INSTRUCTION MANUAL

MST 75-2.5M
POWER MODULE

DIGITALLY CONTROLLED POWER MODULE SYSTEM

1/9 RACK SIZE 200 WATT POWER MODULES
FOR USE WITH KEPCO POWER MODULE CONTROLLERS

KEPCO INC.
An ISO 9001 Company.

MODEL
MST 75-2.5M
POWER MODULE

ORDER NO. M483250	REV. NO. 7

IMPORTANT NOTES:

1) This manual is valid for the following Model and associated serial numbers:

MODEL	SERIAL NO.	REV. NO.

2) A Change Page may be included at the end of the manual. All applicable changes and revision number changes are documented with reference to the equipment serial numbers. Before using this Instruction Manual, check your equipment serial number to identify your model. If in doubt, contact your nearest Kepco Representative, or the Kepco Documentation Office in New York, (718) 461-7000, requesting the correct revision for your particular model and serial number.

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P/N 243-0871

KEPCO
THE POWER SUPPLIER™

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Declaration of Conformity

Application of Council directives: **73/23/EEC (LVD)**
93/68/EEC (CE mark)

Standard to which Conformity is declared:

EN61010-1:1993 (Safety requirements for electrical equipment for measurement, control and laboratory use)

Manufacturer's Name and Address: **KEPCO INC.**
131-38 SANFORD AVENUE
FLUSHING, N.Y. 11352 USA

Importer's Name and Address: REPRESENTATIVE COPY

Type of Equipment: **Component Power Supply**

Model No.: [*PRODUCT MODEL NUMBER*]

Year of Manufacture:

I, the undersigned, declare that the product specified above, when used in conjunction with the conditions of conformance set forth in the product instruction manual, complies with the requirements of the Low Voltage Directive 73/23/EEC, which forms the basis for application of the CE Mark to this product.

Place: KEPCO Inc.
131-38 Sanford Ave.
Flushing, N.Y.11352 USA

Saul Kupferberg
(Full Name)

Date: ______________

VP OF SALES
(position)

Conditions of Conformance
MST "Modular" products

When this product is used in applications governed by the requirements of the EEC, the following restrictions and conditions apply:

1. For European applications, requiring compliance to the Low Voltage Directive, 73/23/EEC, this power supply is considered a component product, designed for "building in". Because it is incomplete in construction, the end product enclosure must provide for compliance to any remaining electrical safety requirements and act as a fire enclosure. (EN61010-1 Cl. 6, Cl. 7, Cl.8, Cl. 9 and EN61010-1 annex F)

2. This power supply is designed for stationary installation, with mains power applied via a KEPCO Rack Adapter.

3. This power supply is considered a Class 1 (earthed) product, and as such depends upon proper connection to protective earth for safety from electric shock. (EN61010-1 Cl. 6.5.4)

4. This power supply is intended for use as part of equipment meant for test, measurement and laboratory use, and is designed to operate from single phase, three wire power systems. This equipment must be installed in a specifically designed KEPCO rack adapter and within a suitably wired equipment rack, utilizing a three wire (grounded) mains connection. See wiring section of this manual for complete electrical wiring instructions. (EN61010-1 Cl. 6.5.4 and Cl.6.10.1)

5. This power supply has secondary output circuits that are considered hazardous.

6. The output wiring terminals of this power supply have not been evaluated for field wiring and, therefore, must be properly configured by the end product manufacturer prior to use.

7. This power supply employs a supplementary circuit protector in the form of a fuse mounted within its enclosure. The fuse protects the power supply itself from damage in the event of a fault condition. For complete circuit protection of the end product, as well as the building wiring, it is required that a primary circuit protection device be fitted to the branch circuit wiring. (EN61010-1 Cl. 9.6.2)

8. Hazardous voltages are present within this power supply during normal operation. All operator adjustments to the product are made via externally accessible switches, controls and signal lines as specified within the product operating instructions. There are no user or operator serviceable parts within the product enclosure. Refer all servicing to qualified and trained Kepco service technicians.

SAFETY INSTRUCTIONS

1. Installation, Operation and Service Precautions

This product is designed for use in accordance with EN 61010-1 and UL 3101 for Installation Category 2, Pollution Degree 2. Hazardous voltages are present within this product during normal operation. This product is designed for use in a KEPCO Rack Adapter product. Operation of this product without a rack adapter should never be attempted. The product should never be operated with the cover removed unless equivalent protection of the operator from accidental contact with hazardous internal voltages is provided.

There are no operator serviceable parts or adjustments within the product enclosure. Refer all servicing to trained service technician.

Source power must be removed from the product prior to performing any servicing.

This product is designed for use with nominal a-c mains voltages indicated on the rating nameplate.

2. Grounding

This product is a Class 1 device which utilizes protective earthing to ensure operator safety.

The PROTECTIVE EARTHING CONDUCTOR TERMINAL must be properly connected prior to application of source power to the product (see instructions on installation herein) in order to ensure safety from electric shock.

PROTECTIVE EARTHING CONDUCTOR TERMINAL - This symbol indicates the point on the product to which the protective earthing conductor must be attached.

EARTH (GROUND) TERMINAL - This symbol is used to indicate a point which is connected to the PROTECTIVE EARTHING TERMINAL. The component installer/ assembler must ensure that this point is connected to the PROTECTIVE EARTHING TERMINAL.

CHASSIS TERMINAL -This symbol indicates frame (chassis) connection, which is supplied as a point of convenience for performance purposes (see instructions on grounding herein). This is not to be confused with the protective earthing point, and may not be used in place of it.

3. Electric Shock Hazards

This product outputs hazardous voltage and energy levels as a function of normal operation. Operators must be trained in its use and exercise caution as well as common sense during use to prevent accidental shock.

This symbol appears adjacent to any external terminals at which hazardous voltage levels as high as 500V d-c may exist in the course of normal or single fault conditions.

This symbol appears adjacent to any external terminals at which hazardous voltage levels in excess of 500V d-c may exist in the course of normal or single fault conditions.

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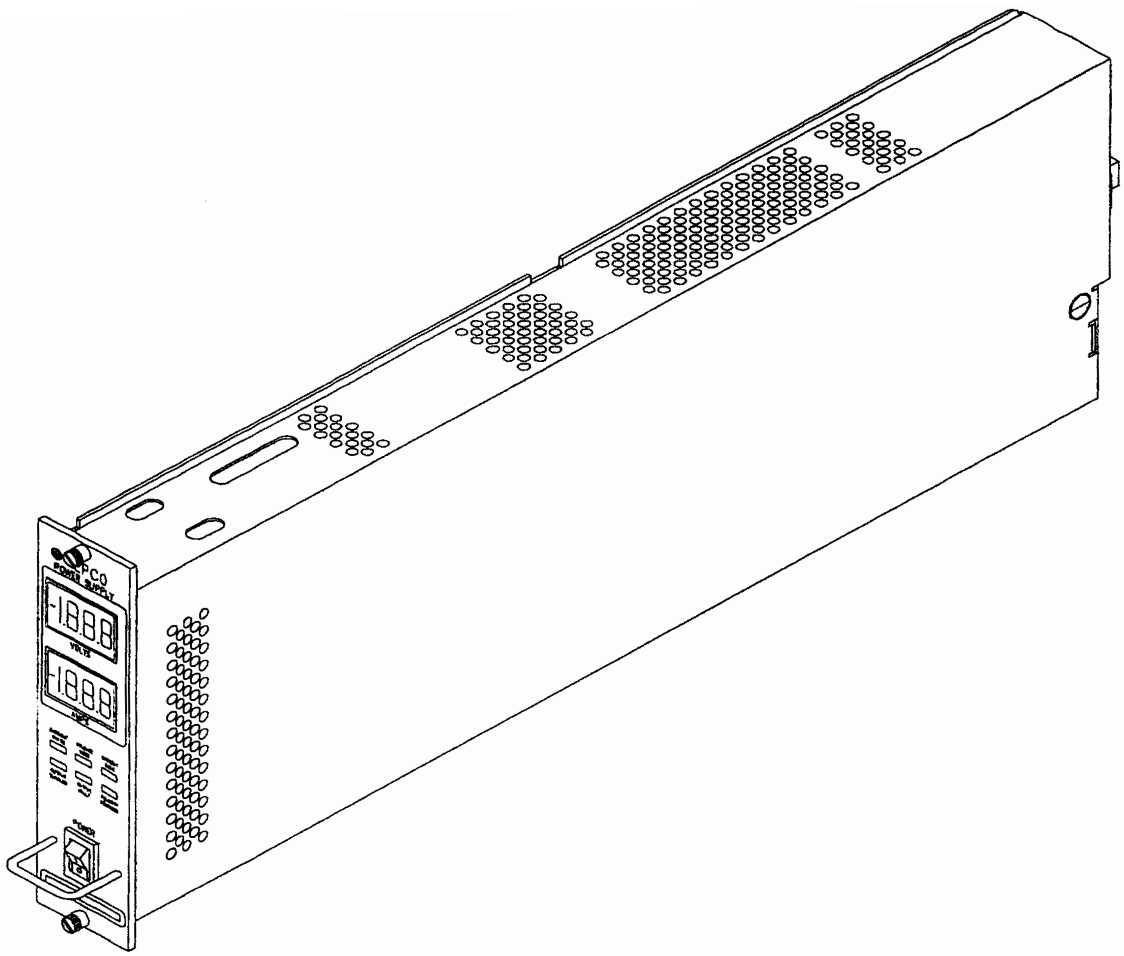

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FIGURE 1-1. MST POWER SUPPLY

SECTION 1 - INTRODUCTION

1.1 SCOPE OF MANUAL

This manual contains instructions for the installation, operation, and maintenance of the MST series of 200 Watt, voltage and current stabilized d-c power supplies (power modules) manufactured by Kepco, Inc., Flushing, New York, U.S.A.

1.2 DESCRIPTION

The Kepco MST 200 Watt Series (Figure 1-1) consists of eight, single-output models as shown in Table 1-1. MST Series Power Modules employ a switch mode preregulator for high efficiency and power density, with linear output stabilization for accuracy and resolution. MST Power Supplies (Modules) are of a modular, plug-in design whose 7" x 1-3/4" cross-section allows nine independently controlled modules to be mounted abreast in a standard (7" x 19" x 22") Kepco Model RA 55 rack adapter or 5 modules in a standard (7" x 12")Kepco Model CA 400 case.

The MST Power Module is controlled digitally via the IEEE 1118 2-wire serial bus ("Bitbus") with 12 bits of resolution over the entire voltage and current ranges. Voltage and current are displayed on LED panel meters, and read back over the control bus with an accuracy of 0.06%. Operating status is displayed on front panel LED indicators and read back over the bus.

An MST Power Module can be installed without powering down the system. Employing current-sharing for parallel operation, they may be "hot-swapped" for redundant (N+1) applications. MST Power Supplies can be operated with universal a-c input power sources (90-264Vac, 47-63Hz) and incorporate power factor correction (0.98) to meet EN 61000-3-2. MST Power Modules can also be configured in series for higher than rated output voltages (500V d-c maximum).

TABLE 1-1. MST MODEL PARAMETERS

MODEL	OUTPUT VOLTAGE Adjustment Range (V d-c)	OUTPUT CURRENT Maximum (Amps)			RIPPLE (mV p-p)		NOISE (mV p-p)	EFFICIENCY (100% Load 120V a-c)
		45° C	55° C	65° C	Source (max.)	SW (max.)	(Spike) 20MHz	
MST 6-20M	0-6	20	16	12	2.5	5	50	51%
MST 15-12M	0-15	12	9.6	7.2	5	10	100	61%
MST 25-8M	0-25	8	6.4	4.8	5	10	100	62%
MST 36-5M	0-36	5	4.0	3.0	5	10	100	63%
MST 55-3.5M	0-55	3.5	2.8	2.1	5	10	100	64%
MST 75.2.5M	0-75	2.5	2.0	1.5	7.5	15	150	64%
MST 100-2M	0-100	2.0	1.6	1.2	7.5	15	150	66%
MST 150-1.2M	0-150	1.2	1.0	0.7	7.5	20	200	66%

1.3 SPECIFICATIONS

The MST Series electrical and mechanical specifications are listed in Tables 1-1 and 1-2.

TABLE 1-2. MST GENERAL SPECIFICATIONS

SPECIFICATIONS		RATING/DESCRIPTION	CONDITION
INPUT			
A-C Voltage	nominal	100-250V a-c	Single phase
	range	90-264 Va-c	Brownout Voltage $\leq$ 85Vrms
Frequency	nominal	50-60 Hz	At >63 Hz, input leakage current exceeds specifcations
	range	47 – 63 Hz (400 Hz)	
Input Current	maximum	3.6A rms	90V a-c Input
Current Harmonics		Within EN 61000-3-2 limits	Any source condition, rated load
Efficiency	minimum	See Model Table 1-1	120V a-c, rated output Load
EMI		FCC Class A, CISPR 11 Class A	Conducted Emissions
Leakage Current	120V a-c, 60Hz	<0.5 mA	
	240V a-c, 50Hz	<1.0 mA	
OUTPUT			
Source Effect	Voltage	0.001%	90 – 132, 176 – 264V a-c, any load condition
	Current	0.005%	
Load Effect	Voltage	±0.002% (±0.004% for MST 6-20M)	10% to 100% Load at E_{MAX}, any source condition
	Current	±0.005%[(1)]	10% to 100% Load at I_{MAX}
Temperature Effect	Voltage	0.01%/°C	Any source/load condition (0 – 45° C)
	Current	0.02%/°C	
Time Effect (drift)	Voltage	0.01%	0.5 – 8.5 hours Any source/load condition
	Current	0.02%	
Programming Resolution	Voltage	12 Bits, 0.024%	% of E_{MAX}
	Current	12 Bits, 0.024%	% of I_{MAX}
Data Read Back Accuracy	Voltage	0.06%	% of E_{MAX}
	Current	0.06%	% of I_{MAX}
Transient Recovery Time		100 Microseconds (500 Microseconds for MST 6-20M)	Return to within stabilization band from 50% load step
Turn On/Off Overshoot		None	Any source/load condition
Error Sense		0.5V maximum/wire	Any source/load condition
MISCELLANEOUS			
Temperature		0° to +65° C (see Table 1-1)	Operating
		–40° to +85° C	Storage
Humidity		0 to 95% RH	Non-condensing Operating & Storage
Shock		20G 11 msec ±50% half sine	3 axes, 3 shocks each axis, non-operating
Vibration		5 – 10Hz 10mm double amplitude	Non-operating, 1 hour each axis
		10 – 55 Hz 2G	
Altitude		Sea level to 10,000 ft.	Any source/load condition
Isolation (Output – Case)		±500 V d-c	
Display	Voltage	3.5 Digit LED, red	Front panel, For reference only
	Current	3.5 Digit LED, red	

(1) Current mode regulation is subject to an additional 0.015% settling effect as well as a d-c offset of up to 3mA based on compliance voltage

TABLE 1-2. MST GENERAL SPECIFICATIONS (CONTINUED)

SPECIFICATIONS		RATING/DESCRIPTION	CONDITION
Status Indicators		Voltage Mode	Green LED
		Current Mode	Amber LED
		Current Share	Amber LED
		Output Enabled	Green LED
		Polarity Reversed	Green LED
		Output Fault	Red LED
Output Enable		Built in power and sense relay	
Polarity Reversal		Built in power and sense relay	
Parallel Connection		N+1 redundancy, forced current share	Currents divided equally
Overvoltage protection		Tracks output setting, power shutdown	Latched, reset by cycling source power off
Overtemperature		Thermostat	
Open sense wire		Automatic detection with power shutdown	
Backup current limit		Tracks output current at 110%	
PHYSICAL			
Type of Construction		Enclosed, plug-in style includes status LEDs, two digital meters, handle and ON/OFF switch	
Cooling		Internal D-C Cooling Fans	Exhaust to rear
Module Dimensions	English	7" x 1.83" x 20"	Refer to Figure 1-2
	Metric	178 x 46.5 x 508 mm	
Weight	English	8 lbs.	
	Metric	3.6 Kg.	
Load Connection		Mates with Positronic POW-R-LOK Series 6 pin connector, Kepco P/N 143-0458 (See Figure 2-6 and Table 2-5),	Mating connectors provided with MST compatible rack adapters
Source Connection		Mates with Molex Minifit, Jr. Series 10 pin connector, Kepco p/n 143-0544 (See Figure 2-6)	Mates with a-c backplane in MST compatible rack adapters

1.4 FEATURES

1.4.1 CONTROL/PROGRAMMING

Control of the MST Power Module is via the IEEE 1118 2-wire serial bus operating at 375KHz; as many as 27 separate modules of either the MST, MAT, MBT or BOP Series design can be addressed via the bus (see Figure 1-3). Decoders for RS232, IEEE-488 and VXI are available in modular form and stand-alone types. As shown in Figure 1-3, the following controllers are available to control of MST (and MAT) Power Modules directly from a computer.

a. Controller Model TMA PC-27 plugs into a half-card slot of a DOS-based PC and allows keyboard control of the MST via the IEEE 1118 bus.

b. Controller Model TMA 4882-27 is free-standing and allows host computers designed for RS232 or IEEE 488 bus communication to control the MST via the IEEE 1118 bus.

c. Controller Model TMA-VXI-27 plugs into a slot in a VXI chassis and allows VXI-based computers to control the MST via the IEEE 1118 bus.

d. Controller Model MST 488-27 plugs into a slot in a Model RA 55 Rack Adapter and allows host computers designed for RS232 or IEEE 488 bus communication to control the MST via the IEEE 1118 bus.

e. The MST Power Module can also be directly controlled via the keypad of the MBT Series ("G" Option) Power Supply via the IEEE 1118 bus.

NOTES:

1. MATERIAL:
   A) CHASSIS & COVER: 0.064 THK. ALUM. 5052-H32.
   B) FRONT PANEL: 0.125 THK. ALUM. 6061-T6.
2. FINISH:
   A) CHASSIS & COVER: YELLOW IRIDITE.
   B) FRONT PANEL: KEPCO GRAY, HARTIN PAINT #15-22493.
3. DIMENSIONS IN PARENTHESES ARE IN MILLIMETERS.
4. TOLERANCES:
   A) BETWEEN MOUNTING HOLES: ±1/64(±0.4).
   B) ALL OTHER DIMENSIONS: ±1/32(±0.8) EXCEPT AS NOTED.

