POWER SUPPLIES
(ADVANCE TYPE PM 21)

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Modular Stabilised Power Supplies PM21 - PM28

Instruction Manual

ADVANCE
INDUSTRIAL
ELECTRONICS

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ADVANCE INDUSTRIAL ELECTRONICS

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The range of modular Stabilised Power Supplies PM21-28 provide d.c. outputs from 4 to 30V in 1V steps at current ratings up to 5A and has two output channels A and B. Both channels are energised from a common a.c. input circuit.

The power supplies are constructed on the modular principle so that various units may be easily assembled or boxed together to form a 19 inch rack panel assembly, if desired.

The output voltage of each unit is preset by making the appropriate internal connections during manufacture, but a front panel control allows adjustment of the output voltage 0.5V either side of the nominal setting. Stabilisation of the output voltage against variations in the a.c. supply is better than 1000 to 1 (or 2mV whichever is the greater) and is effected by a closed loop, automatic voltage control circuit employing series regulator transistors. All units have an output impedance of less than 0.25Ω at 100 kHz. A four terminal sensing network is provided to compensate for the external output lead resistance if necessary.

The circuit incorporates a Zener diode with particular temperature characteristics that help to minimise the effects of changes in ambient temperature on unit performance. The use of silicon semiconductors throughout permits the operation of the modular power supplies at ambient temperatures up to +60°C. A protection device prevents damage to the series regulator transistors in the event of excessive overload current and automatically resets when the overload is removed.

Input Voltages
100, 105, 110, 115, 120, 125V a.c.
200, 210, 220, 230, 240, 250V a.c.
All ± 10% and at a frequency of 48-450Hz.

Output Voltage, Current and Resistance
Output voltage, resistance and current are cross-referenced vertically and horizontally in tabular form below. The output resistance (given in brackets in the voltage column) is less than the specified figure.

	D.C. Output Voltage	
	4V to 15V (2mΩ)	15V to 30V (4mΩ)
Output Current		
0–1A	PM21	PM22
0–3A	PM24	PM25
0–5A	PM27	PM28

All voltages may be preset at any 1V increment and adjusted ±0.5V by means of a front panel control. (Minimum voltage obtainable is 4V)

Output Ripple
Less than 1mV peak to peak at full load.

Output Stability Against ± 10% Change of Input Voltage
Greater than 1000:1 or 2mV whichever is the greater.

Temperature Coefficient
Less than 0.02% per degree C.

Operating Temperature Range
0°C to + 60°C ambient.

Output Impedance
Less than 0.25Ω at 100kHz.

Protection
Overload current protection with automatic resetting. Set to operate at 115% (± 2%) of full load. Short circuit current limited to 10-20% of full load current.

NOTE All circuit references of chassis mounted components in channel B of a PM unit are prefixed with a 1. Where necessary, these references are given in brackets.

3.1 Installation

The power supply modules are secured in position by four or six fixing screws. The fixing centre data for all units is given in Table 1 and Fig.2.

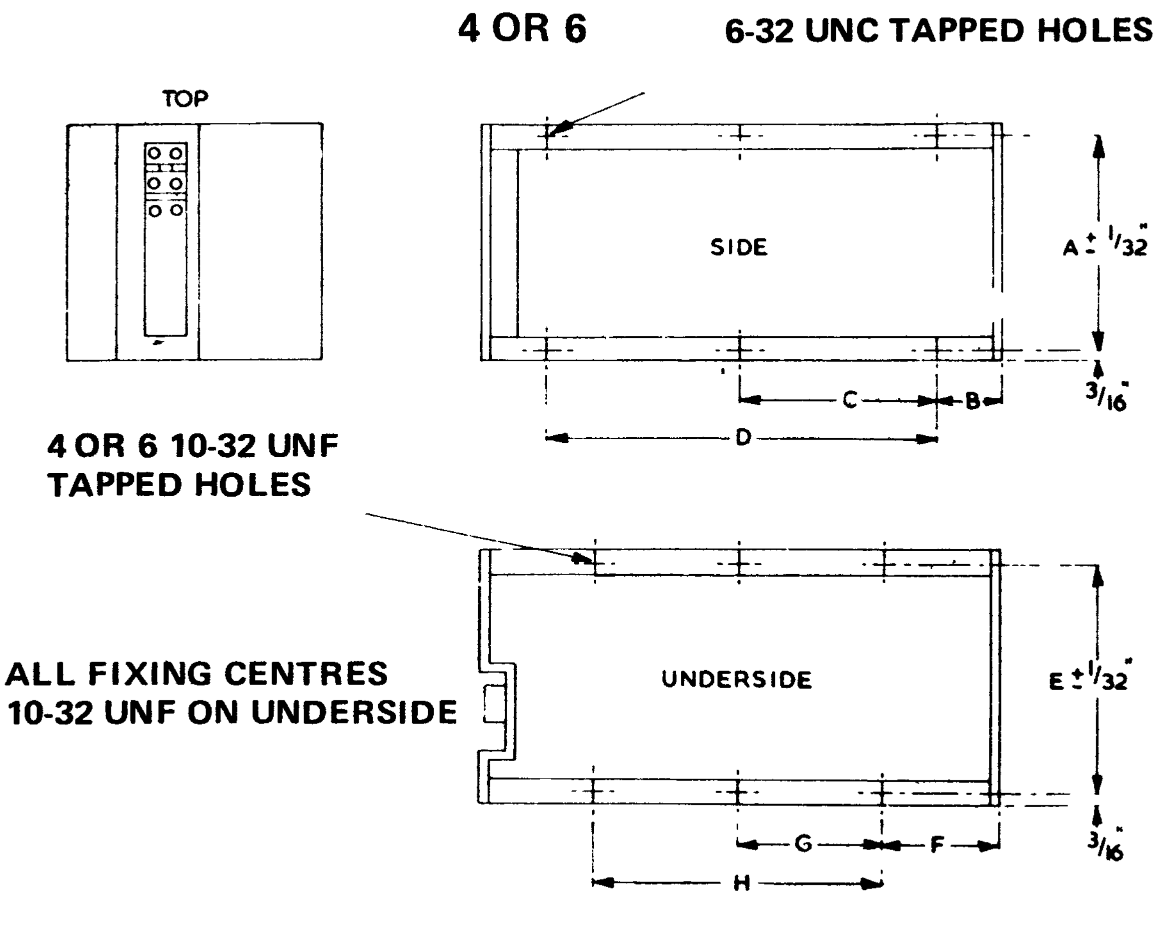


Fig. 2 Fixing Centres

Table 1 Fixing Centre Data

Type	A		B		C		D		E		F		G		H	
	in	*cm.*	*in.*	*cm.*	*in.*	*cm.*	*in*	*cm.*	*in*	*cm.*	*in.*	*cm*	*in*	*cm*	*in.*	*cm.*
PM21	4 3/4	12 07	1	2.54	–	–	7 1/4	18.42	2 29/32	7.39	2	5.08	–	–	5 1/4	13.3
PM22	4 3/4	12.07	1	2 54	–	–	7 1/4	18.42	4 17/64	10.85	2	5.08	–	–	5 1/4	13.3
PM24	4 3/4	12.07	1	2.54	–	–	7 1/4	18.42	7	17.78	2	5.08	–	–	5 1/4	13 3
PM25	4 3/4	12.07	2 1/16	5.24	5 15/32	13.89	10 15/16	27.78	4 17/64	10.85	3	7.62	5 1/16	38.26	9 1/16	23.02
PM27	4 3/4	12.07	2 1/16	5.24	5 15/32	13.89	10 15/16	27.78	4 17/64	10.85	3	7.62	5 1/16	38.26	9 1/16	23 02
PM28	4 3/4	12.07	2 1/16	5.24	5 15/32	13.89	10 15/16	27.78	7	17.78	3	7 62	5 1/16	38.26	9 1/16	23 02

