High Reliability Power Supplies PMA 44 - 56

Instruction Manual

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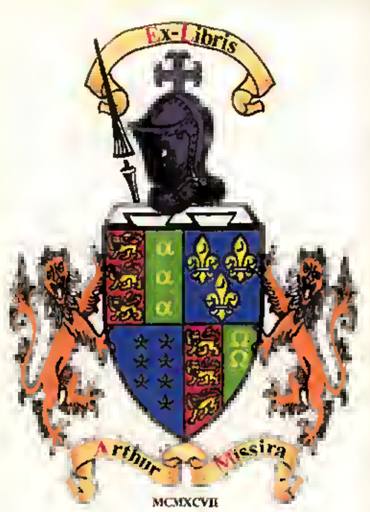

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Instruction Manual

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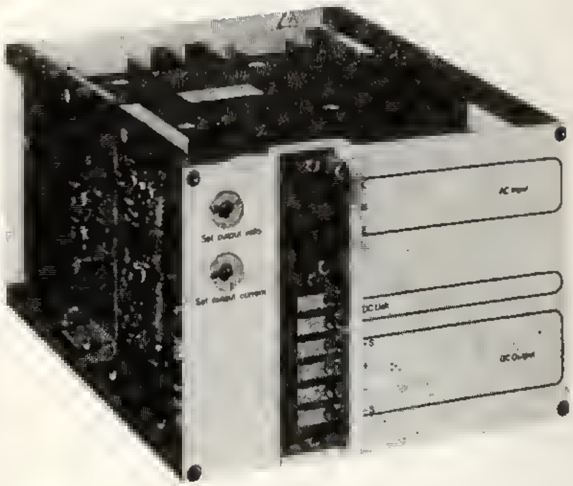


Fig. 1 Typical Modular Power Supply

The range of Modular Power Supplies, PMA16-20, consists of units having a fully variable output of 0 to 7V with a choice of current ratings from 1 to 20A. They have been specifically designed to meet the requirements of Integrated Circuit Technology with particular reference to very high reliability and incorporate a new protection circuit to safeguard both the power supply and the load. This range offers the Integrated Circuit user a power supply to satisfy most applications.

The range of Modular Power Supplies, PMA44-56, marks a radical departure from accepted attitudes in commercial power supply design. The range provides pre-set output voltages in the range 0-50V in current ratings of 1, 3, 5, 10A and 20A with very extensive facilities and a high degree of reliability. Facilities available include the selection of various output characteristics, such as constant current operation, by means of internal links, external programming and optional built in thyristor overvoltage protection.

Particular emphasis has been placed on a high specification, rugged mechanical construction and long-life components. As a result of this attention it is possible to quote estimated MTBF figures for each individual unit.

- 10,000:1 Stability
- Programmeable on Voltage and Current
- MTBF estimated not less than 25,000 hours.

INPUT VOLTAGE
100, 105, 110, 115, 120, 125, 200, 210, 220, 230, 240, 250V±10%
48-450Hz

LINE REGULATION (VOLTAGE MODE)
Less than ±(0.001% + 30μV) for ±10% AC line variation at any specified tap.

LOAD REGULATION (VOLTAGE MODE)
Less than (0.001% + 100μV) for a no load to full load current change.

RIPPLE (VOLTAGE MODE)
Less than 400μV pk-pk, (typically 250μVpk-pk).

TEMPERATURE CO-EFFICIENT (VOLTAGE MODE)
Less than ± (0.01% + 100μV) per °C.

LINE REGULATION (CURRENT MODE PMA 16-20)
Less than ± (.02% +200μA) for ±10% AC line variation at any specified tap for currents in the range 5-100% of rated current.

LOAD REGULATION (CURRENT MODE PMA 16-20)
Less than (0.1% + 2mA) for a no load to full load voltage change.

RIPPLE (CURRENT MODE PMA 16-20)
Less than 0.1% pk-pk of rated output current.

TEMPERATURE CO-EFFICIENT (CURRENT MODE PMA16-20)
Less than 0.1% (of maximum rated output current) per °C.

OUTPUT IMPEDANCE
Less than 0.25Ω at 100kHz. Typically less than 0.1Ω at 100kHz.

RECOVERY TIME
For a full load step change the output voltage will recover in approximately 50μ seconds to within 10mV of the regulation band.

OVERLOAD PROTECTION (PMA 16-20)
Constant current overload protection set at 105% of full load current.

OVERLOAD PROTECTION (PMA 44-56)
Re-entrant overload protection set at 105% of full load current
At switch on the protection may be set to operate at constant current for a period of 200m seconds after which it reverts to re-entrant operation. This facility is optional and may be selected by an internal link but is not available below 4 volts output.

OVERVOLTAGE PROTECTION
Overvoltage protection is by means of a high speed thyristor crowbar with fuse. The trip voltage may be varied by potentiometer or programming resistors. This facility is fitted as standard on PMA 16-20 and as an optional extra which can be built into the unit if required on PMA 44-56.

TEMPERATURE RANGE
10° to +60°C.

INSULATION
Floating output must not exceed ±250V DC from ground. Input tested 500V DC line to ground and line to output greater than 10MΩ.

CONSTANT CURRENT OPERATION
Optional
PMA44-56 can be operated in the constant current mode at reduced ratings. Further details can be found in Fig. 6 Section 3 and Tables 5 to 7.

PROGRAMMING
External programming of both voltage and current by means of external resistors is possible and is restricted to operation within the re-entrant characteristic or within the constant current restrictions if operating in this mode. Further details of this form of operation can be found in Section 3.

PROGRAMMING RESISTANCES

VOLTAGE MODE	1000Ω/V ±¼%
CURRENT MODE	1000Ω/100% of output current ±2% PMA 16-20.
CURRENT MODE (PMA44-56)	100Ω/100% of output current ±3% for re-entrant current mode.
	1050Ω/100% of output current ±3% for constant current mode.

OUTPUT VOLTAGES AND CURRENTS

Output Voltage	Output Current				
	1A	3A	5A	10A	20A
0-7V	PMA16	PMA17	PMA18	PMA19	PMA20
0-15V	PMA44	PMA47	PMA50	PMA53	PMA56
0-30V	PMA45	PMA48	PMA51	PMA54	
30-50V	PMA46	PMA49	PMA52	PMA55	

PMA 16-20 Output voltage continuously variable from 0-7V by a potentiometer on the front panel.

PMA 44-56 Output Voltages factory pre-set in IV increments and variable by ±0.5V min. by a potentiometer on the front panel.

FACTORY FITTED OPTIONS (PMA44-56)
Extra

SUFFIX 'Y' The Power Unit will be set to operate in constant current mode at the ratings in Tables 5, 6 and 7 instead of standard re-entrant mode.

SUFFIX 'Z' A thyristor overvoltage protection circuit will be fitted within the Power Unit normally set to 10% or 1 volt (whichever is greater) above the nominal output voltage.

3.1 INSTALLATION

Dimension Diagram A   Dimension Diagram B

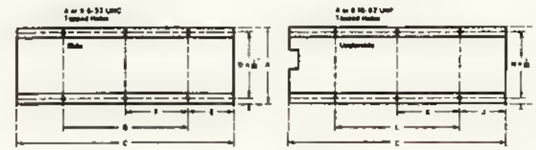


Fig. 2 Dimension Diagrams

Table 1 Fixing Centre Data, Dimensions, Weights and Dissipations

Overall Dimensions and Weights								
Type	Height A		Width B		Length C		Weight	
	in	cm	in	cm	in	cm	lb	kg
PMA16	$5\frac{1}{8}$	13.0	$3\frac{1}{4}$	8.3	$5\frac{1}{8}$	13.0	4	1.8
PMA17	$5\frac{1}{8}$	13.0	$3\frac{1}{4}$	8.3	$9\frac{1}{4}$	23.5	8	3.6
PMA18	$5\frac{1}{8}$	13.0	$4\frac{5}{8}$	11.8	$9\frac{1}{4}$	23.5	11	5.0
PMA19	$5\frac{1}{8}$	13.0	$7\frac{3}{8}$	18.7	$9\frac{1}{4}$	23.5	17	7.7
PMA20	$5\frac{1}{8}$	13.0	$9\frac{1}{8}$	23.2	$15\frac{1}{16}$	38.2	44	20.0
PMA44	$5\frac{1}{8}$	13.0	$3\frac{9}{32}$	8.3	$5\frac{1}{8}$	13.0	4	1.8
PMA45	$5\frac{1}{8}$	13.0	$4\frac{41}{64}$	11.8	$5\frac{1}{8}$	13.0	6	2.7
PMA46	$5\frac{1}{8}$	13.0	$3\frac{9}{32}$	8.3	$9\frac{1}{4}$	23.5	8	3.6
PMA47	$5\frac{1}{8}$	13.0	$3\frac{9}{32}$	8.3	$9\frac{1}{4}$	23.5	8	3.6
PMA48	$5\frac{1}{8}$	13.0	$4\frac{41}{64}$	11.8	$9\frac{1}{4}$	23.5	11	5.0
PMA49	$5\frac{1}{8}$	13.0	$7\frac{3}{8}$	18.7	$9\frac{1}{4}$	23.5	15	6.8
PMA50	$5\frac{1}{8}$	13.0	$4\frac{5}{8}$	11.8	$9\frac{1}{4}$	23.5	11	5.0
PMA51	$5\frac{1}{8}$	13.0	$7\frac{3}{8}$	18.7	$9\frac{1}{4}$	23.5	17	7.7
PMA52	$5\frac{1}{8}$	13.0	$4\frac{5}{8}$	11.8	$15\frac{1}{16}$	38.2	21	9.5
PMA53	$5\frac{1}{8}$	13.0	$7\frac{3}{8}$	18.7	$9\frac{1}{4}$	23.5	17	7.7
PMA54	$5\frac{1}{8}$	13.0	$7\frac{3}{8}$	18.7	$15\frac{1}{16}$	38.2	35	15.9
PMA55	$5\frac{1}{8}$	13.0	$9\frac{1}{8}$	23.2	$15\frac{1}{16}$	38.2	44	20.0
PMA56	$5\frac{1}{8}$	13.0	$9\frac{1}{8}$	23.2	$15\frac{1}{16}$	38.2	44	20.0

Table 1 Fixing Centre Data, Dimensions, Weights and Dissipations (Cont)

