SORENSEN POWER SUPPLIES

Instruction Manual

PTM DUAL SERIES
NARROW RANGE POWER SUPPLIES

INCLUDES THE FOLLOWING PTM MODELS:

MODULE I	MODULE II	MODULE III
12-1D	12-1.6D	12-3D
15-.8D	15-1.5D	15-2.8D

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RAYTHEON

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SORENSEN COMPANY

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1. INTRODUCTION

1.1 PURPOSE

This manual contains operating and maintenance instructions on the dual PTM modular power-supply line, manufactured by the Sorensen Company, 676 Island Pond Road, Manchester, N.H. The line consists of 9 models, all similar in electrical design and physical appearance. The models are grouped into 3 sizes; Modules I, II, & III, which differ in the power output rating and in overall size. (See Table 1-1, General Specifications.)

1.2 DESCRIPTION

1.2.1 General

Designed for operation on any of three separate single-phase inputs, the units provide a variety of highly regulated dc outputs. (Refer to table 1-1 for general specifications.) They also offer extremely fast recovery times as well as characteristically low output impedances.

The supplies are designed to be mounted in any one of three positions; end, bottom or side. Four tapped mounting holes are provided on each side.

For Module II and Module III, an extruded-aluminum finned heat sink (radiator) is supplied on the rear side to eliminate the need for an external heat-dissipation device. For Module I the heat sink is mounted internally.

1.2.2 Functional

Operational features of the PTM series power supplies include remote sensing, remote programming, overload and short-circuit protection by current limiting (foldback), and over-voltage protection by an integral electronic crowbar circuit. (Refer to table 1-1.)

1.2.2.1 Remote Sensing

In applications where variations in the load-lead drops adversely affect load regulation, remote sensing may be used to extend the unit's regulating point from the output terminals to the load. In the PTM series, remote sensing will compensate for 250 mV of drop per load lead, maximum.

1.2.2.2 Remote Programming

With the remote-programming feature, unit output voltage may be altered from a remote location by introducing a calculated resistance into the programming network. The ohms/volt ratio is approximately 500 ± 8%.

1.2.2.3 Series Operation

The PTM dual series is not suitable for series connection. Series operation generally makes start-up difficult because of the foldback current-limiting feature.

1.2.2.4 Parallel Operation

The PTM dual series is not suitable for parallel operation.

1.2.2.5 Overcurrent Protection

In the event of an overcurrent condition, such as a short circuit, a current-foldback circuit (pre-set at the factory to 125% of rated current at 40°C), operates to reduce both the unit output voltage and current.

1.2.2.6 Overvoltage Protection

In the event of an overvoltage condition on the output, such as a failure in the power supply or an externally induced condition, an overvoltage electronic crowbar is actuated by an integral OVP sensing circuit. The crowbar acts quickly to reduce the output voltage to approximately zero, and the cause power supply to go into current foldback condition.

1.3 Input Options

Standard PTM Dual models are factory wired for 115 Vac operation. Units may be field or factory modified, however, to accept inputs of 220 Vac (M1 option) or 230 Vac (M2 option). Refer to Figure 2-1 on page 2-3 for required input transformer modifications.

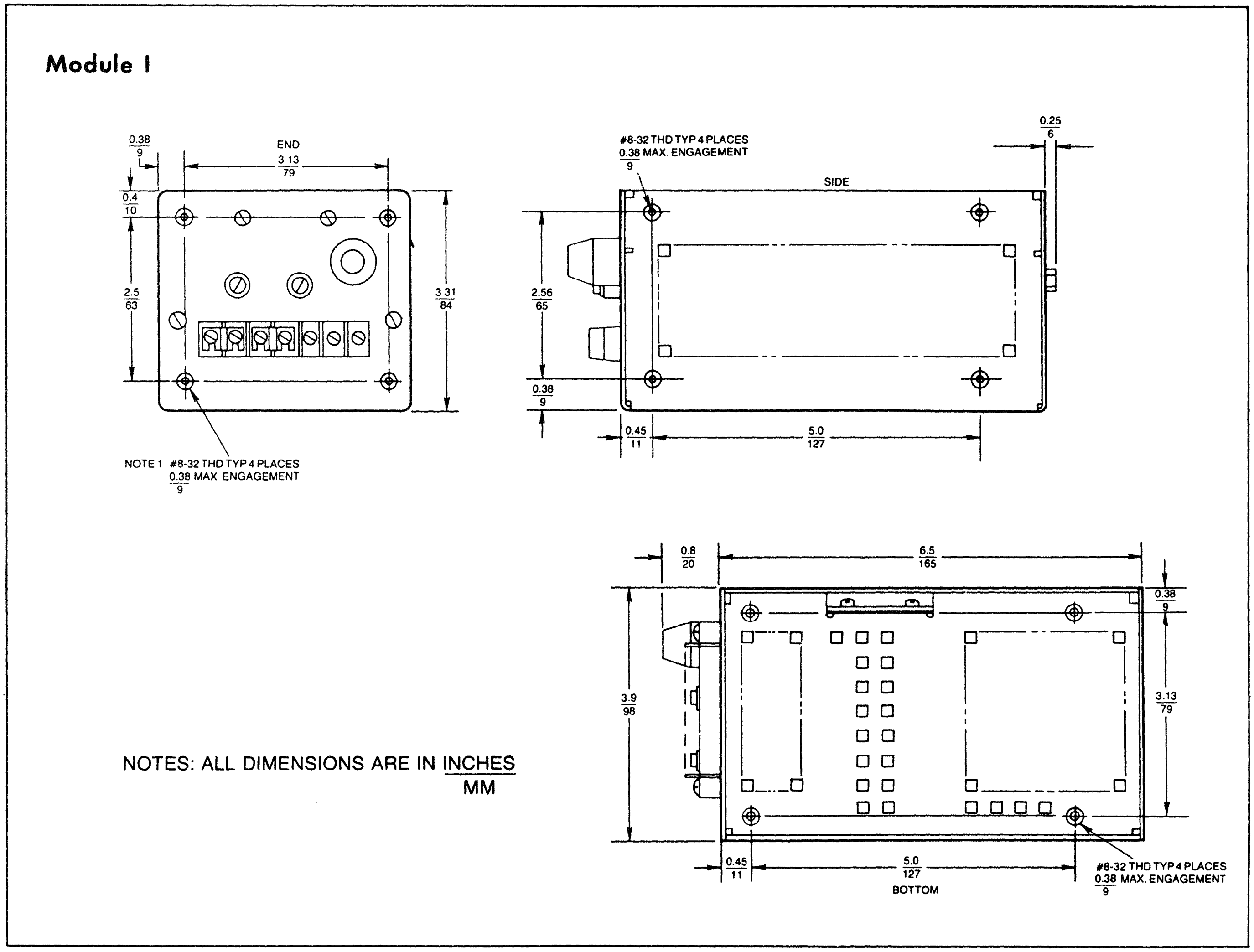
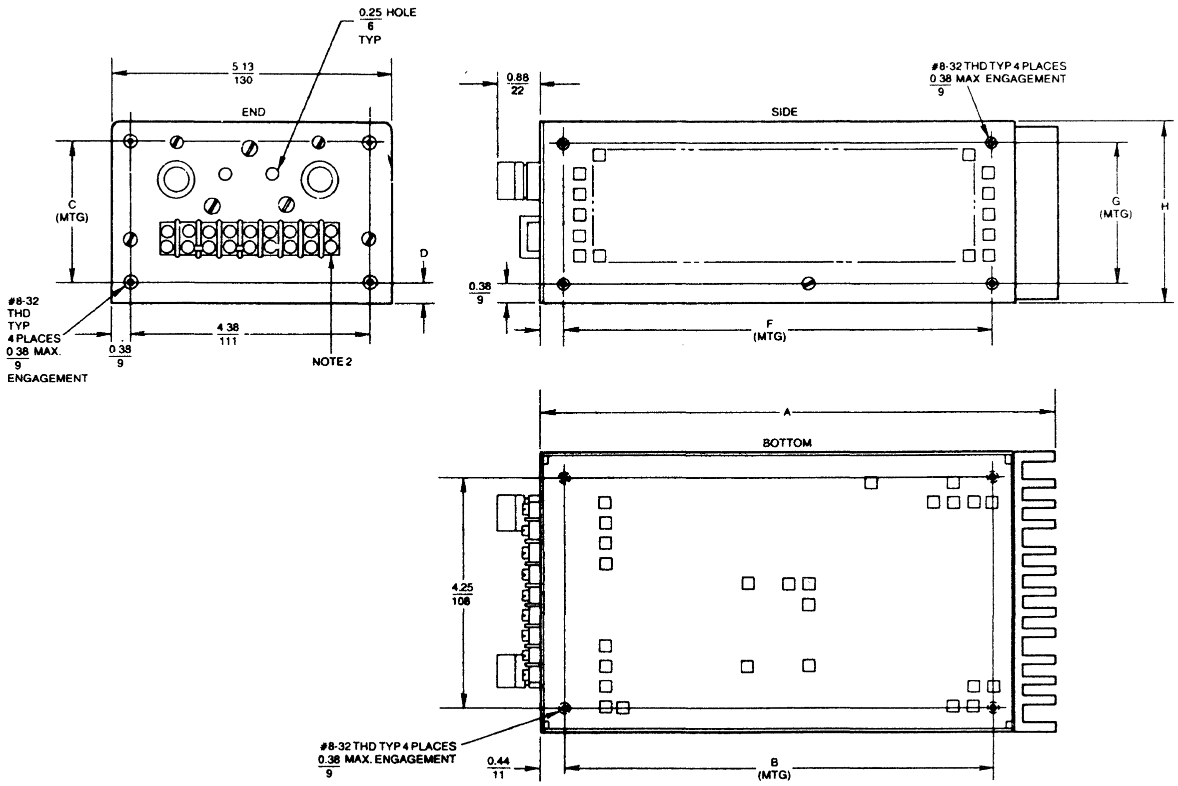


Figure 1-1 PTM Outline Drawing (Module I)

Modules II, III



Case	A	B	C	D	E	F	G	H
II	6.5 / 165	5.0 / 128	2.5 / 63	0.46 / 11	0.45 / 11	5.0 / 128	2.56 / 65	3.3 / 84
III	9.5 / 241	7.88 / 200	2.5 / 63	0.46 / 11	0.44 / 11	7.88 / 200	2.56 / 65	3.3 / 84

(Dimensions)

NOTES: ALL DIMENSIONS ARE IN $\frac{\text{INCHES.}}{\text{MM}}$

NOTE 1: SCREW SIZE #6-32 (EXCEPT FOR PTM DUAL, AC INPUT #5-40).
2: CASE II & III SCREW SIZE #5-40, CASE IIIB & DUALS #6-32).

