Black Star

4503 INTELLIGENT MULTIMETER
40999 COUNT

SERVICE MANUAL

Designed and manufactured in the U.K. by:

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WARNING

THE 4503 IS A MAINS POWERED INSTRUMENT. THE FOLLOWING SERVICING AND CALIBRATION INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY DO NOT PERFORM ANY SERVICING UNLESS YOU ARE QUALIFIED TO DO SO.

SPECIFICATION

DC VOLTAGE

Range	Resolution	Accuracy
.4V	10uV	±0.03% rdg ±0.01% fs
4V	100uV	±0.03% rdg ±0.01% fs
40V	1mV	±0.03% rdg ±0.01% fs
400V	10mV	±0.03% rdg ±0.01% fs
1000V	100mV	±0.05% rdg ±0.01% fs

Maximum permissible input voltage: 1000V DC (.4V range 1000V DC 5 sec.)
Input impedance: 10MΩ ±0.25%
Normal mode rejection ratio: 60dB @ 50Hz
Common mode rejection ratio: 100dB @ 50Hz with 1kΩ imbalance

DC CURRENT

Range	Resolution	Accuracy	Voltage Burden	Max. Input
4mA	100nA	±0.1% rdg ±0.02% fs	10uV/count	0.5A (fused)
400mA	10uA	±0.15% rdg ±0.02%fs	10uV/count	0.5A (fused)
10A	1mA	±1% rdg ±0.02% fs	<15uV/count	20A (10 sec.)

AC VOLTAGE TRUE RMS

Range	Resolution	Accuracy (>10% fs)		
		45Hz-400Hz	400Hz-5kHz	5kHz-20kHz
.4V	10uV	±0.5% rdg ±0.1% fs	±1% rdg ±0.1% fs	±3% rdg ±0.1% fs
4V	100uV	±0.5% rdg ±0.1% fs	±1% rdg ±0.1% fs	±5% rdg ±0.1% fs
40V	1mV	±0.5% rdg ±0.1% fs	±2% rdg ±0.1% fs	±5% rdg ±0.1% fs
400V	10mV	±0.5% rdg ±0.1% fs	±2% rdg ±0.1% fs	±5% rdg ±0.1% fs
750V	100mV	±1% rdg ±0.1% fs	±7% rdg ±0.1% fs	±15% rdg ±0.1% fs

Accuracy for .4V range at low levels:

Level	Max. Frequency for < 1% Error	Max. Frequency for <10% Error
10mV	6kHz	15kHz
3mV	1kHz	8kHz

Maximum permissible input voltage: 750V AC (.4V range 1000V pk 10 sec.), 10^6VxHz
Common mode rejection ratio: 40 dB @ 50Hz with 1kΩ imbalance
Crest Factor: < 5 @ fs for <3% increase in error

AC CURRENT TRUE RMS

Range	Resolution	Accuracy 45Hz-1kHz	Voltage Burden	Max. Input
4mA	100nA	±0.5% rdg ± 0.1% fs	10uV/count	0.5A (fused)
400mA	10uA	±0.5% rdg ± 0.1% fs	10uV/count	0.5A (fused)
10A	1mA	±1.5% rdg ± 0.1% fs	<15uV/count	20A (10 sec.)

Crest Factor: < 2 @ fs for <2% increase in error

RESISTANCE

Range	Resolution	Accuracy	Excitation Current
.4kΩ	10mΩ	±0.1% rdg ±0.02% fs	0.5mA
4kΩ	100mΩ	±0.1% rdg ±0.02% fs	0.1mA
40kΩ	1Ω	±0.1% rdg ±0.02% fs	10uA
400kΩ	10Ω	±0.15% rdg ±0.02% fs	1uA
4000kΩ	100Ω	±0.3% rdg ±0.03% fs	100nA
40MΩ	1kΩ	±1% rdg ±0.04% fs	100nA

Maximum permissible input voltage: 370V pk
Full scale voltage: 40MΩ 1V; all other ranges 400mV

AUTORANGING CAPABILITY

Autoranging on all voltage and resistance ranges and 4mA/400mA (AC and DC) current ranges.

OTHER FEATURES

NULL	Removes residual offset on DC voltage and resistance ranges
HOLD	Display hold
CONTINUITY	Audible continuity test
DIODE TEST	Diode forward voltage measured with excitation current 1mA, 1Vfs
FILTER	Averaging noise reduction filter
dB	Calculation error ±0.02dB. User selectable reference impedance
DATA LOGGER	250 reading logger. User settable sample interval
% DEVIATION	Deviation in % from user selected nominal reference value
Ax+b	Scale and offset measurement. User selected scale factor and offset
REL	Allows user to make relative measurements

CALIBRATION

Closed case, fully automatic, via IEEE-488 or RS232 (except AC frequency response).

INTERFACING

Full IEEE-488/GP-IB talker/listener. Also RS232. Interfaces built-in.

IEEE-488/GP-IB SUBSET IMPLEMENTION

SH1	Source handshake — complete capability
AH1	Acceptor handshake — complete capability
T5	Basic talker + serial poll + talk only mode + unaddress if MLA
TE0	Extended talker — no capability
L4	Basic listener + unaddress if MTA
LE0	Extended listener — no capability
SR1	Service request — complete capability
RL1	Remote/local — complete capability
PP2	Parallel poll — remote configuration
DC1	Device clear — complete capability
DT0	Device trigger — no capability
C0	Not a controller

CONTROLLABLE FUNCTIONS

All ranges and functions (except 10A AC and DC) are settable and controllable via the built-in IEEE-488/GP-IB and RS232 interfaces. The string terminator may be selected, and the conditions under which an IEEE-488/GP-IB service request is initiated. Serial and parallel polling are supported. Instrument status, error messages and readings may be requested.

GENERAL

The accuracy specifications apply over a temperature of 18°C to 22°C typically for 1 year.
Accuracy Temperature Coefficient: Typically <0.1 x applicable accuracy spec. per °C (10°C to 18°C, 22°C to 35°C)
Maximum Common Mode Input Voltage: 500V DC or peak AC.
Mains Input Voltage: 220/240V ±10%
Display: 13mm LED, 6 digit
Scale length: 4¾ digit, 40999 counts max. Polarity: Automatic
Reading Rate: 3 per sec. Zero: automatic
Operating Temperature Range: 5°C to 40°C, 10% to 80% RH.
Supplied Accessories: Built-in IEEE-488/GP-IB and RS232 Interfaces, Instruction Manual, Spare Fuse, Test Lead Set, Mains Lead, Demonstration Software
Optional Accessories: Service Manual, Carry Case
Size: 219mm x 240mm x 98mm (product only) Weight: 1.6kg (product only) 2.2kg (packed)
310mm x 330mm x 135mm (packed)

THIS SERVICE MANUAL IS FOR USE WITH THE LATEST VERSION OF THE 4503 WHICH HAS A MAXIMUM COUNT OF 40,999. A SEPARATE SERVICE MANUAL IS AVAILABLE FOR EARLIER VERSIONS WITH A 20,999 COUNT.

INTRODUCTION

The Black Star 4503 Intelligent Multimeter is a microprocessor based instrument of high complexity, and servicing should only be undertaken by competent qualified service personnel with access to appropriate test equipment.

DISMANTLING THE INSTRUMENT

WARNING!

High voltages are present inside this instrument. Disconnect all voltage sources before opening the case. If adjustments are required with the power or external voltages connected to the instrument, these should only be carried out by suitably qualified persons who are aware of the hazards.

1. Invert the instrument and remove the metal leg by firmly pushing inwards on one side.
2. Remove the 4 screws recessed in the feet.
3. Place the instrument the correct way up.
4. Carefully remove the top case half.
5. If only calibration is required then further dismantling is unnecessary.
6. If component replacement is necessary then proceed as follows:
7. Remove the 2 side expansion pieces.
8. Remove the 2 M3 nuts and shake-proof washers securing the upper screen.
9. Remove the 2 hexagonal metal pillars.
10. Remove the 5 M3 nuts securing the main P.C.B. to the lower screen, 2 of these also fix the IEEE 488 socket to the P.C.B.
11. Remove the ribbon cable assembly from the socket on the main p.c.b. taking care not to damage the pins on the connector.
12. The front panel assembly, rear panel assembly and the main p.c.b. may now be carefully lifted from the case and separated from the lower screen.

RE-ASSEMBLY

To re-assemble the 4503 follow the above procedure in reverse order.

CIRCUIT DESCRIPTION

DIGITAL SECTION

The operation of the instrument is controlled by IC100 — the 6303X microprocessor, and its associated components. The control program is held in the 32K EPROM U101, and the RAM U102 provides working memory, and holds the calibration constants. Ten individually check-summed copies of the calibration constants are stored in the calibration memory, so that if one or more copies are corrupted (causing the message 'CALERR' to appear on the display at power-up), the instrument can correct itself using the remaining good copies (see later for more information).

Memory decoding

U103, U104 and U105 provide the memory decoding with the following address ranges:

$8000 — $FFFF EPROM (control program) memory.
$7000 — $7FFF Write-protected (calibration) RAM.
$6000 — $6FFF Non-write protected (normal) RAM.
$4000 MC68488 GPIA control IC.

U104 and U105 also provide the following functions:

1. Generation of power-up reset pulse (U104-D).
2. Signal conditioning of received end-of-conversation pulse (U105-D, U105-E).
3. Control of memory write-protection.

RS232 interface

The RS232 interface uses the 6303X internal asynchronous communications facilities and runs at a fixed 9600 baud. Hardware hand-shaking is provided via U108-B (RTS) and Q114 (CTS). The data out is supplied by U108-A and data is received via Q113.

GPIB interface

The GPIB interface uses the MC68488 GPIA (U114) and its associated buffers to handle GPIB communications. The bus buffers comprise U115, U116, U117, U118 and U109. The GPIB lines are all buffered except for ATN, REN, IFC (these lines are input only).

Power supply, power-up reset and memory back-up

The +5V dig supply is stabilised by regulator U113 (LM7805). The power-up reset circuit guarantees that on power-up the processor reset line is held low for approximately 300ms, i.e. until the power supply voltages have stabilised. When power is applied C112 is discharged, holding the U104-D output and the processor reset line low. Q104 charges the memory back-up battery via R118, and ensures that the battery will not discharge when power is removed. D104 supplies the back-up power to the RAM. When the power rails have stabilised, D105 (5V1 zener) holds Q102 emitter at approximately 0V, i.e. Q102 is turned off. If power is removed the +5V rail starts to fall, causing Q102 emitter to go negative, turning Q102 on, discharging C112 and pulling the reset line low. The reset line goes low when the +5V rail falls to approximately 4.5V. D104 ensures that C111 charges quickly when the power is applied.

Q103 supplies the chip-select signal to the RAM and ensures that when the power is removed the chip-select line goes up to the back-up battery voltage and prevents the battery from discharging into U104-C.

The two sections of the circuitry are separated by the isolation barrier. The power supplies are isolated via the transformer and the signals via the opto-isolators.

CIRCUIT DESCRIPTION

ANALOG SECTION

The analog section of the instrument may be considered to include all the circuitry on the analog side of the isolation barrier and contains both analog and digital circuitry. The interface to the microprocessor is accomplished by the four opto-isolators U109, U110, U111 and U112.