Fixing Centres								
Type	D		E		F		G	
	in	cm	in	cm	in	cm	in	cm
PMA16	$4\frac{3}{4}$	12.07	1	2.54	—	—	$3\frac{1}{8}$	7.94
PMA17	$4\frac{3}{4}$	12.07	1	2.54	—	—	$7\frac{1}{4}$	18.42
PMA18	$4\frac{3}{4}$	12.07	1	2.54	—	—	$7\frac{1}{4}$	18.42
PMA19	$4\frac{3}{4}$	12.07	1	2.54	—	—	$7\frac{1}{4}$	18.42
PMA20	$4\frac{3}{4}$	12.07	$2\frac{1}{16}$	5.24	$5\frac{15}{32}$	13.89	$10\frac{15}{16}$	27.78
PMA44	$4\frac{3}{4}$	12.07	1	2.54	—	—	$3\frac{1}{8}$	7.94
PMA45	$4\frac{3}{4}$	12.07	1	2.54	—	—	$3\frac{1}{8}$	7.94
PMA46	$4\frac{3}{4}$	12.07	1	2.54	—	—	$7\frac{1}{4}$	18.42
PMA47	$4\frac{3}{4}$	12.07	1	2.54	—	—	$7\frac{1}{4}$	18.42
PMA48	$4\frac{3}{4}$	12.07	1	2.54	—	—	$7\frac{1}{4}$	18.42
PMA49	$4\frac{3}{4}$	12.07	1	2.54	—	—	$7\frac{1}{4}$	18.42
PMA50	$4\frac{3}{4}$	12.07	1	2,54	—	—	$7\frac{1}{4}$	18.42
PMA51	$4\frac{3}{4}$	12.07	1	2.54	—	—	$7\frac{1}{4}$	18.42
PMA52	$4\frac{3}{4}$	12.07	$2\frac{1}{16}$	5.24	$5\frac{15}{32}$	13.89	$10\frac{15}{16}$	27.78
PMA53	$4\frac{3}{4}$	12.07	1	2.54	—	—	$7\frac{1}{4}$	18.42
PMA54	$4\frac{3}{4}$	12.07	$2\frac{1}{16}$	5.24	$5\frac{15}{32}$	13.89	$10\frac{15}{16}$	27.78
PMA55	$4\frac{3}{4}$	12.07	$2\frac{1}{16}$	5.24	$5\frac{15}{32}$	13.89	$10\frac{15}{16}$	27.78
PMA56	$4\frac{3}{4}$	12.07	$2\frac{1}{16}$	5.24	$5\frac{15}{32}$	13.89	$10\frac{15}{16}$	27.78
Type	H		J		K		L	
	in	cm	in	cm	in	cm	in	cm
PMA16	$2\frac{29}{32}$	7.39	$1\frac{1}{2}$	3.81	—	—	$2\frac{1}{8}$	5.40
PMA17	$2\frac{29}{32}$	7.39	2	5.08	—	—	$5\frac{1}{4}$	13.30
PMA18	$4\frac{17}{64}$	10.85	2	5.08	—	—	$5\frac{1}{4}$	13.30
PMA19	7	17.78	2	5.08	—	—	$5\frac{1}{4}$	13.30
PMA20	$8\frac{3}{4}$	22.23	3	7.62	$5\frac{1}{16}$	12.86	$9\frac{1}{16}$	23.02
PMA44	$2\frac{29}{32}$	7.39	$1\frac{1}{2}$	3.81	—	—	$2\frac{1}{8}$	5.40
PMA45	$4\frac{17}{64}$	10.85	$1\frac{1}{2}$	3.81	—	—	$2\frac{1}{8}$	5.40
PMA46	$2\frac{29}{32}$	7.39	2	5.08	—	—	$5\frac{1}{4}$	13.30
PMA47	$2\frac{29}{32}$	7.39	2	5.08	—	—	$5\frac{1}{4}$	13.30
PMA48	$4\frac{17}{64}$	10.85	2	5.08	—	—	$5\frac{1}{4}$	13.30
PMA49	7	17.78	2	5.08	—	—	$5\frac{1}{4}$	13.30
PMA50	$4\frac{17}{64}$	10.85	2	5.08	—	—	$5\frac{1}{4}$	13.30
PMA51	7	17.78	2	5.08	—	—	$5\frac{1}{4}$	13.30
PMA52	$4\frac{17}{64}$	10.85	3	7.62	$5\frac{1}{16}$	12.86	$9\frac{1}{16}$	23.02
PMA53	7	17.78	2	5.08	—	—	$5\frac{1}{4}$	13.30
PMA54	7	17.78	3	7.62	$5\frac{1}{16}$	12.86	$9\frac{1}{16}$	23.02
PMA55	$8\frac{3}{4}$	22.23	3	7.62	$5\frac{1}{16}$	12.86	$9\frac{1}{16}$	23.02
PMA56	$8\frac{3}{4}$	22.23	3	7.62	$5\frac{1}{16}$	12.86	$9\frac{1}{16}$	23.02

Table 1 Fixing Centra Data, Dimensions, Weights & Dissipations (Cont)

Power Dissipations at Maximum Input Voltage					
Unit	Max Full Load	Max Overload	Unit	Max Full Load	Max Overload
PMA16	8W	15W	PMA48	45W	60W
PMA17	24W	45W	PMA49	60W	95W
PMA18	40W	75W	PMA50	50W	60W
PMA19	80W	150W	PMA51	65W	105W
PMA20	160W	300W	PMA52	90W	155W
PMA44	12W	13W	PMA53	95W	130W
PMA45	15W	20W	PMA54	130W	200W
PMA46	20W	33W	PMA55	180W	310W
PMA47	30W	35W	PMA56	190W	260W

3.2 AC SUPPLY AND PRELIMINARY CHECKS

Verify that the connections to the primary of supply transformer T1 corresponds to the voltage of the local supply and that the supply fuse FS1 is correct for the unit in use (see Table 4).

The primary connections of T1 should be paralleled when the local supply is 100 to 125V. Fig. 3 shows the connections for a 110V supply and Table 2 gives the connections for supplies between 100 and 125V.

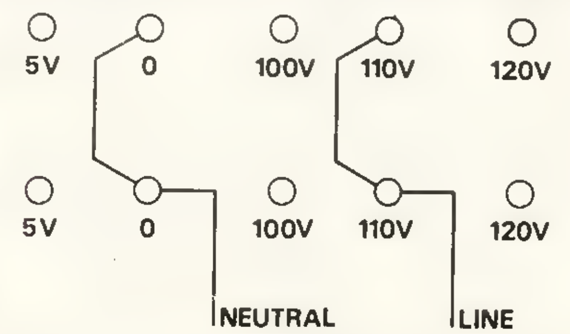


Fig. 3 Transformer Primary Connections for 110V

Table 2 Transformer Primary Connections 100-125V

Supply	Neutral	Line	Neutral Link Between	Line Link Between
100V	0	100	0-0	100-100
105V	5	100	5-5	100-100
110V	0	110	0-0	110-110
115V	5	110	5-5	110-110
120V	0	120	0-0	120-120
125V	5	120	5-5	120-120

When a 200 to 250V supply is available the primary connections of T1 should be made in series. Fig. 4 shows the series connections to be made for a 240V supply and Table 3 gives the connections for supplies between 200 and 250V.

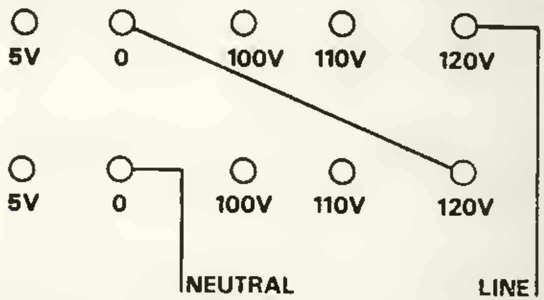


Fig. 4 Transformer Primary Connections for 240V

Table 3 Transformer Primary Connections 200-250V

Supply	Neutral to Inner Tag	Line to Outer Tag	Diagonal Link Between
200	0	100	0-100
210	5	100	5-100
220	0	110	0-110
230	5	110	5-110
240	0	120	0-120
250	5	120	5-120

Table 4 Fuse Rating (fuses up to 10A must be HRC type)

Power Supply	FS1 200-250V		FS1 100-125V		FS2 DC Fuse	
	Rating	Size	Rating	Size	Rating	Size
PMA16	1A	00	2A	00	2.5A	00
PMA17	2A	00	4A	00	4A	00
PMA18	3A	0	7A	0	7.5A	0
PMA19	5A	0	10A	0	12A	0
PMA20	7A	0	15A	0	25A	*
PMA44	1A	00	2.5A	00	2.5A	00
PMA45	2.5A	00	4A	00	2.5A	00
PMA46	2.5A	00	4A	00	2.5A	00
PMA47	2.5A	00	4A	00	4A	00
PMA48	3A	0	7A	0	5A	0
PMA49	5A	0	10A	0	7A	0
PMA50	3A	0	7A	0	7A	0
PMA51	5A	0	10A	0	7A	0
PMA52	7A	0	15A	0	7A	0
PMA53	5A	0	10A	0	12A	0
PMA54	7A	0	15A	0	12A	0
PMA55	10A	0	20A	0	12A	0
PMA56	10A	0	20A	0	25A	*

*Fast Blow E.E. GS150/25

Before the mains supply is connected to the unit ensure that the correct fuses are fitted as specified in Table 4. Check that the following terminal links on terminal block TB2 (mounted on the front panel) and TB3 (mounted on the left-hand side of the unit) are in position.

(1) 1 and 2 on TB2 (DC LINK)
(2) 3 (+s) to 4 on TB2) DC output
(3) 6 (−s) to 5 on TB2
(4) 1 and 2 on TB3 (External programming of current)
(5) 4 and 5 on TB3 (External programming of voltage)

NOTE If these links are not made the unit will not operate satisfactorily.
When the preliminary checks have been completed connect the mains supply to the following terminals on TB1.

Line	to 1
Neutral	to 2
Ground	to 3

3.3 RESETTING THE OUTPUT VOLTAGE (PMA44-56)
(a) SETTING THE OUTPUT VOLTAGE
The unit is adjusted in the factory to provide the voltage indicated on the serial number panel with a further ±0.5 V control available on the SET OUTPUT VOLTS control positioned on the front panel. The following conditions should be observed.

(1) The level of output voltage does not exceed the trip level of the over-voltage protection circuit (when fitted).

(b) TO CHANGE THE OUTPUT VOLTAGE
(1) Connect a voltmeter across terminals 3 (+s) and 6 (−s) on TB2.
(2) Adjust the transformer taps on the secondary of T1 and R110, R111, R117 and (R50 and R57 if fitted), as shown on Tables 8, 9 and 10.
(3) Switch on the AC Supply.
(4) Adjust the SET OUTPUT VOLTS control to obtain the exact output level required.

(c) EXTERNAL PROGRAMMING OF OUTPUT VOLTAGE (see Section 3.7).

3.4 RESETTING THE OVERLOAD PROTECTION
(a) The current limit level is set at 105% by resistor R105 and can only be varied by external programming as described in Section 3.7.

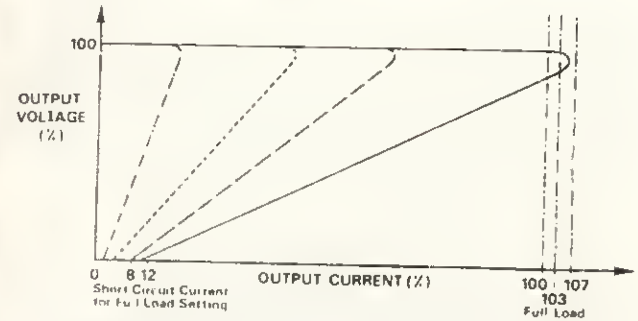


Fig. 5 Output Voltage Plotted Against Output Current (PMA44-56)

NOTE As the output current setting is reduced so the maximum short circuit current is reduced proportionately, as shown on Fig. 5.

(b) TO OPERATE THE POWER SUPPLY IN CONSTANT CURRENT MODE (PMA44-56)
Remove the link between terminals 20 and 21, and 18 and 19 on the

AUX PC Board and fit an external programming resistor between terminals 2 and 3 on TB3 having first removed the link between terminals 1 and 2. The maximum nominal currents allowable are shown on Tables 5, 6 and 7.

