7081/7071
DIGITAL VOLT METER

Maintenance Manual

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instruments

7081/7071
DIGITAL VOLT METER

SAFETY

These instruments have been designed and tested in accordance with the recommendations of IEC 348 Class 1. They are primarily intended for indoor use, and for such use are supplied in a safe condition. However, no degradation of their safety will be caused if they are occasionally subjected to temperatures below normal room temperature.

This manual contains information and warnings which the user should follow to ensure his own safety and for the continued safe operation of the instruments. The 7081 and 7071 have been engineered with ease of use as one of the primary considerations. Attention has also been given to making the instruments immune to most inadvertent overloads. It should be appreciated, however, that even the most sophisticated measuring instrument can be dangerous when connected to high voltages, unless elementary safety precautions are observed.

The voltage limits of 1kV on AC and DC mean that no damage will be caused to the instruments at this level of input. Other than the displayed reading, however, no indication is given to the user that a voltage of such magnitude is present at the input terminals. Care should therefore be exercised whenever dvm input leads are being connected to/removed from live circuits, especially where high voltages are known to exist, or high transients could occur.

Similarly, when using the instruments on mains operated equipment capable of delivering high voltage outputs, it is strongly recommended that the equipment under test is NOT switched off with a dvm still connected. For example, consider a 7081 connected across the secondary winding of a large mains transformer. The instruments very high input resistance is such that in the event of the mains supply being interrupted, the resultant back emf induced in the undamped secondary could be in the order of 100kV. This is obviously hazardous to the user and would certainly harm the voltmeter.

Whenever it is likely that the safety of the instruments have been impaired, e.g. if there are any visible signs of damage, failure to perform correctly, or if the specfications have been exceeded in any way, the instrument should be made inoperative and referred to a suitable repair organisation.

Any adjustment, maintenance or repair of these instruments should be carried out only by a skilled person who is aware of the hazards associated with mains operated equipment. Such adjustment, maintenance or repair should be carried out in accordance with the procedures, and observing the precautions, detailed in this Maintenance Manual.

CONTENTS

CHAPTER 1

General Information

CONTENTS

Figures

1.1 INTRODUCTION

This manual contains technical information that is intended primarily to meet the needs of the service engineer. A detailed treatment of the principles of operation is not included but the descriptive text covering each circuit diagram is sufficient to enable the reader to understand the purpose of the circuit and its effect on its input(s). To facilitate fault diagnosis, attention is drawn to peculiarities of circuits, together with any precautions necessary when carrying out checks.

Both the 7081 and 7071 have identical electronic circuits. This means that all the circuits diagrams included in this manual are valid for both instruments. The difference between these two instruments exists primarily at the software level, and on the higher specification components required by the 7081 . The 7081 undergoes a significantly more rigourous quality control proceedure.

1.2 PRESENTATION OF INFORMATION

The circuit diagrams are arranged to fold out clear to the right. Signal paths are indicated by bold lines, arrows being used where necessary to indicate the direction of functional flow. In general this is from left to right, feedback paths flowing from right to left. To prevent ambiguity, however, and where space is limited, this convention has not been followed rigidly.

In addition to the circuit diagrams, lined drawings are reproduced in the manual to facilitate rapid identification of components during diagnostic checks.

1.2.1 Power Rails

These are represented by short, detached bars annotated to show the nominal voltage. Several separate bars, annotated with the same voltage, may appear on a diagram. These are electrically connected to a common rail derived from the Power Supply circuits.

Note that voltages specified on the circuit diagrams are in all cases nominal values, the actual values being dependent upon the load offered to the supply by the specific circuit. Inconsistencies between actual measured values and those quoted should not, therefore, be regarded with suspicion without considering other symptoms of possible unserviceability.

1.2.2 Split Pads

Split pads are used to provide a means of isolating various parts of the circuit for fault diagnosis. They are simply bridged with solder, open circuit being effected by removing the solder. It should be noted that excessive heat applied during this operation could damage the solder trace - a small, low wattage iron should be used.

1.2.3 Test Points

A further aid to rapid circuit check-out is the provision of test pins. These are indicated on the circuit diagrams and clearly marked on the pcb's.

1.3 PRINCIPLES OF OPERATION

The 7081 and 7071 employ an A-to-D Converter, which transforms the input voltage to a time analogue. This in turn is split into discrete, equal length time units, which are counted and the result displayed as a numerical indication of the measured quantity.

The V-to-T converter produces a pulse train, the pulse width being variable and proportional to the magnitude of the input signal. The pulses gate the output of a fixed frequency clock into a counter, over a time period which can be selected by the user. At the end of the time period, the total accumulated in the counter is a measure of the input during that time. An integrating technique is used whereby the total count is divided by the number of gating pulses used. The result obtained is displayed as a direct reading of the measured quantity.

Since the total count is much longer when operating at the longer integration times, the counter requires more capacity. This results in an increase in scale length and it follows that the display sensitivity is improved hand-in-hand with the increased measurement resolution.

1.4 FUNCTIONAL DESCRIPTION

The circuits of the 7081 and 7071 can conveniently be divided up into four major functional sub-divisions:

* Signal Conditioning
* A-to-D Converter
* Digital Section
* Power Supply

An input is processed by the Signal Conditioning circuits, which convert all measured quantities into a dc voltage, scaled to a level suitable for further processing. Input protection, reference and guard circuits are included in this sub-section.

The correctly scaled dc signal is converted to a train of digital pulses by the A-to-D Converter, these pulses being used to gate the output of a Clock circuit.

Control of the measurement conversion and timing of the control sequences by the microprocessor set are two important functions of the Digital Section. It also contains the reversable counters which accumulate the gated clock pulses, and the latches which shift the counter contents to the databus.

The power supply provides all dc power for the instrument analog and digital circuits.

1.4.1 Signal Conditioning

The A-to-D Converter is capable of handling dc volts only, regardless of the measurement being taken. Therefore, the Signal Conditioning circuits convert the input to a dc voltage level. Once converted, the input signal is applied to an amplifier, the gain of which is determined by the range on which the instrument is operating. The amplifier output is compared with the instrument's reference and both signals are applied to the A-to-D Converter.

1.4.2 A-to-D Converter

The analogue input is converted to digital form by a circuit which produces a pulse train - the width of the pulses is proportional to the magnitude of the input. This technique is known as voltage-to-time conversion, the method employed being a variant in which "time" is in fact the difference between two distinct time periods. It is this differential which is used to control the number of clock pulses finally accumulated in an up/down counter in the Digital Section.

1.4.3 Digital Section

The Digital Section comprises the phase comparator which produces the pulses that are counted to digitally measure the applied input; the microprocessor clock which supplies timing and synchronising signals for the digital circuits and a microprocessor set for controlling and shifting data.

The microprocessor set consists of two Central Processing Units and their associated memory devices as shown in Figure 1.1.

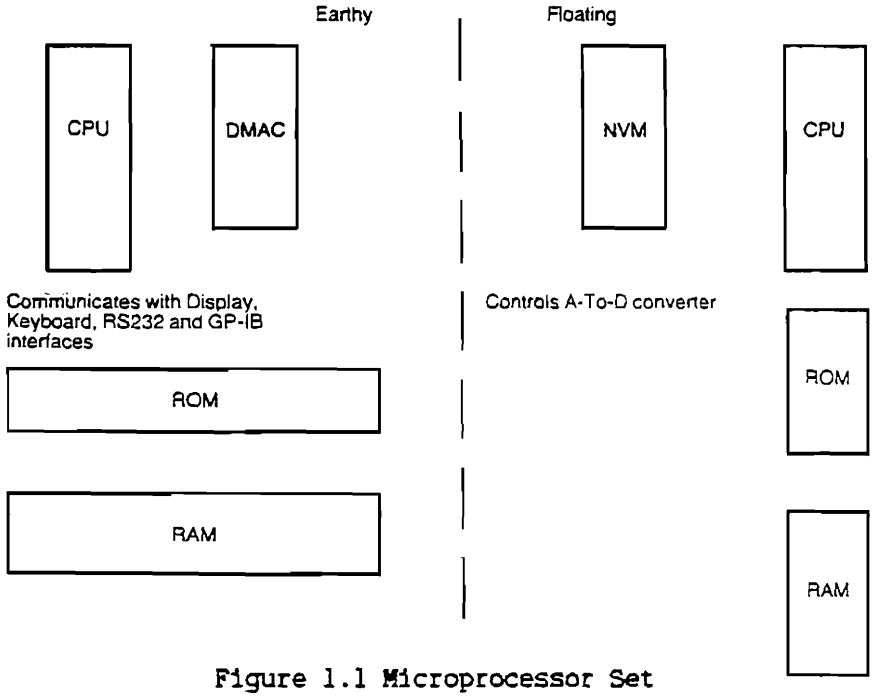


Figure 1.1 Microprocessor Set

The 'Floating' processor controls the A-to-D Converter and the range/mode drive circuits, and communicates with the Non-Volatile Memory (NVM) and the 'Earthy' processor. It has its own internal Read Only Memory (ROM) but also utilises external Random Access Memory (RAM) and ROM.

The 'Earthy' processor performs the following functions:

* communicates with the 'Floating' processor to command measurements.
* communicates with the Display, Keyboard, RS232 and GP-IB interfaces.
* calibrates results.
* controls the processing of results.
* controls the storage of results.

It has its own ROM and RAM set. In addition, some of the data movement is handled by a Direct Memory Access Controller (DMAC).

1.4.4 Power Supply

The Power Supply features two pulse width-modulated switching regulators to provide both the "earthy" and "floating" supply rails. A mains transformer is used to connect the rear panel ac input to the regulators through full-wave rectifiers. A Power Fail Detect circuit is also included.

Note: The analogue boards (printed circuit boards 5 and 6) form a calibrated set and may be used with any other digital boards (and vice versa) provided that the software fitted is of the same issue and status. This is possible because the Non-Volatile Memory (NVM), which holds the calibration constants, is located on the analogue boards.

1.5 FAULT DIAGNOSIS GUIDE

Owing to the complex nature of 7081/7071 circuits it is virtually impossible to document fully all fault conditions that might arise. However, it is possible to quickly narrow down a fault condition to a particular PCB, and sometimes to an area of just a few components. The following pages should prove especially useful since the comments are based firmly on the experiences of the 7081/7071 Test and Service Personnel.

Note: Sometimes an instrument may be suspected of being faulty because it gives 'wrong' or unstable reading. In cases like these, the fault quite often turns out to be a poor understanding of measurement techniques by the user. Before dismantling the 7081 or 7071, make absolutely certain during measurement or calibration that the proper precautions are taken to guard against interference, thermal emfs, high resistance leads, etc.

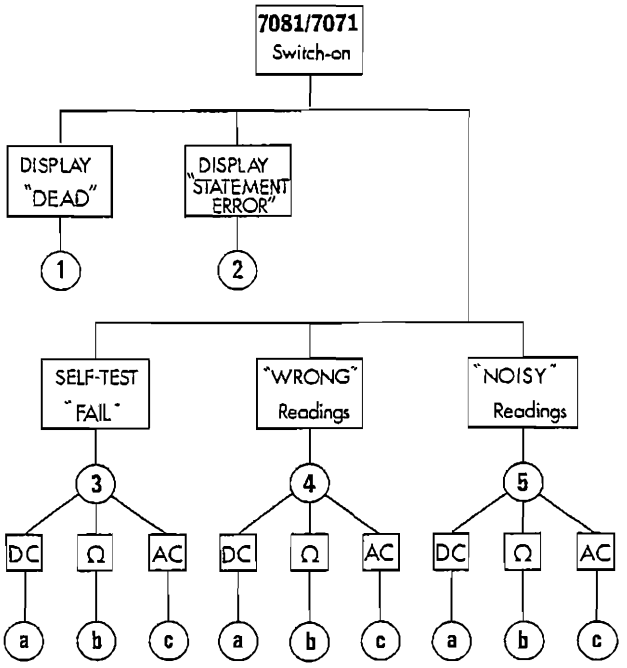


Figure 1.2 Fault Diagnosis Flow Chart

1.5.1 Display 'Dead'
Check the +5V rail at D58 cathode, PCB3.

If the indicator lamps are also blank the fault could lie on PCB3 or PCB4. If substitute boards are available, use these to narrow down the search. The failure could be a MPU, DMA, RAM or ROM fault. Suspect ICs 401, 402, 406 to 411, 430, 412 to 415, or a display system fault on PCB3.

If the display shows incorrect symbols and figures, a PCB1 failure should be suspected.

1.5.2 Display Statement Error
A correctly calibrated instrument must always show a RESUMED statement on power-up. Under error conditions, the following statements might be seen:

INITIALISED - This indicates that the NMI routine for retaining the history file at power-down was incorrect. Check the power supply of IC56; the battery circuit of PCB4 RAM.

CAL INCOMPLETE - This indicates that the NVM on PCB5 has not received all calibration constants following a calibration routine.

NVM FAIL - This could indicate a failure of the NVM circuitry, or of IC804. A spare NVM would prove useful here.

WAIT @ F - This could indicate a communication failure between the 'floating' and 'earthy' PCBs. Check IC9, IC10, IC11 or the clock of PCB3. On PCB5 check IC801, IC803, IC826 or the clock.

MAINS FAULT - This indicates that a mains character has not been received from the earthy side and would normally indicate a PCB5 failure. Check IC303, IC834, IC801. If the fault still persists, PCB3 must be suspected.

@F - This indicates that the WAIT @ F stage has been passed, but a fault probably exists in the 'floating' link. That is, in terms of the information flow between the 'earthy' and 'floating' circuits. The fault could lie on PCB3 or PCB5. Rarely, PCB4 or PCB1 could be faulty.

The fault is often due to a temperature sensitive IC and manifests itself after the instrument has been switched on for some time. It is difficult to localise this fault but it is more prevalent on PCB5. Check the floating logic sheet or V-T converter (sheet 1).

Suitable replacement boards and/or judicious use of a tin of freezer spray would not go amiss here.

1.5.3 Self-Test Fail

A fail here usually indicates a major fault in the PCB 5 analogue section.

(a) DC

A fail of the 0V test probably indicates a faul in the V-T converter stage (sheet 1), IC201, or the circuits associated with the RATIO circuit (sheet 3) of the integrator input.

If the 0V test passes but shows a fail at 10V, a fault could lie in the input amplifier which prevents the 10V reference level from being fed to the V-T converter.

(b) OHMS

If a kΩ fault is indicated check that there is:

(i) approximately 20V across R604
(ii) approximately 6V across F609.

If either of these is wrong suspect IC601 or IC602. Failing these, check TR610 and the circuits around IC604.

(c) AC

Where an AC fail is indicated it is beneficial to check the AC level at TP705 to see whether the fault lies in the AC buffer or the AC converter. As an approximation, with 1V, 1kHz applied to 7081/7071 input, range 1V, TP705 should be 1V rms. The corresponding level out of the converter should be 5VDC (@ TP757).

1.5.4 'Wrong' Readings

(a) DC

With a shorting-plug applied to the instrument input check the ranges 10V to 0.1V. If the indicated zero error gets larger as the range is reduced this indicates a fault in the chopper channel of the input amplifier. Check operation of IC101, IC104, IC401, IC404, IC405, and TR404.

If a constant error appears on all ranges suspect the V-T converter (sheet 1), IC201 or the input switching circuits to SP201.

If the zero readings are correct but the scaling of the readings is wrong (with an input applied) firstly check that the correct level is being applied to the V-T converter at SP201. If the level is correct check the reference voltage supplies (±10V).

(b) OHMS

A failure to provide correct resistance readings is usually due to incorrect levels at TP601 or TP603. The fault could lie in IC601, IC602, IC605, TR601, or TR602. If these are fine then check IC604, IC606, TR610, TR605, and D605.

(c) AC

Reference to section 6.7.1 can usually indicate the area of failure. If the system is basically working but the readings are incorrect then the various gain defining resistors could be suspect: R725, R750, R751a and R751b.

1.5.5 Noisy Readings

(a) DC

Noisy readings on the 0.1V range are especially indicate of a noisy component in the input amplifier. Suspect component in the input amplifier. Suspect components D403, TR401, TR412, IC401. If the 10V range is also noisy (with short circuited input) then IC201 is a likely cause.

(b) OHMS

Noisy readings on the kΩ ranges when the DC ranges are normal could be caused by IC601, IC602, IC603. Also D601, D602, D616, D617 could produce noise if they become 'leaky'.

(c) AC

If the AC readings are noisy the switching circuits around TR758 and TR759 could be at fault. Unstable readings could be produced by a breakdown by any of the FETs TR770 to TR779. By applying an input of approximately 1V @ 1khz to input, and heating up the FET's individually with a hot-air gun (never apply direct heat to a component!), the fault may be quite quickly found by examining the display for any unreasonable large change in value.

The setting of the balance control RV751 is quite critical to ensure a minimum of noise on the AC readings. See Test Procedure for the correct adjustment of this pot.

CHAPTER 2

Printed Circuit Board 1

CONTENTS

2.1 INTRODUCTION

This printed circuit board permits processed data to be digitally displayed and the front panel annunciators to be lit as required.

2.2 DATA INPUT

Processed data enters the printed circuit board via PL101, pins 14 to 21, and is applied to octal D flip-flops IC101 and IC102. IC101 is clocked by EDATSTB- and IC102 by ODATSTB-. On the rising edge of the clock signals the data is transferred to the Q5 outputs of IC101 and IC102 from where it is fed to both the Annunciator and the Display circuitry.

2.3 ANNUNCIATORS

The Q outputs of IC101 and IC102 are applied to the D inputs of IC110/111 and IC112 respectively. IC110 to 112 are controlled by the BLANK+ signal such that, when BLANK+ goes to logic 0, a rising clock edge causes the D inputs to be transferred to the Q outputs to light the LED annunciators. IC111 and IC112 are clocked by one $\overline{Q}$ output of IC106 and IC110 is clocked by the other $\overline{Q}$ output.

2.4 ANNUNCIATOR CLOCK SIGNALS

IC106 is driven by the Serial Data Ouput from Display drivers IC107 and IC108.

The serial data is applied to the D input of IC106 and transferred, upon a rising 4800Hz clock edge, to the Q output. The inverse of the data signal also appears at the $\overline{Q}$ output and is used directly to clock IC111 and IC112. The Q output is applied to the D input of the second stage of IC106. On the next rising clock edge, the inverse of the original IC106 input appears at the $\overline{Q}$ output and is used to clock IC110. IC110 is delayed by one 4800Hz clock cycle with respect to IC111 and IC112.

IC110 to IC112 are used to drive the annunciators indicated in Table 2.1.

Table 2.1 Annunciators

IC	Annunciator
110	NULL ON, SAMPLE, TRACK, TALK, LISTEN, PROGRAM
111	5x9, COMPUTE, LOCAL, SRQ, 6x9, 7x9, 8x9, DIG FILT; [7081] 4½, COMPUTE, LOCAL, SRQ, 5½, 6½, 7½, DIG FILT; [7071]
112	$\overline{V---}$, V~, V~ $\overline{+---}$, Ω, ~FILT, TRUE Ω, RATIO, AUTO

2.5 DISPLAY

The Q outputs from IC101 and IC102 are applied, via Buffers IC104 and IC105, to the Display, DS101. This display is controlled, via its grid inputs, by Display Drivers IC107 and IC108.

DSPDAT+ is applied to the Serial Data Input of IC108. On a rising edge of the 4800Hz signal, DSPDAT+ is transferred to IC108's internal shift registers. When the BLANK+ signal falls to logic 0, the data signal is passed out of the device, via its parallel output pins, to the grid inputs (G1 to 10) of DS101.

The Serial Data Output from IC108 is applied to the Serial Data Input pin of IC107. IC107 operates in exactly the same fashion as IC108 except that there is a delay, with respect to IC108, of one clock pulse. The parallel outputs from IC107 are applied to the grid inputs (G11 to 20) of DS101.

Serial Data Output from IC107 is applied to the D input of IC106 as described under 'Annunciator Clock Signals'.

The anode inputs to DS101, i.e. inputs a to n, ',' and '.', denote which segment of the display digits is to be lit (see Figure 2.1). The grid inputs denote which of the twenty digits are to be lit.

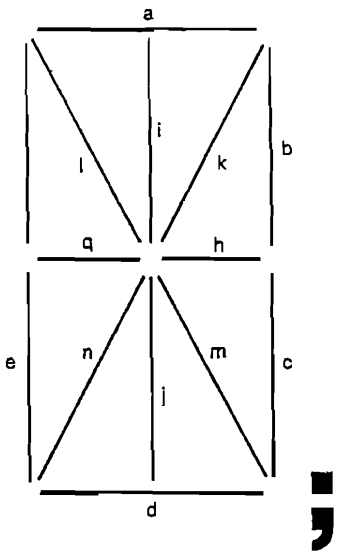


Figure 2.1 Display Segments

DS101 lights when the grid and anode inputs are positive with respect to the filament inputs. F1 and F2 supply the filament inputs to DS101.

CAUTION: The outputs of IC107 and IC108 are rated at 40V maximum. Care must be taken when probing these ICs not to connect an output to an input pin as the inputs are rated at only 5.5V maximum.

CHAPTER 3

Printed Circuit Board 3

CONTENTS

3.1 INTRODUCTION

Printed circuit board 3 contains the main power supplies; the floating link, which provides the interface between the 'earthy' and 'floating' circuits; the microprocessor clock and reset circuits; and the RS232, Minate, Keyboard and Display interfaces. Figure 3.1 shows the interconnection between these circuits.

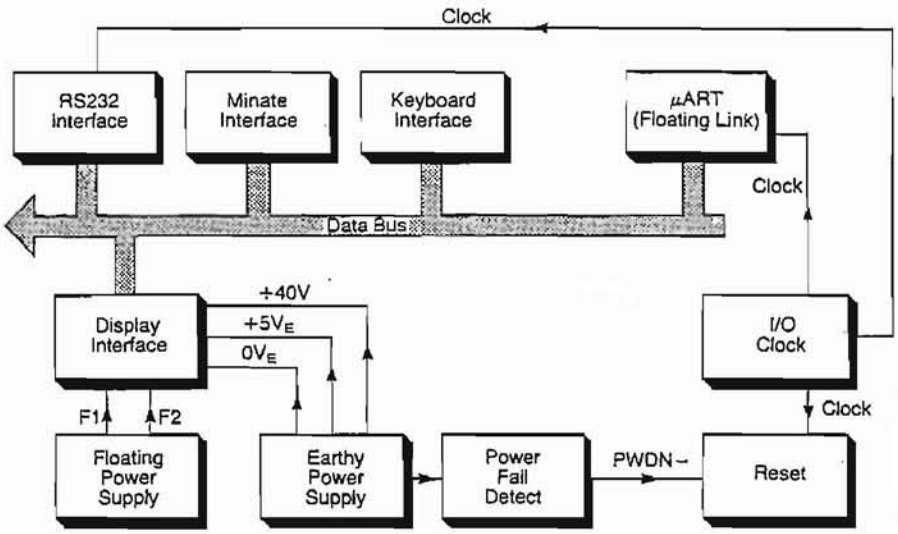


Figure 3.1 Printed Circuit Board 3 Interconnections

3.2 FLOATING LINK (Sheet 1)

A 7081 or 7071 is controlled by two microprocessors, one on the floating side and one on the earthy side. The two processors communicate through a two-wire serial link, which is optically isolated by IC10 and IC11. On the earthy side, the link is serviced by a UART, IC9. This operates under DMA control when receiving and under program control when transmitting.

3.2.1 Link Handshake

To ensure that the earthy and floating processors stay in step, all messages sent through the link are acknowledged. The processor which receives a message replies with a single character.

An exception to the single character reply occurs when new commands are sent by the earthy processor to the floating processor. In this case the single character is replaced by the new command. New commands are sent to the floating processor only when it is expecting an aknowledgement.

3.2.2 Wakeup

To keep the earthy side aware of the overload status of the analogue circuitry when the instrument is not measuring, the floating side prompts single glug integrations at 50ms intervals. Range information is sent also so that the earthy side can keep track of the analogue range during auto-range operation.

3.2.3 Negative Acknowledge

Most errors that may occur on the floating link can be detected by the receiving processor, which responds with a negative acknowledgement.

The DMA is allocated a buffer for the received characters and if an attempt is made to use more buffer space than that allowed (buffer overflow) a 'float full' interrupt (DMA FL INT-) is generated. A 'float full' interrupt is also generated if a negative acknowledgement (which is a request to resend) is received from the floating side. The two error conditions are distinguished by the state of the 'float receive single' flag, which is set if a single character is expected (negative or positive acknowledgement). A buffer overflow results in a negative acknowledgement. A negative acknowledgement sets a flag which prompts a resend of the last message after a finite period of time.

The receipt of an End of String (EOS) generates an EOS Interrupt, which causes the received message to be inspected. Each character is placed in the buffer with a status byte that indicates whether or not the character was received correctly.

3.2.4 Power Up Sequence

The floating side is pushed out of reset by a character sent from the earthy side. This then displays WAIT @ F.

As part of its reset procedure, the floating side determines the mains frequency and sends one of three characters denoting the frequency to the earthy side. If the character sent is unrecognised, the system goes to the floating reset state and MAINS FAULT is displayed.

If the mains character is valid, the floating side begins by presetting the hold-off counter. To do this it forces a hold-off message to the earthy side. Instead of giving a positive acknowledgement the earthy side sends a new command, i.e. DUMP, NVM. This starts a succession of messages from the floating side, all of which are acknowledged. An NVM or calibration state message is then displayed. Or, if the NVM DUMP has been successful, RESUMED or INITIALISED is displayed.

3.3 RS232 INTERFACE (Sheet 1)

The RS232 Interface circuit consists of the asynchronous communications interface adaptor (ACIA), IC19, buffers and drivers, IC4, IC25, and interface connector SK3.

The ACIA (IC19) provides a means of efficiently interfacing the microprocessor on printed circuit board 4 to devices requiring an asynchronous serial data format.

In the transmission of asynchronous data, no pre-synchronised clock is provided with the data. Also, the gaps between the data characters require that synchronisation be re-established for each character. Therefore, the receiving device must be capable of establishing bit and character synchronisation from the characteristics of the asynchronous format. Each character consists of a specified number of data bits preceded by a start bit and followed by one or more stop bits. The purpose of the start bit is to enable a receiving system to synchronise its clock to this bit for sampling purposes and thereby establish character synchronisation. The stop bit is used as a final check on character synchronisation.

The microprocessor processes eight bit parallel bytes that do not include start and stop elements. Therefore, serial data received in an asynchronous format must be converted to parallel form with the start and stop elements stripped from each character. Likewise, in order to transmit serial data, the parallel data byte from the microprocessor must be converted to serial form with the start and stop elements added to each character. This serial-to-parallel/parallel-to serial conversion is the primary function of IC19.

Data flow between the microprocessor and IC19 is via 8 bidirectional lines, D0 through D7, that interface with the microprocessor data bus. The direction of data flow is controlled by the microprocessor via the Read/Write (R/$\overline{W}$) input to IC19.

IC19 is enabled by a logic 0 signal ($4800) applied to its $\overline{CS2}$ input. Specific registers within the ACIA are selected by the A0 signal applied to its Register Select (RS) input. The microprocessor can read or write into the internal registers by addressing the ACIA, via the address bus, using these two input lines.

The microprocessor also applies a timing signal to the ACIA via the Enable input. The Enable (E) pulse conditions the ACIA's internal interrupt control circuitry and times the status/control changes.

The RS232 side of IC19 is configured as a DCE (data communications equipment) and is normally connected, via SK3, to a DTE (data terminal equipment) without an intervening modem link. Pin 2 of SK3 is marked TxD to indicate the path of data transmitted by a terminal to the instrument; Pin 3 is marked 'RCVD' to indicate the path of data received by a terminal from the instrument. Pins 5, 6, 8 and 20 are linked together inside so that a terminal sending DTR (data terminal ready) receives back the enabling states of CTS (clear to send), DSR (data set ready) and DCD (data carrier detect) whether the 7081 or 7071 is ready or not.

The Tx and Rx Clock inputs are both tied to the output of the MPU clock circuit on IC8 pin 6.

IC19 requests an interrupt to the microprocessor via its IRQ- output, which is applied to the Interrupt circuitry of IC13 as RS232INT-.

The pin/signal assignments for the RS232 connector are given in Table 3.1.

Table 3.1 RS232 Connector Pin/Signal Assignments

Pin No.	Signal
1	Ground
2	Transmit Data (TxD) - Input to 7081 or 7071
3	Receive Data (RCVD) - Output from 7081 or 7071
5	Clear to Send (CTS)
6	Data Set Ready (DSR)
7	0V
8	Data Carrier Detect (DCD)
20	Data Terminal Ready (DTR)

3.4 MINATE INTERFACE (Sheet 1)

The Minate Interface consists of peripheral interface adaptor (PIA) IC20, MOSFETs TR6 and TR7, and interface connector PL4.

When IC20 is enabled by a logic 0 $5400 signal to its $\overline{CS2}$ input the data flows between the microprocessor and IC20 on the data bus, via eight bi-directional data lines (D0 through D7). The direction of data flow is controlled by the microprocessor via IC20 Read/Write (R/$\overline{W}$) input. Two addressing inputs RS0 and RS1 are used in conjunction with a control bit within the PIA for selecting specific registers in IC20. The microprocessor uses these address lines and the R/$\overline{W}$ signal to write into the PIA's internal registers.

The microprocessor applies a timing signal to IC20, via the enable input. This signal conditions the PIA's internal interrupt control circuitry and also controls the timing of the peripheral control signals.

The interface side of the PIA includes two 8-bit bi-directional data buses (PA0-PA7 and PB0-PB7) and four Interrupt control lines (CA1, CA2, CB1 and CB2). All of these lines are TTL compatible. In addition, all lines serving as outputs on the B side of the PIA can supply up to 1mA of drive current at 1.5V.

The outputs of IC20 are used as follows:

* lines PB0 to PB7 are fed to the N.V. Clock circuit,
* lines PA0 to PA7 and CA2, CB2 are fed to the Minate Connector,
* line CA2 is supplied to the gate of MOSFET TR6 to turn it on,
* line CB2 provides the same function for MOSFET TR7.

The pin/signal assignments for the Minate connector are given in Table 3.2.

Table 3.2 Minate Connector Pin/Signal Assignments

Pin No.	Signal
1	1
2	2
3	4
4	8
5	10 Device Control
6	20
7	40
8	80
9	Contact closure remote trigger
10	Out of Limit high
11	Out of Limit low
12	0VE
13	+5V
24	TTL compatible digitise complete signal
25	1kV probe enable

3.5 KEYBOARD INTERFACE (Sheet 1)

The Keyboard Interface consists of peripheral interface adaptor (PIA) IC21 and BCD to decimal decoder IC23.

When IC21 is enabled by a logic low $4C00 signal applied to its $\overline{CS2}$ input the data flows between the microprocessor and IC21 on the data bus, via eight bi-directional data lines (D0 through D7). The direction of data flow is controlled by the microprocessor via IC21 Read/Write (R/$\overline{W}$) input. Two addressing inputs, RS0 and RS1, are used in conjunction with a control bit within the PIA for selecting specific registers in IC21. The microprocessor can read or write into the PIA's internal registers by addressing the PIA via the system address bits using these input lines and the R/$\overline{W}$ signal.

The microprocessor applies a timing signal to IC21 via the enable input. This signal conditions the PIA's internal interrupt control circuitry and also controls the timing of the peripheral control signals.

The interface side of the PIA includes two 8-bit bidirectional data buses (PA0 to PA7 and PB0 to PB7) and one Interrupt control line, CB2.

Outputs PB0 to PB3 of IC21 are connected to inputs A, B, C and D of IC23, the 0 to 9 outputs of which are connected directly to the instrument keyboard. Table 3.3 shows the logic states of these pins relative to the A to D inputs. Outputs PB0 to PB3 are also connected to IC26 the N.V. clock chip.

The inputs of IC21 are used as follows:

* Line PB4 (1kV range select) is connected to the Minate interface connector.
* Lines PB5 to PB7 are connected to the RS232 switch to enable reading of the baud rate set.
* Lines PA0 to PA4 are connected to the keyboard.
* Line PA5 is connected to the calibration switch on the instrument front panel.
* Lines PA6 and PA7 are connected to switch S1 for stimulus program activation.
* Line CB2 is connected to the Minate interface connector.

Refer to Table 3.4 for a listing of the Keyboard Matrix Connections.

Table 3.3 IC23 Logic States

D	C	B	A	0	1	2	3	4	5	6	7	8	9
L	L	L	L	L	H	H	H	H	H	H	H	H	H
L	L	L	H	H	L	H	H	H	H	H	H	H	H
L	L	H	L	H	H	L	H	H	H	H	H	H	H
L	L	H	H	H	H	H	L	H	H	H	H	H	H
L	H	L	L	H	H	H	H	L	H	H	H	H	H
L	H	L	H	H	H	H	H	H	L	H	H	H	H
L	H	H	L	H	H	H	H	H	H	L	H	H	H
L	H	H	H	H	H	H	H	H	H	H	L	H	H
H	L	L	L	H	H	H	H	H	H	H	H	L	H
H	L	L	H	H	H	H	H	H	H	H	H	H	L

L = logic low
H = logic high

Table 3.4 Keyboard Matrix Connections

Column / Row		PL2 Pin Numbers							
		1	2	3	4	5	11	12	13
PL2 PINNOS	6	V	RATIO	TRU Ω	AUTO	DIG FILT	NULL ON	HIST →	SAMPLE
	7	Ω	⎓ ~+---	~ FILT	PROG	SELF TEST	INITIAL-ISE	MEM	
	8	V~	⎓ V---		COMPUTE	LOCAL	SRQ		
	9	6 x 9	5 x 9	Δ	7 x 9	8 x 9	NULL	HIST ←	TRACK

3.6 **DISPLAY INTERFACE** (Sheet 1)

Display data from the data bus (lines D7 to D0) is applied through inverting line drivers (IC22) to the Display, via PL6 pins 14 to 21. Outputs $\overline{D6}$, $\overline{D5}$, $\overline{D4}$, $\overline{D1}$ from IC22 and D7, D3, D2, D0 from the data bus are applied to NAND gate IC24. If the EOS character appears during a receive DMA Bus cycle, the output from IC24 (end of string) is applied to IC3 in the interrupt circuitry to generate an EOS INT via IC16 Q output.

Chapter 4 includes a full description of the Display Interface operation in relation to the DMA.

Refer to Figure 3.3 for the display timing.

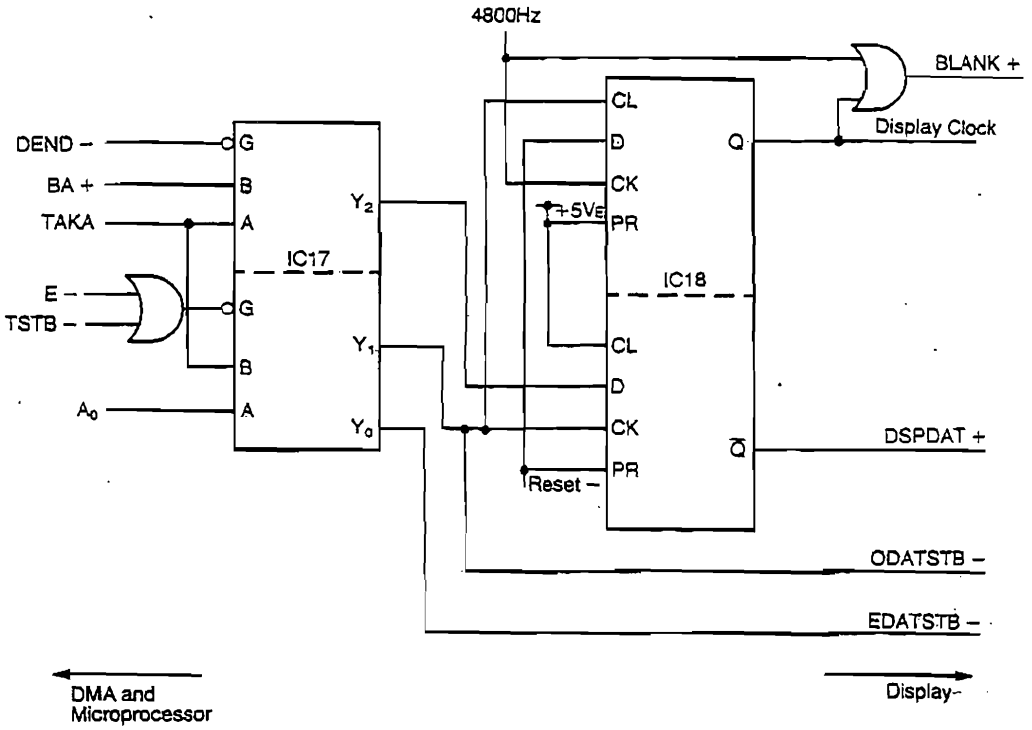
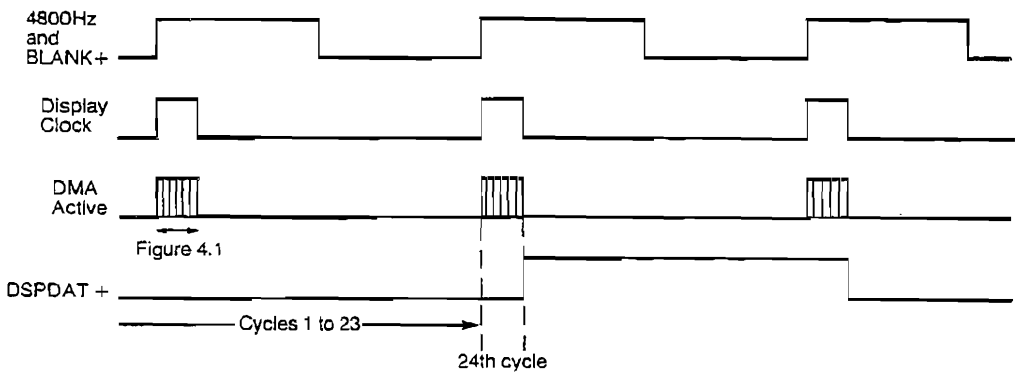


Figure 3.2 Display Interface



If the DMA fails, Display Clock will remain at logic 1 and the Display will be blanked

Figure 3.3 Display Interface Timing

3.7 I/O CLOCK (Sheet 1)

A 1.2288MHz clock signal is generated by crystal X1, Inverters IC1 and associated components, and applied to the Clock input of part 1 of binary counter IC2. IC2 divides the signal by 8 to give 153.6kHz at its Q_C output and by 16 to give 76.8kHz at its Q_D output. The QC output signal is applied to IC8 D7 input, and the QD output signal to the D6 input of IC8, and to the Clock input of divider IC7.