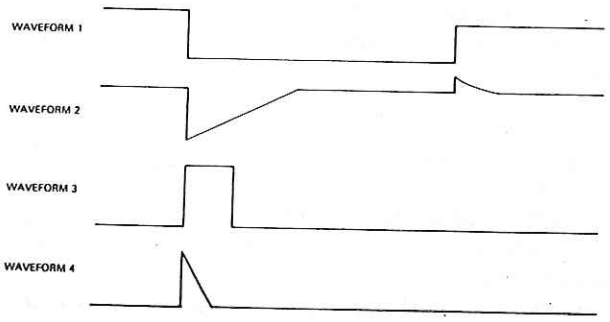
The microprocessor communicates with the A/D converter serially; the serial interface also generates the relay drive signals, and the diode test voltage source. The A/D converter is a Maxim MAX134 (U4), and contains five internal read/write registers. These are accessed by read, write, data and address signals. The read, write and address signals are generated by U2 (these are uni-directional signals), and the bi-directional data signals are read/written by the shift register (U6). The shift registers are connected in series, so that data is shifted into U2 (8 bits) and then from U2 to U6 (4 bits). In order to read from and write to the MAX134 it is necessary to write 12 bits (8 to U2, 4 to U6) twice (24 bits in total) as follows:

To write to the MAX134 register 0, send 4 data bits (which will end up in U6), set the write line low (U2 bit 3), and set the address (MAX134 pins 3, 4 and 5) to 0. When the MAX134 has accepted the data, set the write line high again by writing 12 more bits to the shift registers. The integrator R12 and C15 is provided to delay the write pulse in order to allow some data and address set-up time. Although the data appears in good time, the address appears simultaneously with the write pulse. Note that the data appears before the address and write pulse because the U2 outputs are prevented from changing by the time constant provided by R38 and C34 (in conjunction with D8) — this hold-off prevents spurious outputs from appearing at U2 outputs while data is being clocked through. The clock line is normally high allowing the outputs of U2 to be updated.

Since the shift registers are updated relatively infrequently, the average dc level at the clock and data

inputs can be relied upon, so the data line is used (via R5, C11 and U3-A) to drive relay RL1.

To read the ADC register 2, set the ADC address to 2, set the read line low, send 4 bits of dummy data (which will not be used). Refer to diagram below when reading this description of the wave-forms. When the read ADC read line goes low (wave-form 1), the negative going pulse at U4 pin 40 is differentiated by C14 and R11 (wave-form 2). This pulse is inverted and squared by U5-A (wave-form 3), and applied to the OE input (pin 1) in order to turn off the outputs and allow the ADC data output lines (U4 pins 39, 38, 37 and 36) to drive U6 data input pins (3, 4, 5 and 6) via resistors R21, R22, R23 and R24. In order to load the CD40104 a clock pulse is needed and this is provided by differentiating the positive pulse (wave-form 3) to produce the wave-form shown (wave-form 4). This wave-form is applied to U5-B (pin 5) and is inverted on to U6 clock input. U6 responds to a positive-going clock pulse, so the data which is now available at U6 data inputs is clocked into U6 approximately 30us after the leading edge of the read pulse. Once U6 has been loaded 12 more bits are sent to the shift registers to clear the read pulse and to clock the data from U6 back into the microprocessor via opto-isolators U110 and U100 input port P22.



Relay drive

The relays are driven by non-inverting op-amps (U3-A, U3-B and U3-C) which are powered from ANV++ and ANV−− to ensure an adequate drive voltage. AC coupling is used so that the drive voltage to the relays will be (ANV++ + ANV−−).

Analog signal switching

Voltage ranges:

Range switching on DC and AC volts is performed within the MAX134. On the 400mV range the input is taken from R27 and R42 with C36 by-passing the high value resistors and R41 preventing excessive current pulses when high voltages are applied. RL2 is in the off position connecting U4 pin 27 (400mV input) to the signal. Q3 provides over-voltage protection.

On all other ranges RL2 is in the on position connecting the 400mV input to analog ground. The input signal is then applied via R39 and the precision attenuator network RP1. R39 in conjunction with varistors V1, V2 and V3 limits the maximum input over-voltage to approximately 1250 volts, above this voltage the varistors develop a low resistance characteristic and hold the input down. AC compensation is provided by C19, VC1 (for the 400V range), VC2 (4V range), C20, C21 and VC3 (40V range), C22 (400V range) and C23, C24, C37 (4000V range 750V rms max). On DC and AC voltage ranges RL1 is on connecting the bottom of the attenuator to analog ground.

Resistance ranges

On Ohms RL2 is off and RL1 is on. The Ohms reference voltage (U4 pin 32) is applied to the relevant reference resistor by switches inside the MAX134. The reference current then flows through R39 into the V/Ohms socket and into the resistance being measured. The voltage across the test resistance is monitored via R27 and R42 in the same way as the 400mV ranges. The reference resistors used on the various ranges are as follows:

400Ω	1K
4KΩ	10K
40KΩ	100K
400KΩ	1000K
4000KΩ	10M
40MΩ	10M

Current ranges

Only three current ranges are provided — 4mA, 400mA and 10A. The currents are measured by measuring the voltage generated across R18 (2mA), R19 (400mA) and R20 (10A). Switching between the 4mA and 400mA ranges is accomplished by RL3. The current shunts are connected in series and the resulting voltage is measured at U4 pin 33. Diodes D2, D3, D9, D10 and D11 provide over-current protection to a maximum of 1A continuous (at which current the 0.5A fuse FS1 will fail).

AC voltage and current

The TRUE-RMS converter U1 is an AD737 type integrated circuit, and computes the RMS value of the input wave-form. Capacitor C1 causes the conversion to be AC-coupled, i.e. the DC component of the RMS value is ignored. If C1 is shorted out the conversion becomes DC coupled, i.e. the DC component of the signal is included in the measurement, but the accuracy and linearity of the converter are impaired. The switching in and out of the RMS converter is done inside the MAX134 and is controlled by the setting in the MAX134 control registers.

CALIBRATION PROCEDURE

General

The instrument should be calibrated following a warm-up period of at least 30 minutes in an ambient termperature of 18°C to 22°C. If the AC compensation is to be adjusted this must be done with the case open, once this is completed the instrument must be re-cased and allowed to stabilise for 30 minutes before further calibration is attempted.

Equipment requirements

1. In order to perform closed case calibration you will need either a GPIB computer or RS232 equipped computer operating at 9600 baud.

2. Calibration sources of accuracy at least 5 times better than the instrument specification.

Procedure

If the AC compensation requires adjustment, dismantle the instrument, being careful not to disturb the screens or the input wiring, and ensure that the main p.c.b. position is not changed relative to the lower screen (this would adversely affect the high frequency accuracy).

The following assumes that the instrument is correctly calibrated at 50Hz. If it is not then the calibration figures at 50Hz should be noted for each range, and these figures used instead of those given below; e.g. if you apply 1V at 50Hz on the 4V range and the reading is 1.0200V then when you apply 1V at 10kHz adjust for a reading of 1.0200V not 1.0000V.

To adjust the high frequency response proceed as follows:

Select the 400V AC range, apply 100V 10KHz and adjust VC1 using an insulated trimming tool until the display reads 100.00 ± 1%.

(a) Select the 4000V AC range, apply 750V 400Hz and check that the reading is between 742.5 and 757.5, if it is not then adjust the values of the select-on-test capacitors C24 and/or C37. Disconnect the input signal.

(b) Select the 4V AC range, apply 1V 10KHz and adjust VC2 for a reading of 1.0000 ± 1%.

(c) Select the 40V AC range, apply 10V 10KHz and adjust VC3 for a reading of 10.000 ± 1%.

Re-case the multimeter and leave for 30 minutes before performing further calibration.

Closed case calibration

The instrument may be calibrated either completely or on individual ranges only. Calibration may be carried via the front panel controls, the GPIB or the RS232 computer interfaces. To enable calibration and allow writing to the calibration memory, a shorted 3.5mm jack plug must be inserted into the rear panel calibration socket. When the plug is inserted the front panel CAL lamp will flash. When the plug is in position the power must NOT be removed otherwise the calibration memory may be corrupted. If the CAL function is selected the lamp will stop flashing and remain on, the calibration function is then enabled. To disable the calibration function (and before removing the power), remove the jack plug, the CAL lamp will then go out and normal operation will resume.

The ranges are then calibrated by applying two input levels on each range, one close to full scale and one at or close to zero.

Front panel calibration

With the CAL lamp flashing, press the SHIFT key, causing the SHIFT lamp to flash, then press the CAL key (the 4000 range key), the CAL lamp will light continuously and the message 'CAL' will appear on the display.

To calibrate the 4VDC range, for example, proceed as follows:

1. Select the 4VDC range.

2. Apply a precisely known reference voltage e.g. 4.0000V.

3. Press the SHIFT key followed by the RECALL key. The current measurement value will be displayed with the first digit flashing. The value displayed may now be edited to agree with the reference voltage, e.g. 4.0000V. Once you have entered the correct reading press the ENTER key; the instrument will measure the reference voltage and when completed it will display the message 'DONE'.

4. Short the inputs together.

5. Press the SHIFT then RECALL keys.

6. Edit the display using the numeric keys and if necessary the ± key until the display reads 0.0000, then press the ENTER key. The instrument will measure the input voltage and when complete will display 'DONE' followed by either 'GOOD' or 'BAD'. At this point the instrument calculates its calibration constants and stores them in the calibration memory. If the calculated constants are within limits the 'GOOD' message is displayed, otherwise the 'BAD' message is displayed. If the 'BAD' message is displayed you may have made an error, either entered an incorrect value or applied the wrong voltage, so repeat the high and low calibration points.

The above procedure should be repeated for each range that you wish to calibrate.

NOTE!

If you wish to calibrate the high AC and DC voltage ranges ensure that these ranges are done after the other voltage and resistance ranges. The multimeter main p.c.b. (in common with all multimeters) will suffer from a certain amount of dielectric absorption, this will cause an apparent leakage current to flow and small offsets to appear. The dielectric absorption effect will continue for a short time after the high voltage has been removed and the accuracy will be impaired, so it is important to perform all low voltage and resistance calibration before a high voltage is applied.

The current ranges should be calibrated after the voltage and resistance ranges. The 10A AC and DC ranges should be calibrated after the others in order to prevent problems caused by self-heating when 10A is flowing.

The preferred order of calibration is:

400Ω, 4KΩ, 40KΩ, 400KΩ, 4000KΩ, 40MΩ, .4V DC, 4V DC, 40V DC, 400V DC, .4V AC, 4V AC, 40V AC, 400V AC, 750V AC, 1000V DC, 4mA DC, 400mA DC, 4mA AC, 400mA AC, 10A AC, 10A DC.

On all functions the calibration high point should be close to full scale (subject to not exceeding the maximum input levels). On DCV, DCmA and Ohms a low point of 0 may be used, but on ACV and ACmA a low point of 10% of full-scale should be used, do NOT use zero. With zero input a small reading will be seen on the AC functions. This is normal and may be ignored.

RS232 CALIBRATION

General

The basic procedure is the same as front panel calibration, i.e. the calibration jack plug is inserted into the CAL socket causing the CAL lamp to flash. The command 'C1' is then sent, causing the CAL lamp to stay on continuously. Each range must then be calibrated at two points, the high point (close to full scale) and the low point (close to 0). The high and low calibration commands begin with the letters 'H' and 'L' respectively. To send a calibration high point of 4.000V send the command 'H4.0000' or 'H4'. To send a low point of 0V, send the command 'L0'. The instrument measures the input voltage each time and when it has finished the message 'DONE' appears on the display and the string 'DONE 〈term〉' is sent to the computer via the RS232 port. 〈term〉 is the currently selected terminator (〈CR〉, 〈LF〉, 〈CRLF〉 or none).

Example: to calibrate the 4V DC range do the following:

1. Send the command string 'F1R1' (select the 4V DC range).
2. Apply 4.0000V to the multimeter point.
3. Send the command 'H4'.
4. Wait until the message 'DONE' is returned.
5. Apply 0.0000V to the multimeter input.
6. Send the command 'L0'.
7. Wait until the messages 'DONE' followed by 'GOOD' or 'BAD' are returned. If the message 'GOOD' appears then calibration of this range is finished. If the message 'BAD' appears, a mistake has probably been made so repeat the high and low calibration steps.