NOTE At no time must the current exceed the limit shown on Fig. 6.

For currents other than those shown on Tables 5, 6 and 7 calculate programming resistor values as per specification, Section 2.

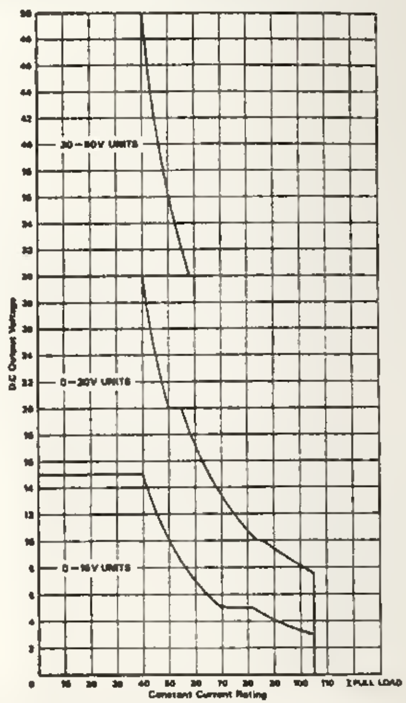


Fig. 6 Output current in constant current mode.

(c) CONSTANT CURRENT SWITCH ON (PMA44-56)
To remove the 200mS constant current switch on facility, remove the link between the terminals 20 and 21 on the AUX PC Board.

Table 5 Maximum Current in Constant Current Mode

With Output Volts set to	Nominal Output Current (Max)				
	PM44	PM47	PM50	PM53	PM56
1	1.0A	3.0A	5.0A	10A	20A
2	1.0	3.0	5.0	10	20
3	1.0	3.0	5.0	10	20
4	.83	2.9	4.1	8.3	16.6
5	.74	2.2	3.7	7.4	14.8
6	.62	1.9	3.1	6.2	12.4
7	.57	1.7	2.8	5.7	11.4
8	.54	1.6	2.7	5.4	10.8
9	.50	1.5	2.5	5.0	10.0
10	.48	1.4	2.4	4.8	9.6
11	.45	1.4	2.2	4.5	9.0
12	.42	1.3	2.1	4.2	8.4
13	.40	1.2	2.0	4.0	8.0
14	.39	1.2	1.9	3.9	7.8
15	.37	1.1	1.8	3.7	7.4

Table 6

With Output Volts set to	Nominal Output Current (Max)			
	PM46	PM48	PM51	PM54
1	1.0A	3.0A	5A	10A
2	1.0	3.0	6	10
3	1.0	3.0	5	10
4	1.0	3.0	5	10
5	1.0	3.0	5	10
6	1.0	3.0	5	10
7	1.0	3.0	5	10
8	.90	2.7	4.5	9
9	.82	2.5	4.1	8.2
10	.77	2.3	3.8	7.7
11	.72	2.2	3.6	7.2
12	.68	2.0	3.4	6.8
13	.65	1.9	3.2	6.5
14	.61	1.8	3.0	6.1
15	.58	1.7	2.9	5.8
16	.57	1.7	2.8	5.7
17	.55	1.6	2.7	5.5
18	.52	1.6	2.6	5.2
19	.51	1.5	2.5	5.1
20	.50	1.5	2.5	5.0
21	.47	1.4	2.3	4.7
22	.44	1.3	2.2	4.4
23	.43	1.3	2.1	4.3
24	.42	1.3	2.1	4.2
25	.40	1.2	2.0	4.0
26	.39	1.2	1.9	3.9
27	.38	1.1	1.9	3.8
28	.37	1.1	1.8	3.7
29	.36	1.1	1.8	3.6
30	.35	1.0	1.7	3.5

Table 7

With Output Volts set to	Nominal Output Current (Max)			
	PM46	PM49	PM52	PM55
30	.52A	1.8A	2.6A	5.2A
31	.51	1.5	2.5	5.1
32	.50	1.5	2.5	5.0
33	.49	1.5	2.4	4.9
34	.48	1.4	2.4	4.8
35	.47	1.4	2.4	4.7
36	.46	1.4	2.3	4.6
37	.45	1.3	2.3	4.5
38	.44	1.3	2.2	4.4
39	.43	1.3	2.2	4.3
40	.42	1.3	2.1	4.2
41	.41	1.2	2.1	4.1
42	.40	1.2	2.0	4.0
43	.39	1.2	2.0	3.9
44	.38	1.1	1.9	3.8
45	.38	1.1	1.9	3.8
46	.37	1.1	1.9	3.7
47	.37	1.1	1.9	3.7
48	.36	1.1	1.8	3.8
49	.36	1.1	1.8	3.6
50	.35	1.0	1.8	3.5

3.5 RESETTING THE OVERVOLTAGE PROTECTION (IF FITTED)

(1) Having checked that the overload protection is working, connect a voltmeter from terminal 4 (+) to terminal 5 (–) on TB2.
(2) Set the overvoltage control (RV50) mounted on the Overvoltage Board to the maximum setting – fully clockwise.
(3) Set the output voltage by rotating the SET OUTPUT VOLTS control to the required overvoltage level.
(4) Slowly turn RV50 counter-clockwise until the overvoltage circuit operates. Operation is evident by a reduction to approximately 1V on the voltmeter.
(5) Reduce the output voltage by rotating the SET OUTPUT VOLTS control to give approximately normal voltage.
(6) Switch off the AC supply and then switch on again to reset the circuit.
(7) Increase the output voltage by slowly rotating the SET OUTPUT VOLTS control. This will check the operation of the circuit at the level indicated on the voltmeter.
(8) Check the output voltage setting.

NOTE. For overvoltage settings which are out of the range of the internal SET OUTPUT VOLTS potentiometer either use must be made of the external voltage programming facility to achieve these higher voltages or the overvoltage must be applied from some external source of controllable and current limited voltage.

3.6 UNIT CONNECTIONS (PMA44-56)

Tables 8, 9 and 10 show the connections that should be made between the various secondary windings of T1 and the values of R110, R111, R117 and (R50 and R57 if fitted) that should be inserted to obtain the required output voltage. These resistors are located on the AUX PC Board and R50 and R57 on the O/V PC Board.

NOTE When the overvoltage circuit is fitted it is necessary to change the link on the O/V PC board when operating units above 7V i.e.

0 - 7V LINK terminals 1 and 9
8 - 50V LINK terminals 1 and 8

3.7 PROGRAMMING CURRENT AND VOLTAGE

Output Characteristics and Programming

To enable users of these power supplies to have a wide range of operating conditions care has been taken in the design to accommodate facilities for modifying the basic operating characteristic. It will be appreciated that an alteration to the normal characteristic of the power unit must impose certain limits to its operating area.

3.7.1. EXTERNAL PROGRAMMING

Voltage, current and overvoltage protection levels can be controlled externally. To utilise the facility it is necessary to remove terminal links (which disconnect the internal controls from circuit) and connect external resistors by means of remote lines if necessary. By using resistors whose values correspond to the voltage or current required voltage control, current control and overvoltage control can be effected remotely.

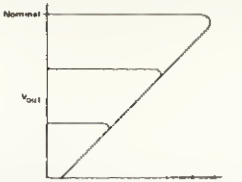


Fig. 7 External programming.

NOTE If remote lines are used their resistance is to be included in the value of the programming resistor and they should be shielded from stray electromagnetic fields to minimise 'noise' pick-up.

3.7.1. (a) VOLTAGE CONTROL

For external control of voltage the SET OUTPUT VOLTS potentiometer is disconnected from circuit and replaced by an external potentiometer or fixed resistor. The level of the output voltage is related to the value of the external resistance by the 1000Ω/V scale factor for all units.

NOTE When the voltage is reduced from the set MAX the MAX current setting is also reduced if re-entrant current mode protection is in use. See Fig. 7.

To connect the unit for external programming of voltage the procedure is as follows:

(1) Switch off AC supply.
(2) Disconnect the link across terminals 4 and 5 of TB3.
(3) Connect the external programme resistor to terminal 4 of TB3 and terminal 6 of TB2. (–ve SENSE).
(4) Switch on the AC supply.

3.7.1. (b) CURRENT CONTROL
For external control of current R105 is disconnected from circuit and replaced by an external potentiometer or fixed resistor. The level of current is related to the value of the external resistance by the Ω/A scale factor which is given in Section 2 for each of the power supplies. To connect the unit for external programming of current the procedure is as follows:–

(1) Switch off the AC supply.
(2) Disconnect the link across terminals 1 and 2 of TB3.
(3) Connect the external programme resistor to terminals 3 and 2 of TB3.
(4) Switch on the AC supply.

3.7.1. (c) OVERVOLTAGE CONTROL
For external control of the overvoltage protection circuit RV50 is disconnected from circuit and replaced by an external potentiometer or resistors. A resistance range from 0 to 3.3KΩ corresponds approximately to an overvoltage protection range of
2.5V to 120% of FULL OUTPUT VOLTAGE FOR 0-7V AND 0-15V UNITS
3V to 120% of FULL OUTPUT VOLTAGE FOR 0-30V UNITS
5V to 120% of FULL OUTPUT VOLTAGE FOR 30-50V UNITS

To connect the unit for external programming of overvoltage protection the procedure is as follows:–

(1) Switch off the AC supply.
(2) Disconnect the link across terminals 4 and 5 on the overvoltage printed circuit board.
(3) Connect an external programme potentiometer of 3.3KΩ resistance to terminals 4 (slider), 6 and 7 of the printed circuit board connector. Alternatively connect fixed resistors between terminals 7 and 4 and between terminals 6 and 4.
(4) Switch on the AC supply.
(5) Adjust for overvoltage setting.

3.8 PARALLEL AND SERIES OPERATION
3.8.1. Up to a maximum of 5 modular power units can be operated in parallel (or 3, 20A units) and should be connected as shown in Fig. 8. For best voltage regulation terminal 6 of TB3 on each unit (labelled 'P' on the circuit diagram) should be returned to a common point and four-terminal sensing used as described in Section 3.10 – but this is not essential.

NOTE When units are connected in parallel the built-in thyristor of the optional overvoltage circuit in each unit must be made inoperative because it is not possible to ensure that each thyristor will have an equal share of total current under fault conditions unless connected as shown in Fig. 9. This is done by removing the gate connection of the thyristor either at the thyristor itself or at the overvoltage PC board (terminal 3).

If overvoltage protection is required an external thyristor of suitable rating for the total parallel current of all units should be used. Its gate terminal should be connected to pin 3 on the overvoltage board of one unit after disconnecting the existing gate connection to D102. A gate firing current of approximately 50mA is available from pin 3. The cathode should be connected to the common negative line and the anode to the common positive line. Set overvoltage as in Section 3.5. All other units should have gate connections to pin 3 removed as outlined above.

