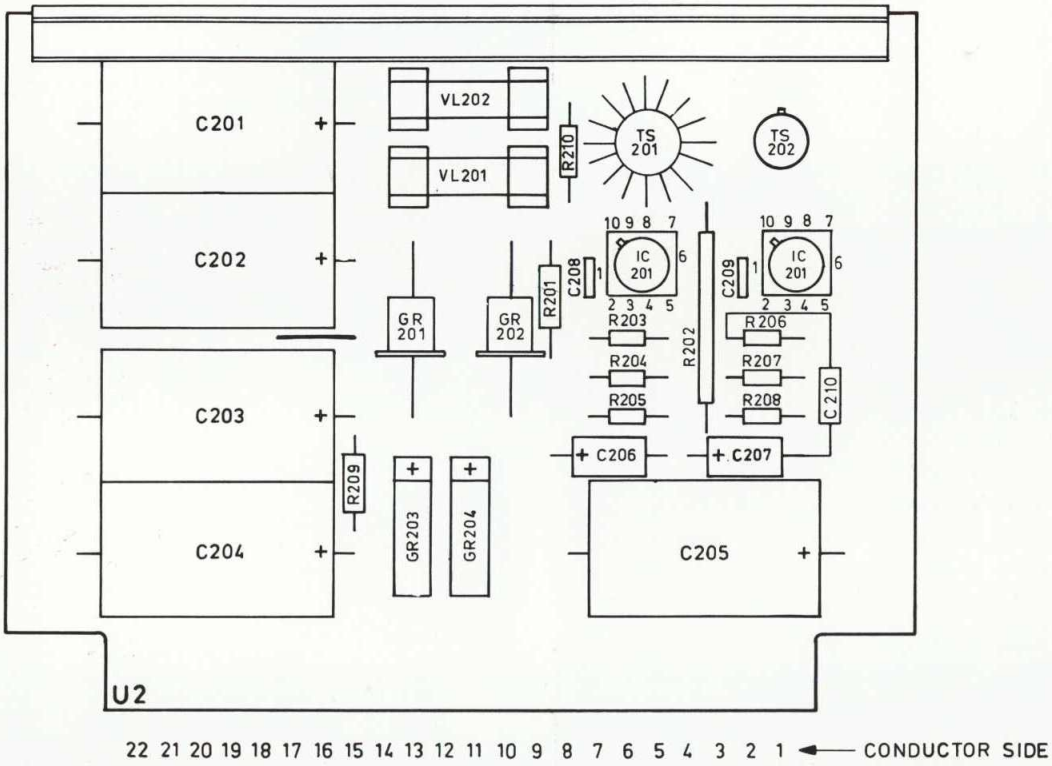
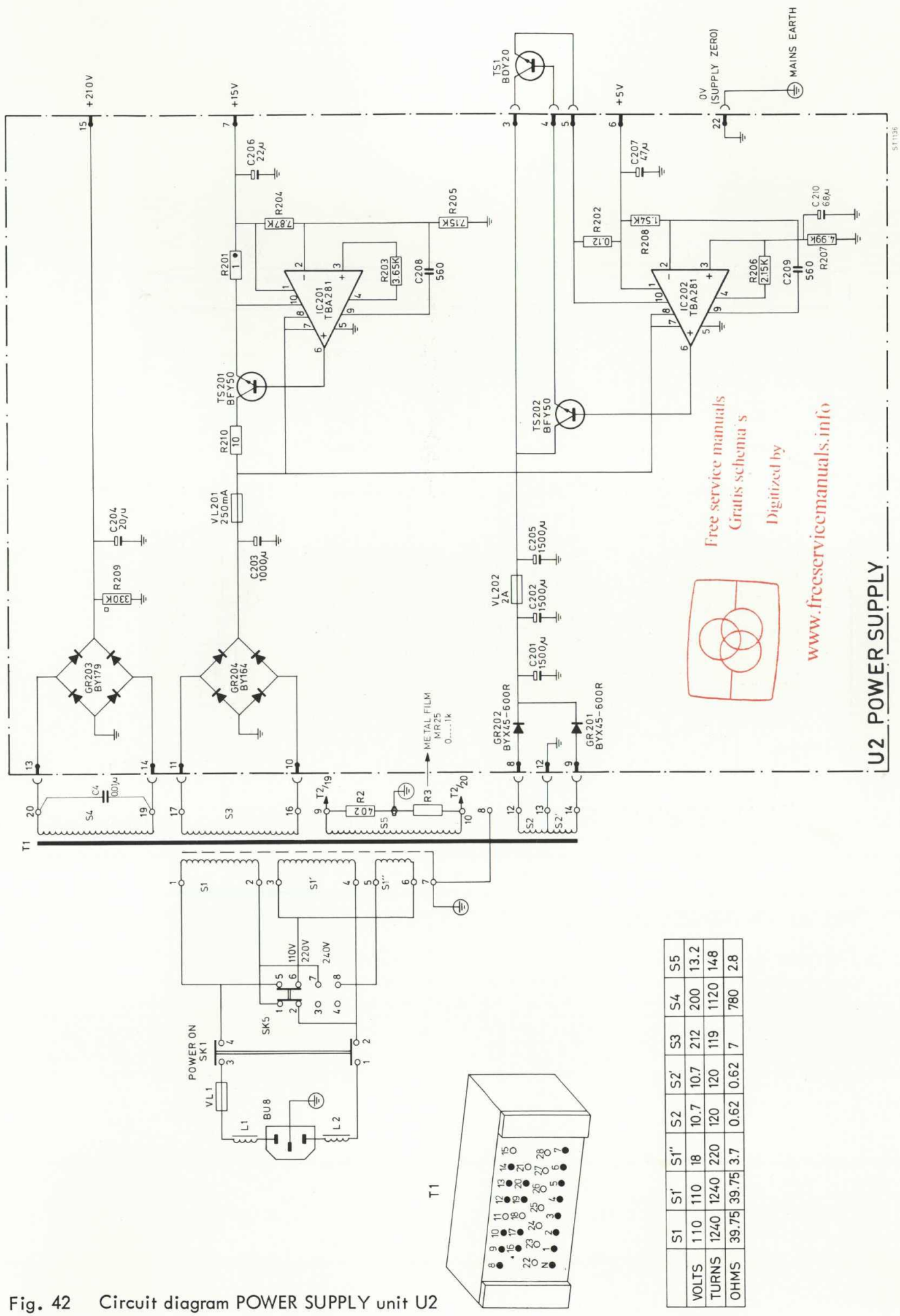



Fig. 41 Printed wiring board U2

ST1135




| | S1 | S1' | S1'' | S2 | S2' | S3 | S4 | S5 |
|---|---|---|---|---|---|---|---|---|
| VOLTS | 110 | 110 | 18 | 10.7 | 10.7 | 212 | 200 | 13.2 |
| TURNS | 1240 | 1240 | 220 | 120 | 120 | 119 | 1120 | 148 |
| OHMS | 39.75 | 39.75 | 3.7 | 0.62 | 0.62 | 7 | 780 | 2.8 |