3.2 A.C. Supply

NOTE The live side of the mains is connected to the A terminal block and the neutral side to the B terminal block. The second terminal on each block is used for the earth connection.

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.

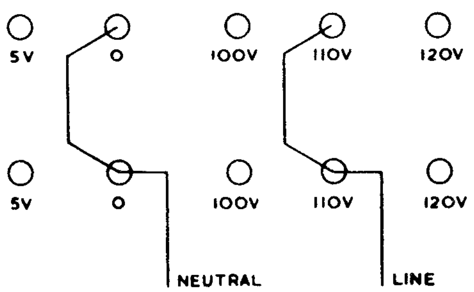


Fig. 3 Transformer Primary Connections for 110V

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.

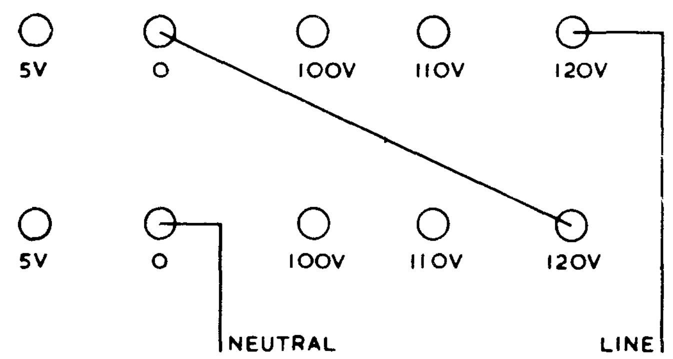


Fig. 4 Transformer Primary Connections for 240V.

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 Ratings (Up to 10A must be H.R.C. type) Size 'O'

Power Supply	Fuse Rating 200–250V	Fuse Rating 100–125V
PM21	2A	3A
PM22	3A	5A
PM24	5A	7A
PM25	7A	10A
PM27	7A	10A
PM28	7A	12A

3.3 Resetting the Output Voltage

The unit is adjusted in the factory to provide the voltage indicated on the serial number panel, with a further ± 0.5V control available on the SET O/P VOLTS control, if it is required to change the output voltage from the factory preset value, proceed as follows:

(1) Switch off the a.c. supply.

(2) Set up the connections on the terminal panel of the supply transformer to obtain the required output voltage in accordance with the information provided in Tables 5 and 6. Replace R26 (R126) and R27 (R127) at the bottom of the printed circuit board with resistors of the value stated in the appropriate table. On 4-7V units, R26 (R126) or R32 (R132) are replaced.

NOTE The unstabilised d.c. supply will be approximately 10V higher than that indicated on the transformer tagboard.

(3) With reference to Fig.10 and Fig.11 (Fig.12), ensure that the following terminals on the terminal panel are linked.

(a) 4 and 5 DC LINK.

(b) 6 and 7 +s to +) DC O/P
(c) 8 and 9 – to –S)

NOTE If these links are not made, the unit will not stabilise correctly.

(4) Connect a voltmeter between the +s and −s terminals 6 and 9 respectively.
(5) Plug the printed circuit board into the extension unit (Part No. 19014 available as an optional extra) and plug the extension unit into the printed board connector on the power supply.

NOTE The extension board is unnecessary if there is side access to the unit.

(6) Adjust the SET O/P VOLTS control RV21 (RV121) on the terminal panel to the mid-position.
(7) Switch on the a.c. supply.
(8) Adjust the SET VOLTS control RV2 on the printed circuit board until the voltmeter indicates the required voltage.

NOTE If the output voltage has been altered, it will be necessary to adjust the setting of the automatic overload cutout, using the procedure detailed in Section 3.4.

If a change of voltage range from 4 to 7V or 8 to 15V is made on the 4 to 15V units (or vice versa), it will be necessary to change the printed circuit board. (See Sect. 5.2 for Part No.).

3.4 Resetting the Overload Cut-Out

Having checked the output voltage and readjusted, if necessary, proceed as follows:

(1) Rotate the SET CURRENT control RV1 on the printed circuit board to the fully clockwise positions.

CAUTION: IN THIS CONDITION THE CUT-OUT IS INOPERATIVE

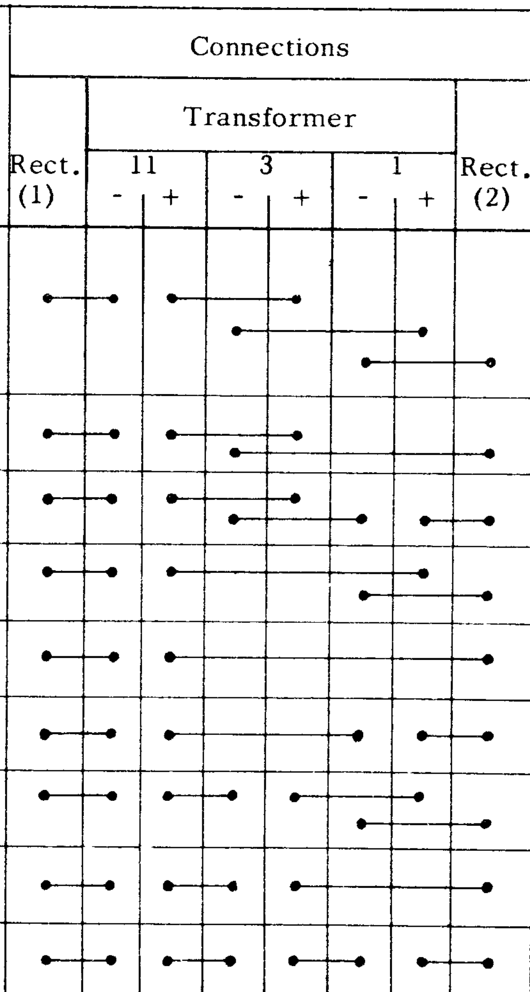
(2) Connect a suitable ammeter and an adjustable load between terminals 7 and 8 and carefully adjust the load until the ammeter indicates that the unit is delivering its maximum rated output current.
(3) Rotate RV1 counter-clockwise until the output voltage starts to fall, and then rotate the control a small amount in the clockwise direction.
(4) Decrease the load resistance slowly and verify that the maximum load current available for any value of load resistance is between 113% and 117% of the maximum rated output current. Readjust RV1 if necessary, to obtain this figure.