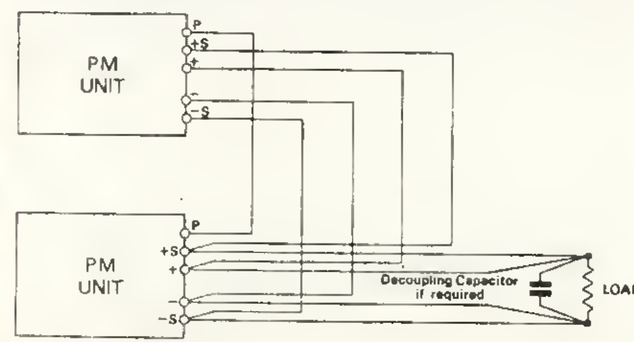


Fig. 8 Parallel Operation

3.8.2. PARALLEL OPERATION WITH BUILT IN THYRISTORS

Units should be connected as shown in Fig. 9 under the conditions as follows: –

(a) If necessary each unit is to be set up separately to the required operating conditions as detailed in paragraphs 3.4 and 3.5.
(b) A diode of the same current and voltage rating as the power module must be connected in series with each output (cathode of the diode to negative terminal of power module).
(c) Link the 'P' terminals 6 on TB3.
(d) Link the sensing terminals as shown in Fig. 9.

NOTE Because the forward voltage drop of the diode uses all the allowable external lead voltage drop no extra lead length can be allowed for four terminal sensing.

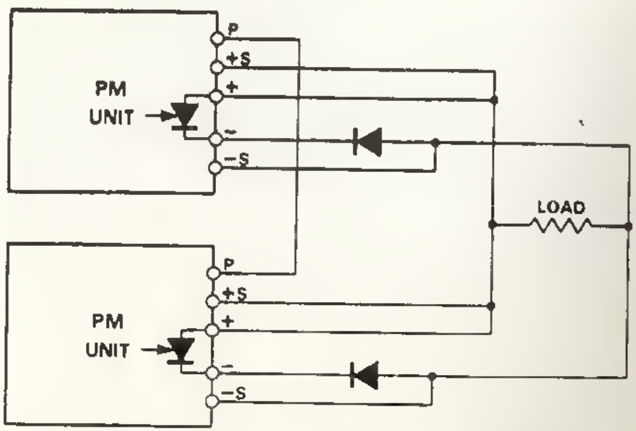


Fig. 9 Parallel Operation with Overvoltage Circuits Fitted

NOTE R106 must be removed from between terminals –ve and –ve sense.

3.8.3. It is also possible to operate modular power units in series under certain conditions as follows: –

(a) If necessary each unit is to be set up separately to the required operating conditions as detailed in paragraphs 3.4 and 3.5.
(b) A diode, of the same current and voltage rating as the power module, must be connected across EACH power module output (cathode of of diode to positive terminal of power module).
(c) The number of modules connected in series is limited to give a maximum of 250V DC.

3.9 OPERATION WITH OTHER POWER SUPPLY UNITS

When power modules are used in conjunction with other power supplies of opposite polarity provision must be made as in 3.8.3(b) to protect the power module against reverse voltage conditions. The rating of the diode used must be sufficient to carry the fault current generated.

3.10 FOUR-TERMINAL SENSING

Where long external output leads are used, four-terminal sensing is provided to enable the load voltage regulation of the power supply to be maintained at the load connections. The two links between the +ve output and the +ve sense, and the –ve output and the –ve sense terminals should be removed and connections made as shown in Fig. 10. These output connections should be run together and a decoupling capacitor, similar to C102 in the power supply, connected at the load terminals if the high frequency output impedance is to be maintained. Parallel connection should be made as shown in Fig. 11.

The maximum permissible voltage drop in the external leads when using four-terminal sensing is 0.5V total in both leads i.e. 0.25V in each lead +ve and –ve or 0.5V in one supply lead with a ground return of negligible resistance. The total permissible length of lead for 0.5V drop is listed in Table 11 for various wire sizes and current ratings. Note that this is the total permissible loop length 'go and return' and that the power supply can only be situated at half this distance from the load for a two wire +ve and –ve lead system.

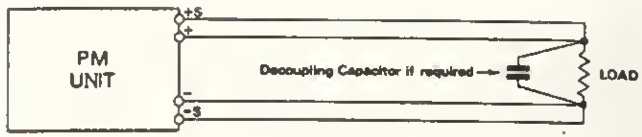


Fig. 10 Four-terminal Sensing

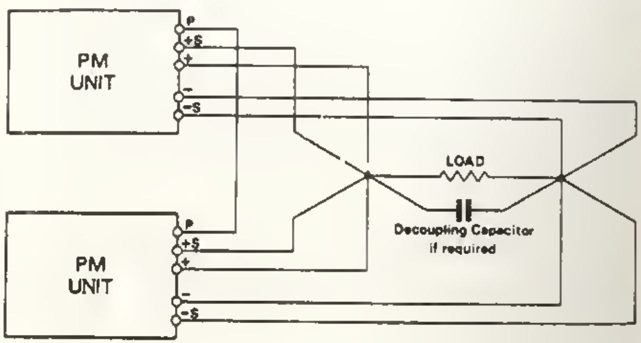


Fig. 11 Four-terminal Sensing (Parallel)

Table 8 Voltage Adjustments PMA44, 47, 50, 53, 56

CONNECTIONS							RESISTOR VALUES				
Volts out	Rec (1)	Transformer 8 − +	4 − +	2 − +	1 − +	Rec (2)	R110	R111	R117	R50	R57
1							22Ω	22Ω	LINK	470Ω	91Ω
2							150Ω	12Ω	1K	470Ω	91Ω
3							270Ω	22Ω	2K	470Ω	91Ω
4							390Ω	33Ω	3K	470Ω	91Ω
5							560Ω	LINK	4K	470Ω	91Ω
6							680Ω	LINK	5K	470Ω	91Ω
7							820Ω	LINK	6K	470Ω	91Ω
8							910Ω	LINK	7K	120Ω	51Ω
9							910Ω	180Ω	8K	120Ω	51Ω
10							1.2K	LINK	9K	120Ω	51Ω
11							1.2K	150Ω	10K	470Ω	51Ω
12							1.2K	270Ω	11K	470Ω	51Ω
13							1.5K	100Ω	12K	470Ω	51Ω
14							1.5K	220Ω	13K	470Ω	150Ω
15							1.8K	47Ω	14K	470Ω	150Ω

NOTE

Resistor Types

R110 R111	Electrosil TR5 ±2%
R117	HOLCO H4
	25ppm. 1%
R50	Electrosil TR5±2%
R57	Electrosil TR5±2%

Table 9 Voltage Adjustments PMA45, 48, 51, 54

CONNECTIONS							RESISTOR VALUES				
Volts out	Rec (1)	Transformer 17 – +	9 – +	3 – +	1 – +	Rec (2)	R110	R111	R117	R50	R57
1							22Ω	22Ω	LINK	470Ω	91Ω
2							150Ω	12Ω	1K	470Ω	91Ω
3							270Ω	22Ω	2K	470Ω	91Ω
4							390Ω	33Ω	3K	470Ω	91Ω
5							560Ω	LINK	4K	470Ω	91Ω
6							680Ω	LINK	5K	470Ω	91Ω
7							820Ω	LINK	6K	470Ω	91Ω
8							910Ω	LINK	7K	120Ω	51Ω
9							910Ω	180Ω	8K	120Ω	51Ω
10							1.2K	LINK	9K	120Ω	51Ω
11							1.2K	150Ω	10K	470Ω	51Ω
12							1.2K	270Ω	11K	470Ω	51Ω
13							1.5K	100Ω	12K	470Ω	51Ω
14							1.5K	220Ω	13K	470Ω	150Ω
15							1.8K	47Ω	14K	470Ω	150Ω
16							1.8K	180Ω	14.5K	470Ω	150Ω
17							1.8K	330Ω	15.5K	470Ω	150Ω
18							1.8K	470Ω	16.5K	470Ω	150Ω
19							2.2K	180Ω	17.5K	470Ω	220Ω
20							2.2K	330Ω	18.5K	470Ω	220Ω
21							2.2K	430Ω	19.5K	1.5K	220Ω
22							2.2K	560Ω	20.5K	1.5K	220Ω
23							2.7K	220Ω	21.5K	1.5K	220Ω
24							2.7K	330Ω	22.5K	1.5K	220Ω
25							3.0K	180Ω	23.5K	1.5K	330Ω
26							3.3K	LINK	24.5K	1.5K	330Ω
27							3.3K	120Ω	25.5K	1.5K	330Ω
28							3.3K	270Ω	26.5K	1.5K	330Ω
29							3.3K	390Ω	27.5K	1.5K	330Ω
30							3.3K	510Ω	28.5K	1.5K	330Ω

NOTE
Resistor Types

R110 R111	Electrosil TR5 ±2%
R117	HOLCO H4 25ppm ±1%
R50	Electrosil TR5 ±2%
R57	Up to 18V Electrosil TR5 ±2% 19-30V Welwyn W21 ±5%

Table 10 Voltage Adjustment PMA46, 49, 52, 55

CONNECTIONS							RESISTOR VALUES				
Volts out	Rec (1)	Transformer 40 – +	6 – +	3 – +	1 – +	Rec (2)	R110	R111	R117	R50	R57
30							3.3K	510Ω	28.5K	1.5K	330Ω
31							3.6K	330Ω	29.5K	2.7K	390Ω
32							3.6K	470Ω	30.5K	2.7K	390Ω
33							3.6K	620Ω	31.5K	2.7K	470Ω
34							3.9K	470Ω	32.5K	2.7K	470Ω
35							3.9K	560Ω	33.5K	2.7K	470Ω
36							2.4K	1.2K	34.5K	2.7K	470Ω
37							2.7K	2.0K	35.5K	2.7K	470Ω
38							2.7K	2.2K	36.5K	2.7K	560Ω
39							3.0K	2.0K	37.5K	3.3K	560Ω
40							3.3K	1.8K	38.5K	3.3K	560Ω
41							3.3K	2.0K	39.5K	3.3K	560Ω
42							3.6K	1.8K	40.5K	3.3K	560Ω
43							3.3K	2.2K	41.5K	3.3K	560Ω
44							3.6K	2.0K	42.5K	3.9K	560Ω
45							3.6K	2.2K	43.5K	3.9K	680Ω
46							3.9K	2.0K	44.5K	3.9K	680Ω
47							4.3K	1.8K	45.5K	3.9K	680Ω
48							4.7K	1.5K	46.5K	4.3K	680Ω
49							4.3K	2.0K	47.5K	4.3K	680Ω
50							4.3K	2.2K	48.5K	4.3K	680Ω

NOTE
Resistor Types

R110 R111	Electrosil TR5 ±2%
R117	HOLCO H4 25ppm. ±1%
R50	Electrosil TR5 ±2%
R57	30-32V Welwyn W21 ±5% 33-50V Welwyn W22 ±5%

Table 11 Permissible lead length for four-terminal sensing

Wire	Lead Length (feet and metres)									
Size	PMA16, 44, 45 46		PMA17, 47, 48 49		PMA18, 50, 51 52		PMA19, 53, 54, 55		PMA20, 56	
	ft	m	ft	m	ft	m	ft	m	ft	m
7/0076	19	6								
14/0076	38	12	13	4						
23/0076	60	18	20	6	12	3.5				
40/0076			68	21	21	6.5	10	3		
70/0076					37	11	18	5.5	9	2.7
110/0076					58	18	29	9	14	4.5
162/0076							43	13	21	6.5

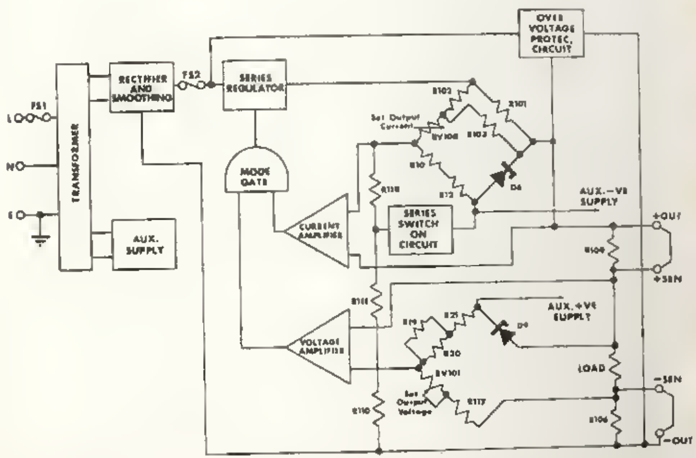


Fig. 12 Functional Diagram of Power Unit

4.1 GENERAL

A simplified functional diagram of the circuitry of the power unit is shown in Fig. 12. The voltage and current modes of operation are controlled by two independent bridge circuits. Any variation of load current or output voltage produces an out-of-balance condition of the associated bridge. The output of the bridge is applied to a comparator amplifier whose output is fed into a mode gate. The output of the mode gate controls the output resistance of a series regulator which (assuming the initial variation was within the preset operating limits of the unit) restores the original mode conditions.