GPIB CALIBRATION

General

The basic procedure is the same as RS232 calibration, i.e. the calibration jack plug is inserted, causing the 'CAL' lamp to flash. Then the command C1' is sent causing the 'CAL' lamp to come on continuously. The high and low commands begin with the letters 'H' and 'L' respectively. To send a calibration high point of 4.0000V send the command 'H4.0000' or 'H4'. To send a calibration low point of 0V send the command 'L0'. The instrument measures the input voltage each time and displays the message 'DONE', it then informs the controller by sending a service request if the service request is enabled. See the Operating Manual for more information on the SRQ function. Assuming that SRQ is enabled and that you send the high command before the low command, then after the high command the instrument measures the input and when it has finished (approximately 3 seconds) it will request service, and the SRQ response byte returned will be 42 HEX, i.e. calibration completed. After the low command it will measure the input then request service and return either 44 HEX (range calibration OK) or 48 HEX (calibration error constants out of range). If you do not use SRQ to detect completion you may instead read back a response string the same as RS232 except the response string is treated by the instrument as an error string and must therefore be read using the '!' command. For example, send the high or low cal value, e.g. 'H4.012' then wait 3 seconds, send the command '!' and the instrument will send back the command 'DONE' if the point was the first of the pair and if it was finished. If it was the second of the pair, 'DONE' is not returned (as it is with RS232) but either 'GOOD' or 'BAD'. If the cal point was not complete the message 'ERROR 00' will be returned.

Example: calibrate the 4V DC range using service request.

1. Send the command 'P15' (enable all service requests).
2. Send the command string 'F1R2' (select the 4V DC range).
3. Apply 4.0000V DC to the input.

PARTS LIST

FRONT PANEL P.C.B.

CIRCUIT POSITION	DESCRIPTION	PART No.
Resistors, fixed		
R1	CF W33 560R	18-017
R2	CF W33 560R	18-017
R3	CF W33 10K	18-029
R4	CF W33 10K	18-029
R5	CF W33 10K	18-029
R6	CF W33 10K	18-029
RP1	8 x 220R DIL Resistor pack	18-191
Capacitors		
C1	Electrolytic 100u 6V3	20-011
C2	Ceramic 100n 25V	20-020
C3	Ceramic 100n 25V	20-020
Semiconductors		
TR1	BC212A	22-001
TR2	BC212A	22-001
TR3	BC212A	22-001
D1-D6	1N4148	23-005
Integrated Circuits		
U1	74HC4094	24-103
U2	74HC4094	24-103
Connectors		
CON1	40-way IC skt (2)	14-013
CON2	24-way IC skt (2)	14-084
CON3	14-way Ribbon 'C' form	14-058
Switches		
SWB1	Function 1	16-025
SWB2	Function 3	16-025
SWB3	Function 2	16-026
SWB4	Range	16-027
Displays		
X1-X6	7-Seg LED 0.56"	26-002
LD1-LD21	LED Lamp	26-001
Miscellaneous		
PCB	Front Panel PCB	30-037
Integrated Circuits		
U1	AD737JN	24-113
U2	74HC4094	24-103

MAIN P.C.B.

CIRCUIT POSITION	DESCRIPTION	PART No.
U3	TL074	24-116
U4	MAX134	24-117
U5	CD4070	24-059
U6	CD40104	24-104
U8	AD589JH	24-114
U9	78L05	24-105
U10	79L05	24-037
U100	HD6303X	24-115
U101	27C256	24-106
U102	6264-LP15	24-088
U103	74HC00	24-007
U104	74HC32	24-093
U105	74HC04	24-016
U108	TL072	24-074
U109	4N36	24-107
U110	4N36	24-107
U111	4N36	24-107
U112	4N36	24-107
U113	7805	24-036
U114	MC68488	24-111
U115	7438	24-108
U116	7438	24-108
U117	7438	24-108
U118	74HCT14	24-109
U119	74HCT14	24-109
U120	74HCT125	24-110
Semiconductors		
D1	1N4148	23-005
D2	1N4001	23-003
D3	1N4001	23-003
D4	1N4001	23-003
D5	1N4001	23-003
D6	1N4001	23-003
D7	1N4001	23-003
D8	1N4148	23-005
D9	1N4001	23-003
D10	1N4001	23-003
D11	1N4001	23-003
D100	1N4001	23-003
D101	1N4001	23-003
D102	1N4001	23-003
D103	1N4001	23-003
D104	1N4148	23-005
D105	BZY88 C5V1	23-009

4. Send the command 'H4'.
5. Wait until the instrument requests service.
6. Check that the SRQ response byte is 42HEX.
7. Apply 0.0000V to the input.
8. Send the command 'L0'.
9. Wait until the instrument requests service.
10. Check that the SRQ response byte is 44 HEX. If it is not an error has occurred so take the appropriate action.

Example: calibrate the 4V DC range without using SRQ.

1. Send the command string 'F1R2' (select the 4V DC range).
2. Apply 4.0000V DC to the input.
3. Send the command 'H2'.
4. Wait approximately 3 seconds and then send the '!' command.
5. Request a string from the instrument, check that the message 'GOOD' is returned. If the message 'ERROR 00' is returned repeat from step 4.
6. Apply 0.0000V to the input.
7. Send the command 'L0'.
8. Wait for approximately 3 seconds and send the '!' command.
9. Request a string from the instrument, check that the message 'GOOD' is returned. If the message 'ERROR 00' is returned repeat from step 8.
10. If the message 'GOOD' appears calibration of this range is complete. If the message 'BAD' appears a mistake has probably occurred so repeat the high and low calibration steps.

The above procedures should be carried out for each range to be calibrated.

Correction of calibration constants

Under normal situations the calibration memory will not become corrupted. If, however, this happens, then as long as some of the calibration constants are still intact the instrument will correct itself. To correct the calibration memory proceed as follows:

You should have available a computer equipped with a 9600 baud serial interface. Connect the 4503 to the serial port of the computer. Run a terminal emulation program on the program, the terminal program BSTERM on the demonstration disk is ideal for this purpose. Ensure that the serial interface is operational, you will get only one chance to record the corrections. Start the 'LOG' file if you are using the BSTERM program (this will record the correction process to disk for later examination). Insert the calibration jack plug into the rear panel 'CAL' socket. The 4503 will display the message 'CALERR', then start with the 400mV range and work through all its ranges providing information in the following form:

range 00: 01 02 05
range 01:
range 02:
range 03:
range 04:
range 05: 04 06
...
...
...
range 23:

Where range 00 refers to the 400mV range, range 01 refers to the 4V range etc. and the numbers following the range refer to the corrupted copies of the calibration constants. In the example above on the 400mV range copies 1, 2 and 5 were corrupted, copies 0, 3, 4, 6, 7, 8 and 9 were correct. On range 05, the 4mA range, copies 4 and 6 were corrupted and the others were correct, and in all other ranges there was no corruption. In this case the instrument would correct itself. The 4503 will only fail to correct itself if all ten copies become corrupted on any one range. If all ten copies are corrupted the instrument is probably faulty and should be repaired and then re-calibrated. The ranges corresponding to the range numbers are:

range 00 — 04 : 400mV DC to 1000V DC
range 05 — 07 : 4mA DC, 400mA DC, 10A DC
range 08 — 13 : 400Ω to 40MΩ
range 14 : diode test
range 15 — 19 : 400mV AC to 750V AC
range 20 — 22 : 4mA AC, 400mA AC, 10A AC
range 23 : continuity test

When the instrument has finished it will show the total number of errors encountered. A significant loss of calibration constants will only normally occur if a fault develops in the RAM battery back-up system.

CIRCUIT POSITION	DESCRIPTION			PART No.
D106	1N4148			23-005
Q1	BC182			22-009
Q2	BC212A			22-001
Q3	BC212A			22-001
Q4	BC182			22-009
Q5	BC182			22-009
Q100	BC182			22-009
Q101	BC182			22-009
Q102	BC182			22-009
Q103	BC182			22-009
Q104	BC212A			22-001
Q113	BC182			22-009
Q114	BC182			22-009
Resistors, fixed				
R3	CF	W33	22R	18-074
R4	CF	W33	22R	18-074
R5	CF	W33	470K	18-109
R6	MF	W25	620K	18-180
R8	CF	W33	1M2	18-077
R9	CF	W33	1M2	18-077
R10	CF	W33	12K	18-085
R11	CF	W33	100K	18-037
R12	CF	W33	470K	18-109
R13	CF	W33	22R	18-074
R14	CF	W33	22R	18-074
R15	CF	W33	33K	18-084
R16	CF	W33	4K7	18-027
R17	CF	W33	4K7	18-027
R18	MF	W25	99R 0.1% 15ppm	18-181
R19	MF	W25	1R 25/50ppm	18-105
R20	WW	5W	R01	18-095
R21	CF	W33	10K	18-029
R22	CF	W33	10K	18-029
R23	CF	W33	10K	18-029
R24	CF	W33	10K	18-029
R25	CF	W33	3K3	18-063
R26	CF	W33	22K	18-030
R27	CF	W50	270K	18-184
R28	MF	W25	270K 5ppm	18-182
R28	MF	W25	120K 5ppm	18-213
R29	MF	W25	100K 5ppm	18-183
R30	CF	W33	1K8	18-023
R31	CF	W33	1K8	18-023
R32	CF	W33	6K8	18-076
R33	CF	W33	330R	18-015
R34	CF	W33	560R	18-017
R35	CF	W33	220R	18-013
R36	CF	W33	1K0	18-020
R37	CF	W33	220R	18-013

CIRCUIT POSITION	DESCRIPTION			PART No.
R38	CF	W33	470K	18-109
R39	CF	1W	1K0	18-107
R41	CF	W33	12K	18-085
R42	CF	W50	270K	18-184
R43	CF	W33	4K7	18-027
R45	CF	W33	2K7	18-025
R46	CF	W33	2K7	18-025
R44	CF	W33	4K7	18-027
R47	CF	W33	100K	18-037
R48	CF	W33	27K	18-126
R100	CF	W33	12K	18-085
R101	CF	W33	3K3	18-063
R102	CF	W33	330R	18-015
R104	CF	W33	330R	18-015
R105	CF	W33	12K	18-085
R106	CF	W33	12K	18-065
R107	CF	W33	1K0	18-020
R108	CF	W33	470K	18-109
R109	CF	W33	3K3	18-063
R110	CF	W33	1K0	18-020
R111	CF	W33	47K	18-031
R112	CF	W33	4K7	18-027
R113	CF	w33	100K	18-037
R114	CF	W33	470K	18-109
R115	CF	W33	3K3	18-063
R116	CF	W33	22K	18-030
R118	CF	W33	2K2	18-024
R124	CF	W33	12K	18-085
R125	CF	W33	12K	18-085
R126	CF	W33	12K	18-085
R127	CF	W33	3K3	18-063
R128	CF	W33	12K	18-085
R129	CF	W33	12K	18-085
R130	CF	W33	4K7	18-027
R131	CF	W33	4K7	18-027
R132	CF	W33	1K0	18-020
R133	CF	W33	330R	18-015
R134	CF	W33	3K3	18-063
R136	CF	W33	22K	18-030
R137	CF	W33	100K	18-037
R138	CF	W33	470K	18-109
R139	CF	W33	12K	18-085
R140	CF	W33	12K	18-085
R141	CF	W33	12K	18-085
R142	CF	W33	12K	18-085
R143	CF	W33	12K	18-085
R144	CF	W33	12K	18-085
R145	CF	W33	12K	18-085
R146	CF	W33	12K	18-085
R151	CF	W33	220R	18-013

CIRCUIT POSITION	DESCRIPTION	PART No.
R153	CF W33 220R	18-013
R154	CF W33 220R	18-013
PTC1	1K0 PTC Thermistor	18-106
RP1	1776-C64 Network	18-185
RP2	100K x 7 SIL Resistor pack	18-186
X100	2K7 x 8 SIL Resistor pack	18-187
X101	6K8 x 8 SIL	18-188
X102	2K7 x 8 SIL	18-187
X103	6K8 x 8 SIL	18-188
Resistors, variable		
V1	Varistor 416V	18-190
V2	Varistor 416V	18-190
V3	Varistor 416V	18-190
Capacitors, fixed		
C1	Electrolytic 10u 16V	20-018
C2	Electrolytic 10u 16V	20-018
C3	Electrolytic 33u 16V	20-077
C4	Electrolytic 10u 16V	20-018
C5	Electrolytic 10u 16V	20-018
C7	Polypropylene 4n7	20-127
C8	Polyester 22n 63V	20-043
C9	Polyester 22n 63V	20-043
C10	Ceramic 10p 100V	20-128
C11	Ceramic 100n 25V	20-020
C12	Electrolytic 47u 25V	20-129
C13	Ceramic 10n 63V	20-072
C14	Ceramic 330p 63V	20-081
C15	Ceramic 10p 100V	20-128
C16	Electrolytic 10u 16V	20-018
C17	Electrolytic 10u 16V	20-018
C18	Ceramic 330p 63V	20-081
C19	Polystyrene 10p 1KV	20-074
C20	SOT	
C21	Polystyrene 560p 2.5% 30V	20-130
C22	Polystyrene 6n8 2.5% 30V	20-131
C23	SOT	
C24	SOT	
C25	Electrolytic 47u 25V	20-129
C26	Electrolytic 47u 25V	20-129
C27	Polyester 220n 63V	20-109
C28	Electrolytic 1u 63V	20-132
C29	Electrolytic 10u 16V	20-018
C30	Electrolytic 470u 16V	20-031
C31	Electrolytic 470u 16V	20-031
C32	Electrolytic 100u 10V	20-115
C33	Electrolytic 100u 10V	20-115
C34	Ceramic 330p 63V	20-081
C35	Ceramic 100n 25V	20-020