Figure 1-2 PTM Outline Drawing (Modules II, III)

TABLE 1-1 GENERAL SPECIFICATIONS (ALL MODELS)

MODULE I	INPUT V	INPUT A	OUTPUT (+)V	OUTPUT A	OUTPUT (-)V	OUTPUT A	NOMINAL AC INPUT FUSE (A)
12-1D 15-.8D	105-125 105-125	.60 .60	11-13 14-16	1.0 .8	11-13 14-16	1.0 .8	1.0 1.0
12-1DM1 15-.8DM1	200-240 200-240	.35 .35	11-13 14-16	1.0 .8	11-13 14-16	1.0 .8	.5 .5
12-1DM2 15-.8DM2	210-250 210-250	.30 .30	11-13 14-16	1.0 .8	11-13 14-16	1.0 .8	.5 .5
MODULE II							
12-1.6D 15-1.5D	105-125 105-125	.90 .90	11-13 14-16	1.6 1.5	11-13 14-16	1.6 1.5	1.5 1.5
12-1.6DM1 15-1.5DM1	200-240 200-240	.80 .80	11-13 14-16	1.6 1.5	11-13 14-16	1.6 1.5	.75 .75
12-1.6DM2 15-1.5DM2	210-250 210-250	.45 .45	11-13 14-16	1.6 1.5	11-13 14-16	1.6 1.5	.75 .75
MODULE III							
12-3D 15-2.8D	105-125 105-125	1.8 1.8	11-13 14-16	3.0 2.8	11-13 14-16	3.0 2.8	2.0 2.0
12-3DM1 15-2.8DM1	200-240 200-240	.96 .96	11-13 14-16	3.0 2.8	11-13 14-16	3.0 2.8	1.0 1.0
12-3DM2 15-2.8DM2	210-250 210-250	.90 .90	11-13 14-16	3.0 2.8	11-13 14-16	3.0 2.8	1.0 1.0

TABLE 1-1 GENERAL SPECIFICATIONS (cont'd)

Turn-ON/OFF Overshoot:	None (output voltage)
Transient Response:	50 microseconds for load changes of 10 to 100% or 100 to 10%, based on recovery to within a ±20 mV band
Remote Programming:	500 ohms per volt (approximately)
Current Limit:	Automatic, adjustable, foldback-type. Minimum range 50 to 130% of 40°C rated current. Factory set to approximately 125% of rated (40°C) current (see individual unit specifications).
Overvoltage Limit:	Automatic, adjustable (OVP) crowbar action, self-contained. Factory set (see individual unit specifications for setting). Outputs are sensed separately and both outputs are shorted by an internal SCR within 50 microseconds. OVP stability .05%/°C of voltage trip setting (typical).
EMI (RFI):	Requirements CE03 (conducted emissions over 20 kHz to 50 MHz) and RE02 (radiated emissions over 15 kHz to 10 GHz) of MIL-STD-461 apply.
Stability:	After one hour warm-up, 0.1% for 24 hours with all external effects held constant.
Parallel Operation:	Not recommended.
Series Operation:	Not recommended.

TABLE 1-1 GENERAL SPECIFICATIONS (cont'd)

Remote Sensing:	250 mV drop per leg maximum. Remote sense (+) & (-) terminals provided
Ambient Rating:	0 to 71°C (see current ratings in individual unit specifications)
Cooling:	Natural convection (maintain free airflow from under unit)
Dimensions inches (mm):	Module I Module II Module III
Width:	3-7/8 (98) 5-1/8 (120) 5-1/8 (130)
Height:	3-5/16 (84) 3-5/16 (84) 3-5/16 (84)
Depth:	6-1/2 (165) 6-1/2 (165) 9-1/2 (241)
Weight lbs. (kg):	5-1/4 (2.4) 7-1/2 (3.4) 11 (5)
Input-Output Connections:	All connections on Modules II & III are made to a 10-terminal barrier strip using #5-40 screws. On Module I all input connections are made on a 3-terminal barrier strip. A 7-terminal barrier strap is used for the output connections.

TABLE 1-1 UNIT SPECIFICATIONS-MODULE I

Model No			12-1D		15-.8D	
Output Ratings Nominal Voltage (Vdc) Voltage Range (Vdc) Regulation (mV) Current (Adc)* @ 40°C @ 50°C @ 60°C @ 71°C			 +12 11-12 6.5 1.0 .9 .7 .4	 -12 11-12 6.5 1.0 .9 .7 .4	 +15 14-16 8.0 .8 .72 .56 .32	 -15 14-16 8.0 .8 .72 .56 .32
Current Limit (Adc) Factory set to			1.2	1.2	.95	.95
Overvoltage Limit (Vdc) Factory set to			14.6	14.6	17.5	17.5
Input Ratings Efficiency (%) Power Factor (%)			 55 80	 55 80	 54 80	 54 80
Output Adjust Resolution (mV)			25	25	25	25

**NOTE*

Specifications listed for balanced load conditions. If unit is to be operated with unbalanced loads, consult factory for applications assistance.

TABLE 1-1 UNIT SPECIFICATIONS-MODULE II

Model No.			12-1.6D		15-1.5D	
Output Ratings						
Nominal Voltage (Vdc)			+12	-12	+15	-15
Voltage Range (Vdc)			11-13	11-13	14-16	14-16
Regulation (mV)			6.5	6.5	8.0	8.0
Current (Adc)*						
@ 40°C			1.6	1.6	1.5	1.5
@ 50°C			1.4	1.4	1.35	1.35
@ 60°C			1.1	1.1	1.05	1.05
@ 71°C			.65	.65	.6	.6
Current Limit (Adc) Factory set to			1.8	1.8	1.7	1.7
Overvoltage Limit (Vdc) Factory set to			14.6	14.6	17.5	17.5
Input Ratings						
Efficiency (%)			53	53	52	52
Power Factor (%)			81	81	81	81
Output Adjust Resolution (mV)			25	25	25	25

**NOTE*

Specifications listed for balanced load conditions. If unit is to be operated with unbalanced loads, consult factory for applications assistance.

TABLE 1-1 UNIT SPECIFICATIONS-MODULE III

Model No.			12-3D		15-2.8D	
Output Ratings						
Nominal Voltage (Vdc)			+12	-12	+15	-15
Voltage Range (Vdc)			11-12	11-12	14-16	14-16
Regulation (mV)			6.5	6.5	8.0	8.0
Current (Adc)*						
@ 40°C			3.0	3.0	2.8	2.8
@ 50°C			2.7	2.7	2.4	2.4
@ 60°C			2.1	2.1	1.9	1.9
@ 71°C			1.2	1.2	1.1	1.1
Current Limit (Adc) Factory set to			3.4	3.4	3.2	3.2
Overvoltage Limit (Vdc) Factory set to			14.6	14.6	17.5	17.5
Input Ratings						
Efficiency (%)			57	57	56	56
Power Factor (%)			82	82	82	82
Output Adjust Resolution (mV)			25	25	25	25

**NOTE*

Specifications listed for balanced load conditions. If unit is to be operated with unbalanced loads, consult factory for applications assitance.

2. INSTALLATION

2.1 GENERAL

Following unpacking, general inspection and preliminary check-out procedures should be performed to assure that the unit is in proper working order. These consist of visually inspecting for physical damage and performing a few electrical checks. If it is determined that the unit is damaged, the carrier should be notified immediately. The carrier's claim agent will prepare a report of damage. The user is required to send this report to the Service Department, Sorensen Company, 676 Island Pond Road, Manchester, N.H. 03103. Sorensen will advise the user as to what action is required to repair or replace the supply.

2.2 INSPECTION

Check for damage incurred during shipment as follows:

1. Inspect enclosures for dents, chips and other obvious signs of damage.

2. Check condition of external terminal board. Make certain that all terminal screws are in place and that links are fitted over the barrier strips between terminals 1 and 2, 3 and 4, and between 5, 6 and 7.

3. Inspect fuse holders for evidence of damage.

4. If internal damage is suspected;

   a. Remove the (4) flat-head screws on front panel.

   b. (Group III Only) remove the (2) flat-head screws, one on each side.

c. Remove the (6) round-head screws on rear heat sink, top edge and end side.

d. Loosen the (2) round-head screws on the lower edge of the heat sink.

e. Inspect PCB, transformer, capacitor and potentiometers.

5. The PCB and potentiometer bracket assembly can be removed by removing the three round-head screws retaining the bracket to the front panel.

6. The heat-sink assembly at the rear can be removed by removing the two lower rear round-head screws. Check that the power transistors are firmly plugged into their sockets. These may be readily removed for servicing.

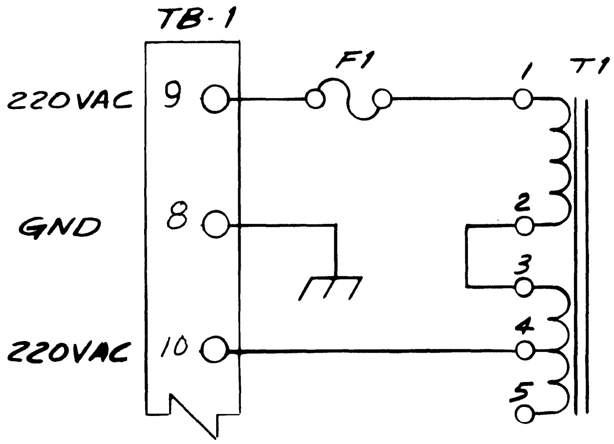
2.3 INPUT CONNECTIONS

If either of the two alternatives to a nominal 115-Vac input is to be used, transformer T1 primary tap wiring should be changed as indicated in figure 2-1. The factory-wired 115-Vac configuration is included to facilitate reconversion to this input if such action becomes desirable. Remount enclosures following inspection or tap changing.

2.4 ELECTRICAL CHECK

To perform an initial electrical check, proceed as follows:

1. Make certain that the unit is located in an area where free passage of air is unrestricted. For Modules II & III connect input leads to terminals 9 and 10 (IN) on unit terminal board. Use terminal 8 (GND) for input system ground. For Module



220 VAC INPUT
(M1 OPTION)

MODULE I (SAME AS 115 Vac EXCEPT)

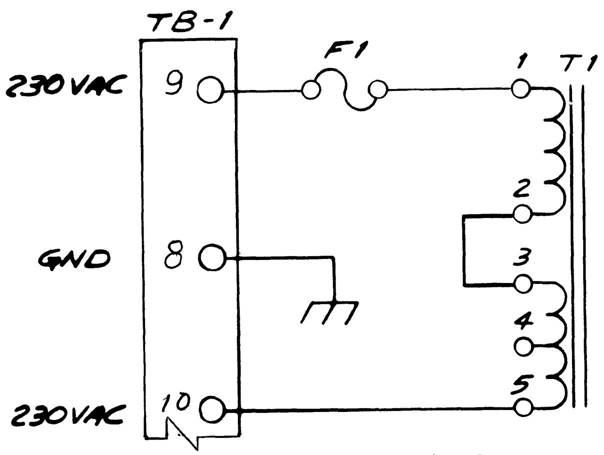
1) REMOVE JUMPER FROM T1-1 TO T1-3
2) REMOVE JUMPER FROM T1-2 to T1-5
   &LOCATE FROM T1-2 to T1-3
3) REMOVE JUMPER FROM TB1-2 to T1-5
   & LOCATE FROM TB1-2 TO T1-4
4) CHANGE FUSES:

.5 AMP. 250V to .25 AMP. 250V-PN 226-7176P32 (5/12DI)
OR
1 AMP. 250V to .5 AMP. 250V-PN 226-7176P36 (all others)

MODULES II AND III (SAME AS 115 Vac EXCEPT)

1) REMOVE JUMPER FROM T1-1 TO T1-3
2) REMOVE JUMPER FROM T1-2 TO T1-5
3) REMOVE JUMPER FROM TB1-10 TO T1-5
   & LOCATE FROM TB1-10 TO T1-4
4) CHANGE FUSES:

1.5 AMP. 250V TO .75 AMP. 250V-PN 226-7176P38 (MOD.II)
OR
2 AMP, 250V TO 1 AMP, 250V, PN 226-7176P39 (MOD. III)



230 VAC INPUT
(M2 OPTION)

MODULE I (SAME AS 115 Vac EXCEPT)

1) REMOVE JUMPER FROM T1-1 to T1-3
2) REMOVE JUMPER FROM T1-2 TO T1-5
   & LOCATE FROM T1-2 TO T1-3
3) CHANGE FUSES:

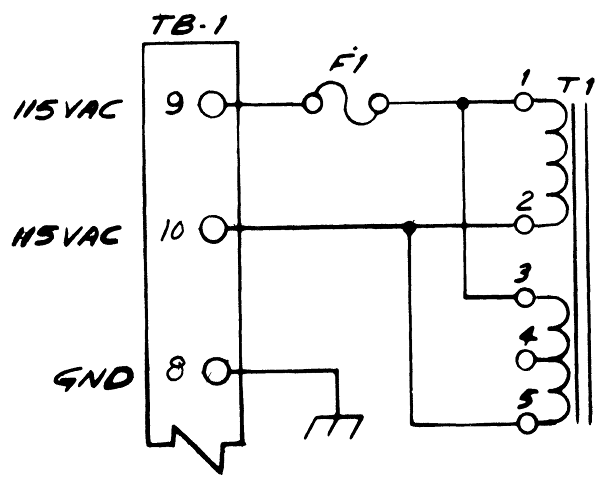
.5 AMP. 250V to .25 AMP. 250V-PN 226-7176P32 (5/12DI)
OR
1 AMP. 250V TO .5AMP. 250V-PN 226-7176P 36 (all others)

MODULES II & III (SAME AS 115 Vac EXCEPT)

1) REMOVE JUMPER FROM T1-1 TO T1-3
2) REMOVE JUMPER FROM T1-2 TO T1-5
3) CHANGE FUSES:

1.5 AMP. 250V TO .75 AMP. 250V-PN 226-7176P38 (MOD. II)

2 AMP 250V TO 1 AMP. 250V-PN 226-7176P39 (MOD. III)



115 VAC INPUT

MODULE I

T1 PIN 1 TO TB-1 PIN 1
T1 PIN 2 TO TB-1 PIN 2
TB-1 PIN 3 IS GND.

MODULES II & III

T1 PIN 1 TO TB-1 PIN 9
T1 PIN 2 TO TB-1 PIN 10
TB-1 PIN 8 IS GND.

FIGURE 2-1 INPUT CONNECTIONS

I use 3-position terminal board. Connect input leads to terminals 1 and 2, and use terminal 3 (GND) for input system ground.

2. Connect a dc voltmeter across terminals 2 and 4, (+V) and 4 and 6 (-V). Select a voltage range compatible with rated output.

3. Apply nominal rated input power.

4. Rotate output adjust sufficiently to swing the dc voltmeter from minimum to maximum rated voltage (per table 1-1). Do not exceed the maximum ratings.

5. Set output voltage to the unit's nominal value and remove input power.

2.5 MOUNTING

These units may be mounted in a variety of positions and locations, including rack mounting.

1. For cantilever - type mounting from a vertical panel or wall (where free access to vertical airflow is available):

   End Mounting - Use knockout per figure 2-2 for Module I units, figure 2-3 for Module II units, or figure 2-4 for Module III units. This knockout clears the terminal block and fuses.

   Side or Bottom Mounting - No knockout is needed. Use the four mounting holes shown in figures 2-2, 2-3 or 2-4.

2. For flat mounting from a horizontal surface (where free access to vertical airflow is not available):

End Mounting - Not recommended.

Side Mounting - Use knockout per figures 2-2, 2-3 or 2-4. Note that dotted area is suggested for additional heat-sink cooling, but is optional for Modules II & III only.

Bottom Mounting - Use knockout per figures 2-2, 2-3 or 2-4.

3. Vertical panel mounting per 1. preceding is preferred since maximum airflow is assured. Horizontal surface mounting per 2. preceding, using bottom mounting with proper knockout is the second preference.

4. Mounting screws should be No. 8-32 and just long enough to penetrate 1/4 inch into the PTM unit and through the mounting surface and lock/flat washers used.

NOTE

Vertical panel mounting per paragraph 1 preceding is preferred since maximum airflow is assured. Horizontal surface mounting, using bottom mounting with proper knockout is the second preference.

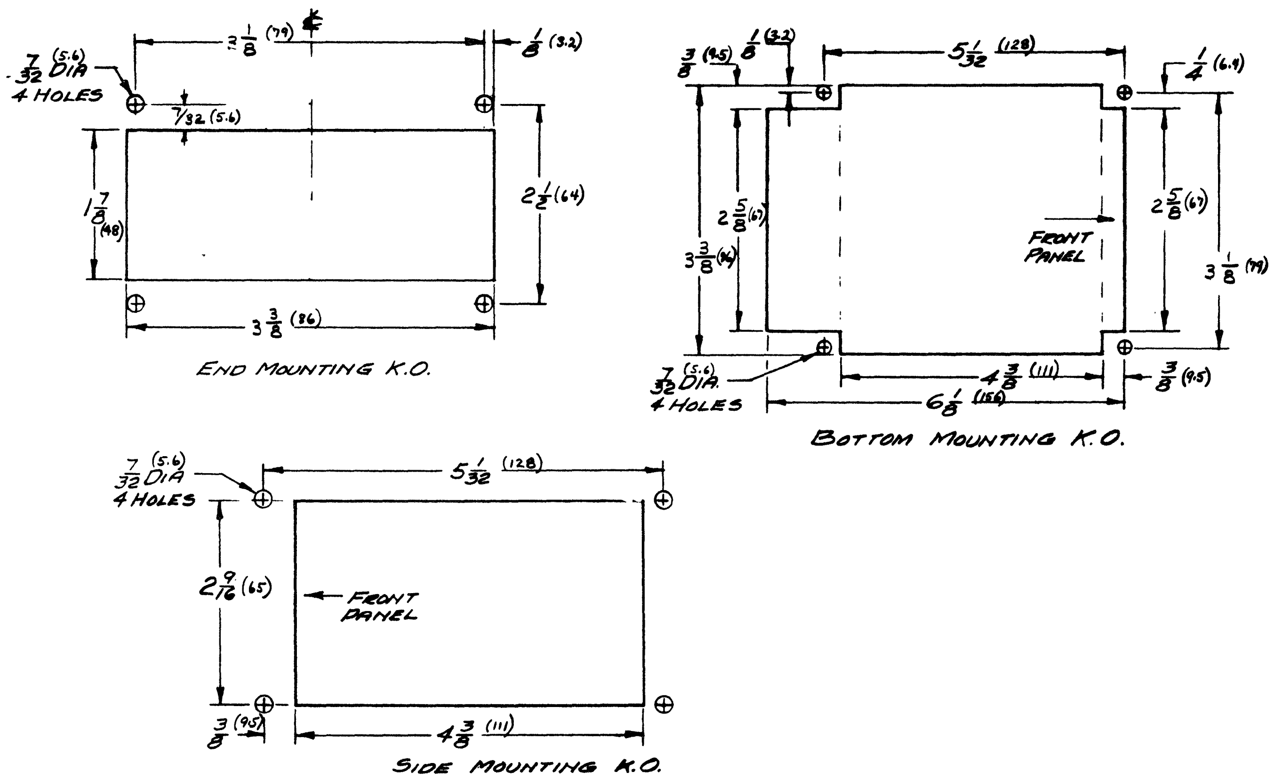


Figure 2-2 Knockout Dimensions Module I

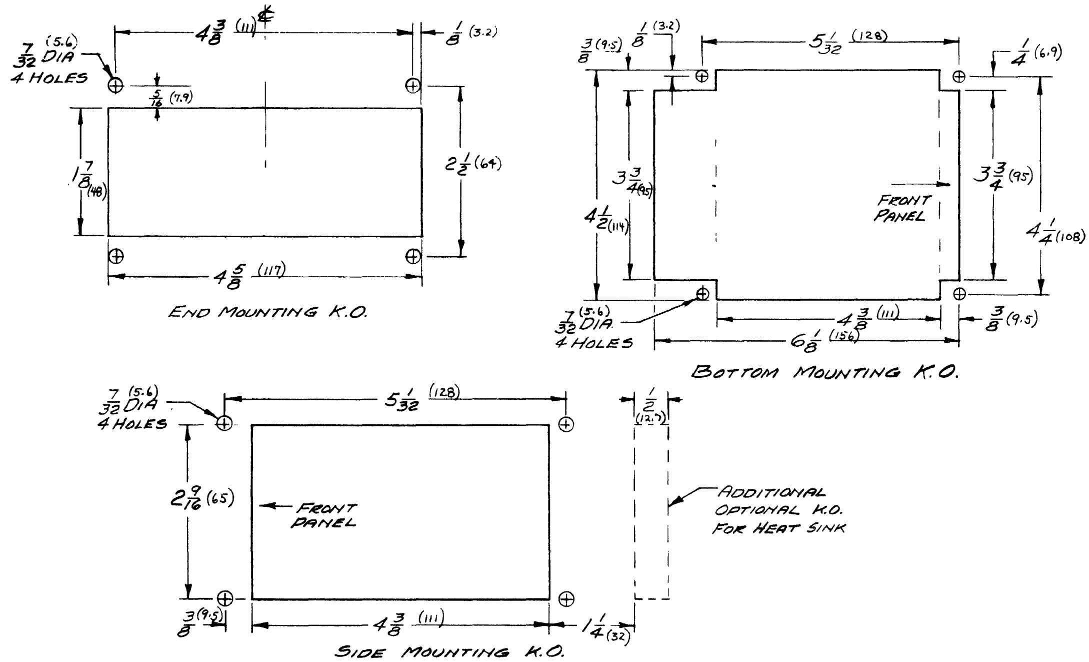


Figure 2-3 Knockout Dimensions Module II

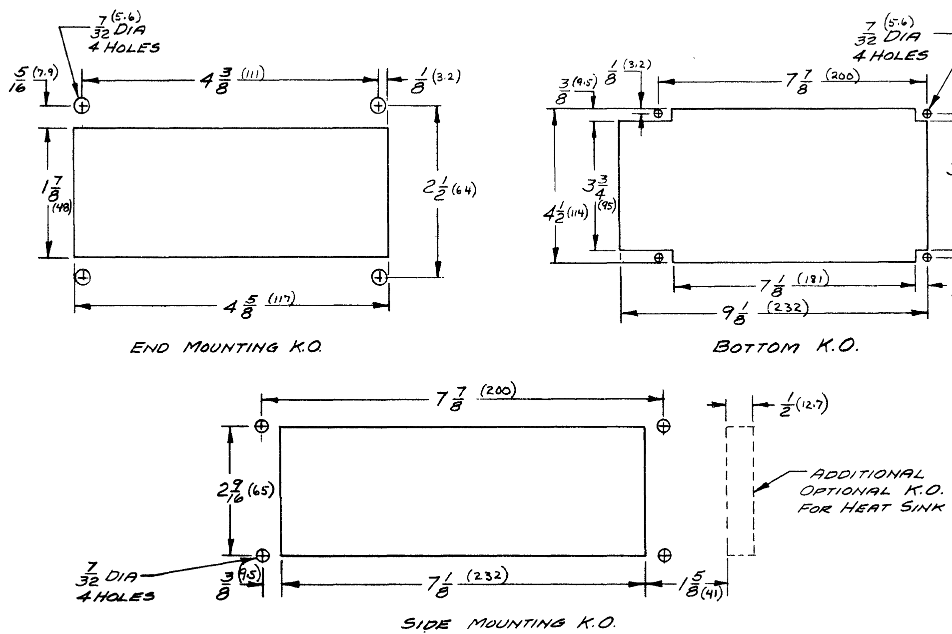


Figure 2-4 Knockout Dimensions Module III

3. OPERATION

3.1 GENERAL

This section contains instructions on how to adapt the unit to, and operate it in, a number of varied applications. These include local sensing, remote sensing, and remote programming.