The circuit cannot operate in both modes simultaneously and only the control signal from the bridge corresponding to the mode of operation passes through the gate. Crossover from one mode to another is automatic and the point of crossover is determined by the setting of the potentiometer SET OUTPUT VOLTS and R105.

An auxiliary stabilised power supply is also incorporated. This supplies the bridge circuits and the comparator amplifiers; to simplify the functional diagram the output connections of the auxiliary supply are not shown. Overvoltage protection is afforded by a sensing circuit connected across the stabilised output terminals. The level at which the circuit operates is controlled by the setting of a potentiometer.

4.2 SUPPLY RECTIFICATION AND SMOOTHING

The AC input voltage within the range 100V-125V and 200V-250V, 48Hz to 450Hz is applied, via the terminals of TB1, to the primary of T1. Interconnection of the primary terminals for different voltage supplies is given in Section 3.2.

The transformer has two secondary windings. The output voltage derived from one winding is used for the auxiliary supply. This AC voltage is full-wave rectified by D1 and D2 and smoothed by R1 and C1. The output voltage of the other winding connected as per Section 3.6 is applied to the bridge rectifier MR100 and then smoothed by C101. The resultant 'raw' DC is protected by fuse FS2 and then applied to the series regulator.

4.3 SERIES REGULATOR

The series regulator contains transistor TR100 and transistor TR101, (which may consist of several transistors in parallel) arranged in a Darlington-pair configuration. An increasing positive signal applied to the base of TR100 decreases the output resistance of the circuit; conversely, a decreasing signal increases the output resistance. Each transistor in TR101 has a separate resistor in the emitter circuit to provide current sharing between transistors. The voltage developed by the flow of load current through the resistor R101 is connected across a common potential divider network of resistors R102 and R103 to provide a voltage signal proportional to the output current which is standardised at 0.85V for 100% output current.

4.4 BRIDGE REFERENCE SOURCES

Two zener diodes D6 and D9 are used as the reference sources in the current and voltage bridges respectively. The current supply to D9 is further stabilised by zener diodes D7 and D8. The current through D9 is held constant and accurately determined by D7, D8, R13, R14, R15 and the action of the auxiliary stabiliser circuit.

4.5 AUXILIARY STABILISER

This is effectively a constant current generator feeding the amplifiers and the reference sources. TR1 compares the voltage drop across the current sensing resistor R2 with that across the zener diode D3. Any difference in voltages is amplified by TR1 and fed to TR2 the action of the circuit being such that the voltage across and hence the current through R2 is held constant.

4.6 VOLTAGE CONTROL BRIDGE

The essential part of this circuit is redrawn here for clarity. A bridge circuit is formed such that the bridge is balanced when

$$\frac{e_{ref}}{V_{out}} = \frac{R_x}{R_y} \quad \text{or} \quad V_{out} = \frac{e_{ref}}{R_x}(R_y)$$

Any unbalance voltage is detected by the amplifier IC2 and fed to the series regulator such that the circuit maintains this balance.

Hence $\quad V_{out} = k\,R_y \quad$ where $\quad k = \dfrac{e_{ref}}{R_x}$

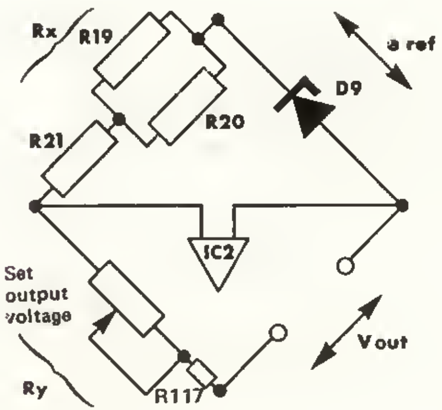


Fig. 13 Voltage Control Circuit

4.7 CURRENT CONTROL BRIDGE

The essential part of the circuit is shown here for clarity:

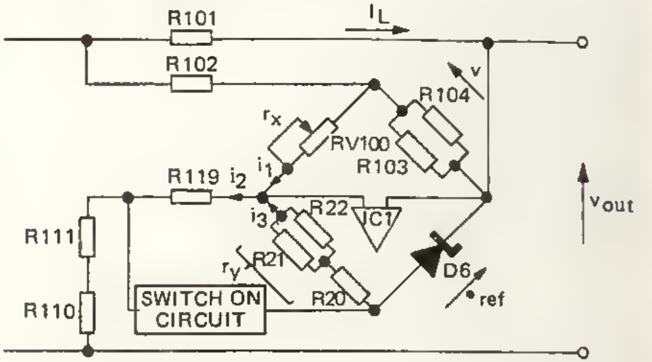


Fig. 14 Current Control Circuit

Ignoring for the moment the re-entrant resistors R110, 111 and 119 (PMA44-56 only).

At balance

$$\frac{v}{e_{ref}} = \frac{R_x}{R_y}$$

Now v is directly proportional to the load current i_{Load} as this gives rise to a voltage drop across R101 which is divided down to a standard value by R102, R103 and R104.

Therefore $\quad v = k1\, i_L = R_x \dfrac{e_{ref}}{R_y}$

or $\quad i_L = R_x \dfrac{k2}{k1}$

where k1 is the constant relating v to the load current i_L and $k2 = \dfrac{e_{ref}}{R_y}$

The action of the circuit is such that the bridge is kept balanced any error voltage being amplified by IC1 and fed to the series regulator in order to achieve this.

4.7.1. RE-ENTRANT CURRENT MODE (PMA44-56)

In this mode, R110, R111 and R119 are connected.

The balance equation shown in Section 4.6 can be modified as follows! –

When the bridge is balanced, $v_{ry} = e_{ref}$

and $v = v_{rx} = R_x i_1$

also $i_2 + i_3 = i_1$ and $v = kl\, i_L$

Therefore $R_x(i_2 + i_3) = kl\, i_L$

This shows that if R_x is constant the output current is proportional to the sum of i_2 and i_3.

Now i_3 is constant since it is $\dfrac{e_{ref}}{R_y}$, i_2 on the other hand is $\dfrac{V_{out}}{R119 + R110 + R111}$ i.e. proportional to the output voltage.

Now consider what happens when there is a short circuit on the output: the output voltage is zero hence i_2 is zero and the output current is proportional to i_3 only. As the load resistance is increased so does the output voltage. This results in i_3 increasing and as the output current is proportional to $i_2 + i_3$ this increases too. This gives rise to the re-entrant characteristics. The circuit values are so arranged that i_3 is approximately 12% of i_2 at nominal output voltage, and hence so is the short circuit current approximately 12% of the maximum output current.

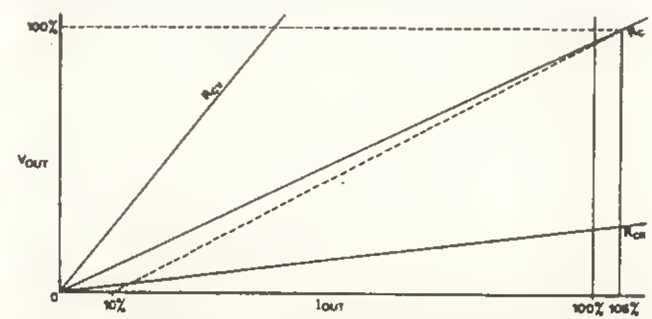


Fig. 15 Output Voltage Plotted Against Output Current in Re-entrant Mode

4.7.2. CONSTANT CURRENT MODE
R119, 110, 111 are disconnected for this characteristic therefore leaving $i_1 = i_3$.

Hence the output current is essentially constant and independent of the output voltage.

4.7.3. SERIES SWITCH-ON CIRCUIT (PMA44-56)
It is sometimes desired to have re-entrant current protection generally but to have the full output current available at switch on for starting up the load or when supplies are connected in series.

The circuit and characteristics are that of the re-entrant circuit except that a switch-on circuit is connected between the junction of R119, R111 and R20, D6. This affects i_2 such that for the first 200mS after switch-on i_2 is held at its final, full-output voltage value irrespective of the state of the output voltage.

This is done by clamping the junction of R119, R111 to −2V for the first 200mS after switch-on. TR102 is turned on by C103 charging up for this period through R114.

4.8 MODE GATE
During either mode of operation both amplifiers IC1 and IC2 produce output signals. When the voltage amplifier IC2 is in control (i.e. during "constant voltage" operation) D5 is forward biased and D4 is reverse biased. D4 therefore blocks any signals from the current amplifier when in this mode.

During constant current operation the reverse is true: D4 is conducting and IC1 is operational, D5 blocking any signals from IC2.

The crossover from one mode to the other is completely automatic.

4.9 CROSSOVER IN THE MODE GATE

The crossover action is best understood by considering the action of the circuit when, say, it is operating in the constant voltage mode and the load resistance is decreased taking the unit into the constant current mode.

Initially in the constant voltage mode IC2 controls the output. TR3 is supplied with base current through R7 and IC2 controls the output by taking some of this current away from TR3 through D5. Under these conditions D4 is cut off. As the load current is increased IC2 takes less and less current and its output voltage is increasing. At the same time the output voltage of IC1 is decreasing because of the increased load current; however D4 is still cut off.

At the crossover point D4 is just starting to conduct thus transferring the control from IC2 to IC1 and cutting off D5.

4.10 OVERVOLTAGE PROTECTION

The overvoltage protection circuit uses a long-tail pair comparator circuit containing transistors TR50 and TR51. The input to the base of TR51 is derived from R55 which with R54 forms a potential divider across the stabilised output supply. TR51 base voltage is compared with the base voltage of TR50 derived from the potentiometer RV50 connected across a Zener diode reference source D50. The level at which overvoltage protection is required is effected by the setting of RV50; because this level is obviously above the stabilised output voltage, the normal quiescent condition of the long-tail pair is such that TR50 is conducting much more than TR51. In practice, the overvoltage limit is set approximately 10% above the level of the stabilised voltage. If the stabilised output voltage rises above the level set by the SET OUTPUT VOLTS control transistor TR51 conducts and drives TR52 into heavy conduction. The base voltage of TR52 is fixed by the Zener diode D51; consequently, TR52 provides a constant current via R57 to the gate electrode of thyristor D102 which fires and produces a short circuit across the terminals of the stabilised output supply.