IC7 divides the 76.8kHz signal to produce the following frequencies:-

38.4kHz to IC8 D5 input,
19.2kHz to IC8 D4, via inverter IC1 and to IC2 part 2 Clock input,
9.6kHz to IC8 D3 input,
4.8kHz to IC8 D2, via inverter IC1,
2.4kHz to IC8 D1 input,
37.5Hz to provide a Clock signal for the Reset circuitry.

The 19.2kHz signal is applied to IC2 part 2. The QA and QB outputs are ANDed together in IC3 and the output applied to another part of IC3 along with IC2 part 2 Q_D output. The output of this second section of IC3 is fed back to the clear input of IC2 part 2. This feedback causes IC2 part 2 outputs to be reset to zero every 11th clock cycle (see Figure 3.4). The Q_C output of IC2 part 2, i.e. 1745Hz, is passed to IC8 D0 input.

IC8 output, to the RS232 interface, is selected by the values applied to its A, B and C inputs. These inputs are taken from the setting of the RS232 baud rate switch S1.

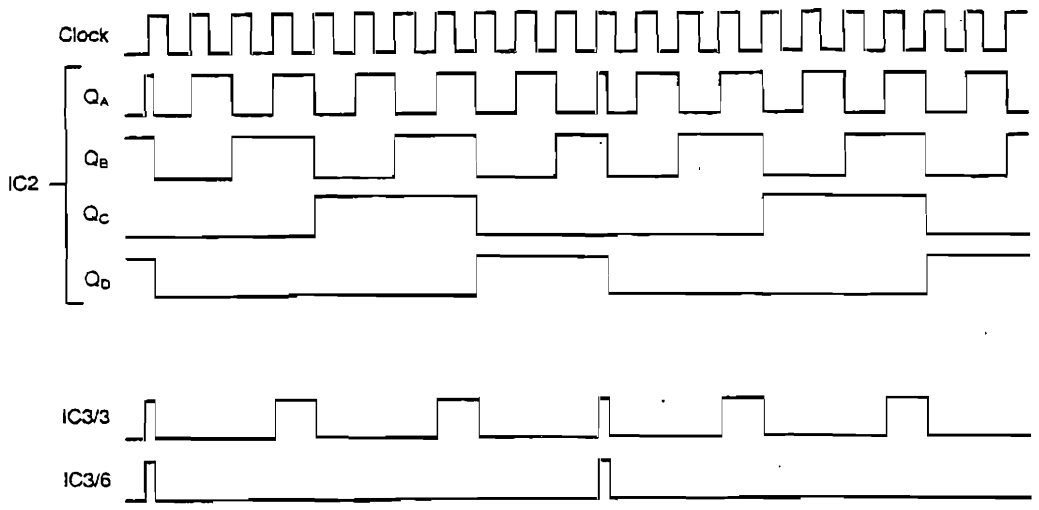


Figure 3.4 I/O Clock Timing

3.8 RESET (Sheet 1)

The microprocessor reset circuit consists of binary counter IC5 and its associated components.

When there is no power loss to the instrument, i.e. PWDN- is at logic 1, IC5 is enabled to count, clocked by the 37.5Hz signal from the I/O Clock circuit. On the tenth count IC5 Q_A output will rise to logic 1 and enable a Reset pulse to the microprocessor set via IC6 pin 3. However, under normal operating conditions the microprocessor (IC401 on board 4) periodically clears IC5 by addressing $4C00 to disable the count. If the microprocssor does not address $4C00 for approximately 130 to 160 milliseconds, reset is enabled.

When a power down occurs, the microprocessor must have sufficient time to run a checksum of its memory contents, etc, before it receives a reset command. The PWDN- signal is therefore applied to capacitor C2 and whilst this capacitor charges up 'Reset-' is held off. The time constant set by C2 and R4 allows sufficient time for the microprocessor to save its memory contents.

If Reset is disabled at switch S1, the microprocessor will not be reset regardless of the state of the power fail input.

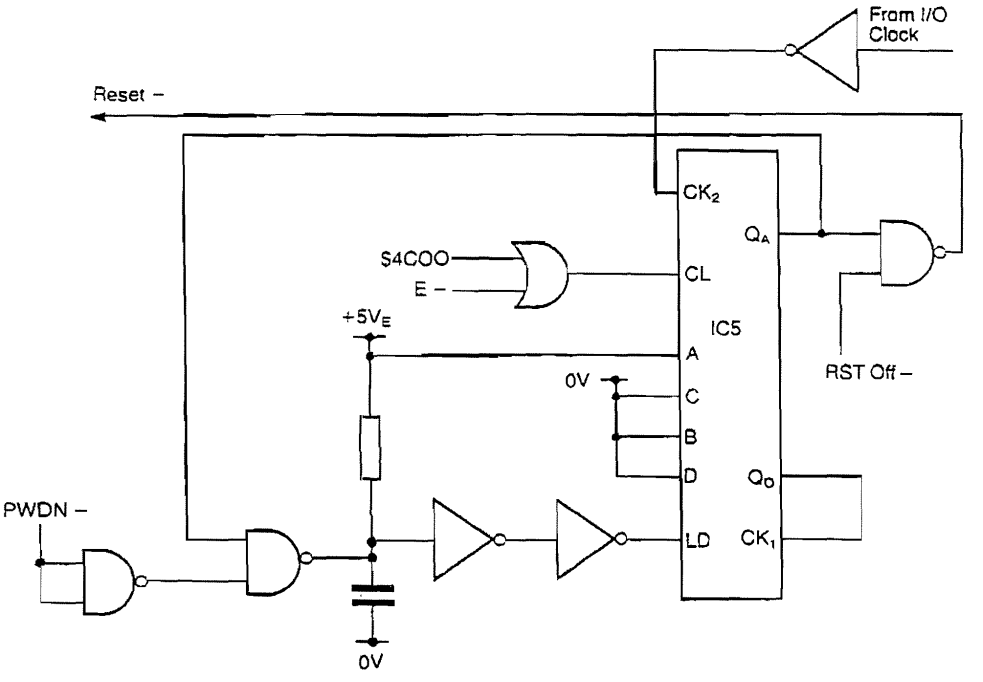


Figure 3.5 Reset Control

3.9 POWER SUPPLIES (Sheet 2)

The instrument is fitted with a multi-purpose mains input unit mounted on the rear panel. This contains the mains input socket, fuses, voltage selector and filter. Switches a to e set the voltage to be supplied to transformer T1.

3.9.1 Earthy Power Supply

The earthy power supply generates ±12V, +5V and +40Vdc for the earthy circuits, and includes a power fail detect circuit.

±12V Supply

The ac voltage is applied, via PL52, to bridge rectifier D54 where it is full-wave rectified. The rectified output is smoothed by capacitors C59 and C60, and passed through resistors R73 and R74. Zener diodes D60 and D61 finally drop the voltage level down to ±12V.

+40V Supply

The ac voltage from PL52 is passed to bridge rectifier D55 via voltage doubling capacitors C56 and C57. The rectified output is smoothed by C58 and applied to 5V regulator IC52. The 30V zener diode D56, between the +5V rail and the G input of IC52, supplies +35V. The +5V added to this by IC52 gives the +40V required. C61 provides high frequency stability.

+5V Supply

The +24V unregulated output from D54 is applied to the +5V circuit at TR54. Refer to the simplified diagram in Figure 3.6.

When TR54 is closed, it is in saturation at a voltage drop of approximately 1V. When TR54 is opened L52 drives its left-hand end negative until diode D57 latches in and conducts; initially at the same instantaneous current that had been flowing in TR54 just prior to its opening. The voltage at point (A) is approximately equal to V_{in} for the time TR54 is closed (T_{on}) and approximately equal to 0V for the time TR54 is open ($T-T_{on}$). The filter L52, C67 averages out the peak-to-peak ripple voltage of V_{in} and produces at V_o, a constant dc output voltage whose value is given by:

$$V_o = Vin \frac{(Ton)}{T}$$

Output voltage Vo is regulated by controlling the ratio of Ton/T. The frequency T is fixed and T_{on}, the duration of the "on" time for TR54, is varied by pulse width modulator IC55, turn-on pulse amplifier TR56, TR53 and associated components.

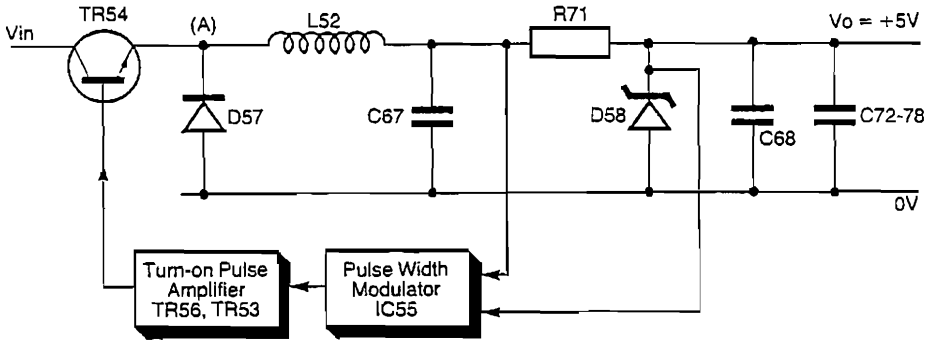


Figure 3.6 +5V Supply Simplified Diagram

Zener diode D58 provides over-voltage protection, capacitor C68 removes voltage spikes and capacitors C72 to C78 provide local high frequency decoupling. R71 provides a current limit of about 2A via IC55.

3.9.2 Power Fail Detect

IC56, D59 and associated components provide a power fail detect circuit the output of which is applied to the reset circuit on Sheet 1.

When the output from capacitor C59 falls to less than +21V the ouput of comparator IC56 falls to the negative rail value. This makes PWDN- equal to logic 0.

3.9.3 Floating Power Supply

The ac voltage from PL51 is applied to bridge rectifier D51. There it is full-wave rectified and smoothed by C51 before being applied to transistor TR52.

When TR52 is closed, it is in saturation at a voltage drop of approximately 1V. When TR52 opens L51 drives its left-hand end negative until D52 latches in and conducts. The voltage at point (B) is therefore approximately equal to V_{in} during the time TR52 is closed (Ton) and approximately equal to 0V during the time TR52 is open (T-Ton). Filter L51, C55 averages out the peak-to-peak ripple voltage of Vin and produces at Vo, a constant dc output voltage given by

$$V_o = Vin \frac{(Ton)}{T}$$

Output voltage Vo is regulated by controlling Ton, the duration of the 'on' time of TR52, via Pulse Width Modulator IC51, Turn-on Pulse Amplifier TR55, TR51 and associated components.

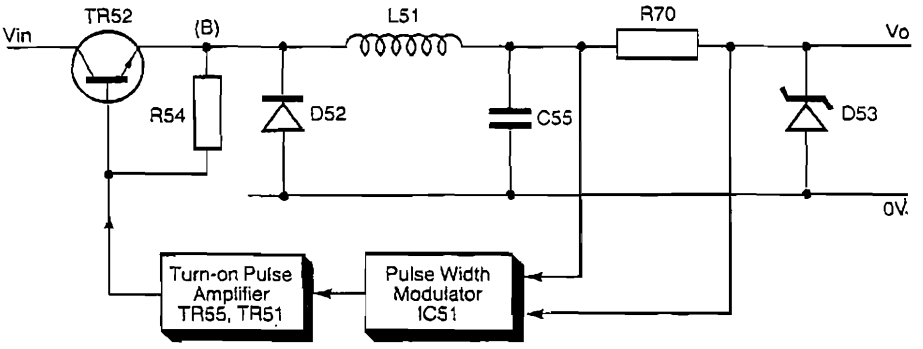


Figure 3.7 Floating Power Supply Simplified Diagram

Zener diode D53 provides overvoltage protection and R70 gives a current limit of about 2A.

A Vo value of $+5V_D$ is output to board 5 via SK51. $+5V_S$ is output to provide voltage sensing. The signal is returned to the circuit and compared with the reference value supplied to IC51.

SK51 also outputs 31V and 17V ac for use on board 5 the 'floating power supply circuit.

3.10 TEST POINTS

The following Test Points are provided to assist in printed circuit board fault-finding.

Table 3.5 Test Points

Test Point (TP)	Signal
1	TR52 Drain
2	0V
3	BLEEPER +
4	BLEEPER -
5	B1 -
6	B1 +
51	IC55 CT input
52	IC51 CT input
53	OVE
54	+5VD
55	OVF
56	+12V
57	OVE

CHAPTER 4

Printed Circuit Board 14

CONTENTS

4.1 MICROPROCESSOR SET

This circuit controls the other logic boards and consists of a microprocessor IC401, read only memory (ROM) IC412 to 415 and IC430, and random access memory (RAM) IC406 to 411.

IC401 contains all the functions required for multi-instruction processing; an arithmetic and logic unit; instruction decode and address registers; an instruction register; all of the clock and logic circuits required for timing and a full complement of data bus lines.

The microprocessor can modify its sequence of addresses on the basis of the results of previous operations. It can also store its own state when interrupted (IRQ) and continue from where it left off, when the Interrupt cycle is satisfied.

4.1.1 Read/write (R/$\overline{W}$)

This signal determines the direction of data flow between the microprocessor and its peripherals. When R/$\overline{W}$ is at logic 1, Read is selected; when at logic 0, Write is operative.

4.1.2 Interrupt Request (IRQ)

Several of the 7081 and 7071 internal and interface interrupt signals (DMA INT-, RS232 INT-, GP-IB INT- etc.) are combined in IC13 on printed circuit board 3 to form an Interrupt signal to the microprocessor. A logic 0 IRQ- from IC13 causes the microprocessor to initiate the interrupt sequence which begins with the microprocessor, after finishing its current instruction, testing the Interrupt Mask in the Condition Code Register and storing the contents of its programmable registers in memory locations specified by the Stack Pointer.

IC13 outputs a unique set of values on its A, B and C outputs, dependent upon which of the interrupts has been generated, to IC15 which buffers the signals and passes them onto the data bus. The microprocessor reads these signals from the data bus and thereby knows which interrupt requires service.

When the interrupt has been serviced, the microprocessor carries on from where it stopped.

4.1.3 Non-Maskable Interrupt (NMI)

The Non-Maskable Interrupt (NMI) is recognised by the microprocessor as soon as the NMI- line goes to logic zero. The interrupt is used as a power-failure sensor.

Except for the fact that it cannot be masked, the NMI interrupt sequence is similar to IRQ. After completing its current instruction, the microprocessor stacks its registers, sets the Interrupt Mask and fetches the starting address of the NMI interrupt service routine.

4.1.4 Reset (RESET-)

The Reset interrupt is used following power on to reach an initialising program that sets up system starting conditions. Therefore, the RESET- sequence is initiated by a positive going edge. Also, since it is normally used only in start-up mode, there is no reason to save the microprocessor contents on the stack.

4.1.5 Address Bus and Data Bus

The 16 line (A0 to A15) address bus controls data transfer between the microprocessor set, input/output interfaces, memories etc. The transference of data can take place over part of, or the whole of the 8 data lines of the data bus (D0 to D7).

4.2 ADDRESS DECODERS

The Address Decode circuit provides enable signals for the rest of the circuitry on this printed circuit board and consists of decoders IC416, 417 and 418, 2-to-1 Selector IC419 and associated components.

IC416 uses address lines A13, A14 and A15 to generate logic 0 enable signals to the ROM and address decoder IC417. Refer to Table 4.1.

Table 4.1 IC416 Operation

Address Lines			IC416 Output Signals					
A13	A14	A15	$E000 (IC412)	$C000 (IC413)	$A000 (IC414)	$8000 (IC415)	$6000 (IC430)	$4000 (IC417)
0	0	0	1	1	1	1	1	1
1	0	0	1	1	1	1	1	1
0	1	0	1	1	1	1	1	0
1	1	0	1	1	1	1	0	1
0	0	1	1	1	1	0	1	1
1	0	1	1	1	0	1	1	1
0	1	1	1	0	1	1	1	1
1	1	1	0	1	1	1	1	1

IC417 is enabled by a logic 0, $4000 signal from IC416 to produce logic 0 signals, from address lines A10 to A12, to PL401, IC419, IC420 and the DMA, IC402. Refer to Table 4.2.

Table 4.2 IC417 Operation

Address Lines			IC417 Output Signals							
A10	A11	A12	$5C00 (PL401, 40)	$5800 (PL401, 39)	$5400 (PL401, 33)	$5000 (IC419, 13,11)	$4C00 (PL401, 37)	$4800 (PL401, 36)	$4400 (IC420, 8)	DMA SELECT (IC402,2)
0	0	0	1	1	1	1	1	1	1	0
1	0	0	1	1	1	1	1	1	0	1
0	1	0	1	1	1	1	1	0	1	1
1	1	0	1	1	1	1	0	1	1	1
0	0	1	1	1	1	0	1	1	1	1
1	0	1	1	1	0	1	1	1	1	1
0	1	1	1	0	1	1	1	1	1	1
1	1	1	0	1	1	1	1	1	1	1

IC418 is enabled by the A14 and A15 signals from the address bus, i.e. as long as both these signals are the same, IC418 uses address lines A11, A12 and A13 to provide enable signals to the RAM. Refer to Table 4.3.

Table 4.3 IC418 Operation

Address Lines					IC418 Output Signals					
A11	A12	A13	A14	A15	$2800 (IC411)	$2000 (IC410)	$1800 (IC409)	$1000 (IC408)	$0800 (IC407)	$0000 (IC406)
0	0	0	0	0	1	1	1	1	1	0
1	0	0	0	0	1	1	1	1	0	1
0	1	0	0	0	1	1	1	0	1	1
1	1	0	0	0	1	1	0	1	1	1
0	0	1	0	0	1	0	1	1	1	1
1	0	1	0	0	0	1	1	1	1	1
0	1	1	0	0	1	1	1	1	1	1
1	1	1	0	0	1	1	1	1	1	1
X	X	X	1	1	Disabled					
X	X	X	0	1	Disabled					
X	X	X	1	0	Disabled					

The inputs to IC418, are also dependent upon links LK3 to LK8, which are, in turn, dependent upon the RAM fitted. Refer to Table 4.4.

Table 4.4 Links LK3 to LK8

RAM Fitted	Links Made					
	LK3	LK4	LK5	LK6	LK7	LK8
TC5516P or HM6117P	✓	-	✓	-	✓	-
HM6116P	✓	-	✓	-	✓	-
HM6264	-	✓	-	✓	-	✓

If HM6264 RAMs are fitted, the only enable signals generated by IC418 are $0000 and $2000.

IC419 is enabled by the R/$\overline{W}$ signal from the microprocessor; a Read signal selects the IC419 B inputs for output and a Write signal selects the A inputs. The 1A, 2B, 3A and 4A inputs of IC419 are held to logic 1, the 1B and 2A inputs to logic 0 and the 3B and 4B inputs are supplied by the $5000 signal from IC417. Refer to Table 4.5.

Table 4.5 IC419 Outputs

Inputs		IC416 Output Signals			
Select	$5000	1Y($\overline{RD}$)	2Y($\overline{WR}$)	3Y(R$5000)	4Y(W$5000)
1	1	0	1	1	1
1	0	0	1	0	1
0	1	1	0	1	1
0	0	1	0	1	0

The $\overline{RD}$ and $\overline{WR}$ outputs from IC419 are applied to the GP-IB Interface and the RAM. The R$5000 and W$5000 signals are fed off the printed circuit board via PL401 pins 35 and 34 respectively.

4.3 DIRECT MEMORY ACCESS (DMA)

The DMA procedure used in 7081 and 7071 can be briefly described as follows:-

* The microprocessor, (IC401), loads the DMA controller (IC402) with a starting address for the memory transfer and the number of words to be transferred.

* When the 7081 or 7071 input has data ready to be transferred to the memory or when the output is ready for transfer from the memory, the DMA controller sends a DMA request to the microprocessor.

* The microprocessor acknowledges the DMA request, floats its address and data buses and appropriate control lines, and suspends any processing that requires use of the address and data bus.

* The DMA controller provides an address to memory and control strobes to read or write memory. The input/output provides or accepts the data on the data bus. After a data byte is transferred, the DMA controller increments its address register and decrements its word count register. If the required number of words has not been transferred, the DMA controller repeats this step when the input/output is ready with the next data word.

* When the required number of words has been transferred, the DMA controller terminates the DMA request and interrupts the microprocessor to indicate that the DMA transfer is complete.

The DMA interface consists of a 16-bit address bus, an 8-bit bidirectional data bus and the following control signals; BA+ or DMA GRANT, BREQ- or DMA REQUEST- and R/W.

The BREQ- (DMA Request) signal from the DMA circuitry commands the microprocessor to halt by going low. The Bus Available (BA+) signal from the microprocessor goes to a logic 1 when the microprocessor has halted and all three-state lines are in the high impedance state. The R/W line is a command signal from the DMA channel to control the direction of transfer through the DMA interface. For the system to operate correctly, the DMA circuitry connected to the microprocessor's address bus, data bus and R/W line must have three-state outputs which are in the high impedance state when BA+ is low and the microprocessor is controlling the address, data and control buses. The time from the BREQ- line going low to the microprocessor halting and producing a BA+ (DMA Grant) will be variable depending on what instruction is being executed at the time BREQ- goes low and in which cycle of that instruction BREQ- goes low.

DMA requests involve two byte transfers; the first transfer has address line A0 low (even address) and the second A0 high (odd address). Before and after each transfer, the DMA performs a dummy cycle.

There are two channels which make requests to the DMA; Channel 0, the Display, and Channel 1, the Floating to Earthy Data Link.

4.3.1 Channel 0

Channel 0 requests are clocked by the 4800Hz signal from the I/O Clock circuit on printed circuit board 3. Twenty-four requests are made before the circuit generates an interrupt.

Once the DMA has the bus for a Channel 0 transfer, a dummy cycle occurs followed by the first DMA Transfer. When the transfer begins, Transfer Strobe - (TSTB-), Valid Memory Address - (VMA-) and Transfer Request 0 (TRQ0+) fall to logic low, and, during the transfer, Even Data Strobe - (EDATSTB-) goes low to the Display for half an E clock cycle.

The DMA then performs two dummy cycles followed by the second transfer. During this second transfer Odd Data Strobe - (ODATSTB) goes low to the Display for half on E clock cycle.

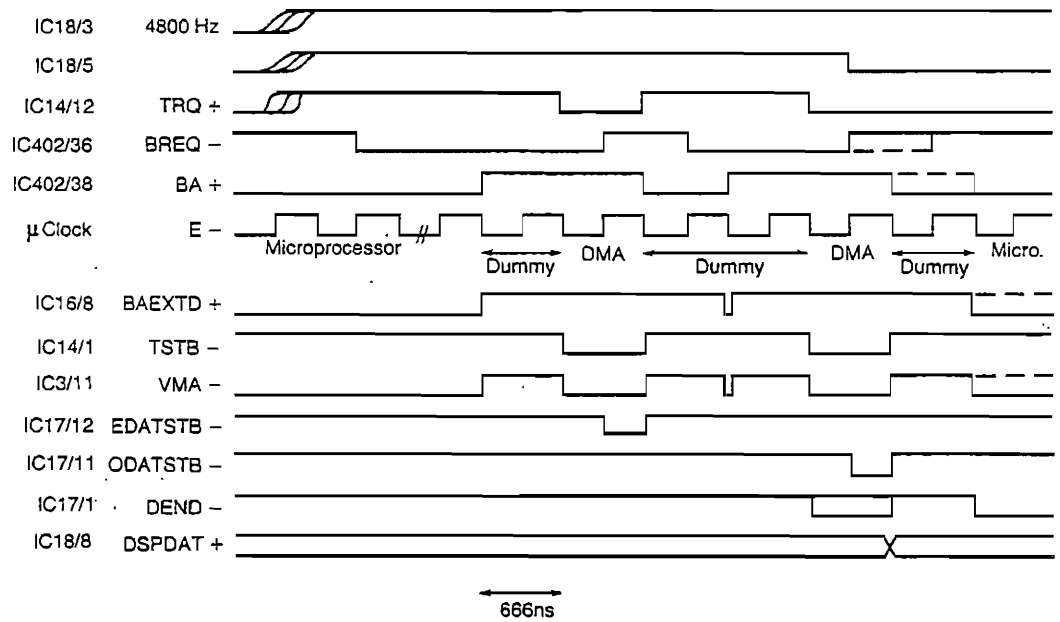
DSPDAT+ goes high on the rising edge of the 24th Odd Data Strobe and goes low on the rising edge of the next.

Refer to Figure 4.1 for the DMA timing for this channel.

4.3.2 Channel 1

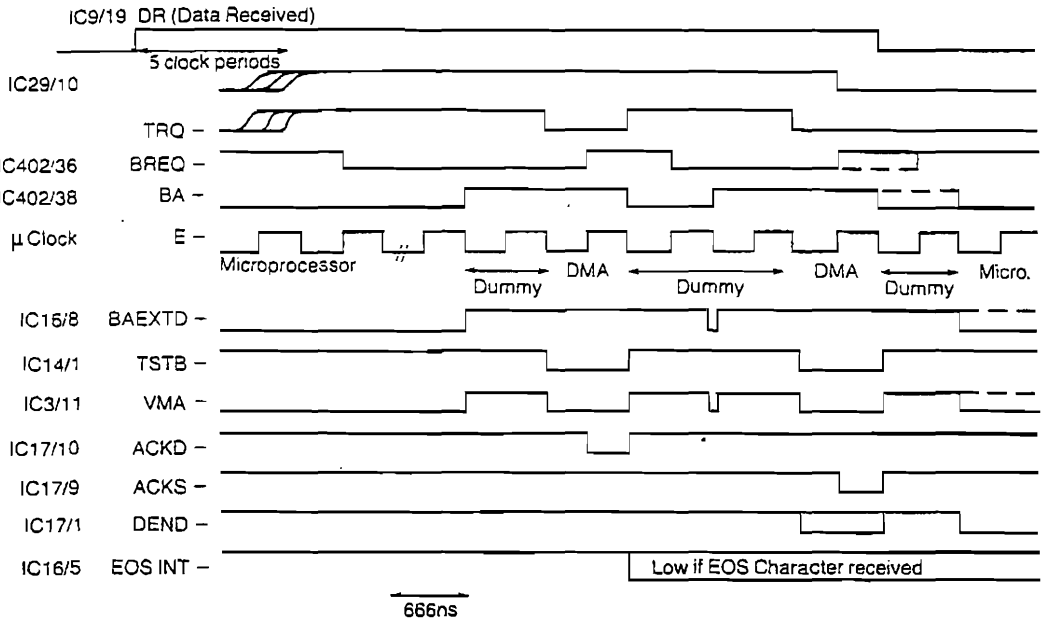
Channel 1 requests, via the Data Received (DR) line from IC9 pin 19 on printed circuit board 2, are delayed in IC29 by five E clock cycles. If a Channel 0 request occurs during this delay, Channel 0 takes the DMA, as it has a higher priority than Channel 1, and clears IC29. Once Channel 0 has finished its transfer, the Channel 1 request appears at the DMA after a further five clock cycles. This delay circuitry prevents latch up occuring between the earthy and floating processors.

Channel 1 transfers are similar to Channel 0 transfers except that Acknowledge Data - (ACKD-) goes low during the first transfer (instead of EDATSTB-) and Acknowledge Status - (ACKS-) goes low during the second transfer (instead of ODATSTB-).



The dotted lines show the Channel 0 Data Chain cycle
TAKA = 0 during this cycle, DSPDAT + goes high and low on the next cycle.

Figure 4.1 DMA Timing - Display (Channel 0)



The dotted lines show the Channel 0 Data Chain cycle
TAKA = 1 during the time that TSTB – is low.

Figure 4.2 DMA Timing - Receive Floating Data (Channel 1)

If an End of String (EOS) character (ASCII 8D) is received during a DMA cycle, an EOS Interrupt is generated, i.e. EOS INT - goes low. The software services this interrupt and resets the DMA channel.

A DMA FL Interrupt is generated if more data comes in than expected or, if a negative acknowledge is received from the floating side.

Refer to Figure 4.2 for the DMA timing for this channel.

In order to exit from the DMA mode, the BREQ- line is switched high (synchronously with the clock), the BA+ signal returns low and the microprocessor resumes control of the bus. When BA+ falls low, the DMA channels address, R/W and data line are in the high impedance state.

4.4 GP-IB INTERFACE

The GP-IB Interface (IC420), with its associated bus-drivers, provides a means of connecting the voltmeter's microprocessor with external devices connected to the IEEE Standard bus. The handshake lines DAV, NRFD, NDAC are handled automatically by IC420.

Essentially the GP-IB Interface comprises fifteen registers, (one, the Address Switch Register IC424, is external to IC420). Seven of the registers may be written to by the microprocessor depending on the state of control lines RD, WR and RS0 to RS2.

4.4.1 GP-IB Address Selection

The voltmeter address and Talk/Listen Status are set up on switch SW801 on printed circuit board 8. The values of the switch settings are then passed via socket SK801 to SK414 on printed circuit board 4 and from there via non-inverting line drivers IC424, to the data bus.

IC424 is enabled by a logic 0 $5800 signal from IC417 in the Address Decode circuit.

4.4.2 GP-IB Signal Lines

The microprocessor/GP-IB Interface and GP-IB Interface/IEEE bus signal lines shown in Figure 4.3 are summarised below:

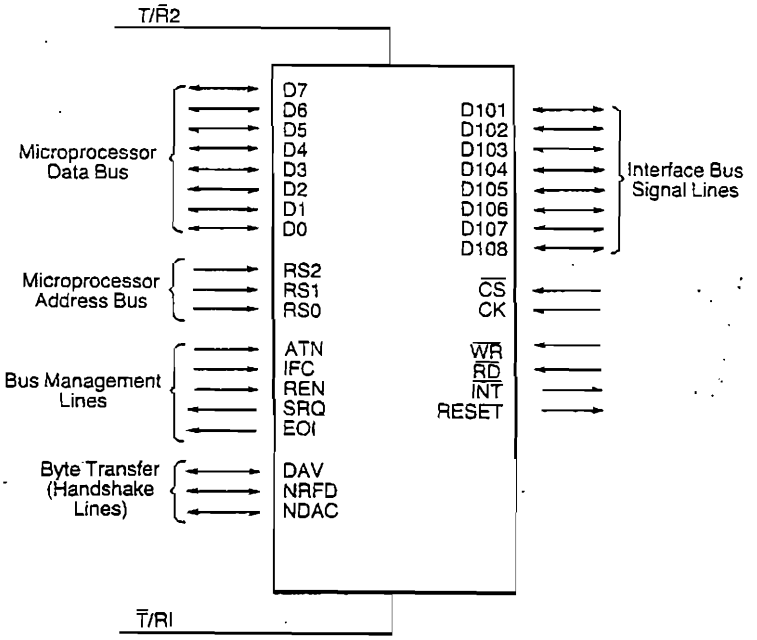


Fig. 4.3 GP-IB Interface Signal Lines

Bidirectional Data (D0-D7) These lines allow data transfer between the microprocessor and the GP-IB. The data bus output drivers are three-state devices that remain in a high impedance (off) state except when the microprocessor performs a GP-IB read operation.

Chip Select ($\overline{CS}$) IC417 selects the GP-IB interface by pulling the line low.

$\overline{RD}$,$\overline{WR}$ These signals are generated by the microprocessor to control register access and the direction of data transfer on the data bus. In conjunction with control lines RS0 to RS2 (see below), the $\overline{RD}$ line, when low, selects one of the eight read only registers; when $\overline{WR}$ is low one of the seven write only registers is selected.

Register Select (RS0, RS1, RS2). Used in combination with $\overline{RD}$ and $\overline{WR}$ for register selection.

Interrupt ($\overline{INT}$) The $\overline{INT}$ output goes to the common interrupt bus for the microprocessor. The $\overline{INT}$ line is set active (low) when an interrupt occurs, and remains so until the microprocessor reads the Interrupt Status register.

Reset The active high Reset line is used to initialise IC420 during power-on/initialise. Reset is driven by an external power-up reset circuit.

Bus Management Lines (ATN, IFC, REN, SRQ, EOI) These lines are used to manage an orderly flow of information across the interface lines.

Attention (ATN) is sent by a controller over the interface. During the ATN active state, devices monitor the data lines (D0 to D7) for addressing or an interface command.

Interface Clear (IFC) This signal is used to put the interface system into a known quiescent state.

Remote Enable (REN) is used to select one of two alternate sources of device programming data: local or remote control.

Service Request (SRQ) When active, the signal indicates the need for attention in addition to requesting an interrupt in the current sequence of events. This indicates to the controller that a device on the bus is in need of service.

End or Identify (EOI) signals the end of a multiple byte transfer signal and, in conjunction with ATN, executes a parallel polling sequence.

Clock Input (CK) Derived from the microprocessor clock generator, this input is used to synchronise control and data transfer throughout the interface.

Signal Lines (DI01 to DI08) These bidirectional lines allow for the flow of eight-bit ASCII interface messages and device dependent messages.

Byte Transfer Lines (NDAC, NRFD, DAV) These lines allow for the proper transfer of each data byte on the bus between talkers and listeners. NRFD is high to indicate that all listeners are "ready for data". A talker indicates that "data is valid" by putting DAV low and the transfer begins when NRFD falls low. Upon the reception of valid data by all listeners, NDAC goes high indicating that the "data has been accepted" by all listeners.

Transmit/Receive Control Signals ($\overline{T}$/R1 and T/$\overline{R2}$) These two signals control IC421 and 422 which drive the interface bus. The transmit/receive inputs of REN, IFC and ATN are held high to receive, while SRQ is held low to transmit. EOI (transmit or receive) is controlled by T/$\overline{R2}$.

4.5 TEST POINTS

The following Test Points are provided to assist in printed circuit board fault finding.

Table 4.6 Test Points

Test Point (TP)	Signal
1	START
2	STOP
3	CLOCK
4	E
5	GND
6	A15
7	OVE
8	Not connected
9	+5V

(TP1, 2, 3 and 5 are used with Locator).

CHAPTER 5

Printed Circuit Board 5

CONTENTS

5.1 INTRODUCTION

Board 5 contains the voltage-to-time converter, the glug counters, the microprocessor and the non-volatile memory (NVM). It also provides a clock divider and oscillator circuit, and the reference, ratio and ohms circuits for the instrument. The board has its own power supply. A schematic of these functions with their interconnections is shown in Figure 5.1.

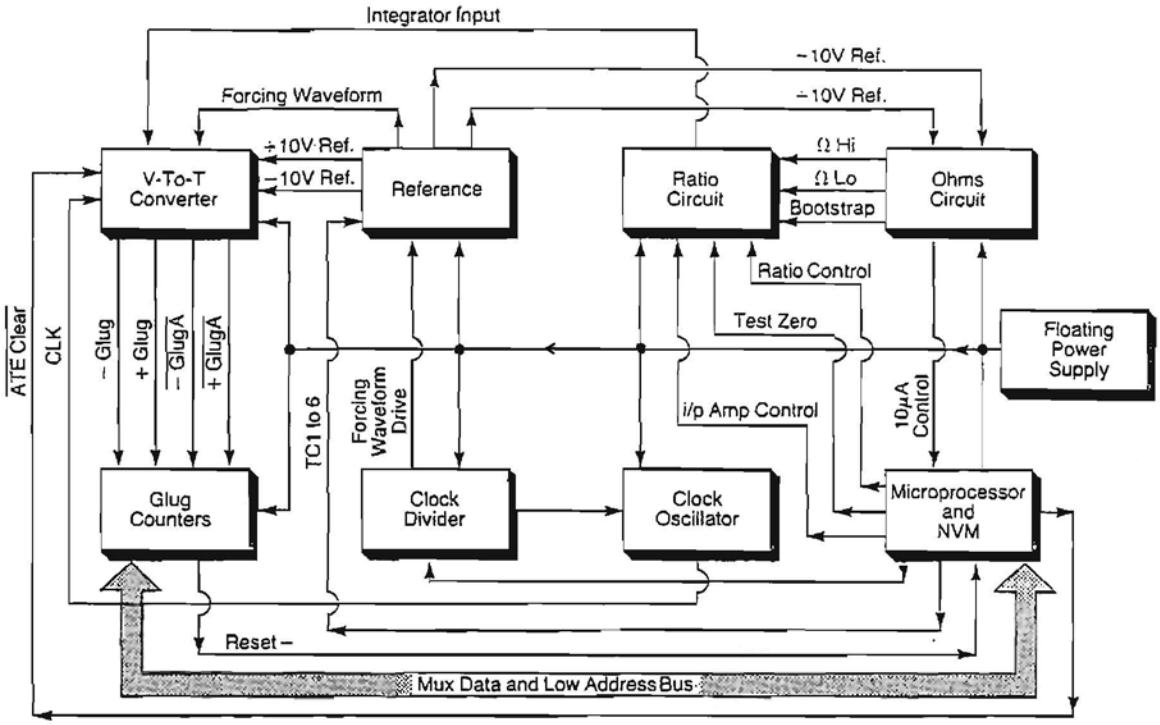


Figure 5.1 Board 5 schematic

5.2 VOLTAGE-TO-TIME CONVERTER (Sheet 1)

This circuit, comprising an integrator, comparators, clock synchronised bi-stables and reference switching FETs/transistors, converts the voltage output from the main amplifier into two pulse trains. The pulses are used to gate the clock into a reversible counter which produces a nett count proportional to the measured input.

The integrator, which comprises IC201 (a d.c part) and IC202 (a conventional fast part) has the following inputs connected:

1. The input to be measured
2. The forcing waveform
3. +Reference, -Reference or 0V.

With the input at 0V, and a 160Hz forcing square wave applied continuously to the integrator, the output is driven alternatively positive and negative through the thresholds of the two comparators IC203 and IC204. The state of the two comparators is followed by IC205, which synchronises the transitions to the clock. Outputs from IC205 are then used to drive FETs TR201 to

TR204, TR207, TR208 and transistors TR205, TR206, which switch the reference voltages or 0V to the integrator input. With this arrangement the output will always remain dynamically balanced about zero, irrespective of the input to the integrator.

The ratio of R202 to R201 is set so that, without calibration, the instrument is guaranteed to read high and a calibration constant of <1 is required. This ensures that there are no missing digitised codes.

5.3 REFERENCE VOLTAGE (Sheet 2)

The reference voltage (+10V, -10V) is generated from D301 by IC305 and scaling resistors R306 a to d. IC306 and R305 determine the zero of the V-to-T convertor as they are used to center the reference voltage.

IC307 switches between +10V and -10V to generate the forcing waveform. R310 and R311 reduce transients (due to this switching) on the reference voltage.

R308 and R309 current limit the reference output in the event of a short-circuit. D302 ensures that, at power-up, the reference circuit starts-up in the correct direction. (The reference circuit has two stable operating states.)