CIRCUIT POSITION	DESCRIPTION	Part No.
C36	Ceramic 10n 1KV	20-076
C37	SOT	
C38	Polyester 220n 63V	20-109
C39	Ceramic 330p 63V	20-081
C40	Ceramic 100n 25V	20-020
C41	Ceramic 10n 63V	20-072
C42	Ceramic 100n 25V	20-020
C43	Ceramic 100n 25V	20-020
C44	Ceramic 330p 63V	20-109
C45	Electrolytic 10u 16V	20-018
C46	Electrolytic 10u 16V	20-018
C100	Ceramic 10p	20-128
C101	Ceramic 10p	20-128
C102	Ceramic 100n 25V	20-020
C103	Ceramic 100n 25V	20-020
C104	Ceramic 100n 25V	20-020
C105	Ceramic 100n 25V	20-020
C106	Electrolytic 100u 10V	20-115
C107	Ceramic 100n 25V	20-020
C108	Ceramic 100n 25V	20-020
C109	Electrolytic 4700u 16V	20-133
C110	Electrolytic 470u 16V	20-031
C111	Electrolytic 47u 25V	20-129
C112	Electrolytic 10u 16V	20-018
C113	Electrolytic 1u 63V	20-132
C114	Ceramic 10n 63V	20-072
C116	Electrolytic 100u 10V	20-115
C118	Ceramic 10n 63V	20-072
C119	Ceramic 10n 63V	20-072
C120	Ceramic 10p 100V	20-128
C121	Ceramic 100p 63V	20-015
C122	Ceramic 100p 64V	20-015
C123	Ceramic 100p 63V	20-015
C124	Ceramic 100p 63V	20-015
C125	Ceramic 100p 63V	20-015
C126	Ceramic 100p 63V	20-015
C127	Ceramic 100p 63V	20-015
C128	Ceramic 100p 63V	20-015
C129	Ceramic 10n 63V	20-072
Capacitors, variable		
VC1	2-18p 300V	21-007
VC2	2-20p	21-003
VC3	5-60p	21-002
Crystals		
XTL1	32.768KHz	25-007
XTL2	4.9152MHz	25-006
Switches		
SW1	6-way Piano dil	16-028

CIRCUIT POSITION	DESCRIPTION	Part No.
Relays		
RL1	1-Pole 12V	34-002
RL2	1-Pole 12V	34-002
RL3	1-Pole 12V	34-002
Connectors		
CON1	14-way DIL skt	14-056
CON2	2-way SIL Header	14-069
CON3	3-way SIL Header	14-070
CON4	6-way IDC connector	14-031
CON5	24-way GPIB PCB mounting	14-082
Miscellaneous		
Terminal pins 1mm (13)		14-005
PCB		30-036
IC Socket 40-way (2)		14-013
IC Socket 28-way (1)		14-004
IC Socket 6-way (1)		14-083
IC Socket 64-way 'shrink dip'		14-092
Battery 2.4V 100mAh		32-018
Buzzer		26-004
Heatsink (1)		38-005

REAR PANEL ASSEMBLY

DESCRIPTION	Part No.
Rear panel printed	28-029
Socket, mains IEC	14-017
Socket 9-way 'D' female panel mounting	14-057
Switch, mains on/off	16-011
Insulating boot	15-005
Transformer, mains	40-011
Tag solder (5)	14-035
Screw M3 x 8 (2) Pozi	13-032
Screw M3 x 10 Pozi C/S zing plate (1)	13-023
Screw M3 x 16 Pozi C/S zinc plate (1)	13-054
Mounting stud for 9-way 'D' (2)	13-052
Washer, shakeproof M3 (4)	13-018
Nut, full M3 (5)	13-019
Sleeving H15 (14)	15-004
Socket jack 3.5mm panel mounting	14-085
Fuse 5 x 20mm 100mA HRC anti-surge	33-006
Fuse 0.25" x 1.25" 600V HRC	33-009
Fuse Holder 6.2 x 32mm	14-106
Fuse Carrier 6.2 x 32mm	14-107
Self Adhesive insulator	??-???

DESCRIPTION	PART No.

FRONT PANEL ASSEMBLY

Front panel printed	28-033
Socket 4mm bulkhead safety White (1)	14-105
Socket 4mm bulkhead safety Red (2)	14-103
Socket 4mm bulkhead safety Black (1)	14-104
Sleeving H50 (4)	15-020
Button, Grey (18)	29-014
Blanking Plug (4)	14-086
Nut M3 (2)	13-019
Washer M3 shakeproof (1)	13-018
Tag solder (1)	14-035

LOWER SCREEN ASSEMBLY

Screen, Lower drilled	15-024
Screw M3 x 16 (4)	13-050
Plastic screw M3 x 16 (2)	13-067
Spacer M3 Hex 6.35mm (4)	13-048
Plastic spacer 6.35mm (2)	13-069
Plastic nut M3 (2)	13-068
Nut M3 full (2)	13-019
Washer, shakeproof M3 (8)	13-018
Screw No.4 x ¼" Pn Hd. Pozi zinc plate (8)	13-010

UPPER SCREEN ASSEMBLY

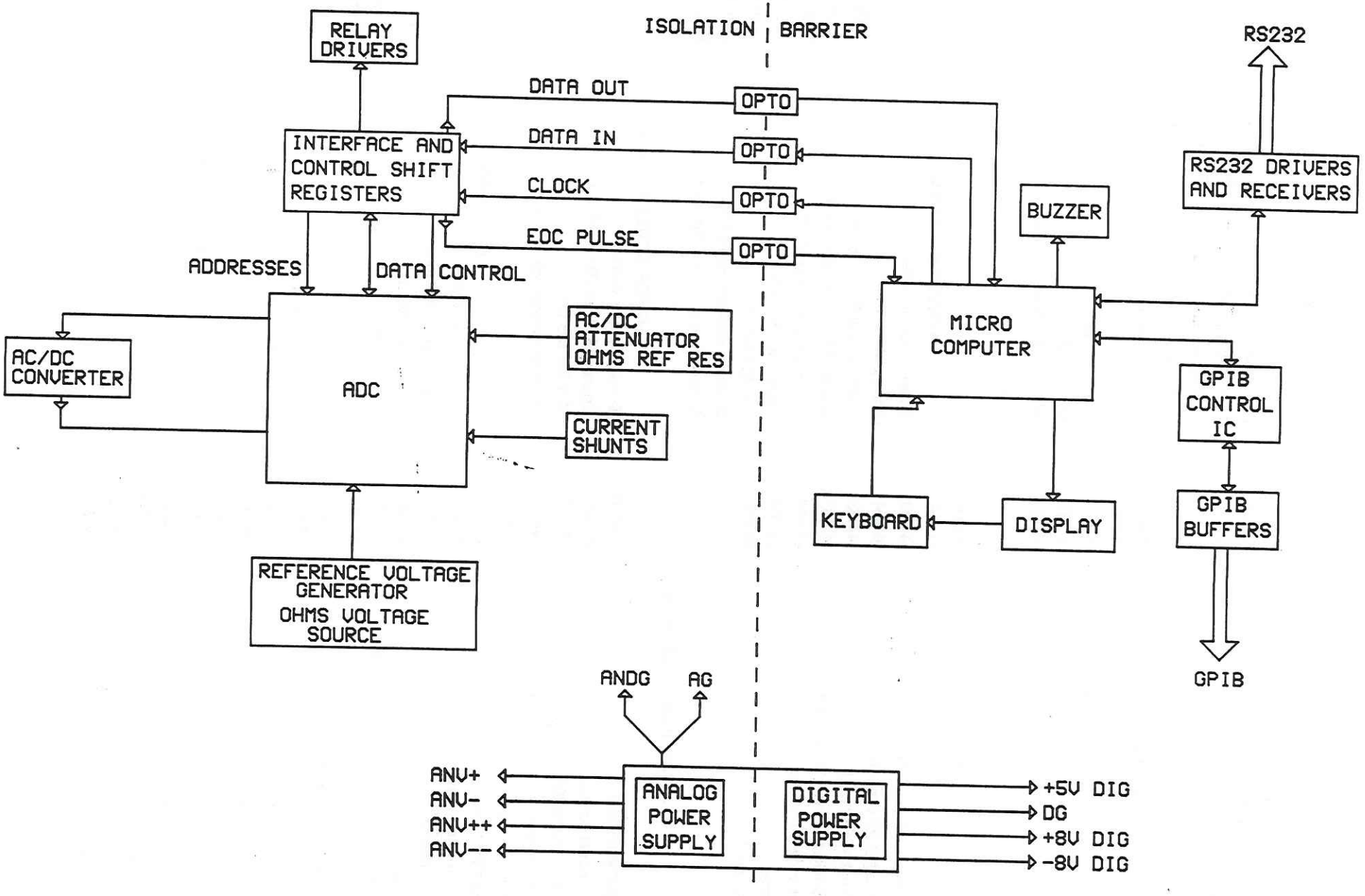
Screen, Upper drilled	15-025
Spacer M3 Hex 20mm M/F (2)	13-040
Nut full M3 (2)	13-019
Washer shakeproof M3 (2)	13-018

CASE PARTS

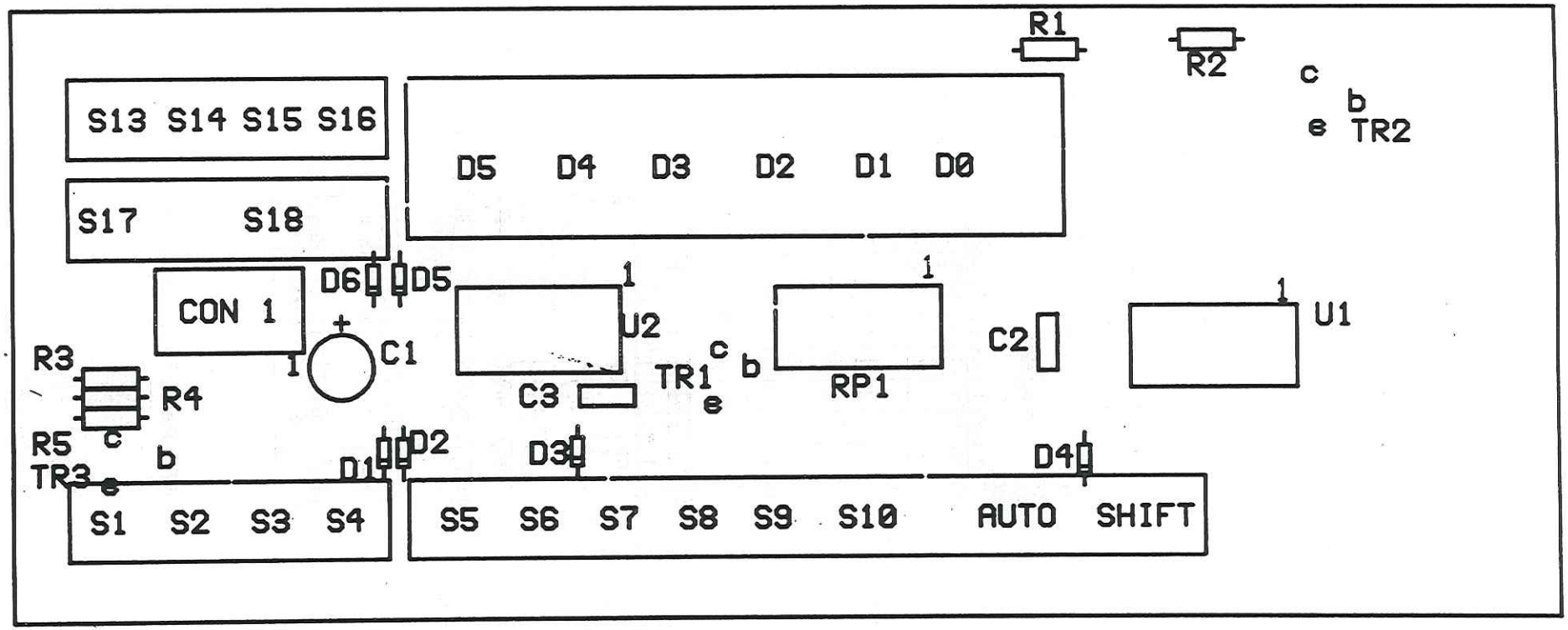
Case, Lower drilled	27-002
Case, Upper with inserts	27-001
Expansion strip (2)	27-003
Foot A (2)	27-004
Foot B (2)	27-005
Leg	27-008
Pad Neoprene (4)	27-009
Screw M3 x 70 (4)	13-003