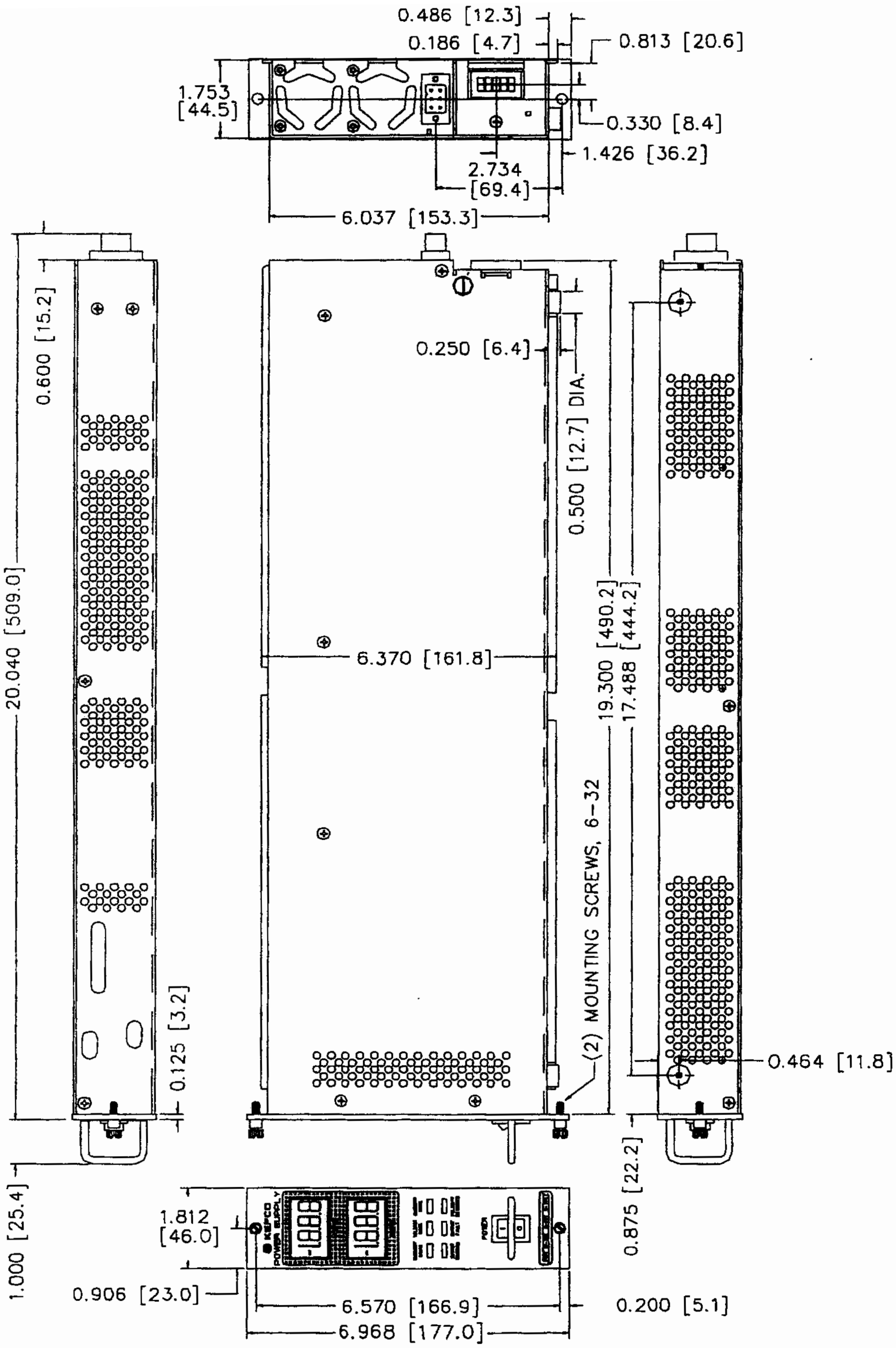

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FIGURE 1-2. MST POWER SUPPLY, MECHANICAL OUTLINE DRAWING

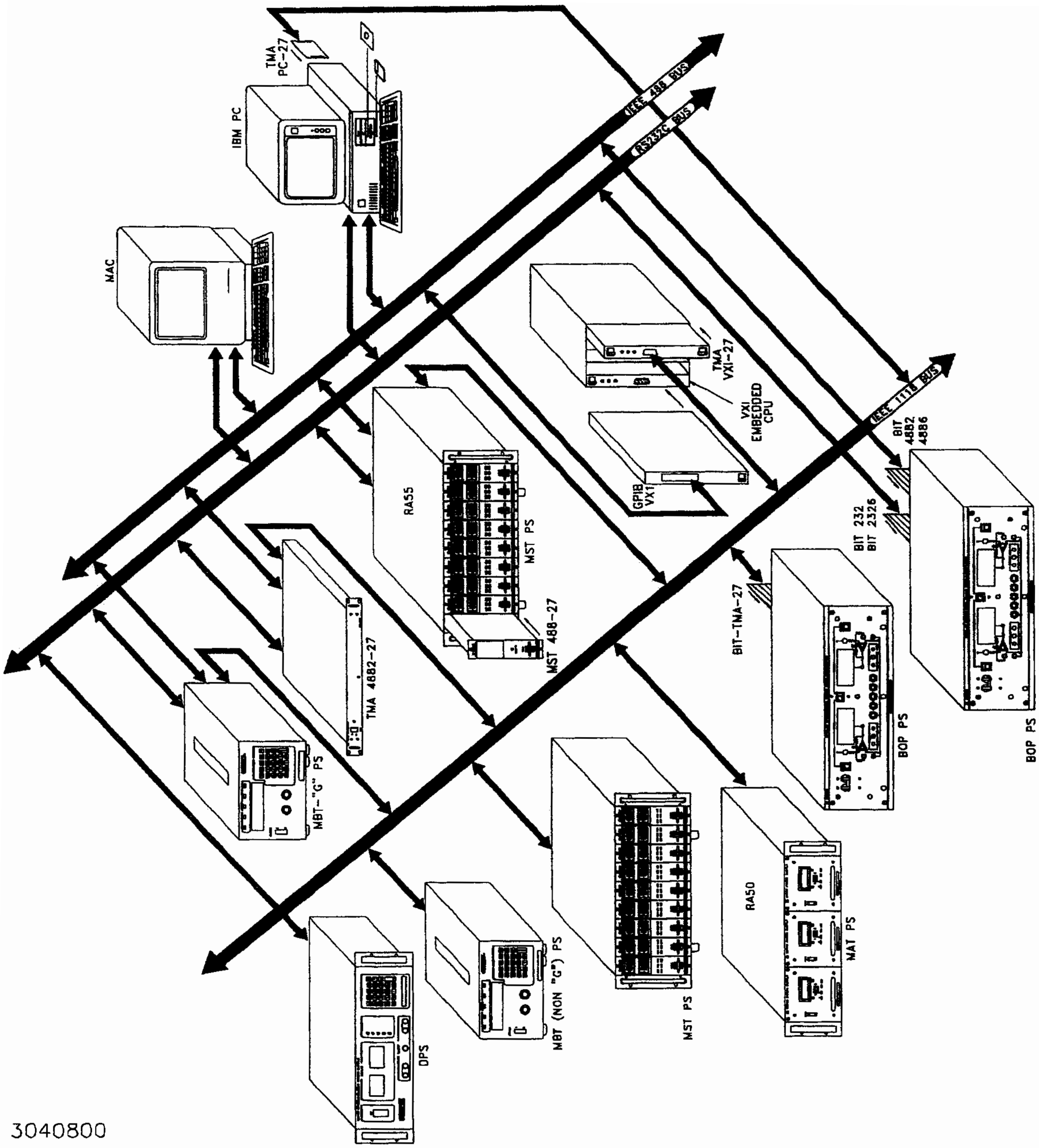


FIGURE 1-3. REMOTELY CONTROLLED POWER SUPPLY CONFIGURATIONS USING KEPCO PRODUCTS

1.4.2 STATUS INDICATORS

Six status indicators at the front panel provide operational information (see Table 2-2):

- VOLTAGE MODE
- CURRENT MODE
- CURRENT SHARE
- OUTPUT ENABLED
- POLARITY REVERSED
- OUTPUT FAULT

1.4.3 FRONT PANEL METERS

Two digital meters at the front panel provide displays of output voltage and current. These displays show 3.5 digits and are provided for reference only, accurate to 0.5% (typical) for voltage and 1.5% (typical) for current.

1.4.4 OUTPUT ENABLE/DISABLE AND POLARITY REVERSAL

The MST Power Module features integral relays to enable/disable the output and to allow polarity reversal. Separate relays are provided for power and sense connections. Disabling the MST as a voltage source means opening the connection between the power supply and its load. Disabling the MST as a current source means shorting the power supply's output terminals. The polarity reversal relays provide for two-quadrant operation.

1.4.5 PROTECTION

The MST Power Module incorporates the following protection circuits which cause the MST to automatically isolate the load and force power module output voltage and current to zero.

- Overvoltage protection: Tracks output voltage; activated if the output goes out of tolerance (see PAR. 3.7.2).
- Overcurrent protection: Tracks output current; activated if the output goes out of tolerance (see PAR. 3.7.2).
- Overtemperature: Activated when the internal temperature exceeds a safe operating threshold (see PAR. 3.7.3).
- AC loss: Activated if loss of source power detected (see PAR. 3.7.4).
- Open power lead and sense wire: Activated if an open sense wire or open power lead is detected (see PAR. 3.7.5).

1.4.6 SERIES CONFIGURATIONS

The output of the MST Power Module "floats;" so that MST Power Modules can be connected in series to obtain higher output voltages, up to a maximum of ± 500 Volts referenced to the chassis (see PAR. 3.6).

1.4.7 PARALLEL CONFIGURATION

A parallel configuration may be employed for higher output current and for N + 1 redundant, "hot-swap" applications. When connected in a parallel configuration, MST Power Modules employ forced current sharing to ensure equal distribution of the load among all power modules, improving performance, reducing component stress, and increasing reliability (see PAR. 3.5).

1.5 OPTIONS

The F option (F appended to the Model Number, e.g., MST 6-20MF) incorporates additional filtering to provide significant output noise reduction in the range of 1KHz to 10MHz. Contact Kepco Sales Engineering for additional information regarding performance and availability.

1.6 ACCESSORIES

The MST Power Module is designed for installation in Kepco Rack Adapter Model RA 55 which accommodates nine 1/9 rack size power modules. With a 1/9 rack Controller module installed, the RA55 will accommodate eight 1/9 rack power modules. Connecting cables and IEEE 1118 bus daisy chain terminations are supplied with the RA 55 Rack Adapter. Additional accessories are listed in Table 1-3.

TABLE 1-3. ACCESSORIES

ACCESSORY	PART NUMBER	USE
MATING CONNECTOR (DC OUTPUT)	142-0372	Mates with DC OUTPUT connector, Kepco P/N 143-0457 (Positronic POW-R-LOK Series 6 pin connector).
LOAD CONNECTOR PINS	107-0327	Replacement pins for DC OUTPUT connector.
LOAD CABLE	118-0849	Pre-wired 7-ft. long load/signal cabled (rated 20A).
INPUT POWER/COMMUNICATION CABLE	118-0850	Allows power and communication connections to MST power module not installed in RA 55 Rack Adapter.

SECTION 2 - INSTALLATION

2.1 UNPACKING AND INSPECTION

This instrument has been thoroughly inspected and tested prior to packing and is ready for operation. After careful unpacking, inspect for shipping damage before attempting to operate. Perform the preliminary operational check as outlined in PAR. 2.5. If any indication of damage is found, file an immediate claim with the responsible transport service.

NOTE

If the Power Modules are shipped pre-installed in the RA 55 Rack Adapter, each module is secured to the RA 55 Rack Adapter by two shipping screws. These screws must be removed from the bottom of the rack adapter, otherwise the modules cannot be removed from the rack adapter.

2.2 TERMINATIONS AND CONTROLS

a. Internal Calibration Controls: Refer to Figure 2-4 and Table 2-1.

b. Front Panel: Refer to Figure 2-1 and Table 2-2.

c. Rear Panel: Refer to Figure 2-1 and Table 2-3.

TABLE 2-1. FUNCTIONS OF INTERNAL CONTROLS

REFERENCE DESIGNATION	CONTROL	PURPOSE
R49	+5 V REF	This is a primary adjustment for the analog circuits.
R11	E_O Zero	This control is used to adjust the output voltage of the Power Module to zero. E_O $_{Zero}$ calibrates the Power Module in the Voltage mode.
R51	I_O Zero	This control is used to adjust the output current of the Power Module to zero. I_O $_{Zero}$ calibrates the Power Module in the Current mode.
R50	Current Sensing Zero	This adjustment calibrates the current monitor amplifier to zero.
R52	Full Scale Current Adjust	This adjustment calibrates the programmed full scale value.
R47	V_{REF}	This is a full scale voltage adjustment.
R48	I_{REF}	This is a current read back accuracy adjustment.

2.3 A-C INPUT REQUIREMENT

MST Power Modules operate from single-phase a-c mains power over the specified voltage and frequency ranges without adjustment or modification.

2.4 COOLING

The power transistors and rectifiers in the MST Power Module are maintained within their operating temperature range by means of internal heat sink assemblies cooled by internal fans. PANEL OPENINGS AND THE TOP OF THE CASE MUST BE KEPT CLEAR FROM OBSTRUCTIONS TO INSURE PROPER AIR CIRCULATION. If installed in confined spaces, care must be taken that the ambient temperature (the temperature immediately surrounding the

Power Module) does not rise above the limit specified (45° C). Periodic cleaning of the power module interior is recommended.

TABLE 2-2. FRONT PANEL CONTROLS AND INDICATORS

CONTROL/INDICATOR	FUNCTION
POWER switch	Turns a-c power ON/OFF.
VOLTAGE MODE indicator - green LED	Goes on to indicate MST is operating as a voltage source (see PAR. 3.2.1).
CURRENT MODE indicator -amber LED	Goes on to indicate MST is operating as a current source (see PAR. 3.2.2).
POLARITY REVERSED indicator - green LED	Goes on when negative output programmed while the output is enabled.(see PAR. 3.3).
OUTPUT ENABLE indicator - green LED	Goes on to indicate power relays are closed and output regulator is enabled (see PAR. 3.4).
OUTPUT FAULT indicator - red LED	Goes on to indicate internal power module fault detected (see PAR. 3.7).
CURRENT SHARE indicator - amber LED	Goes on to indicate that unit is operating as "slave" module when used in a parallel configuration (see PAR. 3.5).
VOLTS meter	Displays output voltage.
AMPS meter	Displays output current.

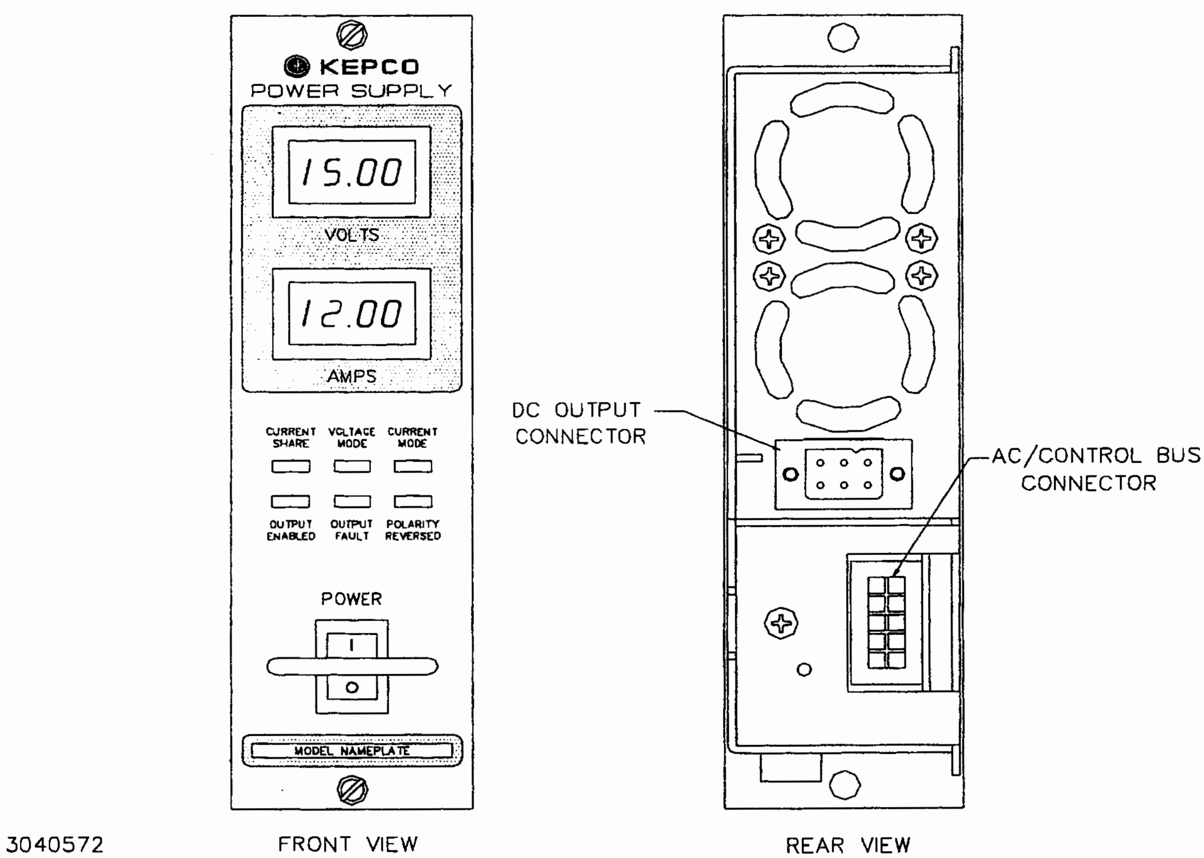


FIGURE 2-1. FRONT AND REAR VIEWS OF THE MST POWER MODULE

TABLE 2-3. REAR TERMINATIONS

REAR TERMINATION	FUNCTION
AC Input/Control Bus connector	Connects the MST Power Module to single-phase a-c power, safety ground, and two-wire IEEE 1118 bi-directional Control Bus.
DC output connector	Connects the MST Power Module output lines, sensing lines, frame ground lines and current share bus to the load.

2.5 PRELIMINARY CHECK-OUT

2.5.1 REQUIRED EQUIPMENT

- Host computer w/communication cable for selected controller
- Kepco Controller (See PAR. 1.4.1).
- RA 55 or CA 400 reack adapter; alternative is to use Input Power/Communication Cable (see Table 1-3)
- Load Interface Cable or mating load connector (see Table 1-3)
- Digital Voltmeter (DVM)
- Switch (SPST) rated 32V d-c, 1A

2.5.2 INITIAL SETUP

Initial set-up is as follows (See Figure 2-3):

1. Connect the Unit under test (UUT) to the computer/controller interface (refer to the appropriate Controller Instruction Manual and to the Rack Adater (RA 55 or CA 400) Instruction Manual for source power connections). NOTE: An Alternative configuration using the Input Power Communication cable in place of the rack adapter may be used.
2. Install the MST Power Module into a vacant rack adapater slot (see PAR. 2.6.2).
3. Configure the Load Interface Cable as shown in Figure 2-2. If the Load Interface Cable is not available, wire load mating connector is shown in Figure 2-2.

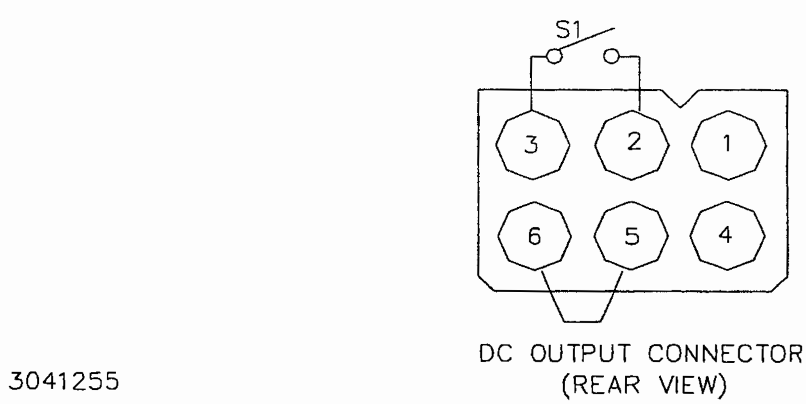


FIGURE 2-2. DC OUTPUT CONNECTOR CONFIGURATION FOR PRELIMINARY CHECKOUT

4. Apply a-c power first to the MST power module(s), then to the Controller.
5. Set switch S1 (Figure 2-3) to CLOSE SENSE position.

NOTE: If the sequence in step 4, above, is reversed (i.e., a-c power applied to the Controller first and MST power modules last), the operator must send an IEEE 488 Device Clear command via the Host Computer prior to issuing other commands.

For proper time delays between commands refer to PAR. 3.1.2. For details on the CIIL or SCPI commands, refer to the Instruction Manual for the applicable controller (see PAR. 1.4.1).

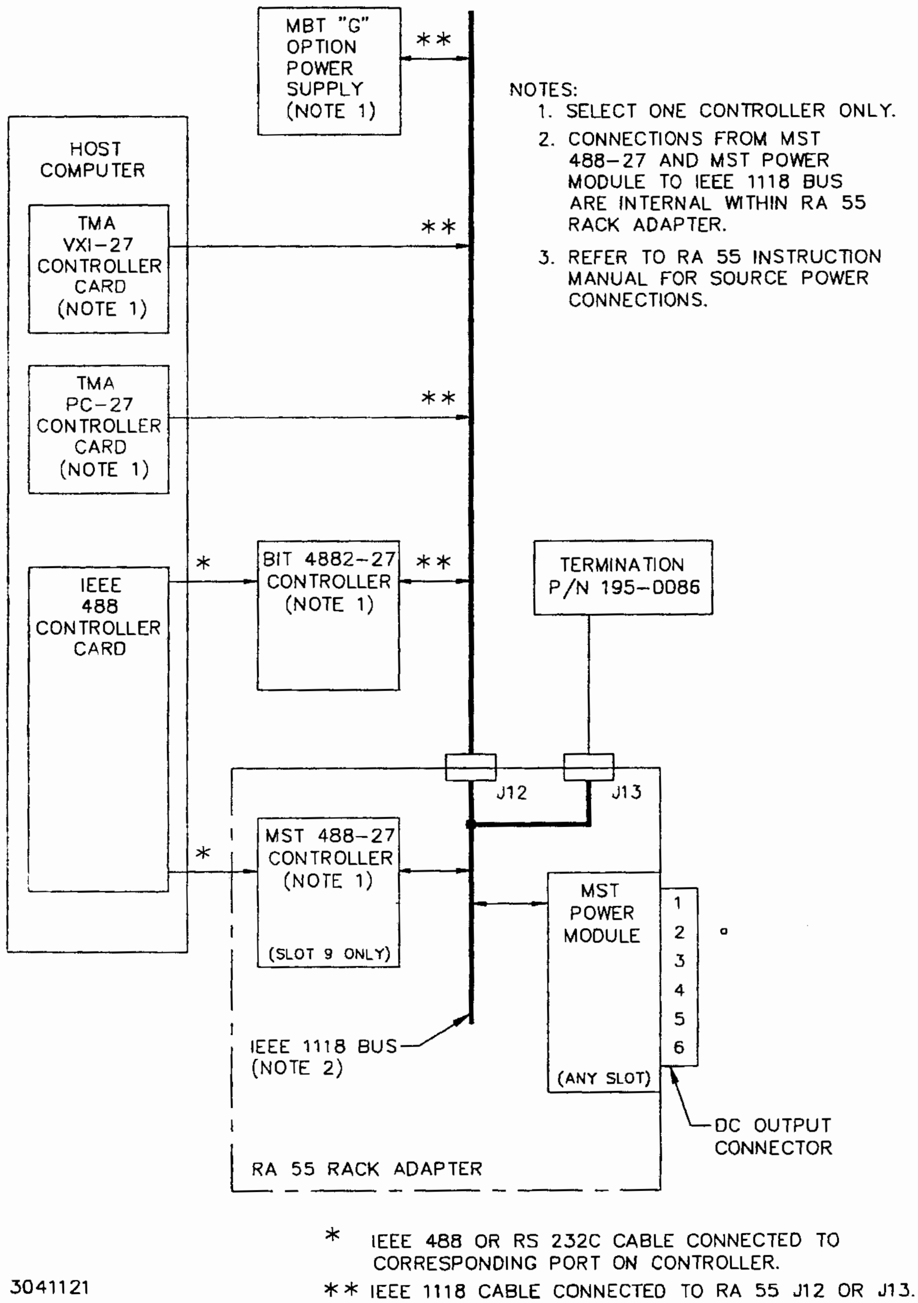


FIGURE 2-3. INITIAL CHECKOUT SETUP

2.5.3 CHECKOUT PROCEDURE

The following checkout procedure requires commands to be issued by the host computer in order to program the power module or read back information (voltage, current or status) from the power module; it does not include the IEEE 488 Bus Commands.

NOTE: The following procedure provides specific SCPI and CIIL commands where necessary to implement the applicable step. These commands are for a Model MST 36-5M Power Module set to Control Bus Address 1 (the factory default setting); for addresses other than 1, change commands accordingly (see applicable Controller Instruction Manual for details).

1. Issue commands from the host computer to initialize the Power Module.

SCPI COMMAND	CIIL COMMAND
`*RST`	`DCL`

NOTE: Both SCPI and CIIL commands must be issued in the proper syntax; incorrect syntax can result in the Power Module being "locked out" from accepting further commands. If this occurs, initialize the power module (see step 1 above). If the "locked out" condition persists, turn off MST power for approximately 10 seconds, then reapply power. (Refer to applicable Controller Instruction Manual for details regarding syntax.)

2. Issue commands from the host computer to set the MST Power Module to Voltage Mode, program output voltage to $+E_{MAX}$, current limit to I_{MAX} and enable the output.

SCPI COMMANDS	CIIL COMMANDS
`FUNC1:MODE VOLT` `VOLT1 36; CURR1 5; OUTP ON`	`FNC DCS :CH1 SET VOLT 36 SET CURL 5` `CLS :CH1`

NOTE: E_{MAX} is the maximum output voltage of the unit listed in Table 1-1; I_{MAX} is the maximum output current of the unit as listed in Table 1-1 for 45° C.

3. Verify that VOLTAGE MODE and OUTPUT ENABLED indicators on front panel are on and VOLTS meter on front panel indicates E_{MAX}.