The remainder of the circuit is concerned with

(a) setting up the linear component of the temperature coefficient of D301 and

(b) compensating for the curved component of the temperature coefficient of D301.

The linear component is controlled by IC301, which is a D-to-A convertor, and IC304, which is a buffer. The digital signals present on TC1 to TC6 control the output current of IC301 and thus the output voltage of IC304, which may swing between 0V and -10V. This in turn varies the current through D301 and hence varies the linear temperature coefficient. R303 converts the output swing of 0V to -10V into a current swing through the diode.

The curved component of the temperature coefficient is compensated for by D351, IC351 and associated components.

D351 generates a current proportional to absolute temperature of 1µA/K. This is offset by a current through R351 such that, at 27°C (300K), the voltage at pin 2 of IC351A is approximately zero. As a result, IC351B output will also be at zero, since it has no input, and transistor IC352 pins 3,4,5 will be biased off.

When the temperature is less than 27°C, IC351A pin 2 goes negative. This produces a positive output, which is fed back via D352. Hence IC351A acts as a virtual earth amplifier with an input of 1µA for every degree Centigrade below 27°C.

The ratio of R352 to R353 (6.8k:10k) causes a positive current to flow into IC351B virtual earth, and an equal current of +0.6µA/°C to flow through transistors IC352 pins 1,2,3,9,10 and 11.

The action of IC352 is similar to that of the rms convertor and the output current from IC352 pin 5 is $(Iin)_2/Iref$ where Iref is the current supplied by R354. Hence a square law relationship is established between the output current and the input current.

When the temperature is greater than 27°C, IC351A pin 2 goes positive. This produces a negative output, which is blocked by D352. Hence, the voltage at IC351A pin 2 (source impedance 33k-R351) is developed across the load of R352 and R353 in series. The current at IC351B pin 6 (virtual earth) is again 0.6µA/°C and causes an equal current to flow through IC352 pins 1,2,3,9,10 and 11.

The result is that for all temperatures a positive current of 0.6µA/°C flows into IC351B virtual earth, i.e. IC351A effectively performs the function of the absoluter in the AC RMS converter.

The output current from IC352 pin 5 is therefore:

$$\frac{[(T-27)\times 0.6]_2}{I\ ref} \quad \mu A$$

where T is the temperature in degrees Centigrade.

The output current is developed across R355, so that it is added to the zener voltage. This is because the diode characteristic is such that on either side of 27°C, the voltage falls.

5.4 RATIO CIRCUIT (Sheet 3)

Ratio measurements are performed using Hi and Lo lines. The voltages are switched through their own amplifier to avoid difficult switching of the main input amplifer. The ratio signals are routed into the main system just before the integrator.

TR502 buffers the input and generates bootstrapped rails to power the main amplifier IC502. TR504 protects IC503 against over voltage during negative measurements.

Switching allows either the ratio output, the input amplifier output, or zero to be measured. Zero is used during a drift correct or self-test. Transistors TR505 and TR506 are used to switch the signals as long as the input or output lies in the range $-15V < V < +15V$.

To prevent variation of resistance at turn-on, transistors TR505, TR506, TR508, TR509, TR516 and TR517 must be turned on by a voltage which has a fixed value above the signal voltage. This is supplied by the input signal 'I/p AMP + 5V BOOTSTRAP'. If this is not the case, non-linearity occurs as the input impedance to the integrator is only 160kΩ.

Relay RL1 isolates the current source terminals from the current sources in non-kohm modes, when a two-wire cable is being used and RL501 connects the 10μA current source straight into the integrator for the kohm self-test facility.

5.5 OHMS CIRCUIT (Sheet 4)

True four-terminal ohms measurements are made since the current source is floating with an independent power supply. The reference is transferred across to the independent supply using IC601, IC602 and optocouplers IC605 a and b to give isolation. The only currents which flow between the two sections are insulation leakage currents and amplifier bias currents (~10pA).

The reference is generated across R604. This provides a current which regenerates a voltage across R609. This is then applied across either R611 or R612 to create either 10μA or 1mA. FET switching is employed and hence a separate current switch and voltage sense FET is required for each position.

D608 ensures that the voltage dropped across TR607 and TR609 does not forward bias the gate-source junction and D605, D609, D610 are protection diodes in the event of a mains voltage being inadvertantly applied to the terminals.

In some cases the reference voltages collapse briefly after power-up and this can inject current into pin 10 of IC601 and IC602 via capacitors C605 and C606. R616 and R617 limit this current to a value which does not cause latch-up.

Since the power rails are assymetrical about 0V and only one transformer winding is used, D615 is included in the circuit to improve the balance and equalise the voltage stress on IC607 and IC608.

This circuit is used for measuring resistances up to 1MΩ. Above this value a conductance method is used, ratio-ing the unknown resistor to the 9.9MΩ attenuator resistor. The switching for this is done in the input attenuator.

5.6 GLUG COUNTERS (Sheet 5)

The outputs from the V-to-T converter $\overline{-GLUGA}$, $\overline{+GLUGA}$, +GLUG and -GLUG are used to gate clock into a reversible counter chain comprising IC812, IC807, IC810 and IC811.

If the output of NOR-gate IC822 pin 10 rises to logic high, the counters are inhibited.

The $\overline{Q}$ output of D flip-flop IC835 determines the direction of the count; if $\overline{Q}$ goes low, the counters count up, if $\overline{Q}$ goes high, the counters count down. As the D and Clock inputs to IC835 are permanently tied to V_{EE}, the state of the $\overline{Q}$ output is solely dependent upon the state of the Reset and Clear inputs, i.e. $\overline{-GLUGA}$ and $\overline{+GLUGA}$ respectively. If $\overline{-GLUGA}$ goes low, the $\overline{Q}$ output also goes low and conversely, if $\overline{+GLUGA}$ goes low, the $\overline{Q}$ output goes high.

$\overline{+GLUGA}$ and $\overline{-GLUGA}$ are derived from the $\overline{Q}$ outputs of IC205 b and d in the V-to-T converter. IC205 b has comparator IC203 output applied to its D input and IC205d has comparator IC204 output applied to its D input. Both flip-flops are clocked by the 5.24MHz clock signal from IC835 in the clock oscillator circuit. Figure 5.2 shows the timing of $\overline{+GLUGA}$ and $\overline{-GLUGA}$ generation and the operation of the counter enable direction pulses.

The Q output of IC205b is applied to the D input of IC205a which outputs +GLUG on the next rising clock edge to IC821 pin 10 and IC822 pin 8.

IC821 gates together +GLUG and $\overline{+GLUGA}$ to supply the 'clear' signal for IC813. Clear is generated when both $\overline{+GLUGA}$ and +GLUG are logic high.

The $\overline{Q}$ output from IC205d is also applied to the D input of IC205c which outputs -GLUG on the next rising clock edge to IC822 pin 9. IC822 provides 'chip enable' for IC812 as previously described.

IC813 acts as a glug synchronisation monostable and is continuously triggered until the final count down pulse, when the Q_B output (pin 13) goes low. Latches IC809 and IC808 then record the contents of the counters. After 0.5µs, IC813 triggers to reload the counters with zero and to send an interrupt request (IRQ-) to the microprocessor IC801. The microprocessor then reads the contents of the two latches (by sending GLUG HI- and GLUG LO- via IC805) and also re-enables IC813 in readiness for the next glug input.

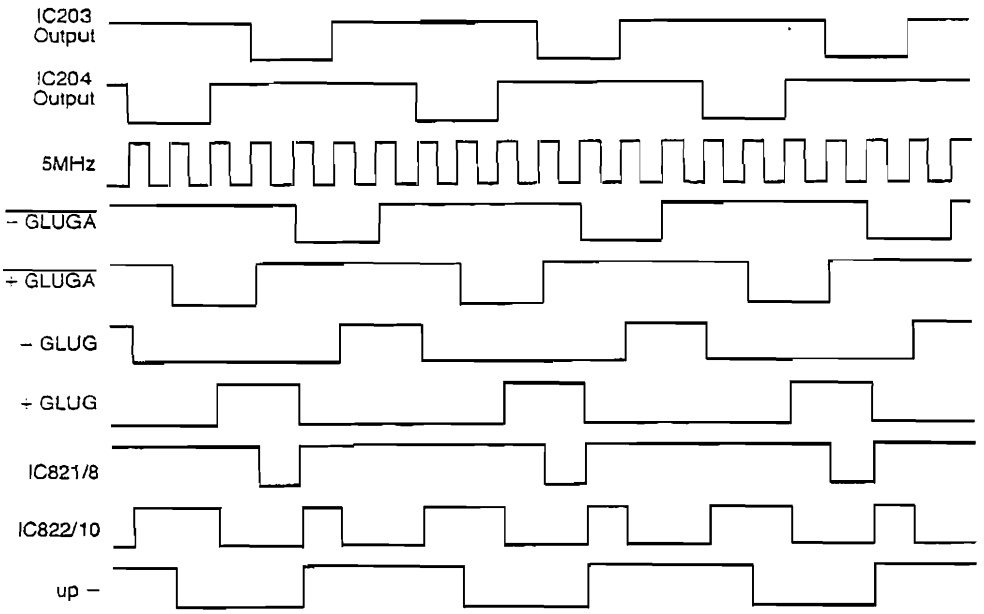


Figure 5.2 Glug Generation and Timing

5.7 CLOCK DIVIDER (Sheet 5)

A mains derived 17VAC signal is buffered and isolated by IC303 before being applied to IC834. The output from IC834 pin 6 is applied to the microprocessor IC801 pin 19, which measures the mains frequency and sets its 400Hz, $\overline{60Hz}$ lines accordingly. Refer to Table 5.1.

Table 5.1 Microprocessor Frequency Settings

Mains Frequency	Microprocessor Output Lines	
	400Hz	$\overline{60Hz}$
50Hz	0	1
60Hz	0	0
400Hz	1	1

If the mains frequency is equal to 50Hz, the Q_C output of IC819 is low to IC822 pin 2. IC822 therefore passes the mains frequency (50Hz) to the clock input of IC820. $\overline{60Hz}$ is high to the A input enabling IC820 to divide the input frequency by 5 to give 10Hz at its Q_B output. If the mains frequency is $\overline{60Hz}$, 60Hz is low and IC820 divides the input by 6 to give 10Hz at QB. With a 400Hz mains frequency, the top half of IC819 is enabled giving 400 ÷ 8, ie 50Hz, at its Q_C output. IC822 is disabled at pin 6 but enabled at pin 2 to pass this 50Hz signal to IC820 pin 2. IC820 then divides the frequency by 5 to give 10Hz at its Q_B output.

The bottom half of IC819 is driven by IC814 and IC815. IC814 is clocked by the 5.24MHz signal from the clock oscillator circuit. The 5.24MHz signal is repeatedly divided down by IC814 and IC815 until 160Hz is output to IC819 clock input. IC819 divides this clock by 16 to give the 10Hz signal for IC824.

The forcing waveform drive signal for the reference circuit is also derived from IC814 and IC815. The Q_A (640Hz) and Q_C (160Hz) signals from IC815 are applied to the D3, D1, D2 and D0 inputs respectively of IC833. When IC833 receives a logic high FWS signal from IC830, it outputs 640Hz at YO to the reference circuit. (The 640Hz signal is used when the unit is configured for nines = 3). If FWS is at logic low, IC833 outputs 160Hz to the reference circuit.

5.8 CLOCK OSCILLATOR (Sheet 5)

The mean dc level on C814 controls the varactor diodes D808 and D809, the capacitance of which determines the frequency of the LC oscillator (TR805, L801 etc.) The output from the clock oscillator is applied via TR806 and TR807 to IC835 which divides the frequency by two to give a clock output. This is divided by 524288 (2^{19}) to give the 10HzC signal from IC819/818. The 10HzC signal is phase-locked to the 10Hz derived from the mains input. Thus, the clock oscillator outputs approximately 5.24MHz which varies with the mains frequency.

5.9 NON-VOLATILE MEMORY (NVM) (Sheet 5)

The NVM (IC804) is organised in 1024 x 4 bit nibbles and is accessed via the normal address bus, to specify the NVM address, and the microprocessor (IC801) port 1 (P10 to P15), to specify the function required and to pass data.

The NVM has logical addresses in the range 0 to 1023 and physical addresses in the range 0 to 2046 (even values only). Since the access time of the NVM is slower than the normal microprocessor cycle time, the NVM is addressed twice for each operation. IC805, 823 and 806 convert an even address into the address to be accessed and assert 'chip select'. An odd address causes chip select to be unasserted.

As the NVM holds the calibration data for the instrument, the integrity of the storage is vital. Two data validation measures are used:

1. The information is duplicated on two pages.

2. Each page has an 8-bit checksum (stored in two consecutive nibbles). Since a simple checksum would not detect an 'all zeroes' failure, the stored checksum is offset by a value held in ROM (IC803). At calibration the information is written into both pages.

At power-up, information is read out of the NVM as a complete page. Page 1 is checked first by the microprocessor (IC801) and, if it is found to be correct, it is transmitted to the 'earthy' processor IC401 on board 4. If page 1 is found to be faulty, page 2 is checked. If page 2 is found to be correct, it is transmitted across; the 'earthy' processor uses this page whilst flagging a non-fatal error condition to the user. If page 2 is also faulty, the 'earthy' processor will use page 2 information whilst flagging a calibration error condition to the user.

An NVM erase voltage is generated by TR804, D806 and associated components, but is present at the NVM only when (i) the NVM is addressed (ii) an even address is applied to IC806, and (iii) Write is enabled. The NVM is not necessarily erased if the Erase voltage is present; erase has to be enabled first.

5.10 FLOATING POWER SUPPLY (Sheet 6)

This circuit produces the floating power for the analogue circuits.

The ±15V supplies are produced from a bridge rectifier circuit, D901 and voltage regulators IC901, IC902. The ±28V supplies are obtained from the same inputs via a voltage doubler and voltage regulators IC903 and IC904.

5.11 TEST POINTS

The following Test Points are provided to assist in printed circuit board fault-finding.

Table 5.2 Test Points

Test Point (TP)	Signal
201	Integrator
202	-Glug
203	+Glug
204	Glugs
205	0V
301	Current
302	10V Ref
303	-10V
304	3.8V
305	0V
501	Ratio In
502	Ratio 6V
503	Ratio -6V
504	Ratio Out
505	0V
601	10V
602	-10V
603	-25V
604	0V
605	22V
606	37V
607	IC604 Input
608	IC604 Output
609	Ohms Control
801	Free S/S
802	Clock
803	GND
804	$6400
805	-15V
806	$6500
807	Frequency
901	28V
902	15V
903	0V
904	-15V
905	-10V
906	-28V

CHAPTER 6

Printed Circuit Board 6

CONTENTS

6.1 INTRODUCTION

Board 6 contains the input and signal conditioning circuits for the instrument, including the input amplifier, ac attenuator and rms converter. A schematic of these functions, with their interconnections, is shown in Fig 6.1.

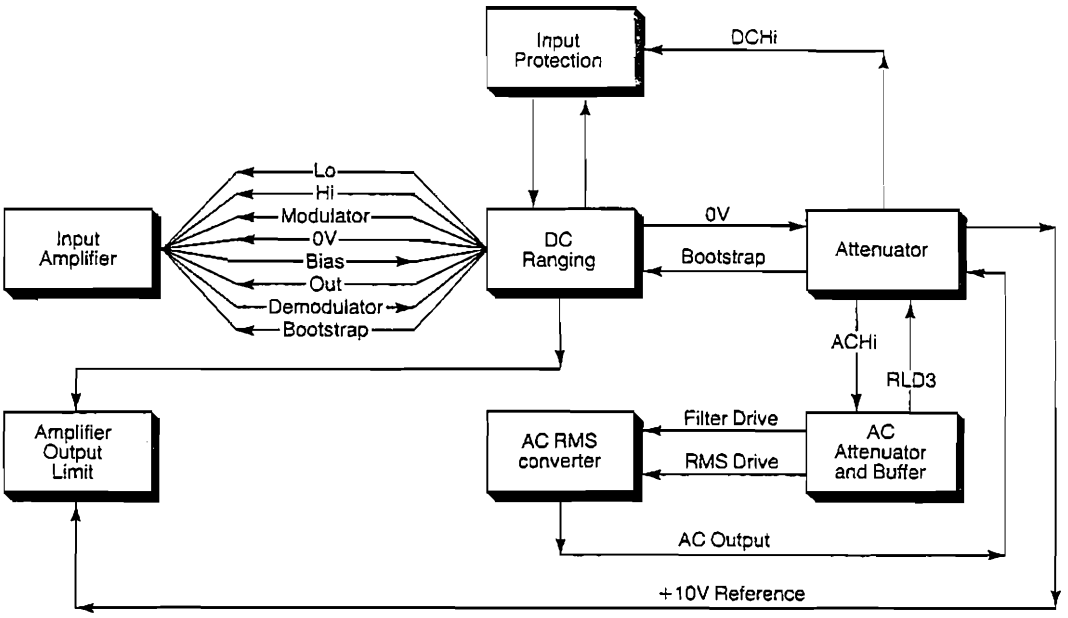


Figure 6.1 Board 6 schematic.

6.2 ATTENUATOR (Sheet 1)

The voltmeter input signals, from either the front or rear panel connector, enter printed circuit board 6 and are fed, via the front/rear switch S1, through various combinations of relays and resistors, depending upon the measurement function selected. The resistors attenuate the signals to the levels required for the voltmeter's circuitry. Table 6.1 indicates the relays made for different measurement functions.

Table 6.1 Attenuator Relays

Function	Relays On
0 to 10V dc	RL5
10 to 1000Vdc	RL4, RL6
Vac	RL3
0 to 1MΩ	RL5
1MΩ to 1GΩ	RL2, RL5, RL6
10V Test	RL2, RL4

Note: RL7 is closed whilst RL5 opens or closes.

AC input signals are passed onto the AC Attenuator and Buffer; dc and resistance signals to the DC Ranging circuit.

6.3 INPUT AMPLIFIER (Sheet 2)

The voltage applied to the amplifier, via the Hi and Lo lines, is limited by diodes D401 and D408 to protect the circuit from accidental overload. The limited voltage is then applied to input FET pair TR401. IC401 is connected to the drains of TR401 to improve the common mode rejection and hence the settling time to transients; if the offset does not change the chopper channel need not resettle.

The output from IC401 is fed directly to IC402 and from IC402 to the amplifier output limit circuitry.

The offset from TR401 is fed, via a filter circuit consisting of R407, R408 and C404, to a bridge modulator made up of four low leakage FETs: TR406, TR407, TR408 and TR409. IC406 provides anti-phase switching signals for the modulator. The amplitude of these signals is determined by diode D404. The resultant modulated signal from the FETs is then amplified by low noise amplifier TR404 and high gain amplifier IC404.

Any dc output is removed by capacitor C410 and the signal is demodulated by IC405 and its associated components.

The amplified offset is fed back into IC401 via R406, which is balanced by R404 to give rejection of rail noise.

IC402 is unity gain stable but TR401 provides gain for its inputs. This extra gain is "lost" by C401 (R402 + R401) in the lower limit and R403 (C401) in the upper limit. The result is to make the combination of TR401 and R403 have a gain of one and no phase shift at high frequencies.

The cross-over frequency between the high frequency amplifier and the chopper channel is approximately 8Hz so that a 6dB per octave roll-off is maintained for most frequencies.

TR412 and IC402 provide low voltages which are defined relative to the input voltage, e.g. -6.2V. These can be used to provide rail currents for TR401 and TR404.

6.4 DC RANGING (Sheet 3)

The gain of the main input amplifier is controlled by the scaling resistor network in this circuit. The network also provides an additional measure of input amplifier protection, relative to the bootstrap.

6.4.1 Input Protection

Despite the use of an input attenuator, large input swings could still overdrive the input amplifier. The input protection circuit provides an extra safeguard, limiting the signal line excursions to approximately 15V. The circuit consists of diode D101, zener diode D102, D103 and associated resistors.

6.4.2 Ranging

Resistors R111 to R114 form the feedback paths for the input amplifier. The feedback, and hence the gain, is selected by one of the F.E.T. switches TR101 to TR103 which are driven from board 5 via the opto-isolators in IC104.

6.5 AMPLIFIER OUTPUT LIMIT (Sheet 3)

This circuit, which consists of operational amplifiers IC102, IC103, diodes D107 to D114 and associated components, ensures that the input amplifier output does not exceed ±15V. If the output is within these limits, the voltage at the non-inverting inputs to IC102 and IC103 is within ±10V. The circuit operation is as follows:

0V input to IC102

Amplifier output equals -12V. D112 is forward biased, thus enabling the IC102 feedback loop. IC103 output equals +12V, but its inverting input is kept at -10V by the reference input. Under these conditions, D107 and D108 are reversed biased and no current flows to D109, D110, R110.

+10V input to IC102

Amplifier output equals -2V. D112 is still forward biased. IC103 output equals +22V, therefore D107 and D108 are still reverse biased.

+15V input to IC102

Amplifier output rises above -2V. D112 is reversed biased, thus disabling the feedback loop. The amplifier (IC102) output therefore rises rapidly in an attempt to equalise its inputs. IC103 output, on the other hand, continues to track the input (V_{in} + 12) because of the -10V reference applied to its inverting input. Therefore, as TP106 rises to the rail voltage and TP107 equals +27V, diodes D107 and D108 become forward biased switching D109, D110, R110 onto the input amplifier feedback loop.

Large negative voltages input to IC102

D114 in the feedback loop of IC103 becomes reverse biased and forces IC103 output more negative in an attempt to equalise its inputs. IC102, on the other hand, continues to track negative inputs. D107 and D108 are again forward biased and switch D109, D110, R110 into the input amplifier feedback loop.

6.6 AC ATTENUATOR AND BUFFER (Sheet 4)

This circuit is required to accommodate either rms ac only or the rms of the ac + dc. For the ac only case, RL701 is closed, RL702 open. For the ac + dc case, both RL701 and RL702 are closed. In any other mode RL702 is closed to keep C701 discharged.

The ac gain of the attenuator is one at RL703 for high frequencies. At low frequencies the gain is rolled off by C701, R703, 707 and 708 in the ac only mode but, in the ac + dc mode, the gain begins to roll off because of C701, R703, 707 and 708 and then, flattens off again at about 0.95 because of R702. Therefore, to give a flat ac + dc response, a similar network, C702, R701 and R704 is introduced into the feedback path of buffer amplifier IC705.

For ac only, the buffer amplifier has a gain of one at all frequencies. In practice, a large capacitor is put in series with TR704 (C703). This gives a slight lift in response at low frequencies to counteract the effect of C701 at frequencies just above the cut-off point.

In the 100mV and 1V ranges, the signal passes through R711 at low frequencies and R722 plus C709 at high frequencies to clamp diodes D712 and D713. The combination of R711 and C709 in parallel, combined with the amplifier input capacitance, gives a gain of about 0.9985.

For the 10V and 100V ranges, the attenuator is put in the ÷100 position and the buffer set to either X1 or X10. C706 and C720 compensate for capacitance across R703.

For the 1000V range, the attenuator is put in the ÷1000 position (R706).

For ac self-test, the attenuator is set to the 1000V position and a square wave generated from the forcing waveform is injected into the bottom of the attenuator. This method of injecting a low signal into the attenuator gives good isolation from the test voltage when normal measurement is being made without adding another relay to the sensitive input amplifier node.

IC705 forms the basis of the buffer amplifier. C704 is included in the circuit to prevent IC705 oscillating in the region of 50Hz. A gain of either 1 or 10 is required from the buffer amplifier, both with a bandwidth of at least 7MHz. TR703 and associated components C714, R721 and R720 provide the gain of 10. They are switched into the feedback loop by IC706, D716, D715, D717 and TR702 acting as a common-base amplifier. IC706 pin 1 is logic low so that D715 is forward biased and D716 causes the cathode of D715 to clamp at -9V. TR702 is an emitter follower which drives the common-base amplifier.

C712 compensates the feedback attenuator for the capacitive loading by the various components connected through TR706 when it is turned on.

To get a gain of one, the output stage is saturated; for this, the bias to TR703 is changed by turning off the low collector output, pin 1, of IC706. As a result, current flows from the positive rail through R705f, g, R716 and R720 (D715 is now reverse biased), and turns TR703 on. This effectively couples the emitter follower TR702 directly to the output. R718 is needed to decouple TR702 from the output load, which is fairly capacitive. Feedback is now unattenuated through TR705, giving an overall gain of one.

IC704 guards the sensitive input lines to the buffer amplifier and reduces the capacitance to ground. It also provides switch-on drive for TR704, TR705 and TR706.

6.7 AC RMS CONVERTER (Sheet 5)

The rms converter can be divided into two specific sections:

1. The absoluter, which converts the alternating signal into one with a single polarity.

2. The converter, that converts the varying single polarity input into a dc signal which represents the rms value of that input.

6.7.1 The Absoluter

The absoluter consists of a fast virtual earth amplifier with a pair of diodes in the output that generate the positive and negative components of the output signal separately. The bandwidth of the rms converter depends primarily on the bandwidth of this circuit and, for this reason, it is constructed to be as fast as possible. To speed up the output transition, from positive to negative polarity, the two diodes are driven by a constant current stage.

The input current is generated by R750 and the feedback is through R750 or R753 depending on the polarity. The positive output voltage is added to the original input signal (but with twice the weighting) through R751. Thus, for an input of -S volts, the converter has an input current of:

$$\frac{-S}{10k} + \frac{2S}{10k} = \frac{S}{10k}$$

For an input of +S volts, the converter input current equals:

$$\frac{S}{10k} + \frac{0S}{10k} = \frac{S}{10k}$$

i.e. the input current is always positive.

The amplifier consists of two paths; a fast, low accuracy path and a slow, high accuracy path.

The fast path is through TR762 (a source follower), TR763 (an emitter follower), TR751 (common base) and TR764 which is the constant current output stage. The 100kHz frequency response is set by RV752. This component controls the phase shift of network C760, R759 and RV752 at 100kHz, and hence the gain.

The slow path is through integrator IC752. Change over from one path to the other occurs at 100kHz.

6.7.2 The Converter

The basic amplifier is very similar to the absoluter amplifier, but with RV752 replaced with a fixed resistor (R767) and a variable resistor (RV753) added. This allows the gain bandwidth product to be adjusted and, in effect, allows the 1MHz gain to be controlled.

A simplified circuit diagram of the converter is shown in Figure 6.2.

i) Transistors A and B, in conjunction with IC753, produce a voltage at the emitters of B and C, which is equal to $2\log_e I_{in}$

ii) D develops a voltage at its emitter which is equal to $\log_e aV(I_{out})$, where $av(I_{out})$ is the average value of I_{out} derived from the filter output.

iii) The difference between (i) and (ii) is developed across the base emitter junction of C to produce I_{out}:

$$\exp(2\log_e I_{in} - \log_e av(I_{out})) = I_{out}$$

which implies

$$\frac{I_{in}^2}{av(Iout)} = I_{out}$$

(iv) This is filtered again, to give:

$$av[I_{in}^2 - av(I_{out})] = av[I_{out}]$$

which implies

$$avI_{in}^2 = [av(I_{out})]^2$$

or

$$av(I_{out}) = \sqrt{avI_{in}^2}$$

In other words, the filter output (avI_{out}) is $\sqrt{avI_{in}^2}$ which is simply the definition of the rms value of Iin.

To obtain good gain stability transistors A and D are a matched pair; similarly B and C. Any offset between these transistors appears as a gain error given by:

$$\exp(\log_e I + V_{offset}) = I_{exp}\ V_{offset}$$

If $V_{offset} = 0$, $\exp V_{offset} = 1$.

However, even the use of matched pairs can give a certain improvement only, particularly with respect to long term drift, so the circuit goes one stage further.

Transistor pair A and D are swapped over at a rate of 10Hz, similarly B and C. The effect can be seen mathematically, i.e. the output is given by

$$\tfrac{1}{2}\exp(\log_e I + V_{offset}) + \tfrac{1}{2}\exp(\log_e I - V_{offset})$$

$$= \tfrac{1}{2}\,[I\exp V_{offset} + I\exp(-V_{offset})]$$

For small values of V_{offset}, a Taylor expansion may be used, i.e.

$$\exp V_{offset} = 1 + V_{offset} + \frac{V_{offset}^2}{2}$$

giving:

$$\tfrac{1}{2}[I\exp V_{offset} + I\exp(-V_{offset})] = \tfrac{1}{2}I(2 + V_{offset}^2)$$

$$= I\left(1 + \frac{V_{offset}^2}{2}\right)$$

The unchopped error would have been:

$$I\left(1 + V_{offset} + \frac{V_{offset}^2}{2}\right)$$

The components which achieve the switching are TR770 to TR779 inclusive. They are driven through resistors to minimise the transient disturbance by IC750, which switches between -15V and -1.3V. TR780 performs logic level shifting.

If the voltmeter is using an integration rate below 100ms on ac, a reading may be generated with the chopper in one of two states and no averaging effect will occur. Thus, as a result of V_{offset}, two possible outputs could occur, differing by more than one bit. For this reason, RV751, R791 and R790 are included to reduce the offset to a minimum.

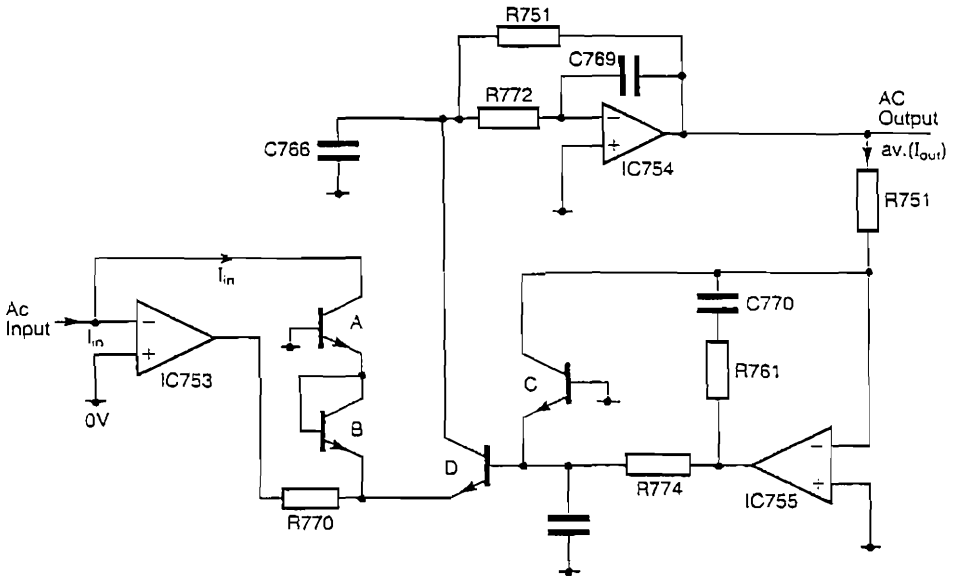


Figure 6.2 Converter

6.8 TEST POINTS

The following Test Points are provided to assist in printed circuit board fault-finding.

Table 6.2 Test Points

Test Point (TP)	Signal
101	HI
102	LO
103	DC Output
104	Bootstrap
105	0V Mytchett
106	+15 Clamp
107	-15 Clamp
401	Bootstrap
402	Chopper Output
403	Demodulator Output
404	Demodulator
405	0V
702	AC Bootstrap
705	Buffer Output
750	Rectifier Bias
751	Log Bias
753	Bias
756	Log Drive
757	RMS Output

CHAPTER 7

Component Parts Lists and Circuit Diagrams

CONTENTS

7.1 INTRODUCTION

This chapter contains detailed Parts Lists and Circuit Diagrams for each of the printed circuit boards fitted in the instrument. When ordering spare parts, it is essential to quote the instrument serial number, located on the rear panel, as well as the full description shown in the appropriate parts lists.

7.2 Component Parts List Abbreviations

7.2.1 Circuit Reference

B	- Battery	R	- Resistor (Ω)
C	- Capacitor (µF)	RL	- Relay
CSR	- Thyristor	RNL	- Non Linear Resistor (Ω)
D	- Diode	RV	- Variable Resistor (Ω)
FS	- Fuse	S	- Switch
IC	- Integrated Circuit	SK	- Socket
L	- Inductor	T	- Transformer
LP	- Lamp (including Neon)	TP	- Terminal Post (or Test Point)
LK	- Link	TR	- Transistor
MSP	- Mains Selector Panel	X	- Other components
PL	- Plug		

7.2.2 Component Types

Fixed Resistors

CACP	Carbon Compositiion
CAFM	Carbon Film
CKCA	Cracked Carbon
MEFM	Metal Film
MEGL	Metal Glaze
MEOX	Metal Oxide
POWW	Power Wirewound
PRWW	Precision Wirewound
TEMP	Temperature Sensitive
TKFM	Thick Film
TNFM	Thin Film
VOLT	Voltage Sensitive

Variable Resistors

CAFM	Carbon Front Panel Multiturn
CAFS	Carbon Front Panel Single Turn
CAPM	Carbon Preset Multiturn
CAPS	Carbon Preset Single Turn
CMFM	Cermet Front Panel Multiturn
CMFS	Cermet Front Panel Single Turn
CMPM	Cermet Preset Multiturn
CMPS	Cermet Preset Single Turn
CMPS	Cermet Preset Single Turn
WWFM	Wirewound Front Panel Multiturn
WWFS	Wirewound Front Panel Single Turn
WWPM	Wirewound Preset Multiturn
WWPS	Wirewoud Preset Single Turn

Capacitors

AIR	Air
ALME	Aluminimum Electolytic
ALMS	Aluminimum Solid
CARB	Polycarbonate
CERM	Ceramic
ESTF	Polyester Foil
ESTM	Polyester Metallised
MICA	Mica
GLAS	Glass
MLAC	Metallised Lacquer
PAPF	Paper Foil
PAPM	Paper Metallised
PTFE	PTFE
PYLN	Polyproylene Film
STYR	Polystyrene
TAND	Tantalum Dry
TANF	Tantalum Foil
TANW	Tantalum Wet

PCB 1 Parts List

Cct Ref.	General Description				Solartron Part No.
R101	CACP	5Ω6	1/2W	10%	172305600
R102	CACP	10k	1/4W	10%	172041000
R103	CACP	10k	1/4W	10%	172041000
R104	CACP	10k	1/4W	10%	172041000
C101	CERM	47n	12V	20%	241744700
C102	CERM	47n	12V	20%	241744700
C103	CERM	47n	12V	20%	241744700
C104	CERM	100n	40V	+80% -20%	208450140
C105	CERM	100n	40V	+80% -20%	208450140
C106	CERM	100n	40V	+80% -20%	208450140
C107	CERM	330p	500V	20%	241323300
IC101	LS273				510004380
IC102	LS273				510004380
IC103	Resistor Pack, 150				160400587
IC104	UDN6118				510005710
IC105	UDN6118				510005710
IC106	LS74				510002600
IC107	UCN4810A				510005180
IC108	UCN4810A				510005180
IC110	LS374				510004390
IC111	LS374				510004390
IC112	LS374				510004390
IC113	Resistor Pack, 150				160400587
D101 to D122	LED				300750280
DS101	FG209M				300730460
PL101	Plug, 26 way				351326030
	Stick-on Feet				420310260

PCB 3 Parts List

Cct Ref.	General Description				Solartron Part No.
R1	CACP	1k5	1/4W	10%	172031500
R2	CACP	1k5	1/4W	10%	172031500
R3	CACP	10k	1/4W	10%	172041000
R4	CACP	47k	1/4W	10%	172044700
R5	CACP	10k	1/4W	10%	172041000
R6	CACP	470	1/4W	10%	172024700
R7	CACP	150	1/4W	10%	172021500
R8	CACP	1k5	1/4W	10%	172031500
R9	CACP	1k	1/4W	10%	172031000
R10	CACP	3k3	1/4W	10%	172033300
R11	CACP	27k	1/4W	10%	172042700
R12	CACP	10k	1/4W	10%	172041000
R13	CACP	47k	1/4W	10%	172044700
R14	CACP	22k	1/4W	10%	172042200
R15	CACP	10k	1/4W	10%	172041000
R16	CACP	10k	1/4W	10%	172041000
R17	CACP	1k	1/4W	10%	172031000
R18	CACP	1k5	1/4W	10%	172031500
R19	CACP	15k	1/4W	10%	172041500
R51	CACP	100	1/4W	10%	172021000
R52	CACP	1k8	1/4W	10%	172031800
R53	MEFM	3k3	1/8W	0.5%	192733302
R54	CACP	100	1/4W	10%	172021000
R55	CACP	47k	1/4W	10%	172044700
R56	CACP	10k	1/4W	10%	172041000
R57	CACP	22	1/4W	10%	172012200
R58	CACP	22	1/4W	10%	172012200
R59	MEFM	470k	1/8W	0.5%	192754702
R60	CACP	1k8	1/4W	10%	172031800
R61	MEFM	3k3	1/8W	0.5%	192733302
R62	CACP	100	1/4W	10%	172021000
R63	CACP	47k	1/4W	10%	172044700
R64	CACP	10k	1/4W	10%	172041000
R65	MEFM	33k	1/8W	0.5%	192743302
R66	MEFM	12k	1/8W	0.5%	192741202
R67	MEFM	22k	1/8W	0.5%	192742202

PCB 3 Parts List (cont.1)

Cct Ref.	General Description			Part No.	Solartron
R68	MEFM	3k9	1/8W	0.5%	192733902
R69	MEFM	3k9	1/8W	0.5%	192733902
R70	POWW	0Ω1		10%	160200088
R71	POWW	0Ω1		10%	160200088
R72	MEFM	470k	1/8W	0.5%	192754702
R73	CACP	1k5	1/4W	10%	172031500
R74	CACP	1k5	1/4W	10%	172031500
C1	CERM	68p	500V	20%	241316800
C2	TAND	4µ7	10V	20%	265464700
C3	VAR	2 to 27p			290030280
C4	CERM	22p	500V	20%	241312200
C5	CERM	150p	500V	20%	241321500
C6	CERM	100p	500V	20%	241321000
C10	TAND	1µ	35V	20%	266061000
C51	ALME	2200µ	63V	+50%-10%	208600264
C52	ESTF	4n7	100V	10%	227034700
C53	ESTF	10n	100V	10%	227041000
C54	TAND	1µ	35V	20%	266061000
C55	TAND	220µ	10V	20%	265482200
C56	ALME	47µ	40V	+50%-10%	273774700
C57	ALME	47µ	40V	+50%-10%	273774700
C58	ALME	47µ	40V	+50%-10%	273774700
C59	ALME	4700µ	50V	+50%-10%	208600268
C60	ALME	22µ	40V	+50%-10%	273772200
C61	ESTM	100n	100V	10%	225451000
C62	TAND	10µ	25V		208700108
C64	ESTF	4n7	100V	10%	227034700
C65	ESTF	10n	100V	10%	227041000
C66	TAND	1µ	35V	20%	266061000
C67	TAND	220µ	10V	20%	265482200
C68	ALME	220µ	10V	+100%-10%	273182200
C69	ESTM	100n	100V	10%	225451000
C70	ESTM	100n	100V	10%	225451000
C71 to C78	CERM	47n	12V	+50%-25%	241744700
B1	Battery				800400260