Fig. 42 Circuit diagram POWER SUPPLY unit U2

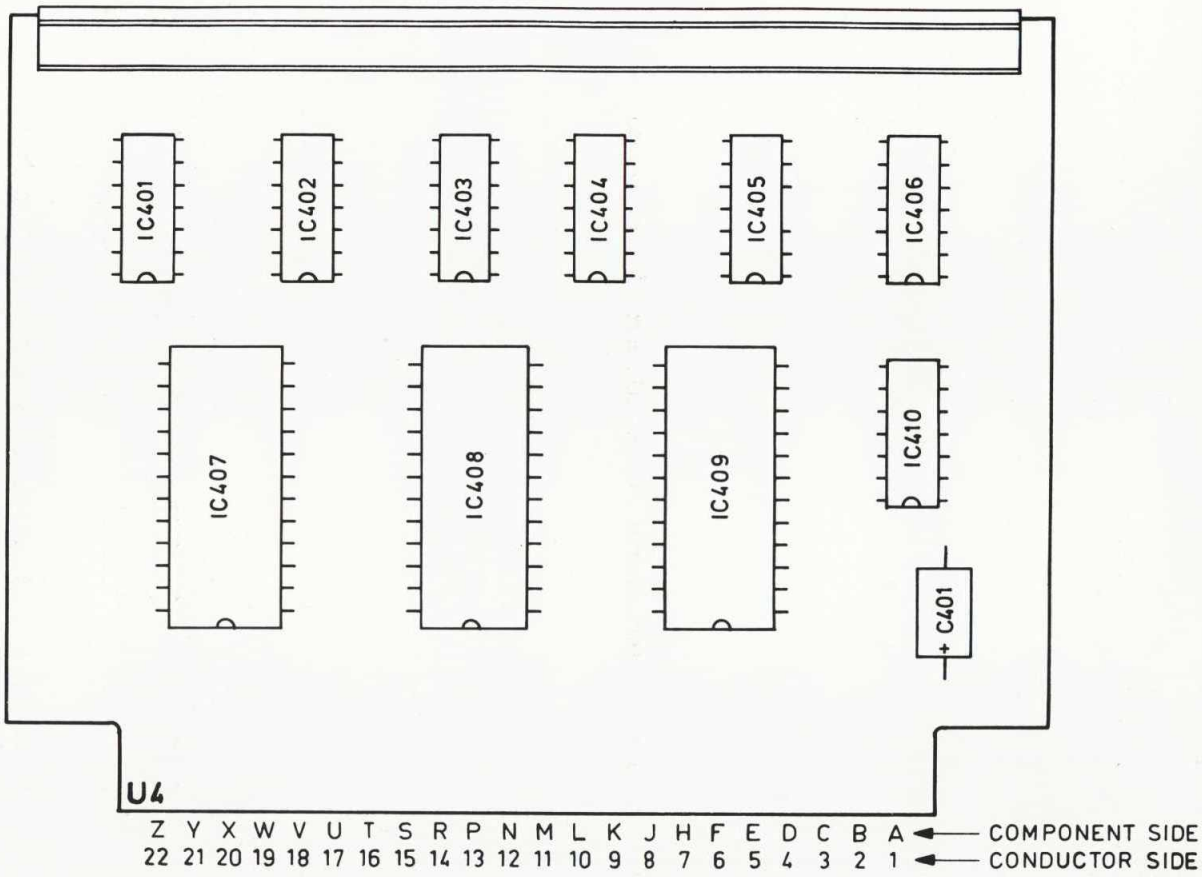



Fig. 43 Printed wiring board U4

MA7321

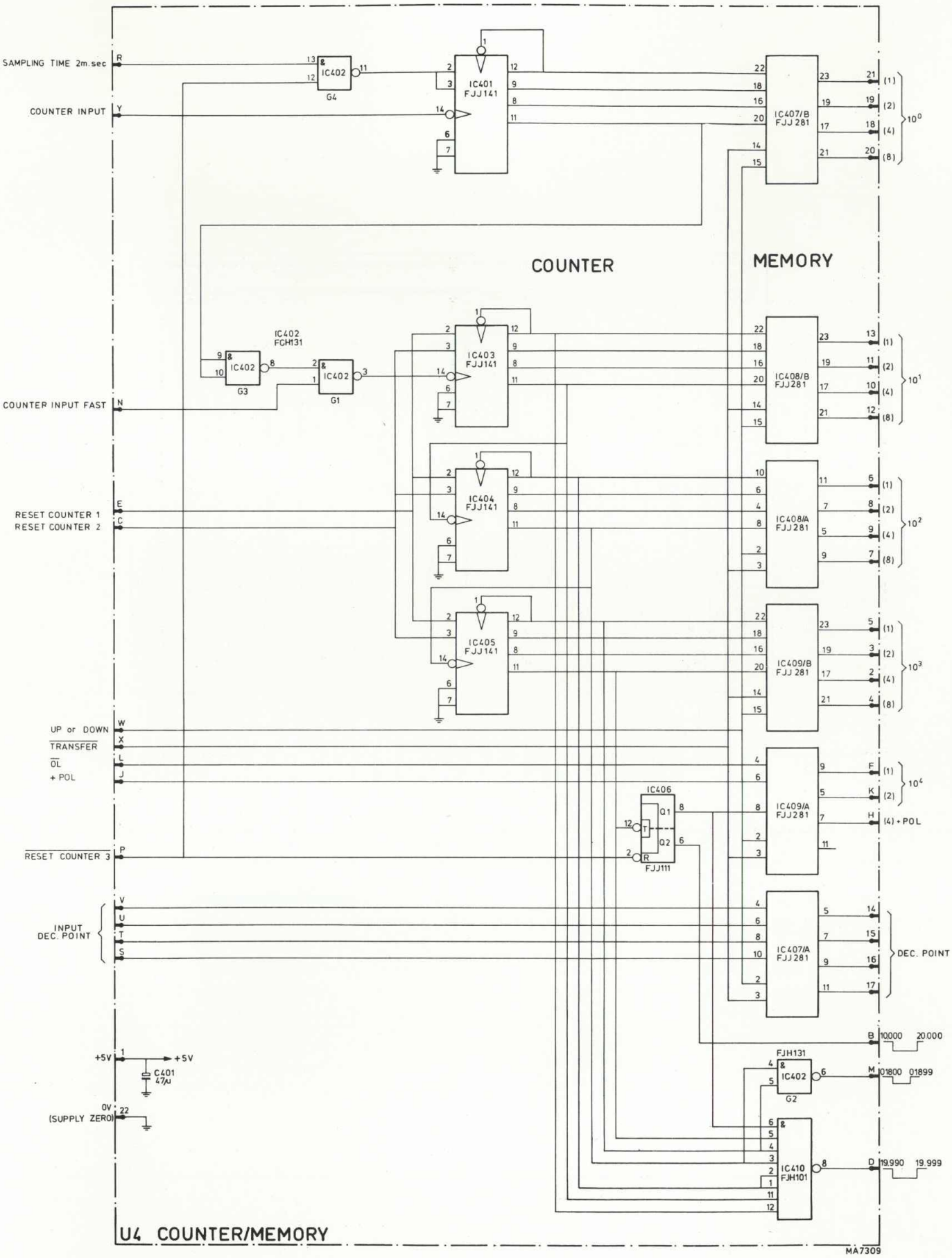



Fig. 44 Circuit diagram COUNTER / MEMORY unit U4

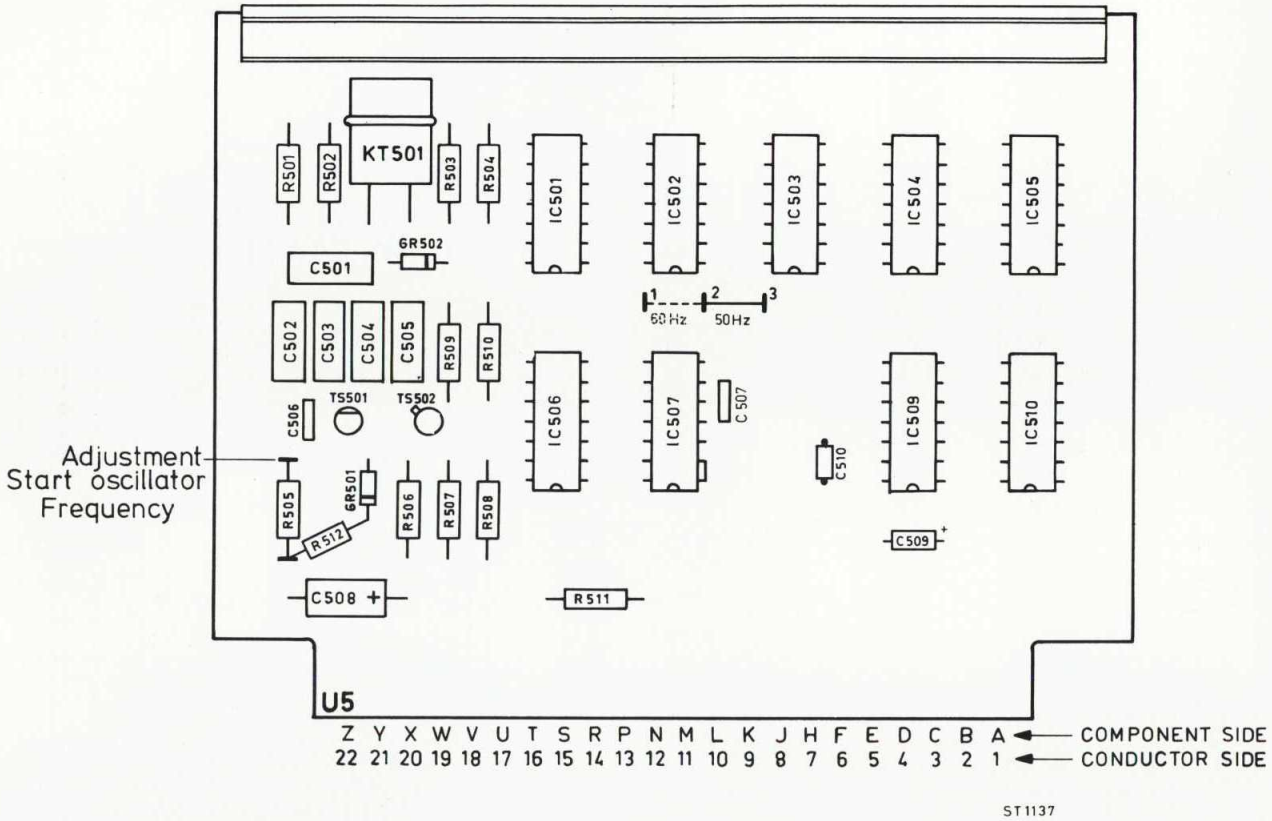



Fig. 45 Printed wiring board U5

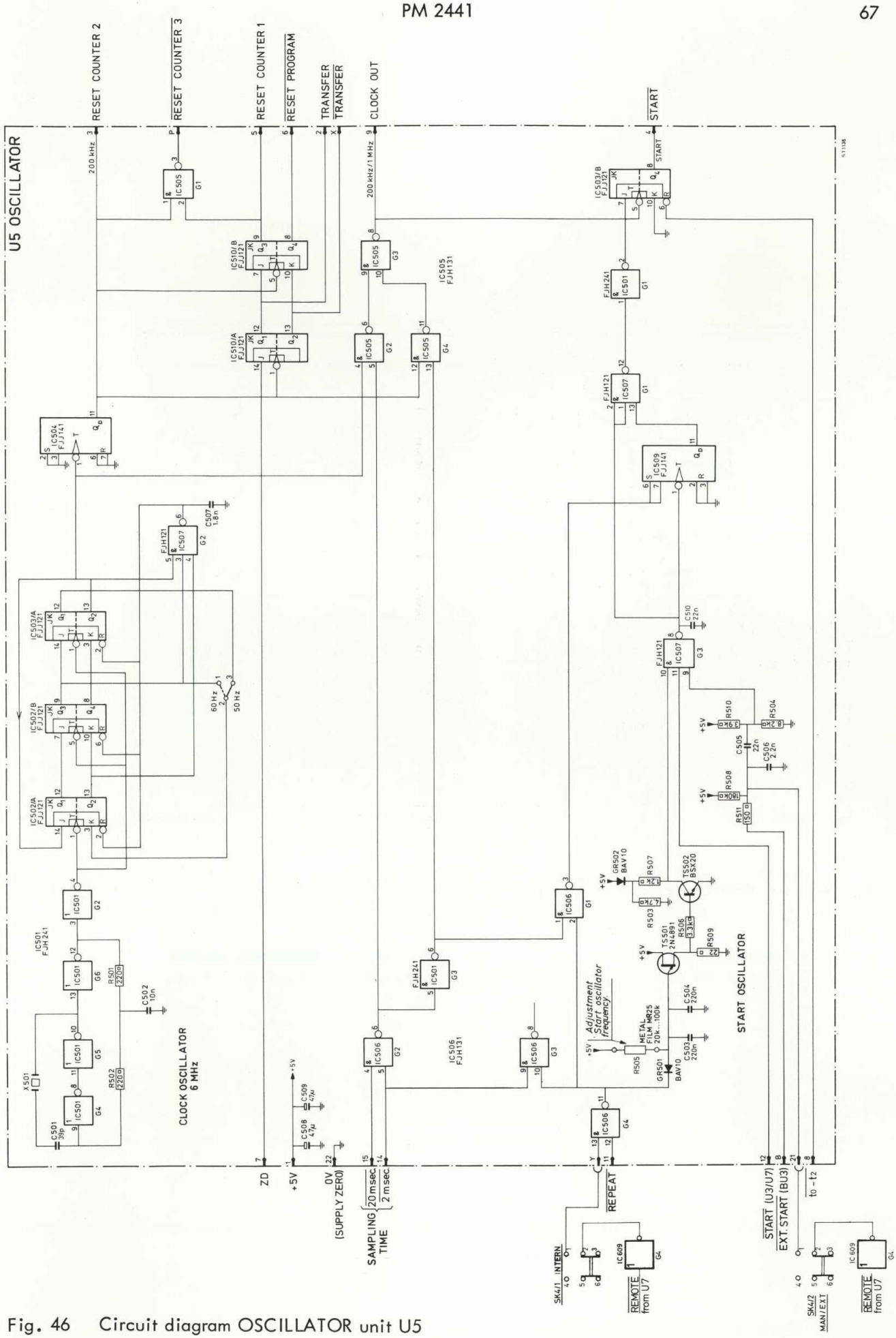



Fig. 46 Circuit diagram OSCILLATOR unit U5

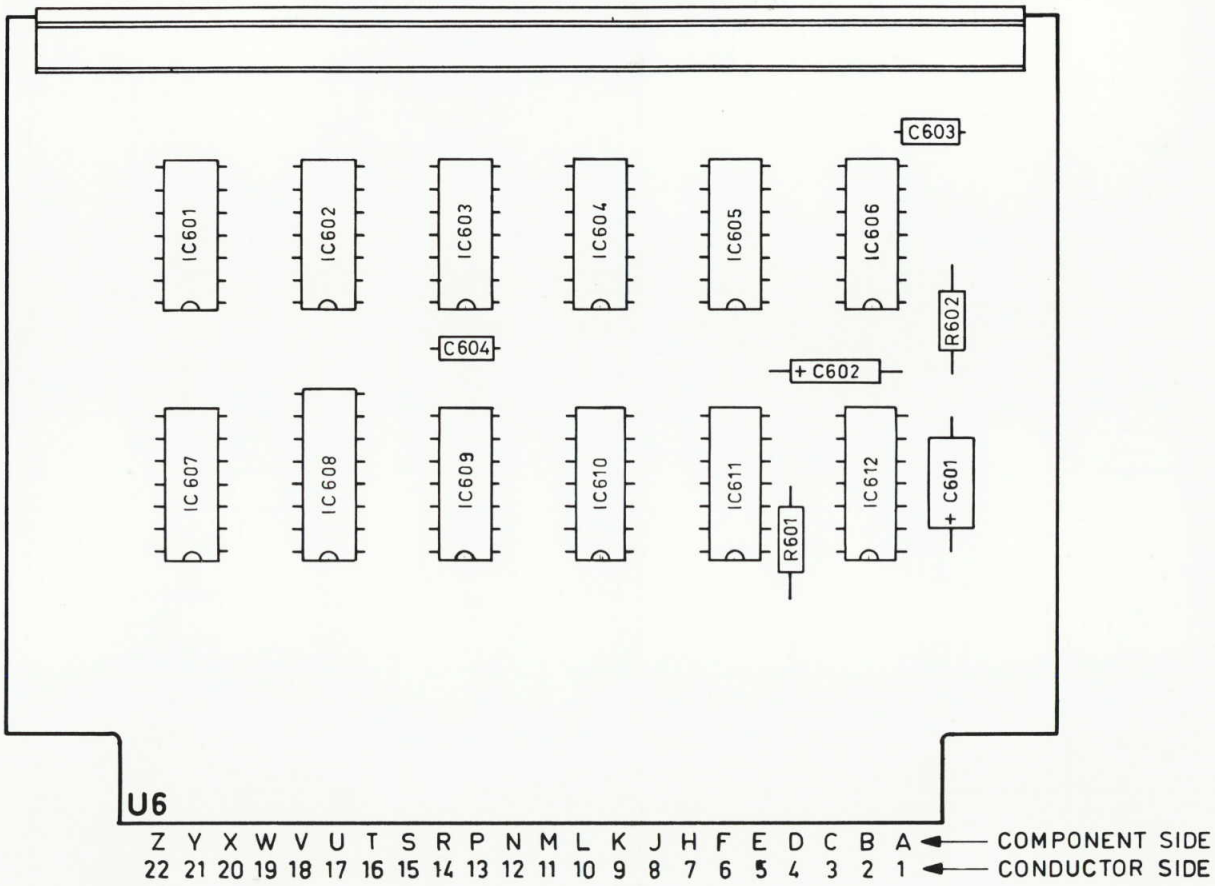



Fig. 47 Printed wiring board U6

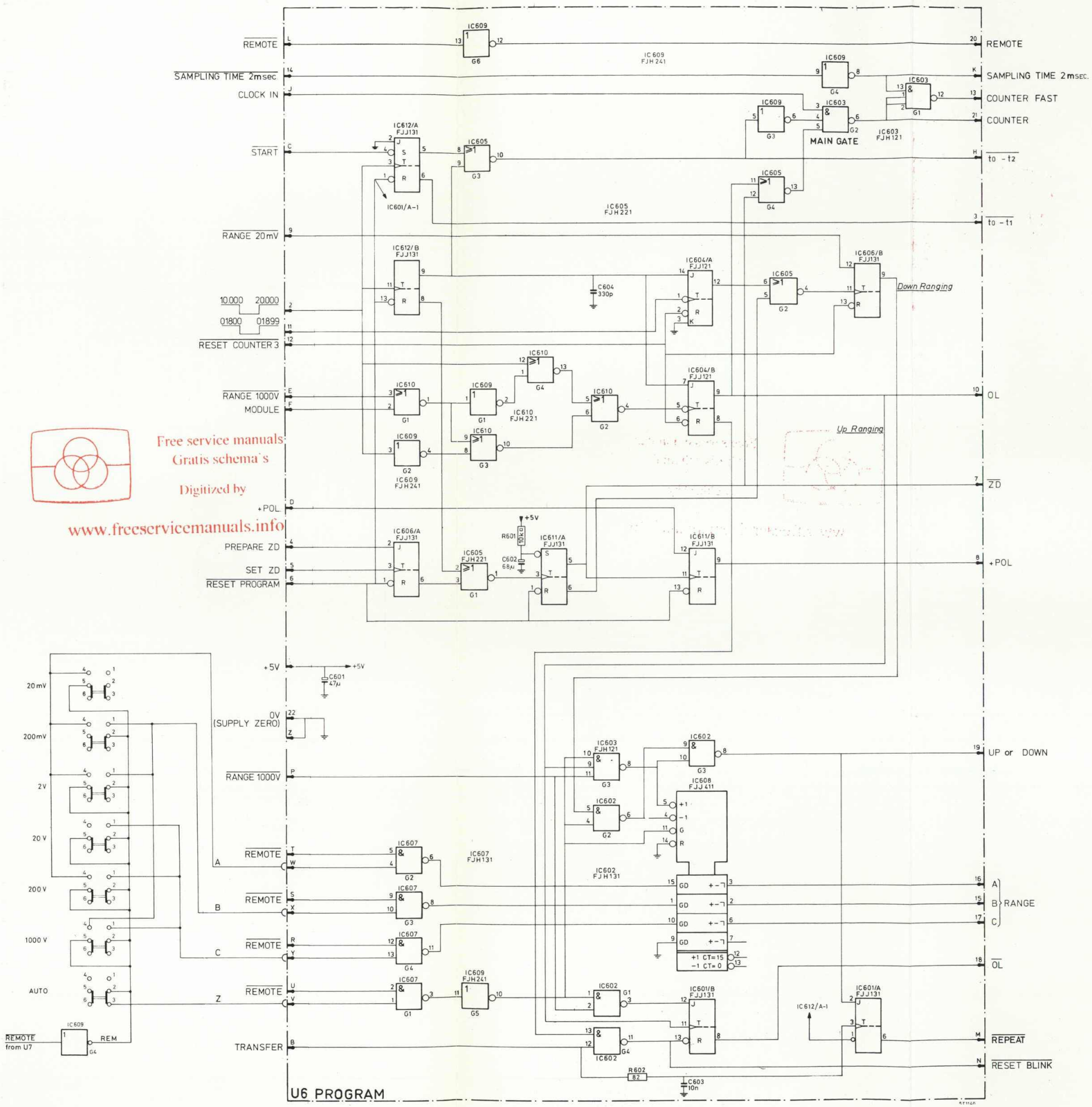





Fig. 48 Circuit diagram PROGRAM unit U6

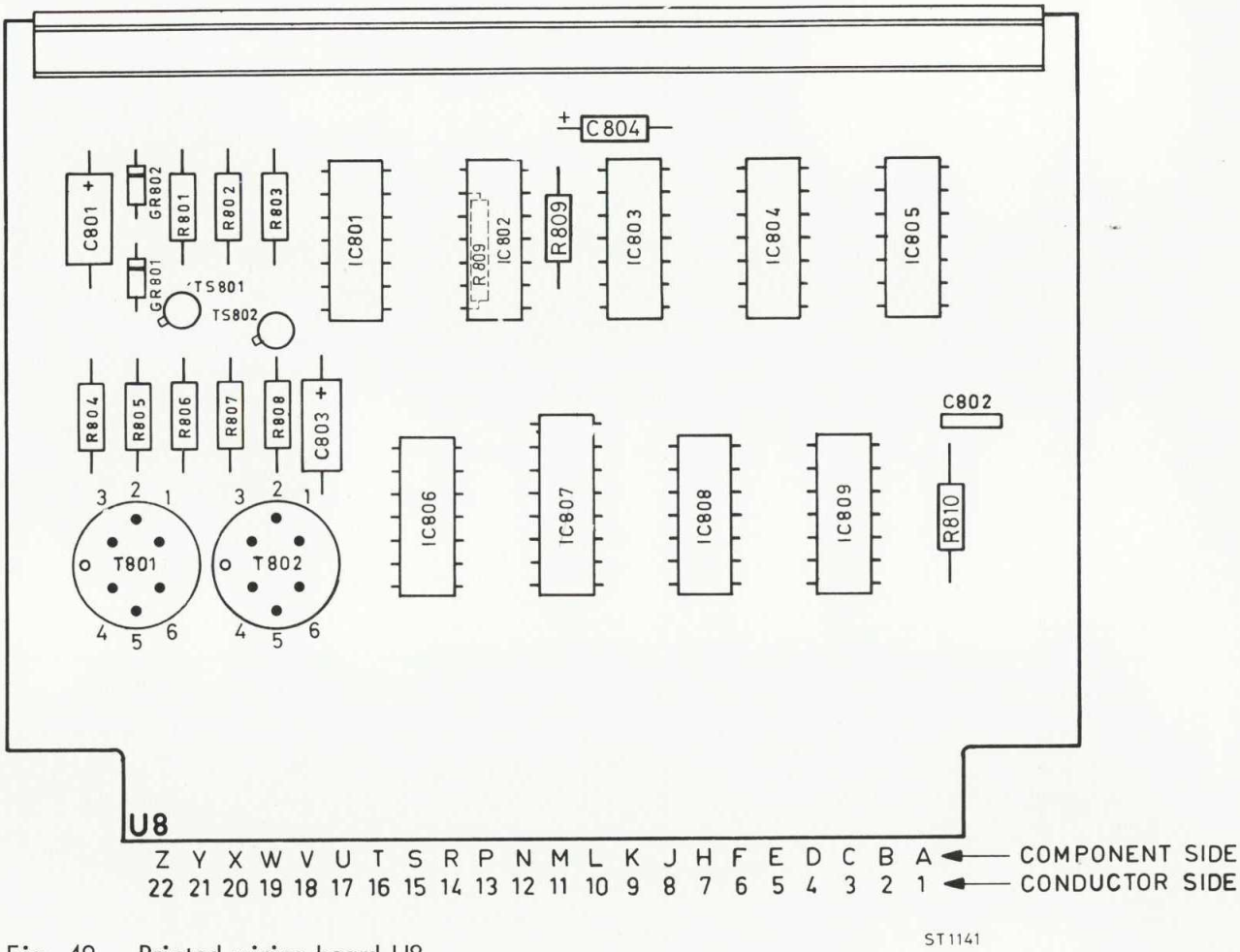



Fig. 49 Printed wiring board U8

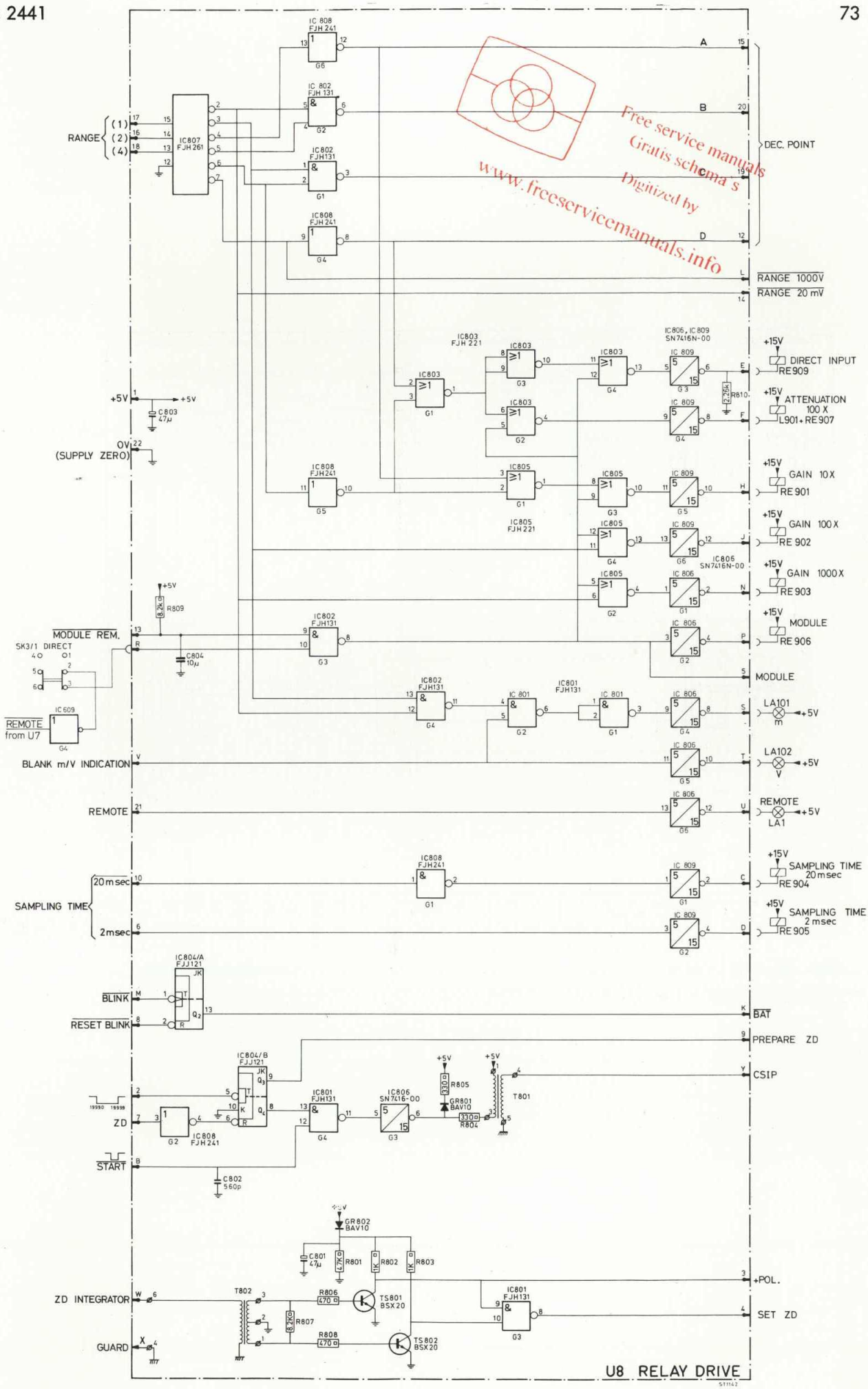



Fig. 50 Circuit diagram RELAY DRIVE unit U8

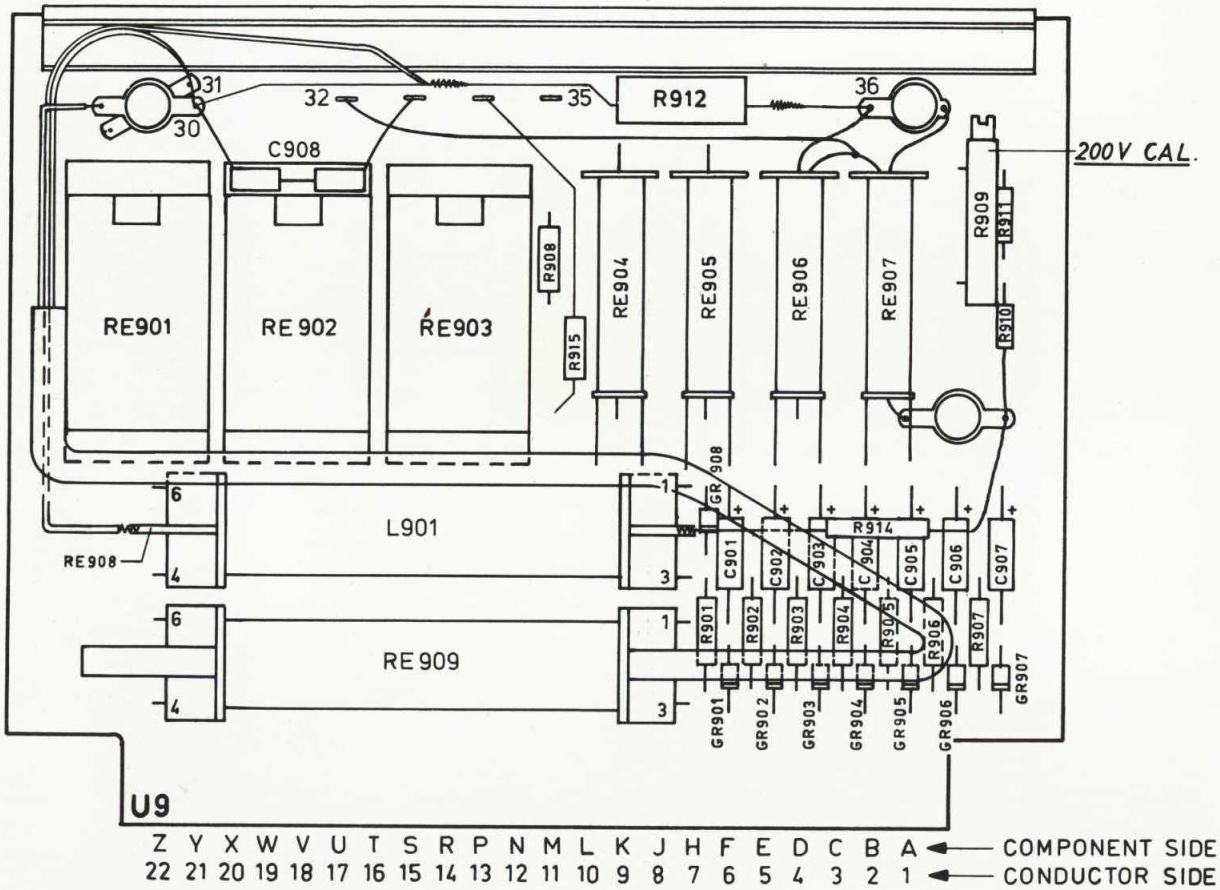