MISCELLANEOUS

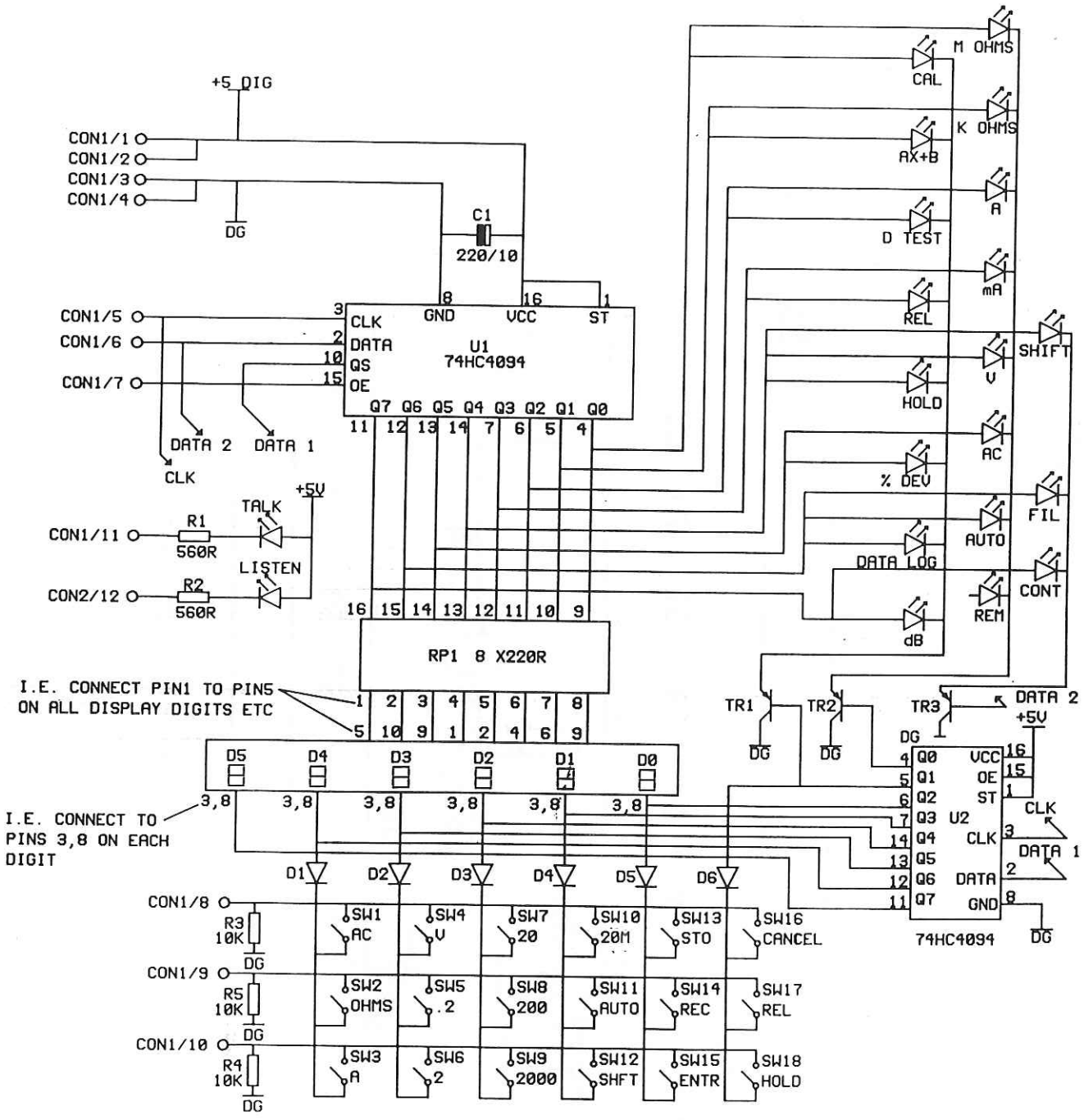
Demo Floppy Disk 5.25" 360K	31-061



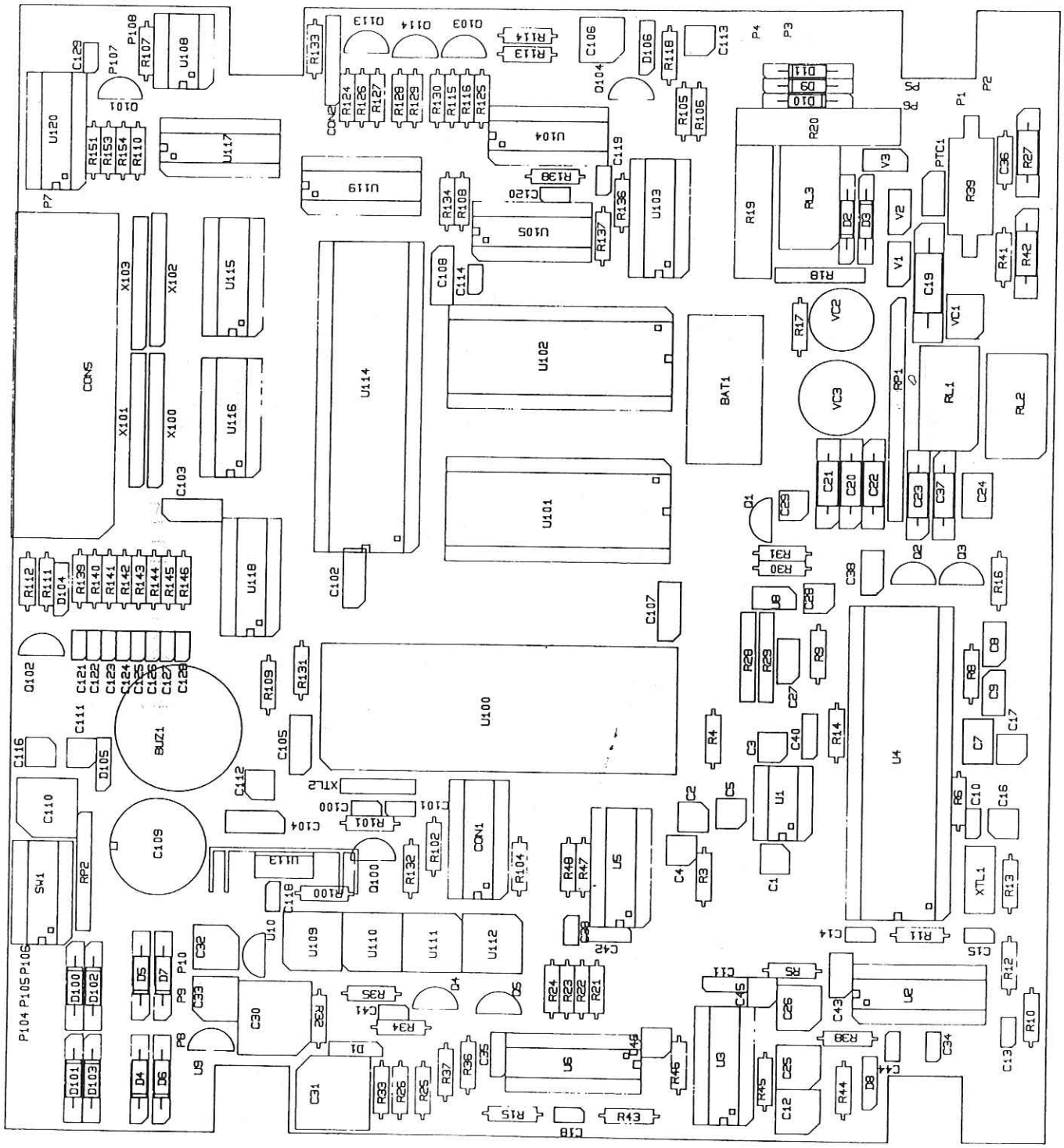
FUNCTIONAL BLOCK DIAGRAM



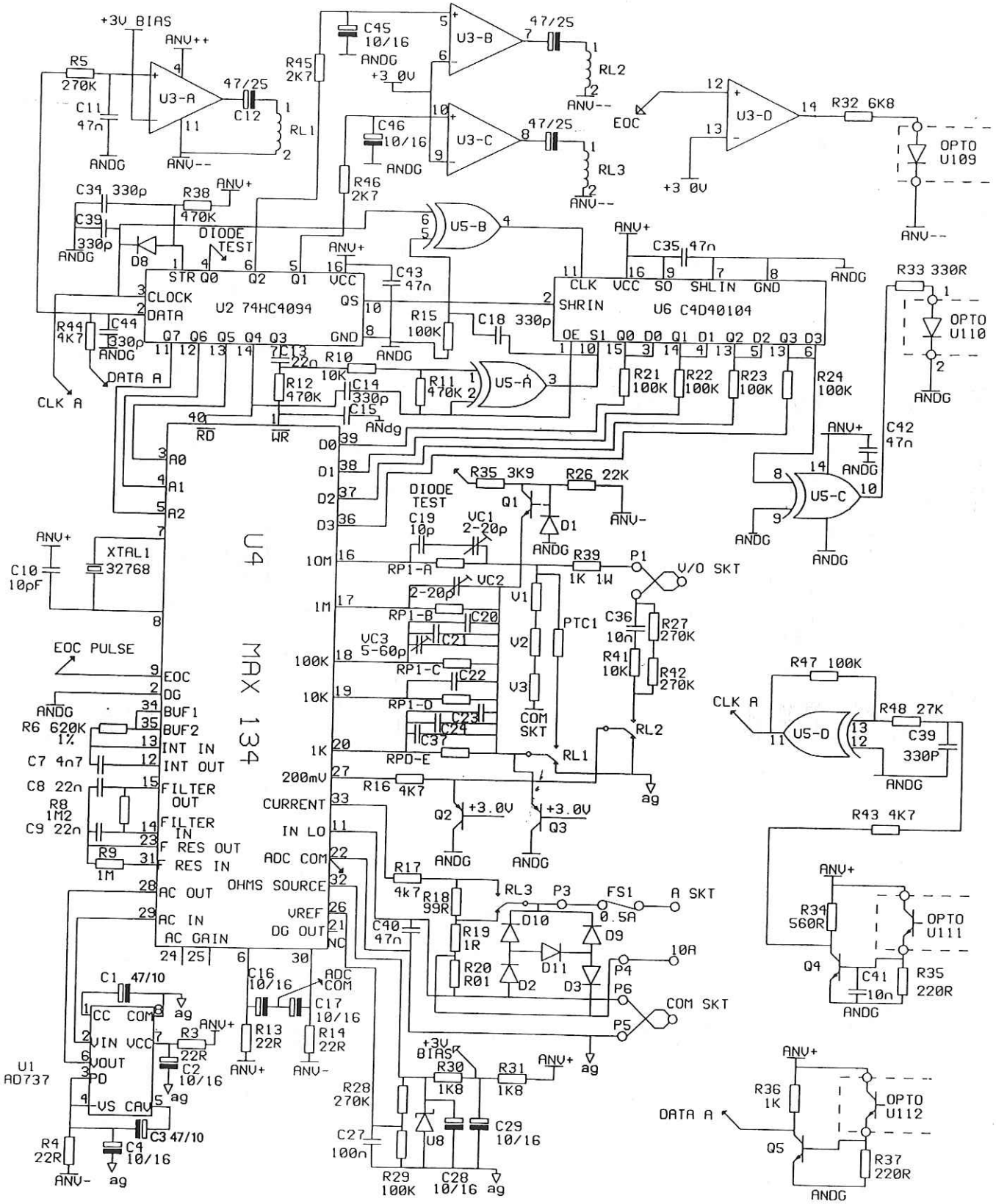
COMPONENT LAYOUT - FRONT PANEL P.C.B.