PCB 3 Parts list (cont. 2)

Cct Ref.	General Description	Solartron Part No.
IC1	74LS04	510002690
IC2	74LS393	510004470
IC3	74LS08	510002910
IC4	74LS14	510003120
IC5	74LS196	510004710
IC6	74LS03	510004140
IC7	CD4040BE	510001820
IC8	74LS151	510002720
IC9	6402	510002820
IC10	6N136	300540150
IC11	6N136	300540150
IC12	Resistor pack 6.8k (15 off)	160400569
IC13	LS148	510005800
IC14	74LS157	510002240
IC15	74LS367	510003030
IC16	74LS74A	510002600
IC17	74F139	510005880
IC18	74LS74A	510002600
IC19	68A50	510003011
IC20	68A21	510002851
IC21	68A21	510002851
IC22	74LS240	510005310
IC23	74LS145	510004990
IC24	74LS30	510003560
IC25	LM301	510001270
IC26	MM58174N	510005480
IC27	LS32	510093140
IC28	LS107	510004550
IC29	LS164	510002890
IC51	TL494	510000690
IC52	7805 Regulator	510000500
IC55	TL494	510090690
IC56	LM311	510091280
TR1	BC214L	
TR2	3N163	300554530
TR3	MPSA13	
TR4	BC107	300553320
TR6	VN10KM	300555860
TR7	VN10KM	300555860

PCB 3 Parts List (cont.3)

Cct Ref.	General Description	Solartron Part No.
TR51	2N2907A	
TR52	BD131	
TR53	2N2907A	
TR54	BD131	
TR55	U1897	300553800
TR56	U1897	300553800
D1	SD3	300522160
D2	SD3	300522160
D3	SD3	300522160
D51	WO4	300524700
D52	VSK340	300525850
D53	IN5339B	300526000
D54	WO4	300524700
D55	WO4	300524700
D56	C30	300521430
D57	VSK340	300525850
D58	IN5339B	300526000
D59	C5V6	300521450
D60	C12	300521480
D61	C12	300521480
PL1	Ribbon Plug, 40 way	352340110
PL2	Bergstik Plug, 15 way	352336070
PL3	Amp Header, 2 way	352302080
PL4	Ribbon Plug, 26 way	352326110
PL5	Ribbon Plug, 26 way	352326110
PL6	Ribbon Plug, 26 way	352326110
PL51	Amp Header, 8 way	352308060
PL52	Amp Header, 6 way	352306090
LS1	RM10 Inductor, 250µH	309511001
LS2	RM10 Inductor, 250µH	309511001
N1	Mains Selector	550001480
	Mains Switch	375500020
S1	8-pole DIL Switch	375000540
SK1	Socket, 40 way DIL	300585190
SK2	Socket, 40 way DIL	300585190
SK3	Socket, 40 way DIL	300585190
SK4	Socket, 24 way DIL	300584190
SK51	Socket, 16 way DIL	300584860

PCB 3 Parts List (cont.4)

Cct Ref.	General Description	Solartron Part No.
FS1	Fuse 200mA 240V	360106280
FS2	Fuse 200mA 240V	360106280
T1	Mains transformer	309617701
X1	Crystal 1.2288MHz	300810360
X2	Crystal 32.768kHz	300810640
TP1	Test Hook	355400760
TP2	Test Hook	355400760
TP3	Amp Disconnect Pin	355900550
TP4	Amp Disconnect Pin	355900550
TP5	Terminal Lug	355500430
TP6	Terminal Lug	355500430
TP51	Test Hook	355400760
TP52	Test Hook	355400760
TP53	Amp Disconnect Pin	355900550
TP54	Test Hook	355400760
TP55	Test Hook	355400760
TP56	Test Hook	355400760
TP57	Test Hook	355400760
	PCB Hinge (2)	412011220
	PCB Edge Support (2)	412011230

PCB 5 Parts List

Cct Ref.	General Description				Solartron Part No.
R201	MEFM	160k	Matched Precision		169616002
R202	MEFM	100k	pair		
R203	MEFM	10k	1/8W	0.5%	192741001
R204	MEOX	1k	1/4W	5%	195631000
R205	MEOX	1k	1/4W	5%	195631000
R206	MEOX	100k	1/4W	5%	195651000
R207	MEOX	100k	1/4W	5%	195651000
R208	MEFM	10k	1/8W	0.5%	192741001
R209	MEFM	10k	1/8W	0.5%	192741001
R210	MEOX	10k	1/4W	5%	195641000
R211	MEOX	560	1/4W	5%	195625600
R212	MEOX	10k	1/4W	5%	195641000
R213	MEOX	560	1/4W	5%	195625600
R214	MEFM	680	1/8W	0.5%	192726802
R215	MEFM	680	1/8W	0.5%	192726802
R217	MEOX	22k	1/4W	5%	195642200
R218	MEOX	22k	1/4W	5%	195642200
R219	MEOX	2k2	1/4W	5%	195632200
R220	MEOX	2k2	1/4W	5%	195632200
R221	MEFM	39k	1/8W	0.5%	192743902
R222	MEFM	100k	1/8W	0.5%	192751001
R224	MEOX	68	1/4W	5%	195616800
R301	MEFM	47k	1/8W	2%	160400571
R302	MEFM	470	1/8W	2%	192124700
R303	MEFM	4k7	1/8W	0.5%	192734704
R304	(To be fitted only if supplied with diode D301)				
R305a	MEFM	10k	Matched Precision		169616102
R305b	MEFM	10k	Pair		
R306a	MEFM	6k			
R306b	MEFM	12k7	Matched Precision		169616201
R306c	MEFM	600	Set		
R306d	MEFM	300			
R308	CACP	100	1/8W	10%	172021000
R309	CACP	100	1/8W	10%	172021000
R310	CACP	1k	1/8W	10%	172031000
R311	CACP	1k	1/8W	10%	172031000
R351	MEFM	33k	1.8W	0.5%	192743302
R352	MEOX	6k8	1/4W	5%	195636800
R353	MEOX	10k	1/4W	5%	195641000
R354	MEFM	82k	1/8W	0.5%	192748202

R222 is 270k in early meters (DCP)

R304 is factory selected nominal value 3k (DCP)

PCB 5 Parts List (cont.1)

Cct Ref.	General Description				Solartron Part No.
R355	MEFM	100	1/8W	0.5%	192721002
R501	Network	680			160400570
R502	Network	47k			160400571
R503	MEFM	470	1/8W	2%	192124700
R504	CACP	10k	1/8W	10%	172041000
R505	CACP	3k3	1/8W	10%	172033300
R506	MEFM	470	1/8W	2%	192124700
R507	MEFM	470	1/8W	2%	192124700
R509	CACP	1k	1/8W	10%	172031000
R601	MEOX	2k2	1/4W	5%	195632200
R602	MEOX	2k2	1/4W	5%	195632200
R603	MEFM	100k	1/8W	0.5%	192751001
R604		100k	Precision		169616402
R605	MEFM	100k	1/8W	0.5%	192751001
R606	MEOX	56k	1/4W	5%	195645600
R607a	Network	47k	1.8W	2%	160400571
R607b					
R608	MEOX	1M	1/2W	1%	195461000
R609	MEFM	30k			
R611	MEFM	600k	Matched Precision Set		169616303
R612	MEFM	6k			
R614	POWW	12k	2W	5%	193041200
R615	MEFM	470	1/8W	2%	192124700
R616	MEOX	10k	1/4W	5%	195641000
R617	MEOX	10k	1/4W	5%	195641000
R801	CACP	150	1/4W	10%	172021500
R802	CACP	3k3	1/4W	10%	172033300
R803	CACP	3k3	1/4W	10%	172033300
R804	CACP	22k	1/4W	10%	172042200
R805	CACP	47k	1/4W	10%	172044700
R806	CACP	1M	1/4W	10%	172061000
R807	CACP	100k	1/4W	10%	172051000
R808	CACP	100k	1/4W	10%	172051000
R809	CACP	220k	1/4W	10%	172052200
R810	CACP	100k	1/4W	10%	172051000
R811	CACP	47k	1/4W	10%	172044700
R812	CACP	470	1/4W	10%	172024700
R813	CACP	10k	1/4W	10%	172041000
R814	CACP	1k	1/4W	10%	172031000
R815	CACP	100	1/4W	10%	172021000
R816	CACP	330	1/4W	10%	172023300

PCB 5 Parts List (cont.2)

Cct Ref.	General Description				Solartron Part No.
R817	CACP	27k	1/4W	10%	172042700
R818	CACP	47k	1/4W	10%	172044700
R819	CACP	47k	1/4W	10%	172044700
R820	CACP	3k3	1/4W	10%	172033300
R821	CACP	10k	1/4W	10%	172041000
R822	CACP	680	1/4W	10%	172026800
R823	CACP	10k	1/4W	10%	172041000
R824	CACP	2k7	1/4W	10%	172032700
R825	CACP	6k8	1/4W	10%	172036800
R826	CACP	6k8	1/4W	10%	172036800
R827	CACP	1k	1/4W	10%	172031000
C201	PROP	100n	200V	1%	208100180
C202	ESTM	470n	100V	10%	225454700
C203	ESTM	68n	100V	10%	225446800
C204	CERM	150p	500V	20%	241321500
C205	ESTM	10n	100V	10%	225441000
C208	CERM	10n	500V	+80% -20%	241941000
C209	CERM	10n	500V	+80% -20%	241941000
C210	CERM	2n2	500V	+40% -20%	241332200
C211	CERM	2n2	500V	+40% -20%	241332200
C212	ESTM	470n	100V	10%	225444700
C213	TAND	47µ	20V	10%	265774700
C214	ESTM	100n	100V	10%	225451000
C215	ESTM	100n	100V	10%	225451000
C216	CERM	47n	25V	+50% -25%	241944700
C217	CERM	47n	25V	+50% -25%	241944700
C218	CERM	47n	25V	+50% -25%	241944700
C219	CERM	47n	25V	+50% -25%	241944700
C220	CERM	470p	500V	20%	241324700
C221	CERM	470p	500V	20%	241324700
C223	TAND	22µ	35V	10%	265972200

PCB 5 Parts List (cont.3)

Cct Ref.	General Description				Solartron Part No.
C301	CERM	47n	25V	+50% -25%	241944700
C302	CERM	47n	25V	+50% -25%	241944700
C303	CERM	10p	500V	20%	241311000
C304	CERM	10p	500V	20%	241311000
C305	CERM	10p	500V	20%	241311000
C306	CERM	22p	500V	20%	241322000
C351	CERM	10n	25V	+50% -25%	241941000
C352	CERM	10n	25V	+50% -25%	241941000
C501	ESTM	10n	100V	10%	225441000
C502	ESTM	100n	100V	10%	225451000
C503	ESTM	100n	100V	10%	225451000
C601	ESTM	100n	100V	10%	225451000
C602	ESTM	100n	100V	10%	225451000
C603	ESTM	100n	100V	10%	225451000
C604	ESTM	100n	100V	10%	225451000
C605	ESTM	10n	100V	10%	225441000
C606	ESTM	10n	100V	10%	225441000
C607		100p	100V	20%	208900004
C608	ESTM	33n	400V	10%	226043300
C609	ALME	100	100V	+100% -10%	273981000
C610	ALME	47µ	100V	+100% -10%	273974700
C611	CERM	10n	250V		208450036
C612	CERM	10n	25V	+50% -25%	241941000
C613	CERM	10n	250V		208450036
C614	ESTM	100n	100V	10%	225451000
C615	ESTM	100n	100V	10%	225451000
C616	CERM	47n	25V	+50% -25%	241944700
C617	CERM	47n	25V	+50% -25%	241944700
C801	CERM	22p	500V	20%	241312200
C802	CERM	22p	500V	20%	241312200
C803	CERM	22n	25V	+50% -20%	241842200
C804	ALME	47µ	40V	+50% -10%	273774700

PCB 5 Parts List (cont.4)

Cct Ref.	General Description				Solartron Part No.
C805	TAND	4µ7	10V	20%	265464700
C806	TAND	100µ	10V	20%	265481000
C807	VAR	6-30p	160V	10%	290020450
C808	CERM	10p	250V	20%	208450000
C809	CERM	3n3	500V	+40% -20%	241333300
C810	CERM	330p	500V	10%	208450060
C811	CERM	47n	12V	+50% -25%	241744700
C812	TAND	47µ	6V	20%	265274700
C813	CERM	1n	500V	+40% -20%	241331000
C814	TAND	1µ	35V	20%	266061000
C815	ESTM	100n	100V	10%	225451000
C816	CERM	47n	12V	+50% -25%	241744700
C817	CERM	47n	12V	+50% -25%	241744700
C818	CERM	47n	12V	+50% -25%	241744700
C819	CERM	47n	12V	+50% -25%	241744700
C820	CERM	47n	12V	+50% -25%	241744700
C821	CERM	3n3	500V	+40% -20%	241333300
C822	TAND	22µ	16V		208700106
C823	CERM	47n	12V	+50% -25%	241744700
C824	CERM	47n	12V	+50% -25%	241744700
C825	CERM	47n	12V	+50% -25%	241744700
C826	CERM	47n	12V	+50% -25%	241744700
C901	ALME	220µ	40V		208600262
C902	ALME	220µ	40V		208600262
C903	ALME	1000µ	40V		208600263
C904	ALME	1000µ	40V		208600263
C905	ALME	220µ	40V		208600262
C906	ALME	220µ	40V		208600262
C907	TAND	1µ	35V	20%	266061000
C908	TAND	1µ	35V	20%	266061000
C909	TAND	1µ	35V	20%	266061000
C910	TAND	1µ	35V	20%	266061000

PCB 5 Parts List (cont.5)

Cct Ref.	General Description	Solartron Part No.
C912	TAND 220 10V 20%	265482200
IC201	ICL7650 BCPD	510091810
IC202	LM301	510091270
IC203	LM311	510091280
IC204	LM311	510091280
IC205	74S175	510003460
IC301	AD7533JN	510090670
IC302	ILQ74	300540250
IC303	ILQ74	300540250
IC304	741CH	510091310
IC305	OP07EZ	510091420
IC306	OP07EZ	510091420
IC307	DG301	510091110
IC351	MC1458	510091300
IC352	CA3046	300554090
IC501	ILQ74	300540250
IC502	ICL7650 BCPD	510091810
IC503	78L12	510090450
IC601	ICL7650 BCPD	510091810
IC602	ICL7650 BCPD	510091810
IC603	LH0052	510090260
IC604	ICL7650 BCPD	510091810
IC605	ILQ74	300540250
IC606	TIL111	300540140
IC607	78L15	510090420
IC608	79L15	510090430
IC801	63A03MPU	510006170
IC802	LS373	510004870
IC803	2564*	510005610
* On later models Part No. 2764 is used.		
IC804	ER3400	510005600
IC805	F138	510005870
IC806	LS74A	510002600
IC807	LS191	510004190
IC808	LS374	510004390
IC809	LS374	510004390
IC810	LS191	510004190
IC811	LS191	510004190
IC812	LS191	510004190
IC813	LS163	510004170
IC814	LS393	510004470
IC815	LS393	510004470

PCB 5 Parts List (cont.6)

Cct Ref.	General Description	Solartron Part No.
IC816	LS273	510004380
IC817	LS273	510004380
IC818	LS273	510004380
IC819	LS393	510004470
IC820	LS163	510004170
IC821	LS00	510002000
IC822	LS02	510002230
IC823	LS04	510002690
IC824	CD4046	510005690
IC825	Resistor Pack, 6.8k	160400569
IC826	TC5516P	510005470
IC827	LS161AN	510004160
IC829	ULN2003A	510004980
IC830	LS273	510004380
IC831	F138	510005870
IC833	LS153	510002740
IC834	LS132	510002980
IC835	LS74	510002600
IC901	7815CT	510090320
IC902	7915CT	510090330
IC903	7812CT	510090520
IC904	7912CT	510090530
TR201	VN67AK	300555940
TR202	VN67AK	300555940
TR203	3N163	300554530
TR204	3N163	300554530
TR205	BCY70	300553590
TR206	BCY70	300553590
TR207	VN10	300555860
TR208	VN10	300555860
TR301	BC107	300553320
TR302	BCY70	300553590
TR504	U1897	300553800
TR505	VN67AK	300555940
TR506	VN67AK	300555940
TR508	VN67AK	300555940
TR509	VN67AK	300555940
TR510	U235	300553810
TR512	U1897	300553800
TR513	U1897	300553800

PCB 5 Parts List (cont.7)

Cct Ref.	General Description	Solartron Part No.
TR515	U1899	300554320
TR516	VN67AK	300555940
TR517	VN67AK	300555940
TR518	U1899	300554320
TR519	U1899	300554320
TR601	U1899	300554320
TR602	U1899	300554320
TR603	3N163	300554530
TR604	WM222	300555940
TR605	3N171	300555270
TR606	2N4118A	300555880
TR607	2N4118A	300555880
TR608	2N4118A	300555880
TR609	WN807	300555380
TR610	3N163	300554530
TR801	BCY70	300553590
TR802	BC107	300553320
TR803	2N2484	300552860
TR804	BC107	300553320
TR805	2N2369	300552390
TR806	BCY70	300553590
TR807	2N2369	300552390
D204	Zener, 7.5V	300521460
D205	Zener, 7.5V	300521460
D301	Reference Zener*	70818008A (for 7071 only) 70818007A (for 7071 or 7081)

* Special selection during test. Available from factory on failure only. Package may include a resistor (R304), whose value is selected, on test, to match diode D301.

D302	Zener, 10V	300522760
D351	AD590K	510090760
D352	SD3	300522160
D353	SD3	300522160
D501	DPAD10	300525870
D502	DPAD10	300525870
D503	Zener, 6.8V	300522540
D504	Zener, 15V	300521390
D505	Zener, 15V	300521390
D507	Zener, 5.6V	300521450
D601	WR057	300525770
D602	WR057	300525770

PCB 5 Parts List (cont.8)

Cct Ref.	General Description	Solartron Part No.
D603	DPAD10	300525870
D604	Zener, 8.2V	300521330
D605	DPAD10	300525870
D606	SD3	300522160
D607	SD3	300522160
D608	LED	300750080
D609	DPAD10	300525870
D610	IN4007	300524990
D611	IN4004	300522070
D612	IN4004	300522070
D613	Zener, 10V	300522760
D614	Zener, 10V	300522760
D615	Zener, 3.9V	300521420
D616	WR057	300525770
D617	WR057	300525770
D801	SD3	300522160
D802	SD3	300522160
D803	SD3	300522160
D804	C8V2	300521330
D805	SD3	300522160
D806	SD3	300522160
D807	C3V6	300523890
D808	MV2110	300525320
D809	MV2110	300525320
D810	SD3	300522160
D901	Bridge W04	300524700
D902	IN4004	300522070
D903	IN4004	300522070
D904	IN4004	300522070
D905	IN4004	300522070
RL1	Coto Relay	300652230
RL501	Coto Relay	300652230
L801	Inductor, 33µH	305020440
L802	Inductor, 3.9µH	305020750
PL501	Plug, 34 Way	352334050
PL502	Plug, 10 Way	352310070
PL504	Plug, 4 Way	352304080
SK801	Socket, 40 Way DIL	300584970
SK802	Socket, 28 Way DIL	300585120
SK804	Socket, 22 Way DIL	300584980
SK806	Socket, 24 Way DIL	300584740

PCB 5 Parts List (cont.9)

Cct Ref.	General Description	Solartron Part No.
SK901	Socket, 16 Pin DIL	300584860
S1	Switch, 6-pole DIL	375000570
X801	Crystal, 4.9152MHz	300810590
TP201 to TP205	Test Hook	355400760
TP301 to TP305	Test Hook	355400760
TP501 to TP505	Test Hook	355400760
TP601 to TP609	Test Hook	355400760
TP1 to TP6	Test Hook	355400760
TP901 to TP906	Test Hook	355400760
	Transistor Pads	300584090
	Diode Pad	300584220
	Heat Sink	300584940

PCB 6 Parts List

Cct Ref.	General Description				Solartron Part No.
R1 to R3	MEFM	3M3	Matched Prec. Set		169615802
R4	MEFM	100k			
R5	MEFM	18k		0.1%	160300503
R6	MEFM	18k		0.1%	160300503
R7	CACP	56	1/2W	10%	172315600
R101	MEFM	10k	1/8W	0.5%	192741002
R102	MEFM	24k	1/8W	0.5%	192742402
R103	MEFM	10k	1/8W	0.5%	192741002
R104	MEFM	4k7			160300501
R105	MEFM	47k	1.8W	2%	160400571
R107	MEOX	47k	1/4W	5%	195644700
R109	MEFM	470	1/8W	2%	192124700
R110	CACP	1k	1/8W	10%	172031000
R111	MEFM	9k			
R112	MEFM	1k1	Matched Prec. Set		169615902
R113	MEFM	9k			
R114	MEFM	1k11			
R401	MEFM	33k	1/8W	0.5%	192743302
R402	MEFM	33k	1/8W	0.5%	192743302
R403	CACP	1k	1/4W	10%	172031000
R404	MEFM	470k	1/8W	0.5%	192754702
R405	MEFM	15k	1/8W	0.5%	192741502
R406	MEFM	470k	1/8W	0.5%	192754702
R407	PRWW	15k			160300502
R408	PRWW	15k			160300502
R409	MEFM	270k	1/8W	0.5%	192752701
R410	MEFM	1M	1/4W	1%	198361002
R411	MEFM	1M	1/4W	1%	198361002
R412	MEFM	100k	1/8W	0.5%	192751002
R413	MEFM	100k	1/8W	0.5%	192751002
R414	MEFM	100k	1/8W	0.5%	192751002
R415	MEFM	1M	1/4W	1%	198361002
R416	MEFM	1M	1/4W	1%	198361002
R421	MEFM	100k	1/8W	0.5%	192751002
R422	MEFM	680	1/8W	0.5%	192726802
R423	MEFM	15k	1/8W	0.5%	192741502
R424	MEFM	100k	1/8W	0.5%	192751002

PCB 6 Parts List (cont.1)

Cct Ref.	General Description				Solartron Part No.
R425	MEFM	1M	1/4W	1%	198361002
R426	MEFM	1M	1/4W	1%	198361002
R427	MEFM	1M	1/4W	1%	198361002
R428	MEFM	10k	1/8W	0.5%	192741002
R701	MEFM	47k	1/8W	0.5%	192744102
R702	MEGL	47k	3W	2%	175244700
R703	MEFM	990k			
R707	MEFM	9k	Matched Set		169616601
R708	MEFM	1k			
R705a-g	MEFM	10k	1.8W	2%	192141000
R706	CACP	1k	1/2W	10%	172031000
R709	MEFM	470k	1/8W	0.5%	192754702
R710	MEFM	5k1	1/8W	0.5%	192735102
R711	CACP	1M	1/2W	10%	172361000
R712	MEOX	3k3	1/4W	5%	195633300
R713	MEOX	3k3	1/4W	5%	195633300
R714	MEOX	47k	1/4W	5%	195644700
R715	MEOX	47k	1/4W	5%	195644700
R716	CACP	2k2	1/4W	10%	172032200
R718	CACP	100	1/8W	10%	172021000
R720	CACP	560	1/4W	10%	172025600
R721	CACP	4k7	1/4W	10%	172034700
R722	CACP	1k	1/2W	10%	172331000
R723	CACP	22M	1/2W	10%	172372200
R724	MEFM	965k	1/4W	0.5%	160400530
R725	MEFM	405k/500	Matched Pair		160400604
R729	MEFM	33k	1/8W	0.5%	192743302
R750	Caddock Network 5k/5k			0.1W/R	160400605
R751A	Caddock Network 10k/5k			0.1W/R	160400606
R751B	Caddock Network 50k/50k				160400606
R753	MEFM	5k1	1/8W	0.5%	192735102
R754	MEFM	5k1	1/8W	0.5%	192735102
R755	MEOX	6k8	1/4W	5%	195636800
R756	MEOX	2k2	1/4W	5%	195632200
R757	CACP	220	1/8W	10%	172022200
R758	MEFM	47	1/8W	0.5%	192714702
R759	MEOX	220	1/4W	5%	195622200
R760	MEOX	1k	1/4W	5%	195631000
R761	MEOX	33k	1/4W	5%	195643300
R762	CACP	1k	1/8W	10%	172031000
R763	MEOX	6k8	1/4W	5%	195636800

PCB 6 Parts List (cont.2)

Cct Ref.	General Description				Solartron Part No.
R764	MEOX	1k	1/4W	5%	195631000
R765	CACP	220	1/8W	10%	172022200
R766	MEFM	47	1/8W	0.5%	192714702
R767	MEOX	560	1/4W	5%	195625600
R768	MEOX	1k	1/4W	5%	195631000
R770	MEFM	1k	1/8W	0.5%	192731002
R771	MEOX	100k	1/4W	5%	195651000
R772	MEFM	39k	1/8W	0.5%	192743902
R774	MEFM	1k	1/8W	0.5%	192731002
R775	MEOX	10k	1/4W	5%	195641000
R776	MEOX	10k	1/4W	5%	195641000
R778	MEOX	10k	1/4W	5%	195641000
R779	MEOX	10k	1/4W	5%	195641000
R780		10k	1.8W	2%	192141000
R781	MEOX	10k	1/4W	5%	195641000
R782	MEOX	10k	1/4W	5%	195641000
R784	CACP	1k	1/8W	10%	172031000
R785	CACP	5Ω6	1/2W	10%	172305600
R786	CACP	5Ω6	1/2W	10%	172305600
R787	CACP	220	1/8W	10%	172022200
R788	CACP	220	1/8W	10%	172022200
R790	MEFM	10	1/8W	0.5%	192711002
R791	MEFM	330k	1/8W	0.5%	192753302
RV701	CMPM	5k	1/2W	10%	130935000
RV751	CMPM	100k	1/2W	10%	130951000
RV752	CMPM	500	1/2W	10%	130925000
RV753	CMPM	100	1/2W	10%	130921000
C1	ESTF	22n	400V	10%	222342200
C101	CERM	3n3	500V	20%	241333300
C102	CERM	3n3	500V	20%	241333300
C103	ESTF	1n	400V	10%	222331000
C401	CERM	3n3	500V	20%	241333300
C404	ESTM	22n	100V	10%	225442200
C405	ESTM	100n	100V	10%	225451000
C406	ESTM	100n	100V	10%	225451000
C407	TAND	4µ7	35V	20%	266064700
C408	ESTM	220n	100V	10%	225452200
C409	ESTM	220n	100V	10%	225452200
C410	ESTM	2µ2	100V	10%	225462200
C411	ESTM	2µ2	100V	10%	225462200
C412	ESTM	1	100V	10%	225461000
C413	CERM	10n	25V	+50%-25%	241941000
C414	CERM	47n	25V	+50%-25%	241944700

PCB 6 Parts List (cont.3)

Cct Ref.	General Description				Solartron Part No.
C415	CERM	10n	25V	+50%-25%	241941000
C416	CERM	47n	25V	+50%-25%	241944700
C701	ESTM	220n	1000V	20%	226752200
C702	ESTM	220n	100V	10%	225452200
C703	TAND	1µ5	20V	20%	265861500
C704	CERM	22p	500V	20%	241312200
C705	ESTF	10n	100V	10%	225441000
C708	CERM	10n	25V	+50%-20%	241941000
C709	ESTF	10n	1000V	10%	222841000
C712	CERM	2p2			208450094
C714	TAND	10	25V	20%	208700108
C716	TAND	4µ7	35V	20%	208700109
C717	TAND	4µ7	35V	20%	208700109
C718	CERM	47n	25V	+50%-20%	241944700
C719	CERM	47n	25V	+50%-20%	241944700
C720	CERM	10n	25V	+50%-20%	241941000
C721	CERM	10n	25V	+50%-20%	241941000
C751	ESTF	3n3	400V	10%	222333300
C755	CERM	47n	25V	+50%-20%	241944700
C756	CERM	47n	25V	+50%-20%	241944700
C757	TAND	1µ	35V	20%	266061000
C758	STYR	150p	125V	10%	210221500
C759	CERM	10n	25V	+50%-20%	241941000
C760	ESTF	3n3	400V	10%	222333300
C761	TAND	1	35V	20%	266061000
C762	CERM	47n	25V	+50%-20%	241944700
C763	CERM	47n	25V	+50%-20%	241944700
C764	STYR	150p	125V	10%	210221500
C765	CERM	10p	500V	20%	241311000
C766	ESTM	220n	100V	10%	225452200
C767	ESTM	4µ7	63V	10%	225164700
C768	ESTM	4µ7	63V	10%	225164700
C769	ESTM	220n	100V	10%	225452200
C770	CERM	1n	500V	+40%-20%	241331000
C771	TAND	2µ2	20V	20%	265862200
C775	CERM	10p	500V	20%	241311000
IC101	TIL111				300540140
IC102	LM343D				510091140
IC103	LM343D				510091140
IC104	ILQ74				300540250

PCB 6 Parts List (cont.4)

Cct Ref.	General Description	Solartron Part No.
IC401	CA3183AE	300555390
IC402	LM343D	510091140
IC403	LM343D	510091140
IC404	OPO5CP	510091130
IC405	LH0052	510090260
IC406	4093	510001780
IC701	9D8-CC	
IC702	7406	510000760
IC703	7406	510000760
IC704	LM310	510090040
IC705	OP16FJ	510091370
IC706	LM339	510090490
IC750	4093	510001780
IC752	OP-07EZ	510091420
IC753	OP-07EZ	510091420
IC754	OP-07EZ	510091420
IC755	OP-07EZ	510091420
TR101	WN1001	300555770
TR102	WN1001	300555770
TR103	WN1001	300555770
TR104	P1087	300555550
TR105	UI897	300553800
TR106	UI897	300553800
TR107	UI897	300553800
TR401	WD401	300555370
TR404	MAT01GH	300555930
TR405	2N4303	300553160
TR406	PN4117A	300555950
TR407	PN4117A	300555950
TR408	PN4117A	300555950
TR409	Zener, 16V	300521320
TR410	Zener, 16V	300521320
TR412	2N5905	300554230
TR702	BCY70	300553590
TR703	BFY90	300553890
TR704	U1899	300554320
TR705	U1899	300554320
TR706	U1899	300554320
TR751	BCY70	300553590
TR752	BCY70	300553590
TR755	BCY70	300553590
TR756	BCY70	300553590

PCB 6 Parts List (cont.5)

Cct Ref.	General Description	Solartron Part No.
TR758	MAT01GH	300555930
TR759	MAT01GH	300555930
TR760	U1897	300553800
TR761	U1897	300553800
TR762	U1899	300554320
TR763	2N2369	300552390
TR764	BFY90	300553890
TR765	U1899	300554320
TR766	2N2369	300552390
TR767	BFY90	300553890
TR770	U1897	300553800
TR771	U1897	300553800
TR772	U1897	300553800
TR773	U1897	300553800
TR774	U1897	300553800
TR775	U1897	300553800
TR776	U1897	300553800
TR777	U1897	300553800
TR778	U1897	300553800
TR779	U1897	300553800
TR780	U1899	300554320
D101	DPAD1	300525930
D102	Zener, 16V	300521320
D103	Zener, 16V	300521320
D104	J511	300526040
D105	Zener, 5V1	300521310
D106	J507	300525820
D107	SD3	300522160
D108	SD3	300522160
D109	WRO57	300525770
D110	WRO57	300525770
D111	Zener, 12V	300521480
D112	SD3	300522160
D113	SD3	300522160
D114	Zener, 12V	300521480
D401	WRO57	300525770
D402	J507	300525820
D403	IN821	300522460
D404	Zener, 3V3	300521860
D405	Zener, 5V1	300521310
D406	J507	300525820

PCB 6 Parts List (cont.6)

Cct Ref.	General Description	Solartron Part No.
D407	J507	300525820
D408	WR057	300525770
D409	Zener, 16V	300521320
D410	Zener, 16V	300521320
D711	Zener, 12V	300521480
D712	IN3595	300523590
D713	IN3595	300523590
D714	Zener, 12V	300521480
D715	SD3	300522160
D716	Zener, 8V2	300521330
D717	J511	300526040
D750	HP5082-6221	300525380
D751	HP5082-6221	300525380
D752	Zener, 5V6	300521450
D753	IN3595	300523590
D754	IN3595	300523590
D755	SD3	300522160
D756	SD3	300522160
RL2	Coto Relay 1240-0145	300652250
RL3	Coto Relay 1240-0145	300652250
RL4	Coto Relay 3400-0011	300652270
RL5	Coto Relay 3400-0051	300652290
RL6	Coto Relay 1240-0144	300652260
RL7	Coto Relay 1285-0051	300652310
RL701	Coto Relay 7002-5082	300652300
R1702	Coto Relay 4000-0119	300652320
RL703	Coto Relay 4000-0119	300652320
RL704	Coto Relay CR-4010-5-1011	300652200
RL705	Coto Relay CR-4002-5-1011	300652210
RL706	Coto Relay CR-4002-5-1011	300652210
RL707	Gentech Relay 831C-1	300652180
S1	Front/Rear Switch	377000410
SG1	Spark Gap	300011470
PL603	Amp Mod, 6 Way	352306090
TL1	Turret Lug	355500430
TL2	Turret Lug	355500430

PCB 6 Parts List (cont.7)

Cct Ref.	General Description	Solartron Part No.
TP101 to TP107	Test Hook	355400760
TP401 to TP405	Test Hook	355400760
TP702	Test Hook	355400760
TP705	Test Hook	355400760
TP750 to TP753	Test Hook	355400760
TP756	Test Hook	355400760
TP757	Test Hook	355400760
	Ceramic Beads	470120100
	Ceramic Beads	470120040
	Heatsink	300584200

PCB 8 Parts List

Cct Ref.	General Description	Solartron Part No.
IC801	Resistor Pack, 22k	160400589
SK801	Socket, 16 Way DIL	300584860
SW801	Switch, 8 Way DIL	375000600

PCB 4 &
PCB 14 Parts List

Cct Ref.	General Description				Solartron Part No.
R401	CACP	100k	1/4W	10%	172051000
R402	CACP	100k	1/4W	10%	172051000
R403	CACP	470	1/4W	10%	172024700
R404	CACP	820	1/4W	10%	172028200
R405	CACP	150	1/4W	10%	172021500
R406	CACP	3k3	1/4W	10%	172033300
C401	CERM	22p	500V	20%	241312200
C402	CERM	22p	500V	20%	241312200
C403	CERM	47n	12V	20%	241744700
C404	CERM	47n	12V	20%	241744700
C405	CERM	47n	12V	20%	241744700
C406	CERM	47n	12V	20%	241744700
C407	CERM	47n	12V	20%	241744700
C408	CERM	47n	12V	20%	241744700
C409	TAND	4µ7	10V	20%	265464700
C410	TAND	33µ	10V	20%	265473300
C411	CERM	47n	12V	20%	241744700
C412	CERM	47n	12V	20%	241744700
IC401	MC68B09P				510005121
IC402	MC68A44				510005031
IC403	74LS02				510002230
IC404	Resistor Pack, 22				192112200
IC405	Resistor Pack, 6.8k				160400569
IC406	TC5516P				510005470
IC407	TC5516P				510005470
IC408	TC5516P				510005470
IC409	TC5516P				510005470
IC410	TC5516P				510005470
IC411	TC5516P				510005470
IC412	TMS2564*				510005610
IC413	TMS2564*				510005610
IC414	TMS2564*				510005610
IC415	TMS2564*				510005610
IC416	74LS138				510003530
IC417	74LS138				510003530
IC418	74LS138				510003530
IC419	74LS157				510002240
IC420	8291				510005590

* On later models Part No. 2764 is used. 510006280

PCB 4 &
PCB 14 Parts List (cont. 1)