NOTE If the cut-out setting is too low, say 110%, the voltage regulation at full load may be affected. If the cut-out setting is too high, say 120%, the series regulator transistors may overheat when the unit is on overload at +60°C ambient temperature.

3.5 Unit Connections

Tables 5, 6 and 7 show the connections that should be made between the various secondary windings of T1, and the values of R26 (R126) and R27 (R127) that should be inserted to obtain the required output voltage. These resistors are located on the terminals of the printed circuit board edge connector.

TABLE 5 Voltage Adjustments
PM21, PM24, PM27.



Volts Out	R26 (R126) Ω	R27 (R127) Ω	R32 (R132) KΩ
⊕4	27	-	10
5	68	-	12
6	100	-	15
7	150	-	18
8	390	S.C.	-
9	560	47*	-
10	820	100*	-
11	1K	150*	-
12	1.2K	180*	-
13	1.5K	220+	-
14	1.8K	270+	-
15	1.8K	330+	-

R26, (R126), R32, (R132), type TR5 ±5% Electrosil.
⊕Connections shown in first line of table are common for output voltages 4, 5, 6 and 7.

TABLE 6 Voltage Adjustments
PM22, PM25, PM28.

Volts Out	Connections (Rect.(1), Transformer 22 −/+, 5 −/+, 2 −/+, 1 −/+, Rect.(2))	Resistor Values R26 Ω	Resistor Values R27 Ω
15	Rect.(1)–22(−); 22(+)–5(+); 5(−)–2(+); 2(−)–Rect.(2)	1.8K$^{\emptyset}$	330*
16	Rect.(1)–22(−); 22(+)–5(+); 5(−)–1(+); 1(−)–Rect.(2)	2.2K$^{\emptyset}$	390*
17	Rect.(1)–22(−); 22(+)–5(+); 5(−)–Rect.(2)	2.2K$^{\emptyset}$	390*
18	Rect.(1)–22(−); 22(+)–5(+); 5(−)–1(+); 1(−)–Rect.(2)	2.7K$^{\emptyset}$	470^{+}
19	Rect.(1)–22(−); 22(+)–2(+); 2(−)–1(+); 1(−)–Rect.(2)	2.7K$^{\emptyset}$	470^{+}
20	Rect.(1)–22(−); 22(+)–2(+); 2(−)–Rect.(2)	3.3K$^{\emptyset}$	560^{+}
21	Rect.(1)–22(−); 22(+)–1(+); 1(−)–Rect.(2)	3.3K$^{\emptyset}$	560^{+}
22	Rect.(1)–22(−); 22(+)–Rect.(2)	3.3K$^{\emptyset}$	680**
23	Rect.(1)–22(−); 22(+)–1(−); 1(+)–Rect.(2)	3.9K$^{\emptyset}$	680**
24	Rect.(1)–22(−); 22(+)–2(−); 2(+)–Rect.(2)	3.9K$^{\emptyset}$	680**
25	Rect.(1)–22(−); 22(+)–2(−); 2(+)–1(−); 1(+)–Rect.(2)	3.9K$^{\emptyset}$	820**
26	Rect.(1)–22(−); 22(+)–5(−); 5(+)–1(+); 1(−)–Rect.(2)	4.7K^{++}	820**
27	Rect.(1)–22(−); 22(+)–5(−); 5(+)–Rect.(2)	4.7K^{++}	820**
28	Rect.(1)–22(−); 22(+)–5(−); 5(+)–1(−); 1(+)–Rect.(2)	4.7K^{++}	820**
29	Rect.(1)–22(−); 22(+)–5(−); 5(+)–2(−); 2(+)–Rect.(2)	4.7K^{++}	1K **
30	Rect.(1)–22(−); 22(+)–5(−); 5(+)–2(−); 2(+)–1(−); 1(+)–Rect.(2)	5.6K^{++}	1K **

Resistor type TR5 ± 5% Electrosil
* Resistor type TR6 ± 5% Electrosil
** Resistor type W21 ± 5% Welwyn

3.6 Parallel and Series Operation

Modular power units can be operated in parallel up to a maximum of five units and should be connected as shown in Fig.5. For best voltage regulation the terminals labelled "P" on the front panels should be connected together and four terminal sensing used, but this is not essential. (See Fig.7)

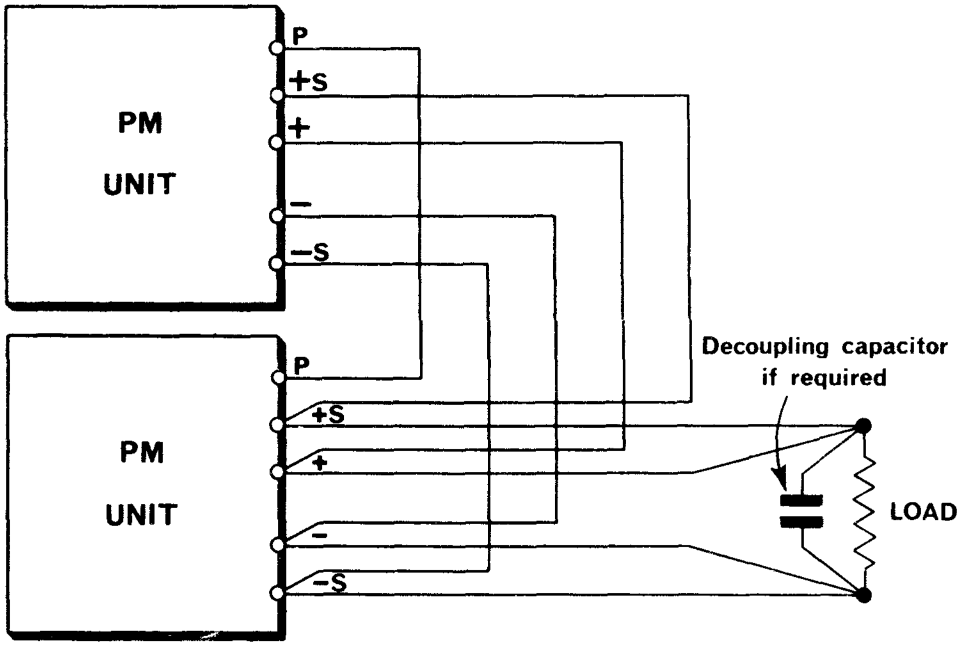


Fig. 5 Parallel Operation

It is also possible to operate modular power supply units in series under certain conditions which are listed below:

(1) If necessary, set up each unit separately as detailed in paragraphs 3.3 and 3.4 to the required operating conditions.