4.11 EXTERNAL PROGRAMMING

Resistance-output voltage and resistance-output current relationships exist and these are expressed as Ω/V and Ω/A scale factors, respectively. By disconnecting the variable resistors from circuit and in their place connecting – by remote lines if necessary – fixed or variable resistors the output voltage or current level can be set by altering the value of resistance. The advantage of this circuit facility is that without any monitoring or metering aid the voltage and current level can be set simply by the value of resistance in circuit. The method of connecting the unit for external programming of output voltage, output current and overvoltage protection is detailed in Section 3.

5.1 ACCESS TO COMPONENTS

All components, except those mounted on the printed circuit boards, are accessible after removing the front panel (held by fixing screws) and detaching the heat sink assemblies from the side bars. Access to the components on the printed circuit board during operating conditions may be obtained by removing the board and connecting it to the socket in the unit via an extension board (Advance Part No. 63265).

NOTE The printed circuit boards must not be removed from the modules without first switching off the AC supply.

5.2 REPLACEMENT SERVICING OF PRINTED CIRCUIT BOARDS

The control boards used in any of the units in the PMA16-20 and PMA44-56 range are interchangeable. The Overvoltage Boards, if fitted in the units are also interchangeable.

The extension board is available as a servicing aid. This board can be used as an extended connector for any printed circuit board in the entire range of modular Stabilised Power Supplies.

All boards are available as spare parts, and the following Advance Part No. should be quoted when ordering.

(1) Control Board	Advance Part No. 62693
(2) Overvoltage Board	Advance Part No. 23321
(3) Extension Board	Advance Part No. 63265

5.3 FAULT FINDING

Determine the state of the output voltage ON LOAD and proceed as outlined in Table 12.

Table 12 Fault Finding Chart

Output Voltage	Fault	Action
No Output	Input Fuse blown	Change fuse.
	MR100 open circuit	Change MR100
	FS1 blown AND OR FS2	Change fuse. Check circuit for cause. TR101 may be short circuit.
	DC LINK OPEN CCT	Refit

Table 12 Fault Finding Chart (Cont)

Output Voltage	Fault	Action
Low Output	TR101 open circuit	Change TR101.
	SET OUTPUT VOLTS control fully anti-clockwise (PMA16-20)	Readjust
	Printed circuit board out of socket of faulty	Replace with new assembly.
	MR100 partially open circuit	Change MR100
	D102 has fired (if fitted)	Check external circuit for overvoltage.
	SET OUTPUT VOLTS control Set Low	Readjust
	Low Re-entrant Links open-circuit.	Replace
	Printed circuit board faulty	Replace with new assembly.
High unstabilised output / High Ripple	TR100 short circuit	Change TR100
	TR101 short circuit	Change TR101
	Printed circuit board faulty	Replace with new assembly. Check to see why D102 has not fired. (If fitted.)
Excessive Output Current	Programming link TB3 (2 & 3) o/c	Replace
	Programming link Resistor o/c	Replace

Please note that if the auxiliary PCB or R101 have been changed R104 may have to be reset as laid down in the 'adjust-on test' procedure.

5.4 MEAN TIME BETWEEN FAILURES

The figures quoted below are estimated from data currently available from international sources. These estimates are based on continuous operation at maximum temperature, output voltage and current and will improve appreciably if units are operated in less arduous conditions. An indication of the possible improvement can be obtained from the accompanying graphs.

Unit	PMA16 PMA17 PMA44-47	PMA18 PMA48-50	PMA19 PMA51-53	PMA20 PMA54-56
Estimated MTBF hrs	35,000	34,000	29,000	25,00

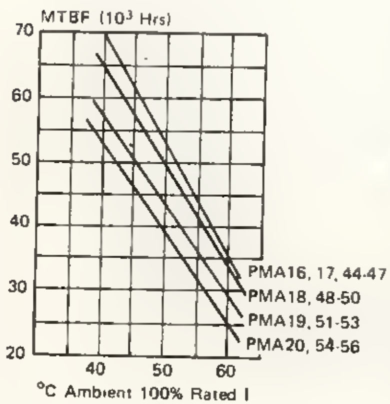


Fig. 16 MTBF at varying temperature

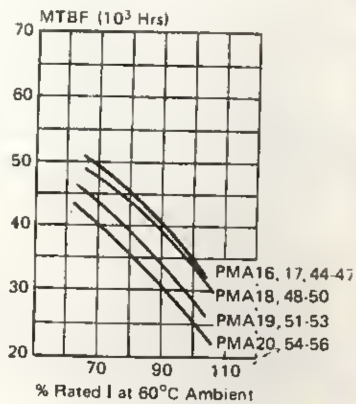


Fig. 17 MTBF at varying load current.

PMA 44 0-7v 1A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 527	1	35078
	CAPACITORS		
C100	CAP FILM 0·1µF 10% 160v	1	804
C101	CAP ELECT 2200µF 40v	1	52840
C102	CAP ELECT 1000µF 40v	1	52869
C105	0·47µF 160v CAP FILM	1	31381
	RESISTORS		
R100	2·7K 2% MO	1	26728
R101	1R 5% 10W WW	1	23066
R102	10 2% MO	1	28771
R105	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	1	26747
	TRANSISTORS		
TR100	40250	1	4224
TR101	STANDARD POWER TRANSISTOR	1	52329
	MISCELLANEOUS		
MR100	RECTIFIER W02	1	19725
RV101	CONTROL POT 2K2 10%	1	53322
FS1	FUSE B/LEE L562 1A	1	1254
FS2	FUSE B/LEE L562 2·5A	1	21189
D102	THYRISTOR BTY 79/100R	1	18693

PMA 45 0-30v 1A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 624	1	35141
	CAPACITORS		
C100	CAP FILM 0·1µF 10% 160v	1	804
C101	CAP ELECT 1200µF 63v	1	52843
C102	CAP ELECT 1000µF 40v	1	52869
C105	1µF 160v CAP FILM	1	31383
	RESISTORS		
R100	4·7K 2% MO	1	26722
R101	1R 5% WW	1	23066
R102	10 2% MO	2	28771
R105	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	1	26747
	TRANSISTORS		
TR100	40250	1	4224
TR101	STANDARD POWER TRANSISTOR	1	52360
	MISCELLANEOUS		
MR100	RECTIFIER W02	1	19725
RV101	CONTROL POT 3K3 10%	1	53323
FS1	FUSE B/LEE L562 2·5A	1	21189
FS2	FUSE B/LEE L562 2·5A	1	21189
D102	THYRISTOR BTY 79/100R	1	18693

PMA 46 30-50v 1A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 529	1	35080
	CAPACITORS		
C100	CAP FILM 0·1µF 10% 160	1	804
C101	CAP ELECT 1500µF 100v	1	51362
C102	CAP ELECT 1000µF 63v	1	52335
C105	1µF 160v CAP FILM	1	31383
	RESISTORS		
R100	6·8K 5% CE	1	2053
R101	1R 5% WW	1	23066
R102	10 2% MO	2	28771
R105	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	1	26747
	TRANSISTORS		
TR100	STANDARD POWER TRANSISTOR	1	52361
TR101	STANDARD POWER TRANSISTOR	1	52361
	MISCELLANEOUS		
MR100	RECTIFIER W02	1	19725
RV101	CONTROL POT 3K3 10%	1	53323
FS1	FUSE B/LEE L562 2·5A	1	21189
FS2	FUSE B/LEE L562 2·5A	1	21189
D102	THYRISTOR BTY 79/100R	1	18693

PMA 47 0-15v 3A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 584	1	35114
	CAPACITORS		
C100	CAP FILM 0·1µF 10% 160	1	804
C101	CAP ELECT 6800µF 40v	1	52841
C102	CAP ELECT 3300µF 25v	1	32320
C105	1µF 160v CAP FILM		31383
	RESISTORS		
R100	820 5% W.W.	1	19642
R101	0·33 5% WW	1	24969
R102	10 2% MO	2	28771
R105	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	1	26747
	TRANSISTORS		
TR100	STANDARD POWER TRANSISTOR	1	52329
TR101	STANDARD POWER TRANSISTOR	1	52329
	MISCELLANEOUS		
MR100	RECTIFIER 1B40K20	1	17763
RV101	CONTROL POT 2K2 10%	1	53322
FS1	FUSE B/LEE L562 2·5A	1	21189
FS2	FUSE B/LEE L562 4A	1	5120
D102	THYRISTOR BTY 87/100R	1	23074

PMA 48 0-30v 3A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 625	1	35141
	CAPACITORS		
C100	CAP FILM 0·1µF 10% 160v	1	804
C101	CAP ELECT 3900µF 63v	1	52844
C102	CAP ELECT 2200µF 40v	1	31844
C105	0·47µF 160v CAP FILM	1	31381
	RESISTORS		
R100	1·5K 5% WW	1	4806
R101	0·68 5% WW	2	23067
R102	10 2% M.O	1	28771
R105	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	2	26747
	TRANSISTORS		
TR100	2N3054	1	4223
TR101	STANDARD POWER TRANSISTOR	2	52360
	MISCELLANEOUS		
MR100	RECTIFIER 1B40X20	1	17763
RV101	CONTROL POT 3K3 10%	1	53323
FS1	FUSE B/LEE L693 240v 3A	1	12699
FS2	FUSE B/LEE L693 5A	1	638
D102	THYRISTOR BTY 87/100R	1	23074

PMA 49 30-50v 3A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 532	1	35083
	CAPACITORS		
C100	CAP FILM 0·1µF 10% 160v	1	804
C101	CAP ELECT 3300µF 100v	1	52797
C102	CAP ELECT 1000µF 63v	1	52335
C105	1µF 160v CAP FILM	1	31383
	RESISTOR		
R100	2·2K WW	1	17745
R101	0·68 WW	2	23067
R102	10 2% MO	2	28771
R105	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	2	26747
	TRANSISTORS		
TR100	STANDARD POWER TRANSISTOR	1	52361
TR101	STANDARD POWER TRANSISTOR	2	52361
	MISCELLANEOUS		
MR100	RECTIFIER 1B40K20	1	17763
RV101	CONTROL POT 3K3 10%	1	53323
FS1	FUSE B/LEE L693 5A	1	638
FS2	FUSE B/LEE L693 7A	1	13040
D102	THYRISTOR BTY 87/100R	1	23074

PMA 50 0-15V 5A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 583	1	35113
	CAPACITORS		
C100	CAP FILM 1µF 10% 160	1	52799
C101	CAP ELECT 12000µF 40v	1	52842
C102	CAP ELECT 3300µF 25v	1	32320
C105	1µF 160v CAP FILM	1	31383
	RESISTORS		
R100	270 5% WW	1	19641
R101	0·39 5% WW	1	25142
R102	10 2% M.O	1	28771
R105	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	2	26747
	TRANSISTORS		
TR100	40250	1	4224
TR101	STANDARD POWER TRANSISTOR	2	52329
	MISCELLANEOUS		
MR100	RECTIFIER	1	52293
RV101	CONTROL POT 2K2 10%	1	53322
FS1	FUSE B/LEE L693 3A	1	12699
FS2	FUSE B/LEE L693 7A	1	13040
D102	THYRISTOR BTY 87/100R	1	23074