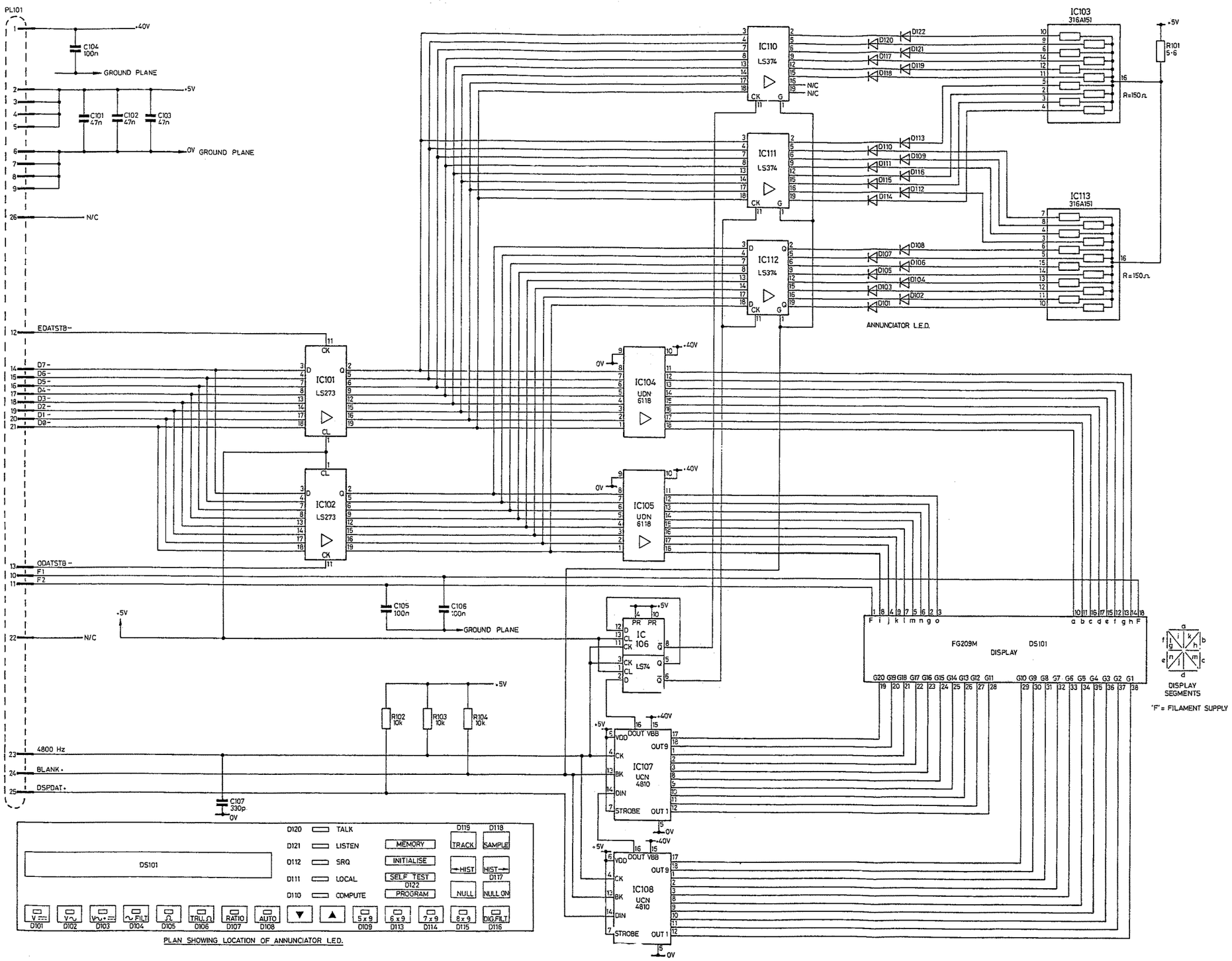
Cct Ref.	General Description	Solartron Part No.
IC421	MC3447	510005700
IC422	MC3447	510005700
IC424	74LS244	510004500
IC430	TMS2564*	510005610
TR401	BCY70	300553590
TR402	BC107	300553320
TR403	2N2369	300552390
D401	SD3	300522160
D403	SD3	300522160
D404	Zener, 3.3V	300521860
SK401	Socket, 40 Way DIL	300585190
SK402	Socket, 28 Way DIL	300585160
SK403	Socket, 28 Way DIL	300585160
SK404	Socket, 28 Way DIL	300585160
SK405	Socket, 28 Way DIL	300585160
SK406	Socket, 28 Way DIL	300585160
SK407	Socket, 28 Way DIL	300585160
SK408	Socket, 24 Way DIL	300584910
SK409	Socket, 24 Way DIL	300584910
SK410	Socket, 24 Way DIL	300584910
SK411	Socket, 24 Way DIL	300584910
SK412	Socket, 24 Way DIL	300584740
SK413	Socket, 16 Way DIL	300584900
SK414a	Socket, 40 Way DIL	300585190
SK414b	Socket, 16 Way DIL	300584860
SK415	Socket, 40 Way DIL	300585190
SK424	Socket, 20 Way DIL	300585220
SK430	Socket, 28 Way DIL	300585160
B401	Battery, 3.6V, 90mA/hr	800400210
PL401	Plug and Ribbon Cable	70810204
X401	Crystal, 6MHz	300810560
TP1 to TP6	Test Hook	355400760
TP7	Amp. Disc. Pin	355900550
TP8	Test Hook	355400760
TP9	Test Hook	355400760
* On later models Part No. 2764 is used.		510006280

7081 General Assembly

Chassis Assembly Part 2	70810002A
Chassis Assembly Part 1	70810003A
Front Moulding Assembly	70810004A
Rear Panel Assembly	70810005A
PCB 3 Assembly	70810503X
PCB 5 Assembly	70810505X
Chassis S/Plate Assembly	70810208A
T/Form PCB 3 Lead	70810217A
Mains SKT Lead Brown	70810218A
Mains SKT Lead Blue	70810219A
Screen	70812021A
Transformer	309617701
Chassis/PCB 5 Lead	70810222A
Cable Clip S/ADH	412090440
Sleeve, Rubber Black	425100000
Sleeve, PTFE Natural	429500080
Sleeving, 4mm Black	425509000
Cable Assembly, 16-Way	359900260
Cable Clip S/ADH	412090340
Display Keyboard Assembly	70810006A
Switch Assembly	70810207B
Keyswitch	377000410
PCB 1 Assembly	70810501X
PCB 4 Assembly	70810504X
PCB 6 Assembly	70810506X
PCB 8 Assembly	70810508X
Cable Assembly	35300233A
Socket, 5-way	352105010
Cover Top Final Assembly	70810007A
Cover Top Assembly	70810209A
Screen Top Cover	70819510X
Screen Insulation	70812011A
Screen Insulation	70812006A
Cover Bottom Final Assembly	70810008A
Cover Bottom Assembly	70810210A
Screen Bottom Assembly	70810213A
Screen Insulation	70812020A
Accessories	70810009A

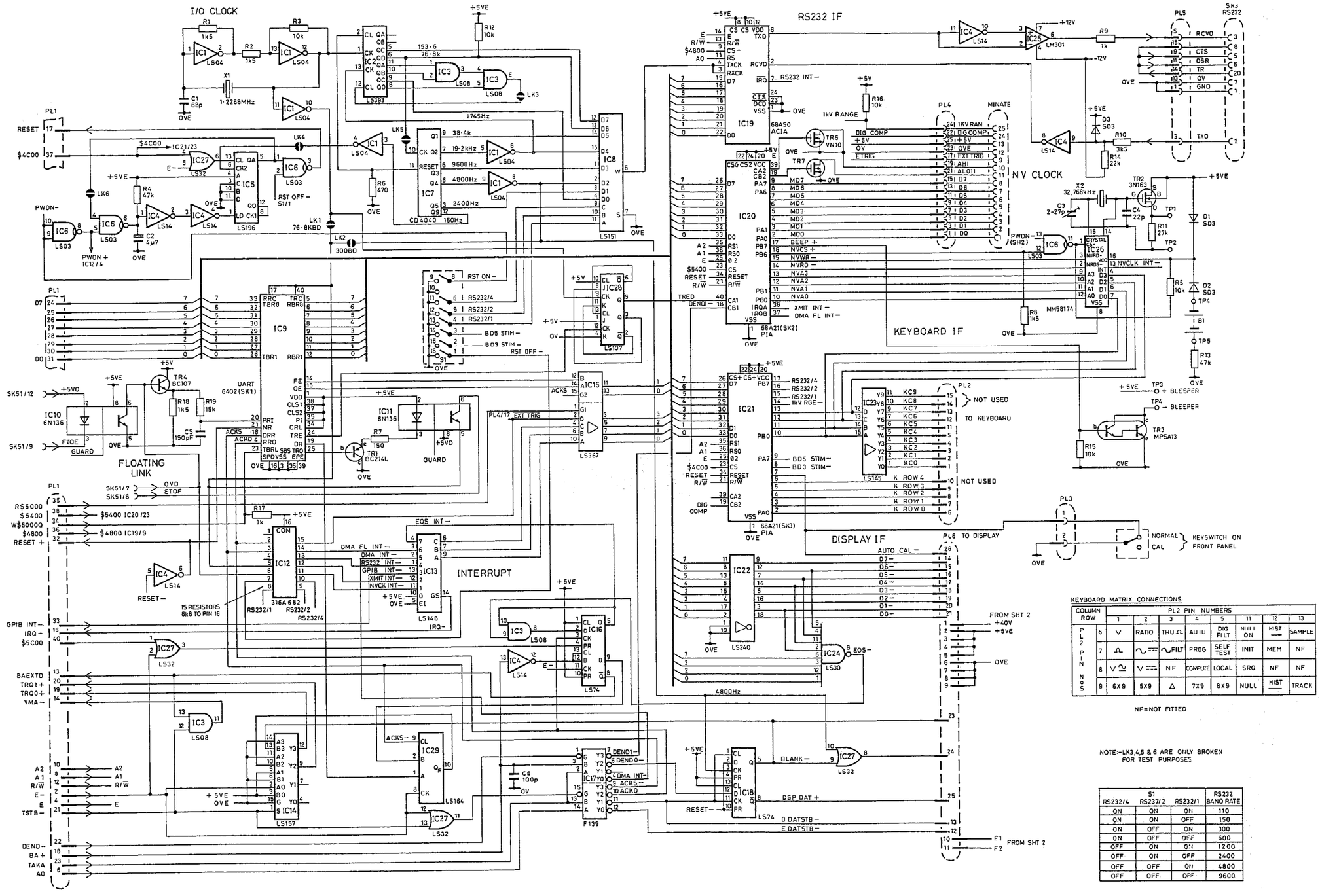
Rear Panel Assembly	
Rear Panel	70812003A
Input Socket/Board 6	70810220A
Cable Assembly, RS232	70810201A
Cable Assembly, Minate	70810202A
Cable Assembly, GP-IB	70810211A
Rear Panel/Trasnformer Lead	70810215A
Socket, 5-way	352105010
Socket, 5-way DIN	352505020
Socket, 4-way	352504100
Mains Switch, DPCO	375500030
Mains Selector	550001480
Fuselink, 200mA (for 240v supply)	360106280
Fuselink, 400mA (for 120V supply)	
Sleeve, Rubber Black	425100500
Sleeve, Rubber Black	425100000

Sleeve, PTFE Natural	429500080
Sleeving, 4mm Black	425509000
Resistor, 1M	172361000
Wire, 7/0.2 PTFE Red	480073020
Wire, 7/0.2 PTFE Green	480073050
Wire, 23/0.2 PVC Green/Yellow	480095740
Board Interconnection Assemblies	
Cable Assembly, Boards 5-6	70810206A
Plug, 34-Way	351334010
Socket, 34-Way	351534010
Ribbon Cable, 34-Way	480095500
Cable Assembly, Boards 5-6	70810205A
Plug, 10-Way	351310040
Socket, 10-Way	351510060
Ribbon Cable, 10-Way	480095560
Cable Assembly, Boards 3-4	70810204A
Plug, 40-Way	351340020
Socket, 40-Way	351540010
Ribbon Cable, 40-Way	480120590
Cable Assembly, Boards 1-3	70810203A
Plug, 26-Way	351326030
Socket, 26-Way	351526020
Ribbon Cable, 26-Way	480095520



PLAN SHOWING LOCATION OF ANNUNCIATOR LED.

Display
70817501



KEYBOARD MATRIX CONNECTIONS

COLUMN ROW		PL2 PIN NUMBERS							
		1	2	3	4	5	11	12	13
PL2 PIN NOS	6	V	RATIO	THU ⎍⎍	AUTO	DIG FILT	NULL ON	HIST ⎓	SAMPLE
	7	⎍	~ ⎓	~FILT	PROG	SELF TEST	INIT	MEM	NF
	8	V ~	V ⎓	NF	COMPUTE	LOCAL	SRQ	NF	NF
	9	6X9	5X9	△	7X9	8X9	NULL	HIST ⎓	TRACK

NF = NOT FITTED

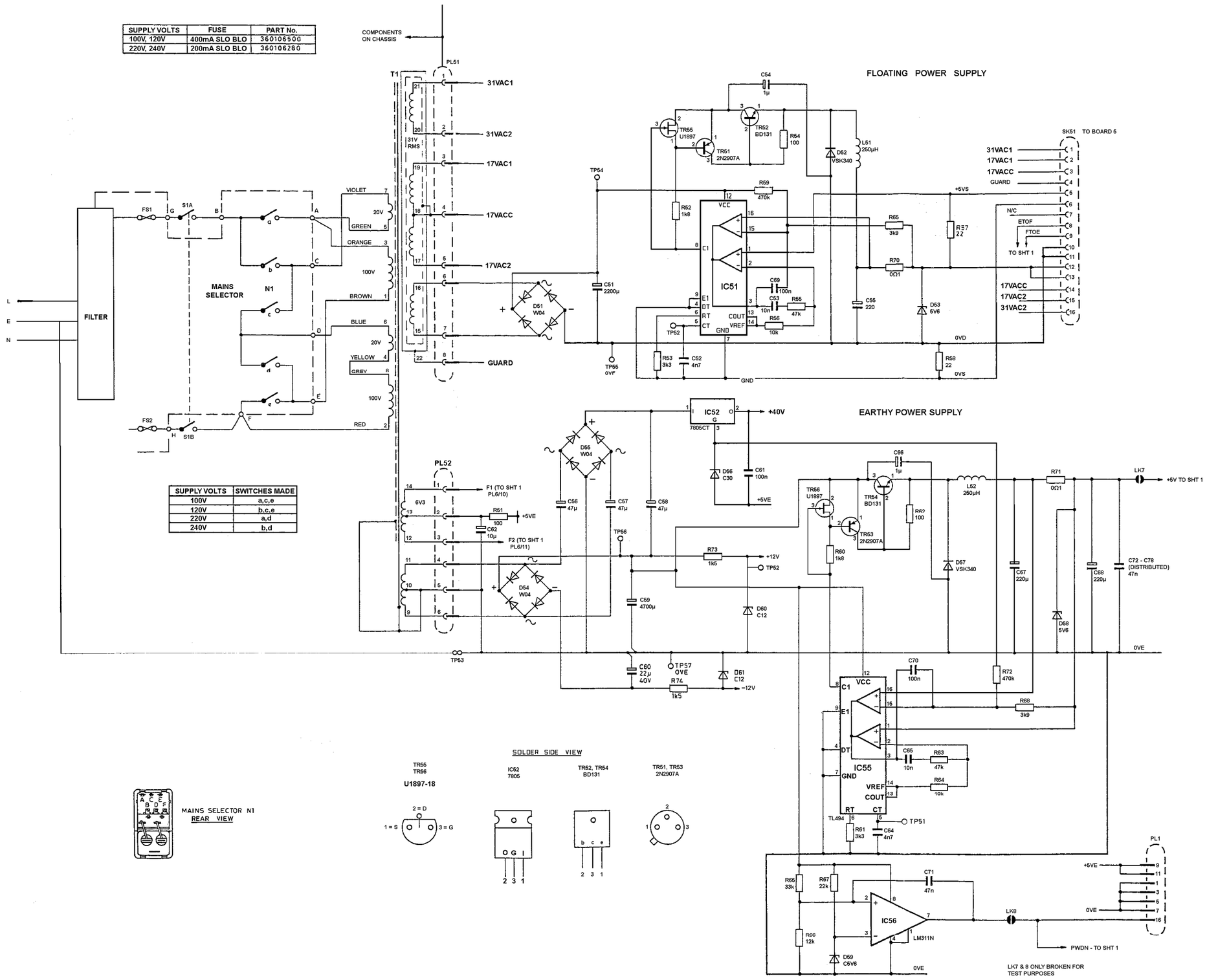
NOTE:- LK3,4,5 & 6 ARE ONLY BROKEN FOR TEST PURPOSES

S1 RS232/4	S1 RS232/2	S1 RS232/1	RS232 BAND RATE
ON	ON	ON	110
ON	ON	OFF	150
ON	OFF	ON	300
ON	OFF	OFF	600
OFF	ON	ON	1200
OFF	ON	OFF	2400
OFF	OFF	ON	4800
OFF	OFF	OFF	9600

Earthy Logic Input/Output (1)
70817503 Sh.1

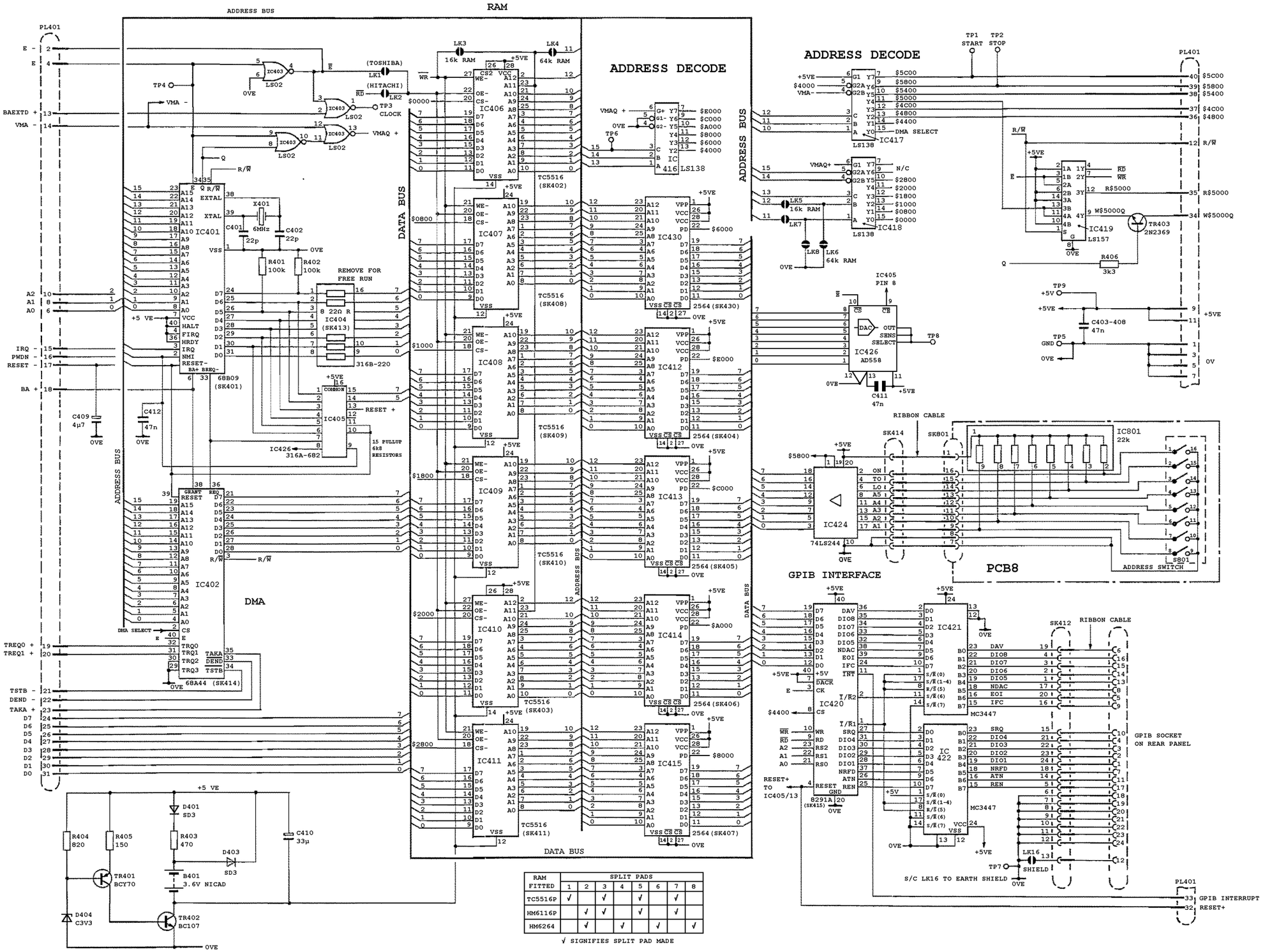
SUPPLY VOLTS	FUSE	PART No.
100V, 120V	400mA SLO BLO	360106500
220V, 240V	200mA SLO BLO	360106280

SUPPLY VOLTS	SWITCHES MADE
100V	a,c,e
120V	b,c,e
220V	a,d
240V	b,d



SOLDER SIDE VIEW

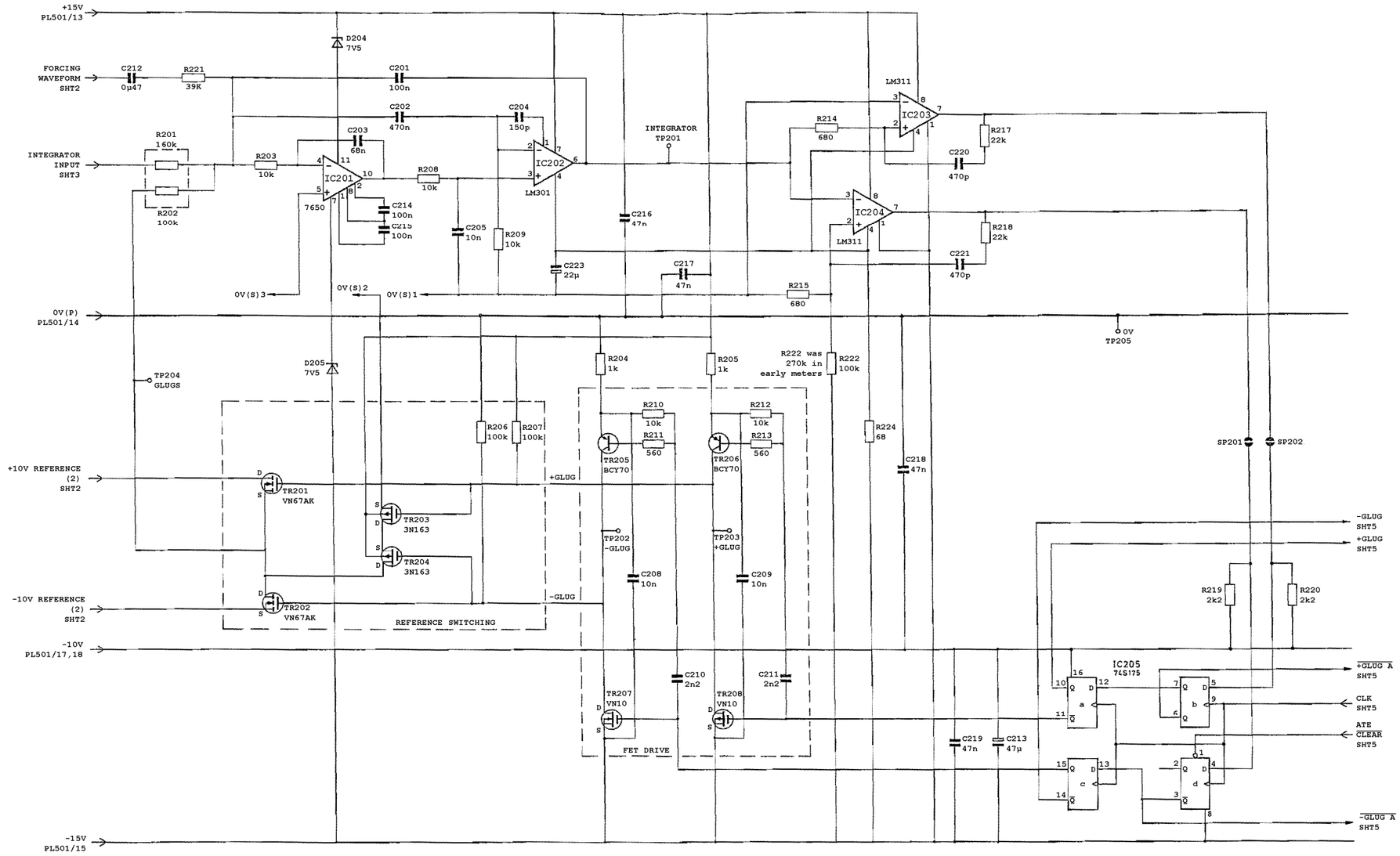
Power Supply (2)
70817503 Sh.2



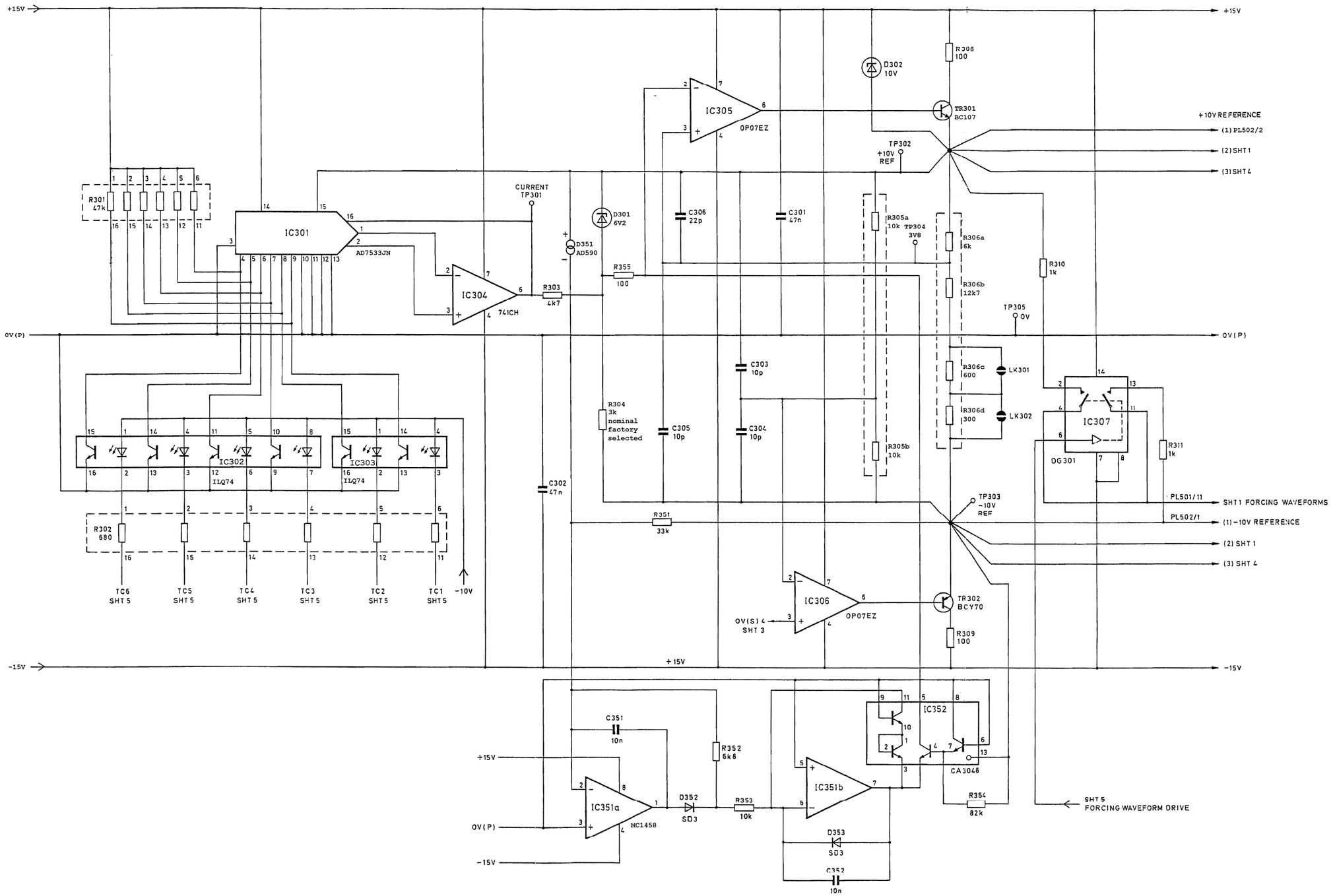
RAM FITTED	SPLIT PADS							
	1	2	3	4	5	6	7	8
TC5516P	√		√		√		√	
HM6116P		√	√		√		√	
HM6264		√		√		√		√

√ SIGNIFIES SPLIT PAD MADE

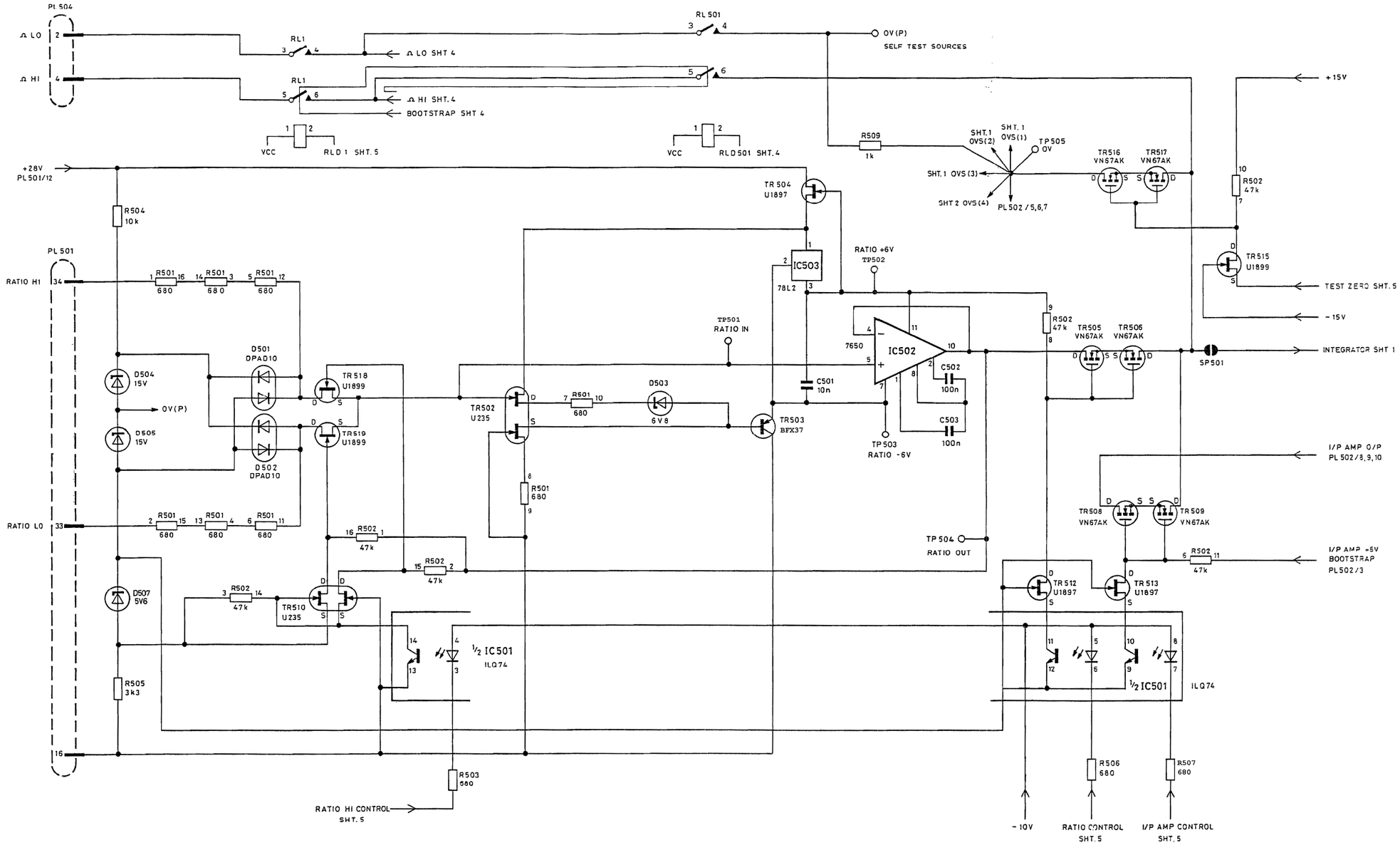
Earthy Processor
70817504/70817508



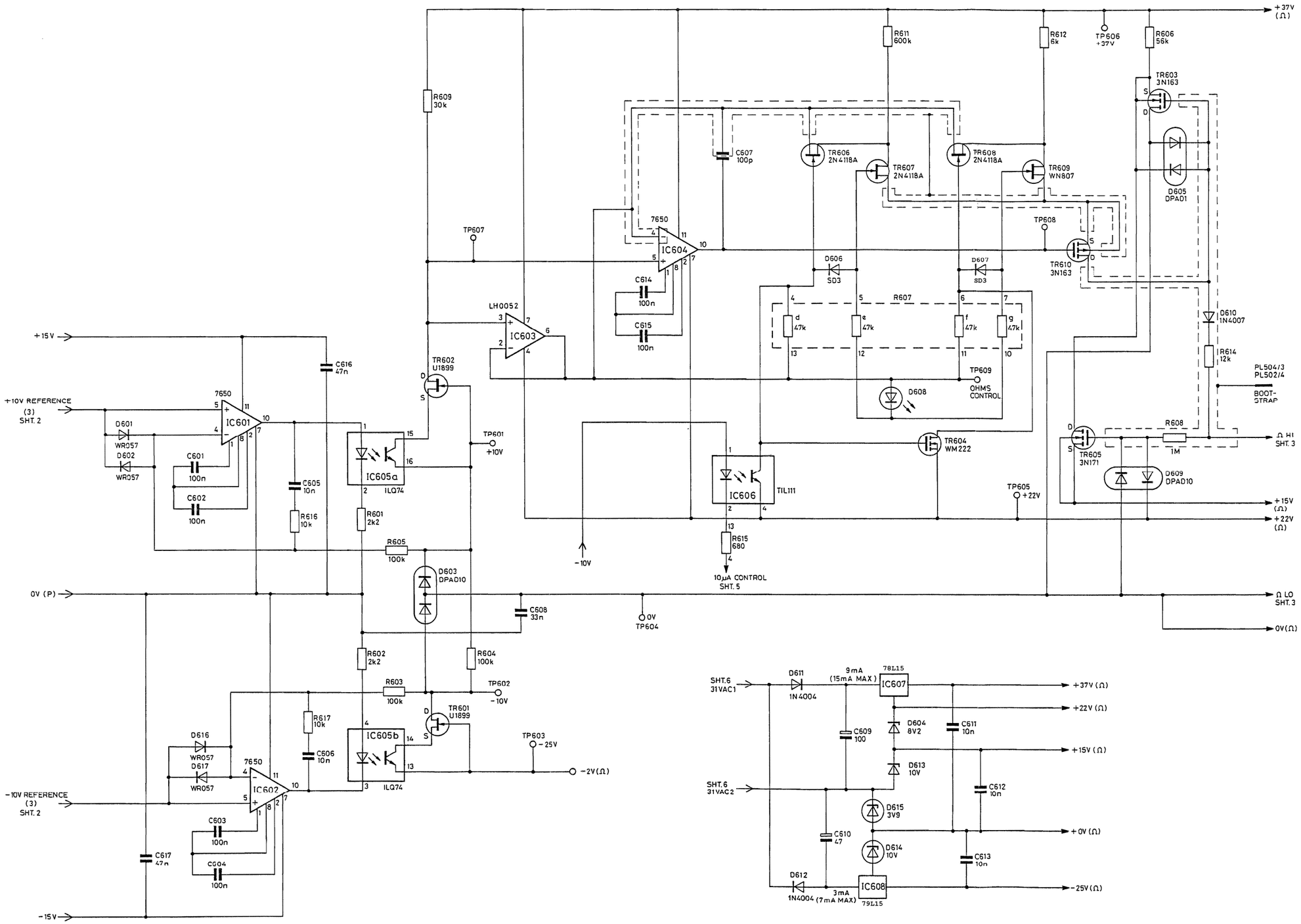
V-to-T Converter (1)
70817505 Sh.1



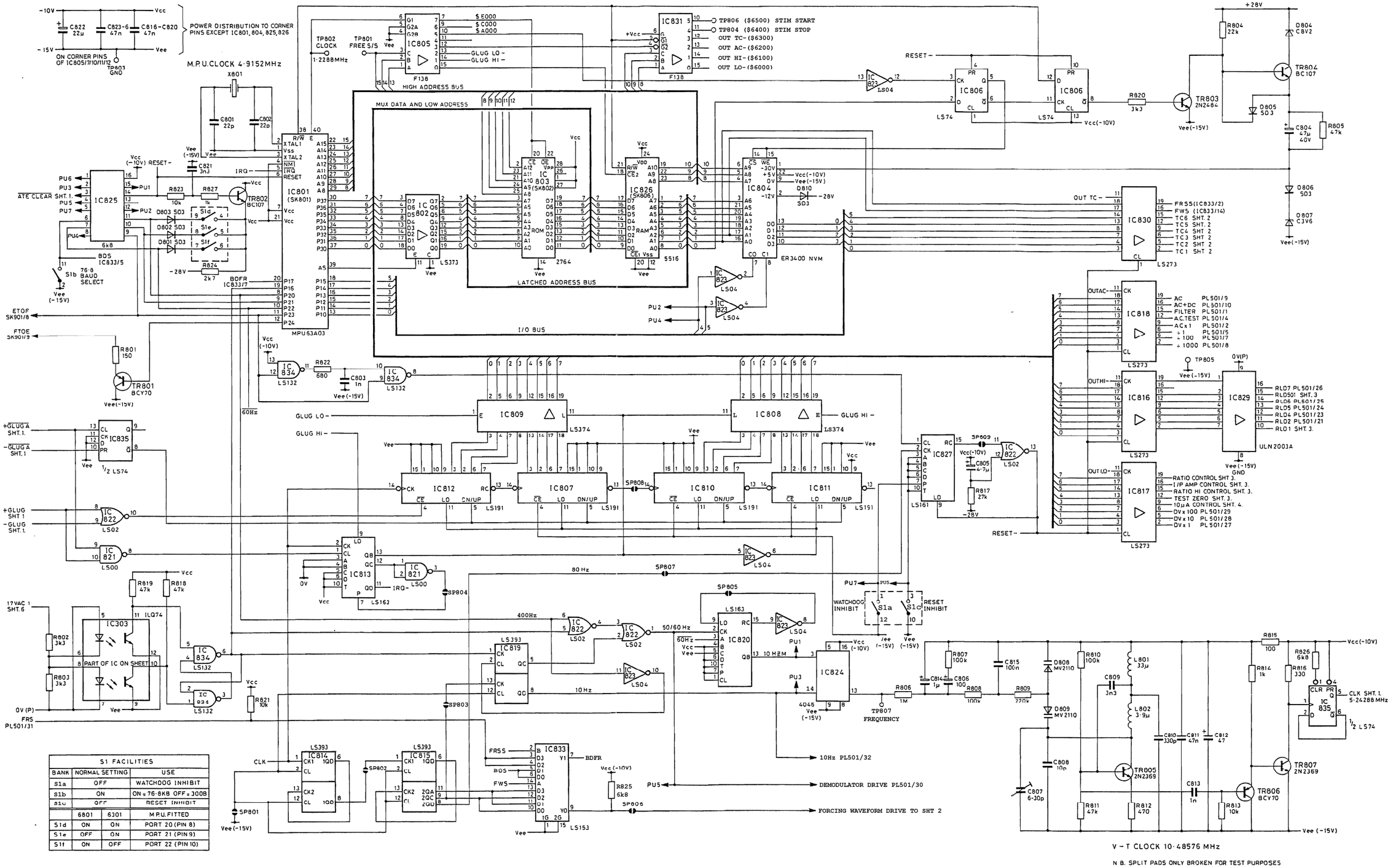
Reference (2)
70817505 Sh.2



Ratio Circuit (3)
70817505 Sh.3

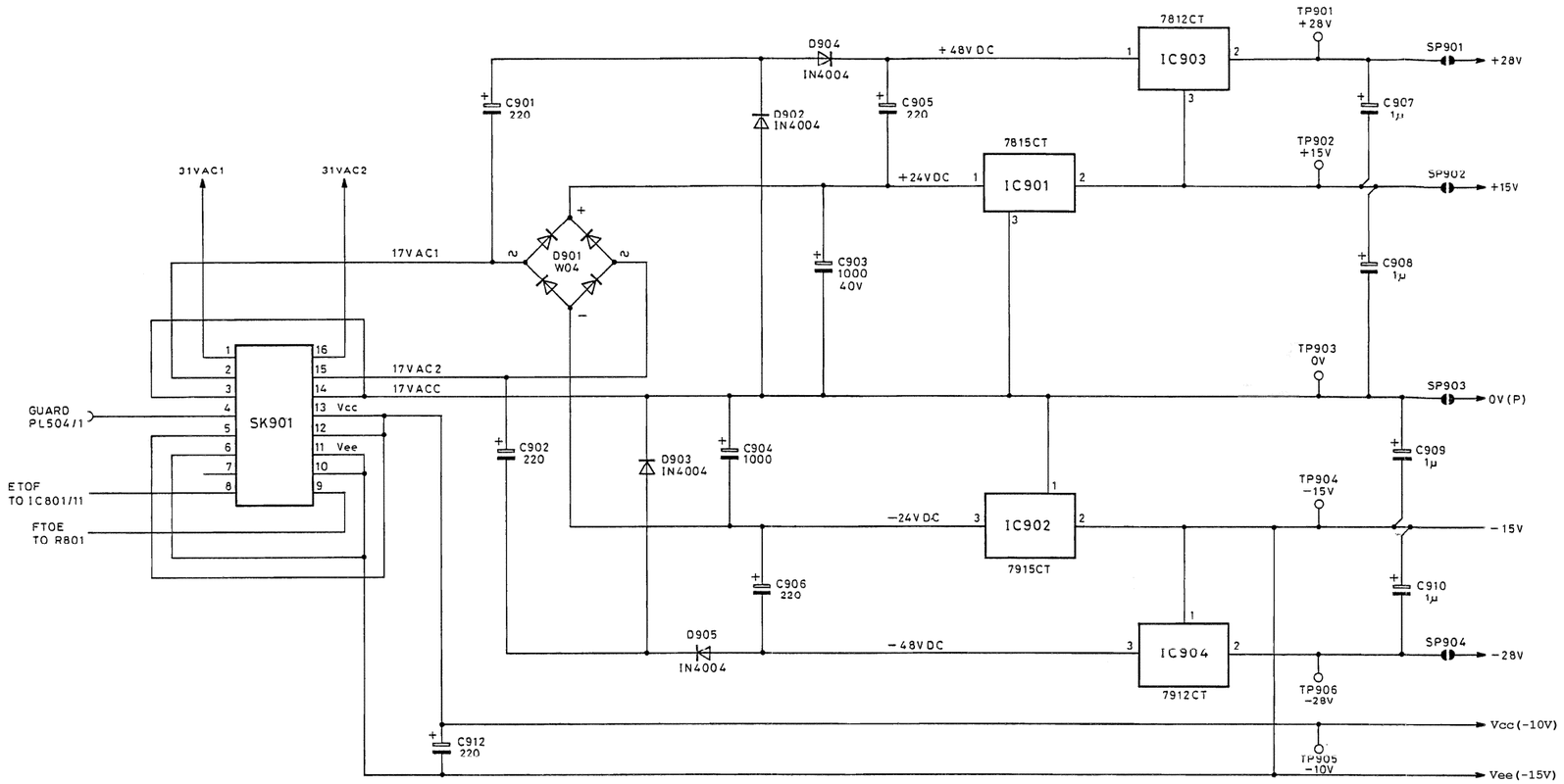


Ohms Circuit (4)
70817505 Sh.4



S1 FACILITIES			
BANK	NORMAL SETTING		USE
S1a	OFF		WATCHDOG INHIBIT
S1b	ON		ON = 76·8KB OFF = 300B
S1c	OFF		RESET INHIBIT
	6801	6301	M.P.U. FITTED
S1d	ON	ON	PORT 20 (PIN 8)
S1e	OFF	ON	PORT 21 (PIN 9)
S1f	ON	OFF	PORT 22 (PIN 10)