(2) Power modules of the same current rating only can be used.

(3) A diode, of the same current and voltage rating as the power module, must be connected across *EACH* power module output. (Positive end of diode to positive terminal of PM).

(4) To reset the cut-out, switch off the supply and load; switch on again.

(5) The number of modules connected in series is limited to a maximum of 250V DC.

3.7 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 3.6 (3) above,to protect the power module against reverse voltage conditions. The diode used must be of sufficient rating to carry the fault current generated.

3.8 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 O/P and the +ve sense and the −ve O/P and the −ve sense terminals should be removed and connections made as shown in Fig. 6. These output connections should be run together and a decoupling capacitor, similar to C22 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.7.

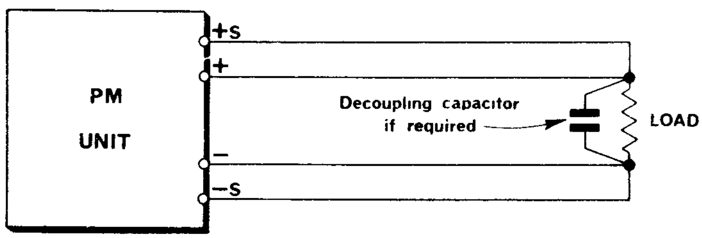


Fig. 6 Four terminal sensing

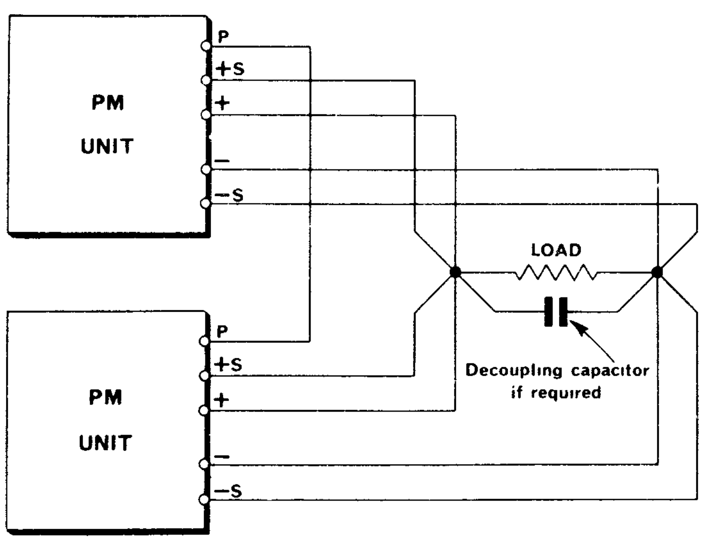


Fig. 7 Four terminal sensing (parallel)

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 negligibly low resistance earth return. The total permissible length of lead for 0.5V drop is listed in Table 7 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.

Table 7 Permissible lead length for 4-terminal sensing

Wire Size	Lead Length (feet)		
	PM21 & 22	PM24 & 25	PM27 & 28
7/0076	19	–	–
14/0076	38	13	–
23/0076	60	20	12
40/0076	–	68	21
70/0076	–	–	37
110/0076	–	–	58
162/0076	–	–	–

NOTE The operation of the A channel and the B channel in the power supply are identical; accordingly, they are not described separately.

4.1 General

The description in the following paragraphs applies to the whole range of modular power supplies. Differences in the basic circuit, which enable the power supplies to provide the various output voltages and currents listed in Section 2, may be determined by examination of Tables 5 to 6 in Section 3 and the component lists and circuit diagrams provided in Section 6.

The circuit of the transistor power module consists of six main sections as shown in Fig.8. These provide rectification and smoothing of the a.c. supply, regulation, automatic control of the output voltage and protection of the regulator transistors against overload. With the exception of the transformer, each section is duplicated in the unit for the B channel.