CAUTION

The sensing and power circuits form a closed loop. Opening this loop, either by removing a terminal board link or disconnecting a sensing or programming lead will result in a high unit output and will cause the OVP crowbar to operate, (Para. 4.3.4).

3.2 CONTROLS

PTM dual units are equipped with two panel output controls. The output adjust control is used to vary the output voltage. Both are factory-set to nominal values (see table 1-1).

3.3 PRE-OPERATION CONSIDERATIONS

3.3.1 Current-Foldback Setting

The current foldback point is factory-set to approximately 125% of rated 40°C current. If the unit is to be operated in other ambients, the rated output current is derated per table 1-1. It is recommended for ambient temperatures above 40°C, the foldback should be reset to approximately 125% of the derated output current.

3.3.2 Current-Foldback Reset

To reset the current foldback, proceed as follows:

1. Adjust R4 and R18 fully counterclockwise (CCW).

2. Short negative output.

3. Adjust R4 potentiometer on printed circuit card until current is approximately that shown on table 4-1 (Short Circuit Limits).

4. Remove short from negative output.

5. Increase load to maximum foldback current as per table 4-1.

6. Adjust R18 clockwise until power supply goes out of regulation.

7. Maximum current limit is then set per table 1-1.

3.3.3 <u>OVP Setting for 12-Volt and 15-Volt Models</u>

1. Set output voltage to nominal value, (12 or 15 volts).

2. Adjust R25 on printed circuit card to its approximate center position.

3. To test for OVP trip point, remove jumper from terminals 1 and 2 or 5 and 6. In either case OVP should trip.

3.4 LOCAL SENSING

The unit is shipped ready for use in the local-sensing mode. In this mode, regulation is at the output terminals, not at the load. If variations in load-line voltage drops are expected to be prohibitive, refer to paragraph 3.5, remote sensing.

To operate the unit, proceed as follows:

1. Connect a voltmeter across output terminals 2 and 4 (+V) or 4 and 6 (-V).

2. Attach the input leads on Modules II or III to terminals 9 and 10. Use terminal 8 (GRD) to ground input system. On Module I, use terminals 1 and 2 on 3-position board. Use terminal 3 to ground input system.

3. Apply nominal input power.

4. Rotate output adjust until desired output voltage is indicated on voltmeter.

5. Remove input power, disconnect voltmeter and connect load leads to terminals 2 and 4 or 4 and 6. Do not remove or loosen any of the interconnecting links. Apply nominal input. Unit supplies highly regulated power to load.

CAUTION

Do not touch enclosure while unit is operating under load. Surface temperature is comparatively high. If unit must be handled immediately after operation, wear heat-resistant gloves.

3.5 REMOTE SENSING

If it is desirable to sense (regulate) unit output at the load rather than at output terminals, remove the links between terminals 1 and 2, 3 and 4, and 5 and 6. Run sense leads from terminals 2, 4 and 6 as shown in figure 3.1. Sensing leads should be fabricated using a shielded and twisted pair of wires. Put unit into operation per paragraph 3.4. With remote sensing unit transient response degenerates slightly. The load carrying leads at terminals 1, 3 and 5 should be selected to limit the voltage drop to 250 millivolts per lead.

3.6 REMOTE PROGRAMMING

The unit may be programmed to supply pre-determined output voltages by inserting a calculated resistance into the voltage-sensing circuit. Programming sensitivity is approximately 500-ohms-per volt; that is 500 ohms are required for each volt difference between the desired output and the minimum value of the unit's specified range. The program resistor should be a 1/8-watt (or larger) precision film resistor with a 25 PPM/^{o}C coefficient (equal to MIL style RN55E). The programming current is approximately 2 milliamperes.

To adapt the unit for remote programming, proceed as follows:

1. With normal local sensing (see paragraph 3.4), apply power and set output control for specified rated minimum output voltage (see table 1-1 for specific model). For example, for a 12-volt module, set the output to 11.0 volts.

2. At this point, any value within rated output range (table 1-1) can be obtained by inserting 500 ohms-per volt difference between the desired voltage and the minimum voltage. For example, to obtain 12.0-volt output in the above example the difference is 12.0 (-) 11.0 or 1.0 volt. The programming resistor should be 1.0 X 500 or 500 ohms.

3. Remove input power. Connect programming resistor (Rp) per figure 3-2. Note that either local or remote sense can be used.

4. Apply input power and verify load voltage across terminals 2 and 4, 4 and 6 as the desired value (using local sense).

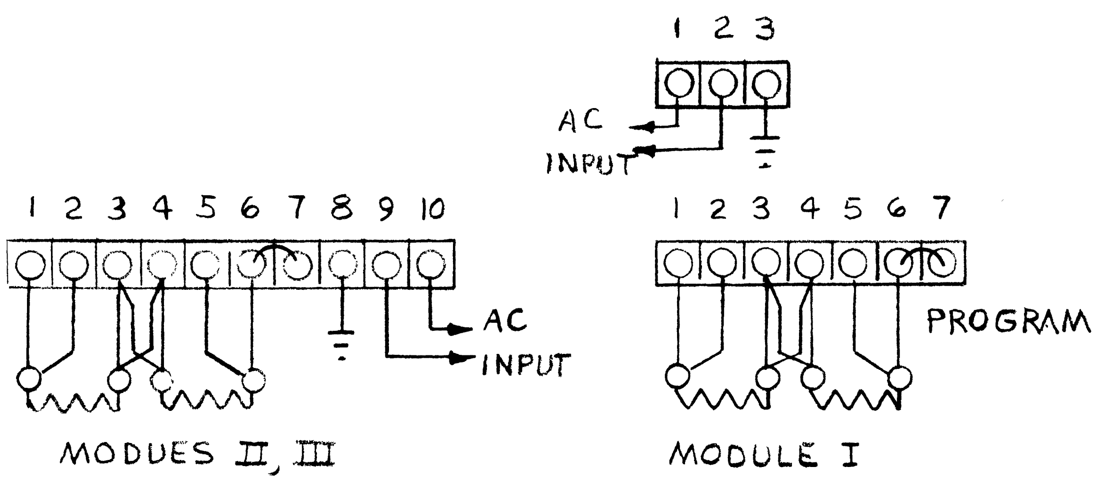


Figure 3-1
Remote Sensing Configuration

3.6.1 Fixed Output Voltage Setting

For the optimum long-term stability of the output voltage, the remote program feature can be used to reduce the long-term drift of the output by disabling the output control. Proceed as follows:

1. Remove top cover per paragraph 2.2.4. Remove three screws holding printed circuit card to front panel per paragraph 2.2.5.
2. Short out the potentiometer R35 or R34 by soldering a wire between the two end pins of the potentiometer.
3. Reassemble printed circuit card and cover.
4. Connect a precision variable potentiometer or decade box for the programming resistor per figure 3-2.
5. Set variable resistor to zero and apply input power.
6. Vary resistor value until desired output voltage is obtained.
7. Remove power, measure variable resistor, and replace it by a fixed precision resistor (see 3.6 preceding for type).
8. Set power to ON and verify that the output voltage is proper value.

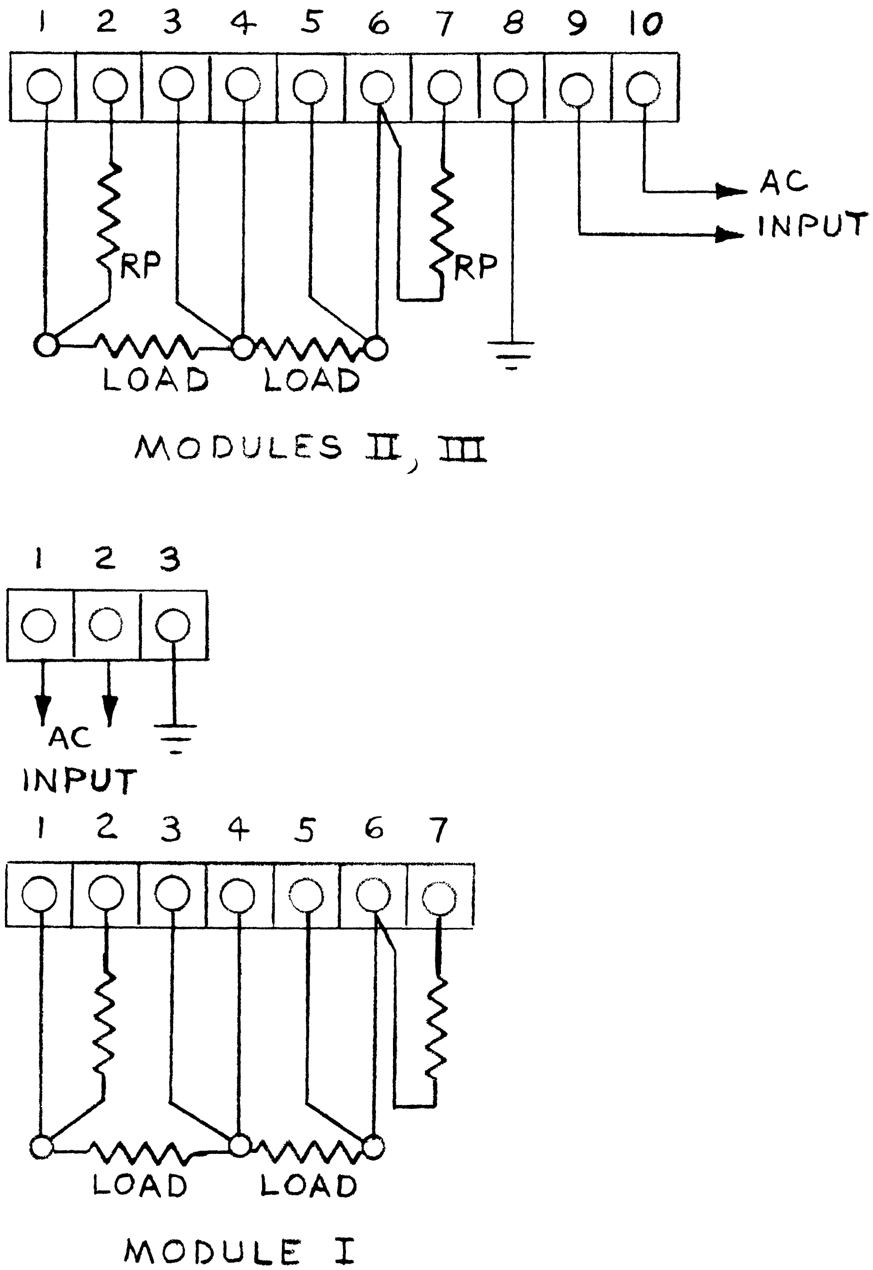


Figure 3-2 Resistance Programming Set-up

4. THEORY OF OPERATION

4.1 GENERAL

This section provides basic PTM unit operating principles which, when used with the troubleshooting data from section 5, should contribute to the rapid isolation of unit faults. Where differences in circuitry among units are significant, separate discussions are provided.