Fig. 51 Printed wiring board U9

ST1143

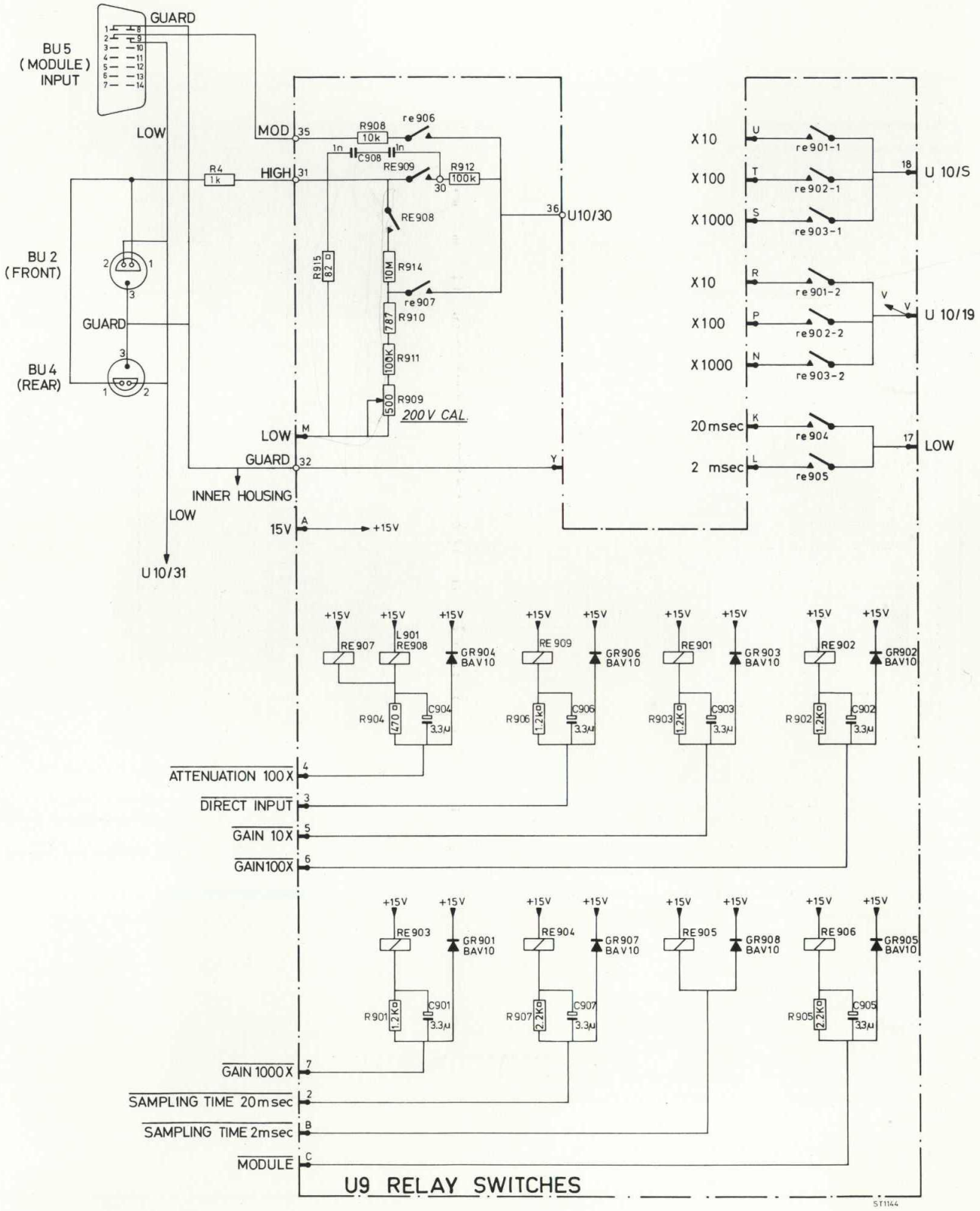
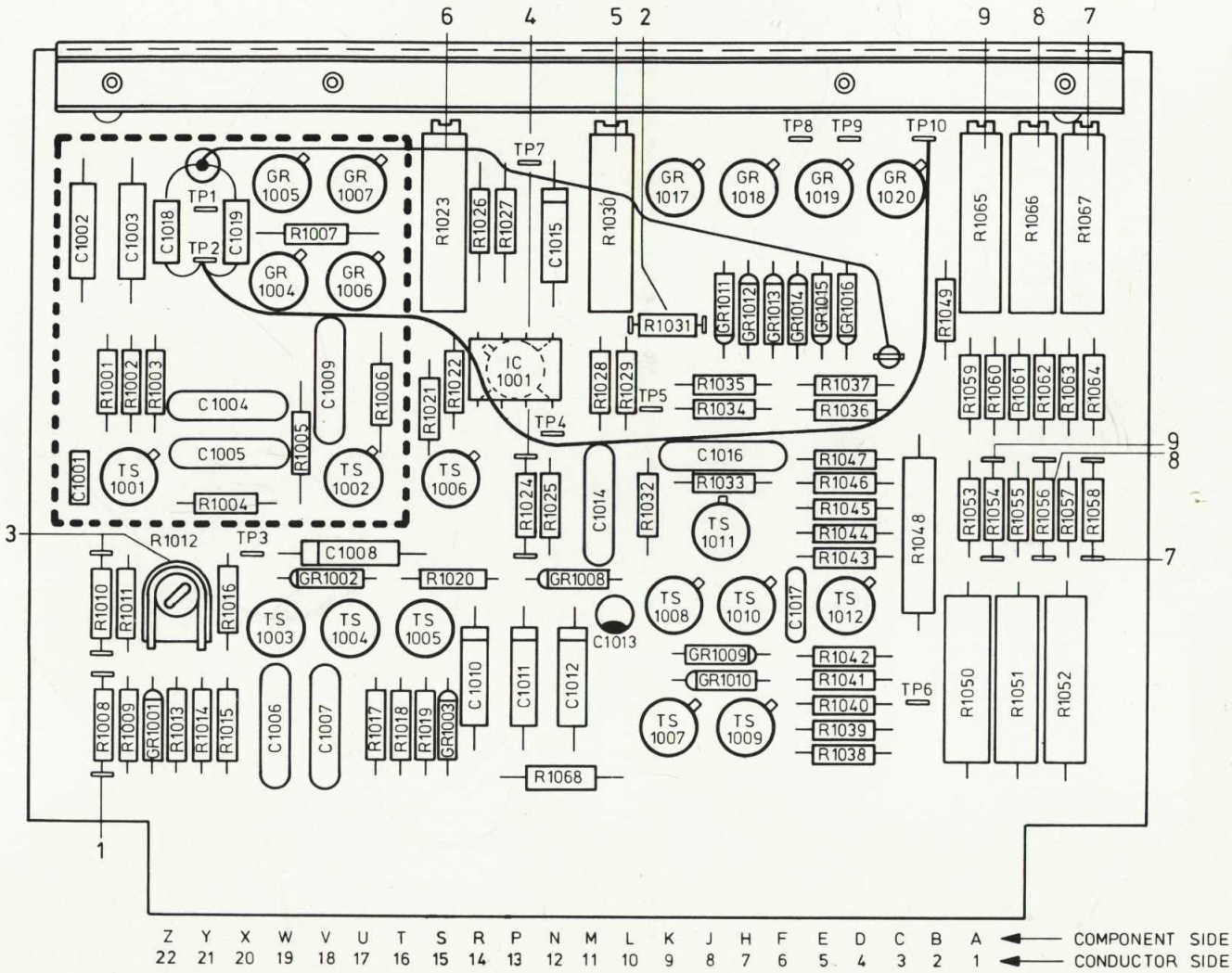



Fig. 52 Circuit diagram RELAY SWITCHES unit U9




## ADJUSTMENT

1. CHOPPER FREQUENCY
2. DRAIN VOLTAGE TS1002
3. MINIMUM SPIKE
4. GAIN IC1001
5. ZERO CURRENT OFFSET

## ZEROING AND CALIBRATION

6. μV ZERO
7. 20mV CALIBRATION
8. 200mV CALIBRATION
9. 2V CALIBRATION

Fig. 53 Printed wiring board U10

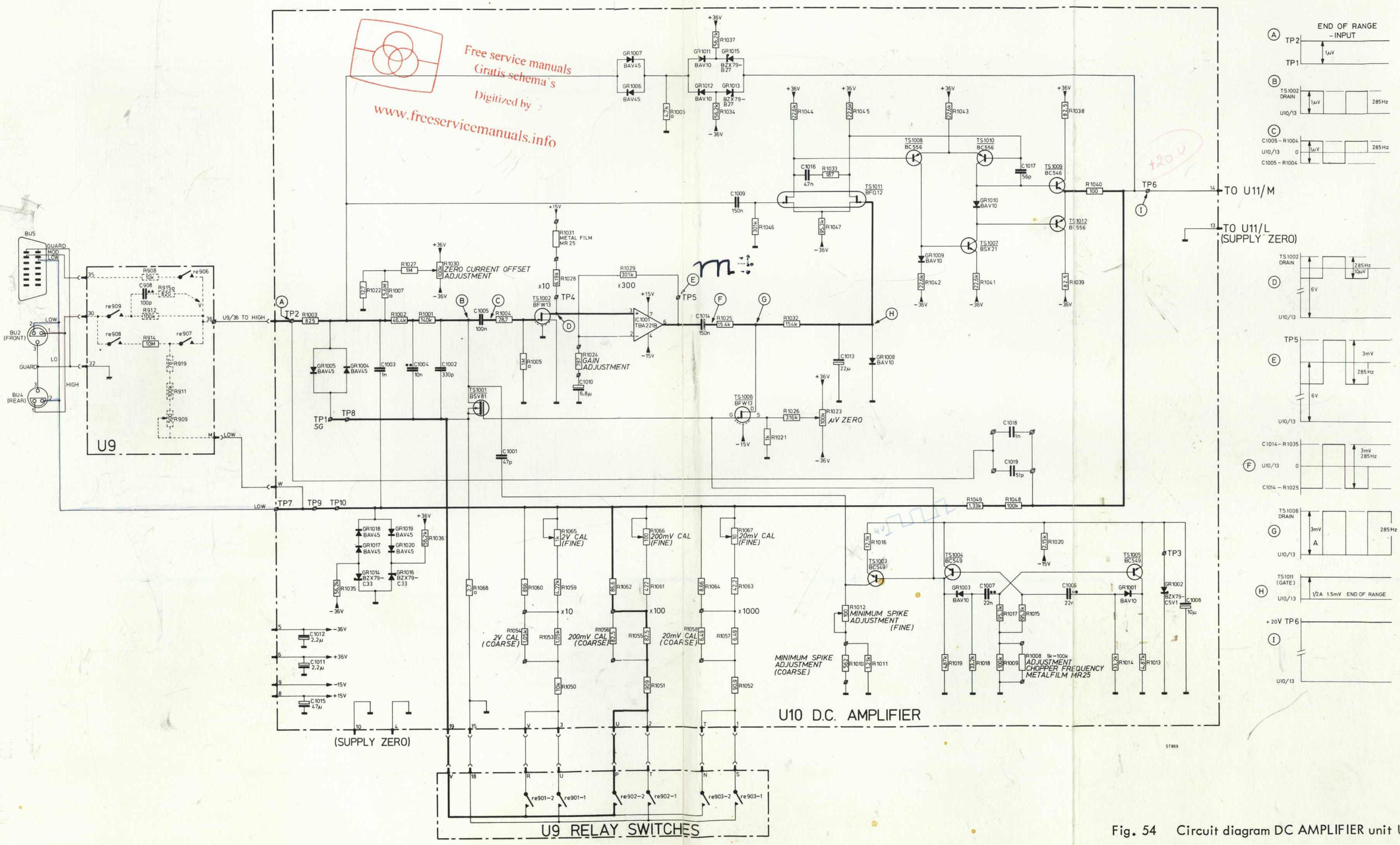
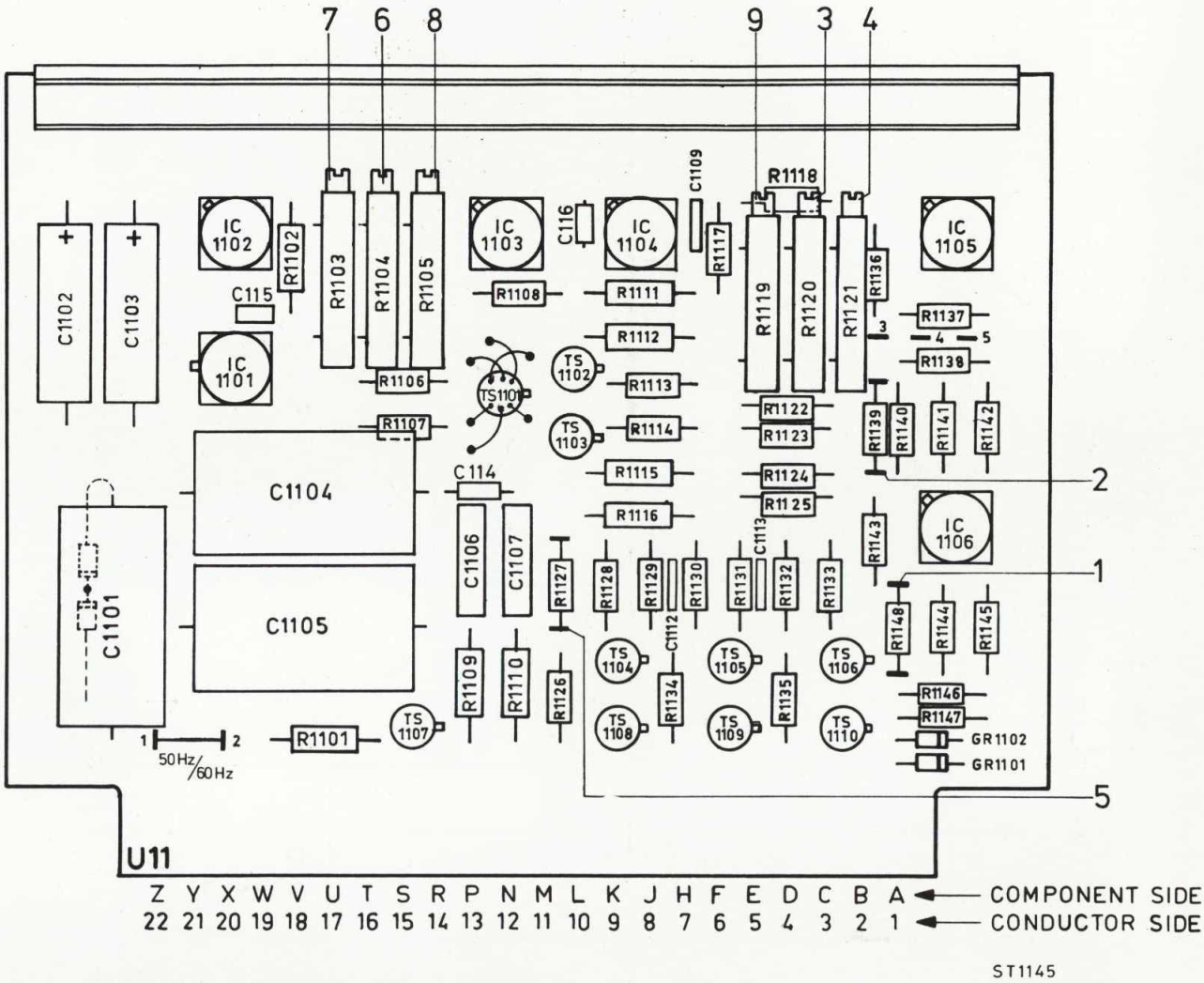



Fig. 54 Circuit diagram DC AMPLIFIER unit U10




1. ADJUSTMENT ZENER CURRENT GR1101
2. ADJUSTMENT + Vreference
3. ZEROING IC1104
4. +, – CALIBRATION
5. ROUGH ADJUSTMENT "20 $V_{CAL}$"
6. ZEROING IC1102
7. OFFSET CORRECTION IC1101
8. DEAD BAND ZERO
9. 20 V CALIBRATION