Floating Logic (5)
70817505 Sh.5



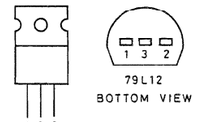
PL501

FILTER	1	2	AC x 1
SPARE	3	4	AC TEST
RLD704	5	6	SPARE
÷ 100	7	8	+1000
AC	9	10	AC+DC
FORCING WAVEFORM	11	12	+28V
+15V	13	14	0V(P)
-15V	15	16	-28V
Vcc	17	18	Vcc
Vee	19	20	Vee
RLD 2	21	22	SPARE
RLD 4	23	24	RLD 5
RLD 6	25	26	RLD 7
D.V x 1	27	28	D.V. x 10
D.V. x 100	29	30	DEMODULATOR
FRS	31	32	10Hz
SPARE	33	34	SPARE

PL502

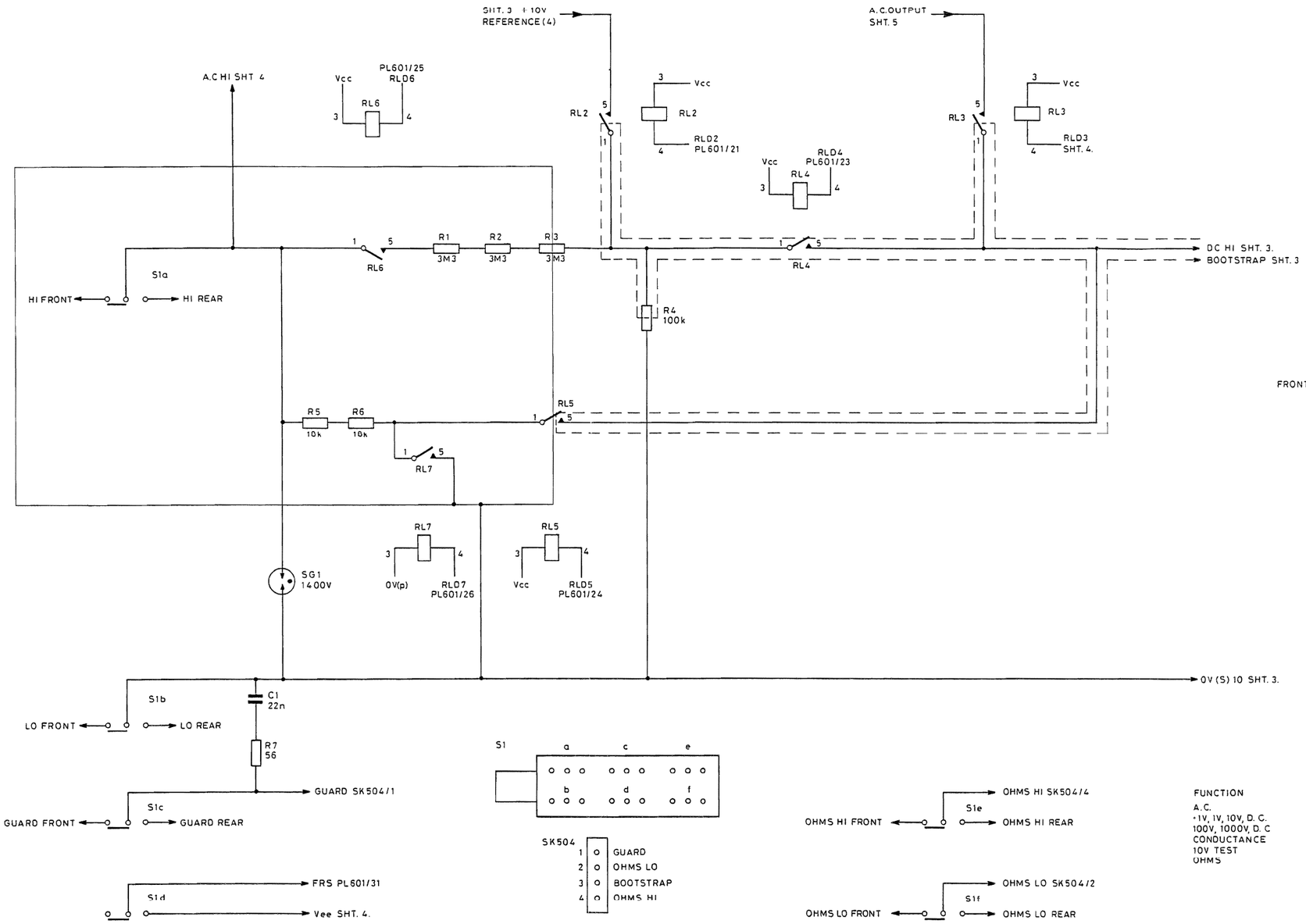
-10V REF	1	2	+10V REF
+5 BOOTSTRAP	3	4	BOOTSTRAP
0V(S)	5	6	0V(S)
0V(S)	7	8	I/P AMP O/P
I/P AMP O/P	9	10	I/P AMP O/P

	1	2	3
7912	GND	IN	OUT
7812	INPUT	OUT	GND

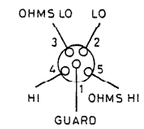


79L12
BOTTOM VIEW

Floating Power Supply (6)
70817505 Sh.6



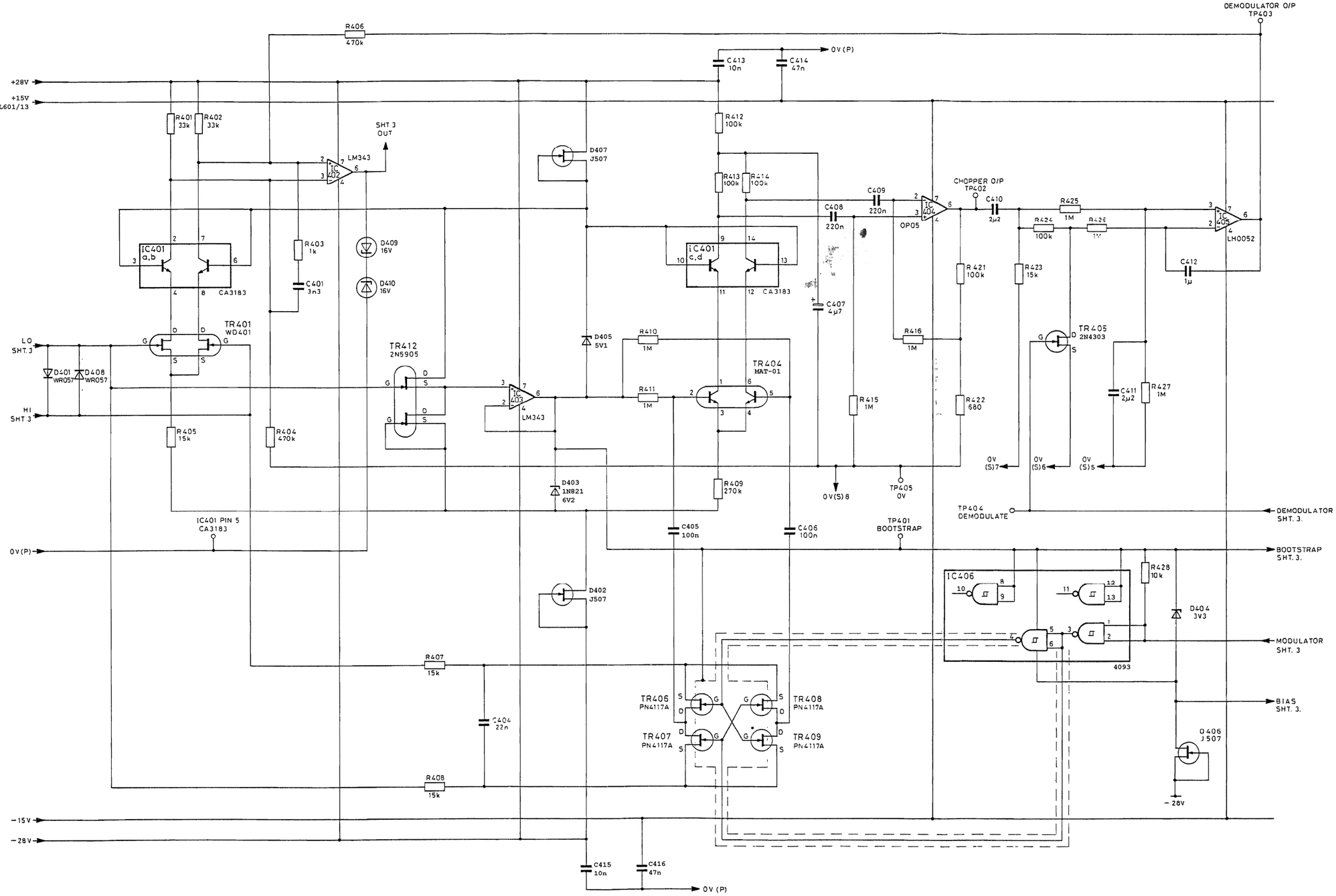
FRONT INPUT SOCKET / REAR SOCKET CONNECTIONS
(EXTERNAL VIEW)



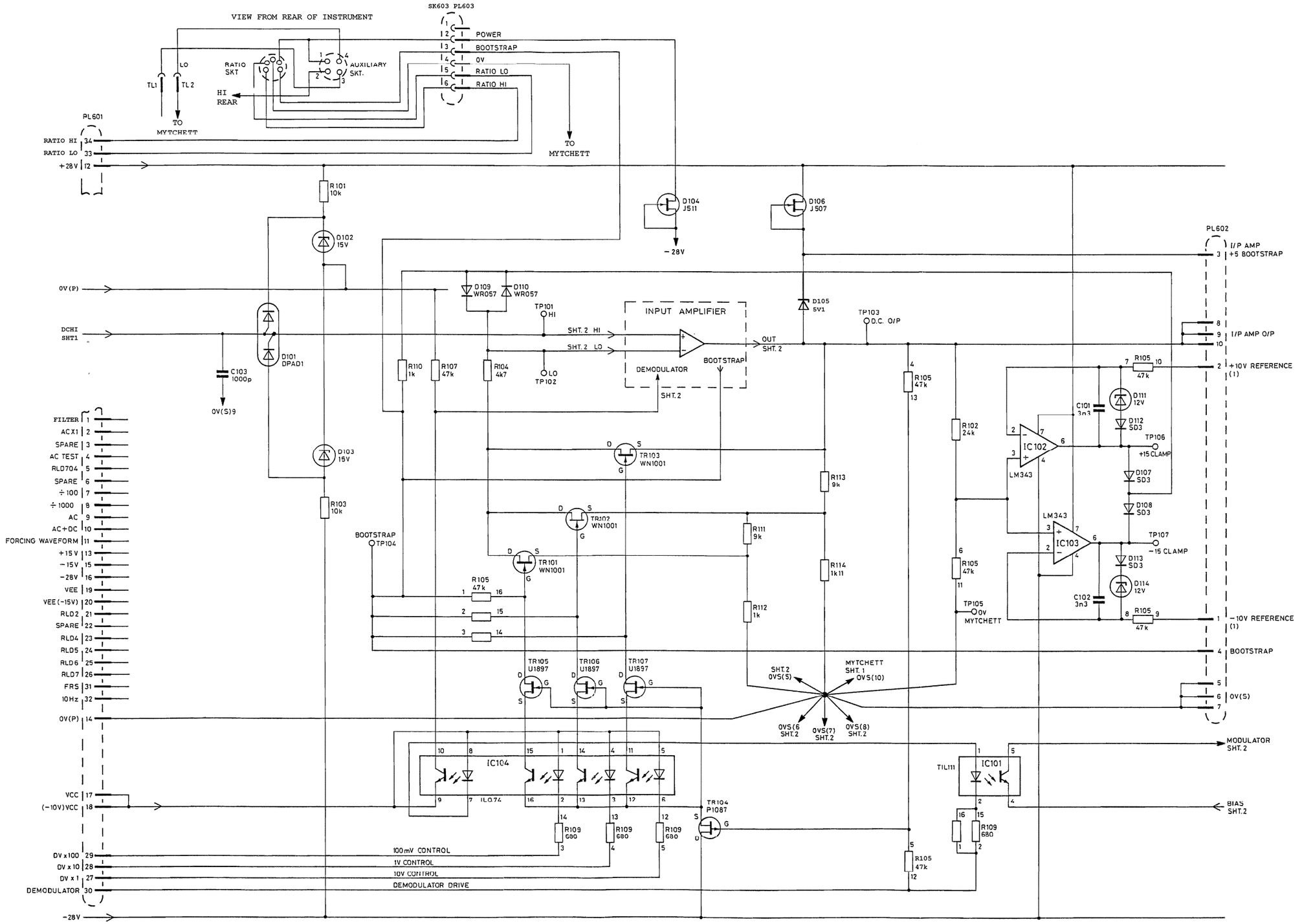
FUNCTION	RELAYS ON
A.C.	RL3
·1V, 1V, 10V, D. C.	RL5
100V, 1000V, D. C	RL4 RL6
CONDUCTANCE	RL2 RL5 RL6
10V TEST	RL2 RL4
OHMS	RL5 RL1

RL7 CLOSED WHILE RL5 OPENS OR CLOSES

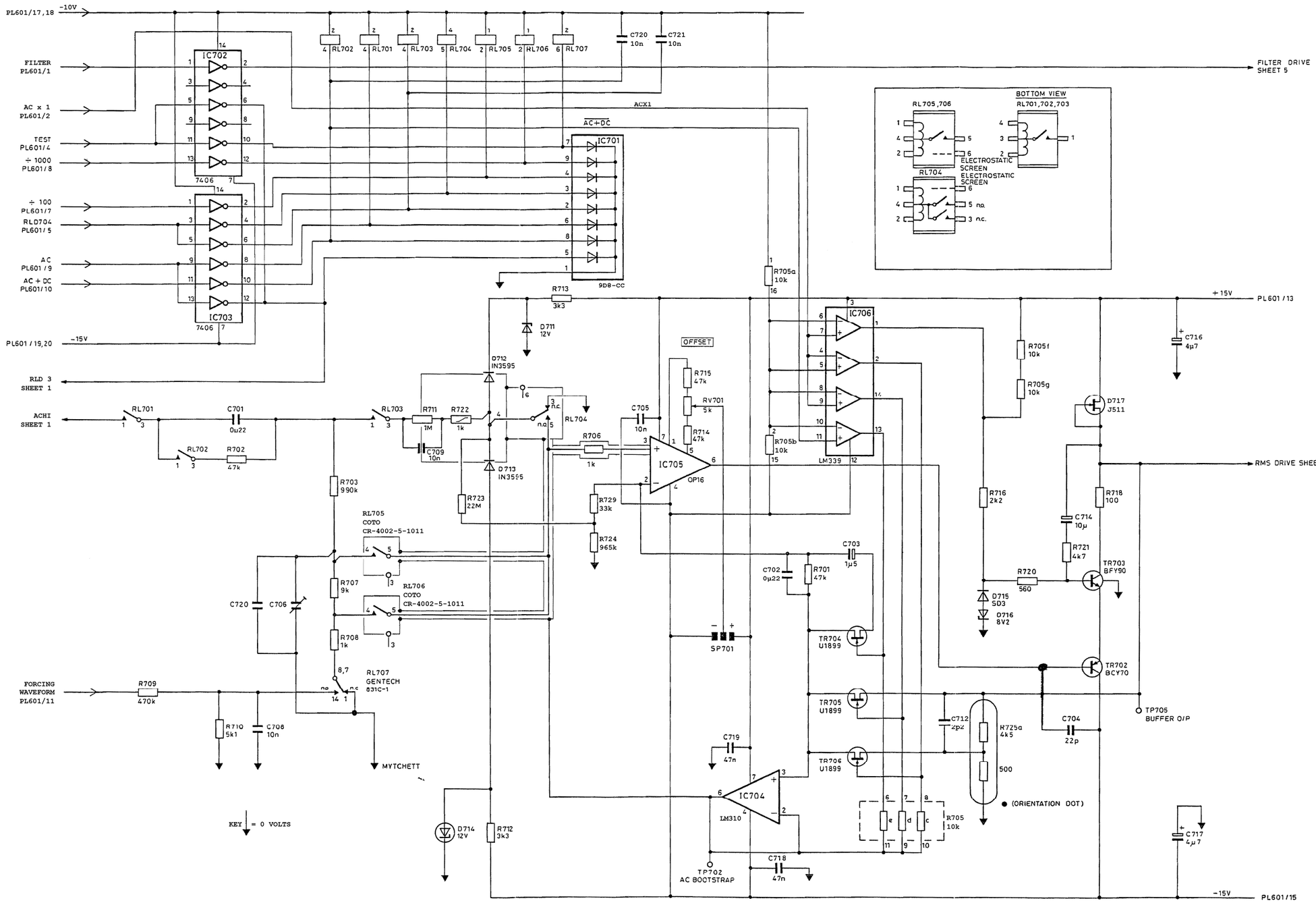
Attenuator (1)
70817506 Sh.1



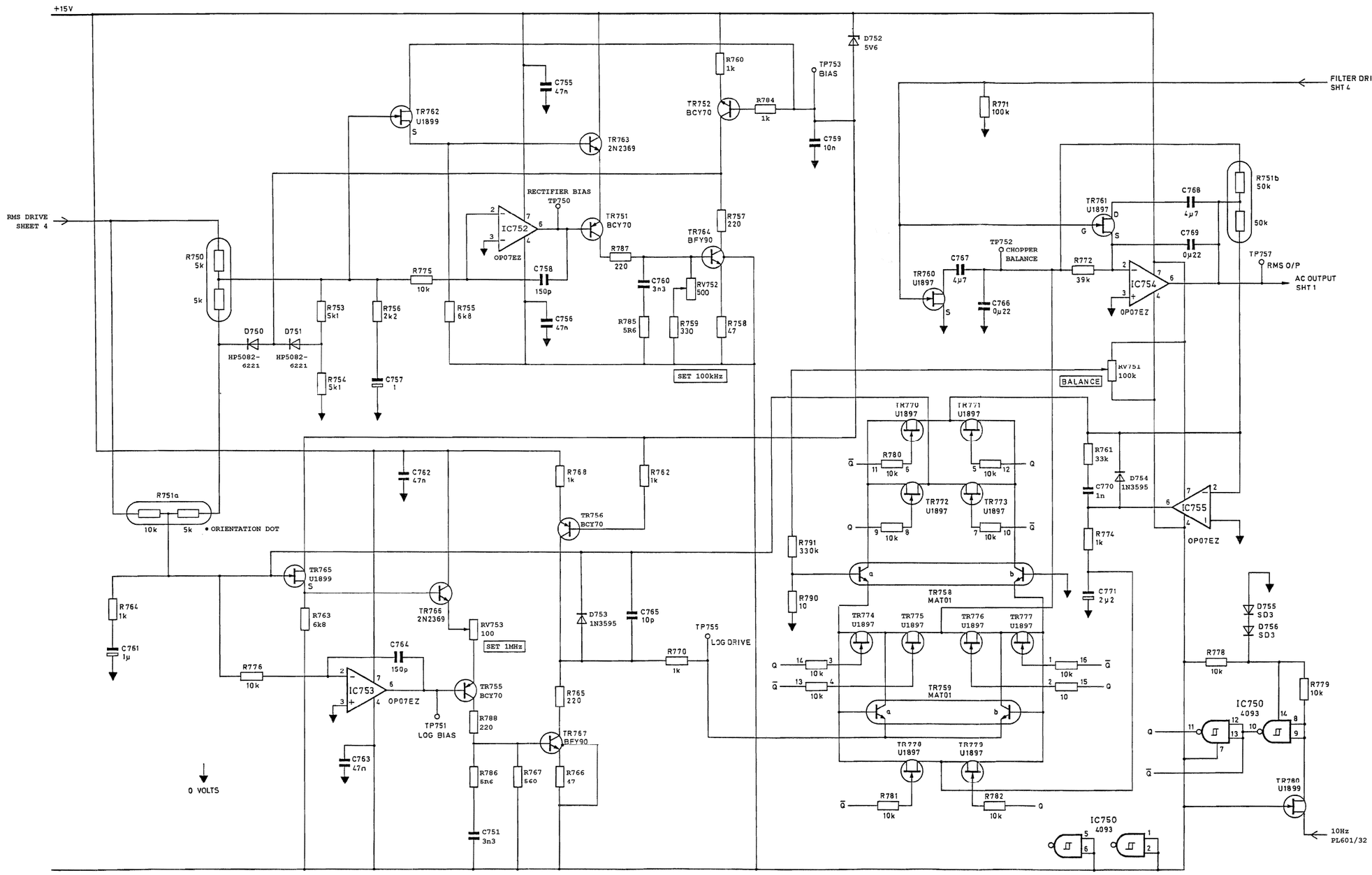
Input Amplifier (2)
70817506 Sh.2

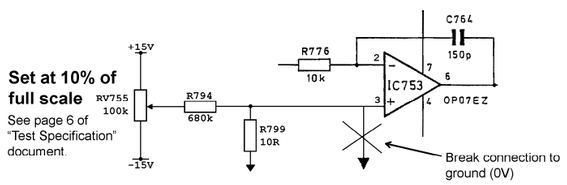


DC Ranging (3)
70817506 Sh.3



AC Attenuator and Buffer (4)
70817506 Sh.4

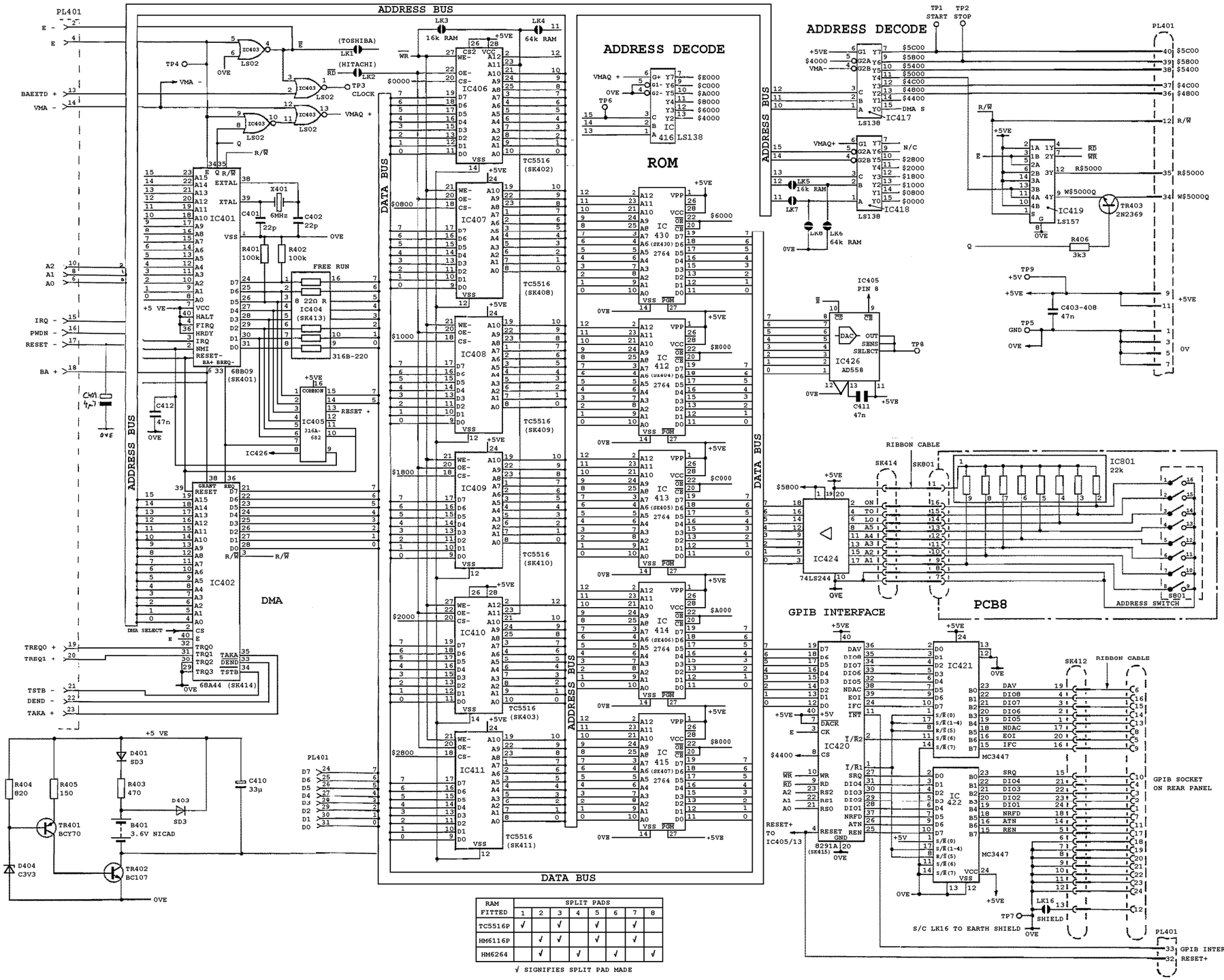




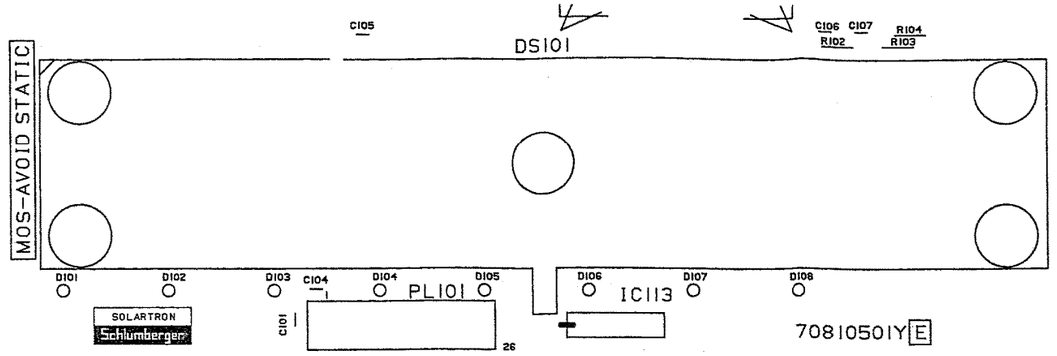
AC Linearity Adjustment Modification made in later meters