4.2 PASSING-STAGE PRINCIPLE

The PTM modules utilize the series passing-stage principle in regulating unit output. With this approach, a variable impedance absorbs the difference between the desired regulated output and the filtered "brute-force" dc. The variable impedance is provided by a transistor stage which is fed by an output-related control signal.

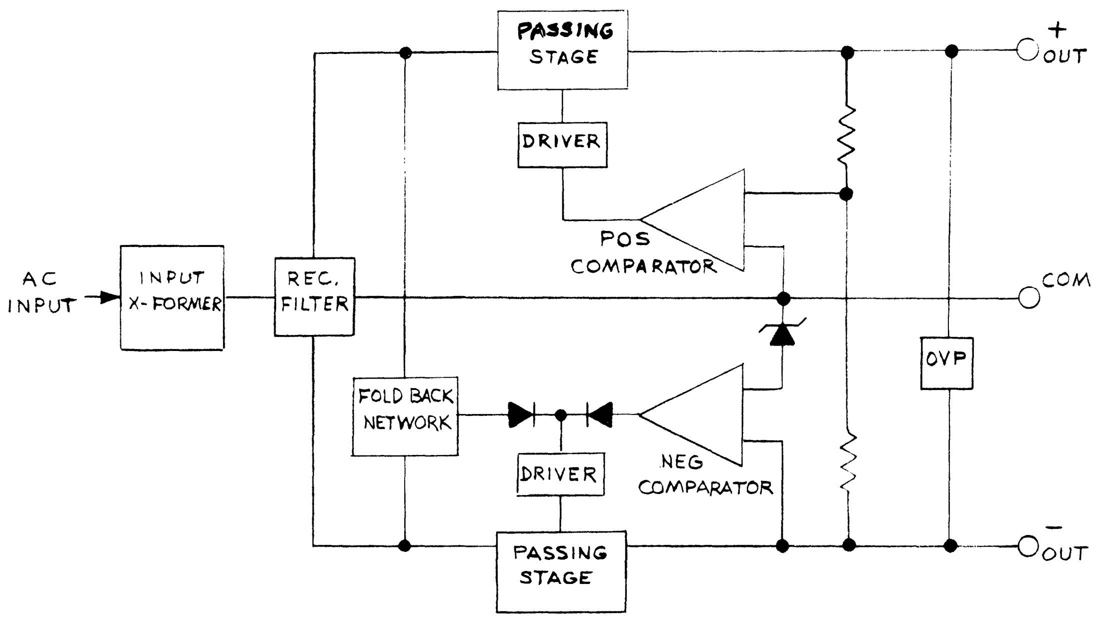


Figure 4-1 PTM Dual Simplified Diagram

4.3 FUNCTIONAL THEORY

Referring to figure 4-1: The transformer center tap steps down the ac input and applies it to a rectifier circuit and filter. The dc output is fed through a passing stage to the load. The passing stage absorbs the difference between the rectifier output and the desired output voltage. The feedback loop to the passing stage includes an output voltage sensing network and a reference voltage. These two signals are compared in a differential amplifier. The amplified error signal is used to vary the drive current to the pass stage. This discussion applies to both positive and negative outputs.

Overcurrent protection is provided by the foldback section. In the event of a short circuit or overload, this circuit reduces the drive on the pass stage. Overvoltage protection is provided by a sensing network which triggers on electronic crowbar circuit in the event of excessive output voltage. (Refer to figure 5-2.)

4.3.1 Sensing and Error Amplification

The positive and negative integrated circuits, U2 and U3 act to maintain a zero error signal across the IC input terminals. The amplified error signal is used to drive the passing stages; via comparators and drivers. The IC output is phased such that an increase in output voltage acts to decrease the drive. This action restores the output voltage to its regulated value (as set by the reference voltage and sense resistors).

4.3.2 Drivers and Passing Stage

Q1 and Q2 serve as drivers for the positive and negative output pass-stages respectively. Resistors R37, R38, R40 and R41 in Module III units insure equal current sharing by all transistors.

4.3.3 Current Foldback Section

Signals from two current monitoring resistors are fed to operational amplifier (U1) input through dividers R1 through R5. These two current signals are added by the divider resistors. The U1 input voltage is then proportional to the sum of the two current-monitoring resistor voltage drops. The output of the current limit operational amplifier is connected to an OR gate consisting of CR1, CR3 and R14. Once the current limit is exceeded, U1 takes control of Q2 thus taking control of the negative supply. The positive supply is slaved to the negative half and is controlled indirectly by U1.

4.3.4 Overvoltage Protection

The dc outputs are protected from an overvoltage condition by an internally adjustable protection circuit. The outputs are sensed separately, and in the event of an overvoltage condition in either output, an internal SCR shorts the positive output to the negative output within 50 microseconds. This feature together with built-in reverse-polarity diodes on each output effectively keeps the outputs within 2.5 volts of the common after an OVP trip. The circuit is designed to tolerate the OVP tripped condition indefinitely. Table 4-1 represents the span of possible trip voltages for all units.

4.3.5 Loop Stability

Inherent in any high-gain feedback amplifier is the tendency for the loop to become unstable under certain operating conditions. To preclude this in the PTM amplifier loop, RC networks consisting of these are C2, C3, C1, R10, R13, C4, C5 and R20 have been incorporated.

TABLE 4-1 POSSIBLE TRIP VOLTAGES

MODEL		SHORT CIRCUIT LIMITS (A)	MAX. FOLDBACK CURRENT LIMITS (A)
MOD I	12-1D	0.4	1.25
	15-.8D	0.4	1.0
MOD II	12-1.6D	0.5	2.0
	15-1.5D	0.5	1.9
MOD III	12-3D	1.0	3.75
	15-2.8D	1.0	3.5

5 SERVICE AND REPAIR

5.1 GENERAL

This section provides troubleshooting data, periodic servicing, and calibration and performance-testing procedures. The troubleshooting data should be used in conjunction with both the schematic diagram, (figure 5-1) and section 4, which outlines the principles of operation. Also, figures 5-2 and 5-3 physically locate the parts contained in a typical supply. Any questions pertaining to repair should be directed to the nearest Sorensen Service Representative or to the Service Dept., Sorensen Company, 676 Island Pond Road, Manchester, N.H. 03103. Should it be necessary to return a unit to the factory for repair, authorization from the Sorensen Service Dept. must first be obtained.

5.2 PERIODIC SERVICING

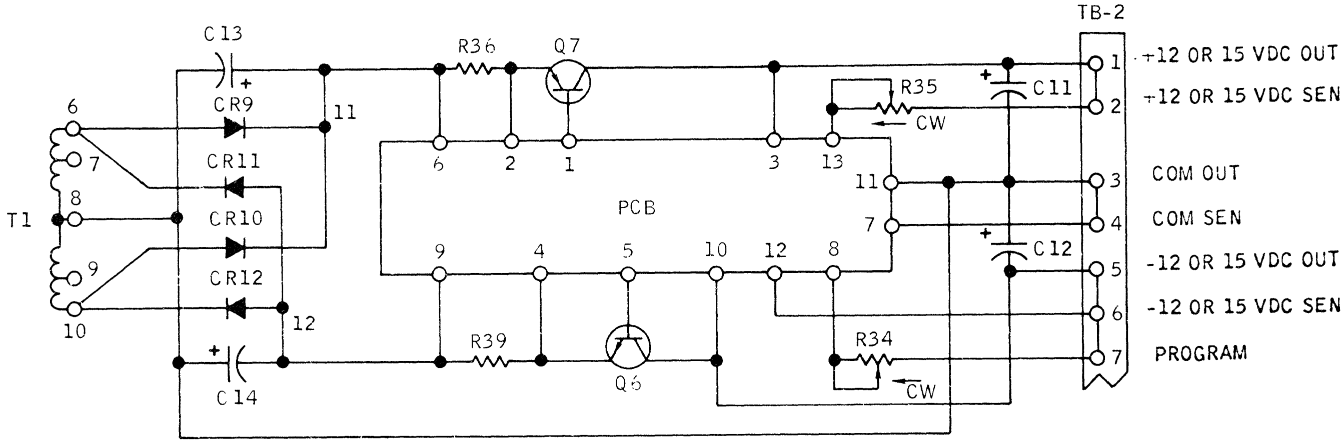
PTM Dual models should periodically be removed from service and cleaned of any accumulations of dust or other debris which could impede natural airflow through the unit.

5.3 CALIBRATION

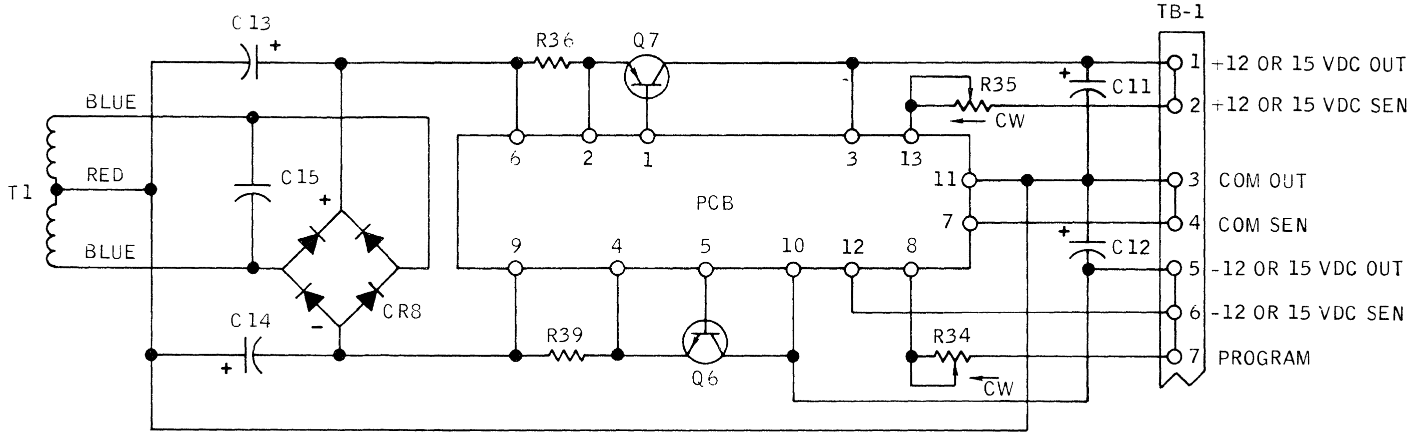
Calibration entails the checking and, if necessary, the adjustment of the foldback and OVP circuits. For foldback adjustments, use the procedure described in section 3, paragraph 3.3.2.* The overvoltage set adjustment procedure is outlined in section 3, paragraph 3.3.3/4. The factory-set limits for these adjustments are listed in table 1-1.