Fig. 55 Printed wiring board U11

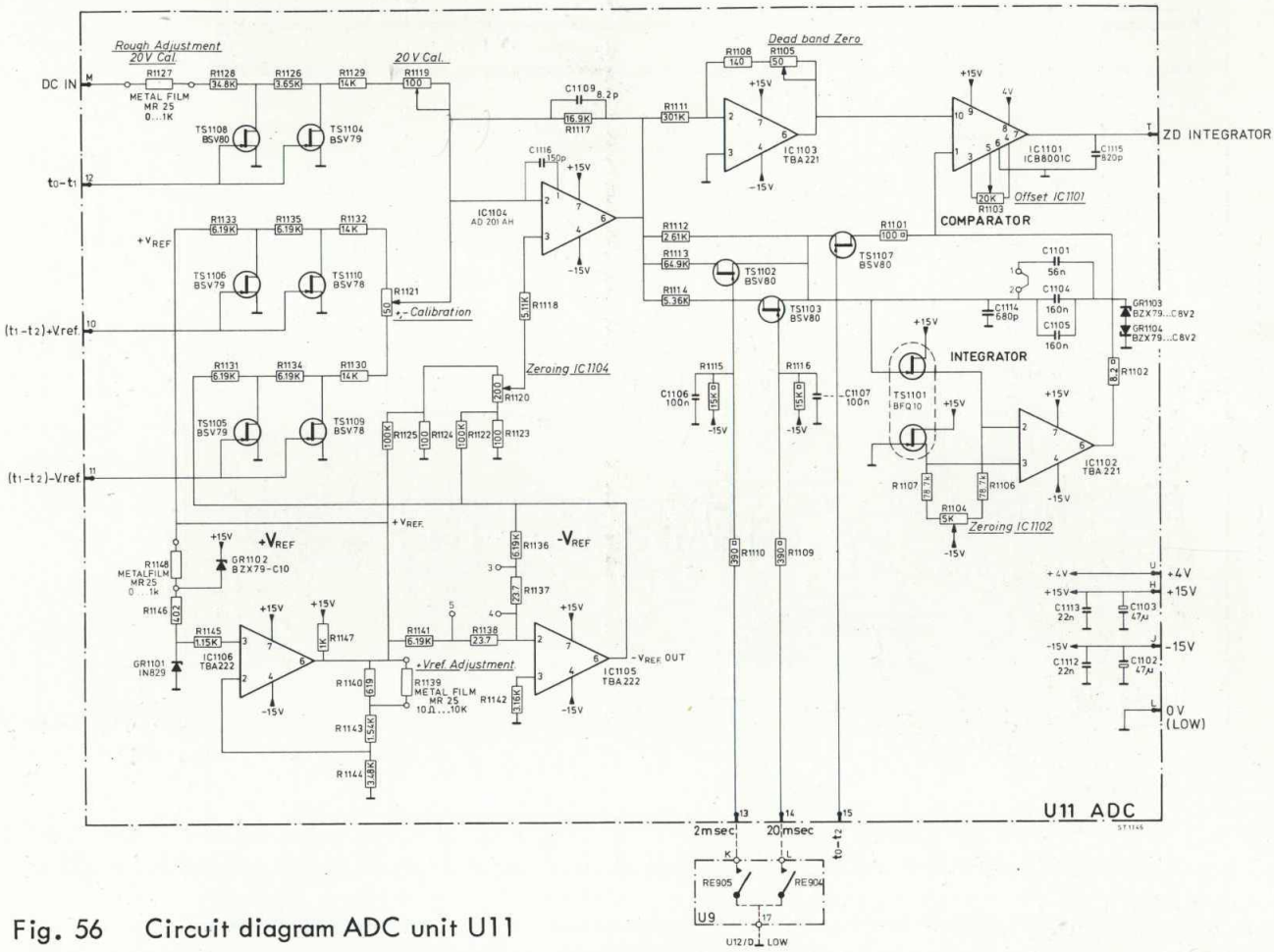



Fig. 56 Circuit diagram ADC unit U11

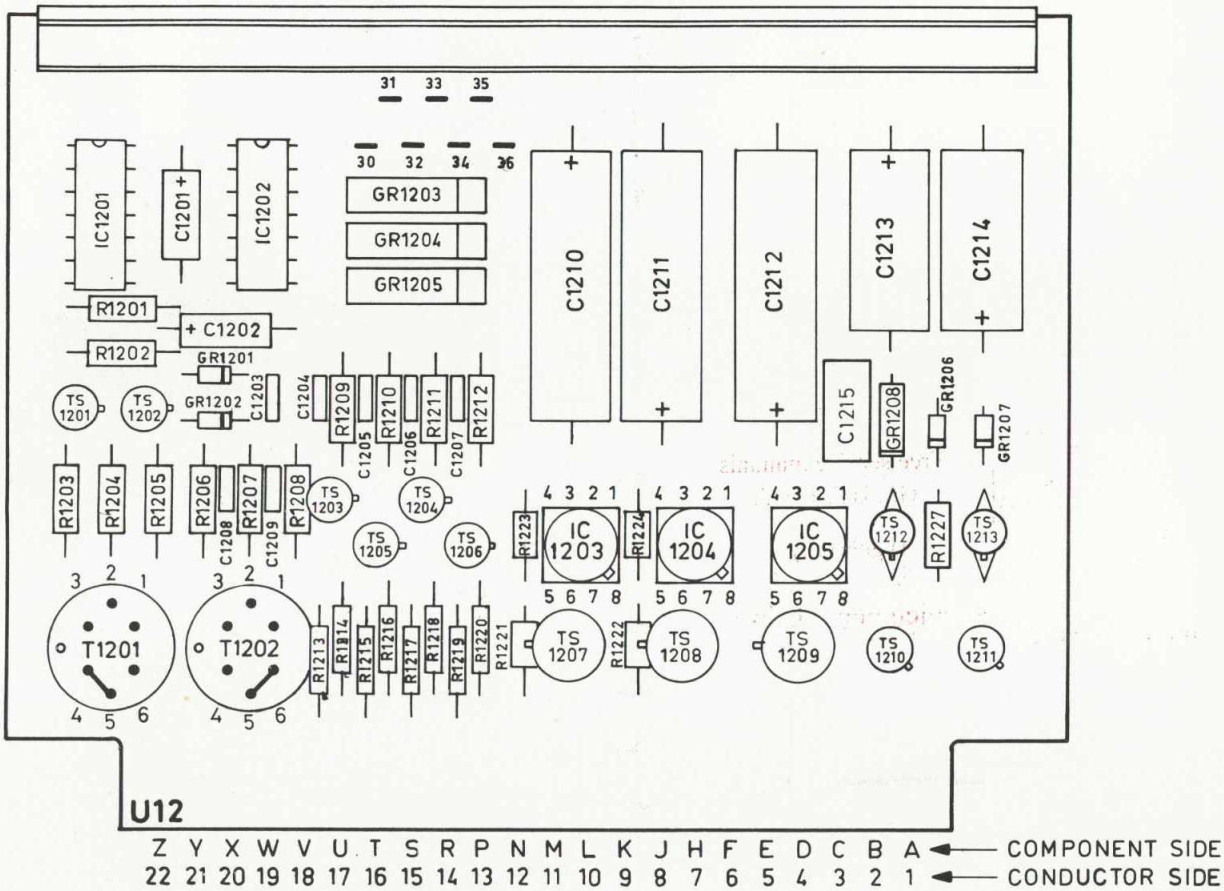
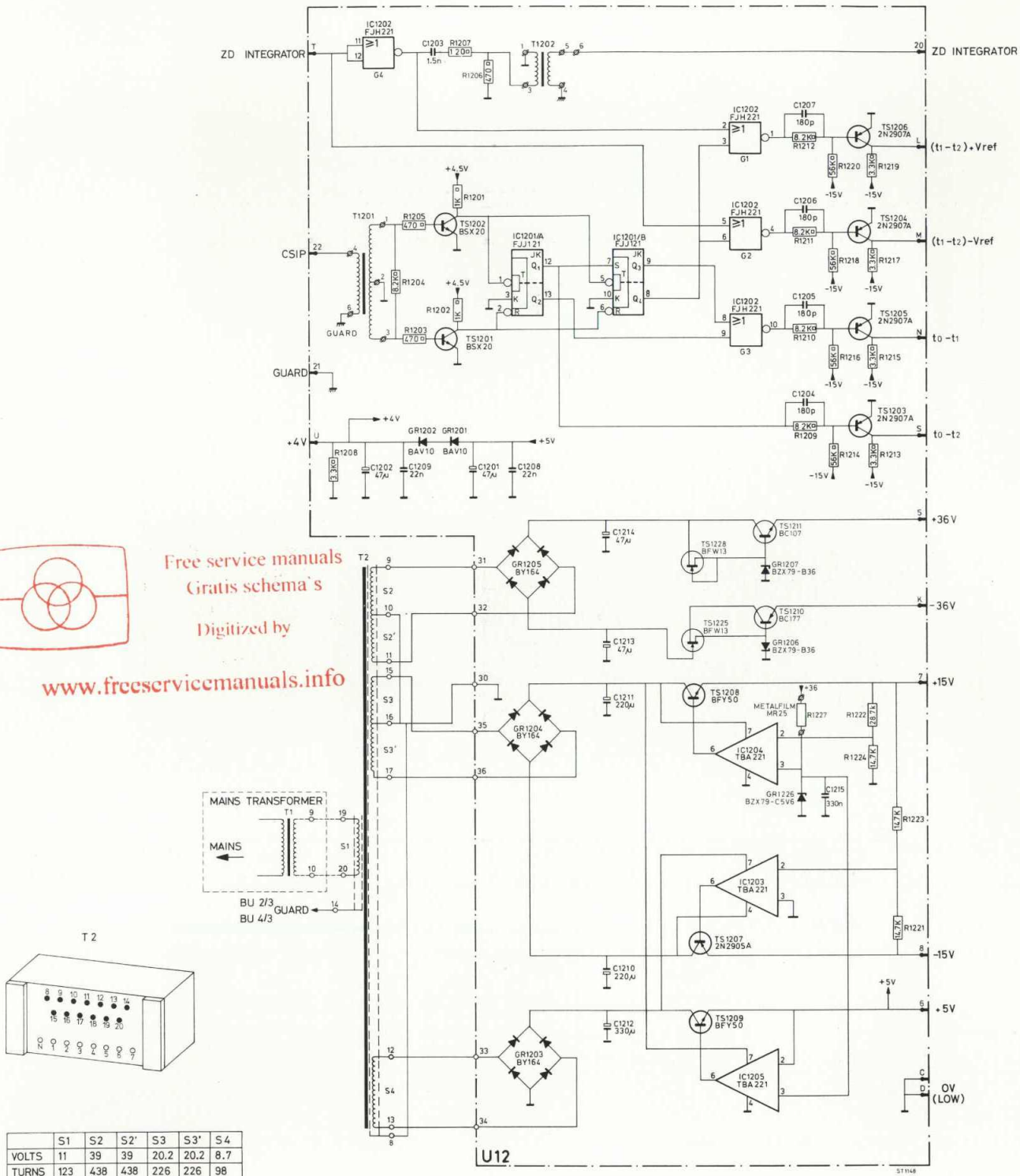



Fig. 57 Printed wiring board U12






| | S1 | S2 | S2' | S3 | S3' | S4 |
|---|---|---|---|---|---|---|
| VOLTS | 11 | 39 | 39 | 20.2 | 20.2 | 8.7 |
| TURNS | 123 | 438 | 438 | 226 | 226 | 98 |
| OHMS | 1.47 | 44.5 | 44.5 | 19.25 | 19.25 | 3.8 |