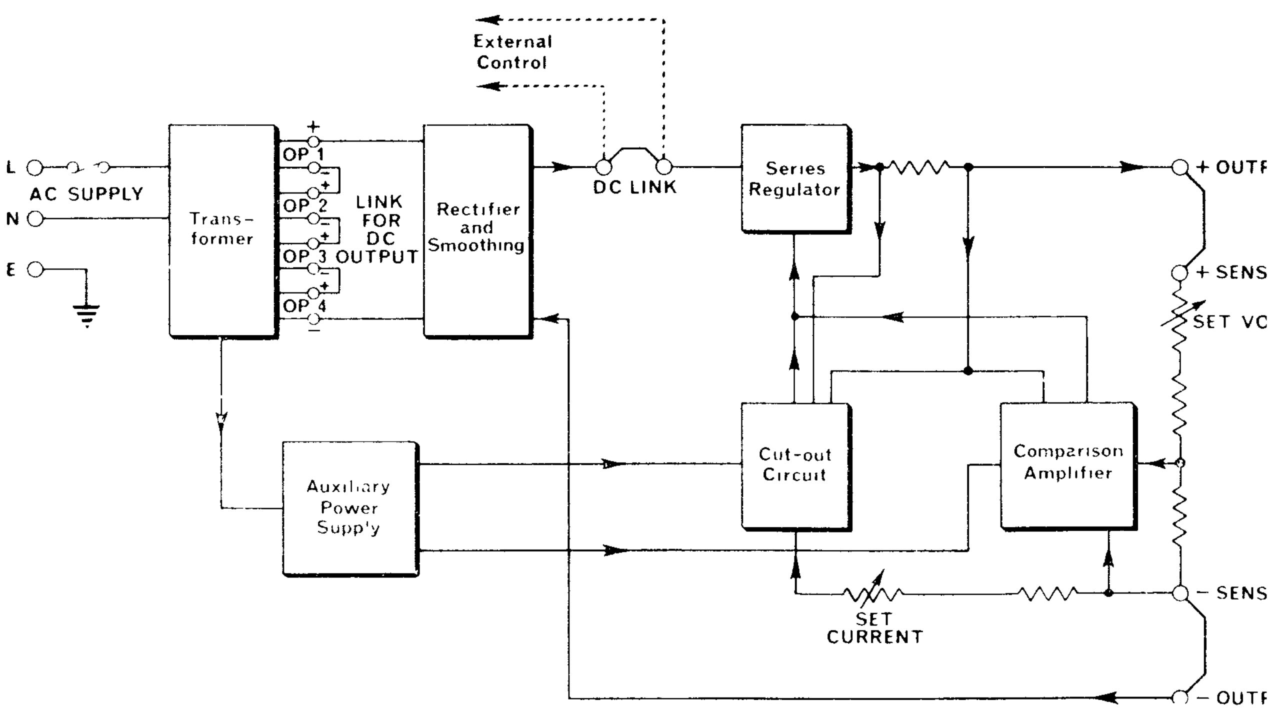


Fig. 8 Functional Diagram

4.2 Supply Rectification and Smoothing (Figs.10,

The 100-250V, 48-450 Hz a.c. input is applied to the appropriate section of the primary winding of T1 through the supply input adjusting links and FS1. Secondary windings on T1 (marked V1, V2, V3, and V4 on the circuit diagram) provide a.c. voltages, which are combined, rectified and smoothed to provide the appropriate input voltage to the regulator for the correct stabilised output voltage. These are connected according to the voltage rating of the particular unit (see Tables 5 to 6 of Section 3). In this way, a drive voltage of the desired amplitude is obtained for the bridge rectifier MR21. The full-wave output from MR21 is smoothed by C21, R21 acting as a bleed resistor, and is applied through the D.C. LINK to the collectors of the regulator transistors VT21 and VT22. This link should be removed if remote control of the output is required, by means of a fuse, switch or relay contact.
Further secondary windings on T1 provide a 45V supply which is half-wave rectified by MR6 and smoothed by C4, and a 15V-0-15V supply which is full-wave rectified by diodes MR1 and MR2, and smoothed by C1. Zener diodes MR3 and MR7 provide 6.2V and 30V d.c. supplies for use in the voltage control and automatic cut-out circuits.

4.3 Voltage Control

(a) 4 to 7V Units (Fig. 10 lower part of circuit) Voltage control of the 4 to 7V units is achieved using a control amplifier comprising a long tailed pair (VT3 and VT4). In this circuit, Zener diode MR5 and diode MR8 and R15 provide a temperature stable reference voltage source. R14 is the common emitter load, and R4 is the collector load for the stage output. The reference voltage which is the difference voltage of MR5 and MR8 is applied to the base of VT3. MR5 is connected to the output voltage line via R26 (R126) which is selected such that the current flowing into MR5 is approximately 20mA.

A portion of the output voltage of the unit is applied to the base of VT4 via the potentiometer chain RV21 (RV121) (SET OUTPUT VOLTS) RV2 and R11. Any variation of the output voltage causes the base of VT4 to go more positive (or negative) with respect to the emitter which causes the transistor to draw more (or less) current. This in turn causes a change in the bias voltage applied via VT1 to the regulator transistors VT21 (VT121) and VT22 (VT122) which together with VT1 form a compound emitter follower stage. This change in bias voltage effectively changes the collector-emitter resistances of VT21 (VT121) and VT22 (VT122) and causes the output voltage to fall (or rise) to the correct value.

Diode MR9 connected to terminal 'P' on the front panel, effects automatic 'slaving' of control amplifiers when power supply units are connected in parallel. If the 'P' connections on parallel power supplies are connected together, the power supply set to the highest voltage takes control. This is because the sensing transistor VT4 in each of the control amplifiers in the other parallelled supplies senses a high voltage at its input terminal and conducts heavily. As a result, MR9 is reversed biased and isolates the voltage control amplifier from the regulator transistors. This method has the advantage that all the parallel power supplies have a common drive voltage and therefore share the load current equally which is not possible without the 'P' connection.

(b) 8 to 50V Units (Fig. 10 upper part of circuit) Part of the output voltage of the unit is applied to the base of transistor VT3, which is supplied from terminal 6 on terminal block TB1(TB2), via RV21 (RV121) (SET O/P VOLTS), R27 (R127) and RV2,, Zener diode MR5 provides a reference potential at the emitter of VT3 R26 (R126) is selected according to the output voltage rating so that approximately 5mA flows in MR6 At this current value the temperature coefficient of the zener diode compensates for that of the base-emitter junction of VT3 and prevents the signal developed across the collector load R4 being affected by changes in temperature.
The potential VT3 collector is applied to the base of VT1. VT1 forms a compound emitter follower with the regulator transistors VT21 (VT121) and VT22 (VT122) and controls the voltage drop across them, thereby controlling the voltage at the output terminals. If the output voltage shows a tendency to rise, for example, the increase is detected in the base-emitter circuit of VT3 and the resulting increase in collector current causes the potential on the base of VT1 to fall. This effectively increases the emitter-collector resistances of VT21 (VT121) and VT22 (VT122) and lowers the output terminals.

Diode MR8 connected to terminal 'P' on the front panel, effects automatic 'slaving' of control amplifiers when power supply units are connected in parallel. If the 'P' connections on parallel power supplies are connected together, the power supply set to the highest voltage takes control. This is because the sensing transistor VT4 in each of the control amplifiers in the other parallelled supplies senses a high voltage at its input terminal and conducts heavily. As a result, MR8 is reversed bias and isolates the voltage control amplifier from the regulator transistors. This method has the advantage that all the parallel power supplies have a common drive voltage and therefore share the load current equally which is not possible without the 'P' connection.

4.4 Overload Cut-Out (Fig. 10)
The regulator transistors are protected from damage due to the flow of excessive currents during overload. This protection is provided by the circuit containing VT2.

A reference voltage is produced at the junction of R7 and R10 by the current flowing through R5, R7, R10, and RV1 and can be varied by adjusting RV1 to SET CURRENT control. A further reference voltage is applied to the emitter of VT2 by the current flowing through R6 and R8.

A voltage proportional to the current drawn by the load is developed across R22 (R122) and is supplied in opposition to the voltage across R7 and R8 via MR4 and R23 (R123) to the base of transistor VT2, In units where more than one resistor forms R22 (R122) the average voltage is obtained by equivalent number of adder resistors. R23 (R123). The diode, MR4, provides thermal compensation for the characteristics of the base-emitter junction of VT2.

As the load current increases and passes the full load rating for the module, the point is reached where the voltage across R22 (R122) exceeds the reference voltage across R7 and R8 by an amount sufficient to start VT2 conducting. When this occurs, VT2 draws current through R4 and the unit changes over from constant voltage operation to constant current operation with control transferring from VT3 (or VT4) to VT2. Formerly the potential on VT1 base was controlled by the output voltage, but now the potential provided by the current flowing in R22 (R122) is compared with the reference potential across R7 and R8. The potential on the base of VT1 is adjusted automatically to obtain steady working conditions.