5.4 TROUBLESHOOTING

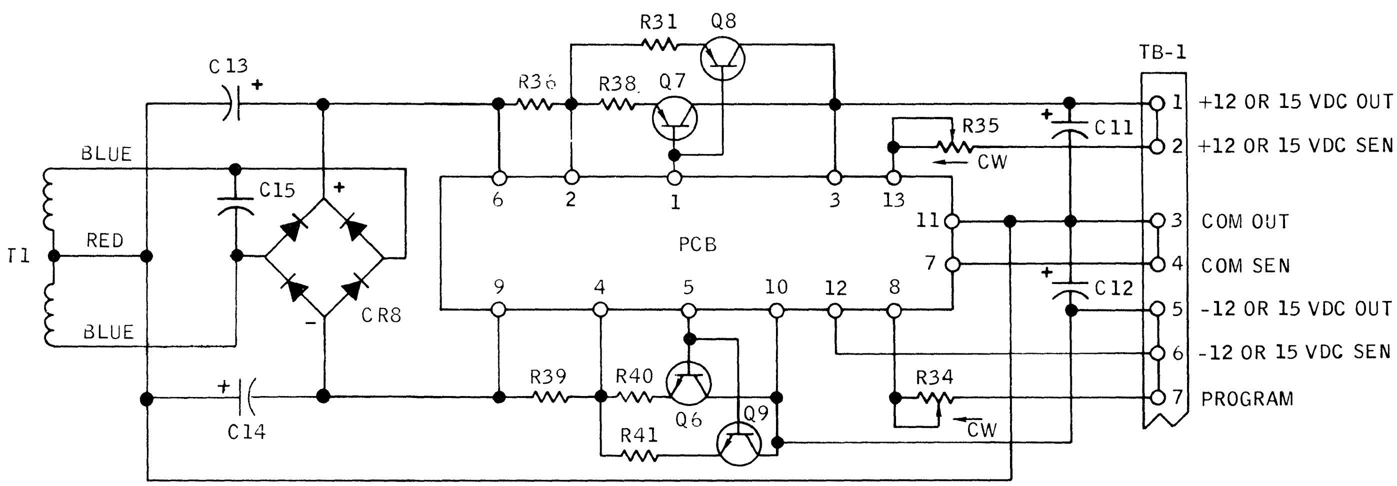
Table 5-1 lists a number of malfunction symptoms and probable causes. The table covers symptoms which are attributable to a single component failure only. This should not be interpreted to mean that there could not be other causes for the tabulated symptoms. Footnotes in the table indicate which components may be damaged due to a "chain-reaction" effect. If any amplifier components are replaced, unit may require recalibration. (Refer to paragraph 5.3.)



MODULE I
12-1D
15-.8D



MODULE II
12-1.6D
15-1.5D



MODULE III
12-3D
15-2.8D

Figure 5-1. Partial Schematic Diagrams

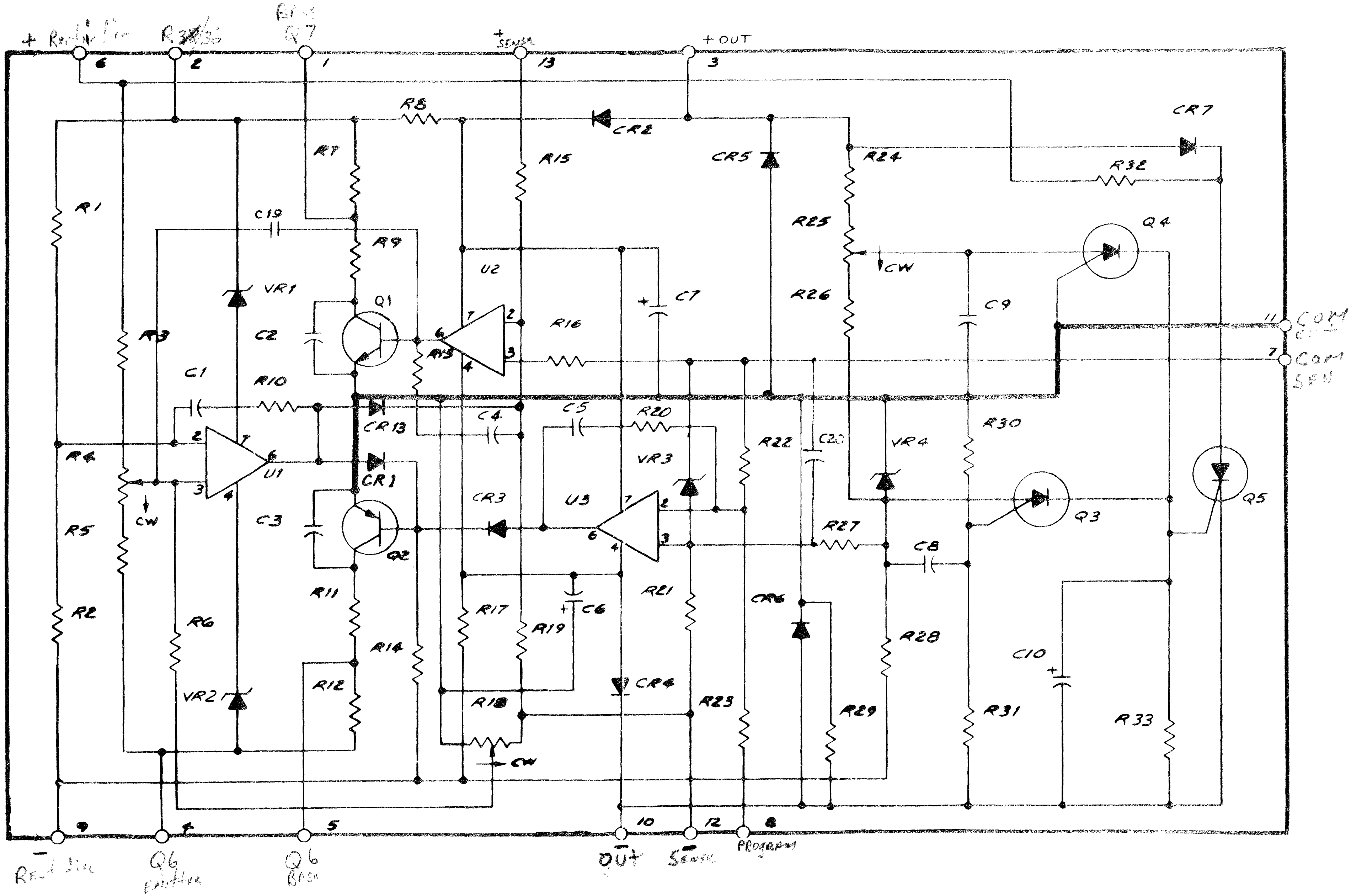


Figure 5-2. Typical P. C. Board Ass'y

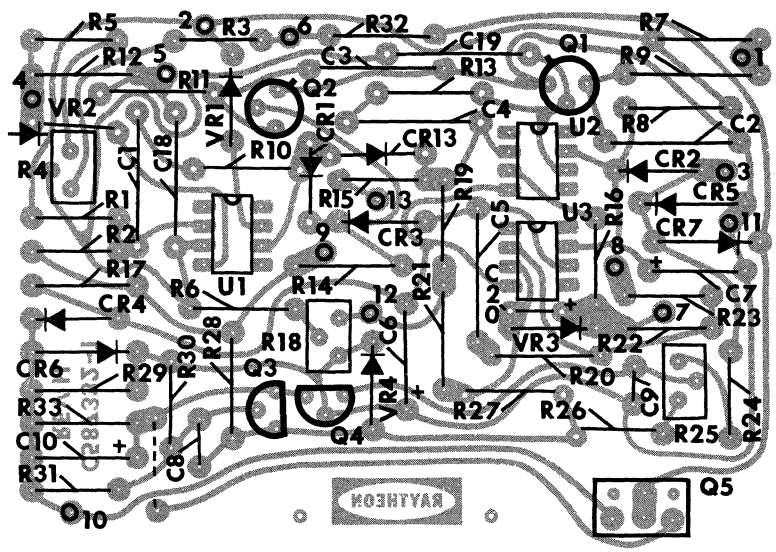


Figure 5-2B Typical PC Card Assembly
(Module II Shown)

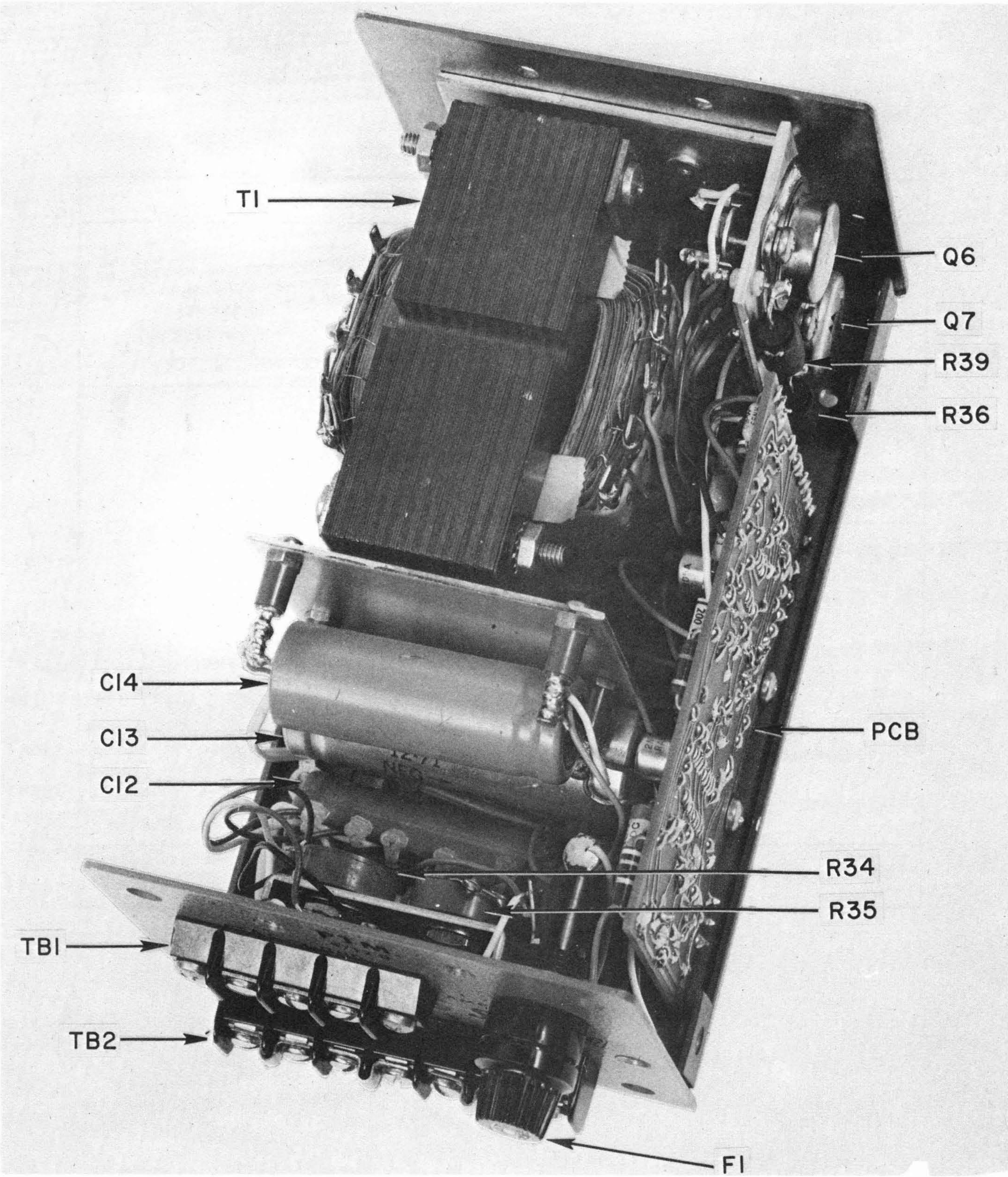


Figure 5-3 Typical Chassis Component Layout

TABLE 5-1 TROUBLESHOOTING DATA

SYMPTOM	PROBABLE CAUSE
No Output (Positive Side):	a. Fuse F1 open. b. Transistor Q1, Q2, Q6, Q7, Q8* or Q9* open. c. U3, U2 or U1 defective.
No Output (Negative Side):	a. Fuse F1 open. b. Transistor Q2, Q6 or Q9* open. c. U3 or U1 defective.
High Output (Positive Side):	a. Transistors Q1, Q7, Q8* or Q9* shorted. b. U2 defective. c. Potentiometer R35 defective. d. Sense links (1-2 or 3-4) open.
High Output (Negative Side):	a. Transistors Q2, Q6 or Q9* shorted. b. U3 defective.
*Q8/Q9 used only in Module III.	