Fig. 58 Circuit diagram INGUARD PROGRAM and SUPPLY unit U12

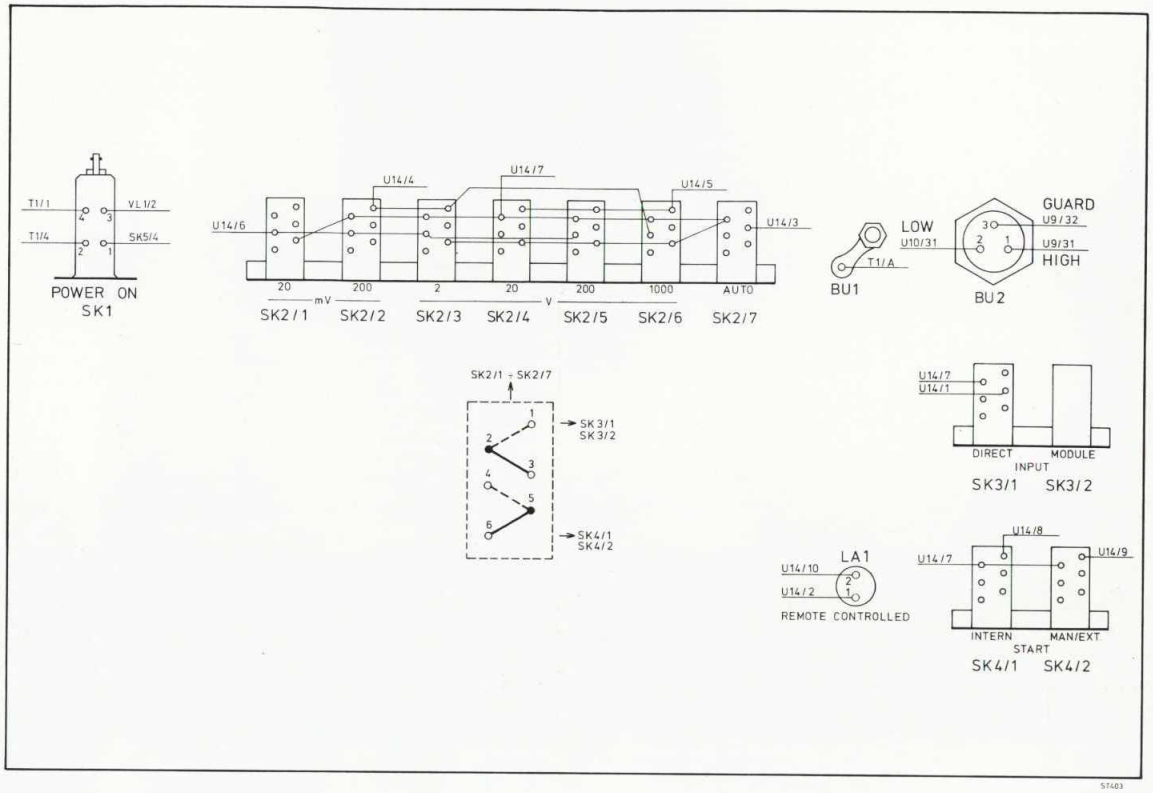



Fig. 59 Wiring diagram

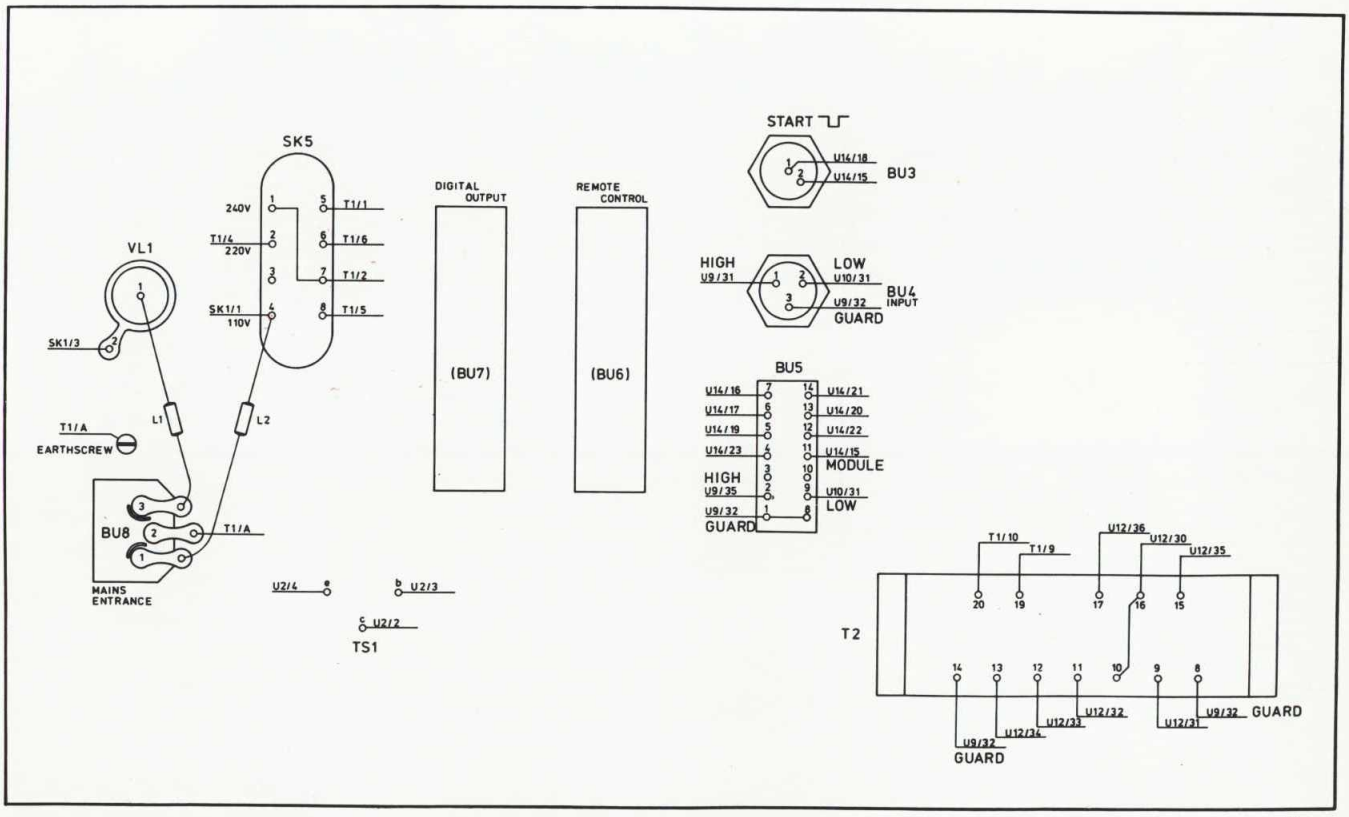



Fig. 59 Wiring diagram

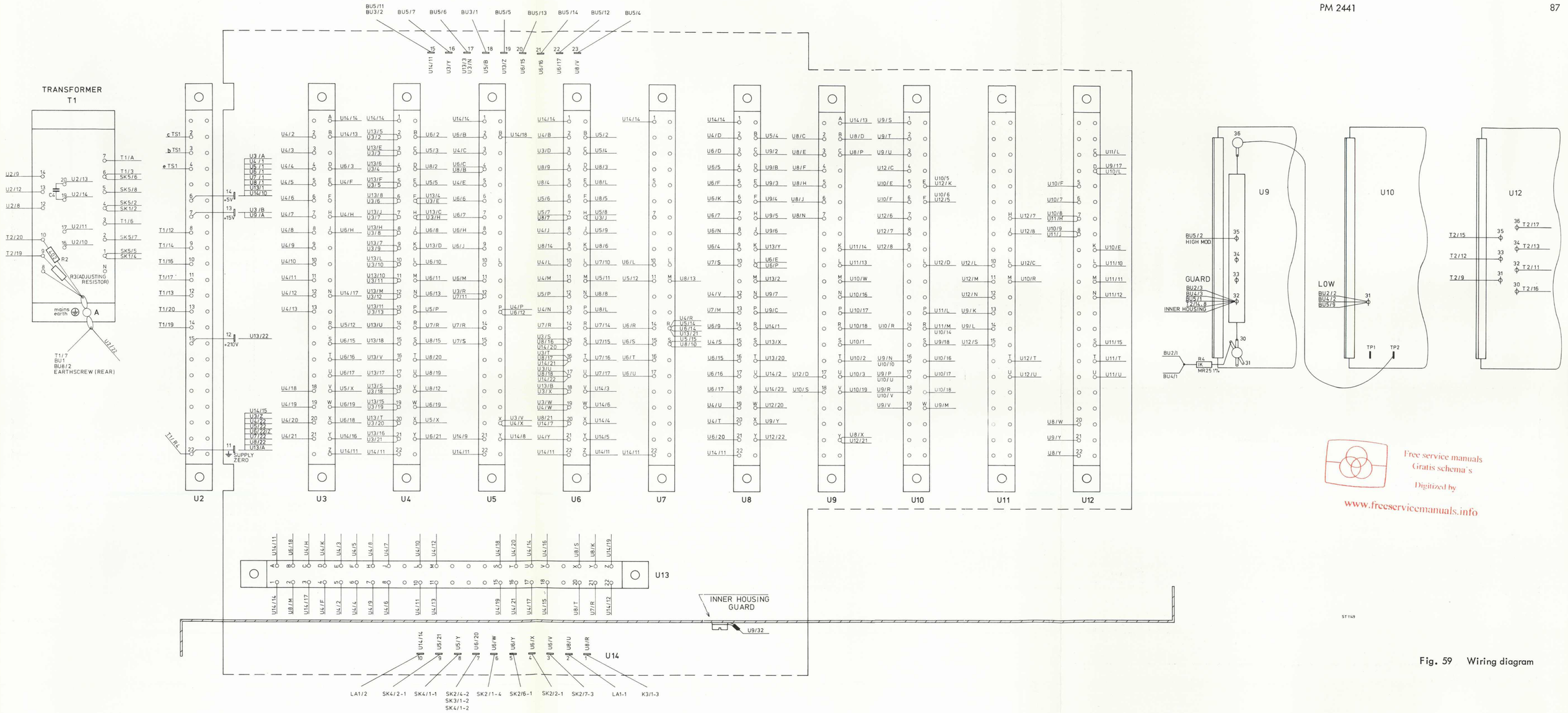





Fig. 59 Wiring diagram

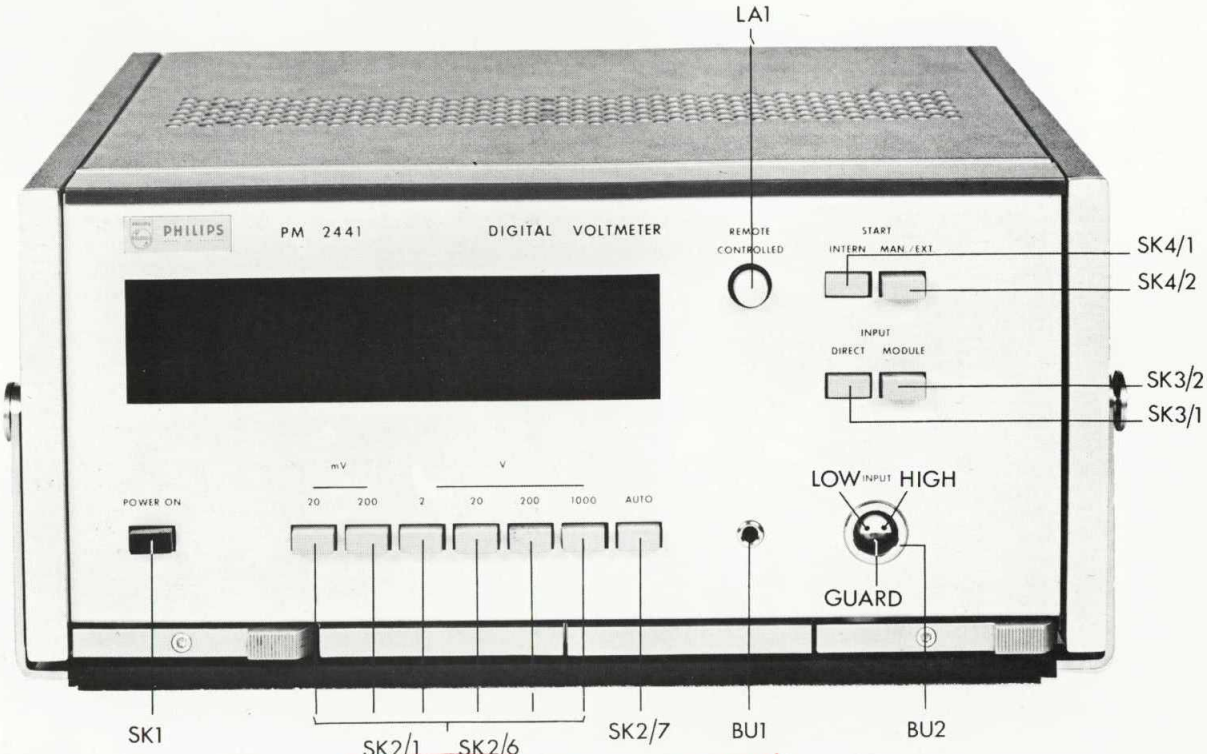



Fig. 60 Front view



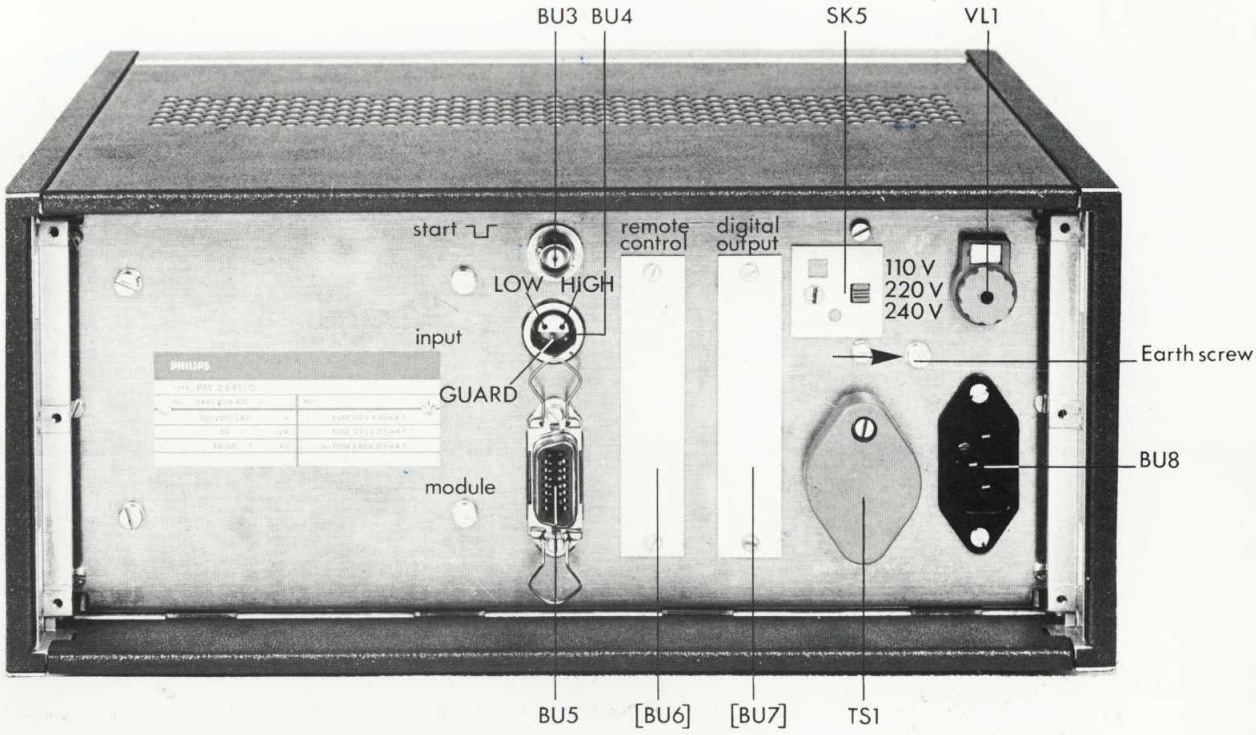



Fig. 61 Rear view

# XI. List of parts

MECHANICAL

| Pos. | Fig. | Qty. | Ordering number | Description | Manufacturer |
|---|---|---|---|---|---|
| - | - | 7 | 5322 255 44044 | IC socket 16 pens | Amp 583527-1 |
| - | - | 8 | 5322 255 44045 | IC socket 8 pens | Jermyn Ind. Mon-8L |
| - | - | 3 | 5322 255 40095 | IC socket 10 pens | Jermyn Ind. Mon-10L |
| 1 | 38 | 3 | 5322 268 14034 | Contact pins 4 pens | Amp 163740-2 |
| 2 | 38 | 1 | 5322 268 14035 | Contact pins 6 pens | Amp 163740-4 |
| 3 | 38 | 2 | 5322 268 14036 | Contact pins 8 pens | Amp 163740-6 |
| U14 | 59 | 1 | 5322 267 60023 | Connector 1 x 22 pole | |
| U14 | 59 | 11 | 5322 267 64005 | Connector 2 x 22 pole | |
| U2 | 41 | 1 | 5322 255 40044 | Cooling plate | |
| - | - | 22 | 5322 462 34101 | Board support | |
| 4 | 62 | 8 | 5322 325 64034 | Insulating plug | |
| LA1 | 60 | 1 | 5322 134 40152 | Lamp | |
| LA1 | 60 | 1 | 5322 255 30002 | Lamp holder | |
| LA1 | 60 | 1 | 5322 381 10217 | Lens | |
| - | - | 1 | 5322 456 14006 | Text plate | |
| - | 60 | 1 | 5322 450 64038 | Window | |
| - | 60 | 1 | 5322 414 24835 | Knob | |
| - | - | 8 | 5322 462 44114 | Foot plug | |
| - | - | 4 | 5322 466 94221 | Brack pivot | |
| - | - | 1 | 5322 405 94039 | Stand-up bracket 4/6 | |
| SK1 | 60 | 1 | 5322 276 14085 | Power-on switch | |
| SK2/1-SK2/7 | 60 | 1 | 5322 276 74009 | Range switches | |
| SK3/1-SK3/2 | 60 | 1 | 5322 276 24009 | Direct/Module switch | |
| SK4/1-SK4/2 | 60 | 1 | 5322 276 24011 | Intern/Extern switch | |
| SK5 | 61 | 1 | 5322 277 20009 | Mains switch | |
| TS1 | 61 | 1 | 5322 255 40091 | Cap for power transistor | |
| TS1 | 61 | 1 | 5322 255 40072 | Mica insulating washer | |
| BU1 | 60 | 1 | 5322 268 24016 | Earth terminal | Hirschmann Bo10 930 160-000 |
| BU2/BU4 | 60/61 | 2 | 5322 267 34017 | DC-input terminal | Lemo Ra2 |
| BU3 | 61 | 1 | 5322 267 14006 | Start input | Kings KC 79-67 |
| BU5 | 61 | 1 | 5322 267 54042 | Module terminal | Amphenol 57-40140 |
| BU8 | 61 | 1 | 5322 265 30066 | Mains entrance | |
| - | - | 1 | 5322 321 10071 | Mains cable | |
| VL1 | 61 | 1 | 5322 253 30014 | Fuse 315 mA D.A. (220V/240V mains) | |
| VL1 | 61 | 1 | 5322 253 30018 | Fuse 630 mA D.A. (110V mains) | |
| VL1 | 61 | 1 | 5322 256 40026 | Fuse holder | |
| - | - | 1 | 5322 395 50085 | Allen key | |
| - | 1 | 1 | 5322 321 24116 | Measuring cable | |



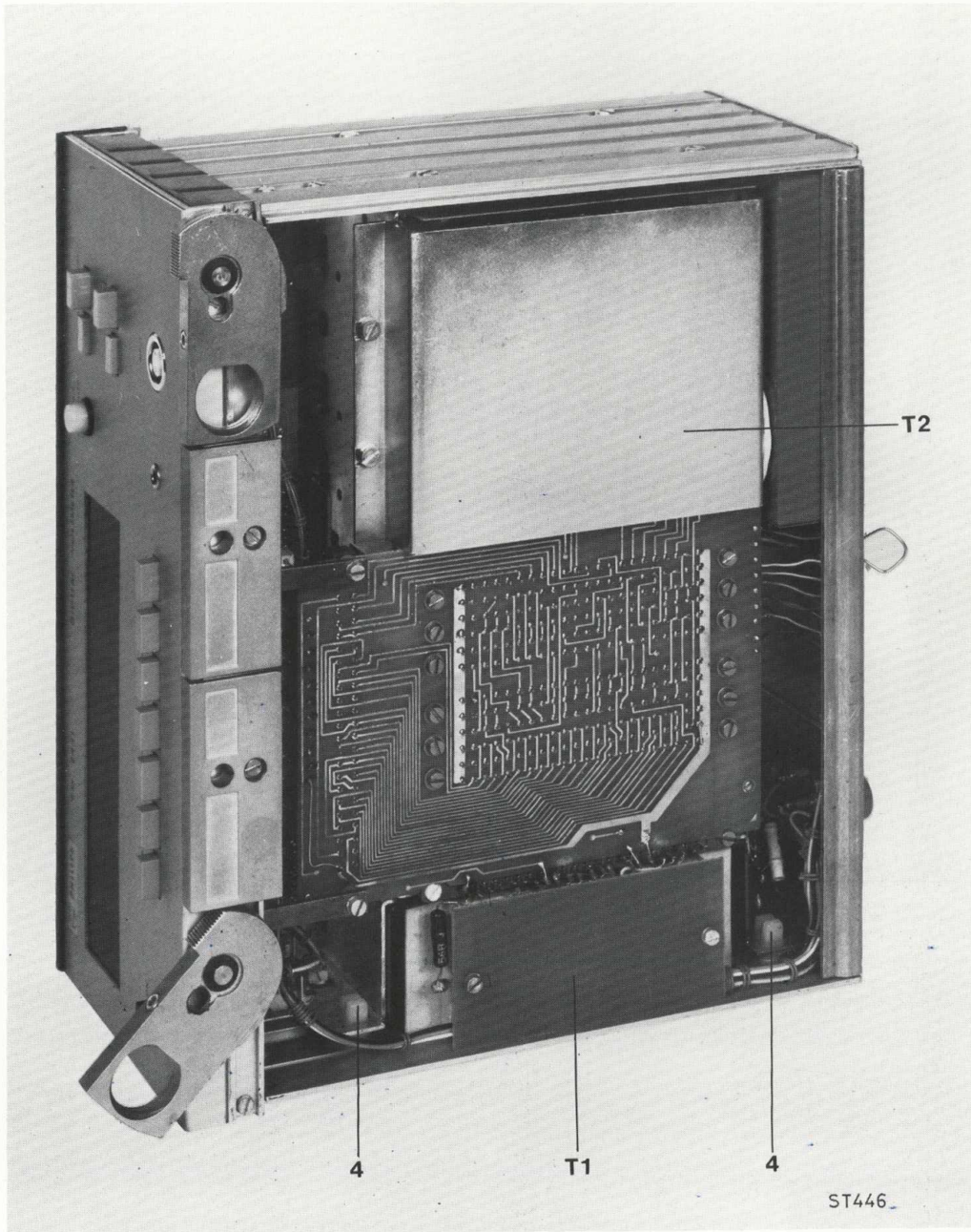



Fig. 62 Bottom view

This parts list does not contain multi-purpose and standard parts. These components are indicated in the circuit diagram by means of identification marks. The specification can be derived from the survey below.

Diese Ersatzteilliste enthält keine Universal- und Standard-Teile. Diese sind im jeweiligen Prinzipschaltbild mit Kennzeichnungen versehen. Die Spezifikation kann aus nachstehender Übersicht abgeleitet werden.

In deze stuklijst zijn geen universele en standaardonderdelen opgenomen. Deze componenten zijn in het principeschema met een merkteken aangegeven. De specificatie van deze merktekens is hieronder vermeld.

La présente liste ne contient pas des pièces universelles et standard. Celles-ci ont été repérées dans le schéma de principe. Leurs specifications sont indiquées ci-dessous.

Esta lista de componentes no comprende componentes universales ni standard. Estos componentes están provistos en el esquema de principio de una marca. El significado de estas marcas se indica a continuación.

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
0,125 W 5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
1 W ≦ 2,2 MΩ, 5%
> 2,2 MΩ, 10%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
0,25 W ≦ 1 MΩ, 5%
> 1 MΩ, 10%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
2 W 5%

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
0,5 W ≦ 5 MΩ, 1%
> 5 ≦ 10 MΩ, 2%
> 10 MΩ, 5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
0,4 – 1,8 W 0,5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
0,5 W ≦ 1,5 MΩ, 5%
> 1,5 MΩ, 10%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
5,5 W ≦ 200 Ω, 10%
> 200 Ω, 5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
10 W 5%

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
500 V

Polyester capacitor
Polyesterkondensator
Polyesterkondensator
Condensateur au polyester
Condensador polyester
400 V

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
700 V

Flat-foil polyester capacitor
Miniatur-Polyesterkondensator (flach)
Platte miniatuur polyesterkondensator
Condensateur au polyester, type plat
Condensador polyester, tipo de placas planas
250 V

Ceramic capacitor, "pin-up"
Keramikkondensator "Pin-up" (Perltyp)
Keramische kondensator "Pin-up" type
Condensateur céramique, type perle
Condensador cerámico, versión "colgable"
500 V

Paper capacitor
Papierkondensator
Papierkondensator
Condensateur au papier
Condensador de papel
1000 V

"Microplate" ceramic capacitor
Miniatur-Scheibenkondensator
"Microplate" keramische kondensator
Condensateur céramique "microplate"
Condensador cerámico "microplaca"
30 V

Wire-wound trimmer
Drahttrimmer
Draadgewonden trimmer
Trimmer à fil
Trimmer bobinado

Mica capacitor
Glimmerkondensator
Micakondensator
Condensateur au mica
Condensador de mica
500 V

Tubular ceramic trimmer
Rohrtrimmer
Buisvormige keramische trimmer
Trimmer céramique tubulaire
Trimmer cerámico tubular

SERVICE

For multi-purpose and standard parts, please see PHILIPS' Service Catalogue.

Für die Universal- und Standard-Teile siehe den PHILIPS Service-Katalog.

Voor universele en standaardonderdelen raadplege men de PHILIPS Service Catalogus.

Pour les pièces universelles et standard veuillez consulter le Catalogue Service PHILIPS.

Para piezas universales y standard consulte el Catálogo de Servicio PHILIPS.



## Miscellaneous

| Item | Ordering number | Description | Manufacturer |
|---|---|---|---|
| T1 | 5322 142 74001 | Mains transformer | |
| T2 | 5322 142 74002 | Secondary transformer | |
| T801 | 5322 158 14035 | Pulse transformer | |
| T802 | 5322 158 34046 | Pulse transformer | |
| T1201 | 5322 158 14035 | Pulse transformer | |
| T1202 | 5322 158 34046 | Pulse transformer | |
| VL201 | 5322 253 20011 | Fuse 250 mA | |
| VL202 | 5322 253 20023 | Fuse 2 A | |
| BU101 | 5322 267 44017 | 6-pole terminal | AMP 163681-4 |
| BU102 | 5322 267 54041 | 8-pole terminal | AMP 163681-6 |
| BU103 | 5322 267 44016 | 4-pole terminal | AMP 163681-2 |
| BU104 | 5322 267 44016 | 4-pole terminal | AMP 163681-2 |
| BU105 | 5322 267 44016 | 4-pole terminal | AMP 163681-2 |
| BU106 | 5322 267 54041 | 8-pole terminal | AMP 163681-6 |
| U1 | 5322 216 74015 | DISPLAY unit, complete | |
| U2 | 5322 216 74038 | POWER SUPPLY unit, complete | |
| U4 | 5322 216 74017 | COUNTER/MEMORY unit, complete | |
| U5 | 5322 216 74018 | OSCILLATOR unit, complete | |
| U6 | 5322 216 74019 | PROGRAM unit, complete | |
| U8 | 5322 216 74021 | RELAY DRIVE unit, complete | |
| U9 | 5322 216 74022 | RELAY SWITCHES unit, complete | |
| U10 | 5322 216 74039 | DC AMPLIFIER unit, complete | |
| U11 | 5322 216 74024 | ADC unit, complete | |
| U12 | 5322 216 74025 | INGUARD PROGRAM and SUPPLY unit, complete | |
| U13 | 5322 216 74026 | INTERCONNECTION unit, complete | |
| U14 | 5322 216 74027 | BOTTOM unit, complete | |
| RE901 | 5322 280 24012 | Reed relay | |
| RE902 | 5322 280 24027 | Reed relay | |
| RE903 | 5322 280 24027 | Reed relay | |
| RE904 | 5322 280 24028 | Reed relay | PHIPPS OF-1A-12 |
| RE905 | 5322 280 24028 | Reed relay | PHIPPS OF-1A-12 |
| RE906 | 5322 280 24032 | Reed relay | PHIPPS OF-1AS-12 |
| RE907 | 5322 280 24032 | Reed relay | PHIPPS OF-1AS-12 |
| RE908 | 5322 280 24029 | Reed relay (without coil) | HAMLIN DRT-5 |
| RE909 | 5322 280 24033 | Reed relay | |
| L901 | 5322 281 64139 | Coil-reed relay of RE908 | |
| TS1 | 5322 130 40132 | Transistor 2N3055 | |
| C4 | 5322 121 44095 | Capacitor 0.01 µF 630 V 20% (Polycarbonate) | |
| L1 | 5322 158 14036 | H.F. Choke | |
| L2 | 5322 158 14036 | H.F. Choke | |
| R2 | 5322 116 54519 | Resistor 402 Ω 1% MR25 | |
| R4 | 5322 116 54549 | MR25 1k 1% | |
| LA2 | 5322 134 40167 | Indicator lamp m/V | |
| LA3 | 5322 134 40167 | Indicator lamp m/V | |

| Item | Ordering number | Description | Manufacturer |
|---|---|---|---|
| B101 | 5322 131 94012 | Indicator +, -, ~ ZM1083 | |
| B102 | 5322 131 94013 | Indicator tube ZM1175C | |
| B103 | 5322 131 94013 | Indicator tube ZM1175C | |
| B104 | 5322 131 94013 | Indicator tube ZM1175C | |
| B105 | 5322 131 94013 | Indicator tube ZM1175C | |
| B106 | 5322 131 94013 | Indicator tube ZM1175C | |
| KT501 | 5322 242 74034 | Crystal 6 MHz | |



ELECTRICAL

Resistors

| Item | Ordering number | Value (Ω) | % | Series | Manufacturer |
|---|---|---|---|---|---|
| R111 | 5322 116 54134 | 33.2 k | 1 | MR30 | |
| R112 | 5322 116 54035 | 24.9 k | 1 | MR30 | |
| R113 | 5322 116 54035 | 24.9 k | 1 | MR30 | |
| R114 | 5322 116 54035 | 24.9 k | 1 | MR30 | |
| R115 | 5322 116 54035 | 24.9 k | 1 | MR30 | |
| R116 | 5322 116 54035 | 24.9 k | 1 | MR30 | |
| R202 | 5322 113 44104 | 20.12 | 10 | 1 Watt glass | |
| R203 | 5322 116 54587 | 3.65 k | 1 | MR25 | |
| R204 | 5322 116 50458 | 7.87 k | 1 | MR25 | |
| R205 | 5322 116 54606 | 7.15 k | 1 | MR25 | |
| R206 | 5322 116 50767 | 2.15 k | 1 | MR25 | |
| R207 | 5322 116 50523 | 4.99 k | 1 | MR25 | |
| R208 | 5322 116 50586 | 1.54 k | 1 | MR25 | |
| R210 | 5322 116 54214 | 10 k | 1 | MR30 | |
| R602 | 5322 116 54462 | 82 k | 1 | MR25 | |
| R810 | 5322 116 50675 | 2.26 k | 1 | MR25 | |
| R908 | 5322 116 54619 | 10 k | 1 | MR25 | |
| R909 | 5322 103 10052 | 500 | 10 | Potm. 1 Watt | BOURNS 3007-1-100 10 Ω |
| R910 | 5322 116 54538 | 787 | 1 | MR25 | |
| R911 | 5322 116 54155 | 100 k | 0.1 | MR24E | |
| R912 | 4822 110 10161 | 100 k | 5 | CR932 Watt | |
| R914 | 5322 116 54215 | 10 M | 0.1 | Metal film 0.5 Watt | |
| R1001 | 5322 116 54259 | 140 k | 1 | MR25 | |
| R1002 | 5322 116 50557 | 46.4 k | 1 | MR25 | |
| R1003 | 5322 116 54541 | 825 | 1 | MR25 | |
| R1004 | 5322 116 54068 | 28.7 k | 1 | MR25 | |
| R1009 | 5322 116 54696 | 100 k | 1 | MR25 | |
| R1010 | 5322 116 54009 | 562 | 1 | MR25 | |
| R1011 | 5322 116 54557 | 1.21 k | 1 | MR25 | |
| R1012 | 5322 101 14011 | 100 | 20 | Potentiometer 0.5 Watt | |
| R1013 | 5322 116 50509 | 4.87 k | 1 | MR25 | |
| R1014 | 5322 116 50482 | 33.2 k | 1 | MR25 | |

Resistors

| Item | Ordering number | Value (Ω) | % | Series |
|---|---|---|---|---|
| R1015 | 5322 116 50567 | 95.3 k | 1 | MR25 |
| R1016 | 5322 116 50572 | 12.1 k | 1 | MR25 |
| R1017 | 5322 116 50567 | 95.3 k | 1 | MR25 |
| R1018 | 5322 116 50482 | 33.2 k | 1 | MR25 |
| R1019 | 5322 116 50509 | 4.87 k | 1 | MR25 |
| R1020 | 5322 116 50767 | 2.15 k | 1 | MR25 |
| R1021 | 5322 116 50747 | 1 k | 1 | MR25 |
| R1022 | 5322 116 54261 | 12.7 | 1 | MR25 |
| R1023 | 5322 103 14003 | 100 k | 10 | Potentiometer 1 Watt |
| R1024 | 5322 116 54538 | 787 | 1 | MR25 |
| R1025 | 5322 116 51543 | 15.4 k | 1 | MR25 |
| R1026 | 5322 116 54154 | 316 k | 1 | MR25 |
| R1027 | 5322 116 54327 | 1 M | 1 | MR30 |
| R1028 | 5322 116 56192 | 6.19 k | 1 | MR25 |
| R1029 | 5322 116 54743 | 301 k | 1 | MR25 |
| R1030 | 5322 103 14003 | 100 k | 10 | Potentiometer 1 Watt |
| R1032 | 5322 116 54174 | 154 k | 1 | MR25 |
| R1033 | 5322 116 54494 | 187 | 1 | MR25 |
| R1034 | 5322 116 54676 | 56.2 k | 1 | MR25 |
| R1035 | 5322 116 54676 | 56.2 k | 1 | MR25 |
| R1036 | 5322 116 54676 | 56.2 k | 1 | MR25 |
| R1037 | 5322 116 54676 | 56.2 k | 1 | MR25 |
| R1038 | 5322 116 54462 | 82.5 | 1 | MR25 |
| R1039 | 5322 116 54462 | 82.5 | 1 | MR25 |
| R1040 | 5322 116 54469 | 100 | 1 | MR25 |
| R1041 | 5322 116 50481 | 22.6 k | 1 | MR25 |
| R1042 | 5322 116 50481 | 22.6 k | 1 | MR25 |
| R1043 | 5322 116 50481 | 22.6 k | 1 | MR25 |
| R1044 | 5322 116 50481 | 22.6 k | 1 | MR25 |
| R1045 | 5322 116 50481 | 22.6 k | 1 | MR25 |
| R1046 | 5322 116 54743 | 301 k | 1 | MR25 |
| R1047 | 5322 116 50567 | 95.3 k | 1 | MR25 |
| R1048 | 5322 116 50462 | 100 k | 0.1 | MR54E |
| R1049 | 5322 116 50779 | 1.33 k | 1 | MR25 |
| R1050 | 5322 116 50276 | 10 k | 0.1 | MR54E |
| R1051 | 5322 116 54932 | 909 | 0.1 | MR54E |
| R1052 | 5322 116 54933 | 90.9 k | 0.1 | MR54E |
| R1053 | 5322 116 54552 | 1.05 k | 1 | MR25 |
| R1054 | 5322 116 54552 | 1.05 k | 1 | MR25 |
| R1055 | 5322 116 54462 | 82.5 k | 1 | MR25 |
| R1056 | 5322 116 54462 | 82.5 k | 1 | MR25 |
| R1057 | 5322 116 54112 | 6.49 k | 1 | MR25 |
| R1058 | 5322 116 54112 | 6.49 k | 1 | MR25 |
| R1059 | 5322 116 50729 | 4.22 k | 1 | MR25 |
| R1060 | 5322 116 54543 | 866 | 1 | MR25 |