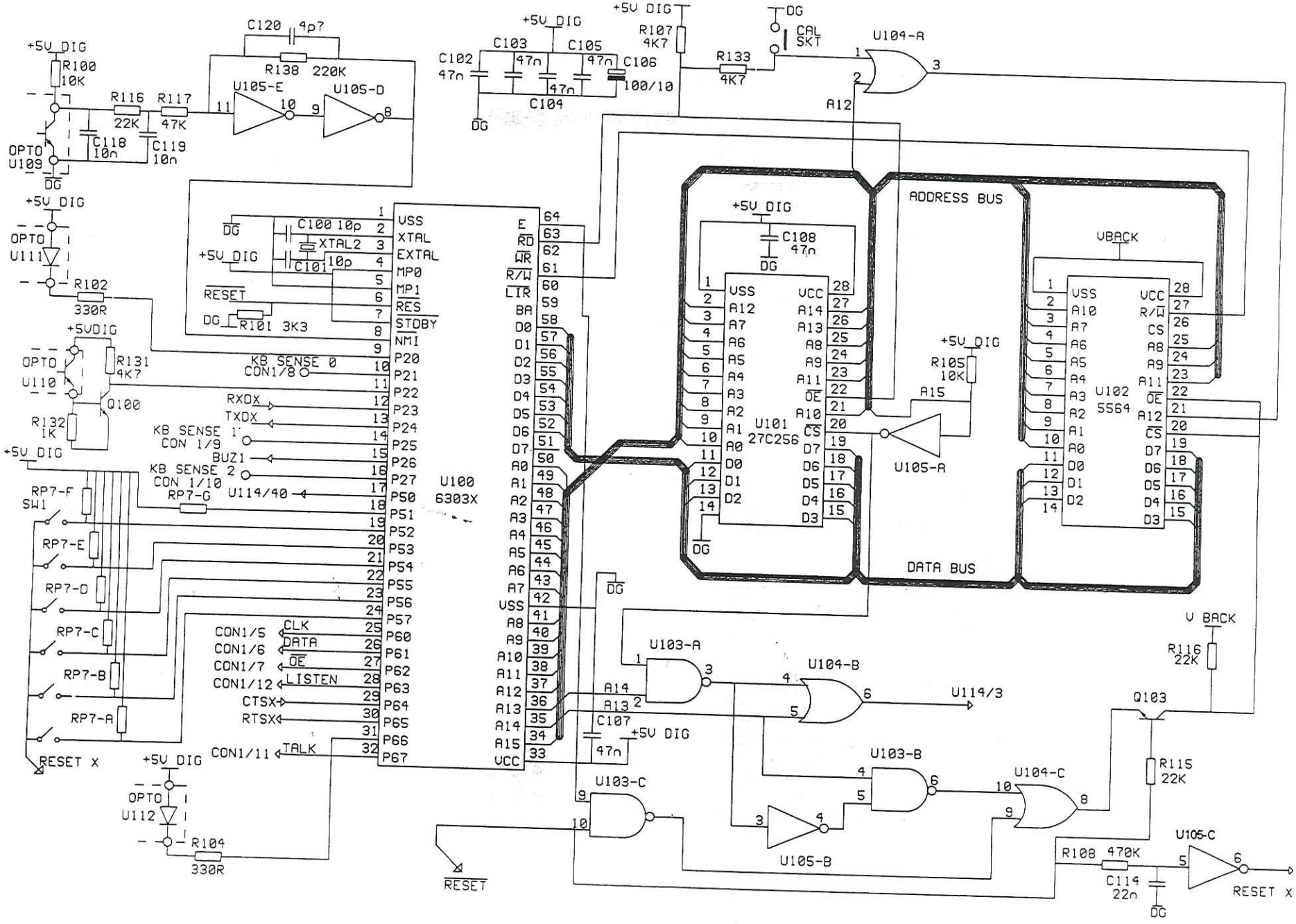
FRONT PANEL P.C.B. CIRCUIT DIAGRAM



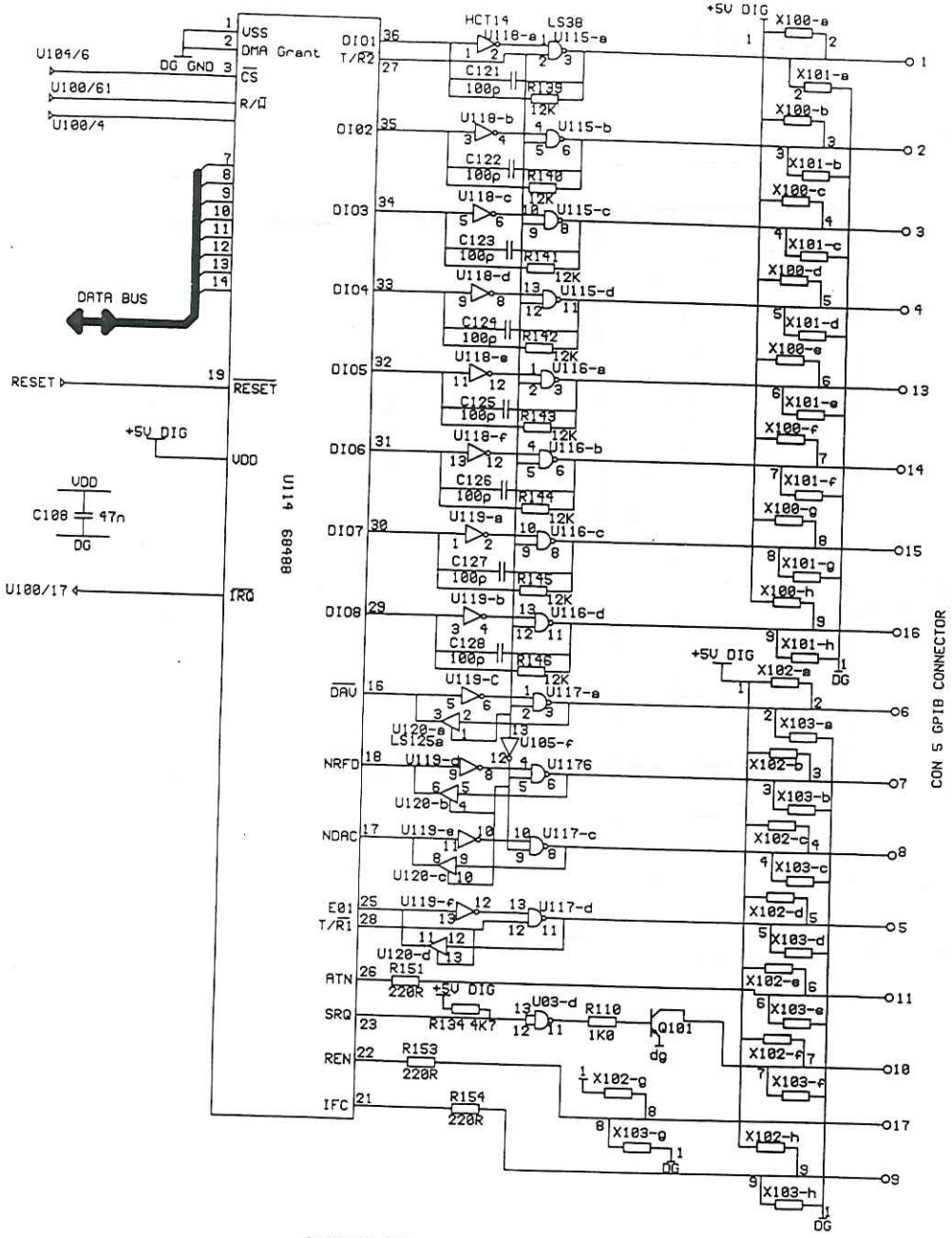
COMPONENT LAYOUT. MAIN P.C.B.