PMA 51 0-30V 5A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 626	1	35142
	CAPACITORS		
C100	CAP FILM 1µF 10% 160v	1	52799
C101	CAP ELECT 7500µF 63v	1	52845
C102	CAP ELECT 3400+3400µF 40v	1	52870
C105	1µF 160v CAP FILM	1	31383
	RESISTORS		
R100	470 5% WW	1	4805
R101	0·82 5% WW	4	25143
R106	22 2% MO	4	26750
R106	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	4	26747
	TRANSISTORS		
TR100	STANDARD POWER TRANS	1	52360
TR101	STANDARD POWER TRANS	4	52360
	MISCELLANEOUS		
MR100	RECTIFIER MDA 980-2	1	52293
RV101	CONTROL POT 3K3 10%	1	53323
FS1	FUSE B/LEE L693 5A	1	638
FS2	FUSE B/LEE L693 7A	1	13040
D102	THYRISTOR BTY87/100R	1	23074

PMA 52 30-50V 5A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 535	1	35085
	CAPACITORS		
C100	CAP FILM 1µF 10% 160v	1	52799
C101	CAP ELECT 5600µF 100v	1	52848
C102	CAP ELECT 2350+2350µF 63v	1	52875
C105	1µF 160v CAP FILM	1	31383
	RESISTORS		
R100	1·5K 5% WW	1	4806
R101	1 5% WW	5	23066
R106	27 2% MO	5	28774
R106	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	5	26747
	TRANSISTORS		
TR100	STANDARD POWER TRANS	1	52361
TR101	STANDARD POWER TRANS	5	52361
	MISCELLANEOUS		
MR100	RECTIFIER MDA 980-3	1	52294
RV101	CONTROL POT 3K3 10%	1	53323
FS1	FUSE B/LEE L693 7A	1	13040
FS2	FUSE B/LEE L693 7A	1	13040
D102	THYRISTOR BTY87/100R	1	23074

PMA 53 0-15V 10A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 582	1	35112
	CAPACITORS		
C100	CAP FILM 0·1µF 10% 160v	1	804
C101	CAP ELECT 12000µF 40v	2	52842
C102	CAP ELECT 5000+5000µF 25v	4	52867
C105	1µF 160v CAP FILM	1	31383
	RESISTORS		
R100	270 5% WW	1	4804
R101	0·39 5% WW	4	25142
R106	22 2% MO	4	26750
R106	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	4	26747
	TRANSISTORS		
TR100	STANDARD POWER TRANS	1	52329
TR101	STANDARD POWER TRANS	4	52329
	MISCELLANEOUS		
MR100	RECTIFIER DIODES DD6123	2	27214
	RECTIFIER DIODES DD6123A	2	27215
RV101	CONTROL POT 2K2 10%	1	53322
FS1	FUSE B/LEE L693 5A	1	638
FS2	FUSE B/LEE L1055 12A	1	20834
D102	THYRISTOR 2N 3896	1	25473

PMA 54 0-30V 10A

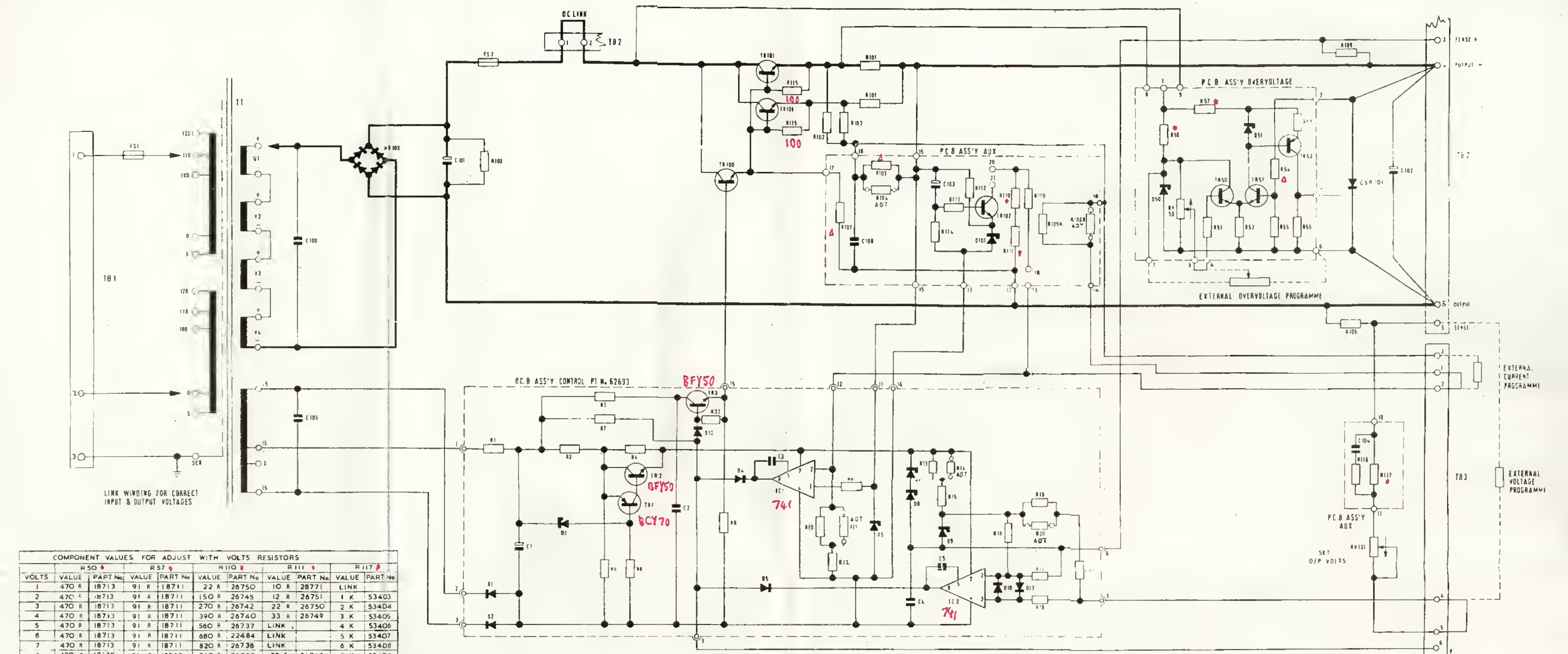
REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 627	1	35143
	CAPACITORS		
C100	CAP FILM 1µF 10% 160v	1	807
C101	CAP ELECT 7500µF 63v	1	52845
C102	CAP ELECT 5000+5000µF 40v	1	52871
C105	1µF 160v CAP FILM	1	31383
	RESISTORS		
R100	470 5% WW	1	19363
R101	0·68 5% WW	7	23067
R106	33 2% MO	7	26749
R106	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	1	26747
	TRANSISTORS		
TR100	STANDARD POWER TRANS	1	52360
TR101	STANDARD POWER TRANS	7	52360
	MISCELLANEOUS		
MR100	RECTIFIER DIODES DD6123	2	27214
	RECTIFIER DIODES DD6123A	2	27215
RV101	CONTROL POT 3K2 10%	1	53323
FS1	FUSE B/LEE L693 7A	1	13040
FS2	FUSE B/LEE L1055 12A	1	20834
D102	THYRISTOR 2N3896	1	25473

PMA 55 30-50V 10A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 538	1	35088
	CAPACITORS		
C100	CAP FILM 1µF 10% 160v	1	807
C101	CAP ELECT 5600µF 100v	2	52848
C102	CAP ELECT 2350+2350µF 63v	2	52875
C105	1µF 160v CAP FILM	1	31383
	RESISTORS		
R100	1K WW	2	18755
R101	1 5% WW	10	23066
R106	51 2% MO	10	28776
R106	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100Ω 2% MO	10	26747
	TRANSISTORS		
TR100	STANDARD POWER TRANS	1	52361
TR101	STANDARD POWER TRANS	10	52361
	MISCELLANEOUS		
MR100	RECTIFIER DIODES DD6123	2	27214
	RECTIFIER DIODES DD6123A	2	27215
RV101	CONTROL POT 3K2 10%	1	53323
FS1	FUSE B/LEE L693 10A	1	4227
FS2	FUSE B/LEE L1055 12A	1	20834
D102	THYRISTOR 2N 3896	1	25473

PMA 56 0-15V 20A

REF	DESCRIPTION	QTY	PART NO
T1	TRANSFORMER MT 618	1	35139
	CAPACITORS		
C100	CAP FILM 1µF 10% 160v	2	807
C101	CAP ELECT 12000µF 40v	4	52842
C102	CAP ELECT 9100µF 25v	1	52838
C105	1µF 160v CAP FILM	1	31383
	RESISTORS		
R100	270 5% WW	2	18767
R101	0·47 5% WW	9	23069
R106	47 2% M.O	9	26748
R106	1000 2% MO	1	27346
R109	1000 2% MO	1	27346
R115	100 2% MO	9	26747
	TRANSISTORS		
TR100	STANDARD POWER TRANS	1	52329
TR101	STANDARD POWER TRANS	9	52329
	MISCELLANEOUS		
MR100	RECTIFIER DIODES DD6123	2	27214
	RECTIFIER DIODES DD6123A	1	27215
RV101	CONTROL POT 2K2 10%	1	53322
FS1	FUSE B/LEE L693 10A	1	4227
FS2	FUSE B/LEE GS150/25 25A	1	19021
D102	THYRISTOR CR 26-051 BI	1	27298