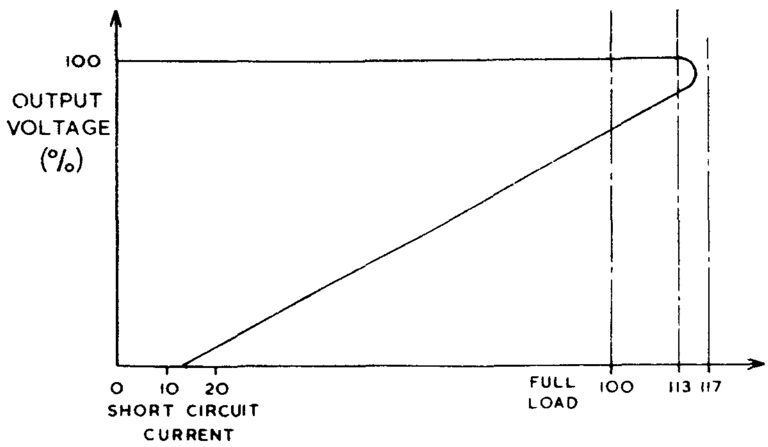
Further increase in load current therefore causes a reduction in the output voltage, but since the potential across R7 and R10 also falls when this occurs, the current reference voltage is reduced and to maintain equilibrium the voltage across R22 (R122) must also fall, which can only be brought about by a reduction in the load current flowing. For any load, a point of equilibrium will be reached and as the load is reduced the voltage will fall as shown in Fig.9. At zero output volts (short circuit), since the reference voltage across R7 is nearly zero, the load current is determined by that part of the reference voltage across R8.

4.5 Constant Current Switch-on
A circuit is incorporated which prevents 'lock-out' during switch-on when two or more power supplies are connected in

series or have common loading. This circuit is operative only during switch-on and clamps the current reference voltage at a level which holds the output current at approximately 115% of full load current for approximately 200ms. This also allows the power supply to switch on into a non-linear, or lamp load, of short time constant. The power supply therefore switches on in a constant-current mode which prevents 'lock-out' from occurring. The recommended maximum lamp load should not exceed approximately 80% of the maximum output power of the power supply.

(a) 4 to 7V Units(Fig. 10 lower part of circuit). An auxiliary negative voltage is generated by the half-wave rectifier MR10 and smoothed by R16 and C5. This voltage provides current for the 2.7V Zener diode MR11 and the CR timing circuit R20 and C6. Resistor R18 discharges C6 on switch-off. When the power supply is switched on, the voltage across C6 is zero and transistor VT5 is held in conduction by R19. This clamps the junction of R10 and RV1 at −2.7V, with respect to the positive output line. This voltage maintains approximately the same current through R7 that would result if the output voltage was at its normal level. The output current is therefore limited to approximately 115% of full load current instead of the normal short-circuit current level of 15% of full load current. The voltage across C6 increases until at approximately 200 ms after switch-on it is large enough to turn off VT5. When this happens, the current protection reverts to its normal re-entrant mode and VT5 then has no further effect on the action of the power supply. Diode MR12 protects VT5 if RV1 is set to zero ohms at switch-on.

(b) 8 to 50V Units(Fig. 10 upper part of circuit). An auxiliary negative voltage is generated by the half-wave rectifier MR9 and smoothed by R14 and C5. This voltage provides current for the 6.2V Zener diode MR10 and the CR timing circuits R18 and C6. Resistor R16 discharges C6 on switch-off. When the power supply is switched on, the voltage across C6 is zero and transistor VT4 is held in conduction by R17. This clamps the junction of R10 and RV1 at −6.2V, with respect to the positive output line. This voltage maintains approximately the same current through R7 that would result if the output voltage was at its normal level. The output current is therefore limited to approximately 115% of full load current instead of the normal short-circuit current level of 15% of full load current. The voltage across C6 increases until at approximately 200ms after switch-on it is large enough to turn off VT4. When this happens, the current protection reverts to its normal re-entrant mode and VT4 then has no further effect on the action of the power supply. Diode MR11 protects VT4 if RV1 is set to zero ohms at switch-on.



OUTPUT CURRENT (%)

(Fig. 9 Output Voltage Plotted Against Output Current)

5.1 Access to Components
All components, except those mounted on the printed circuit board 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 under operating conditions may be obtained by removing the board and connecting it to the socket in the unit via the extension board (Advance Part No. 19014).

5.2 Replacement Servicing
The voltage control boards used in the PM21-28 are as follows:-

(a) 4 to 7V boards	Advance Part No. 23497
(b) 8 to 50V boards	Advance Part No. 23498
Extension board	Advance Part No. 19014

NOTE:– Early versions of the PM21-28 units were fitted with board Part No. 22607 & 22093 respectively. These are identical in circuit to the Part Nos. quoted but were fitted with high stability carbon resistors instead of the present metal-oxide resistors.

5.3 Fault Finding
Determine the state of the output voltage *on load* and proceed as outlined in Table 8. The procedure for channel B in a PM unit is identical to that for channel A.

Table 8 Fault Finding Chart

No Output	Fuse blown	Change fuse
	MR21 open circuit	Change MR21
	DC. Link open circuit	Replace Link
	VT21 open circuit	Change VT21
	P.C. board out of socket or faulty	Replace with new assembly
If output voltage has been changed	Wire on transformer output link open circuit	Re-make joint
	Wire on PC connections open circuit especially pin 12	Re-make joint
Low Output	MR21 partially open circuit	Change MR21
	D.C. Link high resistance	Tighten screws
	+ve or –ve sensing link open circuit	Replace link
	P.C. board faulty	Replace with new Assembly
If output voltage has been changed	D.C. output taps on transformer incorrectly adjusted	Readjust taps
	Cutout operating incorrectly	Reset RV1
	Incorrect adjustment of RV2 or R27	Readjust or replace R27
	R26 open circuit or incorrect value	Replace R26
High unstabilised output. High ripple	VT21 short circuit	Change VT21
	VT22 short circuit	Change VT22
	Printed board faulty	Replace with new assembly
If output voltage has been changed	R27 open circuit	Change R27
	RV2 or R27 setting incorrect	Reset RV2 or change R27

PRINTED CIRCUIT BOARD
(Assy. No. 23497)
FOR 4 to 7V MODULES

Resistors (5% Electrosil TR5 unless specified)

R1	33		19132
R2	470		18713
R3	270		19141
R4	33K		18705
R5	1K		19338
R6	2.7K		18771
R7	1K		19338
R8	56		19135
R9	10		19339
R10	2.2K		18699
R11	220	CGS CR1-5	22969
R12	1K		19338
R13	4.7K		18706
R14	1K		19338
R15	560		18774
R16	100		18702
R17	2.7K		18771
R18	12K		19145
R19	10K		18703
R20	39K		19147
RV1	10K	Plessey MP	2262
RV2	500	Welwyn P25	18917

Capacitors

C1	40μF	25V Mullard	20107
C2	0.01μF	400V Mullard	802
C4	16μF	64V Mullard	22723
C5	12.5μF	25V Mullard	22724
C6	12.5μF	25V Mullard	22724

Diodes

MR1	Texas 1S923	3560
MR2	Texas 1S923	3560
MR3	Zener, STC. ZF6·2	4032
MR4*	Mullard 0A200	1874
MR5	Zener, 2·7 Volt	21002
MR6	Texas 1S923	3560
MR7	Zener, STC. ZF30	4812
MR8*	Mullard 0A200	1874
MR9*	Mullard 0A200	1874
MR10*	Mullard 0A200	1874
MR11	Zener, 2·7 Volt	21002
MR12*	Mullard 0A200	1874