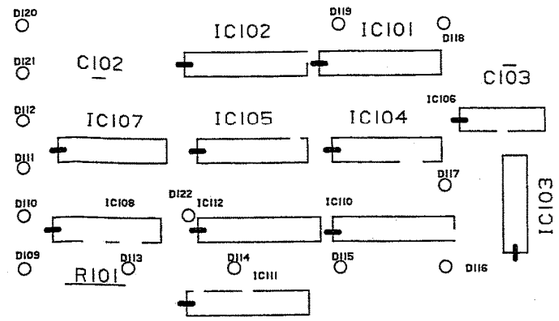
AC RMS Converter (5)
70817506 Sh.5

RAM

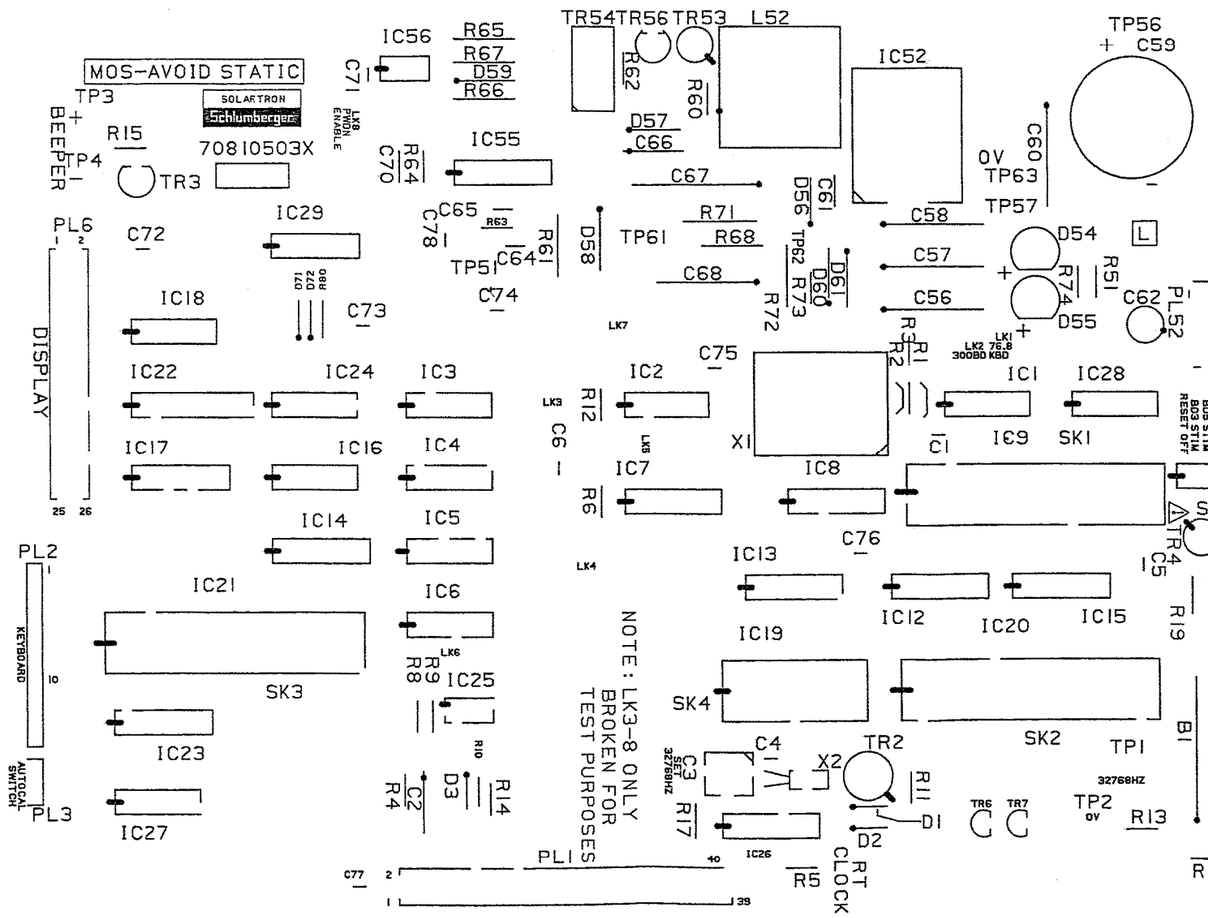


Earthy Processor
70817514/70817508

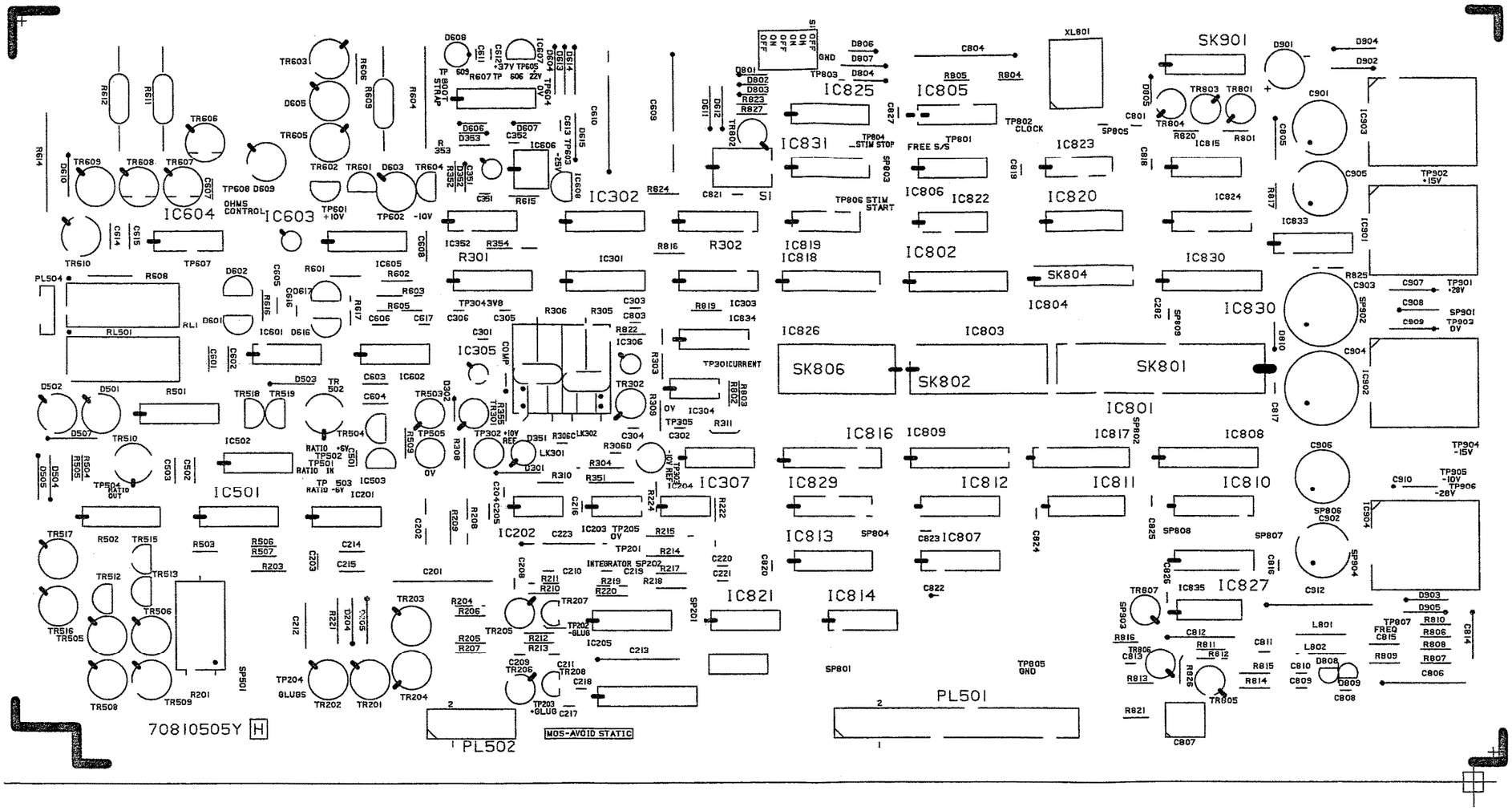




Component Location: Pcb 1



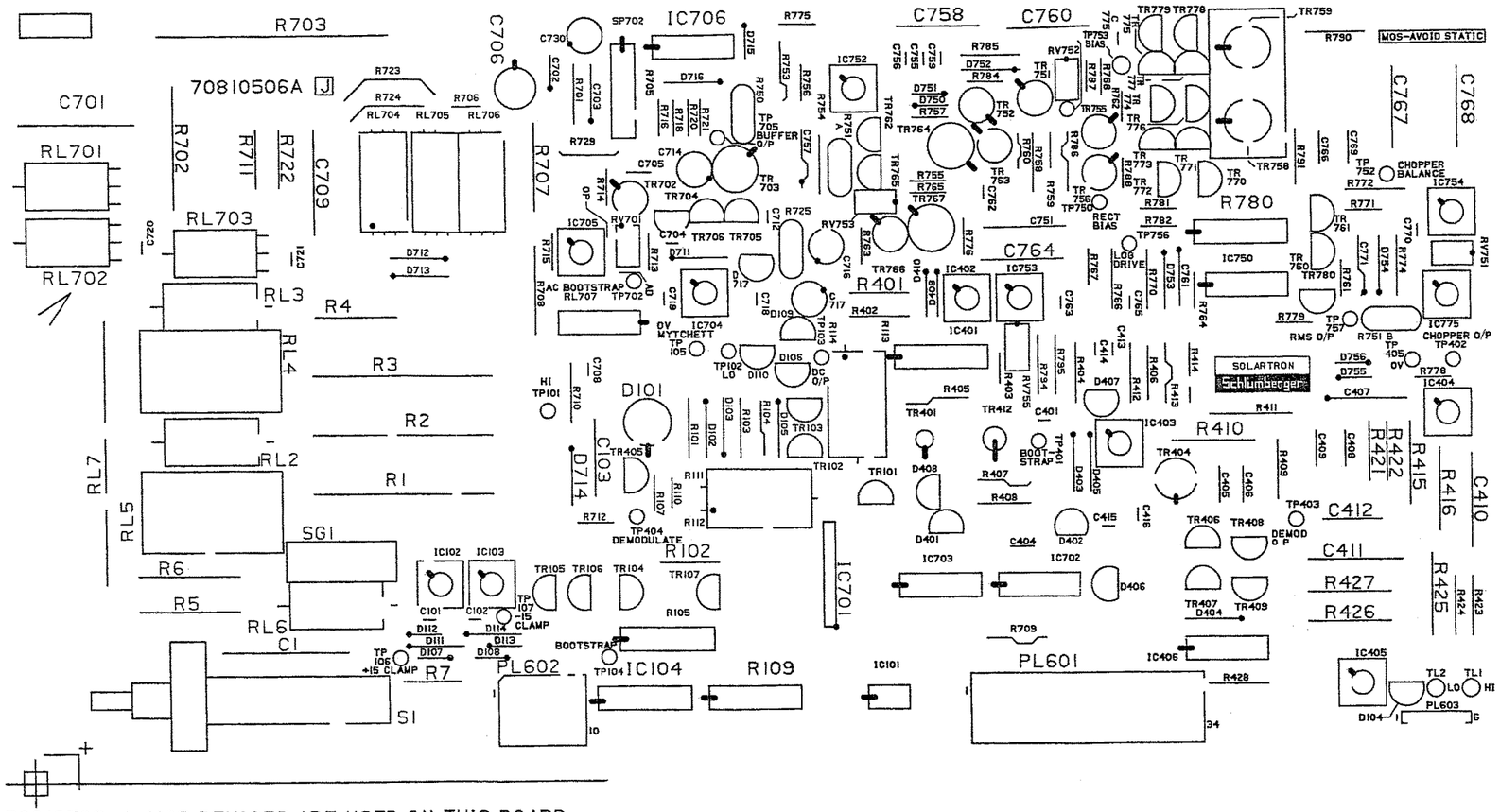
Component Location: Pcb 3



70819505 -H NOTATION

MOS DEVICES USED ON THIS BOARD

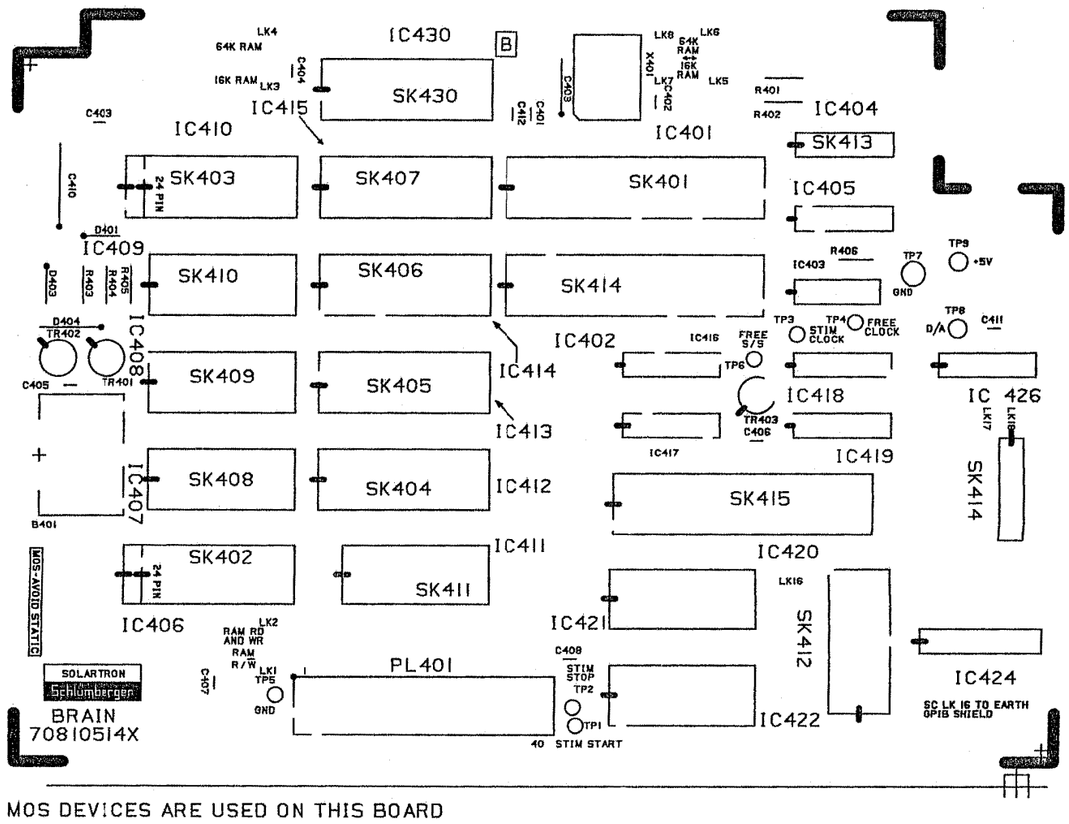
Component Location: Pcb 5



70819506-J MOS DEVICES ARE USED ON THIS BOARD
NOTATION

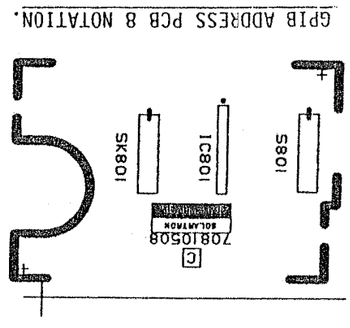
Component Location: Pcb 6

Component Location: Pcb 14



MOS DEVICES ARE USED ON THIS BOARD

Component Location: Pcb 8



CHAPTER 8
Montior, Calibration and Self Test

CONTENTS

8.1 Monitor Command

The MONITOR command enables the user to access the address/data space of both the "earthy" and "floating" processors of the 7081. The command should only be used by qualified service personnel and requires the use of an RS232 terminal operating at a preferred baud rate of 9600. The Reset Inhibit switches on printed circuit boards 3 and 5 should be set to ON, whilst the MONITOR command is being used, and the baud rate switches set to match the baud rate of the terminal.

WARNING: 1. The Reset Inhibit switches must be set to OFF when returning from MONITOR, ie, before the instrument undergoes a Device Clear, Power Off/On or Initialise.

2. Great care must be taken when writing data into the unit using the MONITOR command as incorrect use may result in confused operation and/or loss of calibration constants.

8.1.1 Earthy Monitor

To access the "earthy" processor, enter:

MONITOR Carriage Return (CR)

The 7081 will respond with:

M

Facilities To inspect an address location, enter:

aaaa,

where aaaa is the address in hexadecimal

The 7081 will respond with the contents on the same line, ie;

M 0000, 07-

To inspect the next location, enter:

,

To change the existing value, enter:

dd, CR

ie; M 0000, 07-08

To inspect a new address, enter:

CR

bbbb,

where bbbb is the new address

To initialise the NVM (Non-Volatile Memory), enter:

I CR

This command writes a chequer board pattern into the NVM together with a checksum. Any calibration constants present will be lost.

To transfer to the "floating" processor, enter:

T CR

To exit from MONITOR back to normal operation, enter:

CTRL X

Note: Any alpha hexadecimal characters must be entered in capitals.

Refer to Table 8.1 for a list of the main address locations for Earthy Monitor.

Table 8.1 Earthy Monitor Address Locations

Location	Address		Comments
	Software to AE	Software from AF	
MEMORY	2F1D	2F2E	Used for establishing constant values (see 'Interpreting Data')
	10E0	10F1	Negative acknowledge from floating error counter
	10E2	10F3	Floating to Earthy receive error counter
MAINS FREQUENCY	0F64	0F75	Produces the following possible values: 31 = 50Hz 32 = 60Hz 33 = 400Hz
DUMP OF NVM CONTENTS	1071	1082	Produces the following possible values: 0 = Dump OK 1 = Overrun Error 2 = Underrun Error 3 = Message checksum error
NVM PAGE	1070	1081	Produces the following possible values: 0 = Both pages failed, page 2 used and defaulted where necessary 1 = Page 1 in use 2 = Page 2 in use, page 1 failed
VDC Constants	0F70	0F81	10 constants, ie 5 ranges, 2 constants per range
VAC Constants	0FA2	0FB3	5 constants, ie 5 ranges, 1 constant per range

Location	Address Software to AE	Software from AF	Comments
Ohms Constants	0FBB	0FCC	10 constants, ie 5 ranges, 2 constants per range
Top Ohms Range Constants	0FED	0FFE	3 constants, ie 1 range, 3 constants
Ratio Input Constants	0FFC	100D	1 constant, ie 1 range, 1 constant
Zener Temp-erature coefficient	106E	107F	
Page Checksum	106F	1080	

8.1.2 Floating Monitor

Access to the "floating" processor is only possible via the "earthy" processor. (See previous section).

Once the transfer command has been entered, the unit will respond with the sign on message "DIS EM FLOAT" followed by the prompt !, indicating that the unit is in the RAM/ROM mode.

Two modes are possible:

* To change to RAM/ROM mode, enter:-

  R CR

  The 7081 will respond with:-

  !

* To change to NVM mode, enter:-

  N CR

  The 7081 will respond with:-

  "

Facilities To inspect an address location, enter:

aaaa

where aaaa is the address in hexadecimal.

To change the value, enter:-

dd CR

Note: If the NVM mode is enabled, addresses 0 to 3FF only have any meaning.

To print a block of memory, enter:

P SSSS, FFFF

where SSSS, is the start address in hexadecimal and FFFF is the end address in hexadecimal e.g.

```
"P0,A0
0000 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 ........
0010 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 ........
0020 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 ........
0030 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 ........
0040 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 ........
0050 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 ........
0060 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 ........
0070 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 ........
0080 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 ........
0090 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 ........
00A0 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 0A 05 ........
```

To return to the "earthy" processor, enter:-

CTRL X

WARNING: Writing to the NVM will destroy the calibration constants.

Refer to Table 8.2 for a list of the main address locations for Floating Monitor.

Table 8.2 Floating Monitor Address Locations

Location	Address		Comments
	Software to AE	Software from AF	
Link Receiver Error Counter	0068	002E	Earthy to Floating link receive error counter.
Link Transmit Error Counter	0084	0030	Floating to Earthy Link counter
ROM Ident		FFDA	

8.1.3 Interpreting Calibration Constant Data

Each calibration constant consists of a packed binary number of 5 bytes in the following form:-

Byte No.	0	1	2	3	4
sign bit	7 bit 2's complement exponent	32	bit	mantissa	

The easiest way to interpret the value of a constant is to write the number into the 7081 memory, come out of monitor, turn on the RS232 output and type MEMORY? The value will be output at the terminal in engineering format. For example:

```
M 0F70,71-,AA-,80-,00-,00-
M 2F1D,00-71,18-AA,0A-80,18-00,00-00
M
OUT,RS232,ON
OK
MEM?
OK
Memory contents = 20.3251838E-06
```

When inspecting the NVM, each location is only a nibble wide. Therefore, each constant occupies ten locations not five as in the RAM copy on the "earthy" side. The NVM has two identical pages: locations 0 to 1FF are page 1 and locations 200 to 3FF page 2. In order to interpret a number it is first necessary to reform the bytes from the nibbles. The first nibble of a byte pair is the most significant nibble, the second nibble the least significant. Once reformed the five byte number can be put into the memory as before, e.g.

```
M T
* DIS EM FLOAT *
!N
"0,07-,01-,0A-,0A-,08-,00-,00-,00-,00-,00-
"
M 2F1D,00-71,18-AA,0A-80,18-00,00-00

M
OUT,RS232,ON
OK
MEM?
OK
Memory contents = 20.3251838E-06
```

Constants are given in ascending range, all the constants for each range being grouped together in the order (where applicable) of Zero, High, Open.

8.2 Calibration Messages

The responses to the CALIBRATE? command are described below. Reference should also be made to the MONITOR command for a further breakdown.

FAIL 1 - this message is output if the checksum in page 1 and/or page 2 of the NVM has failed. It is equivalent to the front panel 'NVM FAIL' message, which could appear at power up.

FAIL 2 - if a failure occurs during the transfer of the calibration constants from the NVM to the RAM, this message is output. It is equivalent to the front panel 'DUMP FAIL' message, which could appear at power up.

FAIL 3 - this message is output if some of the calibration constants are out of range and default values have been susbstituted. It is equivalent to the front panel 'CAL INCOMPLETE' message, which could appear at power up.

OK - if this message is output, the transfer of the calibration constants has been successfully completed and no errors have been found.

8.3 Calibration Commands

Two commands are provided to enable inspection or refresh of the unit calibration constants. They can both be activated via the RS232 or GP-IB interfaces.

8.3.1 CALIBRATE, DUMP

This command enables an output of all the calibration constants, with headings, and the zener temperature coefficient current token.

To activate a calibration dump, the following procedure should be used. (It is assumed that an RS232 terminal is connected to the voltmeter).

* Turn the front panel calibration key to the CAL position.
* Enter,
  Output,RS232,ON
  CALIBRATE,DUMP
* The voltmeter will respond with the output shown in Figure 8.1.

```
VDC CALIBRATION CONSTANTS
 8.04662704E-06
 164.224612E-03
-834.465026E-09
 1.64196003E+00
-953.674316E-09
 16.4218391E+00
-298.023223E-09
 164.185607E+00
-774.860382E-09
 1.64381286E+03
VAC CALIBRATION CONSTANTS
 327.550067E-03
 3.27523722E+00
 32.7807025E+00
 328.446396E+00
 3.29051217E+03
KOHM CALIBRATION CONSTANTS
 8.04662704E-06
 165.944119E-03
-834.465026E-09
 1.65961519E+00
-953.674316E-09
 16.5984867E+00
-834.465026E-09
 165.980795E+00
-953.674316E-09
 1.66008452E+03
TOP OHMS RANGE CALIBRATION CONSTANTS
-953.674316E-09
 9.90188959E+03
 602.393984E-03
RATIO TERMINALS CALIBRATION CONSTANT
 16.4375923E+00
ZENER CURRENT TOKEN VALUE
068
```

Fig. 8.1 CALIBRATE, DUMP Output

Vdc Calibration Constants These constants are given in the following order: 0.1 Volt range zero, 0.1 Volt range high, 1.0 Volt range zero, 1.0 Volt range high, etc., up to 1000 Volt range high. The values take into account the range factor and the digital full scale constant value of 16777216. As the 7081 is designed to produce slightly high results before calibration, the high constants are slightly less than the full scale value, i.e. 1.0Volt range high = 1.64196003, 10 Volt range high = 16.4218391, etc.

Vac Calibration Constants The Vac mode has high calibration constants only, given in the order: 0.1 Volt range, 1.0 Volt range, etc., up to 1000 Volt range. The constants are measured at half the full scale value and so are equal to twice the nominal values expected, i.e. 1.0 Volt range constant = 3.27523722 which is approximately equal to 1.64 x 2.

Kohms Calibration Constants These constants appear in the following order: 0.1k ohms range zero, 0.1k ohms range high, 1.0k ohms range zero, 1.0k ohms range high, etc., up to 1000k ohms range high. The zero constants are obtained from the Volts dc set according to the range on which the ohms measurement is taken. The zero constants are transferred to the k ohms set when an NVM dump is performed.

Top Ohms Constants The three constants for the M ohms range are given in the order: zero, open, high. The zero is taken from the 1000k ohm range and the open value is derived from the reference circuit.

Ratio Constant The Ratio has a calibration high constant but no zero as any zero offsets in the circuit would be cancelled out by the subtraction of Ratio Lo from Ratio Hi. The constant is measured on the Ratio 10 Volts range.

Zener Current Token Value This value represents the code sent by the microprocessor to set up the reference zener current. It is designed to give the diode the lowest temperature coefficient.

8.3.2 CALIBRATE, REFRESH

This command enables a refresh of the NVM, i.e. the present calibration constants are written back into the NVM. The sequence of operation is as follows:

* Microprocessor checks both pages of the NVM.
* First correct page is down-loaded to the RAM.
* Microprocessor checks the RAM
* RAM contents are written into both pages of the NVM.
* Microprocessor checks both pages of the NVM.

To activate a calibration constants refresh, the following procedure should be adopted. (It is again assumed that an RS232 terminal is connected to the voltmeter).

* Turn the front panel calibration key to the CAL position.

* Enter,
  Output,RS232,ON
  CALIBRATE,REFRESH

* One of the following messages will appear:

REFRESH COMPLETE - refresh has been successful and no faults have been found.

REFRESH COMPLETE NVM PAGE 1 WAS FAULTY
- refresh has been successful. Page 1 of the NVM was originally faulty but is now correct.

REFRESH COMPLETE NVM PAGE 2 WAS FAULTY
- refresh has been successful. Page 2 of the NVM was originally faulty but is now correct.

REFRESH FAIL RAM COPY FAIL
- refresh has been unsuccessful as the RAM copy is faulty.

REFRESH FAIL NVM PAGE 1 IS FAULTY
- refresh has been unsuccessful. Page 1 of the NVM is faulty.

REFRESH FAIL NVM PAGE 2 IS FAULTY
- refresh has been unsuccessful. Page 2 of the NVM is faulty.

REFRESH FAIL NVM PAGE 1 & 2 ARE FAULTY
- refresh has been unsuccessful. Both pages of the NVM are faulty.

Note: The 7081 display outputs either REFRESH COMPLETE or REFRESH FAIL.

8.4 7081 Calibration

The 7081 is sent from the factory in a fully calibrated state but, if the unit is damaged or the specifications exceeded, re-calibration may be required. Owing to the high accuracy of 7081, the calibration reference values entered should be very precise. Solartron will re-calibrate the unit if the user is unable to supply precise references.

Note: All calibration should be performed in a stable temperature environment, i.e. variation of less than ±1°C.

8.4.1 Complete Re-calibration

If a new Non-Volatile Memory (NVM) is installed in the unit, it is necessary to perform a complete re-calibration of 7081 using the procedure given below.

It is assumed that an RS232 terminal device is connected to the 7081.

* With reference to Section 8.1, set the Reset Inhibit switches to ON and initialise the NVM.

* Exit from MONITOR and set the Reset Inhibit switches to OFF.

* Turn the front panel key operated switch to the CAL position.

* Insert a short circuit plug into the input socket and enter the following command:

  CALIBRATE, VDC=0.1, ZERO

* Wait a few seconds for the unit to complete the 'zero' calibration, then remove the short circuit plug and connect a reference supply of approximately 0.1 volts dc to the input.

* Enter:

  CALIBRATED, VDC=0.1, HIGH=0.100012

  where 0.10012 is the 'exact' value of the reference supply.

* Repeat the previous three steps for each of the volts dc ranges, using a suitable reference input.

* Connect an ac reference supply of approximately 0.1 volts to the input.

* Enter:

  CALIBRATE, VAC=0.1, HIGH=0.100012

  where 0.10012 is the 'exact' value of the reference supply.

* Repeat these two steps for each of the volts ac ranges, using a suitable reference input.

* Remove the input lead and leave the input open circuit.

* Enter:

  CALIBRATE, KOHM = 10000, OPEN

* Wait a few seconds for the unit to complete the 'open' calibration, then connect a reference supply of approximately 10000 kohms to the input.

* Enter:

  CALIBRATE, KOHM = 10000, HIGH = 10000

  where 10000 is the 'exact' value of the reference.

* Connect a reference supply of approximately 1000 kohms to the input and enter:

CALIBRATE, KOHM = 1000, HIGH = 1000

where 1000 is the 'exact' value of the reference.

* Repeat the previous step for each of the remaining kohms ranges, using a suitable reference input.

* Connect a reference supply of approximately 10 volts dc to the ~~input~~. to the ratio reference input on the rear panel (This step performs the RATIO calibration)

* Enter:

CALIBRATE, REFERENCE, HIGH = 10.000012

where 10.000012 is the 'exact' value of the reference.

* Do not attempt to re-calibrate the zener diode. Refer to Solartron.

8.4.2 Partial Re-calibration

If a particular range or mode requires re-calibration, it is recommended that the NVM first be refreshed using the procedure set out in Section 8.3.2. The range/mode can then be re-calibrated as described in the previous section.

Whenever calibration is being carried out, reference should be made to the CALIBRATE command described in Chapter 3, of 7081 Operating Manual, Part 2.

8.4.3 GP-IB Calibration Program

When calibrating the 7081 over the GP-IB a program is required which (a) commands the 7081 to calibrate the necessary ranges/modes and (b) tells the operator when to connect the reference supplies, etc. The following example program, written in HP9835A Basic, calibrates the 10 Volts dc range and could be adapted or expanded for other modes/ranges. To use a program of this type, the controller must be able to perform both a parallel and a serial poll.

```
10 !EXAMPLE CALIBRATION OF 7081
20 !set up program parameters
30 S=0
40 P=0
50 Waiting=0
60 Signal=0
70 Rqs=6
80 Rdy=4
90 !INITIALISE 7081
100 RESET 716
110 OUTPUT 716;"INITIALISE"
120 WAIT 3000
130 GOSUB Setremote
140 PRINT "TURN KEY TO CAL ON 7081"
150 DISP "PRESS CONTINUE WHEN READY"
160 PAUSE
170 ON INT#7 GOSUB Intserve
```

```
180 CONTROL MASK 7;128
190 CARD ENABLE 7
200 OUTPUT 716;"CALIBRATE,REFRESH"
210 OUTPUT 716;"SRQ,READY,ON"
220 Signal=0
230 GOSUB Waitsignal!WAIT FOR REFRESH END
240 OUTPUT 716;"SRQ,OFF"
250 PRINT"                    CALIBRATE,VDC,10,ZERO"
260 GOSUB Shortcircuit
270 OUTPUT 716;"CALIBRATE,VDC,10,ZERO"
280 OUTPUT 716;"SRQ,READY,ON"
290 GOSUB Waitsignal!WAIT FOR COMPLETION
300 OUTPUT 716;"SRQ,OFF"
310 PRINT"                    CALIBRATE,VDC,10,HIGH=[ref.value]"
320 GOSUB Connect
330 OUTPUT 716;"CALIBRATE,VDC,10,HIGH=10.0"
340 OUTPUT 716;"SRQ,READY,ON"
350 GOSUB Waitsignal!WAIT FOR COMPLETION
360 OUTPUT 716;"SRQ,OFF"
370 DISP"10VDC RANGE CALIBRATION COMPLETE"
380 STOP
390 Shortcircuit:!
400 PRINT"INSERT SHORTING PLUG INTO 7081 INPUT"
410 DISP"PRESS CONTINUE WHEN READY"
420 PAUSE
430 RETURN
440 Connect:!
450 PRINT"CONNECT REFERENCE TO 7081 INPUT"
460 DISP"PRESS CONTINUE WHEN READY"
470 PAUSE
480 RETURN
490 Setremote:!
500 Remote=1
510 REMOTE 716
520 LOCAL LOCKOUT 7
530 RETURN
540 Intserve:!
550 Int=Int+1
560 PRINT"INTERRUPT#";Int
570 PPOLL CONFIGURE 716;"00001011"
580 P=PPOLL(7)
590 GOSUB Remotelocal
600 IF BIT(P,3)<>1 THEN GOTO Endpol
610 STATUS 716;S
620 IF BIT(S,Rqs)<>1 THEN GOTO Endpol
630 IF BIT(S,Rdy)=1 THEN GOTO Endtry
640 Signal=1
650 Waiting=0
660 Endtry:!
670 Endpol:!
680 PPOLL UNCONFIGURE 716
690 GOSUB Remotelocal
700 CARD ENABLE 7
710 RETURN
720 Waitsignal:!
```

```
730 Waiting=1
740 Idle=0
750 Repeatwait:!
760 Idle=Idle+1
770 DISP "Status:Waiting for interrupt";Idle
780 IF Signal=0 THEN GOTO Repeatwait
790 Signal=0
800 PRINT " "
810 RETURN
820 Remotelocal:!
830 IF Remote=0 THEN GOTO Elseremote
840 GOSUB Setremote
850 GOTO Endremote
860 Elseremote:!
870 GOSUB Setlocal
880 Endremote:!
890 RETURN
900 Setlocal:!
910 Remote=0
920 LOCAL 7
930 RETURN
940 END
```

Lines 10 to 80 - set up the program parameters, i.e. serial poll and parallel poll registers, waiting flag for the background routine, interrupt acknowledge flag and serial poll bits.

Lines 90 to 130 - initialise the 7081 and set it to remote.

Lines 140 to 380 - calibrate the 10 Volts dc range.

Lines 390 to 430 - 'Shortcircuit' subroutine to tell the operator to insert the shorting plug.

Lines 440 to 380 - 'Connect' subroutine to tell the operator to connect the reference supply.

Lines 490 to 530 - 'Setremote' subroutine to put 7081 into remote.

Lines 540 - 710 - 'Intserve' subroutine for servicing interrupts.

Lines 720 to 810 - 'Waitsignal' subroutine which is a background routine used when the controller is waiting for 7081 to produce interrupts.

Lines 820 to 890 - 'Remotelocal' subroutine which decides if 7081 was in remote or local and returns to its previous state.

Lines 900 to 940 - 'Setlocal' subroutine which sets 7081 to local.

8.5 Self Test

If 7081 fails the self test, initiated by either pressing the front panel self test control or sending the Test command via one of the interfaces, the area of failure can be investigated using the MODE Command.

MODe,TEST 0vdc - measures the integrator zero and outputs the results.

MODe,TEST 10vdc - measures the reference voltage. A value of approximately 10 volts should be output. Values in the region of 9.8 to 10.2 volts are acceptable.

MODe,TEST Kohm - measures a resistor in the V-to-T converter circuit. A value of 166 Kohms should be output.

MODe,TEST Ac - the reference forcing waveform is attenuated to a 100mV square wave and passed through the ac circuitry. Readings of 100mV ± 10% should be obtained if the circuits are operating correctly.

CHAPTER 9
Setting Up Procedure

CONTENTS

9.1 Introduction

This chapter provides a comprehensive setting-up procedure which may be necessary after rectification and/or component replacement on the voltmeter.

9.2 Test Equipment

The test equipment listed below should be available to carry out setting-up procedures.

(a) Oscilloscope (20MHz bandwidth)
(b) Digital Voltmeter (eg Type 7060)
(c) Calibrator
(d) Variac Transformer
(e) Silent 700 (or similar RS232 terminal)
(f) RS232 Cable
(g) Frequency Counter (e.g. HP5135A)
(h) 240V/400Hz Power Supply Unit

9.3 Safety

The instrument should be disconnected from the mains supply before any attempt is made to remove the printed circuit boards.

9.4 Printed Circuit Board 4 Test

* Ensure that the following links are fitted depending upon the RAM used:-

RAM	1	2	3	4	5	6	7	8	16
5516/6117	In	Out	In	Out	In	Out	In	Out	Out
6116	Out	In	In	Out	In	Out	In	Out	Out
6264	Out	In	Out	In	Out	In	Out	In	Out

* Check that the printed circuit board is correctly connected to the following:-
  Printed Circuit Board 3 via PL1
  GP-IB Socket via SK412
  Printed Circuit Board 8 via SK414.

* Switch on the voltmeter and check that "INITIALISED" appears in the display.

* Switch off and then on again, and check that "RESUMED" appears in the display. (This assumes a fully calibrated printed circuit board 5).

* Press the front panel "initialise" control and check that "INITIALISED" appears in the display.

* Set the GP-IB address switch to address 7. Switch off and then on again, and press the "local" control. "GP-IB ADDRESS=7" should appear in the display.

* Set the address switch to address 16. Switch off and then on again, and press the "local" control. "GP-IB ADDRESS = 16" should appear in the display.

9.5 Printed Circuit Board 6 Test

All measurements are relative to OV "MYTCHETT" with oscilloscope settings of [\div], [\div], [trigger=].

* Check that the printed circuit board is correctly connected to the following:
  Printed Circuit Board 5 via PL501, PL502
  Ratio/Reference socket via PL603

* Switch the voltmeter on and connect an oscilloscope (set to 500mV, 2ms, Line) to TP402 "CHOPPER O/P". The observed results should be in the ranges:
  spikes <1V peak
  noise <0.5V peak

* To check the main amplifier offset, connect a digital voltmeter (set to Vdc) to TP403 "DEMOD O/P". The digital voltmeter result should be:
  -10V < reading < +10V

* To set the ac offset voltage, connect the digital voltmeter (set to Vdc) to TP705 "BUFFER O/P" and adjust RV701 until -100µV < reading <+100µV.

* Connect the calibrator Low to S1 right second pin back and calibrator High to S1 left, second pin back. With the digital voltmeter set first to Vdc, check the ranges shown below:-

7081 Setting	Expected Digital Voltmeter Result
100mV, 1V, 10V dc	Zero < 10µV, full scale +0% to +4%
100V dc	Zero < 1mV, full scale +0% to +4%
100mV, 1V, ac	Zero < 500µV, full scale +0% to +4%
10V ac	Zero < 50mV, full scale +0% to +4%

* Connect a 1V, 1kHz source and press the 7081 front panel V~ control. With an oscilloscope (set to 20mV, 5ms, External) connected to TP752 "CHOPPER BALANCE", trigger from R779, adjust RV751 "BALANCE" until the flattest trace is achieved.

* Connect a 1V, 100kHz source and adjust RV752 to give a reading of 1.00000 ± 20 bits.

* Connect a 1V, 1MHz source and adjust RV753 to give a reading of 1.00000 ± 100 bits.

* Repeat the previous two steps.

9.6 Assembly Check

* Ensure that links 1, 3, 4, 5, 6, 7 and 8, on printed circuit board 3, are installed.

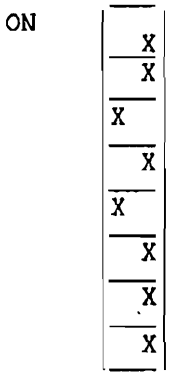
* Check that the following split pads, on printed circuit board 5, are made:- 201, 202, 501, 801, 802, 803, 804, 805, 806, 807, 808, 809, 901, 902, 903, 904.

* Set the mains power selector to 240V and check that a 200mA fuse is installed.

* Set the GP-IB address to 18, ie

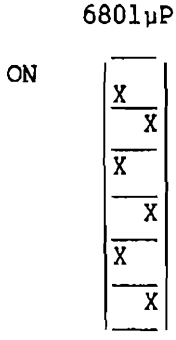
	X			X			X	ON
X		X	X		X	X		OFF

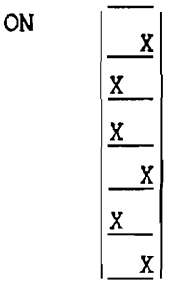
* Set S1, on printed circuit board 3, as follows:-



* Check that the shorting clip (printed circuit board 3) has been removed from TR2.

* Set S1, on printed circuit board 5, as follows:-





* Check that printed circuit board 3 is connected to the following:-
RUN/CAL switch via PL3
Keyboard via PL2
Printed Circuit Board 1 via PL6
Printed Circuit Board 5 via SK51

RS232 Socket via PL5
Minate Socket via PL4
Transformer via PL51, PL52
Beeper via TP3, TP4
0V Earth via TP53.

* Check that printed circuit board 4 is connected to the following:-
Printed Circuit Board 8 via SK414.
GP-IB Socket via SK412
Printed Circuit Board 3 via PL1.

* Ensure that printed circuit board 5 is connected to printed circuit board 3 via SK901. Also check that the orientation of IC801 and IC826, on printed circuit board 5, is correct, as their orientation should be the reverse of all the other ICs.

* Ensure that the shorting clips are removed from TR203, TR204, TR603, TR605, TR610 (printed circuit board 5).

* Check that printed circuit board 6 is connected to the following:-
Printed Circuit Board 5 via PL501, PL502, PL504.
Ratio Socket (High, Low) via PL603 (TL1, TL2).

9.7 Power Supply and Digital Checks

* Connect the 7081 power input to a variac and gradually increase the input to 240V. "NVM FAIL" should be displayed but "CAL INCOMPLETE", "INITIALISED or "RESUMED" are also acceptable.

* Check that there are no missing or additional display segments.

* Check the keyboard operation by pressing each key and listening for a "beep".

* Ensure that the LED annunciators work.

* Press "initialise" followed by "DIG FILT". The "compute" LED should light.

* Press "$\overline{V---}$" followed by "V". The second beep should be twice as long as the first.

* Connect the 7081 to a variac source. Set the variac first to 216 and then to 264V, and check, using a digital voltmeter, that each of the following test point voltages is within the stated range:-

Printed Circuit Board	Measure Across	Low Mains Input	High Mains Limit
3	TP53-56	24	35
	TP54-55	24	35
	TP53-IC52 pin 1	38	42
	TP53-D58 cathode	4.75	5.25
	TP53-D53 cathode	4.75	5.25
	TP53-D60 cathode	11.4	12.6
	TP53-D61 anode	11.4	12.6

Printed Circuit Board	Measure Across	Low Mains Input	High Mains Limit
5	TP903-D904 cathode	29	45
	TP903-901	25.6	28.4
	TP903-902	14.2	15.8
	TP903-904	-14.2	-15.8
	TP903-906	-25.6	-28.4
	C609	36	53
	TP604-606	35	39
	TP604-603	-23.7	-26.3

* Connect normal 240V ac mains power (increase mains from zero using a variac each time) and check that the voltage across IC901 left hand pin and TP903 is not less than +17.5V. Repeat test with 198V ac input on the 220V setting.

* Change to a 400mA fuse and repeat step 8 for 108V ac input on the 120V ac setting and 90V ac input on the 100V ac setting.

* Refit 200mA fuse and return to the 240V setting.

* Connect a Silent 700 to the RS232 port. Set the Silent 700 NUM, LOW SPEED and HALF DUP switches OFF and the ON LINE switch ON.

  Type: OUT,RS,ON:MEAS,SING

  One result should be printed out.

* Connect frequency counter ground to printed circuit board 3 TP2 and probe TP1. Adjust C3 for a frequency in the range of 32767.99 to 32768.01Hz.

  Set up date by typing on the Silent 700, for example: DATE = 14,3,83

  Set up the time by typing, for example: TIME = 14,22

  Check that the values have been accepted by typing

  TIME?:DATE?

* Press "initialise". The display should return with "NVM FAIL".

9.8 Analogue Checks

* Phase Locked Loop Frequency Set a bench supply to +2.5V. Connect the low terminal to TP904 and the high (+2.5V) to the negative end of C806. Connect the low terminal of a frequency counter to TP904 and probe IC835 pin 5. Adjust C807 for a frequency between 5.21MHz and 5.27MHz.

* Using a high impedance voltmeter (e.g. 7060) monitor the voltage at the negative end of C806 with respect to TP904. The voltage should settle to 2.5V ± 0.3. Adjust C807 to correct, if necessary.

Disconnect the bench supply and switch on the 7081 using 60Hz mains frequency. Check that, after settling, the voltage on C807 is 2.5V ± 0.5.

* Reference Voltage Connect the 7060 between TP302(+10V) and TP303(-10V), ensuring that LK301 and LK302 are configured as follows:-

Voltage	LK301	LK302
19.7-20V	OPEN	OPEN
20-20.31V	OPEN	BRIDGED
20.31-20.63V	BRIDGED	OPEN
20.63-20.96V	BRIDGED	BRIDGED

* D-A Converter Check the operation of the digital-to-analogue converter by connecting a 7060 to TP305(0V) and TP301 "CURRENT". Switch 7081 to CAL (front panel key): Type:

CALIBRATE, ZENER, 064

and wait for the command to be executed.

Press "initialise" on the front panel.

The 7060 should read <10mV

Now type:

OUT,RS,ON
CALIBRATE,ZENER,124

and wait for the commands to be executed.

Press "initialise". The 7060 should read -9.18V ± 0.2V.

* Connect scope ground to the printed circuit boards 0V level, (scope should be set to 5V, 2ms, AUTO) and probe TP204 "GLUGS".

Short circuit the 7081 input. The waveform should have a period of 6.25ms.

Type : MODE,TEST 0:NINES,3

The period should reduce to 1.56ms.

Set scope to 5V, 100ns, AUTO and check that each edge has a rise or fall time of <300ns and that the gap time is 13 ± 3µs.

* Check that the voltage across R355 is less than 100µV at room temperature.