Resistors

| Item | Ordering number | Value (Ω) | % | Series | Manufacturer |
|---|---|---|---|---|---|
| R1061 | 5322 116 50459 | 422 | 1 | MR25 | |
| R1062 | 5322 116 54464 | 86.6 k | 1 | MR25 | |
| R1063 | 5322 116 51052 | 42.2 | 1 | MR25 | |
| R1064 | 5322 116 51051 | 8.66 k | 1 | MR25 | |
| R1065 | 5322 103 10023 | 1 k | 10 | Potm. 1 W | |
| R1066 | 5322 103 10047 | 100 | 10 | Potm. 1 W | |
| R1067 | 5322 103 10065 | 10 | 10 | Potm. 1 W | |
| R1103 | 5322 103 10075 | 20 k | 10 | Potm. 1 W | BOURNS 3007-P-1-203 20 kΩ |
| R1104 | 5322 103 10049 | 5 k | 10 | Potm. 1 W | BOURNS 3007-P-1-502 5 kΩ |
| R1105 | 5322 103 14035 | 50 | 10 | Potm. 1 W | BOURNS 3007-P-1-500 50 Ω |
| R1106 | 5322 116 50533 | 78.7 k | 1 | MR25 | |
| R1107 | 5322 116 50533 | 78.7 k | 1 | MR25 | |
| R1108 | 5322 116 54484 | 140 | 1 | MR25 | |
| R1111 | 5322 116 51027 | 301 k | 1 | MR30 | |
| R1112 | 5322 116 50825 | 261 k | 1 | MR25 | |
| R1113 | 5322 116 50514 | 64.9 k | 1 | MR25 | |
| R1114 | 5322 116 54597 | 5.30 k | 1 | MR25 | |
| R1117 | 5322 116 54635 | 16.9 k | 1 | MR25 | |
| R1118 | 5322 116 54595 | 5.11 k | 1 | MR25 | |
| R1119 | 5322 116 10047 | 100 | 10 | Potm. 1 W | BOURNS 3007-P-1-101 100 Ω |
| R1120 | 5322 103 10118 | 200 | 10 | Potm. 1 W | BOURNS 3007-P-1-201 200 Ω |
| R1121 | 5322 103 14035 | 50 | 10 | Potm. 1 W | BOURNS 3007-P-1-500 50 Ω |
| R1122 | 5322 116 54696 | 100 k | 1 | MR25 | |
| R1123 | 5322 116 54469 | 100 | 1 | MR25 | |
| R1124 | 5322 116 54469 | 100 | 1 | MR25 | |
| R1125 | 5322 116 54696 | 100 k | 1 | MR25 | |
| R1126 | 5322 116 54221 | 3.65 k | 0.1 | MR24E | |
| R1128 | 5322 116 51059 | 34.8 k | 0.1 | MR24E | |
| R1129 | 5322 116 54222 | 14 k | 0.1 | MR24E | |
| R1130 | 5322 116 54222 | 14 k | 0.1 | MR24E | |
| R1131 | 5322 116 54223 | 6.19 k | 0.1 | MR24E | |
| R1132 | 5322 116 54222 | 14 k | 0.1 | MR24E | |
| R1133 | 5322 116 54223 | 6.19 k | 0.1 | MR24E | |
| R1134 | 5322 116 54223 | 6.19 k | 0.1 | MR24E | |
| R1135 | 5322 116 54223 | 6.19 k | 0.1 | MR24E | |
| R1136 | 5322 116 54223 | 6.19 k | 0.1 | MR24E | |
| R1137 | 5322 116 54014 | 23.7 | 1 | MR25 | |
| R1138 | 5322 116 54014 | 23.7 | 1 | MR25 | |
| R1140 | 5322 116 54224 | 619 | 0.1 | MR24E | |
| R1141 | 5322 116 54223 | 6.19 k | 0.1 | MR24E | |
| R1142 | 5322 116 50579 | 3.19 k | 1 | MR25 | |
| R1143 | 5322 116 54077 | 1.54 k | 0.1 | MR24E | |
| R1144 | 5322 116 54225 | 3.48 k | 0.1 | MR24E | |
| R1145 | 5322 116 50415 | 1.15 k | 1 | MR25 | |
| R1146 | 5322 116 54519 | 402 | 1 | MR25 | |

Resistors

| Item | Ordering number | Value (Ω) | % | Series |
|---|---|---|---|---|
| R1147 | 5322 116 54549 | 1 k | 1 | MR25 |
| R1221 | 5322 116 54632 | 14.7 k | 1 | MR25 |
| R1222 | 5322 116 54068 | 28.7 k | 1 | MR25 |
| R1223 | 5322 116 54632 | 14.7 k | 1 | MR25 |
| R1224 | 5322 116 54632 | 14.7 k | 1 | MR25 |
| R1227 | 5322 116 54696 | 100 k | 1 | MR25 |

Capacitors

| Item | Ordering number | Value | % | V | Description |
|---|---|---|---|---|---|
| C101 | 5322 124 20373 | 47 µF | | 10 | Electrolytic |
| C102 | 4822 124 20348 | 4.7 µF | | 16 | Electrolytic |
| C201 | 4822 124 20423 | 1500 µF | | 16 | Electrolytic |
| C202 | 4822 124 20423 | 1500 µF | | 16 | Electrolytic |
| C203 | 4822 124 20419 | 1000 µF | | 25 | Electrolytic |
| C204 | 4822 124 20224 | 20 µF | | 350 | Electrolytic |
| C205 | 4822 124 20423 | 1500 µF | | 16 | Electrolytic |
| C206 | 4822 124 20362 | 22 µF | | 25 | Electrolytic |
| C207 | 5322 125 20373 | 47 µF | | 10 | Electrolytic |
| C208 | 5322 122 30115 | 560 pF | 10 | 100 | Ceramic |
| C209 | 5322 122 30115 | 560 pF | 10 | 100 | Ceramic |
| C210 | 4822 124 20453 | 68 µF | | 6.4 | Electrolytic |
| C401 | 5322 124 20373 | 47 µF | | 10 | Electrolytic |
| C501 | 4822 122 31203 | 3.9 pF | 2 | 50 | Ceramic |
| C502 | 5322 121 40047 | 0.01 µF | 20 | 250 | Polystyrene |
| C503 | 4822 121 40232 | 220 nF | 10 | 100 | Polystyrene |
| C504 | 4822 121 40232 | 220 nF | 10 | 100 | Polystyrene |
| C505 | 5322 121 40045 | 0.022 µF | 20 | 250 | Polystyrene |
| C506 | 5322 122 30124 | 2.2 nF | 10 | 100 | Ceramic |
| C507 | 4822 122 30048 | 1.8 nF | 10 | 100 | Ceramic |
| C508 | 5322 124 20373 | 47 µF | | 10 | Electrolytic |
| C601 | 5322 124 20373 | 47 µF | | 10 | Electrolytic |
| C602 | 5322 116 54462 | 68 µF | | 6.4 | Electrolytic |
| C603 | 5322 122 30043 | 10 nF | -20/+80 | 63 | Ceramic |
| C604 | 5322 121 54019 | 330 pF | | 250 | Ceramic |
| C801 | 5322 124 20373 | 47 µF | | 10 | Electrolytic |
| C802 | 5322 122 30115 | 560 pF | 10 | 100 | Ceramic |
| C803 | 5322 124 20373 | 47 µF | | 10 | Electrolytic |
| C804 | 4822 124 20353 | 10 µF | | 6.3 | Electrolytic |
| C901 | 4822 124 20345 | 3.3 µF | | 25 | Electrolytic |
| C902 | 4822 124 20345 | 3.3 µF | | 25 | Electrolytic |
| C903 | 4822 124 20345 | 3.3 µF | | 25 | Electrolytic |
| C904 | 4822 124 20345 | 3.3 µF | | 25 | Electrolytic |
| C905 | 4822 124 20345 | 3.3 µF | | 25 | Electrolytic |
| C906 | 4822 124 20345 | 3.3 µF | | 25 | Electrolytic |
| C509 | 5322 124 20373 | 47 µF | | 10 | Electrolytic |
| C510 | 5322 122 30103 | 22 nF | -20/+80 | 63 | Ceramic |

| Item | Ordering number | Value | | % | V | Description |
|---|---|---|---|---|---|---|
| C907 | 4822 124 20345 | 3.3 | µF | | 25 | Electrolytic |
| C908 | 4822 121 50591 | 1 | nF | 5 | 500 | Ceramic |
| C1001 | 4822 122 31072 | 47 | pF | 2 | 100 | Ceramic |
| C1002 | 5322 121 54077 | 330 | pF | 5 | 250 | Polystyrene |
| C1003 | 4822 121 50424 | 1 | nF | 5 | 125 | Polystyrene |
| C1005 | 4822 121 41161 | 100 | nF | 10 | 100 | Polyester |
| C1008 | 4822 124 20451 | 100 | µF | | 6.3 | Electrolytic |
| C1009 | 4822 121 40104 | 150 | nF | 10 | 100 | Polyester |
| C1010 | 4822 124 20458 | 6.8 | µF | | 10 | Electrolytic |
| C1011 | 4822 124 20482 | 2.2 | µF | | 40 | Electrolytic |
| C1012 | 4822 124 20482 | 2.2 | µF | | 40 | Electrolytic |
| C1013 | 4822 124 14029 | 22 | µF | 20 | 4 | Electrolytic (Tantal) |
| C1014 | 4822 121 41152 | 150 | nF | 10 | 100 | Polyester |
| C1015 | 4822 124 20466 | 4.7 | µF | | 16 | Electrolytic |
| C1016 | 4822 121 41152 | 47 | nF | 10 | 100 | Polyester |
| C1017 | 4822 122 31074 | 56 | pF | 2 | 100 | Ceramic |
| C1018 | 5322 121 50438 | 1.2 | nF | 1 | 63 | Polyester |
| C1019 | 5322 121 54083 | 51 | pF | 1 | 500 | Polyester |
| C1101 | 5322 121 50405 | 0.056 | µF | 1 | 63 | Polycarbonate |
| C1102 | 5322 124 20371 | 47 | µF | | 25 | Electrolytic |
| C1103 | 5322 124 20371 | 47 | µF | | 25 | Electrolytic |
| C1104 | 5322 121 50421 | 0.16 | µF | 1 | 63 | Polycarbonate |
| C1105 | 5322 121 50421 | 0.16 | µF | 1 | 63 | Polycarbonate |
| C1106 | 5322 121 40323 | 0.1 | µF | 20 | 100 | Polystyrene |
| C1107 | 5322 121 40323 | 0.1 | µF | 20 | 100 | Polystyrene |
| C1109 | 5322 122 30005 | 8.2 | pF | 0.25 pF | 63 | Ceramic |
| C1112 | 5322 122 30103 | 22 | nF | -20/+100 | 40 | Ceramic |
| C1113 | 5322 122 30103 | 22 | nF | -20/+100 | 40 | Ceramic |
| C1114 | 4822 122 30053 | 680 | pF | 10 | 100 | Ceramic |
| C1115 | 5322 122 30031 | 820 | pF | 10 | 100 | Ceramic |
| C1116 | 4822 122 31085 | 150 | pF | 2 | 100 | Ceramic |
| C1201 | 5322 124 20373 | 47 | µF | | 10 | Electrolytic |
| C1202 | 5322 124 20373 | 47 | µF | | 10 | Electrolytic |
| C1203 | 5322 122 30052 | 1.5 | nF | 10 | 100 | Ceramic |
| C1204 | 5322 122 30125 | 180 | pF | 10 | 100 | Ceramic |
| C1205 | 5322 122 30125 | 180 | pF | 10 | 100 | Ceramic |
| C1206 | 5322 122 30125 | 180 | pF | 10 | 100 | Ceramic |
| C1207 | 5322 122 30125 | 180 | pF | 10 | 100 | Ceramic |
| C1208 | 5322 122 30103 | 22 | nF | -20/+100 | 40 | Ceramic |
| C1209 | 5322 122 30103 | 22 | nF | -20/+100 | 40 | Ceramic |
| C1210 | 4822 124 20398 | 220 | µF | | 25 | Electrolytic |
| C1211 | 4822 124 20398 | 220 | µF | | 25 | Electrolytic |
| C1212 | 4822 124 20403 | 330 | µF | | 16 | Electrolytic |
| C1213 | 4822 124 20372 | 47 | µF | | 63 | Electrolytic |
| C1214 | 4822 124 20372 | 47 | µF | | 63 | Electrolytic |
| C1215 | 4822 121 40257 | 0.33 | µF | 10 | 100 | Polyester |

Transistors

| Item | Ordering number | Type |
|---|---|---|
| TS101 | 5322 130 44123 | BFX90 |
| TS102 | 5322 130 44123 | BFX90 |
| TS103 | 5322 130 44123 | BFX90 |
| TS104 | 5322 130 44124 | BF337 |
| TS105 | 5322 130 44124 | BF337 |
| TS106 | 5322 130 44124 | BF337 |
| TS107 | 5322 130 40417 | BSX20 |
| TS108 | 5322 130 40498 | 2N4891 |
| TS109 | 5322 130 40417 | BSX20 |
| TS201 | 5322 130 40294 | BFY50 |
| TS202 | 5322 130 40294 | BFY50 |
| TS501 | 5322 130 40498 | 2N4891 |
| TS502 | 5322 130 40417 | BSX20 |
| TS801 | 5322 130 40417 | BSX20 |
| TS802 | 5322 130 40417 | BSX20 |
| TS1001 | 5322 130 44041 | BSV81 |
| TS1002 | 5322 130 40408 | BFW13 |
| TS1003 | 5322 130 40964 | BC549 |
| TS1004 | 5322 130 40964 | BC549 |
| TS1005 | 5322 130 40964 | BC549 |
| TS1006 | 5322 130 40408 | BFW13 |
| TS1007 | 5322 130 40321 | BSX21 |
| TS1008 | 4822 130 40989 | BC556 |
| TS1009 | 4822 130 41001 | BC546 |
| TS1010 | 4822 130 40989 | BC556 |
| TS1011 | 5322 130 44248 | BFQ12 |
| TS1012 | 4822 130 40989 | BC556 |
| TS1101 | 5322 130 44355 | BFQ10 |
| TS1102 | 5322 130 34044 | BSV80 |
| TS1103 | 5322 130 34044 | BSV80 |
| TS1104 | 5322 130 44017 | BSV79 |
| TS1105 | 5322 130 44017 | BSV79 |
| TS1106 | 5322 130 44017 | BSV79 |
| TS1107 | 5322 130 34044 | BSV80 |
| TS1108 | 5322 130 34044 | BSV80 |
| TS1109 | 5322 130 44093 | BSV78 |
| TS1110 | 5322 130 44093 | BSV78 |
| TS1201 | 5322 130 44017 | BSX20 |
| TS1202 | 5322 130 44017 | BSX20 |
| TS1203 | 5322 130 40621 | 2N2907A |
| TS1204 | 5322 130 40621 | 2N2907A |
| TS1205 | 5322 130 40621 | 2N2907A |
| TS1206 | 5322 130 40621 | 2N2907A |
| TS1207 | 5322 130 40468 | 2N2905A |
| TS1208 | 5322 130 40294 | BFY50 |

| Item | Ordering number | Type |
|---|---|---|
| TS1209 | 5322 130 40294 | BFY50 |
| TS1210 | 4822 130 40522 | BC177 |
| TS1211 | 5322 130 40357 | BC107 |
| TS1225 | 5322 130 40408 | BFW13 |
| TS1228 | 5322 130 40408 | BFW13 |

Diodes

| Item | Ordering number | Type |
|---|---|---|
| GR101 | 5322 130 34139 | BZX79-C56 |
| GR102 | 5322 130 34139 | BZX79-C56 |
| GR103 | 5322 130 34139 | BZX79-C56 |
| GR104 | 5322 130 30605 | BAX17 |
| GR105 | 5322 130 30605 | BAX17 |
| GR106 | 5322 130 30605 | BAX17 |
| GR107 | 5322 130 30605 | BAX17 |
| GR201 | 5322 130 34141 | BYX45-200R |
| GR202 | 5322 130 34141 | BYX45-200R |
| GR203 | 5322 130 30521 | BY179 |
| GR204 | 5322 130 30414 | BY164 |
| GR501 | 5322 130 30594 | BAV10 |
| GR502 | 5322 130 30594 | BAV10 |
| GR801 | 5322 130 30594 | BAV10 |
| GR802 | 5322 130 30594 | BAV10 |
| GR1001 | 5322 130 30594 | BAV10 |
| GR1002 | 5322 130 30767 | BZX79-C5V1 |
| GR1003 | 5322 130 30594 | BAV10 |
| GR1004 | 5322 130 34037 | BAV45 |
| GR1005 | 5322 130 34037 | BAV45 |
| GR1006 | 5322 130 34037 | BAV45 |
| GR1007 | 5322 130 34037 | BAV45 |
| GR1008 | 5322 130 30594 | BAV10 |
| GR1009 | 5322 130 30594 | BAV10 |
| GR1010 | 5322 130 30594 | BAV10 |
| GR1011 | 5322 130 30594 | BAV10 |
| GR1012 | 5322 130 30594 | BAV10 |
| GR1013 | 5322 130 34379 | BZX79-B27 |
| GR1014 | 5322 130 34367 | BZX79-C33 |
| GR1015 | 5322 130 34379 | BZX79-B27 |
| GR1016 | 5322 130 34367 | BZX79-C33 |
| GR1017 | 5322 130 34037 | BAV45 |
| GR1018 | 5322 130 34037 | BAV45 |
| GR1019 | 5322 130 34037 | BAV45 |
| GR1020 | 5322 130 34037 | BAV45 |

| Item | Ordering number | Type |
|---|---|---|
| GR1101 | 5322 130 34153 | 1N829 |
| GR1102 | 5322 130 30774 | BZX79-C10 |
| GR1103 | 5322 130 34119 | BZX79-C8V2 |
| GR1104 | 5322 130 34119 | BZX79-C8V2 |
| GR1201 | 5322 130 30594 | BAV10 |
| GR1202 | 5322 130 30594 | BAV10 |
| GR1203 | 5322 130 30414 | BY164 |
| GR1204 | 5322 130 30414 | BY164 |
| GR1205 | 5322 130 30414 | BY164 |
| GR1206 | 5322 130 34368 | BZX79-B36 |
| GR1207 | 5322 130 34368 | BZX79-B36 |
| GR1226 | 5322 130 30759 | BZX79-C5V6 |

Integrated circuits

| Item | Ordering number | Type |
|---|---|---|
| IC101 | 5322 209 84138 | SN74141N |
| IC102 | 5322 209 84138 | SN74141N |
| IC103 | 5322 209 84138 | SN74141N |
| IC104 | 5322 209 84138 | SN74141N |
| IC105 | 5322 209 84138 | SN74141N |
| IC106 | 5322 209 84138 | SN74141N |
| IC107 | 5322 209 84138 | SN74141N |
| IC201 | 5322 209 80245 | TBA281 |
| IC202 | 5322 209 80245 | TBA281 |
| IC401 | 5322 209 84114 | FJJ141 |
| IC402 | 5322 209 84058 | SN7400N |
| IC403 | 5322 209 84114 | FJJ141/7490N |
| IC404 | 5322 209 84114 | FJJ141/7490N |
| IC405 | 5322 209 84114 | FJJ141/7490N |
| IC406 | 5322 209 80107 | FJJ111/7472N |
| IC407 | 5322 209 84139 | FJJ281/9308 |
| IC408 | 5322 209 84139 | FJJ281/9308 |
| IC409 | 5322 209 84139 | FJJ281/9308 |
| IC410 | 5322 209 84141 | FJH101/7430N |
| IC501 | 5322 209 80208 | FJH241/7404N |
| IC502 | 5322 209 84142 | FJJ121/7473N |
| IC503 | 5322 209 84142 | FJJ121/7473N |
| IC504 | 5322 209 84114 | FJJ141/7490N |
| IC505 | 5322 209 84143 | FJH131/7400N |
| IC506 | 5322 209 84143 | FJH131/7400N |
| IC507 | 5322 209 84144 | FJH121/7410N |
| IC509 | 5322 209 84114 | FJJ141/7490N |
| IC510 | 5322 209 84142 | FJJ121/7473N |
| IC601 | 5322 209 80065 | FJJ131/7474N |
| IC602 | 5322 209 84143 | FJH131/7400N |

| Item | Ordering number | Type |
|---|---|---|
| IC603 | 5322 209 84144 | FJH121/7410N |
| IC604 | 5322 209 84142 | FJJ121/7473N |
| IC605 | 5322 209 84145 | FJH221/7402N |
| IC606 | 5322 209 80065 | FJJ131/7474N |
| IC607 | 5322 209 84143 | FJH131/7400N |
| IC608 | 5322 209 84146 | FJJ411/74193N |
| IC609 | 5322 209 80208 | FJH241/7404N |
| IC610 | 5322 209 84145 | FJH221/7473N |
| IC611 | 5322 209 80065 | FJJ131/7474N |
| IC612 | 5322 209 80065 | FJJ131/7474N |
| IC801 | 5322 209 84143 | FJH131/7400N |
| IC802 | 5322 209 84143 | FJH131/7400N |
| IC803 | 5322 209 84145 | FJH221/7402N |
| IC804 | 5322 209 84142 | FJJ121/7473N |
| IC805 | 5322 209 84145 | FJH221/7402N |
| IC806 | 5322 209 84034 | SN7416N-00 |
| IC807 | 5322 209 84034 | SN7416N-00 |
| IC808 | 5322 209 84147 | FJH241/7404N |
| IC809 | 5322 209 84034 | SN7416N-00 |
| IC1001 | 5322 209 84486 | TBA221B |
| IC1101 | 5322 209 84149 | ICB8001C |
| IC1102 | 5322 209 84112 | TBA221 |
| IC1103 | 5322 209 84112 | TBA221 |
| IC1104 | 5322 209 84535 | AD201AH |
| IC1105 | 5322 209 84091 | TBA222 |
| IC1106 | 5322 209 84091 | TBA222 |
| IC1201 | 5322 209 84142 | FJJ121/7473N |
| IC1202 | 5322 209 84142 | FJJ121/7473N |
| IC1203 | 5322 209 84112 | TBA221 |
| IC1204 | 5322 209 84112 | TBA221 |
| IC1205 | 5322 209 84112 | TBA221 |

# XII. PM 9230 Remote Control

## XII-1. INTRODUCTION

- By application of the PM 9230 in the DC-voltmeter PM 2441 it is possible to "remote control" the PM 2441 completely. By connecting the inputs of the PM 9230 via the amphenol connector to zero, the relevant parts such as: range, sampling time, start pulse and module are activated.
- Operating sequence.
- If the input "REMOTE" is connected to zero, the switching functions of the front panel of the PM 2441 are blocked and the indication lamp "REMOTE CONTROLLED" lights.
- Starting a measurement is effected by setting a negative going pulse to the input "START". The sampling time of this measurement is dependent to the code supplied to the input "SAMPLING TIME" and can be 100 ms, 20 ms or 2 ms.
  At a sampling time of 2 ms the tube that indicates the units is blanked.
- To increase the number of measurements per second, a pulse train can be set to the input "START", however, the measuring speed mentioned in the technical data must be taken into account.
- The manual and automatic range selection is effected by setting the input "RANGE" to zero according the BCD code mentioned in the technical data.
- By setting the input "MODULE" to zero the voltage supplied to the MODULE input of the PM 2441 is measured.
- Via the BNC socket "START" at the rear of the PM 2441 the measurements also can be started by a negative going pulse H = +2.4 - +50 V
  L = −1.5 - + 1 V
  Width = 10 µsec. ... 100 msec.