4. Connect DVM across pins 5 (+) and 2 (–) of the DC Output connector (Figure 2-3) and verify that DVM reads $+E_{MAX}$.

5. Issue commands from the host computer to read back voltage; verify that readback voltage is $+E_{MAX}$.

SCPI COMMANDS	CIIL COMMANDS

`MEAS1:VOLT?`	`FNC DCS VOLT :CH1`
	`INX VOLT`
	`FTH VOLT`

6. Set switch S1 (Figure 2-3) to OPEN SENSE position. Verify that front panel OUTPUT ENABLED indicator is off, and VOLTS meter reads 0V.

7. Issue commands from the host computer to check Status and verify status reads DEV Load Path Fault (CIIL) or Relay Error (SCPI); refer to PAR. 3.1.1.

8. Verify that DVM connected across pins 5 and 2 of DC Output connector reads 0V.

9. Set switch S1 to CLOSE SENSE position and issue commands from the host computer to set the MST Power Module to Voltage Mode, program output voltage to $-E_{MAX}$, current limit to I_{MAX} and enable the output.

SCPI COMMANDS	CIIL COMMANDS
`FUNC1:MODE VOLT` `VOLT1 -36; CURR1 5; OUTP ON`	`FNC DCS :CH1 SET VOLT -36 SET CURL 5` `CLS :CH1`

10. Verify that VOLTAGE MODE, POLARITY REVERSED and OUTPUT ENABLED indicators on front panel are on and VOLTS meter on front panel indicates E_{MAX}.

11. Connect DVM across pins 5 (+) and 2 (–) of the DC Output connector (Figure 2-3) and verify that DVM reads $-E_{MAX}$.

12. Issue commands from the host computer to read back voltage; verify that readback voltage is $-E_{MAX}$.

SCPI COMMANDS	CIIL COMMANDS

`MEAS1:VOLT?`	`FNC DCS VOLT :CH1`
	`INX VOLT`
	`FTH VOLT`

13. Set switch S1 (Figure 2-3) to OPEN SENSE position. Verify that front panel OUTPUT ENABLED indicator is off, and VOLTS meter reads 0V.

14. Verify that DVM connected across pins 5 and 2 of DC Output connector reads 0V.

15. Set switch S1 to CLOSE SENSE position and issue commands from the host computer to set the MST Power Module to Current Mode, program output current to I_{MAX} and voltage limit to $+E_{MAX}$.

SCPI COMMANDS	CIIL COMMANDS
`FUNC1:MODE CURR` `CURR1 5;  VOLT1 36`	`FNC DCS :CH1 SET CURR 5 SET VLTL 36`

16. Verify that CURRENT MODE indicator on front panel is on and AMPS meter on front panel indicates I_{MAX}.

17. Issue commands from the host computer to read back current; verify that read back current is I_{MAX}.

SCPI COMMANDS	CIIL COMMANDS

`MEAS1:CURR?`	`FNC DCS CURR :CH1`
	`INX CURR`
	`FTH CURR`

2.6 INSTALLATION/REMOVAL

The MST Power Module is designed to be rack-mounted in an RA 55 Rack Adapter. Refer to Figure 1-2 for outline dimensions. For installation in confined spaces, care must be taken that the surrounding environment does not exceed the maximum specified ambient temperature (45° C); see PAR. 2.4. The MST Power Module may be shipped either individually, or already installed in an RA 55 Rack Adapter. Follow power module installation procedures in RA 55 Instruction Manual.

2.6.1 CHANGING CONTROL BUS ADDRESS (NODE OR CHANNEL NUMBER)

Each MST Power Module connected to the IEEE 1118 bus must have a unique address (also referred to as node or channel number). The address from 1 to 31 is selected by DIP selector switch S1 accessed through the top of the unit (see Figure 2-4) and can be changed in accordance with Table 2-4. This address is set at Kepco to 1.

NOTE: Although 31 unique addresses are provided, the maximum number of instruments which can be managed by the Kepco Controller is 27.

TABLE 2-4. NODE ADDRESS SELECTION

DECIMAL ADDRESS	SELECTOR SWITCH SECTION (SIGNAL LINE)				
	A3S1-4 (A4)	A3S1-3 (A3)	A3S1-2 (A2)	A3S1-1 (A1)	A3S1-0 (A0)
1	0	0	0	0	1
2	0	0	0	1	0
3	0	0	0	1	1
4	0	0	1	0	0
5	0	0	1	0	1
6	0	0	1	1	0
7	0	0	1	1	1
8	0	1	0	0	0
9	0	1	0	0	1
10	0	1	0	1	0
11	0	1	0	1	1
12	0	1	1	0	0
13	0	1	1	0	1
14	0	1	1	1	0
15	0	1	1	1	1
16	1	0	0	0	0
17	1	0	0	0	1
18	1	0	0	1	0
19	1	0	0	1	1
20	1	0	1	0	0
21	1	0	1	0	1
22	1	0	1	1	0
23	1	0	1	1	1
24	1	1	0	0	0
25	1	1	0	0	1
26	1	1	0	1	0
27	1	1	0	1	1
28	1	1	1	0	0
29	1	1	1	0	1
30	1	1	1	1	0
31	1	1	1	1	1

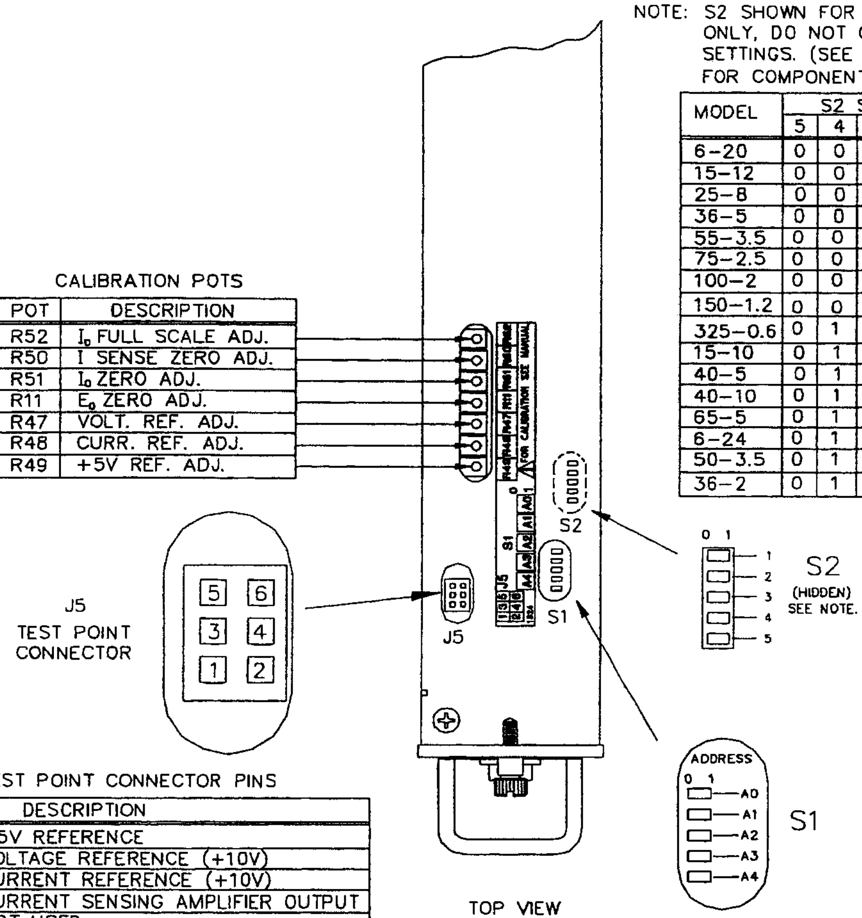
NOTE: If the Power Module is already installed in a Rack Adapter and it is necessary to change the control bus address, the Power Module must first be removed from the Rack Adapter as described in PAR. 2.6.3 below.

NOTE: S2 SHOWN FOR REFERENCE ONLY, DO NOT CHANGE SETTINGS. (SEE FIG. 6-5 FOR COMPONENT LOCATION.)

MODEL	S2 SETTING				
	5	4	3	2	1
6-20	0	0	0	0	0
15-12	0	0	0	0	1
25-8	0	0	0	1	0
36-5	0	0	0	1	1
55-3.5	0	0	1	0	0
75-2.5	0	0	1	0	1
100-2	0	0	1	1	0
150-1.2	0	0	1	1	1
325-0.6	0	1	0	0	0
15-10	0	1	0	0	1
40-5	0	1	0	1	0
40-10	0	1	0	1	1
65-5	0	1	1	0	0
6-24	0	1	1	0	1
50-3.5	0	1	1	1	0
36-2	0	1	1	1	1

CALIBRATION POTS

POT	DESCRIPTION
R52	I_o FULL SCALE ADJ.
R50	I SENSE ZERO ADJ.
R51	I_o ZERO ADJ.
R11	E_o ZERO ADJ.
R47	VOLT. REF. ADJ.
R48	CURR. REF. ADJ.
R49	+5V REF. ADJ.



TEST POINT CONNECTOR PINS

PIN	DESCRIPTION
1	+5V REFERENCE
2	VOLTAGE REFERENCE (+10V)
3	CURRENT REFERENCE (+10V)
4	CURRENT SENSING AMPLIFIER OUTPUT
5	NOT USED
6	SIGNAL GROUND

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FIGURE 2-4. CONFIGURATION AND CALIBRATION CONTROLS AND TESTPOINTS

2.6.2 INSTALLATION

To install the MST Power Module in the RA 55 Rack Adapter or CA400 case, proceed as follows:

1. The factory setting for the control bus address is 1; if address 1 is already in use, refer to PAR. 2.6.1 to change the address setting.

NOTE: If the Power Module is already installed in a Rack Adapter and it is necessary to change the control bus address, the Power Module must first be removed from the Rack Adapter as described in PAR. 2.6.3 below.

2. To ensure full engagement of the module interconnect to the RA 55 Rack Adapter or CA400 case, pull out the two slotted captive thumb screws (at the front of the Module) and turn counterclockwise until the threads engage.

3. Align slots of the Module with the guides of the Rack Adapter and insert Module into Rack Adapter slot. Secure with the two thumb screws (maximum torque applied to thumb screws is 10 foot-lbs).

2.6.3 REMOVAL

To remove the Power Module from the RA 55 Rack Adapter or CA400 case, proceed as follows:

CAUTION

When removing a Module from a Rack Adapter under power, the Module POWER switch must be placed in the OFF position prior to extraction.

1. Loosen the two slotted captive thumb screws that hold the Module in place in the Rack Adapter until they disengage from the Rack Adapter.

2. Extract the module from the Rack Adapter using the front panel handle.

2.7 GROUNDING

Interconnections linking a stabilized Power Module to an a-c power source and a load are critical for both performance considerations and safety requirements. For optimum performance certain rules must be observed. These rules are described in detail in the following paragraphs.

2.7.1 SAFETY GROUNDING

National and international safety standards set procedures for the grounding of a metal cover and chassis of an instrument connected to an a-c power source.

When properly installed in the RA 55 Rack Adapter, the Power Module chassis is connected to the RA 55 safety ground terminal via the GROUND pins of the AC/Control Bus connector (Figure 2-6). For operation of the MST Power Module outside the RA 55 Rack Adapter, consult Kepco Applications Engineering for assistance.

WARNING

RA 55 RACK ADAPTER MUST ALWAYS BE GROUNDED WHEN CONNECTED TO AN A-C POWER SOURCE.

2.7.2 D-C (OUTPUT) GROUNDING

D-C output connections are those between the Power Module and the load, including remote sensing connections. Despite precautions to eliminate noise such as shielding and twisted wire-pairs, output connections may pick up radiated noise of a wide frequency. To minimize such undesired effects, one side of the Power Module output/load may be grounded. Pin 4 of the DC Output connector is connected to chassis (frame) ground. Although the d-c output is isolated from chassis or ground up to ± 500 V d-c, in certain applications the user may elect to terminate either the positive or negative terminals to chassis ground in order to optimize system performance.

Successful d-c grounding depends on careful analysis of the system operation; only general guide lines are provided here. One of the major points, however, is to avoid ground loops. Ground loops are created when two or more points of different ground potentials in the output circuit are grounded. An undesired signal (noise) is developed that is superimposed on the load (output potential). A way to avoid ground loops is to check for points of resistance to ground. Differences in ground potential can be avoided if the output circuit is completely isolated. A single point can then be selected along the Power Module output circuit and returned to ground with a single wire. This method is dependent on the specific application.

2.8 POWER MODULE TO LOAD INTERFACE

The general function of a voltage or current stabilized Power Module is to deliver rated output to the load. The load may be fixed or variable; resistive, capacitive, or inductive; and may be located close to or far away from the Power Module. The Power Module is designed for varied applications. The aim of the following paragraphs is to instruct the user in the interface of the Power Module to the load.

The perfect interface between a Power Module and load insures optimum performance. To approach this state of operation, one must be familiar with certain requirements, such as interconnection guidelines, Ohm's Law and a-c theory.

Load Wire Selection - A stabilized d-c Power Module is not an ideal voltage or current source with zero output impedance (voltage mode) or infinite output impedance (current mode): All voltage sources have some amount of impedance which increases with frequency and all current sources have impedance which decreases with frequency (see Figure 2-5).

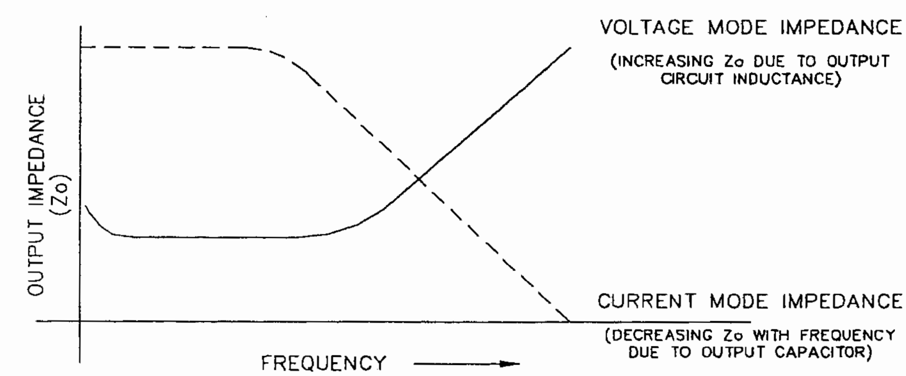

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FIGURE 2-5. OUTPUT IMPEDANCE VS. FREQUENCY

A practical model for a voltage-stabilized Power Module includes a series inductance representing d-c and low frequency source impedance. Load leads should have minimum voltage drops (error sensing discussed in PAR. 2.10 below) and minimum inductance (error sensing does not compensate for this). Similarly a model for a current stabilized Power Module includes a parallel capacitor representing the d-c and low frequency source impedance. These considerations are important if:

- The load is constantly changing value.
- The load is switched "on" and "off."
- The output of the Power Module is step programmed.

- The load is reactive.
- Dynamic output response of the Power Module is of concern.

2.9 CONNECTION, GENERAL

All input and output connections between the Power Module and RA 55 Rack Adapter are made automatically when the Power Module is fully seated in a Rack Adapter slot. Refer to the Rack Adapter Instruction Manual for instructions on connecting RA 55 output connectors to the load, a-c input power, and control signals.

The d-c output connector, labeled DC OUTPUT, is located on the back of chassis (Figure 2-6). For the DC Output Connector pin designations on MST units refer to Table 2-5.

TABLE 2-5. DC OUTPUT CONNECTOR PIN DESIGNATIONS

MST SIGNAL	CONNECTOR PIN
Output Terminal 1 (+)	6
Output Terminal 2 (–)	3
Sense Terminal 1 (+)	5
Sense Terminal 2 (–)	2
Current Share Bus	1
Module Chassis	4
NOTE: The polarity for the terminals indicated above are for output enabled and polarity not reversed (normal).	

2.9.1 LOAD CONNECTION WITH LOCAL ERROR SENSING

The most basic power supply/load interface is a 2-wire connection between the power supply output terminals and the load. This connection method employs local error sensing which consists of connecting the error sense leads (pins 5 and 2) directly to the power supply output (pins 6 and 3). Its main virtue is simplicity: since voltage regulation is maintained at the power supply output, the regulation loop is essentially unaffected by the impedances presented by the load interconnection scheme. The main disadvantage is that it cannot compensate for losses introduced by the interconnection scheme and, therefore, regulation degrades directly as a function of distance and load current. The main applications for this method are for powering primarily resistive and relatively constant loads located close to the power supply, or for loads requiring stabilized current exclusively. The load leads should be tightly twisted to reduce pick-up.

2.9.2 LOAD CONNECTION WITH REMOTE ERROR SENSING

If the load is located at a distance from the power supply terminals, or if reactive and/or modulated loads are present, remote error sensing should be used to minimize their effect on the voltage stabilization. A twisted shielded pair of wires from the sensing terminals directly to the load will compensate for voltage drops in the load interconnection scheme (up to 0.5V maximum per wire); the termination point of the error sensing leads should be at or as close as practical to the load. For these conditions it is also recommended that some amount of local decoupling capacitance be placed at the error sense termination point to minimize the risk of unwanted pick-up affecting the remote error sense function. For very long power module/load interconnecting cables and/or reactive loads, it may be necessary to add decoupling capacitors between the power and sense terminals at the power module side of the cable to suppress oscillation due to cable inductance. A general recommendation is to install a network of one (1) 10μF, 6.3V capacitor paralled by one (1) 0.1μF ceramic capacitor across each output sense pair (pins 6 to 5 and 3 to 2 , respectively).

NOTE: As electrolytic capacitors are normally polarized make sure that the positive (+) terminal of each one are respectively connected to the +V (pin 6) and -S (pin 2) pins.

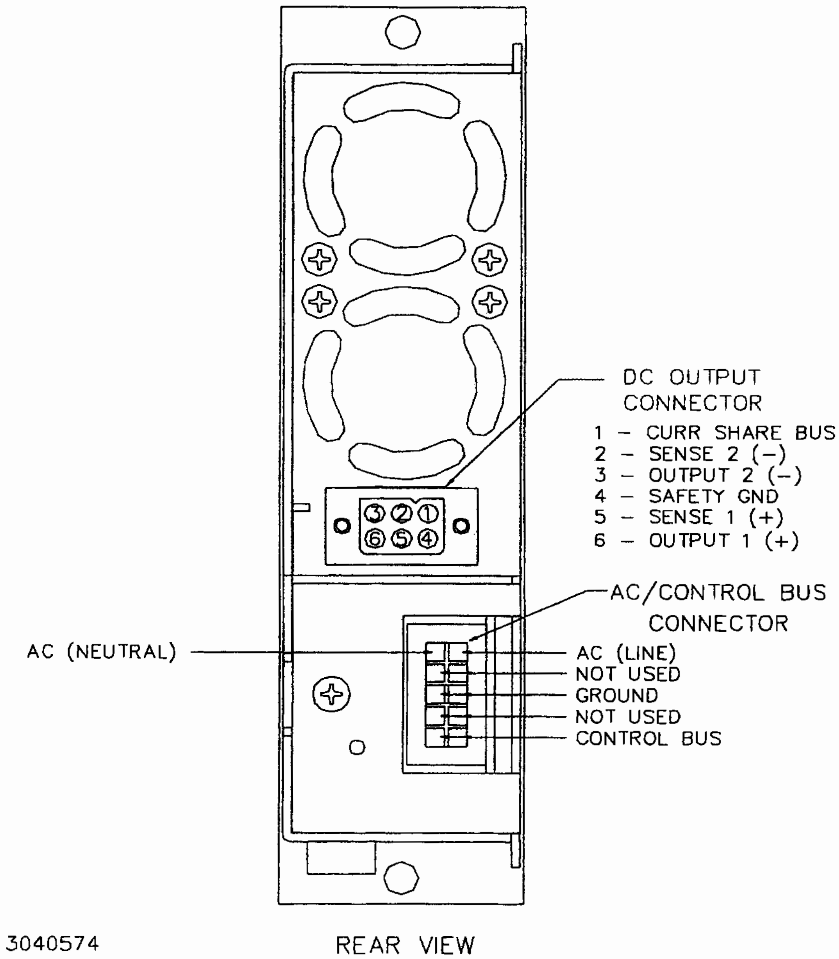


FIGURE 2-6. CONNECTOR LOCATIONS AND PIN ASSIGNMENTS

SECTION 3 - OPERATION

3.1 INTRODUCTION TO CONTROLLING THE MST POWER MODULE OUTPUT

The MST family of Power Modules is designed for remote operation only. Operating the power supply requires a series of commands to be sent to the Power Module from a host computer, via a selected IEEE 1118 bus compatible Controller (see PAR. 1.4.1). The commands may either be pre-programmed or sent individually using a keyboard, depending upon the controller selected.

The MST Power Module responds to both SCPI (Standard Commands for Programmable Instruments) and CIIL (Control Interface Intermediate Language) commands. SCPI and CIIL provide a common language conforming to IEEE 488.2 for instruments. For an explanation of SCPI and CIIL commands and program syntax, refer to the applicable controller Instruction Manual.

3.1.1 STATUS FLAGS (ERROR MESSAGES)

The MST Power Module supplies information to the controller regarding its operating condition when queried via the STAT:QUES:COND? command in SCPI, or via the STA command in CIIL. A listing of the standard error messages for both SCPI and CIIL appear in the Instruction Manuals for the various Kepco Controllers (see PAR.1.4.1). Table 3-1 lists the "catastrophic" status messages of both SCPI and CIIL, along with the related MST Power Module condition.

TABLE 3-1. ERROR MESSAGES

CIIL ERROR MESSAGE	SCPI STATUS MESSAGE	POWER MODULE CONDITION
DEV Power Loss	POWER LOSS	OVERVOLTAGE / OVERCURRENT (See PAR. 3.7.2) SOURCE POWER LOSS (See PAR. 3.7.4)
DEV Crowbarred	None	Not Supported
DEV Over Temperature	OVERTEMPERATURE	OVERTEMPERATURE (See PAR. 3.7.3)
DEV Overload	OVERLOAD	OPERATION IN MODE OTHER THAN PROGRAMMED MODE (See PAR's. 3.2.1, 3.2.2)
DEV Voltage Comparison Error	VOLTAGE ERROR	OUTPUT NOT AT PROGRAMMED VALUE
DEV Current Comparison Error	CURRENT ERROR	OUTPUT NOT AT PROGRAMMED VALUE
DEV Relay Not Opened DEV Relay Not Closed DEV Polarity Error	RELAY ERROR	DEFECT IN ISOLATION OR POLARITY RELAY OPERATION
DEV Load Path Fault	RELAY ERROR	OPEN SENSE LEAD OR OPEN POWER LEAD CONDITION (See PAR. 3.7.5)

3.1.2 TIMING REQUIREMENTS FOR A VALID STATUS

After sending a command that might affect the output of the Power Modules or their relays, it is recommended that the Status command be sent. For detailed information on this command refer to the applicable controller Instruction Manual. For the Controller/MST system status command to be valid, the required time delay before sending the command is as follows:

- After an Open, Close (CIIL only), OUTP ON or OFF (SCPI only), Change of Polarity, or Change of Mode, wait approximately 300 milliseconds.