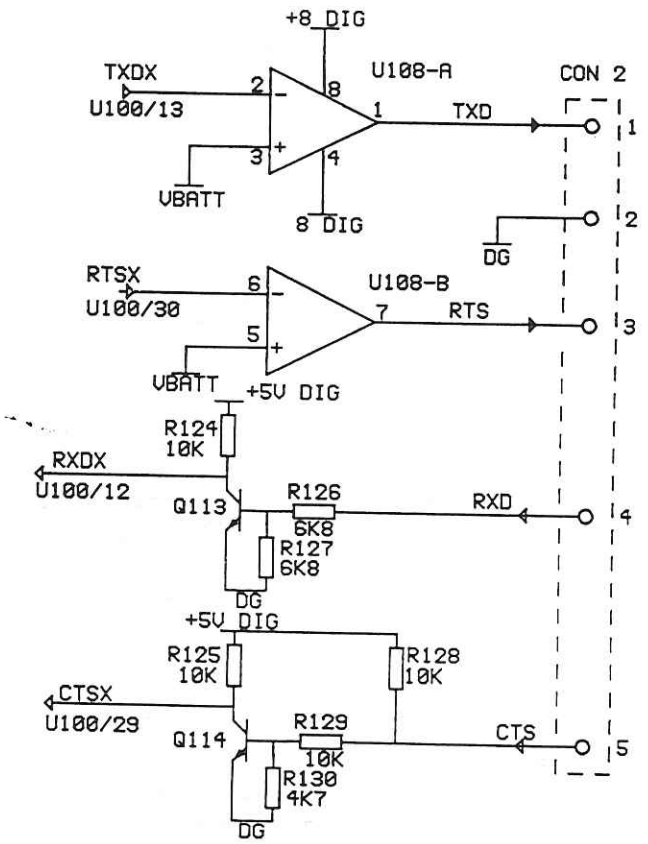
ANALOG CIRCUIT DIAGRAM



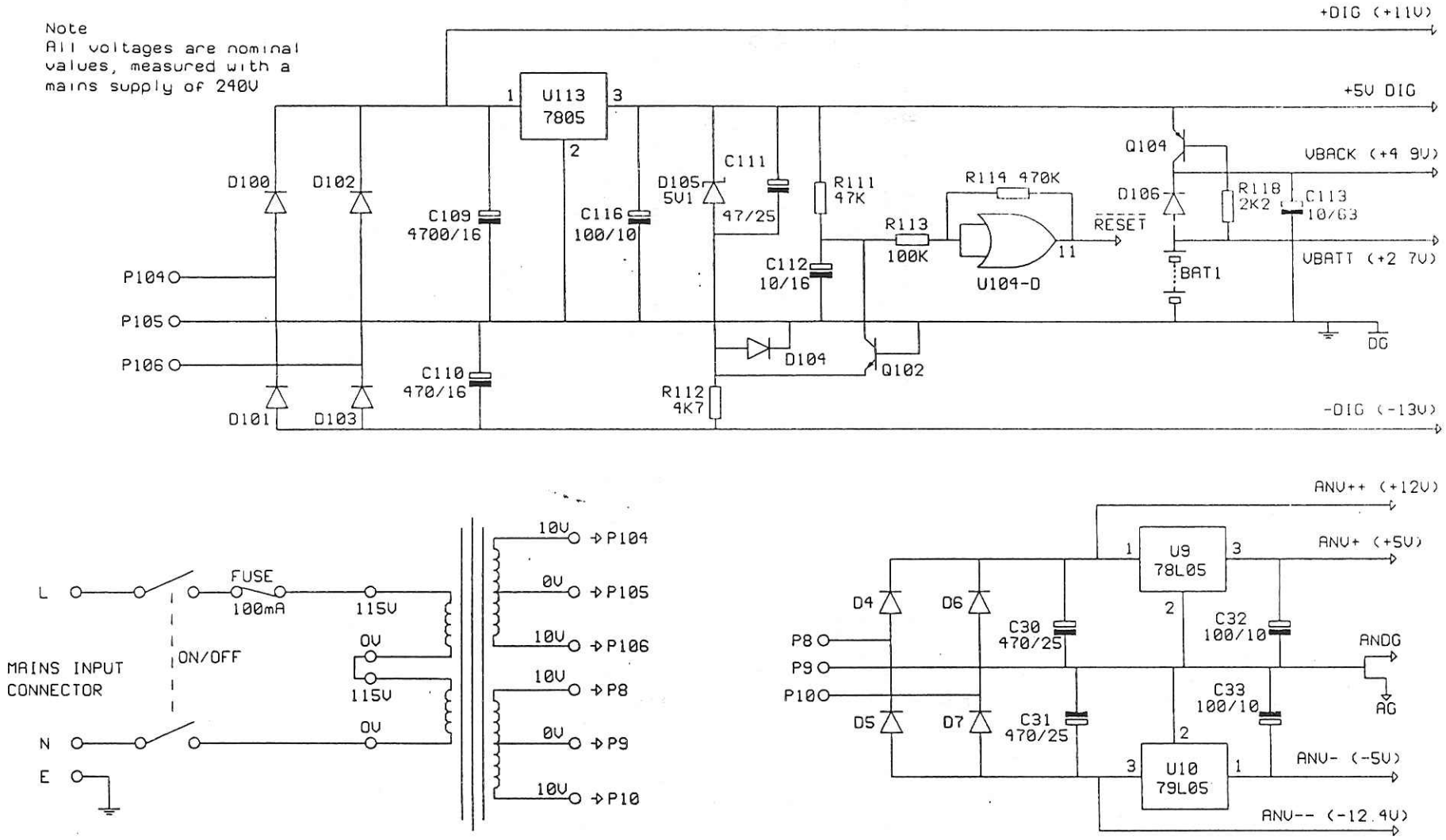
DIGITAL CIRCUIT DIAGRAM (1)



DIGITAL CIRCUIT DIAGRAM (2)



DIGITAL CIRCUIT DIAGRAM (3)



POWER SUPPLY CIRCUIT DIAGRAM

AMENDMENTS

CHANGES TO 4503 SPECIFICATION

1. Voltage burden for 4mA/400mA AC/DC current ranges changes to:
   40μV/count

2. Accuracy of 10A DC current range changes to:
   0 to 5A $\pm$ 1% rdg $\pm$0.02% fs 5A to 10A $\pm$2.5% rdg $\pm$0.02% fs

3. Accuracy of 10A AC current range changes to:
   0 to 5A $\pm$ 1% rdg $\pm$0.1% fs 5A to 10A $\pm$2.5% rdg $\pm$0.1% fs

SOFTWARE CHANGE 4503 (P.15 Instruction Manual)

'T' COMMAND-TRIGGER:substitute copy as below:

T1 - continuous mode
T0 - triggered mode
T? - return the trigger mode state

The instrument can send data to either the GP-IB or to RS232. Upon power-on, it defaults to RS232, switching to the GP-IB if data is sent to it by a GP-IB controller. If data is subsequently received via RS232, communication then continues on RS232 i.e. the instrument communicates with whichever interface last received data, changing as required when data is received.

In T1 mode, the instrument sends readings continuously at conversion rate i.e. 3 readings/sec, but this rate is reduced if the data logger is running, in which case it sends readings at a rate set by the data logger timer. Upon power-on, the instrument remembers the T0 or T1 state in use when last powered-off, and uses that state - thus if it was in T1 state when powered-off, it will again be in T1 when next powered-on. The 'A' command does not affect the T0/T1 state, neither does the front-panel CLEAR command. Note that T1 state on the GP-IB is not the same as talk only; in T1 state, the instrument may be coupled to a listen-only device, and communication will take place. In talk-only mode,the instrument sends data to the GP-IB, as per T1 state (except for not needing a GP-IB controller). Talk only mode affects the GP-IB only - RS232 is controlled only by the T0/T1 state which applies to both interfaces i.e. you cannot have the RS232 in T0 state and the GP-IB in T1 state or vice-versa.

The T? command causes a string ('T0' or 'T1') to be returned reflecting whether the continuous or triggered mode is selected.

AC Voltage measurements

The max value of DC component of signal measured is $\pm$5V on 0.4V range and $\pm$50V all other ranges. If signal has significant DC component, AC couple signal to multimeter using suitable capacitor.

EMC AMENDMENTS

All units are manufactured from the 1st January 1996 (From Serial No.55629) that are sold within the EEC comply with European Regulations EN 50081-1 and 50082-1. These units are covered on the following pages.

SPECIFICATION AMENDMENTS

GENERAL

Power Requirements:	220/240V ac$\pm$10%, 50/60Hz.
Case:	Robust lightweight steel, painted grey.
Weight:	2.7kg
Size:	212(w) x 228(d) x 100(h)mm
EMC:	Complies with EN 50081-1 and EN 50082-1
Installation category(over voltage):	II
Insulation rating:	CLASS I
Operating Temperature:	5° to 40°C Indoor use only
Humidity:	10% to 80% RH(non condensing)
Altitude:	Up to 2000M

PARTS LIST

FRONT PANEL P.C.B.

CIRCUIT POSITION	DESCRIPTION	PART No.
Resistors, fixed		
R1	CF W33 560R	18-017
R2	CF W33 560R	18-017
R3	CF W33 10K	18-029
R4	CF W33 10K	18-029
R5	CF W33 10K	18-029
R6	CF W33 10K	18-029
RP1	8 x 220R DIL Resistor pack	18-191
Capacitors		
C1	Electrolytic 100μ 6V3	20-011
C2	Ceramic 100n 25V	20-020
C3	Ceramic 100n 25V	20-020
Semiconductors		
TR1	BC212A	22-001
TR2	BC212A	22-001
TR3	BC212A	22-001
D1-D6	1N4148	23-005
Integrated Circuits		
U1	74HC4094	24-103
U2	74HC4094	24-103
Connectors		
CON1	40-way IC skt (2)	14-013
CON2	24-way IC skt (2)	14-084
CON3	14-way Ribbon 'C' form	14-058
Switches		
SWB1	Function 1	16-025
SWB2	Function 3	16-025
SWB3	Function 2	16-026
SWB4	Range	16-027
Displays		
X1-X6	7-Seg LED 0.56"	26-002
LD1-LD21	LED Lamp	26-001
Miscellaneous		
PCB	Front Panel PCB	30-037
Integrated Circuits		
U1	AD737JN	24-113
U2	74HC4094	24-103

MAIN P.C.B.

CIRCUIT POSITION	DESCRIPTION	PART No.
U3	TLO74	24-116
U4	MAX134	24-117
U5	CD4070	24-059
U6	CD40104	24-104
U8	AD589JH	21-114
U9	78L05	24-105
U10	79L05	24-037
U100	HD6303X	24-115
U101	27C256	24-106
U102	6264-LP15	24-088
U103	74HC00	24-007
U104	74HC32	24-093
U105	74HC04	24-016
U108	TL072	24-074
U109	4N36	24-107
U110	4N36	24-107
U111	4N36	24-107
U112	4N36	24-107
U113	7805	24-036
U114	MC68488	24-111
U115	7438	24-108
U116	7438	24-108
U117	7438	24-108
U118	74HCT14	24-109
U119	74HCT14	24-109
U120	74HCT125	24-110
Semiconductors		
D1	1N4148	23-005
D2	1N4001	23-003
D3	1N4001	23-003
D4	1N4001	23-003
D5	1N4001	23-003
D6	1N4001	23-003
D7	1N4001	23-003
D8	1N4148	23-005
D9	1N4001	23-003
D10	1N4001	23-003
D11	1N4001	23-003
D100	1N4001	23-003
D101	1N4001	23-003
D102	1N4001	23-003
D103	1N4001	23-003
D104	1N4148	23-005
D105	BZY88 C5V1	23-009
D106	1N4148	23-005
Q1	BC182	22-009
Q2	BC212A	22-001

CIRCUIT POSITION	DESCRIPTION			PART No.
Q3	BC212A			22-001
Q4	BC182			22-009
Q5	BC182			22-009
Q100	BC182			22-009
Q101	BC182			22-009
Q102	BC182			22-009
Q103	BC182			22-009
Q104	BC212A			22-001
Q113	BC182			22-009
Q114	BC182			22-009
Resistors, fixed				
R3	CF	W33	22R	18-074
R4	CF	W33	22R	18-074
R5	CF	W33	470K	18-109
R6	CF	W33	620K	18-180
R8	CF	W33	1M2	18-077
R9	CF	W33	1M2	18-077
R10	CF	W33	12K	18-085
R11	CF	W33	100K	18-037
R12	CF	W33	470k	18-109
R13	CF	W33	22R	18-074
R14	CF	W33	22R	18-074
R15	CF	W33	33K	18-084
R16	CF	W33	4K7	18-027
R17	CF	W33	4K7	18-027
R18	MF	W25	99R 0.1% 15ppm	18-181
R19	MF	W25	1R 25/50ppm	18-105
R20	WW	5W	R01	18-095
R21	CF	W33	10K	18-029
R22	CF	W33	10K	18-029
R23	CF	W33	10K	18-029
R24	CF	W33	10K	18-029
R25	CF	W33	3K3	18-063
R26	CF	W33	22K	18-030
R27	CF	W50	270K	18-184
R28	MF	W25	270K 5ppm	18-182
R28	MF	W25	120K 5ppm	18-213
R29	MF	W25	100K 5ppm	18-183
R30	CF	W33	1K8	18-023
R31	CF	W33	1K8	18-023
R32	CF	W33	6K8	18-076
R33	CF	W33	330R	18-015
R34	CF	W33	560R	18-017
R35	CF	W33	220R	18-013
R36	CF	W33	1K0	18-020
R37	CF	W33	220R	18-013
R38	CF	W33	470K	18-109
R39	CF	1W	1K0	18-107
R41	CF	W33	12K	18-085
R42	CF	W50	270K	18-184
R43	CF	W33	4K7	18-027
R44	CF	W33	4K7	18-027
R45	CF	W33	2K7	18-025

CIRCUIT POSITION	DESCRIPTION			PART No.
R46	CF	W33	2K7	18-025
R47	CF	W33	100K	18-037
R48	CF	W33	27K	18-126
R100	CF	W33	12K	18-085
R101	CF	W33	3K3	18-063
R102	CF	W33	330R	18-015
R104	CF	W33	330R	18-015
R105	CF	W33	12K	18-085
R106	CF	W33	12K	18-085
R107	CF	W33	1K0	18-020
R108	CF	W33	470K	18-109
R109	CF	W33	3K3	18-063
R110	CF	W33	1K0	18-020
R111	CF	W33	47K	18-031
R112	CF	W33	4K7	18-027
R113	CF	W33	100K	18-037
R114	CF	W33	470K	18-109
R115	CF	W33	3K3	18-063
R116	CF	W33	22K	18-030
R118	CF	W33	2K2	18-024
R124	CF	W33	12K	18-085
R125	CF	W33	12K	18-085
R126	CF	W33	12K	18-085
R127	CF	W33	3K3	18-063
R128	CF	W33	12K	18-085
R129	CF	W33	12K	18-085
R130	CF	W33	4K7	18-027
R131	CF	W33	4K7	18-027
R132	CF	W33	1K0	18-020
R133	CF	W33	330R	18-015
R134	CF	W33	3K3	18-063
R136	CF	W33	22K	18-030
R137	CF	W33	100K	18-037
R138	CF	W33	470K	18-109
R139	CF	W33	12K	18-085
R140	CF	W33	12K	18-085
R141	CF	W33	12K	18-085
R142	CF	W33	12K	18-085
R143	CF	W33	12K	18-085
R144	CF	W33	12K	18-085
R145	CF	W33	12K	18-085
R146	CF	W33	12K	18-085
R151	CF	W33	220R	18-013
R153	CF	W33	220R	18-013
R154	CF	W33	220R	18-013
PTC1	1K0 PTC Thermistor			18-106
RP1	1776-C64 Network			18-185
RP2	100K x 7 SIL Resistor pack			18-186
x100	2K7 x 8 SIL Resistor pack			18-187
x101	6K8 x 8 SIL			18-188
x102	2K7 x 8 SIL			18-187
x103	6K8 x 8 SIL			18-188