Transistors

VT1	RCA 2N3053	4039
VT2†	Fairchild A1670	4015
VT3†	Fairchild A1670	4015
VT4†	Fairchild A1670	4015
VT4†	Fairchild A1670	4015

* Alternative. Texas 1S920 Part No. 2542

† Alternative. Texas 2S745A Part No. 2083

PRINTED CIRCUIT BOARD
(Assy. No. 23498)
FOR 8 to 50V MODULES

Ref.	*Value*	*Description*	*Part No.*
Resistors (5% Electrosil TR5 unless specified)			
R1	33		19132
R2	470		18713
R3	270		19141
R4	33K		18705
R5	1K		19338
R6	2.7K		18771
R7	1K		19338
R8	56		19135
R9	10		19339
R10	5.6K		18717
R11	270	CGS CR1.5	22970
R12	1K		19338
R13	4.7K		18706
R14	100		18702
R15	2.7K		18771
R16	39K		19147
R17	10K		18703
R18	39K		19147
RV1	33K	Plessey MP	4852
RV2	100	Welwyn P25	17754
Capacitors			
C1	40μF	25V Mullard	20107
C2	0.01μF	400V Mullard	802
C3	8μF	64V Mullard	22722
C4	16μF	64V Mullard	22723
C5	12.5μF	25V Mullard	22724
C6	12.μF	25V Mullard	22724
Diodes			
MR1	Texas 1S923		3560
MR2		Texas 1S923	3560
MR3		Zener, STC ZF 6·2	4032

Ref.	*Value*	*Description*	*Part No.*
MR4*		Mullard 0200	1874
MR5	Zener	STC ZF 6·2	4032
MR6		Texas 1S923	3560
MR7	Zener	STC ZF 30	4812
MR8		Texas 1S923	3560
MR9		Texas 1S923	3560
MR10	Zener	STC ZF 612	4032
MR11*		Mullard 0A200	1874
Transistors			
VT1		RCA 2N3053	4039
VT2†		Fairchild A1670	4015
VT3†		Fairchild A1670	4015
VT4†		Fairchild A1670	4015

* Alternative. Texas 1S920 Part No. 2542

† Alternative. Texas 2S745A Part No. 2083

For two-channel PM power supplies, two circuit references are given (except for components in the common a.c. input circuit). Channel A circuit reference is given first.

PM 21 MODULES

Ref.		*Value*	*Description*	*Part No.*
Resistors (5% Electrosil TR5 unless specified)				
R21	R121	2.7K		18771
R22	R122	1	±5% CGS VPF4	239
R23	R123	Link		
R24	R124	1.5K		18709
R25	R125	1.5K		18709
R26	R126	See table 5		
R27	R127	See table 5		
R28	R128	100		18702
R29	R129	Link		
R30	R130	100		18702
R31	R131	100		18702
RV21	RV121	100	Colvern Potentiometer	633
Capacitors				
C21	C121	1800	40V Elect. Sprague	22710
C22	C122	500μF	40V Elect. Mullard	3102
C23	C123	0.1μF	160V 10% Mullard	804
C24	C124	0.1μF	160V 10% Mullard	804
Diodes				
MR21	MR121		Bridge Rectifier Pirelli W02	19725
Transistors				
VT21	VT121		RCA 40250	4224
VT22	VT122		RCA 40250	4224
Miscellaneous				
T1			Transformer	MT539
FS1			Fuse:-	
200-250V			Belling Lee 2A L693	13041
100-125V			Belling Lee 3A L693	12699

PM22 MODULES

Resistors (5% Electrosil TR5 unless specified)

R21	R121	4.7K	Electrosil TR6	27108
R22	R122	1	± 5% CGS VPF4	239
R23	R123	Link		
R24	R124	2.7K		18771
R25	R125	2.7K		18771
R26	R126	See table 6		
R27	R127	See table 6		
R28	R128	100		18702
R29	R129	Link		
R30	R130	100		18702
R31	R131	100		18702
RV21	RV121	100	Colvern Potentiometer	633

Capacitors

C21	C121	850μF	75V Elect. Sprague	22716
C22	C122	500μF	40V Elect. Mullard	3102
C23	C123	0.1μF	160V 10% Mullard	804
C24	C124	0.1μF	160V 10% Mullard	804

Diodes

MR21	MR121	Bridge Rectifier Pirelli WO2	19725

Transistors

VT21	VT121	RCA 2N3055	3813
VT22	VT122	RCA 40250	4224

Miscellaneous

T1	Transformer	MT540
FS1	Fuse:-	
200-250V	Belling Lee 3A L693	12699
100-125V	Belling Lee 5A L693	638

PM24 MODULES

Ref.		*Value*	*Description*	*Part No.*
Resistors (5% Electrosil TR5 unless specified)				
R21	R121	8.20	Electrosil TR6	27109
R22	R122	0.27	±5% RWV4-J	18003
R23	R123	Link		

R24	R124	1.5K		18709
R25	R125	1.5K		18709
R26	R126	See table 5		
R27	R127	See table 5		
R28	R128	100		18702
R29	R129	Link		18702
R30	R130	100		18702
R31	R131	100		18702
RV21	RV121	100	Colvern Potentiometer	633

Capacitors

C21	C121	6400μF	40V Elect. Sprague	22708
C22	C122	1250μF	25V Elect. Mullard	19215
C23	C123	0.1μF	160V 10% Mullard	804
C24	C124	0.1μF	160V 10% Mullard	804

Diodes

MR21	MR121		Bridge Rectifier Texas 1B40K20	17763

Transistors

VT21	VT121	RCA	RCA 2N3055	3813
VT22	VT122		RCA 40250	4224

Miscellaneous

T1	Transformer	MT542
FS1	Fuse:-	
200-250V	Belling Lee 5A L693	638
100-125V	Belling Lee 7A L693	13040

PM25 MODULES

Resistors (5% Electrosil TR5 unless specified)

R21	R121	1.5K	±10% CGS VPF 10	4806
R22	R122	2x0.56	±5% RWV4-J	18005
R23	R123	2x10		19339
R24	R124	2.7K		18771
R25	R125	2.7K		18771
R26	R126	See table 6		
R27	R127	See table 6		

Ref.		*Value*	*Description*	*Part No.*
R28	R128	2x100		18702
R29	R129	Link		
R30	R130	100		18702
R31	R131	100		18702
RV21	RV121	100	Colvern Potentiometer	633
Capacitors				
C21	C121	3900μF	7V Elect. Sprague	22714
C22	C122	800μF	40V Elect. Mullard	2799
C23	C123	0.1μF	160V 10% Mullard	804
C24	C124	0.1μF	160V 10% Mullard	804
Diodes				
MR21	MR121		Bridge Rectifier Texas 1B40K20	17763
Transistors				
VT21	VT121		RCA 2x2N3055	3813
VT22	VT122		RCA 40250	4224
Miscellaneous				
T1			Transformer	MT543
FS1			Fuse:-	
200-250V			Belling Lee 7A L693	13040
100-125V			Belling Lee 10A L693	4227