- After a Confidence Test command or an Internal Self Test, wait approximately 400 milliseconds.

- After a Reset command, wait approximately 300 milliseconds.

3.2 OPERATING MODES

MST power modules permit the user to select the operating mode as either Voltage Mode or Current Mode, depending upon the characteristics of the load being driven by the power module. The following paragraphs describe the characteristics and method of selecting the operating mode; note the following:

- only one operating mode may be selected at a time.

- operating mode selection affects only the operation of the fault detector and not the rectangular operating characteristic of the power module.

- the MODE indicators on the front panel indicate the real-time operating mode of the Power Module.

3.2.1 VOLTAGE MODE

In this mode, the Power Module is programmed to behave as a voltage source. The user programs an operating voltage XX with a current limit YY based on the required voltage stabilization point and the maximum anticipated load current. The Power Module is now programmed to provide a stabilized output voltage XX to a load impedance greater than or equal to XX/YY; the VOLTAGE MODE indicator LED is on for these load conditions.

Load impedances below XX/YY are considered to be overloads, and the Power Module will modulate the output voltage between zero and XX as necessary to maintain the load current at YY. Operation with load impedances below XX/YY will result in the CURRENT MODE indicator LED going on and the VOLTAGE MODE indicator going off; a status query at his point will indicate a device overload condition. Increasing the load impedance to a value greater than or equal to the critical value indicated above will result in automatic return to normal operation.

3.2.2 CURRENT MODE

In this mode, the Power Module is programmed to behave as a current source. The user programs an operating current YY with a voltage limit XX based on the required current stabilization point and the maximum anticipated load voltage. The Power Module is now programmed to provide a stabilized output current YY to a load impedance less than or equal to XX/YY; the CURRENT MODE indicator LED is on for these load conditions.

Load impedances greater than XX/YY are considered to be overloads, and the Power Module will modulate the output current between zero and YY as necessary to maintain the load voltage at XX. Operation with load impedances greater than XX/YY will result in the VOLTAGE MODE indicator LED going on and the CURRENT MODE indicator going off; a status query at his point will indicate a device overload condition. Decreasing the load impedance to a value less than or equal to the critical value indicated above will result in automatic return to normal operation.

3.3 OUTPUT POLARITY REVERSAL

MST Power Modules are designed to permit reversal of output terminal polarity via a remote command. Polarity reversal is achieved via relay switching of both power and signal lines, and can be employed in both Voltage and Current operating modes. Polarity reversal can be programmed in advance of output activation (Standby) or "on-the-fly" (Active) while the output is enabled; both methods employ a "dry-switching" scheme in order to extend relay life.

For programming polarity reversal in Standby mode, the user simply issues the polarity reversal command prior to enabling the output; the Power Module will then present reversed output polarity when enabled.

For polarity reversal while the output is enabled, the action is somewhat more complex although essentially transparent to the user. Upon receipt of a polarity reversal command, the Power Module control circuit stores the previous output settings (mode, voltage and current setpoints, etc.). The output of the Power Module is immediately programmed to zero volts and zero amps. A time-out delay of 2 seconds maximum is employed to allow for discharge of any load capacitance through the Power Module's return supply; during this time-out interval, the power supply waits for the output to reach zero volts. When zero volts is established, or at the end of the 2 second time-out, the relays are switched. The output is then reprogrammed to the stored settings and operation continues. During this sequence, error message generation is inhibited. Restoration of the output to normal polarity follows a similar path.

NOTE: The "return supply" current incorporated into MST Power Modules is limited to a maximum value which may in some cases be inadequate to fully discharge all external load capacitance. To ensure dry relay switching for all output conditions, the user must ensure that the external load capacitance can be discharged completely within the 2 second time-out interval by the available current, or dry switching will not take place. The maximum external capacitance value that can be discharged within the 2 second time-out interval is calculated as follows (see Table 3-2):

$$C \leq \frac{I \times T}{\Delta V}$$

where C = Maximum external capacitance allowed to maintain dry switching (Farads)
I = Return supply current (Amps)
V = Output voltage (Volts)
T = Time (Sec) = 2 seconds

CAUTION: FAILURE TO OBSERVE THE "DRY SWITCHING" CRITERIA NOTED ABOVE WILL CAUSE DAMAGE TO THE RELAYS AND VOID THE KEPCO WARRANTY.

In order to allow for settling time, the user should wait approximately 300 milliseconds after completion of polarity reversal before sending a status query in order to avoid erroneous fault messages.

TABLE 3-2. MAXIMUM EXTERNAL CAPACITANCE VALUES TO ENSURE DRY SWITCHING

MODEL	RETURN SUPPLY CURRENT (MILLIAMPS)	MAXIMUM EXTERNAL CAPACITANCE * (μF)
MST 6-20M	400	125,000
MST 15-12M	400	50,000
MST 25-8M	250	20,000
MST 36-5	165	8,800
MST 55-3.5	110	4,000

* Values shown for worst case: T = 2 seconds and ΔV = maximum voltage.

TABLE 3-2. MAXIMUM EXTERNAL CAPACITANCE VALUES TO ENSURE DRY SWITCHING

MODEL	RETURN SUPPLY CURRENT (MILLIAMPS)	MAXIMUM EXTERNAL CAPACITANCE * (μF)
MST 75-2.5	60	1,600
MST 100-2	44	880
MST 150-1.2	30	400
* Values shown for worst case: T = 2 seconds and ΔV = maximum voltage.		

3.4 OUTPUT ENABLE AND DISABLE

Enabling or disabling the output of an MST Power Module differs, depending upon whether it is operating as a voltage source or current source. The difference is determined by the opposite impedance characteristics of an ideal voltage vs. ideal current source. This section defines the "disable" function in terms of ideal voltage or current source characteristics, and details the exact method by which MST Power Modules provides the disable function.

For both voltage and current sources the "disable" condition is always represented by a "no-load" (zero load power) impedance. Regardless of whether the MST is operating in voltage or current mode (see PAR. 3.2), the "disable" condition must ensure that the MST provides zero power to the load, while ensuring full compliance to the load when subsequently enabled. The correct implementation of the disable function, whether for voltage mode or current mode, is automatic.

The definition of an ideal voltage source is a source which will supply stable voltage (Vo) into any load impedance within the limits of its compliance current range (RL = Vo/IMAX). For an ideal voltage source a no-load condition is then defined as infinite impedance, since this is the only load condition at which the delivered power (Vo x Io) is zero. MST Power Modules provide this function by opening all power relays, thus providing an open circuit to the load from the stabilizer output. Enabling the voltage source is accomplished by closing the appropriate relay contacts, depending upon selected output polarity, thus connecting the stabilizer output to the load.

The definition of an ideal current source is a source which will supply stable current (Io) into any load conductance within the limits of its compliance voltage range (GL = Io/VMAX). For an ideal current source a no-load condition is then defined as infinite conductance (zero impedance) since this is the only load condition at which the delivered power is zero. MST Power Modules provide this function by closing all four power relays, thus placing a short circuit (RL=0) at the output of the load stabilizer. While "disabled," output current from the MST load regulator continues to circulate within the power module and through the shorted power relays. Enabling the current source is accomplished by opening the appropriate relays contacts, depending upon the selected output polarity, thus allowing the output current to flow through the load.

As with the output polarity reversal function described in PAR. 3.3, a "dry switching" scheme is employed during the disable and enable functions. For both voltage and current modes of operation, the CIIL command to enable the output at the load is Close (CLS), and to disable the output at the load is Open (OPN); the corresponding SCPI commands are OUTP ON and OUTP OFF, respectively.

3.5 PARALLEL OPERATION

MST Power Modules are specifically designed for operation in parallel, either for increased power or for fault redundancy. The output stabilizer incorporates an active load-sharing scheme to ensure equal distribution of load current among all paralleled modules, resulting in reduced operating stress and higher reliability. The load-share circuitry employed is a single-wire type with the positive error sense connection providing the signal return path.

To determine the number of Power Modules needed for a specific application, the user divides the total required load current (including any transient peaks) by the Power Module's rated current, rounding the result up to the next whole number if necessary. This method determines "N", the minimum number of power modules needed to support the load. For redundant applications this number is increased based on the desired redundancy factor (N+1, N+2, etc.). For non-redundant applications, the user can reduce overall power system operating stress by increasing the number of modules above N.

For parallel operation, all Power Modules should be same model. The module d-c outputs and error sense leads are wired in parallel to the load; the load share terminals from each DC Output connector are daisy-chained together. The user must ensure that the load and sense wiring minimizes loop inductance to prevent stray pickup from injecting noise into the load share signals. Twisted pairs (shielded, if necessary) should be used for both power and error sense leads when remote error sensing is used, with all error sensing lines terminated to the same physical location; if possible, the user should employ local error sensing.

Program each module for Voltage Mode operation at identical output voltage and current limit. The load sharing circuitry will automatically select the "load master" as the module with the highest "effective" voltage supplying power to the output bus; all other modules operate as slaves and are indicated as such by the CURRENT SHARE indicator LED on the front panel of the power module. Since MST Power Modules are enabled sequentially, the enabled modules will generate output voltage errors until the minimum number of modules (N) are turned on; the user should ignore these error flags until all modules are enabled (SCPI provides a method of masking these flags using software). The same is true if modules are disabled sequentially.

3.6 SERIES OPERATION

MST Power Modules are designed to allow series operation to achieve higher output voltage if desired. Series operation requires detailed investigation into all possible output conditions which may result from either normal or abnormal operation to ensure that the power supplies are not exposed to undue stress, especially voltage. This need is increased for MST Power Modules which, because of the sequential turn-on characteristic, may be exposed to greater risk during output enabling and disabling sequences. Users wishing to operate MST Power Modules in series are directed to contact Kepco Applications Engineering for specific guidance.

3.7 FAULT PROTECTION

In addition to providing protection against externally generated faults, MST Power Modules incorporate fault protection circuitry which protects the load in the event of an internal failure or malfunction which may result in loss of output control. The fault classifications are output overvoltage, output overcurrent, internal overtemperature, source power loss and open sense wire. A description of the fault detectors associated with these faults is provided in the following paragraphs.

The response of the Power Module to any of these faults (except for open sense/power lead) is a fault shutdown procedure consisting of the following:

- All output power and signal relays are immediately opened, isolating the Power Module from the load;

- Output voltage and current are programmed to zero;

- The dc-dc converter which powers the output stabilizer is latched off;
- A fault status flag is sent to the Controller indicating a catastrophic failure. Upon receiving a fault status flag, the Controller removes that Control Bus address from the look-up table, preventing further commands from being directed to the faulty power module.

If an open sense lead or open power lead condition is detected, the fault shutdown procedure is as follows:

- All output power and signal relays are immediately opened, isolating the Power Module from the load;
- Output voltage and current are programmed to zero;
- A fault message is sent to the controller (Load Path Fault in CIIL, Relay Error in SCPI).

3.7.1 FAULT RECOVERY

Recovery from a fault status flag condition (described above) requires that the user cycle source power off for a minimum of 5 seconds. After reapplication of source power, a device reset command (RST) must be sent to the module's Control Bus address to restore the address to the look-up table. This procedure eliminates any possibility of casual reapplication of a Power Module to the system load after symptoms of a catastrophic module failure have been detected.

3.7.2 TRACKING OVERVOLTAGE AND OVERCURRENT DETECTORS

The output stabilizer control circuitry of the MST Power Module includes separate overvoltage and overcurrent tracking amplifiers. These devices monitor the actual output voltage and current supplied by the Power Module and compare them to the programmed voltage and current values. In the event that either parameter exceeds the programmed limit by an amount equal to 10% of the Power Module's rated voltage or current, the circuit initiates a fault shutdown procedure including a Device Power Loss status flag. The tolerance of the fault thresholds are ±3%.

3.7.3 OVERTEMPERATURE DETECTORS

Any one of a number of internal or external conditions (i.e., elevated ambient temperature, clogged vent holes, cooling fan failure, etc.) can cause elevation of internal heat sink temperatures to unsafe levels. If unattended, the resultant temperature rise of the power devices will lead to eventual destructive failure. MST Power Modules incorporate two internal thermostatic switches to detect unsafe internal operating temperatures. One is located on the heat sink related to the input preregulator and dc-dc converter, while the second monitors the heat sink related to the output stabilizer. If the temperature of either heat sink rises above a predetermined safe temperature, the related thermostat will change state, initiating a fault shutdown and generating a Device Overtemperature status flag. The thermostat will reset upon return of the heat sink to acceptable operating temperature, however the module recovery procedure (see PAR. 3.7.1) must still be performed.

3.7.4 A-C LOSS DETECTOR

Although MST Power Modules are designed to provide a minimum of 21.5 milliseconds of output hold-up time (one full cycle of 47Hz power), loss of source power for extended periods will eventually result in complete Power Module shutdown. Additionally, certain power loss intervals can create a condition where the internal bias supply for the digital control circuitry decays partially, but not enough to force a system interrupt and reset; when this occurs, it is possible that digital communication and processing can be corrupted without warning or notice. To prevent this, MST Power Modules incorporate a power loss detector which will initiate a fault shutdown with an accompanying Device Power Loss status flag if the internal bulk d-c storage capacitor voltage falls to a level where quality of the internal bias voltages is questionable.

3.7.5 OPEN SENSE/POWER WIRE PROTECTION

In the event that the error sense leads (+S, -S) become disconnected from the power leads, the output voltage will attempt to rise uncontrollably; the MST Power Module fault detection circuitry continuously monitors the error sensing leads to protect against this occurrence. If an open sense lead or power lead condition is detected, the fault detector immediately issues a string of commands which reset the output status to Voltage Mode, Output Disabled (all output relays open) and programs the output voltage and current limit to zero. At the same time, a fault message is sent to the controller (Load Path Fault in CIIL, Relay Error in SCPI). Once the open sense or power lead condition is corrected, the power module is ready to accept additional commands without any further recovery measures; manual reset is not required.

The open sense/power wire protection circuitry can also be triggered by a power lead voltage drop in excess of the 0.5V maximum specified headroom. If the error sense lead connections appear to be correct, the user should double-check the size of the power leads to verify adequate margin. Contact Kepco Applications Engineering for assistance if necessary.

SECTION 4 - THEORY OF OPERATION

4.1 GENERAL

The MST Power Module is a digitally controlled voltage and current stabilized d-c source with a sharp crossover between the voltage and current mode of operation. Digital commands received from the companion Kepco Power Module Controller determine the MST Power Module output. The transmission of digital commands between the controller and MST Power Modules is done over the two wire bi-directional IEEE 1118 Control Bus operating at 375 KHz.

4.1.1 OPERATING MODE

The output voltage E_O and output current I_O of the MST Power Module is determined by their programmed values and by the magnitude of the load resistance (R_L). The crossover resistance (R_{LX}) is given by Ohm's Law $R_{LX} = E_p/I_p$ (see Figure 4-1), where E_p and I_p are programmed voltage and current regulation points.

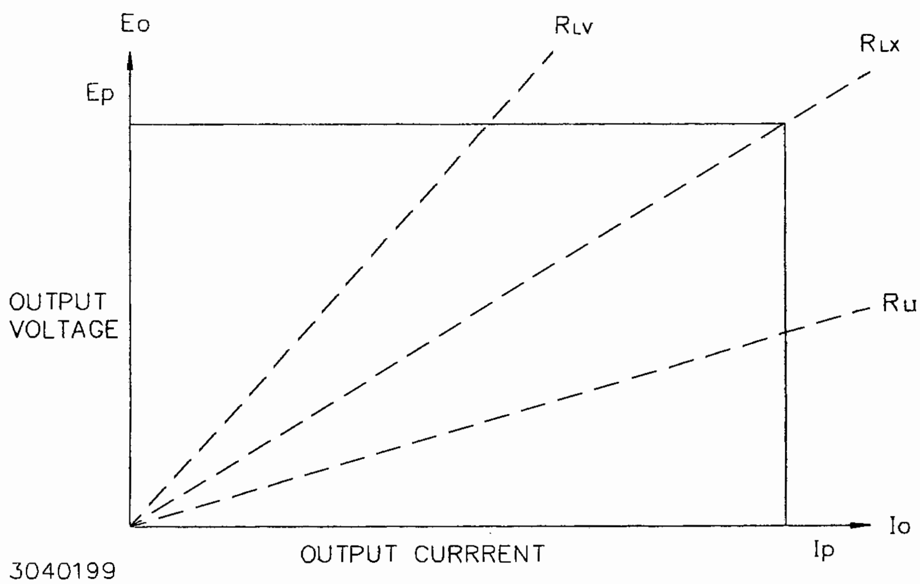


FIGURE 4-1. CROSSOVER CHARACTERISTICS

4.1.2 MST MODULE CROSSOVER CHARACTERISTICS

When the Power Module is programmed to operate as a voltage source with current limit, and the load resistance becomes smaller than R_{LX} (for example R_{LI} in Figure 4-1), the MST Power Module will go into current limit, generating an Overload error message. With a load resistance larger than R_{LX} (for example R_{LV} in Figure 4-1), the MST module will operate as a voltage source and no error message will be issued. The actual output voltage E_O is equal to the programmed voltage E_p whereas the actual output current is determined by the load resistance R_L according to Ohm's law: $I_O=E_O/R_L$.

If the Power Module is programmed to operate as a current source with voltage limit, and the load resistance becomes larger than R_{LX} (for example R_{LV} in Figure 4-1) the MST Power Module will go into voltage limit, generating an Overload error message. With a load resistance smaller than R_{LX} (for example R_{LI} in Figure 4-1) the MST Module will operate as a current source and no error message will be issued. The actual output current I_O is equal to the programmed current I_p whereas the actual output voltage is determined by the load resistance R_L according to Ohm's Law: $E_O = I_O \times R_L$

4.1.3 VOLTAGE COMPARISON EQUIVALENT CIRCUIT

In voltage mode of operation, a voltage comparison amplifier scales and compares the feedback signal from the output voltage with a 0 to +10V Reference Potential generated from a Digital to Analog Converter (DAC) (see Figure 4-2).

A condition of balance exists if $E_O/R_f = E_i/R_i$ and thus ε (see Figure 4-2) approaches zero. A change in either E_i or E_O in the balance equation produces an error signal which, when amplified by the voltage comparison amplifier, becomes a control signal for the MST Power Module driver stage. The control signal is then applied to the pass element (power transistor) to increase or decrease its conductance in order to maintain a desired value of output voltage.

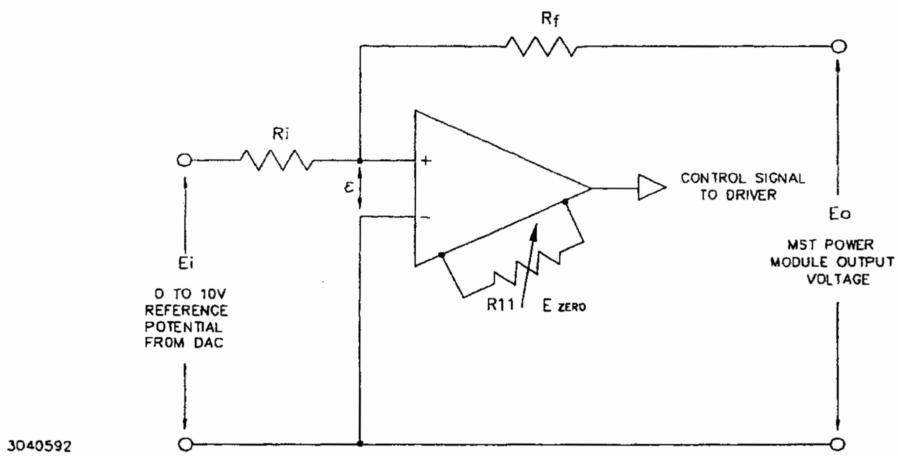


FIGURE 4-2. VOLTAGE COMPARISON EQUIVALENT CIRCUIT

4.1.4 CURRENT COMPARISON EQUIVALENT CIRCUIT

In current mode of operation, a current comparison amplifier scales and compares a feedback signal proportional to the output current to a 0 to +10V Reference Potential. The Reference Potential is generated by another Digital to Analog Converter (see Figure 4-3).

The current feedback is proportional to the flow of output current and is developed through a current sensing resistor R_S in series with the Output Terminal 1 lead. The sensed voltage across R_S is amplified differentially by the current sensing amplifier and then calibrated by a current full scale adjustment amplifier to produce a voltage signal of 0 to –10V which is proportional to the output current.

A condition of balance exists if $G\, I_O R_S/R_f = E_i/R_i$ and thus ε (see Figure 4-3) approaches zero, where G is the gain of the current sensing amplifier. A change in E_i or I_O in the balance equation produces an error signal that, when amplified by the current comparison amplifier, becomes a control signal for the driver stage. The control signal is applied to the pass element (power transistor) to increase or decrease its conductance in order to maintain a desired value of output current.