TABLE 5-1 TROUBLESHOOTING DATA (cont'd)

SYMPTOM	PROBABLE CAUSE
High Output (Negative Side): (cont'd)	c. Potentiometer R34 open. d. Sense links (3-4 or 5-6-7) open.
Low Output (Positive Side):	a. Overload (external) causing foldback limiting. b. OV tripped. c. Defective U3, U2 or U1. d. Potentiometers R4 or R18 need to be readjusted.
Foldback Circuit Inoperative:	a. CR1 open. b. Defective U1. c. Shorted Q1, Q2, Q6, Q7, Q8* or Q9* shorted.
Overvoltage Circuit Inoperative:	a. Shorted Q3, Q4 or Q5. b. Shorted VR4.

* Q8/Q9 used only in Module III.

TABLE 5-1 TROUBLESHOOTING DATA (cont'd)

SYMPTOM	PROBABLE CAUSE
F1 (AC) Fuse Blows:	a. Foldback inoperative. b. Diode(s) shorted*. c. C13 or C14 shorted.
Ripple Specifications Degenerate Positive or Negative:	a. Open diode(s)*. b. IC regulator U2 or U3 defective. c. Foldback set too low.
Regulation Specifications Degenerate:	a. IC regulator U2 or U3 defective. b. Foldback set too low.

*Diode   Used on Modules:

CR8 - II, III
CR9 - I
CR10 - I
CR11 - I
CR12 - I

5.5 PERFORMANCE TESTING

5.5.1 Output-Ripple

To measure output ripple, proceed as follows:

1. Connect a test set-up per figure 5-4. Set oscilloscope for 1 mV/cm vertical sensitivity and 10 ms/cm horizontal. The oscilloscope should have at least a 10-MHz bandwidth. Select a 0-150 Vac meter. Choose a 1-mv range for the rms voltmeter. Select a range for the dc ammeter compatible with the unit output rated current. Use a resistive load capable of fully loading the unit to rated maximum current.

2. At no load, apply an input of 115 Vac @ 60 Hz. Adjust output for nominal voltage (per table 1-1).

3. Apply load and observe oscilloscope and rms meter. Voltmeter should not exceed 1 mV and oscilloscope display should not exceed 5 mV peak-to-peak.

5.5.2 Regulation

To measure the output voltage dc regulation, proceed as follows:

1. Connect unit to test set-up per figure 5-4.

2. Check the ripple per preceding paragraph 5.5.1.

3. Use a sensitive differential dc voltmeter or dvm capable of indicating the output voltage to within 1 mV. (For example, read 12.004 volts on a 12 V unit.)

4. Apply 125 Vac, 60-Hz input at no load. Observe dc-voltmeter indication.

5. Increase load to full rated load with 105 Vac input. The dc-voltmeter indication should not change more than the value listed in table 1-1 under "Unit Specifications".

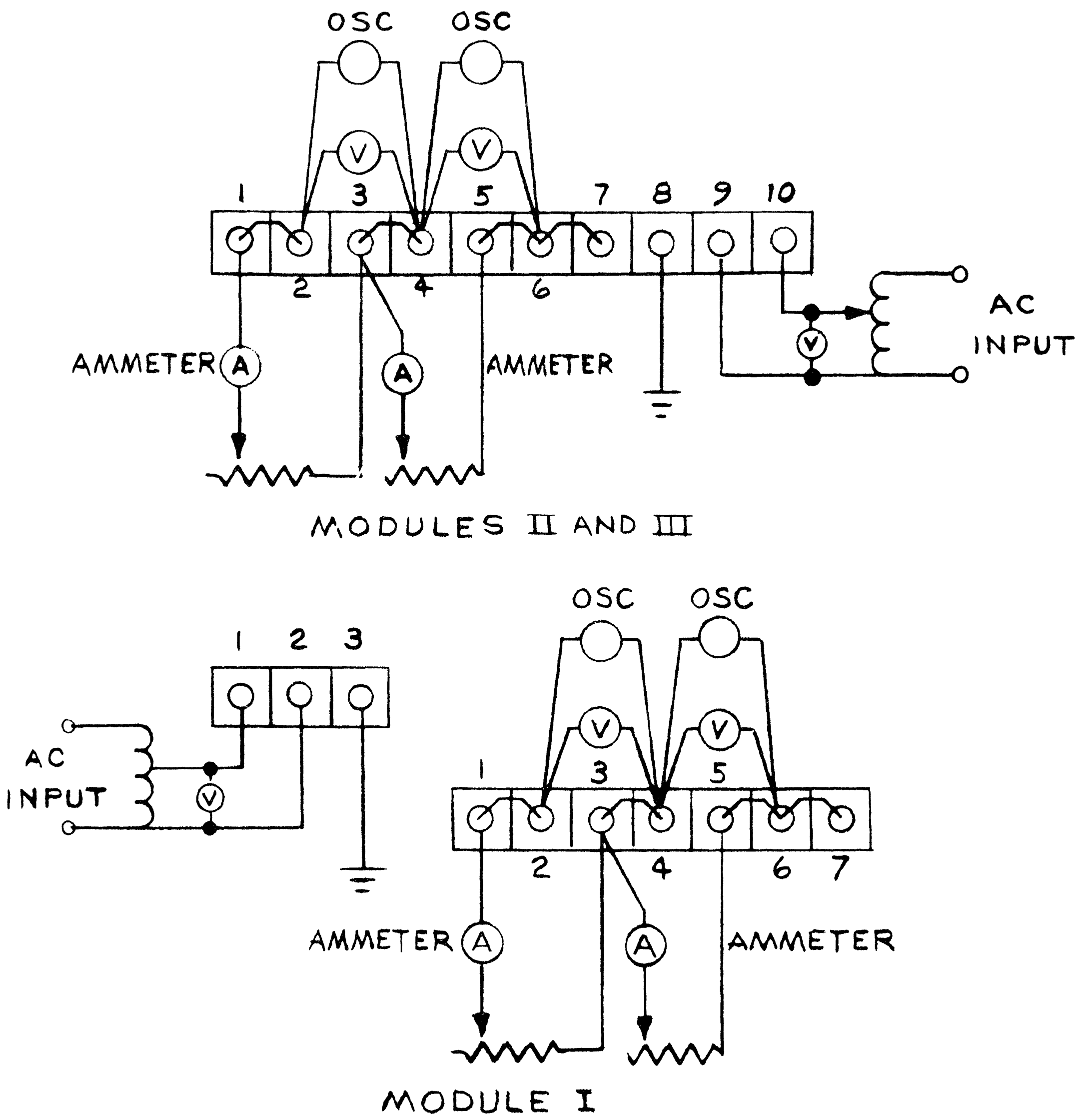


Figure 5-4 Test Equipment Setup

6. REPLACEABLE PARTS LIST

6.1 INTRODUCTION

This section provides a coded replaceable parts list, keyed to both the schematic diagram and parts location diagram appearing in section 5. All models are covered in the parts list.

6.2 APPLICATION

The parts list includes the replaceable parts for the following models:

Model	Final Assemblies
MODULE I	
12-1D	587596-1
15-.8D	587596-2
MODULE II	
12-1.6D	586874-1
15-1.5D	586874-2
MODULE III	
12-3D	586991-1
15-2.8D	586991-2

6.3 TABLE HEADINGS DEFINED

6.3.1 Circuit Symbol

This number will identify the part as called out on the schematic diagram.

6.3.2 Sorensen Part No.

This number should be used when ordering parts directly from

Sorensen Company
Replacement Parts Dept.
676 Island Pond Road
Manchester, N. H. 03103

6.3.3 Mfr., Type

This is the basic group or series under which the part is listed by a manufacturer. The coded identification of representative manufacturers are summarized below, listed alphabetically.

Mfr. Code	Manufacturer	Mfr. Code	Manufacturer
AB	Allen Bradley Co.	MA	Motorola
AM	Ammons Instrument Co.	MAL	P. R. Mallory Co.
AX	Acushnet Capacitor Co.	NS	National Semiconductor
BNS	Bourns, Incorporated	RAM	RAM Electronics
BUS	Bussman Mfg./Div. McGraw-Edison	RCA	RCA Corporation
CD	Cornell-Dublier Corp.	RCL	RCL Electronics
CG	Corning Glass Works	RDM	Radio Material Co./Div. P.R. Mallory
CL	Clarostat Corp.	SAN	Sangamo Electric
CTS	CTS Corporation	SE	Seacor, Incorporated
ELA	Electra/Midland	SEM	Semtech Corporation
EMC	Electromotive Manufacturing Co.	SP	Sprague Electric
GE	General Electric Co.	SR	Sorensen Company
GI	General Illuminating Co.	ST	Solitron Devices
IND	Industrial Devices	STM	STM Corporation
IRC	International Resistance Co.	TEL	Tel-Labs
KEM	Kemet Division Union Carbide Corp.	TI	Texas Instruments
KC	Keystone Carbon	UC	Union Carbide
LF	Littelfuse Corporation	WH	Westinghouse Semiconductor Division
		WL	Ward Leonard