## XII-2. TECHNICAL DATA

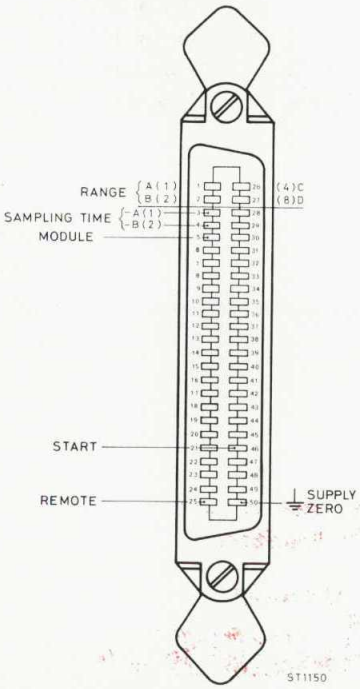



Fig. 63 Remote control connector BU6

| - RANGE | (8) | (4) | (2) | (1) |
|---|---|---|---|---|
| 20 mV | 0 | - | - | 0 |
| 200 mV | 0 | - | 0 | - |
| 2 V | 0 | - | 0 | 0 |
| 20 V | 0 | 0 | - | - |
| 200 V | 0 | 0 | - | 0 |
| 1000 V | 0 | 0 | 0 | - |
| AUTO | - | - | - | - |

- = not activated
0 = activated (connected to zero)

If input D is not activated then the PM 2441 selects the ranges automatically.

| - SAMPLING TIME | (2) | (1) |
|---|---|---|
| 100 ms | - | - |
| 20 ms | - | 0 |
| 2 ms | 0 | - |
| 2 ms | 0 | 0 |

- MODULE
  Measurements via the "MODULE" input of the PM 2441.
  MODULE = 0

- START
  The measurement is started by a negative going pulse
  H = +2.4 V ... +50 V
  L = -1.5 V ... + 1 V

| | | | |
|---|---|---|---|
| SAMPLING TIME | 100 msec. | 20 msec. | 2 msec. |
| MAX. MEASURING SPEED | 4 meas/sec. | 20 meas/sec. | 100 meas/sec. |
| Width | 10µsec. - 100 msec. | 10µsec. - 20 msec. | 10µsec. - 20 msec. |

- REMOTE, activated by zero level

## XII-3. MOUNTING THE UNIT

- Remove the housing.
- Remove the screening plate of the Remote Control input (Fig. 15).
- Place the unit in the clamps.
- Mount the connector with the two screws and nuts of the screening at the rear of the instrument (Fig. 15).
- Mount the plug-in unit again in the cabinet.

## XII-4. LIST OF PARTS OF THE PM 9230

| Item | Ordering number | Description | | | | Manufacturer |
|---|---|---|---|---|---|---|
| C701 | 5322 212 20373 | 10 V | 5% | 47 µF | Electrolytic | |
| C702 | 4822 122 10045 | 500 V | 5% | 100 pF | Ceramic | |
| C703 | 4822 122 10045 | 500 V | 5% | 100 pF | Ceramic | |
| C704 | 4822 122 10045 | 500 V | 5% | 100 pF | Ceramic | |
| C705 | 4822 122 10045 | 500 V | 5% | 100 pF | Ceramic | |
| C706 | 4822 122 10045 | 500 V | 5% | 100 pF | Ceramic | |
| C707 | 4822 122 10045 | 500 V | 5% | 100 pF | Ceramic | |
| C708 | 4822 122 10045 | 500 V | 5% | 100 pF | Ceramic | |
| C709 | 4822 122 10045 | 500 V | 5% | 100 pF | Ceramic | |
| C710 | 4822 122 10045 | 500 V | 5% | 100 pF | Ceramic | |
| GR701 up to GR712 | 5322 130 30613 | BAW62 | | | | |
| IC701 | 5322 209 84147 | F JH241/7404N | | | | |
| IC702 | 5322 209 84172 | U6A993559X | | | | FAIRCHILD |
| IC703 | 5322 209 84172 | U6A993559X | | | | FAIRCHILD |
| BU701 | 5322 267 70015 | 50-pole Amphenol connector | | | | AMPHENOL 57-40500 |

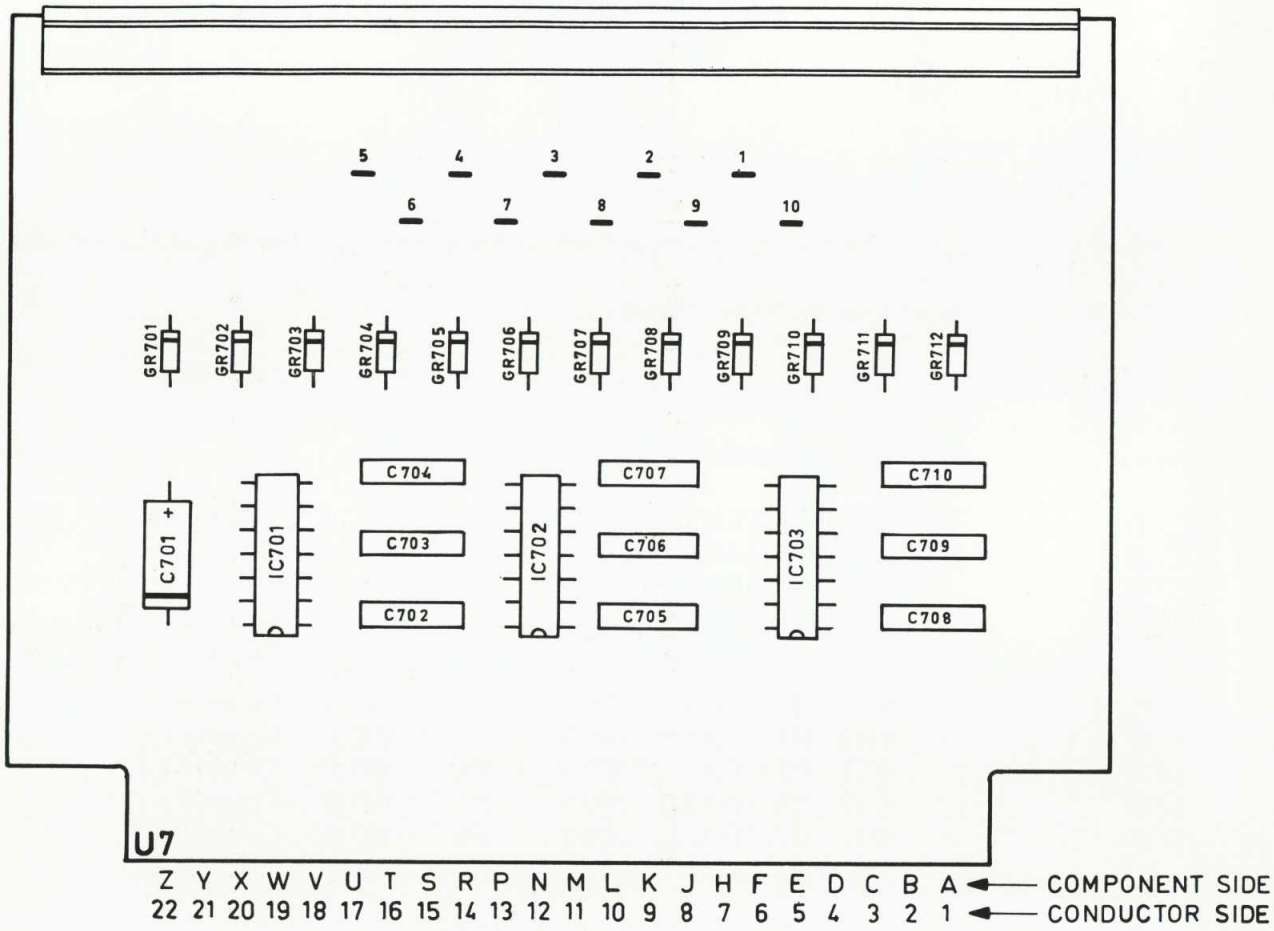



Fig. 64 Printed wiring board U7

MA7324

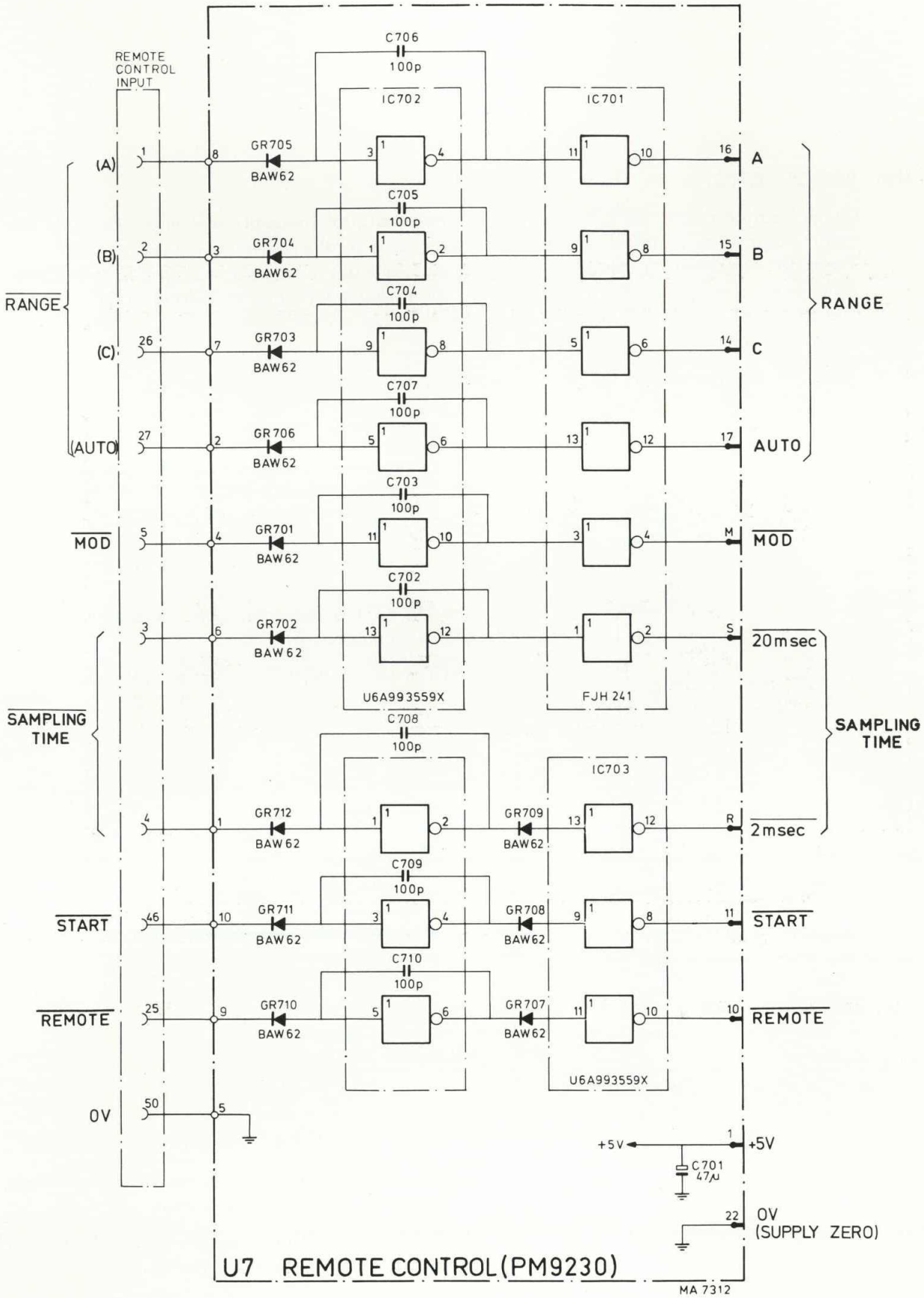



Fig. 65 Circuit diagram REMOTE CONTROL U7 PM 9230

# XIII. PM 9231 Digital Output

## XIII-1. INTRODUCTION

By application of the PM 9231 it is possible to get digital information from the PM 2441 to control a printer, a digital-to-analog converter or a parallel to series converter, etc.
The digital information contains: Result, range, polarity, overload, sampling time and print signal.
With an external pulse it is possible to start the measurement via the digital output connector.
The one level of the BCD output code of the PM 9231 can be switched from +5 V to +15 V with an internal jumper.

This feature allows to use the digital output signals in several systems.

## XIII-2. TECHNICAL DATA

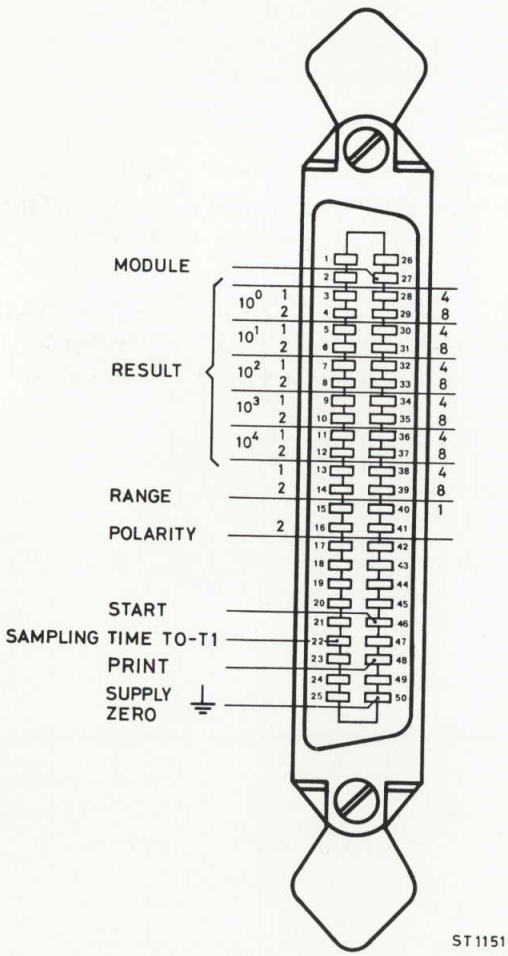



Fig. 66 Digital output connector BU7

Output system - Word parallel-bit parallel
Output code - Positive BCD
Zero level 0 ... 0.4 V
Isink = 5 mA
One level = +5 or +15 V
(Internal jumper)
The PM 9231 is delivered in +15 V output level version
Output resistance 6.2 kΩ

| RESULT $10^0 \ldots 10^3$ BCD code | (8) | (4) | (2) | (1) |
|---|---|---|---|---|
| $10^4$ | 0 | 0 | 0 | 0 = 0 |
| | 0 | 0 | 0 | 0 = 1 |
| | 1 | 0 | 1 | 0 = OL* |

*overload of the 20 mV up to 200 V range and the 1000 V range

| | | (8) | (4) | (2) | (1) |
|---|---|---|---|---|---|
| RANGE | 20 mV | 0 | 1 | 1 | 0 |
| | 200 mV | 0 | 1 | 0 | 1 |
| | 2 V | 0 | 1 | 0 | 0 |
| | 20 V | 0 | 0 | 1 | 1 |
| | 200 V | 0 | 0 | 1 | 0 |
| | 1000 V | 0 | 0 | 0 | 1 |

| POLARITY/AC : | | (4) | (2) |
|---|---|---|---|
| INDICATION : | - | 1 | 0 |
| | + | 0 | 1 |
| | ~ | 1 | 1 |

PRINT : 0 (neg. going pulse width 5 µsec.)

SAMPL. TIME ($t_0 - t_1$) : 0 (neg. going pulse width: 100 ms, 20 ms or 2 ms).

MODULE : 1 (input signals measured via module input of the PM 2441)

Point 23 and 49 of the Amphenol connector are interconnected.

START : 0 (neg. going pulse width 50 µs)
H = +2.4 V ... +50 V
L = -1.5 V ... 1 V

- To start a measurement via the amphenol connector of the PM 9231, the switch MAN/EXT of the PM 2441 must be depressed.
- Also the measurements can be started in the following way:
  1. By depressing the switch MAN/EXT
  2. Via the BNC socket at the rear of the instrument (Switch MAN/EXT must be depressed) by a negative going pulse.
     H = +2.4 V ... +50 V
     L = -1.5 V ... 1 V
     Width: 10 µsec. ... 100 msec.
  3. INTERN (at depressed switch INTERN)
     Measuring speed = 4 meas./sec.
     Sampling time = 100 msec.

## XIII-3. CIRCUIT DESCRIPTION

Result:

The input information for $10^0$, $10^1$, $10^2$ and $10^3$ is derived from unit U4 in positive BCD code. The input information for $10^4$ is derived from unit U4/F (signal B102) and unit U6/18 (signal $\overline{OL}$). Signal B102 is the "one" indicator from the tenthousands indicator tube and signal $\overline{OL}$ is the overload indication.
If there is overload ($\overline{OL}$ is logic 0) tube B102 may indicate 1 (signal B102 is logic 1, which means overload 1000 V range) or 2 (signal B102 is logic 0, which means overload 20 mV up to 200 V range). If there is no overload ($\overline{OL}$ is logic 1) tube B102 may indicate 0 (signal B102 is logic 0) or 1 (signal B102 is logic 1).

| B102 | $\overline{OL}$ | (8) | (4) | (2) | (1) | |
|---|---|---|---|---|---|---|
| E | X | 24 | 9 | 8 | 25 | Indication |
| 0 | 0 | 1 | 0 | 1 | 0 | 2, OL 20 mV up to 200 V range |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 1 | 0 | 1, OL 1000 V range |
| 1 | 1 | 0 | 0 | 0 | 1 | 1 |

Range:

The input information for the RANGE is derived from unit U6 and is supplied in positive BCD code.
On unit U3 the information is inverted.

| Range | C | B | A | (8) | (4) | (2) | (1) |
|---|---|---|---|---|---|---|---|
| | U | T | S | 11 | 23 | 10 | 32 |
| 20 mV | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| 200 mV | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| 2 V | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 20 V | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 200 V | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 1000 V | 1 | 1 | 0 | 0 | 0 | 0 | 1 |

Polarity/AC indication:

The AC indication is derived from the MODULE input BU5 when no module (AC/DC or OHMS to DC-converter) is used signal $\overline{AC}$ is logic 1.
Signal +POL is derived from unit U4/H and is logic 0 at +polarity and logic 1 at -polarity.

| $\overline{AC}$ | +POL | (2) | (1) | |
|---|---|---|---|---|
| N | H | 26 | 6 | Indication |
| 0 | 0 | 1 | 1 | ~ |
| 0 | 1 | 1 | 1 | ~ |
| 1 | 0 | 1 | 0 | + |
| 1 | 1 | 0 | 1 | - |

Print:

Signal UP or DOWN is derived from unit U6/19 and signal $\overline{TRANSFER}$ from unit U5/X.
Output signal $\overline{PRINT}$ is active when it is negative going.
During up- or down-ranging, signal UP or DOWN is logic 1 and controls output signal $\overline{PRINT}$.

| UP or DOWN | $\overline{TRANSFER}$ | $\overline{PRINT}$ |
|---|---|---|
| W | V | 27 |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

$\overline{PRINT}$ negative-going
width = 5 µsec.