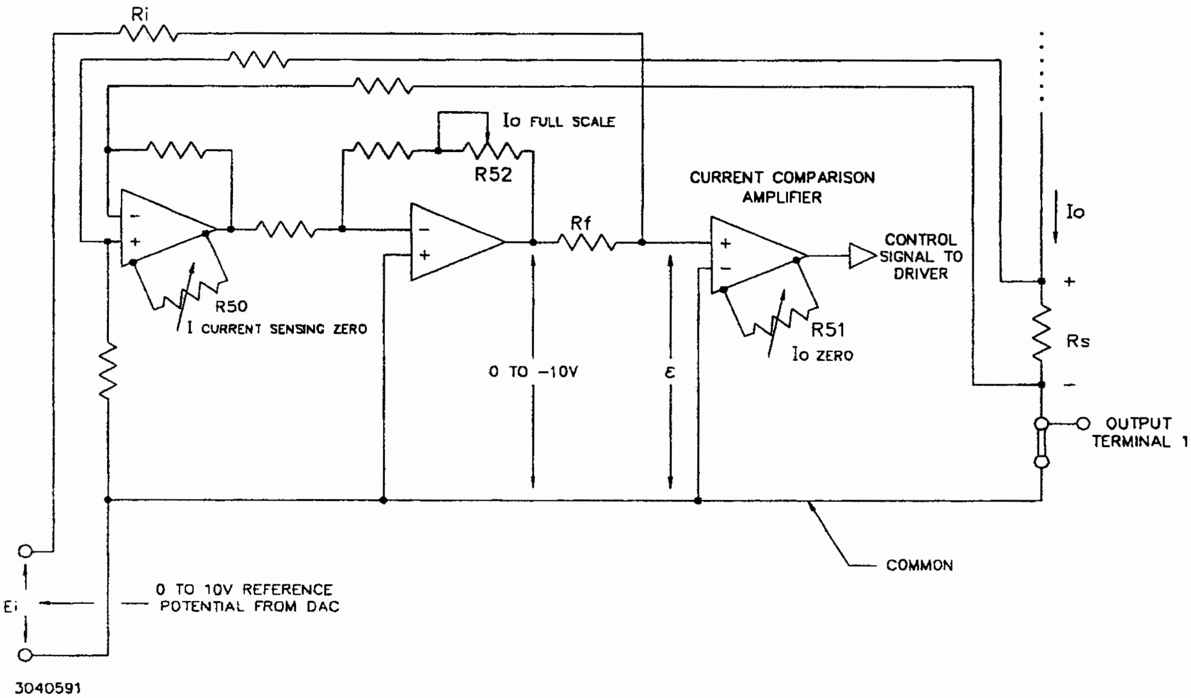


FIGURE 4-3. CURRENT COMPARISON EQUIVALENT CIRCUIT

4.1.5 OUTPUT VOLTAGE AND OUTPUT CURRENT, BUFFER UPDATING

Output voltage and output current are continuously monitored and scaled to 0 to +5V by the voltage and current comparison sensing amplifiers. Two channels of an Analog to Digital Converter (ADC) convert these analog voltages (0 to +5 V d-c) into equivalent digital signals. These digital signals are stored in buffers and updated every one millisecond to new values. On demand from the Controller, the contents of the output voltage or output current buffer are sent to the Controller over the two wire Control Bus.

The digital contents of the output voltage and current buffer are also used to make vital decisions regarding Normal and Abnormal error messages or to terminate the dynamic time-out delay. The end of the dynamic time-out is determined by 3 consecutive "within-specified limit window" determinations of the output parameter (voltage or current) that is being programmed. Any voltage or current reading at the end of the time-out that differs from the programmed value (voltage in commanded Voltage, current in commanded Current mode) by more than 0.25% of full scale value will trigger a Voltage or Current comparison error message. (For example, if Full scale = 100V and Programmed voltage is 20V, 0.25% of 100 = 0.25V; errors occur if the actual voltage is lower that 19.75V or higher than 20.25V.)

4.1.6 PROTECTION FEATURES

4.1.6.1 OVERVOLTAGE AND OVERCURRENT TRACKING CIRCUITS

Among the protective circuits designed for the MST Power Module are overvoltage and overcurrent tracking circuits. These circuits continuously monitor the output voltage and current and compare them with the overvoltage and overcurrent reference potentials. These two references are set at approximately 10% of the full scale reading above the references described in PARs. 4.1.3 and 4.1.4 which are used for error signal generation.

4.1.6.2 SHUTDOWN CIRCUIT

If the voltage or current exceeds the programmed voltage or current by the above established limits, a shutdown circuit is activated. The circuit will cause disabling of the power supply, and the front panel Fault LED will light. A Fault error message is issued and stored in the error buffer.

4.1.6.3 POWER LOSS AND OVERTEMPERATURE PROTECTION

Another additional protective circuit allows the MST Power Module to detect a temperature increase on the power transistor heat sink. An Overtemperature error message is generated if the temperature goes beyond an established limit. There is also a circuit to detect a-c input power loss and issue a Power Loss error message.

4.1.6.4 OPEN SENSE/POWER WIRE PROTECTION

MST Power Module fault detection circuitry provides continuous monitoring of the error sensing leads and power leads to protect against an uncontrollable rise in output voltage due to (a) disconnection of an error sense lead (+S, -S) from the power lead, (b) disconnection of a power (load) lead, or (c) a power lead voltage drop in excess of the 0.5V maximum specified headroom. If an open sense lead or open power lead condition is detected, the fault detector immediately issues a string of commands which reset the output status to Voltage Mode, Output Disabled (all output relays open) and programs the output voltage and current limit to zero. At the same time, a fault message is sent to the controller (Load Path Fault in CIIL, Relay Error in SCPI). Once the open sense/power lead condition is corrected, the power module is ready to accept commands without any additional recovery procedures.

4.1.6.5 AUTOMATIC TURN-OFF OF THE MST POWER MODULE

Error conditions that turn off the MST Power Module also generate flags that are sent out on the High Priority Interrupt line of the microprocessor. This allows error messages to be sent and stored in the Controller before the MST d-c power is completely lost. These flags are:

- Fault
- Overtemperature
- Power loss

4.1.6.6 REVERSE POLARITY PROTECTION

A silicon diode in parallel with output terminals is used to protect the Power Module in the event that a voltage of opposite polarity to the programmed polarity appears at the output terminals.

4.2 MST SERIES BLOCK DIAGRAM CIRCUIT DESCRIPTION (FIGURE 4-4)

4.2.1 INPUT POWER CONDITIONING

Three wire single phase ac power enters the MST power supply via the rear AC/Control Bus connector which mates to the backplane of the RA 55 Rack Adapter. The line phase includes a series fuse to protect the input power source against failure (short) of the MST power supply. A transient suppression device in the input power path protects against lightning strikes. This is followed by EMI filtering, the POWER on/off switch, and additional EMI filtering.

4.2.2 BOOST CONVERTER AND POWER FACTOR CORRECTION CIRCUIT

The main internal d-c voltage is obtained from the rectified ac input via a boost converter which also provides power factor correction. The Power Factor Correction circuit makes the MST module appear as a virtual resistive load to the input source, minimizing input power distortion due to capacitive reactance of the input filter.

The filtered, switched ac from the Input Power Conditioning circuit is fed through a full wave bridge rectifier which allows the PFC to operate as a single quadrant converter, i.e. it always sinks current from a positive voltage source. The PFC operates at approximately 66KHz, providing a rectified sine wave which is used by the control circuit to scale the input current and create an approximate sine wave of input current, in phase with the input voltage.

The resultant 400V d-c output is applied to a d-c:d-c forward converter whose output voltage is dependent on the associated MST model, and to a flyback converter for internal use.

4.2.3 D-C:D-C POWER STAGE

The D-C:D-C power output stage converts the 400V d-c from the boost converter to the programmed output voltage. Output voltage is controlled by the voltage feedback from the pass transistor.

4.2.4 INTERNAL POWER SUPPLY

The internal power supply provides bias and reference voltages used throughout the power module circuitry. The return supply prevents the pass transistor from being either cut off or saturated, ensuring a quick response to programmed commands under all load conditions.

4.2.5 PASS TRANSISTOR, THERMOSTAT

The series regulator transistor is located on a specially constructed heat sink cooled by a fan. The pass transistor is connected in series with the (unregulated) main d-c supply and the output. The effective series resistance of the pass transistor is changed to keep the output voltage (voltage mode) or current (current mode) constant. The control signal for the series pass transistor is received from the Analog Control circuit.

A thermostat near the pass transistor provides an overtemperature indication to the Digital Control circuit if the safe operating temperature range of the pass transistor is exceeded.

4.2.6 CURRENT SENSING RESISTOR, OUTPUT CAPACITOR

The current sensing resistor between the series regulator and the output is used to sense the output current. The voltage drop across this resistor is the current feedback signal (see PAR.4.1.4.)

An important feature of programmable Power Modules is to have a fast response to input commands. The programming speed is determined primarily by the size of the output capacitor. For fast programming speed, the output capacitor should be removed or should be reduced in value. However, a large output capacitor at the output is desirable to maintain low output ripple and noise, to increase stability and to provide a large reservoir of energy for fast recovery to step load changes.

When the output voltage is increased in response to a command, the output capacitor will charge. The charging time is determined by the Power Module current limit setting. The larger the current limit setting, the shorter the charging time.

For a command calling for a reduction in output voltage the output capacitor will discharge. The discharge time is determined by the load resistance and the return supply, ***not*** the Power Module current-limit setting. This leads to the maximum limit recommended for the external capacitor which will still allow "dry switching."Even if the output capacitor has a small value, for light loads the discharge time will be a very long one.

4.2.7 ANALOG CONTROL CIRCUIT

- The function of the Analog Control circuit is to compare Reference Voltages with the voltage and current feedback signals from the power section. The Analog Control circuits generate the control signals for the power section and contains the following circuits:
- Voltage and Current Reference Circuit
- Voltage Comparison Amplifier
- Voltage Monitor Amplifier
- Overvoltage Tracking Amplifier
- Overvoltage Comparator
- Current Comparison Amplifier
- Current Sensing Amplifier
- Current Full Scale Calibration Amplifier
- Overcurrent Tracking Amplifier
- Overcurrent Comparator
- Voltage and Current Overrange Comparator
- Operating Mode comparator
- Analog Gate and Predriver Circuit
- Constant Current Return Supply Circuit

The Analog Control circuit is identical for all MST models with the exception of a few components, such as the voltage and current channel feedback scaling resistors, and the setting of the model identification switch (S1).

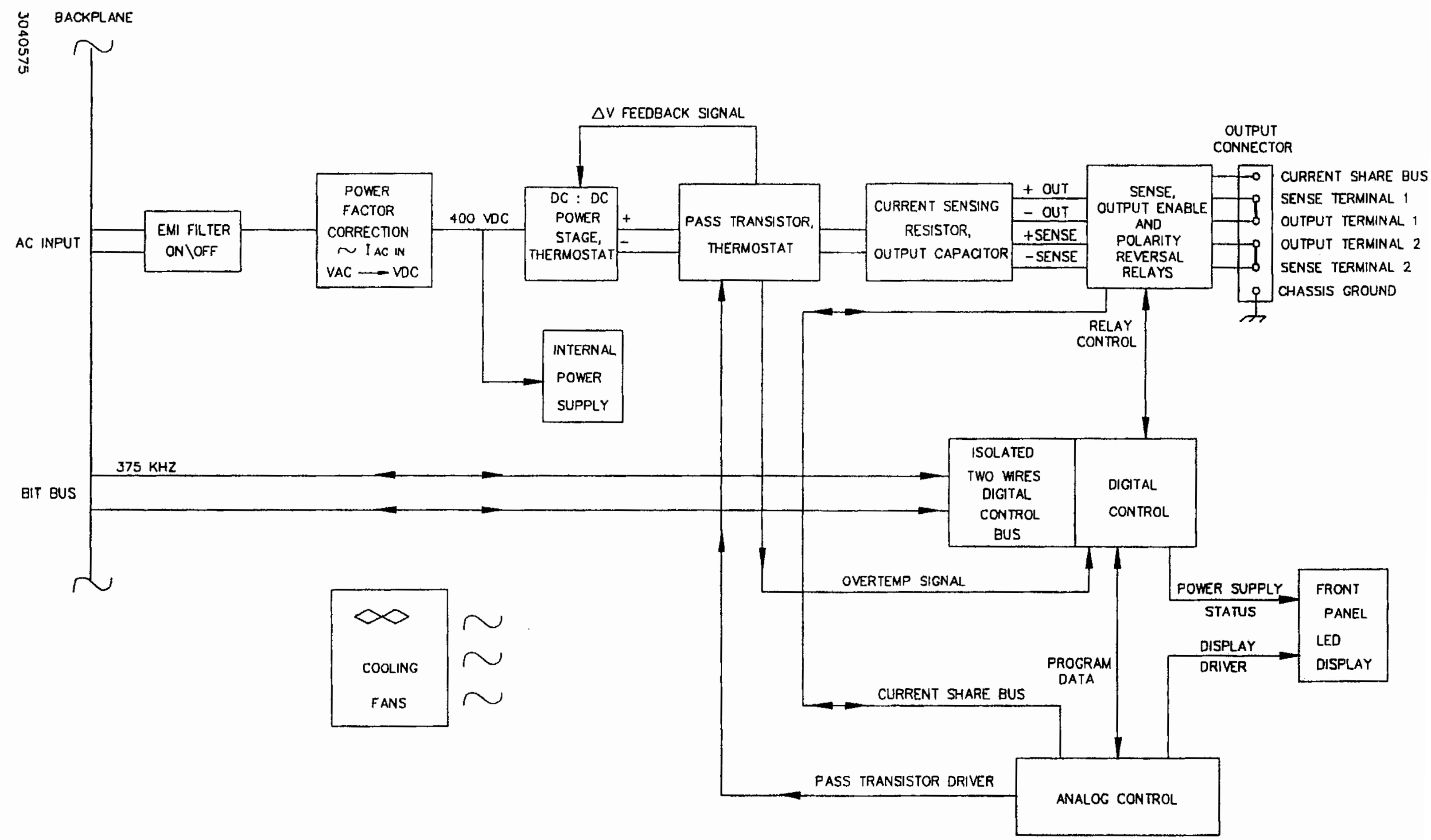


FIGURE 4-4. MST POWER MODULE BLOCK DIAGRAM

4.2.8 SENSE AND POLARITY RELAY CIRCUIT

The Sense and Polarity Relay circuit controls the opening, closing and sequencing of the power and sense relays. This circuit is identical for all MST models and contains the following circuits:

- Logic Circuit for Open/Close Command Sequencing.
- Sense, Output and Polarity Reversal Relays and their Drivers.

This circuit implements the output enable, disable and polarity reversal functions. (See PAR. 3.4 for a definition of enable/disable for both voltage and current modes.) These functions are achieved by activating two of the four power relays and one of the two signal relays. The power relays connect, disconnect or reverse the power module output leads at the rear DC OUTPUT CONNECTOR. The signal relays perform the same functions as the power relays, but they act on the sense leads instead of power leads.

A special sequence is implemented in closing and opening these relays. With a Close command, the power leads are connected to the load first and then the sense leads are connected. For the Open command the sense leads are disconnected first and the power leads afterwards. This sequence avoids the flow of large load currents through the sense relays and sense wires.

To increase the reliability of the MST Power Module operation, a "Dry" switching technique is used. Anytime a command is received from the Controller to Close, Open, or Reverse Polarity of relays, or change the operating mode (voltage or current) the following sequence is implemented:

a. Store the previous or the new values for voltage and current.

b. Program the Voltage and Current References to zero (see PAR. 4.1.5).

c. Wait until zero volts output is established, if less than 2 seconds.

d. Close, open or reverse polarity.

e. Reprogram the output voltage and current to the stored values.

During the above sequence, flags that trigger error messages are inhibited (masked out of the error buffer).

4.2.9 OUTPUT TERMINALS AND D-C CONNECTOR

The internal output terminals and the rear DC OUTPUT connector terminals are connected via four power relays. These relays enable, disable or reverse polarity at the DC OUTPUT connector in either voltage or current mode of operation. With a positive voltage programmed, Terminal 1 will be positive with respect to Terminal 2.

The rear DC OUTPUT connector has two contacts dedicated to the two sense wires (Sense Terminal 1 and Sense Terminal 2). For proper operation the sense wires and load wires should be connected together at the load. The proper connections are as follows:

- Sense Terminal 1 connected with Output Terminal 1.
- Sense Terminal 2 connected with Output Terminal 2.
- Current Share (when used with associated power module connected in parallel configuration) connected to like terminal.

4.2.10 DIGITAL CONTROL CIRCUIT

The Digital Control circuit receives digital commands (over the two wire IEEE 1118 Control Bus) which generate the two reference analog signals (voltage and current). These analog signals control the output of the Power Module. The data processing intelligence of the MST Power Module is contained within the Digital Control circuit. The conversion of digital commands to analog signals, and also analog output voltage and current to digital signals are performed by this circuit. It is identical for all MST models and has the following:

- Isolated two wire IEEE Digital Control Bus Circuit
- High Speed Optoisolators
- Microprocessor and Clock Generator
- Proprietary PROM
- Data RAM
- Decoders and Buffers
- Channel Address Selector Switches
- Dual Digital to Analog Converters
- Measurement Analog to Digital Converter
- Fault Detection Circuit
- AC Power Loss Circuit
- ±15V d-c Regulators
- +5 Volt Precision Reference Circuit
- –5 Volt Regulator

4.2.11 DISPLAY CIRCUIT

The Display circuit generates the signals to drive the LED front panel meters as well as the LED indicators. This circuit is identical for all MST models (except for voltage and current measurement scaling resistors, and decimal point location) and has the following components:

- Two LED Panel Meters
- Six LED Indicators

SECTION 5 - MAINTENANCE

5.1 GENERAL

This section covers basic maintenance and calibration of the Kepco MST Series Power Modules. Removal of the Power Module from the RA 55 or CA 400 Rack Adapter will permit access to unit subassemblies.

5.2 PERIODIC MAINTENANCE

Periodic maintenance consists of cleaning of the power module interior (PAR. 5.2.1) and recalibration of the unit (PAR. 5.5) as required.

5.2.1 CLEANING (REFER TO FIGURE 5-1)

To clean the unit, it is necessary to remove the cover (1) and A2 (7) and A4 (16) to gain access to the interior of the unit (see PAR. 5.3 for disassembly). Vacuum accumulated dust and dirt from the heatsinks (15), fans (11), and components of A1 through A4.

5.3 DISASSEMBLY/REASSEMBLY (REFER TO FIGURE 5-1)

WARNING

TURN POWER OFF AND DISCONNECT UNIT FROM POWER SOURCE BEFORE DISASSEMBLING.

CAUTION: **As disassembly proceeds, tag all components and connectors to facilitate reassembly. Retain screws and washers in carefully marked containers for reassembly. Reassembly using incorrect screws can damage the unit and cause errors.**

5.3.1 GENERAL

The following instructions contain a step by step procedure for disassembling the MST module.

1. It is suggested that a selection of Phillips head and slotted head screw drivers, a 1/4 in. hexdriver, as well as needlenose pliers be made available.

2. Place the MST Power Supply on its left side according to Figure 5-1. Remove the cover (1) by removing four screws (19) from the top of unit, six screws (2) from the side, one screw (3) from the rear, and two screws (4) from the bottom.

NOTE: To gain access to interior of unit for cleaning (PAR. 5.2.1) Perform steps 3 and 4, below; Otherwise refer to PAR. 5.3.2 to continue disassembly.

3. To remove PC board A4 (16), first lift two extractors at the side of connector J7 and disconnect ribbon cables at connectors J7and J3; Unplug the ribbon cable from connector J3 on the A4 board. A small slotted screwdriver should be used for this step (take caution not to damage the ribbon cable during handling). Tag and disconnect connectors at J6, J8, and J9. Remove four screws (18) and washers (17) and lift PC board A4 straight up so that two connectors on A4 disengage from corresponding connectors (J3 and J4) on PC board A3 (14).

LEGEND

1. COVER
2. SCREW (6)
3. SCREW
4. SCREW (2)
5. SCREW (4)
6. WASHER (4)
7. PC BOARD A2
8. SCREW
9. WASHER
10. HEADER (4)
11. FAN (4)
12. CHASSIS
13. PC BOARD A1
14. PC BOARD A3
15. HEATSINK (3)
16. PC BOARD A4
17. WASHER (4)
18. SCREW
19. SCREW (4)

NOTE: QUANTITIES ARE IN PARENTHESES.

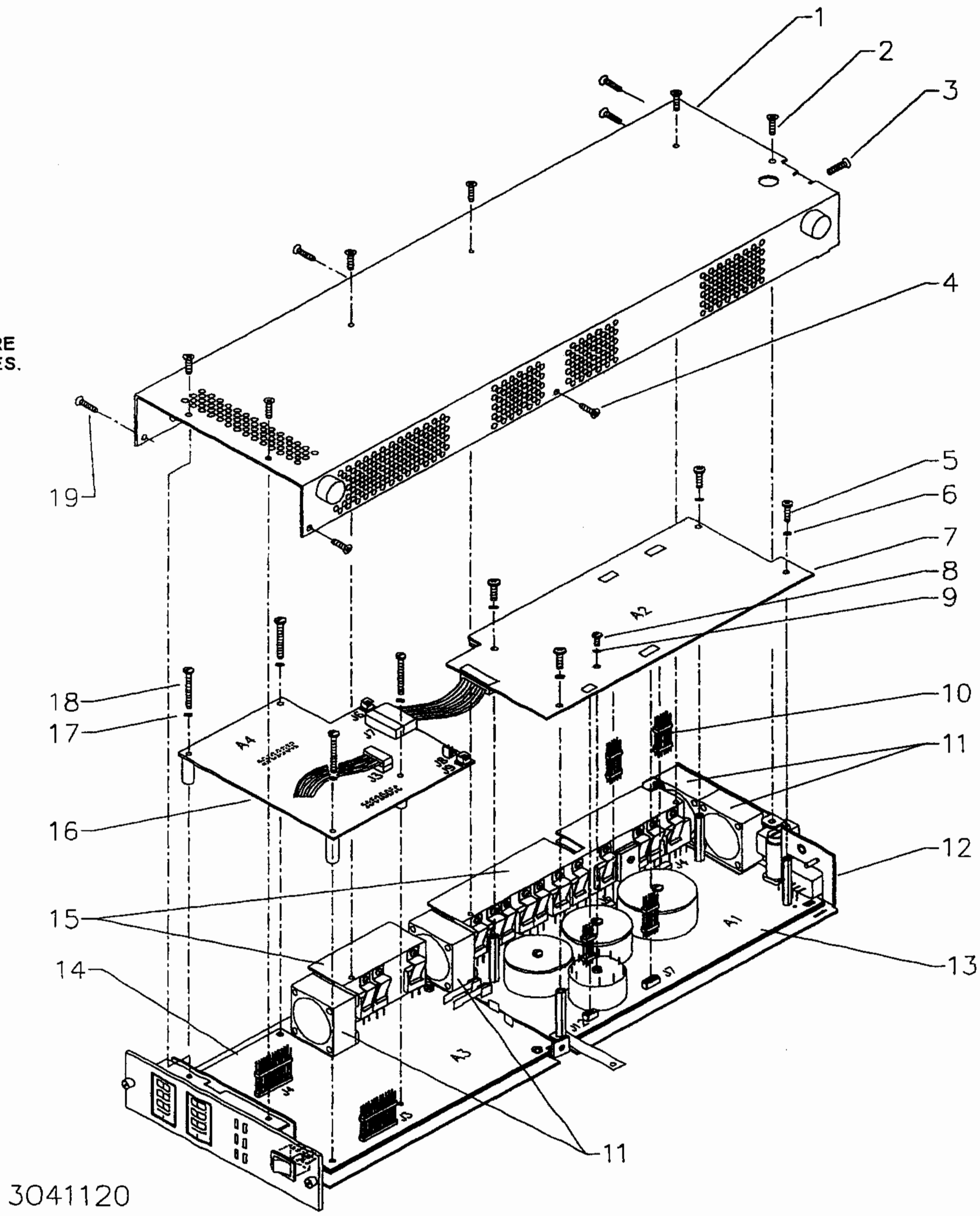


FIGURE 5-1. DISASSEMBLY

4. To remove PC board A2, remove four screws (5) and three washers (6), screw (8) and washer (9) and lift PC board A2 straight up so that four connectors on A2 disengage from corresponding connectors (J4, J6, J7 and J12) on PC board A1 (13).