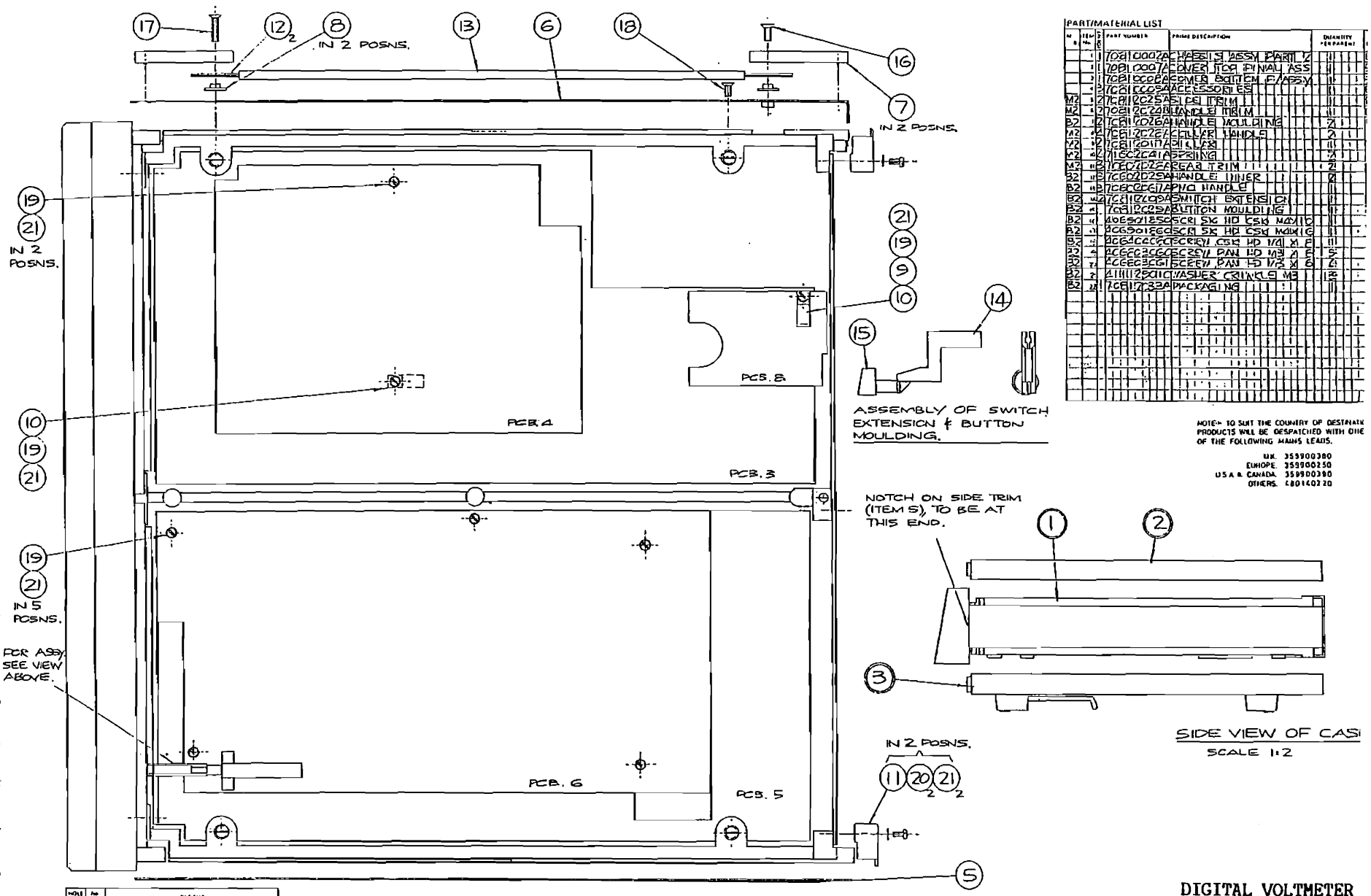
CHAPTER 10

Instrument Assembly Parts

CONTENTS

10.1 INTRODUCTION

This chapter contains detailed engineering drawings for all of the main assembly parts of the 7081/7071 digital voltmeter. The components that make up each assembly part are referenced with an item number which corresponds to a Solartron part number, given in the Assembly Parts List.
When ordering spare parts it is essential to quote the instrument serial number, located on the rear panel of the instrument, as well a full description of the assembly drawing and the component part required in that drawing.



PART/MATERIAL LIST

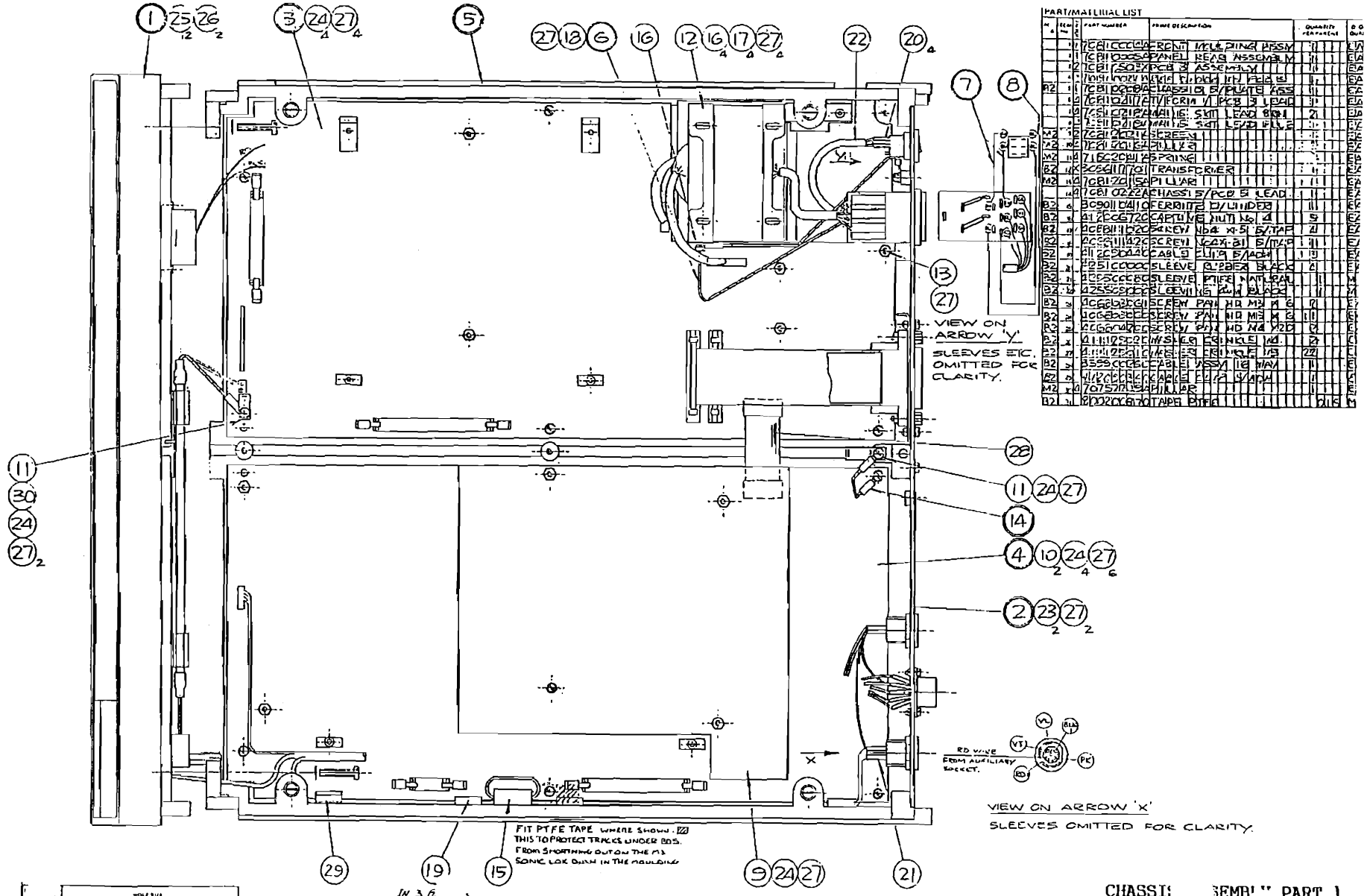
M & B	ITEM No.	QTY PER ASSY	PART NUMBER	PRIME DESCRIPTION	QUANTITY PER PARENT
	1	1	7081 0007 AC	CHASSIS ASSY PART 1	1
	1	1	7081 0007 A	COVER TOP FINAL ASS	1
	1	1	7081 0008 A	COVER BOTTOM F/ASSY	1
	3	1	7081 0005 A	ACCESSORIES	1
M2	4	2	7081 2025 A	SIDE TRIM	2
M2	5	2	7081 2024 B	HANDLE TRIM	2
B2	6	2	7081 0026 A	HANDLE MOULDING	2
M2	7	2	7081 2027 A	CLIP HANDLE	2
M2	8	2	7081 2017 A	SLIDE	2
M2	9	2	7081 2021 A	SPRING	2
M2	10	2	7081 2022 A	REAR TRIM	2
B2	11	2	7081 0025 A	HANDLE INNER	2
B2	12	2	7081 2024 A	PIVOT HANDLE	2
B2	13	2	7081 0029 A	SWITCH EXTENSION	2
B2	14	2	7081 0028 A	BUTTON MOULDING	2
B2	15	4	4065 0012 50	SCREW SKT HD CSK M4X10	4
B2	16	4	2065 0012 50	SCREW SKT HD CSK M4X16	4
B2	17	4	4065 0006 50	SCREW SKT HD 1/4" X 6	4
B2	18	4	4065 0006 50	SCREW PAN HD M3 X 6	4
B2	19	4	4065 0006 50	SCREW PAN HD 1/8" X 6	4
B2	20	2	4111 1250 10	WASHER CRINKLE M3	2
B2	21	1	7081 0030 A	PACKAGING	1

NOTE:- TO SUIT THE COUNTRY OF DESTINATION PRODUCTS WILL BE DESPATCHED WITH ONE OF THE FOLLOWING MAINS LEADS.

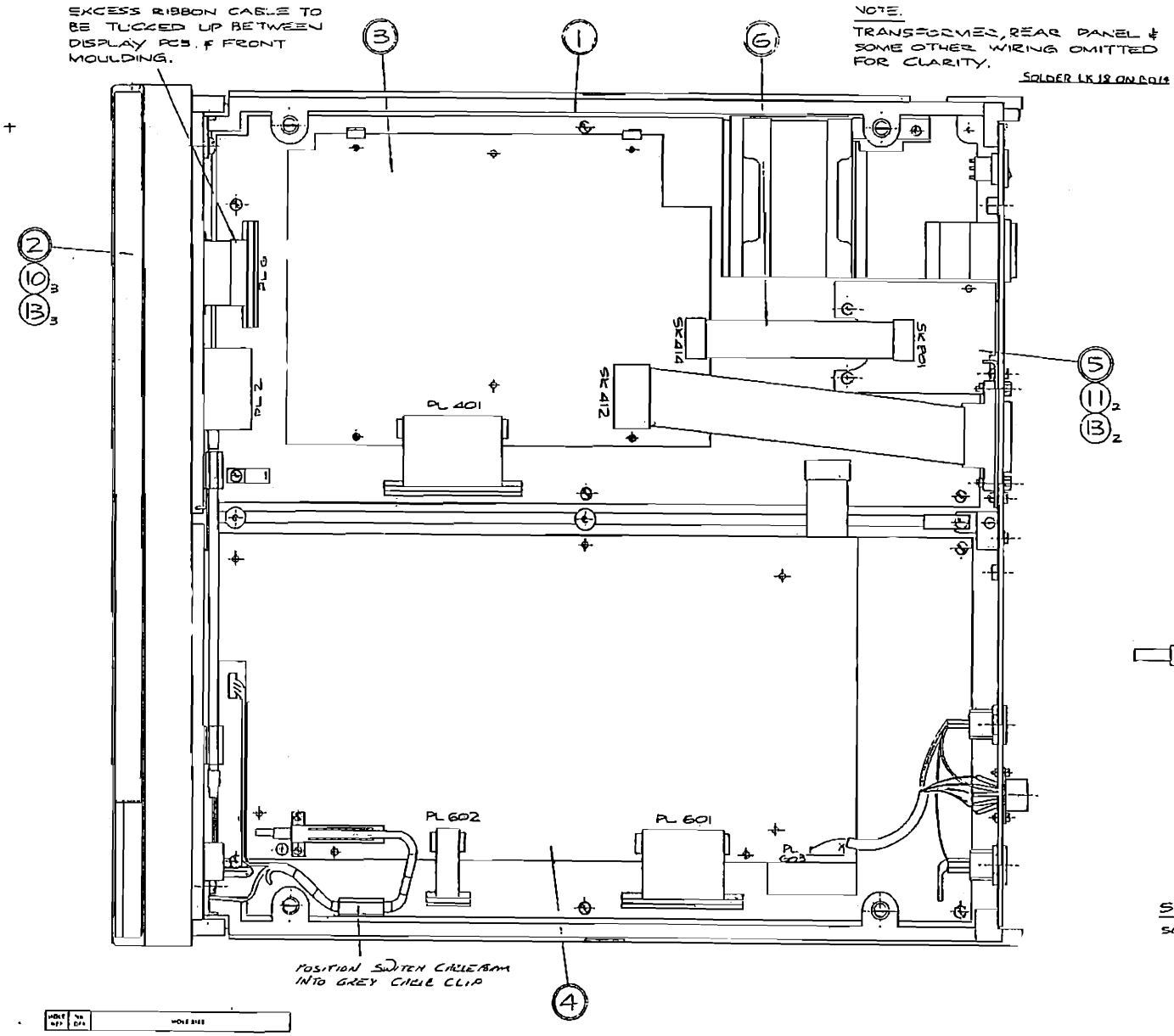
U.K.	3599000300
EUROPE	3599000250
U.S.A. & CANADA	3599000390
OTHERS	4801400220

WHOLE REF	No. OFF	WHOLE SIZE

DIGITAL VOLTMETER
7081A Iss C Sh 1

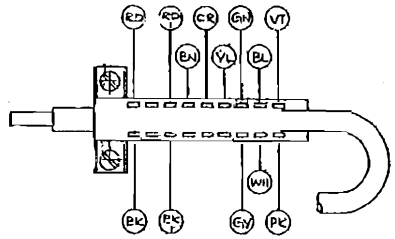


CHASSIS ASSEMBLY PART 1
7081000 ISS G Sh 1



PART/MATERIAL LIST

ITEM	PART NUMBER	PRIME DESCRIPTION	QUANTITY PER PANEL
1	70811	CHASSIS ASSY PART 1	1
2	70811	DISPLAY PCB ASSY	1
3	70811	PCB ASSEMBLY	1
4	70811	PCB ASSEMBLY	1
5	70811	CABLE ASSEMBLY	1
6	55502	SPACER M3 X 6	2
7	55502	PAN HD M3 X 6	2
8	211	2901 WASHER CRINKLE M3	3



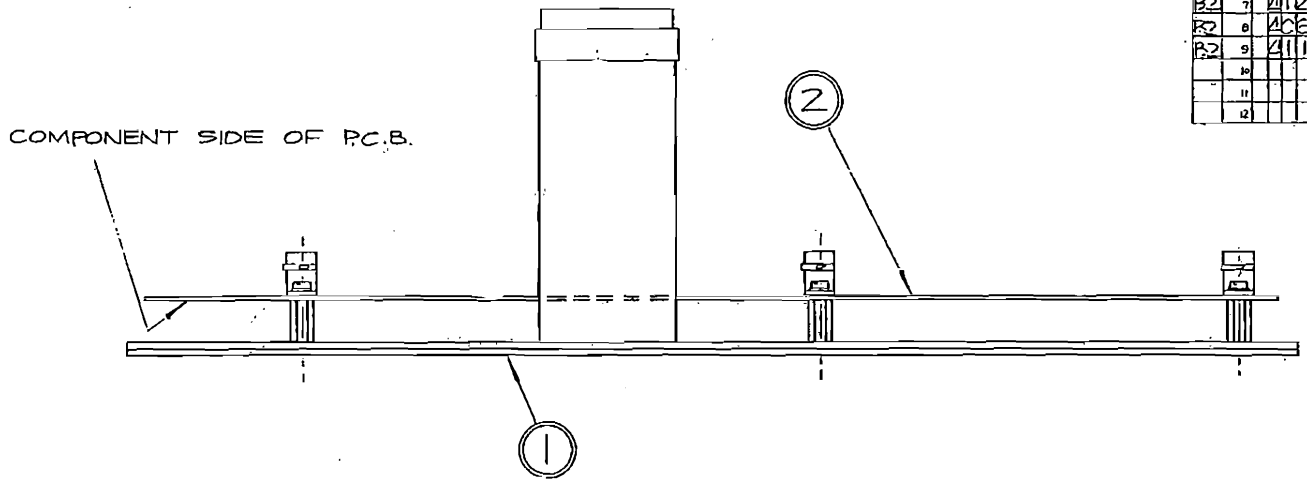
CABLEFORM MUST BE CONTAINED WITHIN THE SWITCH CONTACT PROFILE. CONNECTIONS MUST BE TO THE TIP OF THE TAGS, AND MUST BE ROUND JOINTS (ie. NO SPIKES).

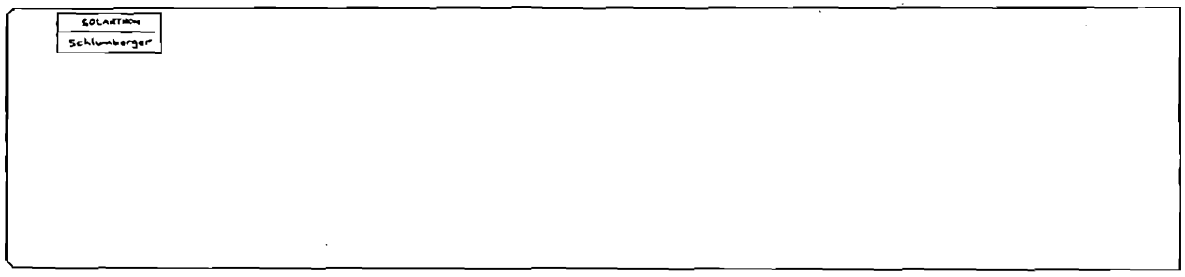
SWITCH WIRING DETAILS.
SCALE 2:1

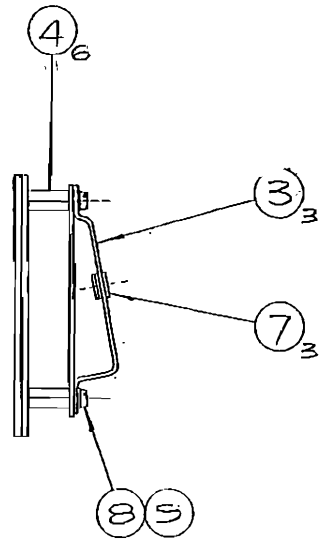
CHASSIS ASSEMBLY PART 2
70810002 Iss E Sh 1

PART/MATERIAL LIST

M/B	ITEM No.	IDENT.	PART NUMBER	PRIME DESCRIPTION	QUANTITY PER PARENT	U OF QUAN
B2	1		70E1DD07	SWITCH ASSEMBLY	1	EA
	2		70B1BE01	PCB 1 ASSEMBLY	1	EA
M2	3		7C01D007	BRACKET	3	EA
M2	4		70B1CC08	SPACER	6	EA
	5					
	6					
B2	7		11ECC672	NUT, CAPTIVE No 2	3	EA
B2	8		4C6E0B05	SCREW PAN HD M2.5 X 5	3	EA
B2	9		11111EC10	MASTER GRIVLE M3	6	EA
	10					
	11					
	12					



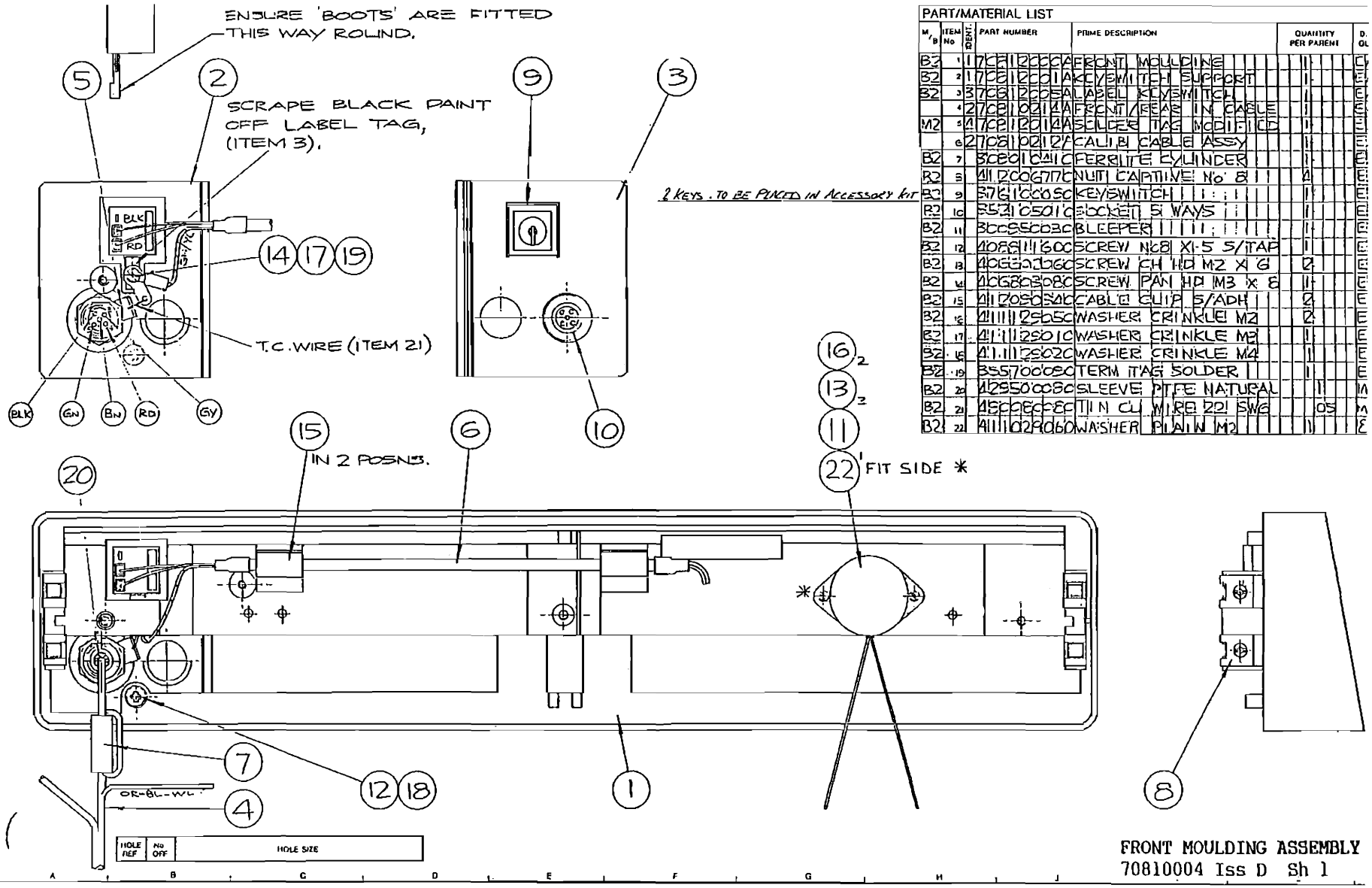




HOLE REF	No OFF	HOLE SIZE

DISPLAY KEYBOARD ASSEMBLY

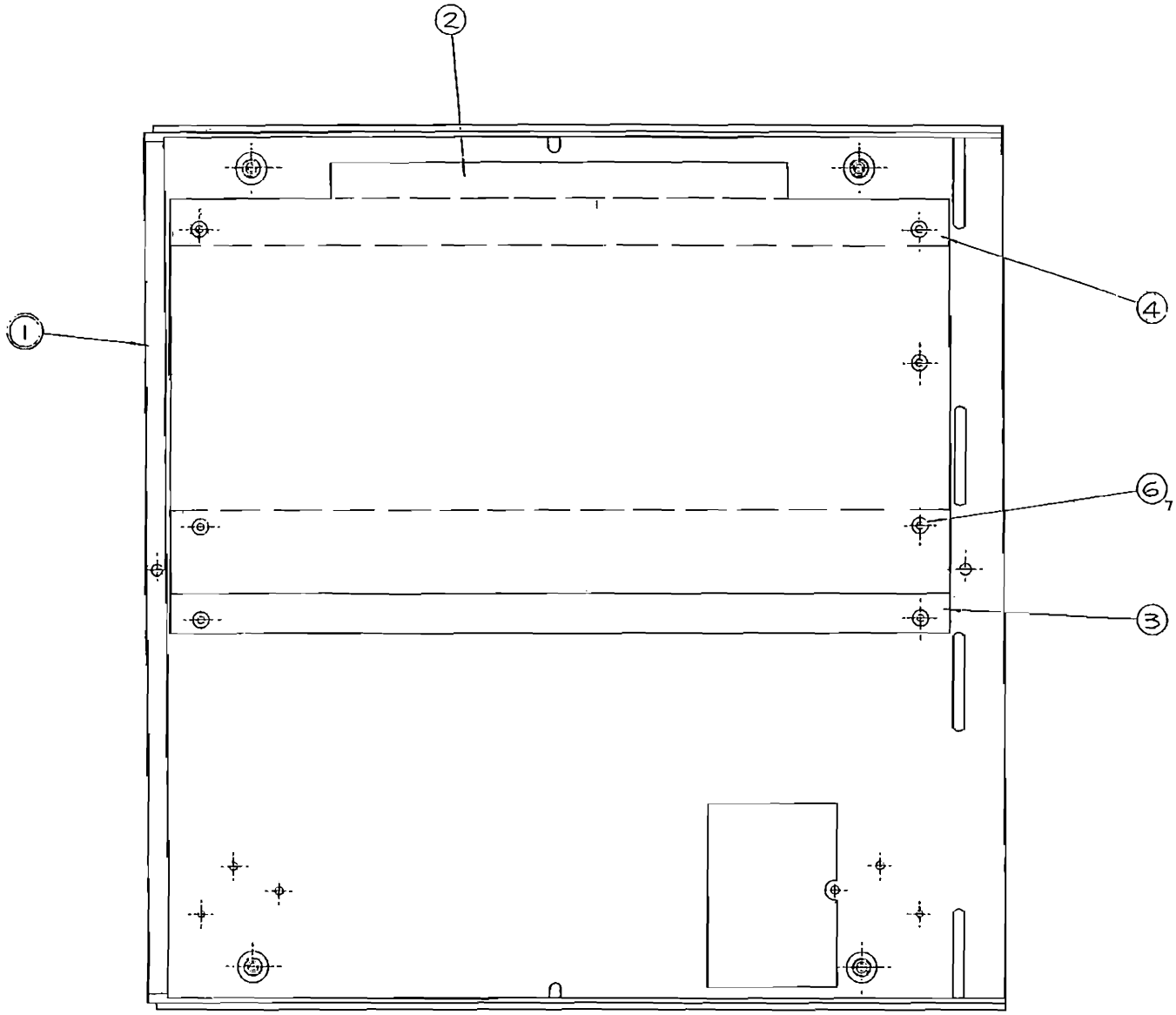
70810006 B 1



PART/MATERIAL LIST

M/B	ITEM No	PART NUMBER	PRIME DESCRIPTION	QUANTITY PER PARENT
B3	1	17CB12CCCAF	FRONT MOULDING	1
B2	2	17CB12C01A	KEYSWITCH SUPPORT	1
B2	3	37CB12C05A	LABEL KEYSWITCH	1
	4	27CB102114A	FRONT/REAR INTERCONNECTING CABLE	1
M2	5	17CB12C14A	SCRUTCHEON TAG MODIFIED	1
	6	27CB102121F	CALIBRATION CABLE ASSY	1
B2	7	3CB01CA1C	FERRITE CYLINDER	1
B2	8	411120G677C	NUT CAPTIVE No 8	4
B2	9	37G1CC05C	KEYSWITCH	1
B2	10	3523105011C	SOCKET 5 WAYS	1
B2	11	BCC55C03C	BLEEPER	1
B2	12	40B611160C	SCREW NC8 X1·5 S/TAP	1
B2	13	40G3J316C	SCREW CH HD M2 X 6	2
B2	14	40G8030B0C	SCREW PAN HD M3 X 8	1
B2	15	411205053CC	CABLE CLIP S/ADH	2
B2	16	411112505C	WASHER CRINKLE M2	2
B2	17	41·1·112501C	WASHER CRINKLE M3	1
B2	18	41·1·112502C	WASHER CRINKLE M4	1
B2	19	3557006080	TERM TAG SOLDER	1
B2	20	412950C080	SLEEVE PTFE NATURAL	1
B2	21	15CC1EC5EC	TIN CU WIRE 22I SWG	.05
B2	22	411102R060	WASHER PLAIN M2	1

FRONT MOULDING ASSEMBLY
70810004 Iss D Sh 1

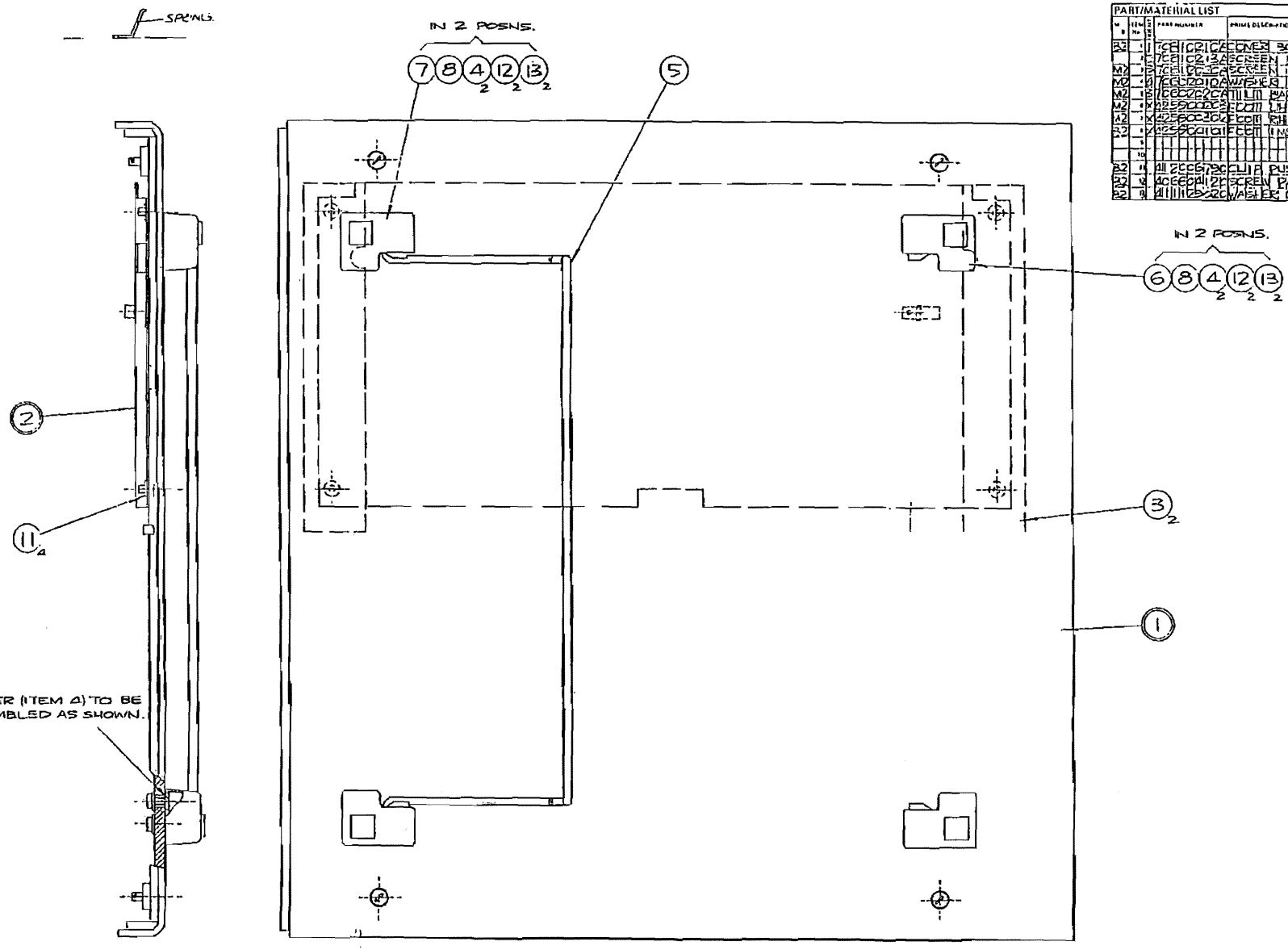


PART/MATERIAL LIST

ITEM NO.	QTY. PER ASSY.	PART NUMBER	ITEM DESCRIPTION	QUANTITY REQUIRED	D OR E
B2	1	7CB1CC2B4	COVER TOP ASSEMBLY	1	E
M2	2	7CB1SS1CX	SCREEN TOP COVER	1	E
M2	2	7CB1200SA	SCREEN INSULATION	1	E
M2	2	7CB1P011A	SCREEN INSULATION	1	E
B2	4	4H2CCC790	CLIP PUSH ON FIX	7	E

COVER TOP[illegible]NAL ASSEMBLY
70810007 A 1

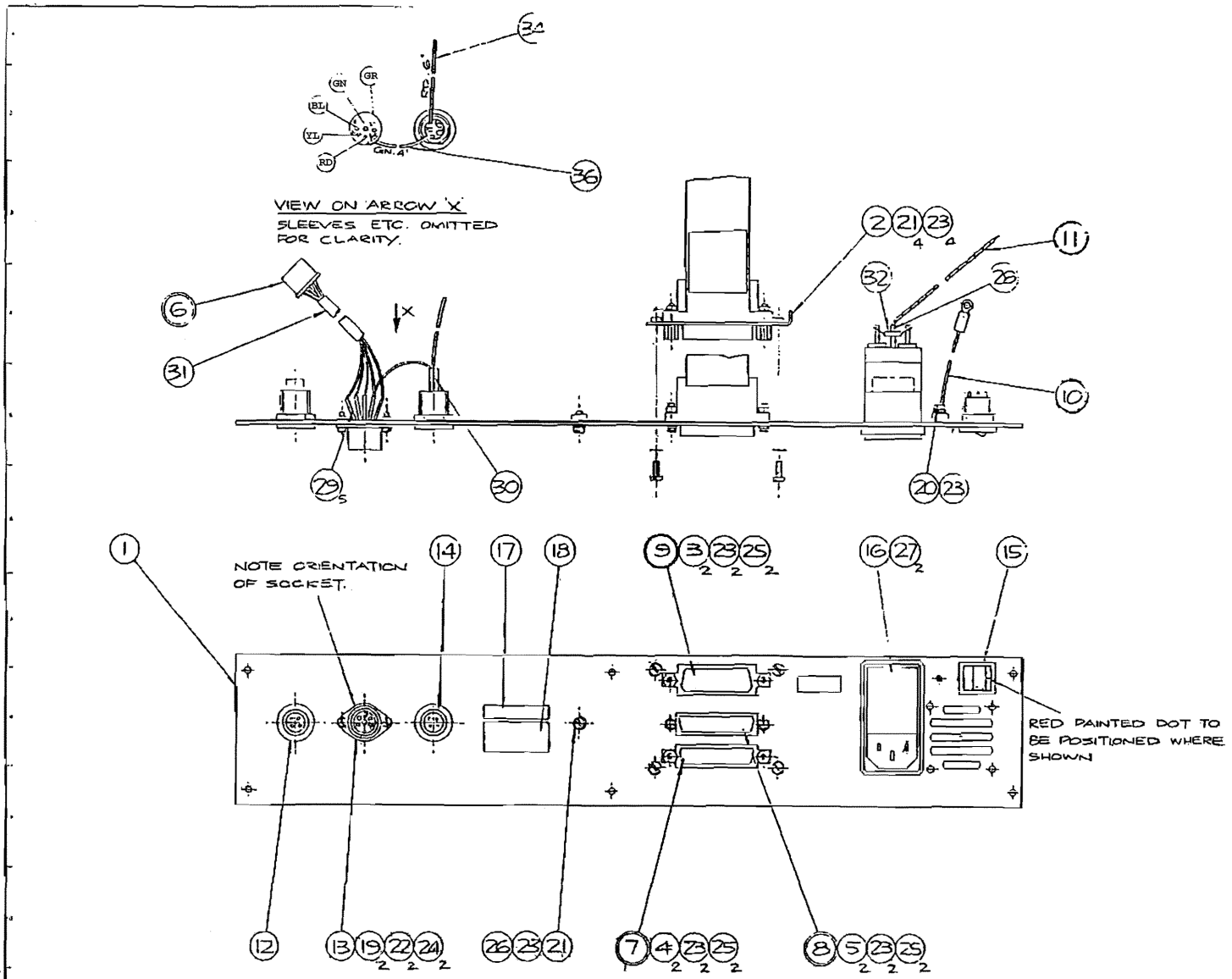
ENSURE SPRING IS BENT/ANGLED
(NOT VERTICAL TO ENSURE SUFFICIENT
CONTACT WITH PCB FITTED AT A LATER STAGE.



PART/MATERIAL LIST

ITEM NO	PART NUMBER	PRIME DESCRIPTION	QUANTITY PER PANEL
M1	70810008	COVER BOTTOM ASSY	1
M2	70810004	SCREEN BOTTOM ASSY	1
M3	70810005	SCREEN INSULATION	2
M4	70810010	WASHER	8
M5	70810011	PAD	2
M6	70810012	FOOT	4
M7	70810013	FOOT	2
M8	70810014	FOOT INSERT	4
M9	70810015	CLIP PUSH ON FIX	4
M10	70810016	SCREW PAN HD M4 X12	2
M11	70810017	WASHER CONICAL M4	2

COVER BOTTOM FINAL ASSEMBLY
70810008 Iss B Sh 1



PART/MATERIAL LIST

ITEM No.	PART NUMBER	NAME OR DESCRIPTION	QUANTITY PER PANEL
M2	1	7C81 2022 PANEL REAR	1
M2	2	7C81 2211 PLATE LOCKING	1
M2	3	7C81 2018 SCREW CAPTIVE LOCK	2
M2	4	7C81 2218 SCREW CAPTIVE LOCK	2
M2	5	7C81 2018 SCREW SLIDE LOCK	2
	6	7C81 C22C CABLE SKT 'A' BUS	1
	7	7C81 C201 CABLE ASSY KS23	1
	8	7C81 C22C CABLE ASSY TERMINATE	1
	9	7C81 C211 CABLE ASSY EARTH	1
	10	7C81 C218 REAR PANEL ASSY	1
B2	11	KE0055 WIRE INSUL PVC	1.25
B2	12	BS0216 SELECTOR SWITCH	1
B2	13	BS2506 SELECTOR SWITCH	1
B2	14	BS2504 SELECTOR SWITCH	1
B2	15	BS7557 CONNECTOR	1
B2	16	FS0001 CONNECTOR	1
	17	12C820 LABEL SERIAL	1
	18	12C820 LABEL	1
B2	19	AC0501 SCREW PAN HD M3	2
B2	20	AC0501 SCREW PAN HD M3	2
B2	21	AC0501 SCREW PAN HD M3	2
B2	22	AI0005 WASHER SHAKEPROOF M3	2
B2	23	AI0005 WASHER SHAKEPROOF M3	12
B2	24	AI0031 NUT PLAIN M3	2
B2	25	AI0031 NUT PLAIN M3	8
B2	26	AI0029 WASHER PLAIN M3	2
B2	27	AE0102 FUSE 1A 20mm A	2
B2	28	FP0102 SLEEVE RUBBER BLACK	1
B2	29	SP0501 SLEEVE SLEEVING BLACK	5
B2	30	FP0502 SLEEVE PTFE NATURAL	1
B2	31	FP0502 SLEEVE PTFE NATURAL	1
B2	32	AI0102 BUSH NYLON BLACK	1
B2	33	AI0102 BUSH NYLON	1
B2	34	KE0055 WIRE PVC 2 PTFE RED	15
B2	35	KE0055 WIRE PVC 2 PTFE GRN	15
	36	7C81 2016 CABLE WIRE STRIPPED	REF

PAN[illegible]REAR ASSEMBLY
70[illegible]05 I[illegible] E Sh[illegible]

INDEX