CIRCUIT POSITION	DESCRIPTION	Part No.
Resistors, variable		
V1	Varistor 416V	18-190
V2	Varistor 416V	18-190
V3	Varistor 416V	18-190
Capacitors, fixed		
C1	Electrolytic 10μ 16V	20-018
C2	Electrolytic 10μ 16V	20-018
C3	Electrolytic 33μ 16V	20-077
C4	Electrolytic 10μ 16V	20-018
C5	Electrolytic 10μ 16V	20-018
C7	Polypropylene 4n7	20-127
C8	Polyester 22n 63V	20-043
C9	Polyester 22n 63V	20-043
C10	Ceramic 10p 100V	20-128
C11	Ceramic 100n 25V	20-020
C12	Electrolytic 47μ 25V	20-129
C13	Ceramic 10n 63V	20-072
C14	Ceramic 330p 63V	20-081
C15	Ceramic 10p 100V	20-128
C16	Electrolytic 10μ 16V	20-018
C17	Electrolytic 10μ 16V	20-018
C18	Ceramic 330p 63V	20-081
C19	Polystyrene 10p 1KV	20-074
C20	SOT	
C21	Polystyrene 560p 2.5% 30V	20-130
C22	Polystyrene 6n8 2.5% 30V	20-131
C23	SOT	
C24	SOT	
C25	Electrolytic 47μ 25V	20-129
C26	Electrolytic 47μ 25V	20-129
C27	Polyester 220n 63V	20-109
C28	Electrolytic 1μ 63V	20-132
C29	Electrolytic 10μ 16V	20-018
C30	Electrolytic 470μ 16V	20-031
C31	Electrolytic 470μ 16V	20-031
C32	Electrolytic 100μ 10V	20-115
C33	Electrolytic 100μ 10V	20-115
C34	Ceramic 330p 63V	20-081
C35	Ceramic 100n 25V	20-020
C36	Ceramic 10n 1KV	20-076
C37	SOT	
C38	Polyester 220n 63V	20-109
C39	Ceramic 330p 63V	20-081
C40	Ceramic 100n 25V	20-020
C41	Ceramic 10n 25V	20-072
C42	Ceramic 100n 25V	20-020
C43	Ceramic 100n 25V	20-020
C44	Polyester 220n 63V	20-109
C45	Electrolytic 10μ 16V	20-018
C46	Electrolytic 10μ 16V	20-018
C100	Ceramic 10p	20-128
C101	Ceramic 10p	20-128

CIRCUIT POSITION	DESCRIPTION	Part No.
C102	Ceramic 100n 25V	20-020
C103	Ceramic 100n 25V	20-020
C104	Ceramic 100n 25V	20-020
C105	Ceramic 100n 25V	20-020
C106	Electrolytic 100μ 10V	20-115
C107	Ceramic 100n 25V	20-020
C108	Ceramic 100n 25V	20-020
C109	Electrolytic 4700μ 16v	20-133
C110	Electrolytic 470μ 16v	20-031
C111	Electrolytic 47μ 16v	20-129
C112	Electrolytic 10μ 16v	20-018
C113	Electrolytic 1μ 63v	20-132
C114	Ceramic 10n 63V	20-072
C116	Electrolytic 100μ 16v	20-115
C118	Ceramic 10n 63V	20-072
C119	Ceramic 10n 63V	20-072
C120	Ceramic 10p 100V	20-128
C121	Ceramic 100p 63V	20-015
C122	Ceramic 100p 63V	20-015
C123	Ceramic 100p 63V	20-015
C124	Ceramic 100p 63V	20-015
C125	Ceramic 100p 63V	20-015
C126	Ceramic 100p 63V	20-015
C127	Ceramic 100p 63V	20-015
C128	Ceramic 100p 63V	20-015
C129	Ceramic 10n 63V	20-072
Capacitors, variable		
VC1	2-18p 300V	21-007
VC2	2-20p	21-003
VC3	5-60P	21-002
Crystals		
XTL1	32.768KHz	25-007
XTL2	4.9152MHz	25-006
Switches		
SW1	6-way Piano dil	16-028
Relays		
RL1	1-Pole 12V	34-002
RL2	1-Pole 12V	34-002
RL3	1-Pole 12V	34-002
Connectors		
CON1	14-way DIL skt	14-056
CON2	2-way SIL Header	14-069
CON3	3-way SIL Header	14-070
CON4	6-way IDC connector	14-031
CON5	24-way GPIB PCB connector	14-031

Miscellanous	
Terminal pins 1mm (13)	14-005
PCB	30-036
IC Socket 40-way (2)	14-013
IC Socket 28-way (1)	14-004
IC Socket 6-way (1)	14-083
IC Socket 64-way 'shrink dip'	14-092
Battery 2.4V 100mAh	32-018
Buzzer	26-004
Heatsink (1)	38-005

REAR PANEL ASSEMBLY

DESCRIPTION	Part No.
Rear panel printed	28-061
IEC Mains filter	17-016
9-way 'D' skt sol/bkt	114-006
Transformer, mains	40-011
Transformer Insulator	15-038
Solder tag (6)14-035	
Screw M3 x 10 POZI ZP CS (1)	13-023
Screw M3 x 16 POZI ZP CS (1)	13-054
Screw M4 x 12 NYLON (2)	13-076
Washer M4 NYLON (2)	13-078
Nut M4 NYLON (2)	13-077
Mounting stud for 9-way 'D' (2)	13-052
Washer, shakeproof M3 (6)	13-018
Full Nut M3 (4)	13-019
Mains on/off switch	16-046
Heatshrink 9.5mm (40mm)	15-036
Heatshrink 19.0mm (50mm)	115-001
Sleeving H15 (17)	15-004
Jack skt 3.5mm panel mounting	14-085
Fuse 5 x 20mm 100mA HRC anti-surge	33-006
Fuse 0.25" x 1.25" 600V HRC	33-009
Fuse Holder 6.2 x 32mm	14-106
Fuse Carrier 6.2 x 32mm	14-107
Blanking Plug (4)	14-086

FRONT PANEL ASSEMBLY

Front panel printed	28-069
4mm Bulkhead Safety skt White (1)	14-105
4mm Bulkhead Safety skt Red (2)	14-103
4mm Bulkhead Safety skt Black (1)	14-104
Sleeving H20 (4)	15-004
Button Grey (18)	29-014
M3 x 16 M/F Spacer (4)	13-098
M3 Nut (4)	13-019
M3 Shakeproof (5)	13-018
Solder tag (1)	14-035

LOWER SCREEN ASSEMBLY

Lower Screen	15-035
Screw M3 x 16 (1)	13-050
Screw M3 x 6 NYLON (6)	13-097
Screw M3 x 6 (4)	113-007

DESCRIPTION	PART No.
Screw M3 x 16 NYLON (5)	13-067
Spacer M3 HEX 6.35mm (1)	13-048
Spacer M3 HEX 6.35mm NYLON (5)	13-069
Nut, full M3 (1)	13-019
NYLON nut M3 (3)	13-068
Solder tag (2)	14-035

UPPER SCREEN ASSEMBLY

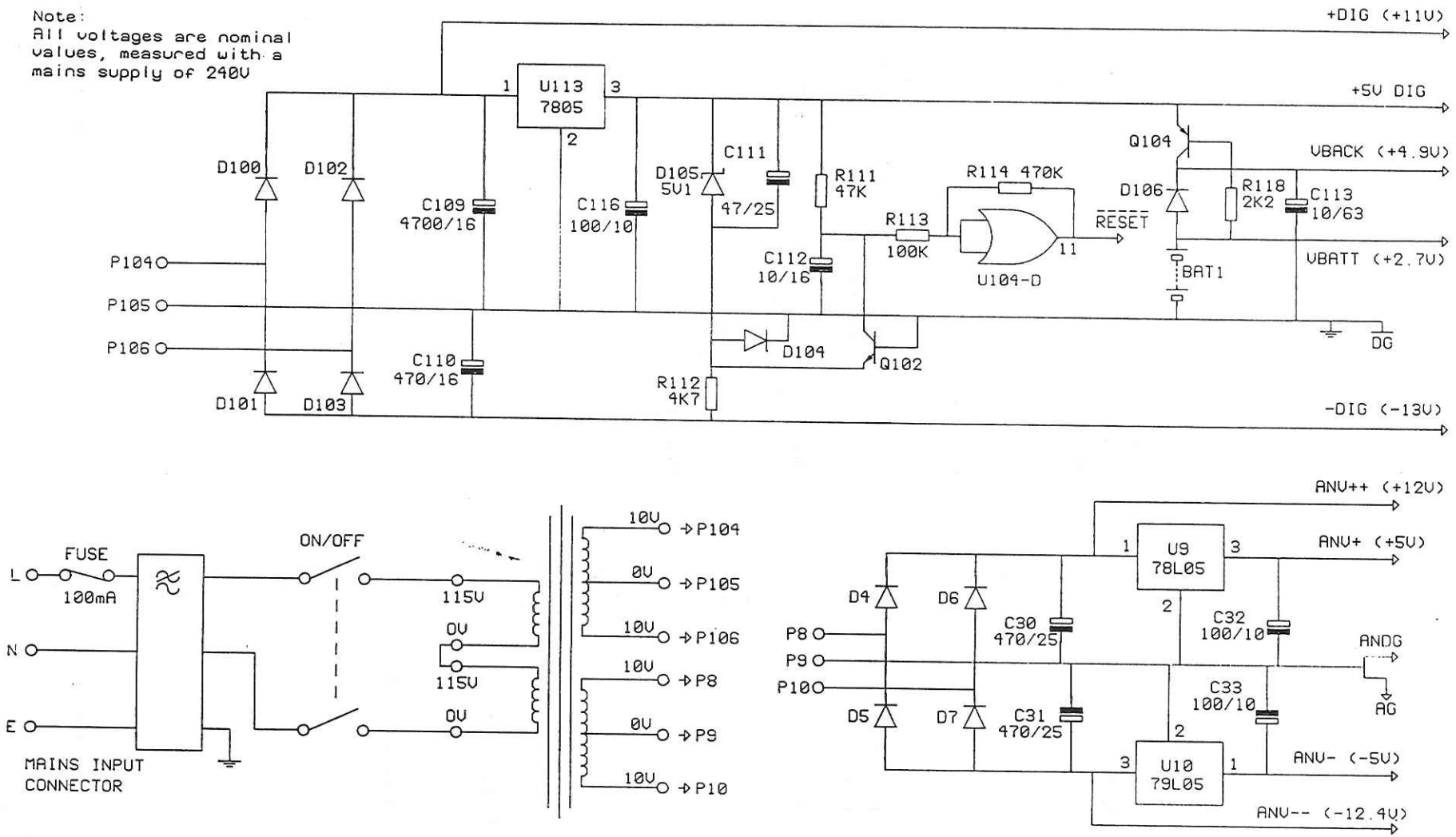
Screen Upper drilled	15-025
NYLON spacer (2)	13-096
Screw M3 x 6 Nylon (2)	13-097
Solder tag (2)	14-035

CASE PARTS

Metal Case	27-063
Foot A (2)	27-004
Foot B (2)	27-005
Leg	27-008
Pad Neoprene (4)	27-009
Screw M3 x 6 POZI PNHD ZP (6)	113-007
Screw M3 x 10 POZI PNHD ZP (4)	13-049
Nut M3,full (4)	13-019
Washer, M3 shakeproof (4)	13-018

MISCELLANEOUS

Demo Floppy Disk 5.25" 360K	31-061
Demo Floppy Disk 3.5" 720K	31-093



POWER SUPPLY CIRCUIT DIAGRAM