5. Remove the fan plugs from connectors J18, J19, J20 (with the use of a small screw driver if needed). Remove four headers (10) from A2 connectors and install on corresponding connector (J4, J6, J7 and J12) of PC board A1 (13) for reassembly.

NOTE: Refer to PAR. 5.4 for reassembly; be sure to observe CAUTION (PAR. 5.4) during reassembly.

5.3.2 A2 BOARD REMOVAL (REFER TO FIGURE 5-2)

1. Remove four Phillips head screws (A21-A24) and one slotted head screw (A25) and associated washers from the A2 board.

2. Lift two extractors at the side of connector J7 and disconnect ribbon cables at connectors J7and J3; unplug the cables going to the connectors J7 and J8 located on the A4 board.

3. To remove PC board A2, remove four screws (5) and three washers (6), screw (8) and washer (9) and lift PC board A2 straight up so that four connectors on A2 disengage from corresponding connectors (J4, J6, J7 and J12) on PC board A1 (13).

4. Remove the fan plugs from connectors J18, J19, J20 (with the use of a small screw driver if needed). Remove four headers (10) from A2 connectors and install on corresponding connector (J4, J6, J7 and J12) of PC board A1 (13) for reassembly.

5. Remove the fan plugs from connectors J18, J19, J20 (with the use of a small screw driver if needed).

5.3.3 REMOVAL OF A3 AND A4 BOARDS

1. Remove A2 board from the Power Supply (see PAR. 5.3.2).

NOTE: If the gold connector-header pins between the A1 and A2 boards (see Figure 5-1) separate from their housings, reinsert the pins into their respective connector housings on the A1 board.

2. Remove the six Phillips head screws from the opposite side of the unit securing A3/A4 to the chassis.

3. Unplug the ribbon cable from connector J3 on the A4 board. A small slotted screwdriver should be used for this step. Take caution not to damage the ribbon cable during handling.

4. Unplug the AC harness that goes to connectors J10 and J11 on the A1 board (pry off with a small slotted screwdriver).

5. Remove two screws from left side of unit and remove the front panel from the module.

6. Remove the four screws (A41 to A44, Figure 5-2) on the A4 board as well as the two Phillips head screws (A31, A32) on the A3 board.

7. Unplug the cable that runs between connector J9 on board A4 and connector J3 on board A1 (pry off with a small slotted screwdriver).

8. Remove two screws securing heat sink to A3 board, then pull the A3 and A4 printed circuit boards about 1/2 inch away from the A1 board to disengage the two quick disconnect assemblies on the A1 board at J8 and J9. Move the A3 and A4 boards close to the output harness and away from the rest of the assembly to provide additional slack and pry off with a small slotted screwdriver.

9. Locate the quick disconnect assembly QD3 and QD4 on the A3 board and remove the cable going to these connectors (on the A3 assembly).

10. Unplug connector J2 on the A3 board and remove the A3 and A4 boards.

5.3.4 SEPARATING A3 AND A4 BOARDS

1. Use a small screw driver to remove the fan plug from connector J6 on the A4 board.

2. Remove two screws from left side of unit securing A3 board heatsink to chassis, then separate the A3 and A4 boards by gently wiggling the assemblies and prying apart.

3. Remove heatsink from A3 by loosening three screws securing three clamps attaching the heatsink to A3 components, then remove the fan from the A3 board heat sink by removing the two slotted screws (A3F1, A3F2, Figure 5-2).

5.3.5 A1 BOARD REMOVAL

1. Remove the two slotted head screws securing L7, insulator L71, T1, and insulator T11 on the A1 board, and also the Phillips head screw securing L3 and insulator L31 on the A1 board (see Figure 5-2).

2. Using a 1/4 inch nut driver or a needle nose pliers, remove the hex spacer at L3's center.

3. Using a 1/4 inch nut driver or a needle nose pliers, remove the nut securing the A1 ground wire to the chassis stud on top of connector J1 on A1 board.

4. With the same tools remove the four hex standoffs, but be very careful not to force them as they are made of aluminum and can snap off. (See PAR. 5.4.1 concerning the extreme care that should be taken during reassembly to avoid cross threading damage.)

5. Remove two screws from left side of unit securing A1 board heatsink to chassis, then slide the A1 printed circuit assembly from the base plate allowing the connector J1 to clear the opening it protrudes through.

6. Finally, remove the fan from the A1 heat sink by removing the two slotted screws.

5.3.6 OUTPUT CABLE REMOVAL

1. Using a 1/4 inch nut driver or a needle nose pliers, remove the two nuts securing the output ground wire (green) to the chassis stud. (It may be necessary to unsolder the output capacitors.)

2. Remove the two screws holding the output connector to the rear of the base plate. Note the exact location of the capacitors before they are removed.

3. Remove the black output harness through the hole in the rear of the base plate.

4. Remove the fans from the rear of the baseplate by unfastening the two slotted screws that hold each fan in place.

5.3.7 FRONT PANEL DISASSEMBLY

1. Remove the two screws holding the front handles.

2. Remove four screws, then pry the A5 assembly from the front panel.

3. Remove the two front panel meters by carefully pushing on the rear of the meters.

4. Remove the on/off switch S1 and the ac harness through the front of the panel.

5. Using a 1/4 inch nut driver or needle nose pliers, remove the four hex standoffs and mounting bracket.

5.4 REASSEMBLY

Reassembly is the reverse of disassembly using same hardware (see CAUTION, PAR. 5.3). Take care to align pins of connectors on PC boards A4 and A2 with corresponding connectors and headers on PC boards A3 and A1, press into place, and secure with hardware removed during disassembly.

CAUTION: Observe cross threading instructions (PAR. 5.4.1) to avoid damaging connector pins.

5.4.1 CROSS THREADING

When reassembling the A1 and A2 boards, great care must be taken to ensure that all the gold connector header pins line properly with their respective connectors on the A1 and A2 boards The four standoffs must line up with their respective holes on each of the corners of the A1 and A2 boards. The quick disconnect connectors QD1, QD2, QD3, and QD4 must be line up so that mating members can properly come together on the printed circuit boards.

5.4.2 CONTINUITY CHECK

After the MST Power Module is assembled, perform the following continuity check to verify that the connectors between the boards are making good electrical contact. Refer to Figure 5-2 and follow the steps indicated. Verify continuity across pins 7 and 9 of connector J16; and across pins 7 and 8 of connector J14 on board A2. If this is not the case, remove the A2 board and reseat all the connector headers on the A1 board. Reassemble the unit again and repeat the continuity check.

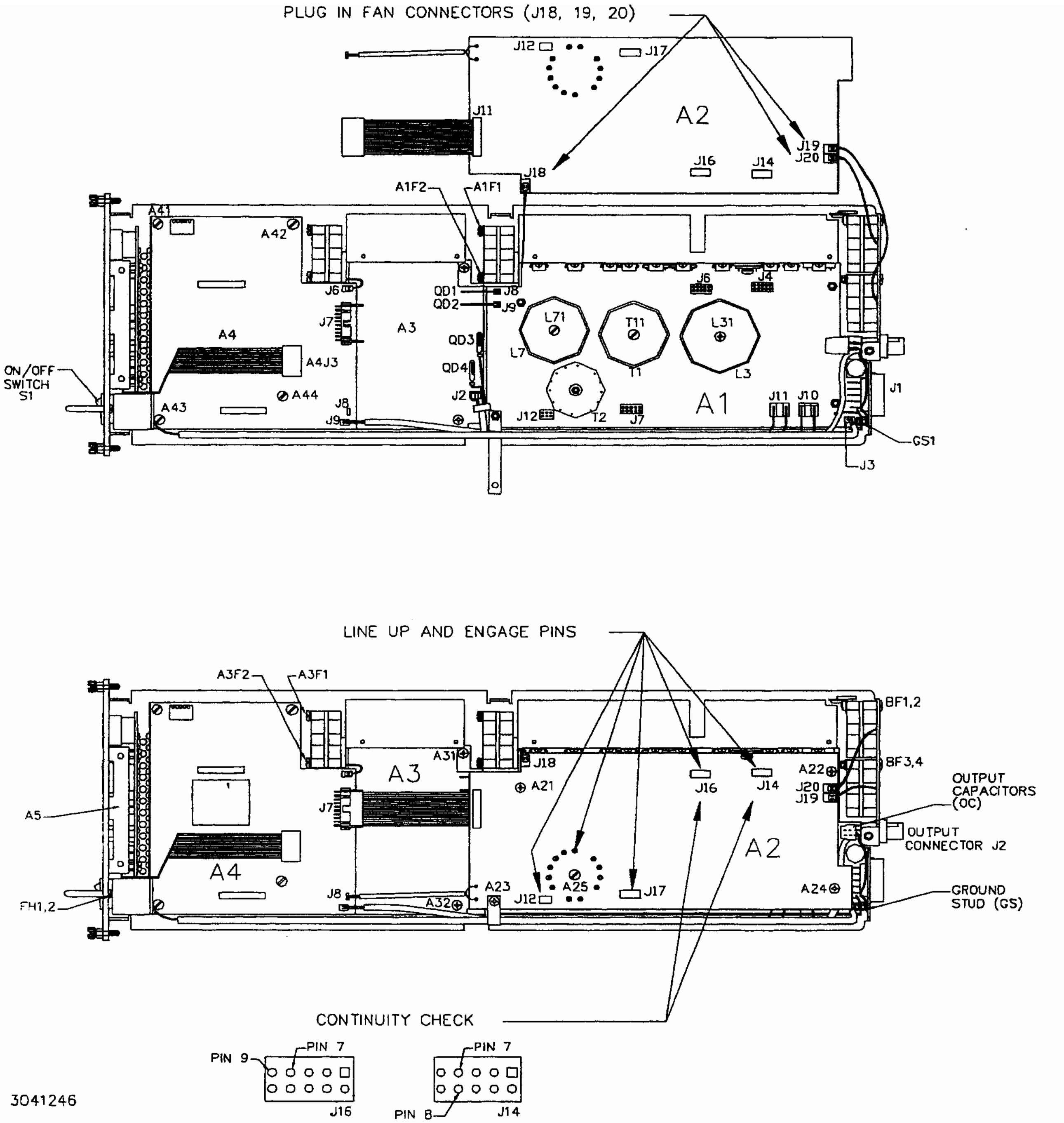


FIGURE 5-2. GUIDE TO MST REASSEMBLY

5.5 CALIBRATION

Calibration of the MST Power Module is recommended for any of the following conditions.

- The unit has been moved.
- Operating environment (temperature, humidity, etc.,) has been altered.
- Periodic maintenance determined by user.
- Inaccurate measurements are suspected.

Perform the procedures outlined below in sequence (see Figure 2-4 for the location of calibration controls). Calibration adjustments are recommended only when the test point value exceeds the indicated tolerance on the measured value. Note that the measured value tolerance is generally an order of magnitude looser than the adjustment tolerance. This avoids unnecessary recalibration, while providing a precision adjustment if calibration is required.

NOTE: E_{MAX} is the maximum output voltage of the unit listed in Table 1-1; I_{MAX} is the maximum output current of the unit as listed in Table 1-1 for 45° C.

5.5.1 EQUIPMENT REQUIRED

Calibration of MST Series Power Modules requires the following equipment:

- Host computer
- RA 55 or CA 400 Rack Adapter, or Input Power/Communication Cable (see Table 1-3)
- Controller Module (Kepco MST 488-27 or TMA Series)
- Digital Voltmeter (DVM): 6½ digit display, 10 μV resolution
- Precision Current Shunt: R_{SHUNT} < 0.02 (EMAX / IMAX)Ω

  where: E_{MAX} = rated Power Module output voltage (e.g., 36V for MST 36-5)
  I_{MAX} = rated Power Module output current (e.g., 5A for MST 36-5)

  NOTE: To avoid errors due to temperature drift of the shunt, a power rating of greater than 10 times actual dissipation is recommended. The above calculation results in a maximum shunt power dissipation of less than 4W, a 100W shunt is adequate for all models)

- Miscellaneous programming interface cables, load cables, etc.

Install the MST Series power module under test (UUT) in the calibration test set-up shown in Figure 5-3

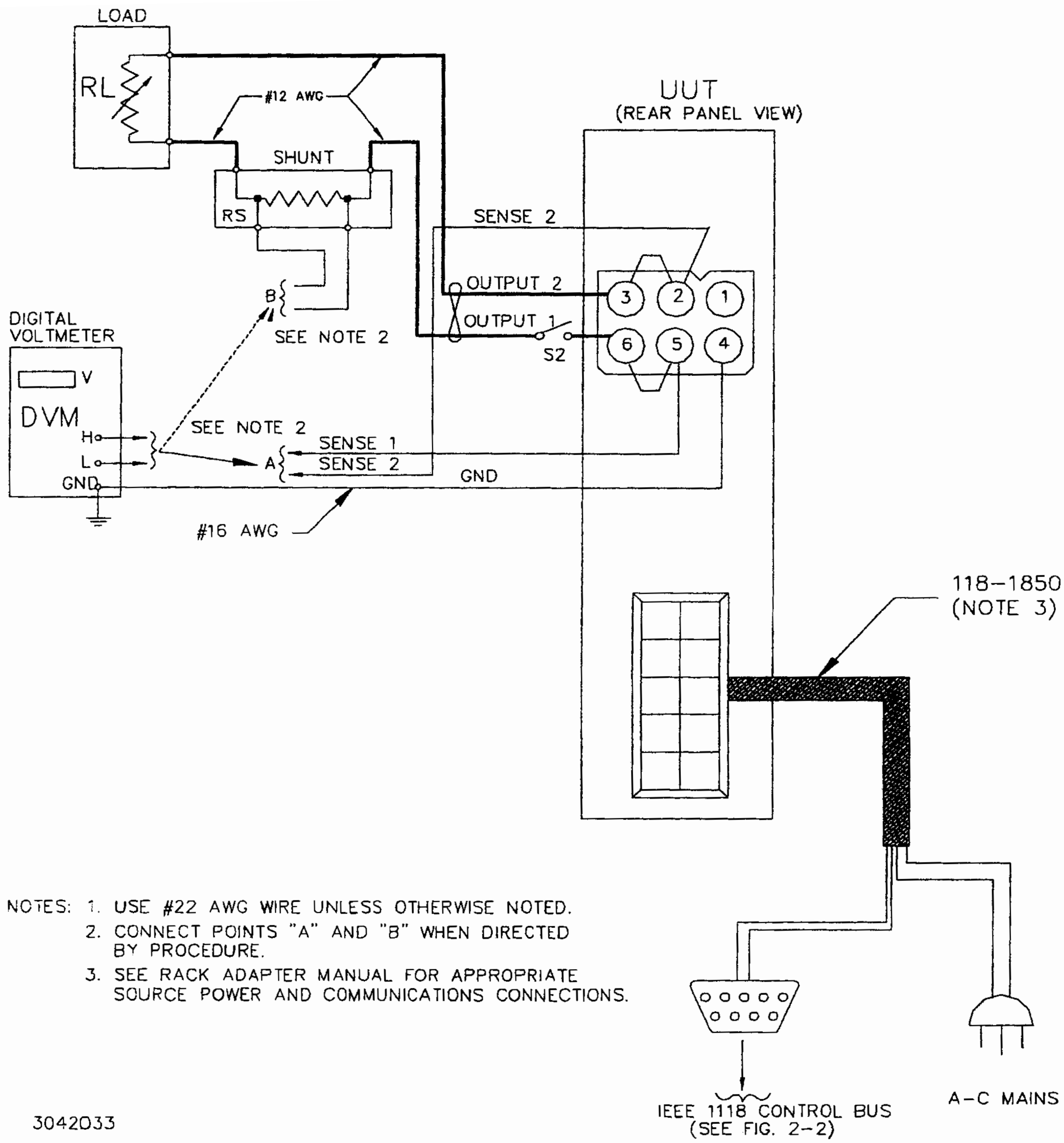


FIGURE 5-3. CALIBRATION TEST SET-UP

5.5.2 +5 VOLTS REFERENCE ADJUST (R49)

This procedure establishes the +5V reference voltage used by the analog circuits.

1. Disconnect the load and turn on the UUT. Proceed to step 3 if VOLTAGE MODE indicator is on.

2. If the CURRENT MODE indicator is on, issue a command from the host computer to set the UUT to Voltage mode. Verify that VOLTAGE MODE indicator is on.

3. Issue a command from the host computer to reset the UUT. This causes the UUT to be programmed to zero volts.

4. Connect the voltmeter to test connector J5, pins 1 (REF) and 6 (GND) (see Figure 2-4) and verify meter reads between 5.00000V ± 500µV volts. If meter reading is outside these limits, adjust potentiometer R49 for reading of +5.00000V ± 50µV.

5.5.3 OUTPUT VOLTAGE (E_O) ZERO ADJUST (R11)

This procedure adjusts the offset of the voltage comparison amplifier to be zero for a programmed output voltage of zero.

1. Configure DC OUTPUT connector as shown in Figure 2-3 and close S1.

2. With the load disconnected, issue a command from the host computer to enable the output (output relays closed). Verify OUTPUT ENABLED and VOLTAGE MODE indicators are on.

3. Connect DVM to DC output connector (see Figure 2-3) pin 5, Sense 1 (+) and pin 2, Sense 2 (–) and verify that output is 0V ± 500µV.

4. If the measured output is outside these limits adjust potentiometer R11 for reading of 0.00000V ± 50µV.

5.5.4 CURRENT SENSE ZERO ADJUST (R50)

This procedure adjusts the current sensing amplifier to zero with no current flowing through the current sensing resistor.

1. Issue command from the host computer to reset the UUT.

2. Verify VOLTAGE MODE indicator is on.

3. Connect voltmeter to test connector J5, pins 4 (CSNS - Current Sense) and 6 (GND) and verify meter reads 0.00000V ± 500µV. If meter reading is outside these limits, adjust potentiometer R50 for 0.00000V ± 50µV.

5.5.5 OUTPUT CURRENT I_O ZERO ADJUST (R51)

This procedure adjusts the offset of the current comparison amplifier to be zero for a programmed output current of zero.

1. Issue commands from the host computer to set the UUT to Current Mode, program output current to 0.0A, voltage limit to E_{MAX} and disable the output.

2. Verify CURRENT MODE indicator is on and OUTPUT ENABLED indicator is off.

3. Connect voltmeter to test connector J5, pins 4 (CSNS - Current Sense) and 6 (GND) and verify voltmeter reads 0.0000V ± 500µV. If voltmeter reading is outside these limits, adjust potentiometer R51 for 0.0000V ± 100µV.

5.5.6 VOLTAGE REFERENCE ADJUST (R47)

This procedure adjusts the internal full scale reference voltage to produce the full scale output voltage E_{MAX} when the full scale voltage is programmed.

1. Issue commands from the host computer to set the UUT to Voltage Mode, program current limit to I_{MAX}, output voltage to E_{MAX} and enable the output.

2. Verify VOLTAGE MODE and OUTPUT ENABLED indicators are on.

3. Connect the voltmeter to DC output connector (see Figure 2-3) pin 5, Sense 1 (+) and pin 2, Sense 2 (–) and verify measured value is within ± 1 LSB (1/4096) of E_{MAX}. If measured value exceeds the acceptable range, adjust potentiometer R47 to E_{MAX}, within the R47 adjustment tolerance of ± 0.5 LSB (1/8192) of E_{MAX}.

5.5.7 CURRENT REFERENCE ADJUST (R48)

This procedure establishes the maximum value of the internal current reference voltage so that the readback current matches the programmed current.

1. Turn off UUT and connect precision shunt across DC Output connector pin 6, Output 1 (+), and pin 3, Output 2 (–).

2. Turn on UUT.

3. Issue commands from the host computer to set the UUT to Current Mode, program output current (I_O) to 0.99 x I_{MAX}, voltage limit to E_{MAX} and enable the output.

4. Verify that CURRENT MODE and OUTPUT ENABLED indicators are on.

5. Issue commands from the host computer to read back current.

6. Verify that the read back value (step 5) is within ± 1 LSB (4096) of the programmed value (step 3). If readback value exceeds acceptable range, adjust R48 for readback value within ±0.5 LSB (1/8192) of the programmed value.

5.5.8 CURRENT (I_O) FULL SCALE ADJUST (R52)

This procedure adjusts the gain of the current sensing amplifier so that the actual full scale output current matches the programmed output current.

1. Issue commands from the host computer to set the UUT to Current Mode, program output current (I_O) to 0.99 x I_{MAX}, voltage limit to E_{MAX} and disable the output. The unit must be operating for a minimum of 20 minutes in Current Mode with output disabled to avoid drift due to temperature fluctuations.

2. Enable the output and verify that CURRENT MODE and OUTPUT ENABLED indicators are on.

3. Record the output current as measured across the external shunt.

4. Issue commands from host computer to read back current.

5. Compare the read back current (step 4) to the measured current (step 3). Verify that measured current is equal to readback current within the acceptable range of ± 1 LSB (1/4096) of I_{MAX}. If the acceptable range is exceeded, adjust R52 until measured current is within ±0.5 LSB (1/8192) of read back current, repeating steps 1 through 5 as necessary.

5.6 PERFORMANCE TESTING

Verification of all parameters specified in Section 1 of this manual requires a controlled environment (test chamber) and specialized test equipment; however, performance verification can be accomplished using standard test equipment as outlined in the following paragraphs. These procedures must be followed closely to ensure valid results. NOTE: Calibration procedure (PAR. 5.5) must be performed prior to performance testing.