Output level:

By means of the jumper on unit U3 it is possible to convert the output level of the output signal from +5 to +15 V.
Integrated circuits IC301, 305 and 306 are level convertors. IC302 is a level convertor with inverting output.

Note: Signal $t_0$ - $t_2$ is not connected to the 50-pole Amphenol connector.

## XIII-4. MOUNTING THE UNIT

- Remove the housing.
- Remove the screening plate of the Digital output (Fig. 15).
- Place the unit in the clamps.
- Mount the connector with the two screws and nuts of the screening at the rear of the instrument (Fig. 15).
- Mount the plug-in unit again in the cabinet.

## XIII-5. LIST OF PARTS OF THE PM 9231

| Item | Ordering number | Description | | | Manufacturer |
|---|---|---|---|---|---|
| R301 up to R327 | 5322 116 50608 | 6.19 kΩ | 1% | | MR25 |
| C301 | 5322 124 20373 | 10 V | | 47 µF | Electrolytic |
| C302 | 4822 124 20368 | 16 V | | 33 µF | Electrolytic |
| C303 | 5322 122 30125 | 10 V | 10% | 180 pF | Ceramic |
| GR301 | 5322 130 30613 | BAW62 | | | |
| GR302 | 5322 130 30613 | BAW62 | | | |
| GR303 | 5322 130 30613 | BAW62 | | | |
| GR304 | 5322 130 30613 | BAW62 | | | |
| GR305 | 5322 130 30613 | BAW62 | | | |
| IC301 | 5322 209 84036 | SN7417N-00 | | | |
| IC302 | 5322 209 84402 | FJH321/7405-51 | | | FAIRCHILD |
| IC303 | 5322 209 84172 | U6A993559X | | | |
| IC304 | 5322 209 84173 | FJH301/7426N | | | |
| IC305 | 5322 209 84036 | SN7417N-00 | | | |
| IC306 | 5322 209 84036 | SN7417N-00 | | | |
| BU301 | 5322 267 70015 | 50-pole Amphenol connector | | | AMPHENOL 57-40500 |

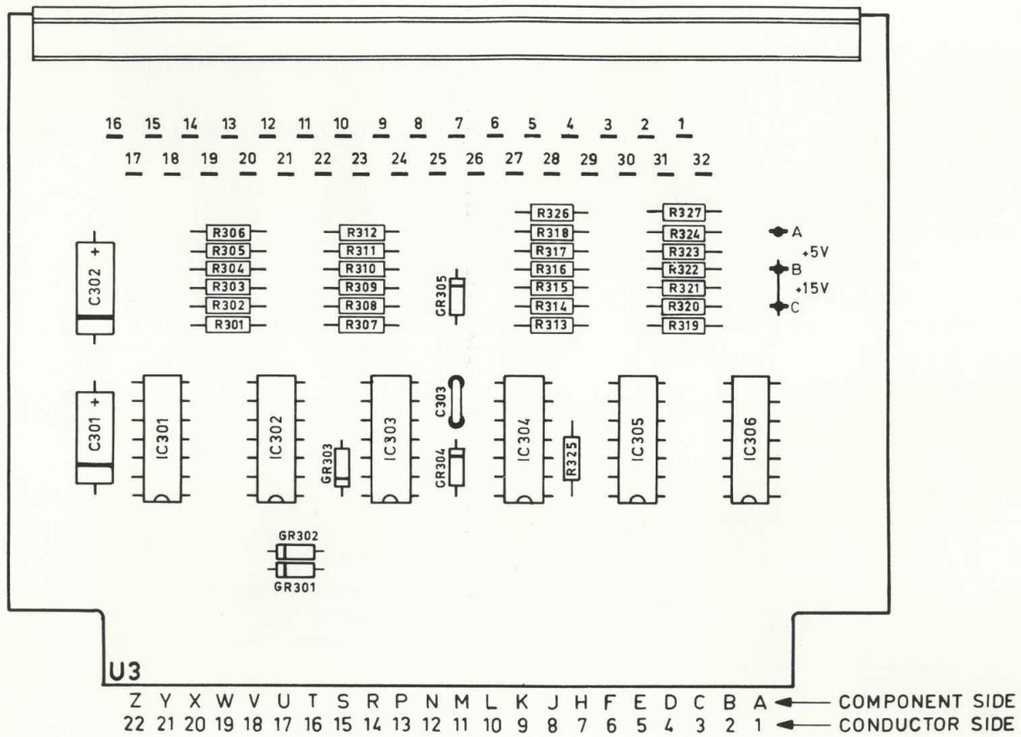
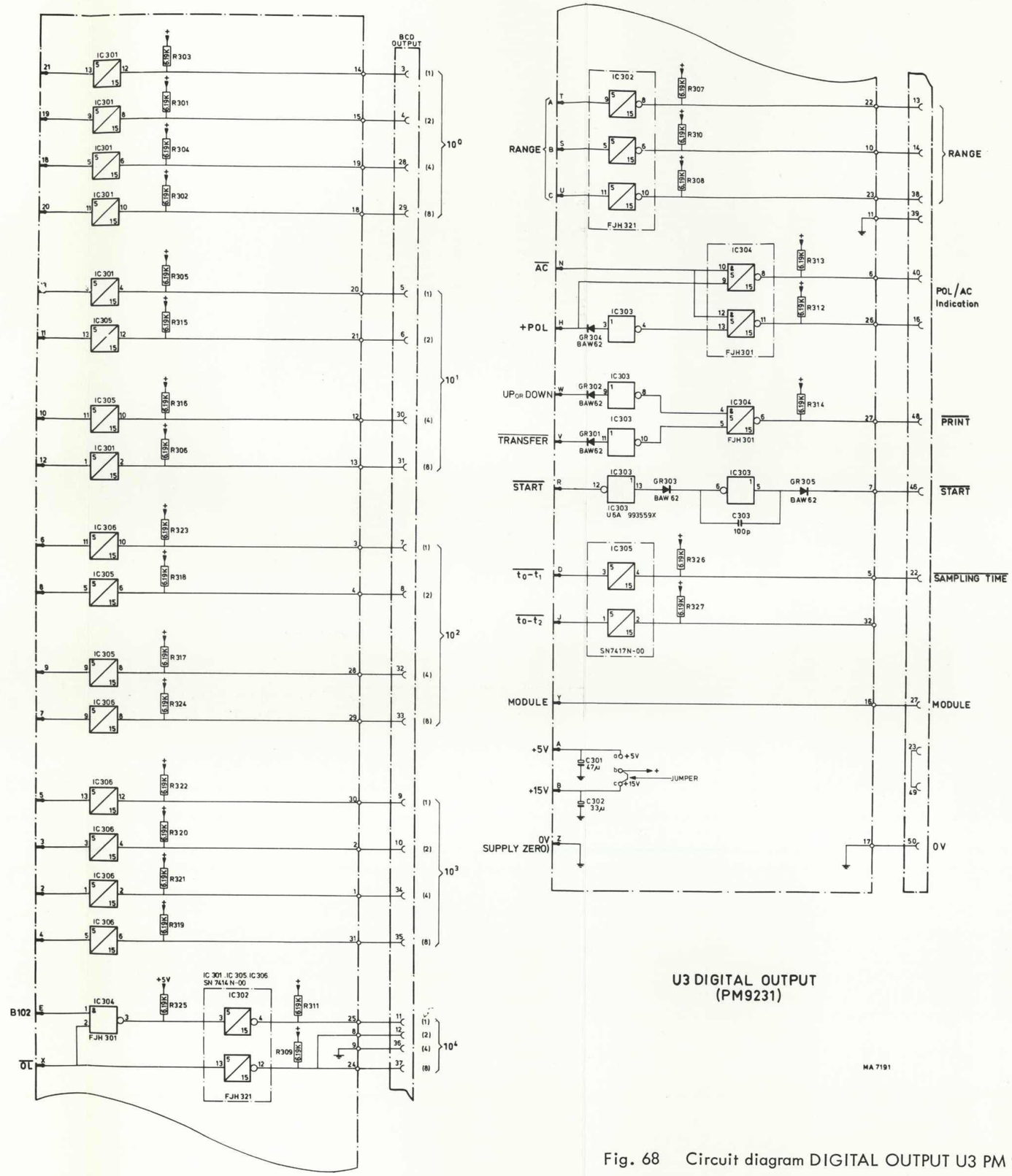



Fig. 67 Printed wiring board U3




U3 DIGITAL OUTPUT (PM9231)

Fig. 68 Circuit diagram DIGITAL OUTPUT U3 PM 9231

# QUALITY REPORTING

## CODING SYSTEM FOR FAILURE DESCRIPTION

The following information is meant for Philips service workshops only and serves as a guide for exact reporting of service repairs and maintenance routines on the workshop charts.
For full details reference is made to Information G1 (Introduction) and Information Cd 689 (Specific information for Test and Measuring Instruments).

### LOCATION

□□□□

Unit number
e.g. 000A or 0001 (for unit A or 1; not 00UA or 00U1)

or: Type number of an accessory (only if delivered with the equipment)
e.g. 9051 or 9532 (for PM 9051 or PM 9532)

or: Unknown/Not applicable
0000

### CATEGORY

□

0 Unknown, not applicable (fault not present, intermittent or disappeared)
1 Software error
2 Readjustment
3 Electrical repair (wiring, solder joint, etc.)
4 Mechanical repair (polishing, filing, remachining, etc.)
5 Replacement
6 Cleaning and/or lubrication
7 Operator error
8 Missing items (on pre-sale test)
9 Environmental requirements are not met

### COMPONENT/SEQUENCE NUMBER

□□□□□

Enter the identification as used in the circuit diagram, e.g.:

| | |
|---|---|
| GR1003 | Diode GR1003 |
| TS0023 | Transistor TS23 |
| IC0101 | Integrated circuit IC101 |
| R0.... | Resistor, potentiometer |
| C0.... | Capacitor, variable capacitor |
| B0.... | Tube, valve |
| LA.... | Lamp |
| VL... | Fuse |
| SK.... | Switch |
| BU.... | Connector, socket, terminal |
| T0.... | Transformer |
| L0.... | Coil |
| X0.... | Crystal |
| CB.... | Circuit block |
| RE.... | Relay |
| ME.... | Meter, indicator |
| BA.... | Battery |
| TR.... | Chopper |

Parts not identified in the circuit diagram:

| | |
|---|---|
| 990000 | Unknown/Not applicable |
| 990001 | Cabinet or rack (text plate, emblem, grip, rail, graticule, etc.) |
| 990002 | Knob (incl. dial knob, cap, etc.) |
| 990003 | Probe (only if attached to instrument) |
| 990004 | Leads and associated plugs |
| 990005 | Holder (valve, transistor, fuse, board, etc.) |
| 990006 | Complete unit (p.w. board, h.t. unit, etc.) |
| 990007 | Accessory (only those without type number) |
| 990008 | Documentation (manual, supplement, etc.) |
| 990009 | Foreign object |
| 990099 | Miscellaneous |

# Sales and service all over the world

**Alger**: Sadetel; 41 Rue des Frères Mouloud Alger; tel. 656613–656607

**Argentina**: Philips Argentina S.A., Cassila Correo 3479, Buenos Aires; tel. T.E. 70, 7741 al 7749

**Australia**: Philips Electrical Pty Ltd., Philips House, 69-79 Clarence Street, Box 2703 G.P.O., Sydney; tel. 2.0223

**België/Belgique**: M.B.L.E. Philips Bedrijfsapparatuur, 80 Rue des Deux Gares, Bruxelles; tel. 02/13.76.00

**Bolivia**: Industrias Bolivianas Philips S.A. LA Jón postal 2964 La Paz tel. 50029

**Brasil**: S.A. Philips Do Brasil; Avenida Paulista 2163; P.O. Box 8681; Sao Paulo S.P.; tel 81–2161.

**Burundi**: Philips S.A.R.L., Avenue de Grèce, B.P. 900, Bujumbura

**Canada**: Philips Electronic Industries Ltd., Scientific and Electronic Equipment Division, Philips House, 116 Vanderhoof Avenue, Toronto 17 M 4G 2JI. tel. (416)-425-5161.

**Chile**: Philips Chiléna S.A., Casilla 2687, Santiago de Chile; tel. 94001

**Colombia**: Industrias Philips de Colombia S.A., Calle 13 no. 51-03, Apartado Nacional 1505, Bogota; tel. 473640

**Costa Rica**: Philips de Costa Rica Ltd., Apartado Postal 4325, San José; tel. 210111

**Danmark**: Philips Elektronik Systemer A/S Afd. Industri & Forskning; Strandlodsvej 4 2300-København S; Tel (0127) AS 2222; telex 27045

**Deutschland** (Bundesrepublik): Philips Elektronik Industrie GmbH, 2000 Hamburg 73, Meiendorferstraße 205; Postfach 730 370; tel. 6797-1

**Ecuador**: Philips Ecuador S.A., Casilla 343, Quito; tel. 239080

**Egypt**: Ph. Scientific Bureau 5 Sherif Str. Cairo – A.R. Egypt P.O. Box 1807; tel. 78457-57739

**Eire**: Philips Electrical (Ireland) Ltd., Newstead, Clonskeagh, Dublin 14; tel. 976611

**El Salvador**: Philips de El Salvador, Apartado Postal 865, San Salvador; tel. 217441

**España**: Philips Ibérica S.A.E., Avenida de America, Apartado 2065, Madrid 17; tel 2462200

**Ethiopia**: Philips Ethiopia (Priv. Ltd. Co.), P.O.B. 2565; Cunningham Street, Addis Abeba; tel. 48300

**Finland**: Oy Philips Ab, Postboks 10255, Helsinki 10; tel. 10915

**France**: Philips Industrie, Division de la S.A. Philips Industrielle et Commerciale 105 Rue de Paris, 93 002 Bobigny; tel. 830-11-11

**Ghana**: Philips (Ghana) Ltd., P.O.B. M 14, Accra; tel. 66019

**Great Britain**: Pye Unicam Ltd., York Street, Cambridge; tel. (0223) 58866

**Guatemala**: Philips de Guatemala S.A., Apartado Postal 238, Guatemala City; tel. 64857

**Hellas**: Philips S.A. Hellénique, 54, Ave Syngrou, Athens; tel 230476, P.O. Box 153

**Honduras**: Hasbun de Honduras Apartado Postal 83, Tegucigalpa; tel. 2-9121...5

**Hong kong**: Philips Hong Kong Ltd., P.O.B. 2108, St. George's Building, 21st floor, Hong Kong; tel. 5-249246

**India**: Philips India Ltd., Shivsagar Estate, Block "A", Dr. Annie Besant Road, P.O.B. 6598, Worli, Bombay 18; tel. 370071

**Indonesia**: P. T. Philips Development Corporation, Jalan Proklamasi 33, P.O.B. 2287, Jakarta; tel. 51985-51986

**Iran**: Philips Iran Ltd., P.O.B. 1297, Teheran; tel. 662281

**Iraq**: Philips Iraq W.L.L. Munir Abbas Building 4th Floor; South Gate. P.O. box 5749 Baghdad; tel. 80409

**Island**: Heimilistaeki SF, Saetún 8, Reykjavik; tel. 24000

**Islas Canarias**: Philips Ibérica S.A.E., Triana 132, Las Palmas; Casilla 39-41, Santa Cruz de Tenerife

**Italia**: Philips S.p.A., Sezione PIT; Viale Elvezia 2, 20052 Monza; tel. (039) 361-441; telex 35290

**Kenya**: Philips (Kenya) Ltd., P.O.B. 30554, Nairobi; tel. 29981

**Malaysia**: Philips Malaya Sdn Bhd. P.O. Box 332, Kuala Lumpur;/Selangor W. Malaysia; tel. 774411

**Mexico**: Philips Comercial S.A. de C.V., Uruapan 7, Apdo 24-328, Mexico 7 D.F.; tel. 25-15-40

**Nederland**: Philips Nederland B.V., Boschdijk, Gebouw VB, Eindhoven; tel. 793333

**Ned. Antillen**: N.V. Philips Antillana, Postbus 523, Willemstad; tel. Curaçao 36222-35464

**New Zealand**: Philips Electronical Industries (N.Z.) Ltd., Professional and Industrial Division, 70-72 Kingsford Smith Street, P.O.B. 2097, Lyall Bay, Wellington; tel. 73-156

**Nigeria**: Philips (Nigeria) Ltd., 6 Ijora Causeway, P.O.B. 1921, Lagos; tel. 45414/7

**Nippon**: Nihon Philips Corporation, P.O.B. 13, World Trade Center, 32nd Floor, Tokyo 105; tel. (03) 435-5211

**Norge**: Norsk A.S. Philips, Postboks 5040, Oslo; tel. 463890

**Österreich**: Oesterreichische Philips Industrie GmbH, Abteilung Industrie Elektronik, Triesterstrasse 64, A-1101 Wien; tel. (0222) 645511/31

**Pakistan**: Philips Electrical Co. of Pakistan Ltd., El-Markaz, M.A. Jinnah Road, P.O.B. 7101, Karachi; tel. 70071

**Paraguay**: Philips del Paraguay S.A., Casilla de Correo 605, Asuncion, tel. 8045-5536-6666

**Perú**: Philips Peruana S.A., Apartado Postal 1841, Lima; tel. 326070

**Philippines**: Philips Industrial Development Inc., 2246 Pasong Tamo P.O.B. 911, Makati Rizal D-708; tel. 889453 to 889456

**Portugal**: Philips Portuguesa S.A.R.L., Av. Eng.° Duarte Pacheco, 6 – Lisboa – 1

**Rwanda**: Philips Rwanda S.A.R.L., B.P. 449, Kigali

**Saoudi Arabia**: A. Rajab and A. Silsilah P.O. box 203 Jeddah - Saudi Arabia; tel. 5113-5114

**Schweiz-Suisse-Svizzera**: Philips A.G., Binzstrasse 15, Postfach 8027, Zürich; tel. 051-442211

**Singapore**: Philips Singapore Private Ltd. P.O. Box 340; Toa Payoh Central Post Office; Singapore 12; tel. 538811

**South Africa**: South African Philips (Pty) Ltd., P.O.B. 7703, 2, Herb Street, New Doornfontein, Johannesburg; tel. 24-0531

**Sverige**: Svenska A.B. Philips, Fack, Lidingövägen 50, Stockholm 27; tel. 08/635000

**Syria**: Philips Moyen-Orient S.A. Rue Fardoss 79 Immeuble Kassas and Sadate B.P. 2442 Damas; tel. 18605-21650

**Taiwan**: Yung Kang Trading Co. Ltd., San Min Building, Gnd Floor, 57-1 Chung Shan N Road, 2 Section, P.O.B. 1467, Taipei; tel. 577281

**Tanzania**: Philips (Tanzania) Ltd., Box 20104, Dar es Salaam; tel. 29571

**Thailand**: Philips Thailand Ltd., 283, Silom Road, Bangkok; tel. 36980, 36984-9

**Turkey**: Türk Philips Ticaret A.S., Posta Kutusu 504, Beyoglu; Gümüssüyü Caddesl 78/80 Istanbul 1 Turkye

**Uganda**: Philips Uganda Ltd. p.o. Box 5300 Kampala; tel. 59039

**Uruguay**: Industrias Philips del Uruguay, Avda Uruguay 1287, Montevideo; tel 915641 Casilla de Correo 294

**U.S.A.**: Philips Test and Measuring Instruments Inc.; 400 Crossways Park Drive, Woodbury, N.Y. 11797; tel. (516) 921-8880

**Venezuela**: C.A. Philips Venezolana, Apartado Postal 1167, Caracas; tel. 360511

**Zaire**: Philips S.Z.R.L., B.P. 1798, Kinshasa; tel. 31887-31888-31693

**Zambia**: Philips Electrical Ltd., Professional Equipment Division, P.O.B. 553, Kitwe; tel. 2526/7/8; Lusaka P.O. Box 1878



750101

**For information on change of address:**
N.V. Philips
Test and Measuring Instruments Dept.
Eindhoven - The Netherlands

**For countries not listed:**
N.V. Philips PIT Export Dept.
Test and Measuring Instruments Dept.
Eindhoven - The Netherlands