COMPONENT VALUES FOR ADJUST WITH VOLTS RESISTORS										
	R 50		R 57		R 110		R 111		R 117	
VOLTS	VALUE	PART No	VALUE	PART No	VALUE	PART No	VALUE	PART No	VALUE	PART No
1	470 R	18713	91 R	18711	22 R	26750	10 R	28771	LINK	
2	470 R	18713	91 R	18711	150 R	26745	12 R	26751	1 K	53403
3	470 R	18713	91 R	18711	270 R	26742	22 R	26750	2 K	53404
4	470 R	18713	91 R	18711	390 R	26740	33 R	26749	3 K	53405
5	470 R	18713	91 R	18711	560 R	26737	LINK		4 K	53406
6	470 R	18713	91 R	18711	680 R	22484	LINK		5 K	53407
7	470 R	18713	91 R	18711	820 R	26736	LINK		6 K	53408
8	120 R	19138	51 R	19562	910 R	26735	33 R	26749	7 K	53409
9	120 R	19138	51 R	19562	1K	27346	82 R	28781	8 K	53410
10	120 R	19138	51 R	19562	1K2	26734	LINK		9 K	53411
11	470 R	18713	51 R	19562	1K2	26734	150 R	26745	10 K	53412
12	470 R	18713	51 R	19562	1K2	26734	270 R	26742	11 K	53413
13	470 R	18713	51 R	19562	1K5	2673[illegible]	100 R	26747	12 K	53414
14	470 R	18713	150 R	19139	1K5	26733	220 R	26743	13 K	53415
15	470 R	18713	150 R	19139	1K8	26732	47 R	26748	14 K	53416
16	470 R	18713	150 R	19139	2K	26731	LINK		14K5	53417
17	470 R	18713	150 R	19139	1K8	26732	330 R	26741	15K5	53418
18	470 R	18713	150 R	19139	1K8	26732	470 R	26739	16K5	53419
19	470 R	18713	220 R	26765	2K2	26730	180 R	26744	17K5	53420
20	470 R	18713	220 R	26765	2K2	26730	330 R	26741	18K5	53421
21	1K5	18709	220 R	26765	2K2	26730	430 R	26752	19K5	53422
22	1K5	18709	220 R	26765	2K2	26730	560 R	26737	20K5	53423
23	1K5	18709	220 R	26765	2K7	26728	220 R	26743	21K5	53424
24	1K5	18709	220 R	26765	2K7	26728	330 R	26741	22K5	53425
25	1K5	18709	330 R	3870	3K0	26727	180 R	26744	23K5	53426
26	1K5	18709	330 R	3870	3K3	26726	LINK		24K5	53427
27	1K5	18709	330 R	3870	3K3	26726	120 R	26746	25K5	53428
28	1K5	18709	330 R	3870	3K3	26726	270 R	26742	26K5	53429
29	1K5	18709	330 R	3870	3K3	26726	390 R	26740	27K5	53430
30	1K5	18709	330 R	3870	3K3	26726	510 R	26738	28K5	53431
31	2K7	18771	390 R	19800	3K6	26725	330 R	26741	29K5	53432
32	2K7	18771	390 R	19800	3K6	26725	470 R	26739	30K5	53433
33	2K7	18771	470 R	231	3K6	26725	620 R	22485	31K5	53434
34	2K7	18771	470 R	231	3K9	26724	470 R	26739	32K5	53435
35	2K7	18771	470 R	231	3K9	26724	560 R	26737	33K5	53436
36	2K7	18771	470 R	231	2K4	26729	2K2	26730	34K5	53437
37	2K7	18771	470 R	231	4K7	26722	LINK		35K5	53438
38	2K7	18771	560 R	19218	2K7	26728	2K2	26730	36K5	53439
39	3K3	18773	560 R	19218	3K0	26727	2K0	26731	37K5	53440
40	3K3	18773	560 R	19218	3K3	26726	1K8	26732	38K5	53441
41	3K3	18773	560 R	19218	3K3	26726	2K0	26731	39K5	53442
42	3K3	18773	560 R	19218	3K6	26725	1K8	26732	40K5	53443
43	3K3	18773	560 R	19218	3K3	26726	2K2	26730	41K5	53444
44	3K9	18701	560 R	19218	5K6	22483	LINK		42K5	53445
45	3K9	18701	680 R	19559	3K6	26735	2K2	26730	43K5	53446
46	3K9	18701	680 R	19559	3K9	26724	2K0	26731	44K5	53447
47	3K9	18701	680 R	19559	4K3	26723	1K8	26732	45K5	53448
48	4K3	19580	680 R	19559	6K2	26795	LINK		46K5	53449
49	4K3	19580	680 R	19559	4K3	26723	2K0	26731	47K5	53450
50	4K3	19580	680 R	19559	4K3	26722	2K2	26730	48K5	53451
RESISTOR TYPES	METAL OXIDE		1-18V M O 2% 19-24V W W 5% 25-50V W W 5%		METAL OXIDE 2%		METAL OXIDE 2%		METAL FILM 1% 25 ppm	
USED ON	O/V P.C.B. ASS'Y.				AUX. P.C.B. ASS'Y.					

COMPONENT LIST FOR CONTROL P.C.B ASS'Y No 62693					
REF	DESCRIPTION	PART No.	REF.	DESCRIPTION	PART No.
R 1	RESISTOR 47 R ± 2% M.O.	26748	C 1	CAPACITOR ELECT. 68µF 63 V	53276
R 2	RESISTOR 130 R ± 2% M O	28784	C 2	CAPACITOR CERAMIC 5600 pF 500V	22394
R 3	RESISTOR 470 R ± 2% M O	26739	C 3	CAPACITOR CERAMIC 220 pF 500V	22379
R 4	RESISTOR 910 R ± 2% M O	26735	C 4	CAPACITOR CERAMIC 5600 pF 500V	22394
R 5	RESISTOR 7K5 ± 2% M.O.	28797	C 5	CAPACITOR CERAMIC 220 pF 500V	22379
R 6	RESISTOR 3K9 ± 2% M.O	26724			
R 7	RESISTOR 30 K ± 2% M.O.	28809	D 1	DIODE 1S923	3560
R 8	RESISTOR 5K1 ± 2% M O	28794	D 2	DIODE 1S923	3560
R 9	RESISTOR 5K1 ± 2% M.O.	28794	D 3	DIODE 4 3V 400mW ZENER	33926
R 10	RESISTOR 1K2 ± 2% M.O.	26734	D 4	DIODE 1S 923	20422
R 11	RESISTOR A.O.T ± 2% M.O. SEE BELOW		D 5	DIODE 1S 923	3560
R 12	RESISTOR 5K6 ± 2% M.O.	22483	D 6	DIODE 5 1V 400mW ZENER	3560
R 13	RESISTOR 560 R ± 2% M.O.	26737	D 7	DIODE 8 2V 400mW ZENER	33928
R 14	RESISTOR A.O.T ± 2% M.O. SEE BELOW		D 8	DIODE 2 7V 400mW ZENER	33921
R 15	RESISTOR 200 R ± 1% M.FILM	50981	D 9	DIODE IN 3497 ZENER	29601
R 16	RESISTOR 33 K ± 2% M.O.	28810	D10	DIODE 1S 923	3560
R 17	RESISTOR 51 R ± 2% M.O	28776	D11	DIODE 1S 923	3560
R 18	RESISTOR 5K1 ± 2% M.O.	28794	D12	DIODE 1S 923	3560
R 19	RESISTOR 1 K ± 1% M FILM	50727			
R 20	RESISTOR A.O.T M.O SEE BELOW		TR 1	TRANS. BCY 70	23354
R 21	RESISTOR 5K6 ± 1% M FILM	52725	TR 2	TRANS BFY 50	26112
R 22	RESISTOR 10 K ± 2% M.O.	28800	TR 3	TRANS. BFY 50	26112
			IC 1	INTEG CIRCUIT ML741 CT	28636
			IC 2	INTEG CIRCUIT ML741 CT	28636

ADJUST ON TEST PROCEDURE	
R 14	ADJUST TO GIVE 1.74 V ± 0.05V ACROSS R15
R 20	ADJUST TO GIVE 1mA ± 2.5µA IN LINK BETWEEN PINS 4 & 5 ON TB3 WITH O/P OPEN CCT
R 11	ADJUST TO GIVE 0.85mA ± 8.5µA IN LINK BETWEEN PINS 1 & 2 ON TB3 WITH O/P SHORT CCT
R104	ADJUST TO GIVE 0.85V ± 8.5mV ACROSS R104 WITH UNIT DELIVERING RATED CURRENT
R105B	ADJUST TO GIVE A MAX O/P CURRENT OF 106 ± 1% OF RATED CURRENT

COMPONENT LIST FOR AUX. P.C.B. ASS'Y		
REF	DESCRIPTION	PART No
R 103	SEE TABLE BELOW	
R 104	RESISTOR ± 2% M.O. SEE A.O.T PROC	
R 105A	RESISTOR 110R ± 2% M.O.	28783
R 107	SEE TABLE BELOW	
R 110	SEE A.W.V. TABLE ON THE LEFT	
R 111	SEE A.W.V. TABLE ON THE LEFT	
R 112	RESISTOR 2K2 ± 2% M.O	26730
R 113	RESISTOR 5K6 ± 2% M.O	22483
R 114	RESISTOR 27 K ± 2% M.O.	28808
R 116	RESISTOR 100 R ± 2% M.O	26747
R 117	SEE A.W.V. TABLE ON THE LEFT	
R 119	RESISTOR 100 R ± 2% M.O	26747
R105 B	RESISTOR ± 2% M.O. SEE A.O.T PROC	
C 103	CAPACITOR ELECT 40µF 6.4 V	26882
C 104	CAPACITOR FILM 3.3µF 63 V	53562
C 108	CAPACITOR CERAMIC 1000pF 500 V	22387
D 101	DIODE 3.3V 400mW ZENER	33923
TR102	TRANS BC108	26110
18-19	LINKS FOR RE-ENTRANT PROTECTION	
18-19 & 20-21	LINKS FOR RE-ENTRANT PROTECTION WITH CONSTANT CURRENT FOR 200 mS AFTER SWITCH ON.	
NO LINKS	CONSTANT CURRENT PROTECTION	

COMPONENT LIST FOR O/V P.C.B. ASS'Y		
REF	DESCRIPTION	PART No
R 50	SEE A.W.V. TABLE ON THE LEFT	
R 51	RESISTOR 1 K ± 2% M.O.	27346
R 52	RESISTOR 1K5 ± 2% M.O	26733
R 53	RESISTOR 33 R ± 2% M.O	26749
R 54	SEE TABLE BELOW	
R 55	RESISTOR 1K5 ± 2% M.O	26733
R 56	RESISTOR 1 K ± 2% M.O	27346
R 57	SEE A.W.V. TABLE ON THE LEFT	
RV 50	POT CARBON 3K3 ± 10 %	4425
D 50	DIODE 5 6 V 400 mW ZENER	33929
D 51	DIODE 2 7 V 400 mW ZENER	33921
TR 50	TRANS 2S745A	20831
TR 51	TRANS 2S745A	20831
TR 52	TRANS ON 0-30V UNITS BFX 88	23337
TR 52	TRANS ON 30-50V UNITS BFX 29	50181
1-9	LINKS ALL UNITS SET BELOW 7V OUTPUT	
1-8	LINKS ALL UNITS SET ABOVE 7V OUTPUT	

UNIT	R 54	PART No	R 103	PART No	R 107	PART No
PMA 44	3K3	26726	100 R	26747	1K5	26733
PMA 45	8K2	28798	100 R	26747	3K3	26726
PMA 46	15 K	28804	100 R	26747	5K6	22483
PMA 47	3K3	26726	110 R	28783	1K5	26733
PMA 48	8K2	28798	91 R	28782	3K3	26726
PMA 49	15 K	28804	91 R	28782	5K6	22483
PMA 50	3K3	26726	150 R	26745	1K5	26733
PMA 51	8K2	28798	62 R	28778	3K3	26726
PMA 52	15 K	28804	100 R	26747	5K6	22483
PMA 53	3K3	26726	130 R	28784	1K5	26733
PMA 54	8K2	28798	130 R	28784	3K3	26726
PMA 55	15 K	28804	100 R	26747	5K6	22483
PMA 56	3K3	26726	91 R	28782	1K5	26733
RESISTOR TYPES - METAL OXIDE 2%						

This instrument is guaranteed for a period of five years from its delivery to the purchaser covering the replacement of defective parts other than fuses.

We maintain comprehensive after sales facilities and the instrument can, if necessary, be returned to our factory for servicing. The Type and Serial Number of the instrument should always be quoted together with full details of any fault and the service required. The Service Department can also provide maintenance and repair information by telephone or letter.

Equipment returned to us for servicing must be adequately packed, preferably in the special box supplied, and shipped with the transportation charges prepaid. We can accept no responsibility for instruments arriving damaged. Should the cause of failure during the guarantee period be due to misuse or abuse of the instrument, or if the guarantee has expired, the repair will be put in hand without delay and charged unless other instructions are received.

OUR SALES, SERVICE AND ENGINEERING DEPARTMENTS ARE READY TO ASSIST YOU AT ALL TIMES.

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