REPLACEABLE PARTS LIST

CIRCUIT SYMBOL	PTM DUAL MODEL 12-1D	15-.8D		12-1.6D	15-1.5D		12-3D	15-2.8D				DESCRIPTION Capacitors (uF unless noted)	SORENSEN PART NUMBER	MANUFACTURER, TYPE
C1	X	X		X	X		X	X				.0068, 200V	24-2409-6	AX, V146XR
C2	X											.001, 200V	24-2409-1	AX, V146XR
				X	X		X	X				.0068, 200V	24-2409-6	AX, V146XR
C3	X	X										.001, 200V	24-2409-1	AX, V146XR
				X	X		X	X				.0068, 200V	24-2409-6	AX, V146XR
C4	X	X		X	X		X	X				.0068, 200V	24-2409-6	AX, V146XR
C5	X	X		X	X		X	X				.0068, 200V	24-2409-6	AX, V146XR
C6	X	X		X	X		X	X				2.2, 20V	586385-2	UC, T110
C7	X	X		X	X		X	X				2.2, 20V	586385-2	UC, T110
C8	X	X		X	X		X	X				820pF, 300V	235-7053P334	EMC, DM15
C9	X	X		X	X		X	X				820pF, 300V	235-7053P334	EMC, DM15
C10	X	X		X	X		X	X				.47, 35V	586058-3	KEM, T110A
C11	X	X		X	X		X	X				1000, 25V	235-7353P84	SP, 39D
C12	X	X		X	X		X	X				1000, 25V	235-7353P84	SP, 39D
C13	X											1700, 25V	235-7353P88	SP, 39D
		X										1200, 30V	24-2449-2	SP, 34D
				X								8500, 25V	586043-1	STM, 91S
					X							4600, 40V	586044-1	STM, 91S
							X					19500, 25V	586043-2	STM, 91S
								X				10600, 40V	586044-2	STM, 91S
C14	X											1700, 25V	235-7353P88	SP, 39D
		X										1200, 30V	24-2449-2	SP, 34D
				X								8500, 25V	586043-1	STM. 91S
					X							4600, 40V	586044-1	STM, 91S
							X					19500, 25V	586043-2	STM, 91S
								X				10600, 24V	586044-2	STM, 91S
C15				X	X		X	X				.33, 200V	24-2409-16	AX, V146XR
C16-18	X	X		X	X		X	X				Not Used		
C19	X	X		X	X		X	X				.0068, 200V	24-2409-6	AX, V146XR
C20	X	X		X	X		X	X				68, 15V	235-7395P43	UC

CIRCUIT SYMBOL	PTM DUAL MODEL 12-1D	15-.8D	12-1.6D	15-1.5D	12-3D	15-2.8D	DESCRIPTION	SORENSEN PART NUMBER	MANUFACTURER, TYPE
							Diodes		
CR1	X	X	X	X	X	X	200 PIV	587565-2	SEM, S12
CR2	X	X	X	X	X	X	200 PIV	587565-2	SEM, S12
CR3	X	X	X	X	X	X	200 PIV	587565-2	SEM, S12
CR4	X	X	X	X	X	X	200 PIV	587565-2	SEM, S12
CR5	X	X	X	X	X	X	1N5401	587566-1	SEM, 3S11
CR6	X	X	X	X	X	X	1N5401	587566-1	SEM, 3S11
CR7	X	X	X	X	X	X	1N5401	587566-1	SEM, 3S11
CR8			X	X	X	X	Bridge	586050-1	SEM, SCBE1
CR9	X	X					100 PIV	587565-1	SEM, S11
CR10	X	X					100 PIV	587565-1	SEM, S11
CR11	X	X					100 PIV	587565-1	SEM, S11
CR12	X	X					100 PIV	587565-1	SEM, S11
CR13	X	X	X	X	X	X	200 PIV	587565-2	SEM, S12
							Fuses		
F1*	X	X					1 Amp, 250V	226-7176P39	BUS, AGC-1
					X	X	2 Amp, 250V	226-7176P43	BUS, AGC-1
			X	X			1.5A, 250V	226-7176P41	BUS, AGC-1
							Transistors		
Q1	X	X					2N2222A	386-7249P57	GE
			X	X	X	X	2N2219A	386-7249P32	GE
Q2	X	X					2N2907A	386-7249P58	GE
			X	X	X	X	2N2905	386-7249P28	GE
Q3	X	X	X	X	X	X	2N6027	386-7304P1	GE
Q4	X	X	X	X	X	X	2N6027	386-7304P1	GE
Q5	X	X					2N4441, Mod	587760-1	SR
			X	X	X	X	2N4441	586820-1	MA
Q6	X	X	X	X	X	X	2N3055	18-151	RCA
Q7	X	X	X	X	X	X	2N6246	586862-3	RCA
Q8					X	X	2N6246	586862-3	RCA
Q9					X	X	2N3055	18-151	RCA

*Ref. page 2-3 for 220V (M1 option) or 230V (M2 option) inputs.

REPLACEABLE PARTS LIST (cont'd)

CIRCUIT SYMBOL	PTM DUAL MODEL 12-1D	15-.8D	12-1.6D	15-1.5D	12-3D	15-2.8D	DESCRIPTION	SORENSEN PART NUMBER	MANUFACTURER, TYPE
							Resistors (ohms, ±10%, 1/8W unless noted)		
R1	X	X	X	X	X	X	15.4K, 1%	586250-131	ELA, MF4
R2	X	X	X	X	X	X	15.4K, 1%	586250-131	ELA, MF4
R3	X	X	X	X	X	X	15.4K, 1%	586250-131	ELA, MF4
R4	X	X	X	X	X	X	500 , 1/2W, Pot	167877-3	BNS, 3389H
R5	X	X	X	X	X	X	15.4K, 1%	586250-131	ELA, MF4
R6	X	X	X	X	X	X	330K, 1/2W	280-1145P164	AB, EB
R7	X	X	X	X			390, 1/2W, 5%	280-1145P58	AB, EB
					X	X	470, 1/2W, 5%	280-1145P61	AB, EB
R8	X	X	X	X	X	X	2200, 1/2W	280-1145P86	AB, EB
R9	X	X					240, 3W, 5%	27-397-82	WL, 3X
			X	X		X	150, 3W, 5%	27-397-77	WL, 3X
					X		110, 3W, 5%	27-397-74	WL, 3X
							270, 1/2W	280-1145P53	AB, EB
R10	X	X	X	X	X	X	150, 1/2W	280-1145P44	AB, EB
R11		X					820, 3W, 5%	27-397-95	WL, 3X
			X			X	240, 3W, 5%	27-397-82	WL, 3X
	X			X			390, 3W, 5%	27-397-87	WL, 3X
					X		180, 3W, 5%	27-397-79	WL, 3X
R12	X	X	X	X			390, 1/2W, 5%	280-1145P58	AB, EB
					X	X	470, 1/2W, 5%	280-1145P61	AB, EB
R13	X	X	X	X	X	X	1200, 1/2W, 5%	280-1145P76	AB, EB
R14	X	X	X	X	X	X	6200, 1/2W, 5%	280-1145P102	AB, EB
R15	X		X		X		5110, 1%	586055-108	ELA, MF4*
		X					6490, 1%	586055-113	ELA, MF4*
				X		X	6490, 1%	586055-113	ELA, MF4*
R16	X	X	X	X	X	X	3650, 1%	586250-101	ELA, MF4

*Order with ±25 PPM (T9 or E) temperature coefficient

REPLACEABLE PARTS LIST (cont'd)

CIRCUIT SYMBOL	PTM DUAL MODEL 12-1D	15-.8D	12-1.6D	15-1.5D	12-3D	15-2.8D	DESCRIPTION	SORENSEN PART NUMBER	MANUFACTURER, TYPE
							Resistors (ohms, ±10%, 1/8W unless noted-cont'd)		
R17	X	X	X	X	X	X	2200, 1/2W	280-1145P86	AB, EB
R18	X	X	X	X	X	X	10K, 1/2W, Pot	586370-7	BNS, 3389H
R19	X		X		X		6190, 1%	586055-112	ELA, MF4*
		X		X		X	7500, 1%	586055-116	ELA, MF4*
R20	X	X	X	X	X	X	1200, 1/2W, 5%	280-1145P76	AB, EB
R21	X		X		X		825, 1%	586250-70	ELA, MF4
		X		X		X	1150, 1%	586250-77	ELA, MF4
R22	X	X	X	X	X	X	3010, 1%	586055-97	ELA, MF4*
R23	X		X		X		2050, 1%	586055-89	ELA, MF4*
		X		X		X	3480, 1%	586250-100	ELA, MF4
R24	X	X	X	X	X	X	2150, 1%	586250-90	ELA, MF4
R25	X	X	X	X	X	X	1000, 1/2W, Pot	586370-4	BNS, 3389H
R26	X	X	X	X	X	X	825, 1%	586250-70	ELA, MF4*
R27	X	X	X	X	X	X	39K, 1/2W	280-1145P131	AB, EB
R28	X	X	X	X	X	X	1000, 1/2W	280-1145P74	AB, EB
R29	X	X	X	X	X	X	1000, 1/2W	280-1145P74	AB, EB
R30	X		X		X		20.5K, 1%	586250-137	ELA, MF4
		X		X		X	13K, 1%	586055-189	ELA, MF4*
R31	X	X	X	X	X	X	21.5K, 1%	586250-138	ELA, MF4
R32	X	X	X	X	X	X	1000, 1/2W	280-1145P74	AB, EB
								280-1145P65	AB, EB
R33	X	X	X	X	X	X	390, 1/2W, 5%		
R34	X	X	X	X	X	X	2500, 2W, Pot	585348-12	BNS, 3859A
R35	X	X	X	X	X	X	2500, 2W, Pot	585348-12	BNS, 3859A
R36	X	X	X	X			.15, 5W	586054-3	RCL, T5
					X	X	.05, 5W	586054-68	RCL, T5
R37					X	X	.33, 5W, 5%	586054-7	RCL, T5
R38					X	X	.33, 5W, 5%	586054-7	RCL, T5

*Order with ±25 PPM (T9 or E) temperature coefficient

REPLACEABLE PARTS LIST (cont'd)

CIRCUIT SYMBOL	PTM DUAL MODEL 12-1D	15-.8D	12-1.6D	15-1.5D	12-3D	15-2.8D	DESCRIPTION	SORENSEN PART NUMBER	MANUFACTURER, TYPE
							Resistors (ohms)		
R39	X	X	X	X			.15, 5W, 5%	586054-3	RCL, T5
					X	X	.05, 5W, 5%	586054-68	RCL, T5
R40					X	X	.33, 5W, 5%	586054-7	RCL, T5
R41					X	X	.33, 5W, 5%	586054-7	RCL, T5
							Transformers		
T1	X						Ass'y	587585-1	SR
		X						587585-2	SR
			X					586808-1	SR
				X				586808-2	SR
					X			586999-1	SR
						X		586999-2	SR
TB1	X	X					3-Terminal Board	247-7201P3	Kulka
			X	X	X	X	10-Terminal Board	587423-10	Kulka, 1599
TB2	X	X					7-Terminal Board	587423-7	Kulka, 1599
							Integrated Circuits		
U1	X	X	X	X	X	X	ICLM741CN	586372-3	NS
U2	X	X	X	X	X	X	ICLM741CN	586372-3	NS
U3	X	X	X	X	X	X	ICLM741CN	586372-3	NS

CIRCUIT SYMBOL	PTM DUAL MODEL 12-1D	15-.8D	12-1.6D	15-1.5D	12-3D	15-2.8D	DESCRIPTION	SORENSEN PART NUMBER	MANUFACTURER, TYPE
							Voltage Regulator		
VR1	X		X		X		1N5235	588101-10	MA
		X		X		X	1N5242	588101-15	MA
VR2	X		X		X		1N5235	588101-10	MA
		X		X		X	1N5242	588101-15	MA
VR3	X	X	X	X	X	X	1N825	588105-3	Transitron
VR4	X	X	X	X	X	X	1N5235	588101-10	MA
							Miscellaneous		
—	X						Printed-circuit Boards	587586-1	SR
		X						587586-2	SR
			X					587373-1	SR
				X				587373-2	SR
					X			587333-1	SR
						X		587333-2	SR
—	X						Schematic Diagrams	D587593	SR
		X						D587594	SR
			X					D586823	SR
				X				D586824	SR
					X			D587593	SR
						X		D587594	SR

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