5.6.1 EQUIPMENT REQUIRED

In addition to that specified in PAR. 5.5.1, the following test equipment is required:

a. **VARIABLE A-C INPUT SOURCE (ACS)**
Continuously adjustable over the ranges 90-132V a-c and 176-264V a-c
500VA minimum output power rating over full voltage range
20 ampere output surge capacity (50 ms) at both 85V and 170V a-c
Frequency selectable 50/60Hz

b) **RESISTIVE LOAD (RL)** - Continuously variable from minimum value to at least 10 times minimum value where RL (minimum) = (EMAX / IMAX)Ω , and load power rating > (EMAX * IMAX) watts

(NOTE: Care must be exercised to avoid loads which contribute their own output noise (esp. electronic loads) or which may artificially amplify the MST output noise (highly inductive resistive loads)).

c. **OSCILLOSCOPE (OS)** - 20MHz bandwidth (incl probes), 2mV/DIV vertical sensitivity

d. **LINE ISOLATION TRANSFORMER** - To be used in conjunction with oscilloscope (above)

e. **VARIABLE D-C POWER SUPPLY** - Adjustable output voltage continuously variable from zero to 1.2 * EMAX) volts at load currents from zero to 10mA

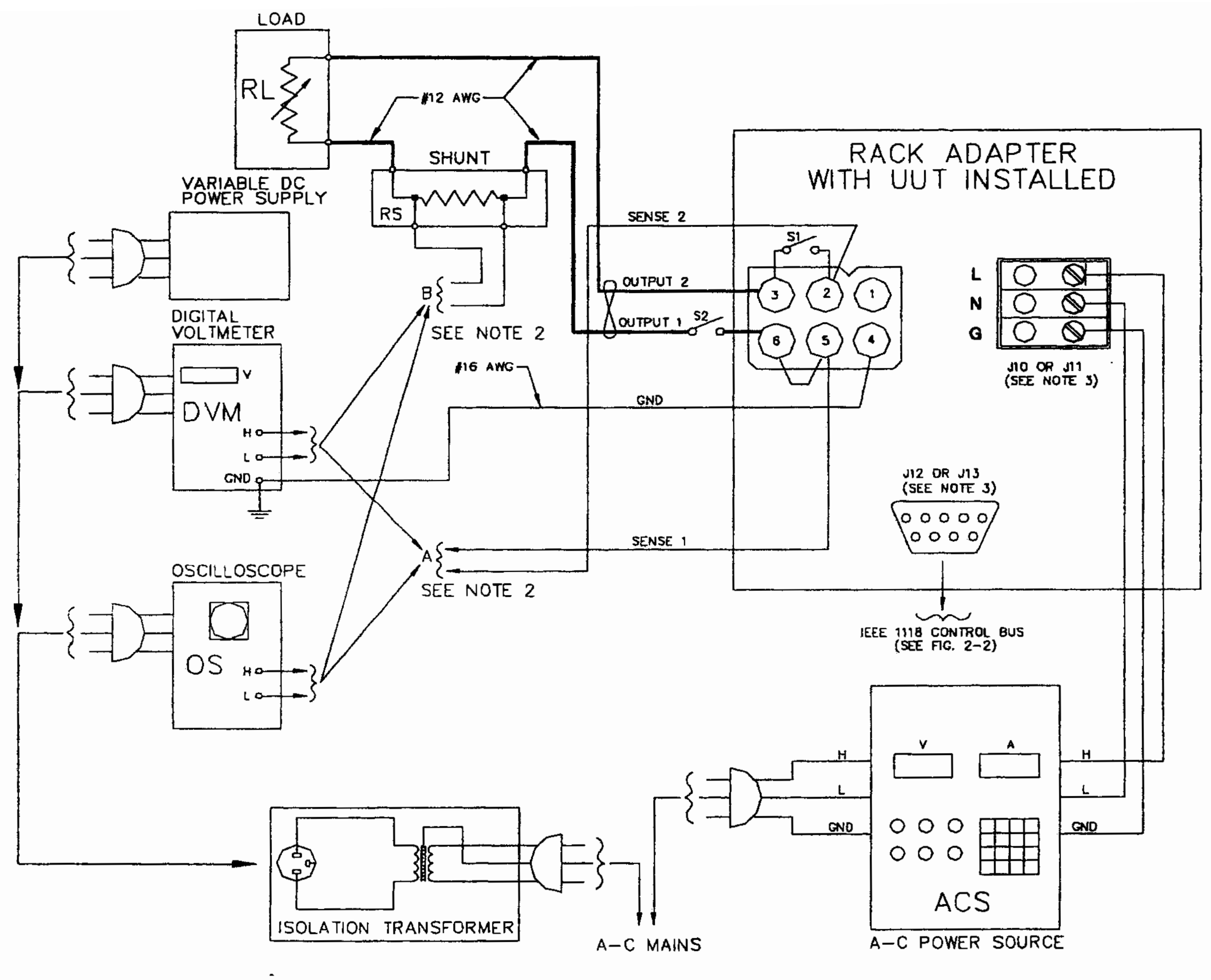
Install the MST Series power module under test (UUT) in the calibration test set-up shown in Figure 5-4. NOTE: Performance testing must be performed with MST Power Module installed in rack adapter.

5.6.2 OPEN SENSE LEAD/OPEN POWER LEAD TEST.

1. Apply a-c power first to the UUT, then to the Controller.

NOTE: If the sequence in step 1, above, is reversed (i.e., a-c power applied to the Controller first and MST power modules last), the operator must send an IEEE 488 Device Clear command via the Host Computer prior to issuing other commands.

2. Set switches S1 and S2 (Figure 5-4) to closed position.



NOTES: 1. USE #22 AWG WIRE UNLESS OTHERWISE NOTED.
2. CONNECT POINTS "A" AND "B" WHEN DIRECTED BY PROCEDURE.
3. CONNECTOR USED DETERMINED BY MST POSITION. BY PROCEDURE.

3041254

FIGURE 5-4. PERFORMANCE TEST SET-UP

3. Issue commands from the host computer to first initialize the UUT, then program it to Voltage Mode, program current limit to I_{MAX}, output voltage to E_{MAX} and enable the output. Verify VOLTAGE MODE and OUTPUT ENABLED indicators are on, OUTPUT FAULT indicator is off.

4. Open S1 to open the sense lead connection.

5. Verify that UUT VOLTAGE MODE indicator is on, all other LEDs are off.

6. Use DVM at DC Output connector of the rack adapter to verify output voltage is zero.

7. Issue commands from the host computer to verify that a fault message was sent to the controller (Load Path Fault in CIIL, Relay Error in CIIL).

8. Close S1 and repeat step 3; verify that output voltage returns to value programmed in step 3.

9. Open S2 to open the power lead connection and repeat steps 5 through 8.

10. Repeat steps 3 through 9 using $-E_{MAX}$ for voltage setting.

5.6.3 CURRENT SHARE TEST

This procedure verifies that the current share circuit is operating properly in both the master and slave configurations.

1. Connect the external DC Power Supply (–) to Sense 1 (pin 5) and (+) to Current Share (pin 1) pins of the RA 55 Rack Adapter Output connector.

2. Connect the Digital voltmeter across the Sense 1 (pin 5) and Current Share (pin 1) of the RA 55 Rack Adapter Output connector.

3. Set the variable load R_L equal to

$$R_L = 10 \times \frac{(E_{max})}{(I_{max})}$$

4. Turn ON the UUT.

5.6.3.1 MASTER CONFIGURATION

1. Issue commands from the host computer to first initialize the UUT, then program it to Voltage Mode, program current limit to I_{MAX}, output voltage to E_{MAX} and enable the output. Verify VOLTAGE MODE and OUTPUT ENABLED indicators are on, OUTPUT FAULT indicator is off.

2. Verify that DVM reading is 1 volt (±0.05 volt)

3. While monitoring the DVM and the front panel CURRENT meter on the UUT, slowly decrease the value of R_L until $R_L = E_{MAX}/I_{MAX}$. Verify that DVM readings increase in proportion to the increase in output current.

4. When the CURRENT MODE indicator goes on and the VOLTAGE MODE indicator goes off, verify that the DVM reads 10V ±0.5V and the UUT front panel CURRENT meter reads I_{MAX}.

5.6.3.2 SLAVE CONFIGURATION

1. Issue commands from the host computer to first initialize the UUT, then program it to Voltage Mode, program current limit to I_{MAX}, output voltage to $E_{MAX}/2$ and enable the output. Verify VOLTAGE MODE and OUTPUT ENABLED indicators are on, OUTPUT FAULT indicator is off.

2. Set the variable load R_L equal to

$$R_L = \frac{(E_{max})}{(I_{max})}$$

3. Turn ON the external DC Power Supply and set the output level to 0 volts.

4. Increase the output voltage of the external DC Power Supply until the CURRENT SHARE indicator goes on. Verify that DVM reads 5.6 volts, +/- 0.2 volts.

5.6.4 OVERVOLTAGE TEST

This procedure verifies that the MST Power Supply shuts down, according to the specifications in Section 1, when an overvoltage condition is present at the output terminals. The test is performed by back-feeding the MST Power Supply output terminals with an external DC Power Supply.

1. Issue commands from the host computer to first initialize the UUT, then program it to Voltage Mode, program output voltage to 0, current limit to 10% of I_{MAX} and enable the output. Verify VOLTAGE MODE and OUTPUT ENABLED indicators are on, OUTPUT FAULT indicator is off.

2. Increase the external Power Supply voltage slowly until the UUT shuts down and the OUTPUT FAULT indicator goes on. Verify that at the point of UUT shutdown, the external voltage is between 0.07% and 0.13% of rated model voltage (E_{MAX}).

3. Issue commands from the host computer to check status; verify that the Status message indicates an output fault condition.

4. Turn off external DC supply and UUT. After approximate 2 seconds (min), apply power to UUT and verify OUTPUT FAULT and OUTPUT ENABLED indicators are off, and VOLTAGE MODE indicator is on.

5.6.5 SOURCE EFFECT MEASUREMENTS

The following paragraphs provide source effect measurements for voltage mode and for current mode.

5.6.5.1 VOLTAGE MODE

NOTE: If using the high range nominal input voltage of 176-264V a-c, use values in brackets during the following procedure.

1. Set ACS (Figure 5-4) for 110V a-c [220V a-c] in accordance with NOTE above.

2. Disconnect load RL.

3. Issue commands from the host computer to first initialize the UUT, then program it to Voltage Mode, program current limit to I_{MAX}, output voltage to E_{MAX} and enable the output. Verify VOLTAGE MODE and OUTPUT ENABLED indicators are on, OUTPUT FAULT indicator is off.

4. Set ACS to deliver 90V a-c [176V a-c] and measure V_O (points "A" of Figure 5-4); record in appropriate cell of worksheet (see Table 5-1).

5. Set ACS to deliver 132V a-c [264V a-c] and repeat step 4.

6. Issue commands from the host computer to disable the UUT output. Verify VOLTAGE MODE indicator is on, OUTPUT FAULT and OUTPUT ENABLED indicators are off.

TABLE 5-1. SOURCE EFFECT WORKSHEET - VOLTAGE MODE

SOURCE VOLTAGE (ACS) SET TO (V a-c)	MEASURED V_O (V d-c)	
	NO LOAD	RATED LOAD
90 [176]		
132 [264]		
$\|\Delta V_O\|$		
SOURCE EFFECT		

7. Set load (RL) to be equal to, or greater than, V_{MAX}/I_{MAX}, in ohms. (e.g., for MST 6-20, set RL $\geq 6/20 = 0.3$ ohms).

8. Issue commands from the host computer to enable the UUT output. Verify VOLTAGE MODE and OUTPUT ENABLED indicators are on, OUTPUT FAULT is off.

9. Repeat steps 4 and 5.

10. Issue commands from the host computer to disable the UUT output. Verify VOLTAGE MODE indicator is on, OUTPUT FAULT and OUTPUT ENABLED indicators are off.

11. Compute the absolute variation of V_O over the range of source voltage for each load condition and record as $|\Delta V_O|$ in the appropriate cell of worksheet (see Table 5-1)

12. Compute Source Effect for both no-load and rated load conditions as follows:

$$\text{SOURCE EFFECT} = \frac{|\Delta V_O|}{E_{MAX}} \times 100$$

Verify that results are within the specified source effect limits of Table 1-2.

5.6.5.2 CURRENT MODE

Test performance as follows:

NOTE: If using the high range nominal input voltage of 176-264V a-c, use values in brackets during the following procedure.

1. Set ACS (Figure 5-4) for 110V a-c [or 220V a-c] in accordance with NOTE above.

2. Connect load RL and set RL to 0 ohm.

3. Turn on power to test equipment and MST power module (Figure 5-4).

4. Issue commands from the host computer to first initialize the UUT, then program it to Current Mode, program current to I_{MAX}, voltage limit to E_{MAX} and enable the output. Verify CURRENT MODE and OUTPUT ENABLED indicators are on, OUTPUT FAULT indicator is off.

5. Set ACS to deliver 90V a-c [176V a-c] and measure V_{RS} (points "B" of Figure 5-4); convert to current using the formula $I_O = V_{RS}/RS$ and record in appropriate cell of worksheet (see Table 5-2).

TABLE 5-2. SOURCE EFFECT WORKSHEET - CURRENT MODE

SOURCE VOLTAGE (ACS) SET TO (V a-c)	MEASURED* I_O (A d-c)	
	NO LOAD	RATED LOAD
90 [176]		
132 [264]		
$\|\Delta I_O\|$		
SOURCE EFFECT		
* VOLTAGE MEASURED ACROSS RS CONVERTED TO I_O BY $I_O = V_{RS}/RS$		

6. Set ACS to deliver 132V a-c [264V a-c] and repeat step 5.

7. Issue commands from the host computer to disable the output. Verify VOLTAGE MODE indicator is on, OUTPUT FAULT and OUTPUT ENABLED indicators are off.

8. Set load (RL) to be equal to, or less than, V_{Omax}/I_{Omax}, in ohms. (e.g., for MST 25-8, set RL $\leq$25/8, 3.125 ohms for example).

9. Issue commands from the host computer to enable the output. Verify that CURRENT MODE indicator is on; if not, adjust RL until CURRENT MODE indicator goes on.

10. Set ACS to deliver 90V a-c [176V a-c] and repeat step 5.

11. Set ACS to deliver 132V a-c [264V a-c] and repeat step 5.

12. Issue commands from the host computer to disable the output. Verify VOLTAGE MODE indicator is on, OUTPUT FAULT and OUTPUT ENABLED indicators are off.

13. Compute the absolute variation of I_O over the range of source voltage for each load condition and record as $|\Delta I_O|$ in the appropriate cell of worksheet (see Table 5-2).

14. Compute Source Effect for both no-load and rated load conditions as follows:

$$\text{SOURCE EFFECT} = \frac{|\Delta I_O|}{I_{MAX}} \times 100$$

Verify that results are within the specified source effect limits of Table 1-2.

5.6.6 LOAD EFFECT MEASUREMENTS

5.6.6.1 VOLTAGE MODE

Test performance as follows:

NOTE: If using the high range nominal input voltage of 176-264V a-c, use values in brackets during the following procedure.

1. Set ACS (Figure 5-4) for 110V a-c (220V a-c) in accordance with NOTE above.
2. Issue commands from the host computer to first initialize the UUT, then program it to Voltage Mode, program current limit to I_{MAX}, output voltage to E_{MAX} and disable the output (e.g., for MST 100-2, program voltage to 100 Volts and current limit to 2 Amperes). Verify VOLTAGE MODE indicator is on, OUTPUT ENABLED and OUTPUT FAULT indicators are off.
3. Connect load RL and set load value to be equal to, or greater than, E_{MAX}/I_{MAX}, in ohms. (e.g., for MST 25-8, set RL = 25/8, 3.125 ohms for example).
4. Issue commands from the host computer to enable the output. Verify VOLTAGE MODE and OUTPUT ENABLED indicators are on, OUTPUT FAULT is off. If necessary, readjust load RL value until the VOLTAGE MODE status indicator stays on.
5. Set ACS to deliver 90V a-c [176V a-c].
6. Use the DVM to measure the UUT output voltage (points "A" of Figure 5-4) and record value in the appropriate cell of worksheet (see Table 5-3).

TABLE 5-3. LOAD EFFECT WORKSHEET - VOLTAGE MODE

SOURCE VOLTAGE (ACS) SET TO (V a-c)	MEASURED V_O (V d-c)		$\lvert\Delta V_O\rvert$
	$RL \geq E_{MAX}/I_{MAX}$	$RL = 10 \times E_{MAX}/I_{MAX}$	
90 [176]			
132 [264]			

7. Adjust value of RL to be 10 x E_{MAX}/I_{MAX}; readjust ACS to deliver 88V a-c [176V a-c] as required and repeat step 6.
8. Set ACS to 132V [264V] a-c and repeat step 6.
9. Adjust value of RL to be equal to E_{MAX}/I_{MAX}, and repeat step 6.
10. Adjust value of RL to be 10 x V_{Omax}/I_{Omax} (e.g., for MST 25-8, adjust RL to 10 x 25/8 = 31.25 ohms) and repeat steps 4 through 6.
11. Compute the absolute difference in output voltage over the range of load conditions for each source voltage and record as $\lvert\Delta V_O\rvert$ in the appropriate cell of worksheet (see Table 5-2).
12. Compute Load Effect for both source voltage conditions as follows:

$$\text{LOAD EFFECT} = \frac{\lvert\Delta V_O\rvert}{E_{MAX}} \times 100$$

Verify that results are within the specified load effect limits of Table 1-2.

5.6.6.2 CURRENT MODE

Test performance as follows:

NOTE: If using the high range nominal input voltage of 176-264V a-c, use values in brackets during the following procedure.

1. Set ACS (Figure 5-4) for 110V a-c [or 220V a-c] in accordance with NOTE above.
2. Issue commands from the host computer to first initialize the UUT, then program it to Current Mode, program current to I_{MAX}, voltage limit to E_{MAX} (e.g., for MST 100-2, set voltage to 100 Volts and current to 2 Amperes) and disable the output. Verify CURRENT MODE indicator is on, OUTPUT ENABLED and OUTPUT FAULT indicators are off.
3. Connect load RL and set load value to be equal to E_{MAX}/I_{OMAX}, in ohms. (e.g., for MST 25-8, set RL $\leq$25/8, 3.125 ohms for example).
4. Set ACS to 90V [176V] a-c.
5. Use the DVM to measure the voltage across the sensing resistor RS (points "B" of Figure 5-4), convert to output current (paragraph 5.6.5.2 step 5), and record value in the appropriate cell of worksheet (see Table 5-4).

TABLE 5-4. LOAD EFFECT WORKSHEET - CURRENT MODE

SOURCE VOLTAGE (ACS) SET TO (V a-c)	MEASURED* I_O (Amperes)		$\lvert\Delta I_O\rvert$
	RL $\leq V_{Omax}/I_{Omax}$	RL = 0.1 X V_{Omax}/I_{Omax}	
90 [176]			
132 [264]			
* VOLTAGE MEASURED ACROSS RS CONVERTED TO I_O BY $I_O = V_{RS}/RS$			

6. Adjust value of RL to be 0.1 x E_{MAX}/I_{MAX} (e.g., for MST 25-8, adjust RL to 0.1 x 25/8 = 0.313 ohms); readjust ACS to 88V [176V] a-c and repeat step 5.
7. Adjust ACS to 132V (264V) a-c and repeat step 5.
8. Adjust value of RL to be E_{MAX}/I_{MAX} (e.g., for MST 25-8, adjust RL to 25/8 = 3.13 ohms); adjust RL as necessary until CURRENT MODE status indicator stays on and repeat step 5.
9. Compute the absolute difference in output current over the range of load conditions for each source voltage and record as $\lvert\Delta I_O\rvert$ in the appropriate cell of worksheet (see Table 5-4).
10. Compute Load Effect for both source voltage conditions as follows:

$$\text{LOAD EFFECT} = \frac{\lvert\Delta I_O\rvert}{I_{MAX}} \times 100$$

Verify that results are within the specified load effect limits of Table 1-2.

5.6.7 RIPPLE AND NOISE (PARD — PERIODIC AND RANDOM DISTURBANCES) TEST

NOTE: If using the high range nominal input voltage of 176-264V a-c, use values in brackets during the following procedure.

1. Set ACS (Figure 5-4) for 115V a-c [230V a-c] in accordance with NOTE above.
2. Set DVM for a-c voltage measurement and set oscilloscope to measure a-c input signals.
3. Issue commands from the host computer to first initialize the UUT, then program it to Voltage Mode, program current limit to I_{MAX}, output voltage to E_{MAX} and disable the output (e.g., for MST 100-2, program voltage to 100 Volts and current limit to 2 Amperes). Verify VOLTAGE MODE indicator is on, OUTPUT ENABLED and OUTPUT FAULT indicators are off.
4. Connect oscilloscope to SENSE 1 and SENSE 2 pins on rear panel (Figure 5-4, points "A"). Measurements must be made using low noise measurement techniques.
5. Adjust value of load RL = E_{MAX}/I_{MAX}.
6. Issue commands from the host computer to enable the output. Verify VOLTAGE MODE and OUTPUT ENABLED indicators are on, OUTPUT FAULT is off. If necessary, readjust load RL value until the VOLTAGE MODE status indicator stays on.
7. Use DVM to measure ripple (mVrms) and oscilloscope to measure noise (mVp-p); record measured values in Table 5-5.

TABLE 5-5. RIPPLE AND NOISE MEASUREMENTS WORKSHEET - VOLTAGE MODE

SOURCE VOLTAGE (ACS) SET TO (V a-c)	RL = E_{MAX}/I_{MAX}		RL = 10 x E_{MAX}/I_{MAX}	
	RIPPLE (mVrms)	NOISE mVp-p	RIPPLE (mVrms)	NOISE mVp-p
115 [230]				
90 [176]				
132 [264]				

8. Repeat step 7 with ACS set to 90V [176V] a-c.
9. Repeat step 7 with ACS set to 132V [264V] a-c.
10. Issue commands from the host computer to disable the output.
11. Adjust value of RL to be equal to 10 x E_{MAX}/I_{MAX} and repeat steps 5 through 7.
12. Repeat step 8 with ACS set to 88V [176V] a-c.
13. Repeat step 8 with ACS set to 115V [230V] a-c.
14. Issue commands from the host computer to disable the output.
15. Verify that the absolute values of ripple and noise noted in Table 5-5 do not exceed the values listed in Table 1-1 for the Model under test.