PM27 MODULES

Resistors (5% Electrosil TR5 unless specified)				
R21	R121	270	±10% CGS VPF 10	4804
R22	R122	2x0.33	±5% CGS VPF4	2158
R23	R123	2x10		19339
R24	R124	1.5K		18709
R25	R125	1.5K		18709
R26	R126	See table 5		
R27	R127	See table 5		
R28	R128	2x100		18702
R29	R129	Link		
R30	R130	100		18702
R31	R131	100		15702
RV21	RV121	100	Colvern Potentiometer	633

Capacitors

C21	C121	12000μF	40V Elect. Sprague	22501
C22	C122	2000μF	25V Elect. Mullard	4847
C23	C123	0.1μF	160V 10% Mullard	804
C24	C124	0.1μF	160V 10% Mullard	804

Diodes

MR21	MR121		Bridge Rectifier Semtech SC BA2	22721

Transistors

VT21	VT121		RCA 2x2N3055	3813
VT22	VT122		RCA 40250	4224

Miscellaneous

T1	Transformer	MT545
FS1	Fuse:-	
200-250V	Belling Lee 7A L693	13040
100-125V	Belling Lee 10A L693	4227

PM28 MODULES

Resistors (5% Electrosil TR5 unless specified)

R21	R121	470	±10% CGS VPF 10	4805
R22	R122	4x0.68	±5% RRC LG75	4261
R23	R123	4x10		19339
R24	R124	2.7K		18771
R25	R125	2.7K		18771
R26	R126	See table 6		
R27	R127	See table 6		
R28	R128	4x100		18702
R29	R129	Link		
R30	R130	100		18702
R31	R131	100		18702
RV21	RV121	100	Colvern Potentiometer	633

Ref.		*Value*	*Description*	*Part No.*
Capacitors				
C21	C121	69,00μF	75V Elect. Spraque	22712
C22	C122	2500μF	40V Elect. Mullard	4848
C23	C123	0.1μF	160V 10% Mullard	804
C24	C124	0.1μF	160V 10% Mullard	804

Diodes		
MR21 MR121	Bridge Rectifier Semtech SCBA2	22721
Transistors		
VT21 VT121	RCA 4x2N3055	3813
VT22 VT122	RCA 40250	4224
Miscellaneous		
T1	Transformer	MT546
FS1	Fuse:-	
200-250V	Belling Lee 7A L693	13040
100-125V	Belling Lee 12A L1055	21184

GUARANTEE AND SERVICE FACILITIES SECTION 7

This instrument is guaranteed for a period of one year from its delivery to the purchase, covering the replacement of defective parts other than tubes, semiconductors and fuses. Tubes and semiconductors are subject to the manufacturers' guarantee.

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 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.

Manual Part No. 50273

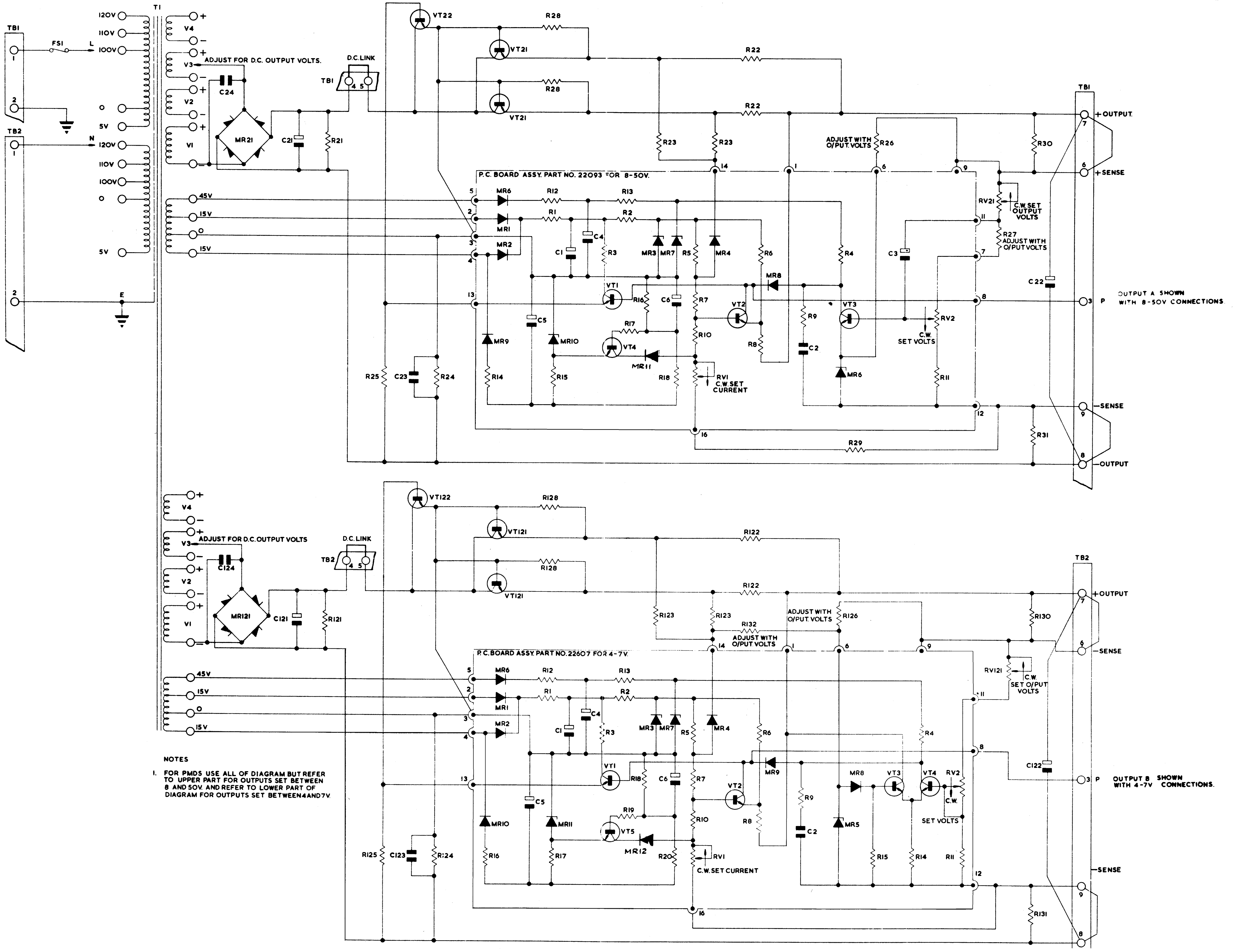


Fig.10 Circuit Diagram PM21-28