5.7 TROUBLESHOOTING:

Modern, high performance digitally programmed Power Modules are sophisticated and require a comprehensive understanding of solid-state circuitry. Servicing of such systems should be made only by personnel familiar with solid state component techniques and closed-loop circuitry.

The following steps are suggested:

1. Check the AC power connections, Control Bus Connectors, and DC Output Connector.
2. Use the Power Module Controller to probe for errors.
3. Remove the Power Module and check internal connections.
4. Kepco Field Engineering Offices or the Kepco Applications Engineering Department are always available for consultation or direct help in difficult service or application problems.

WARNING

HAZARDOUS VOLTAGES AND ENERGY LEVELS ARE PRESENT WITHIN THE MST POWER MODULE. THERE ARE NO USER SERVICEABLE PARTS WITHIN THE ENCLOSURE. REFER ALL SERVICING TO TRAINED SERVICE TECHNICIANS.

SECTION 6 - ELECTRICAL PARTS LIST AND DIAGRAMS

6.1 GENERAL

This section contains the schematic diagrams, the parts location diagrams, and a list of all replaceable electrical parts. All components are listed in alpha-numerical order of their reference designations. ***The parts list first lists all parts common to the MST Series, followed by parts unique to a particular model.*** Consult your Kepco Representative for replacement of parts not listed here.

6.2 ORDERING INFORMATION

To order a replacement part or inquire about parts not listed in the parts list, address order or inquiry either to your authorized Kepco Sales Represenative or to:

KEPCO, INC.
131-38 Sanford Avenue
Flushing, NY 11352

Specify the following information for each part:

- Power Supply Model number, Serial number, and Revision number stamped on the nameplate of the unit.
- Kepco part number. See Parts List.
- Circuit Reference Designation. See Schematic Diagram.
- Description. See Parts List.

To order a part not listed in the parts list, give a complete description and include its function and location.

NOTE: Kepco does not stock or sell complete power supply subassemblies as described here and elsewhere in the instruction manual. Some of the reasons are listed below:

1. Replacement of a complete subassembly is a comparatively rare necessity.
2. Kepco's subassemblies are readily serviceable, since most of them are the "plug- in" type.
3. The nature of a closed loop power supply system requires that subassembly replacement be followed by careful measurement of the total power supply performance. In addition, depending on the function of the subassembly, extensive alignment may be required to restore power supply performance to specified values.

If repairs involving subassembly replacements are required, please contact your local Kepco representative or the Kepco Sales Engineering department in Flushing, New York, NY.

6.3 ABBREVIATIONS USED IN KEPCO PARTS LISTS

6.3.1 REFERENCE DESIGNATORS

A	=	Assembly	FX	=	Fuse Holder	M	=	Meter
B	=	Blower (Fan)	IC	=	Integrated Circuit	P	=	Plug
C	=	Capacitor	J	=	Jack	Q	=	Transistor
CB	=	Circuit Breaker	K	=	Relay	R	=	Resistor
CR	=	Diode	L	=	Inductor	T	=	Transformer
DS	=	Device. Signaling (Lamp)	LC	=	Light-Coupled Device	TB	=	Terminal Block
F	=	Fuse	LED	=	Light Emitting Diode	X	=	Socket

6.3.2 DESCRIPTIVE ABBREVIATIONS

A	=	Ampere	FXD	=	Fixed	PWR	=	Power
a-c	=	Alternating Current	Ge	=	Germanium	RAD	=	Radial
AMP	=	Amplifier	H	=	Henry	RECT	=	Rectifier
AX	=	Axial	Hz	=	Hertz	RECY	=	Recovery
CAP	=	Capacitor	IC	=	Integrated Circuit	REG	=	Regulated
CER	=	Ceramic	K	=	Kilo (10^3)	RES	=	Resistor
CT	=	Center-tap	m	=	Milli (10^{-3})	RMS	=	Root Mean Square
°C	=	Degree Centigrade	MFR	=	Manufacturer	Si	=	Silicon
d-c	=	Direct Current	MET	=	Metal	S-end	=	Single Ended
DPDT	=	Double Pole, Double Throw	n	=	Nano (10^{-9})	SPDT	=	Single Pole, Double Throw
DPST	=	Double Pole, Single Throw	NC	=	Normally Closed	SPST	=	Single Pole, Single Throw
			NO	=	Normally Open			
ELECT	=	Electrolytic	p	=	Pico (10^{-12})	Stud Mt.	=	Stud Mounted
F	=	Farad	PC	=	Printed Circuit	TAN	=	Tantalum
FILM	=	Polyester Film	POT	=	Potentiometer	TSTR	=	Transistor
FLAM	=	Flammable	PIV	=	Peak Inverse Voltage	μ	=	Micro (μ) (10^{-6})
FP	=	Flame-Proof	p-p	=	Peak to Peak	V	=	Volt
°F	=	Degree Fahrenheit	ppm	=	Parts Per Million	W	=	Watt
						WW	=	Wire Wound

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.

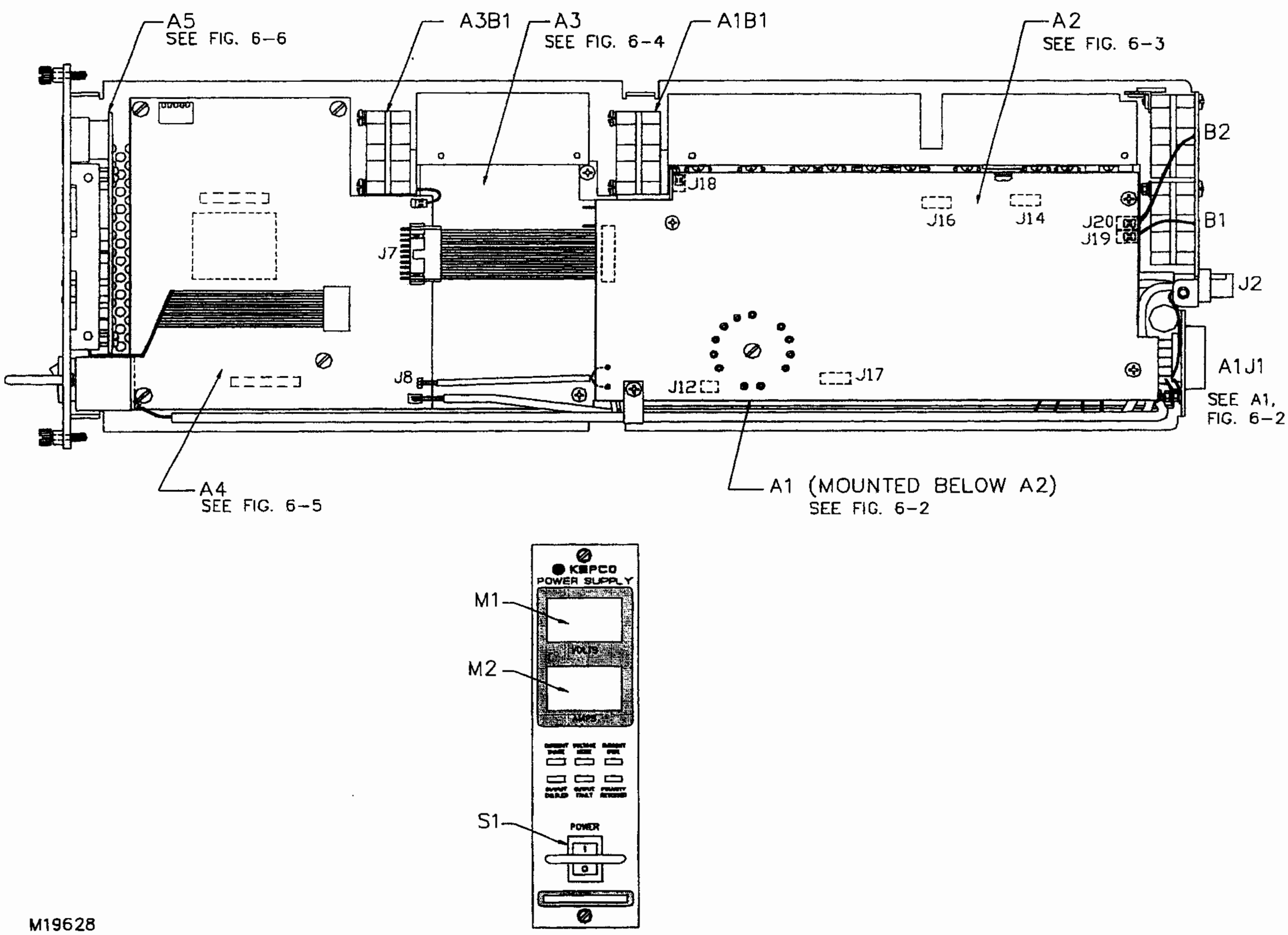


FIGURE 6-1. MST SERIES POWER MODULE, COMPONENT LOCATIONS

NOTE: REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO, INC. ORDERS SHOULD INCLUDE KEPCO PART NUMBER AND DESCRIPTION.

PLEASE NOTE: THE MANUFACTURER'S NAME AND PART NUMBER LISTED FOR EACH ITEM ON REPLACEMENT PARTS LISTS REPRESENTS AT LEAST ONE SOURCE FOR THAT ITEM AND IS LISTED SOLELY FOR THE CONVENIENCE OF KEPCO EQUIPMENT OWNERS IN OBTAINING REPLACEMENT PARTS LOCALLY. WE RESERVE THE RIGHT TO USE EQUIVALENT ITEMS FROM ALTERNATE SOURCES. KEPCO, INC.

MST SERIES **CHASSIS ASSEMBLY (Figure 6-1)** **CODE: MST6TOP**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
B1, B2	2	DC FAN 12V, 0.23A	PANASONIC FBK04F12U-1	148-0048	1
J2	1	RECEPTACLE, 6 SOCKET, PANEL MOUNT	POSITRONIC PLB06F1000	143-0566	1
M1, M2	2	3 1/2 DIGIT PANEL METER +/- 2V DIFF.	DATEL DMS20PC1ARL	135-0565	1
S1	1	MINIATURE ROCKER SWITCH DPST	OSLO CONTROLS R9DKKFT2D	127-0436	1

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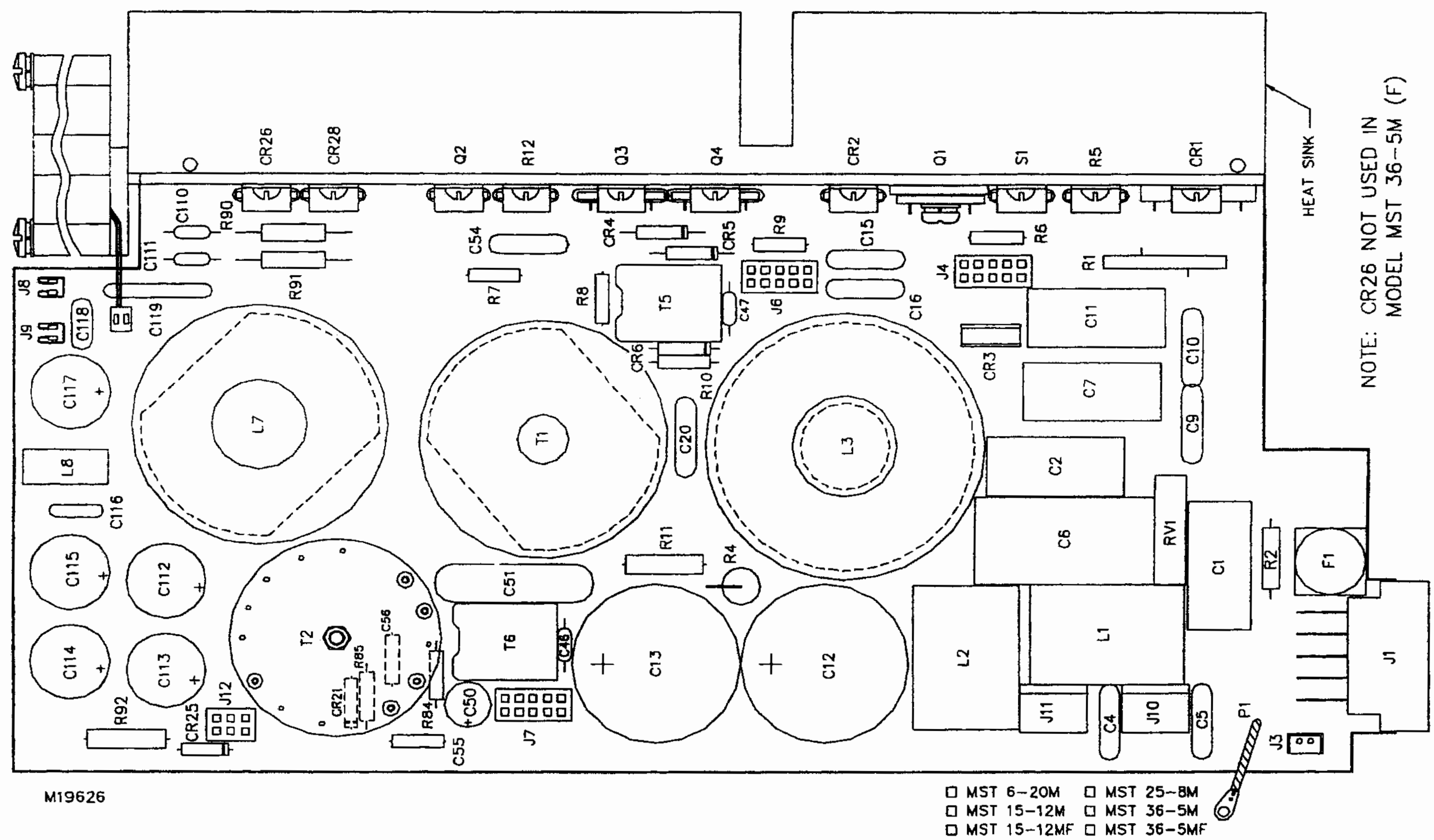

FIGURE 6-2. COMPONENT LOCATION OF MST ASSEMBLY A1

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
@CR2, @CR26, CR27, @Q2, @R12, @R5, @S1	7	INS, SI RUB	FUJI POLY 30H-11-25L	189-0602	1
@F1	1	FUSEHOLDER .500X.500X1.500	WICKMANN 652653	150-0035	1
@L3	1	1NS TOROID VIB DAMPER HSP DIE	KEPCO 189-0568	189-0568	1
@Q1	2	INS TO-3P	BERGQUIST 1009AC-102	189-0579	1
@Q3, @Q4	2	INS TO-3P	FUJI POLY 30H-13.5-25L	189-0604	1

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KEPCO REPLACEMENT PARTS LIST

MST 75-2.5M | A1 ASSEMBLY (Figure 6-2) | CODE: 2361611

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
@T1, L7	2	INS-MAG. DBL-D SHAPE MST DIE	KEPCO 189-0636	189-0636	1
@T2	5	SOCKET PIN	ADV INTC 1728-109-T	143-0603	1
B1	1	DC FAN 12V, 0.23A	PANASONIC FBK04F12U-1	148-0048	1
C1	4	CAP., PAPER, M55V	NISSEI R40LR47400000K	117-1168	1
C4, C5, C9, C10	4	CAP., PAPER, METALLIZED, 2200PF, 20%, 250V	RIFA PME271Y422	117-1009	1
C6	1	CAP., PAPER, METALLIZED, 0.68UF, 20%, 250V	EVOX/RIFA PHE830MF6680M	117-1187	1
C7, 11	2	CAP., PAPER, METALLIZED, 0.22UF, 20%, 250V	EVOX/RIFA PHE830MD6220M	117-1186	1
C12, C13	2	CAP., ELECTRONIC SINGLE END LEADS, 150UF, 20%, 450V	CORNELL-DUBILIE 380151M450K022	117-1063	1
C15, C16	2	CAP., CERAMIC, 1.5UF, 20%, 250V	MARCON TCD51E2E155M	117-1117	1
C20	1	CAP., PAPER, METALLIZED, 4700PF, 20%, 250V	RIFA PME271Y447M	117-1156	1
C46, C47	2	CAP., CERAMIC, 100PF, 10%, 200V	PHILIPS COMPONE A101K17COGKVVWA	117-1085	1
C50	1	CAP., ELECTRONIC SINGLE END LEADS, 100UF, + 44 -20%, 35V	UNITED CHEMICON LXF35VB12IM8X12LL	117-1074	1
C51	1	CAP., MYLAR, METALLIZED, 0.1UF, 10%, 630V	NISSEI ARCOTRON R.71PN1003XX00K	117-1108	1
C54	1	CAP., CERAMIC, 220PF, 10%, 2000V	MAIDA D59X7R221K2KV	117-1106	1
C55, C56	2	CAP., CERAMIC, 100-PF, 10%, 200V	PHILIPS A102K17X7RKVVWA	117-1084	1
C110, C111	2	CAP., CERAMIC, 470PF, 20% 3000V	CERMITE 30GAT47	117-1125	1
C112, C113, C114, C115, C116, C117	6	CAP., ELECTRONIC SINGLE END LEADS, 560UF, + 20%, 35V	UNITED CHEMICON LXF35VB561M15X15LL	117-1142	1
C118	1	CAP., CERAMIC, 0. 1UF, 10%, 200V	KEMETT C340C104K2R5CA	117-1099	1
C119	1	CAP., CERAMIC, 0.1UF, 20%, 500V	NIC COMPONENTS NCD104M500Z5U	117-0087	1
CR1	1	RECT., ENCAPSULATED BRIDGE RECT., 600V 6 A	GENERAL INSTRUM GBU 6J	124-0595	1

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MST 75-2.5M **A1 ASSEMBLY (Figure 6-2)** **CODE: 2361611**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
CR2, 26, 27	3	RECT., SI RECTIFIER, 600V 8 A	INT'L RECTIFIER HFA08TB60	124-0594	1
CR3	1	RECT., SI RECTIFIER, MUR860 600V 8A	MOTOROLA MUR860	124-0602	1
CR4, CR5	2	RECT., SI RECTIFIER, 600V 1A	MOTOROLA MUR160	124-0577	1
CR6	1	RECT., SWITCHING DIODE, 75V 0.4A	MOTOROLA 1N4148	124-0437	1
CR21	1	RECT., SI RECTIFIER, 150V 1A	MOTOROLA MUR115	124-0584	1
CR25	1	DIODE, ZENER, 87V, 5%	MOTOROLA 1N5269B	121-0100	1
F1	1	FUSE, INSTANT BLOW, 5 A 250V GL 5MM X20MM	BUSSMAN GDB5A	141-0098	1
J1	1	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT, 10 PINS	MOLEX 15-24-6100	143-0544	1
J3	1	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT, 2 PINS	AMP 175487-2 175487-2	143-0521	1
J4, J6, J7	3	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT, 10 PINS	SAMTEC SSW-105-01-SD	143-0606	1
J8, J9	2	JACK, QUICK CONNECT (FEMALE), QC PC	ZIERICK 1092-6	107-0300	1
J10, J11	2	JACK, PLUG, PCB MOUNT (STRAIGHT PINS), 3 PINS	ITW PANCOM MLSS156-3	142-0272	1
J12	1	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT, 6 PINS	SAMTECH SSW-103-01-SD	143-0608	1
L1	1	INDUCTOR, , CHK COMMON MODE 1MH, 5AMPS AC	COILTRONICS INC 1011-05102	176-0065	1
L2	1	INDUCTOR, CHK	STANDEX ELECTRONICS CT1022100	176-0059	1
L3	1	INDUCTOR, CHOKE, INPUT FILTER,	KEPCO 100-2393	100-2393	1
L7	1	INDUCTOR, CHOKE, OUTPUT FIL-TER	KEPCO 100-2362	100-2362	1
L8	1	INDUCTOR, CHOKE, INPUT FILTER	KEPCO 100-2466	100-2466	1
Q1, Q3, Q4	3	TRANSISTOR, FIELD EFFECT, 500V	INT'L RECT IRFP450	119-0158	1
Q2	1	TRANSISTOR, FIELD EFFECT, 1KV	INT'L RECT IRFBG30	119-0159	1

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KEPCO REPLACEMENT PARTS LIST

MST 75-2.5M **A1 ASSEMBLY (Figure 6-2)** **CODE: 2361611**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
RV1	1	VARISTOR, MOV	SIEMENS S20K320	125-0014	1
R1	1	RES., MISCELLANEOUS RESISTORS, 16 OHM, 25%	KEYSTONE CARBON TYPE CL-70	115-2828	1
R2	1	RES., FIX., CARBON FILM, 330 KOHM, 1/2W, 5%	IRC/SHALLCROSS CF-1/4	115-0250	1
R4	1	RES., FIX., CARBON FILM, 330 KOHM, 0W, 5%	LIBERTY INT'L R-200	115-0083	1
R5	1	RES., FIX., METAL FILM, 0.15 OHM, 20W, 1%	CADDOCK ELECTRO MP821	115-2885	1
R6, R7, R8, R9	4	RES., FIX., CARBON FILM, 10 KOHM, 1/4W, 5%	IRC SHALLCROSS CF 1/4	115-2211	1
R10	1	RES., FIX., PRECISION, METAL-FILM, 17.8 OHM, 1/4W, 1%	VISHAY DALE ELECT. CCF-55	115-2924	1
R11	1	RES., FIX., METAL FILM, FUSIBLE, 5 OHM, 1/2W, 5%	DALE TYPE CMF-60-64	115-2817	1
R12	1	RES., FIX., METAL FILM, 330 OHM, 20W, 10%	CADDOCK ELECTRO MP820.	115-2886	1
R84, R85	2	RES., FIX., CARBON FILM, 100 OHM, 1/4W, 5%	IRC GBT 1/4	115-2231	1
R90, R91	2	RES., FIX., CARBON FILM, 330 OHM,2W, 5%	KOA SPEER RSS 2 331 5 T521	115-2974	1
R92	1	RES., FIX., CARBON FILM, 15K OHM, 1W, 3%	TEPRO TS-1W	115-1414	1
S1	1	SWITCH, THERMOSTAT (N.O.), SW-THERMO SP ST 5VDC .02A	MOTOROLA 1N2622B	127-0449	1
T1	1	TRANSFORMER, POWER, TRF-POWER MST 75-2.5M	KEPCO 100-2453	100-2453	1
T2	1	TRANSFORMER, AUXILARY, TRF AUX MST SERIES	KEPCO 100-2359	100-2359	1
T5, T6	2	TRANSFORMER, , PCB TRF	PULSE ENG. 67050	175-0456	1

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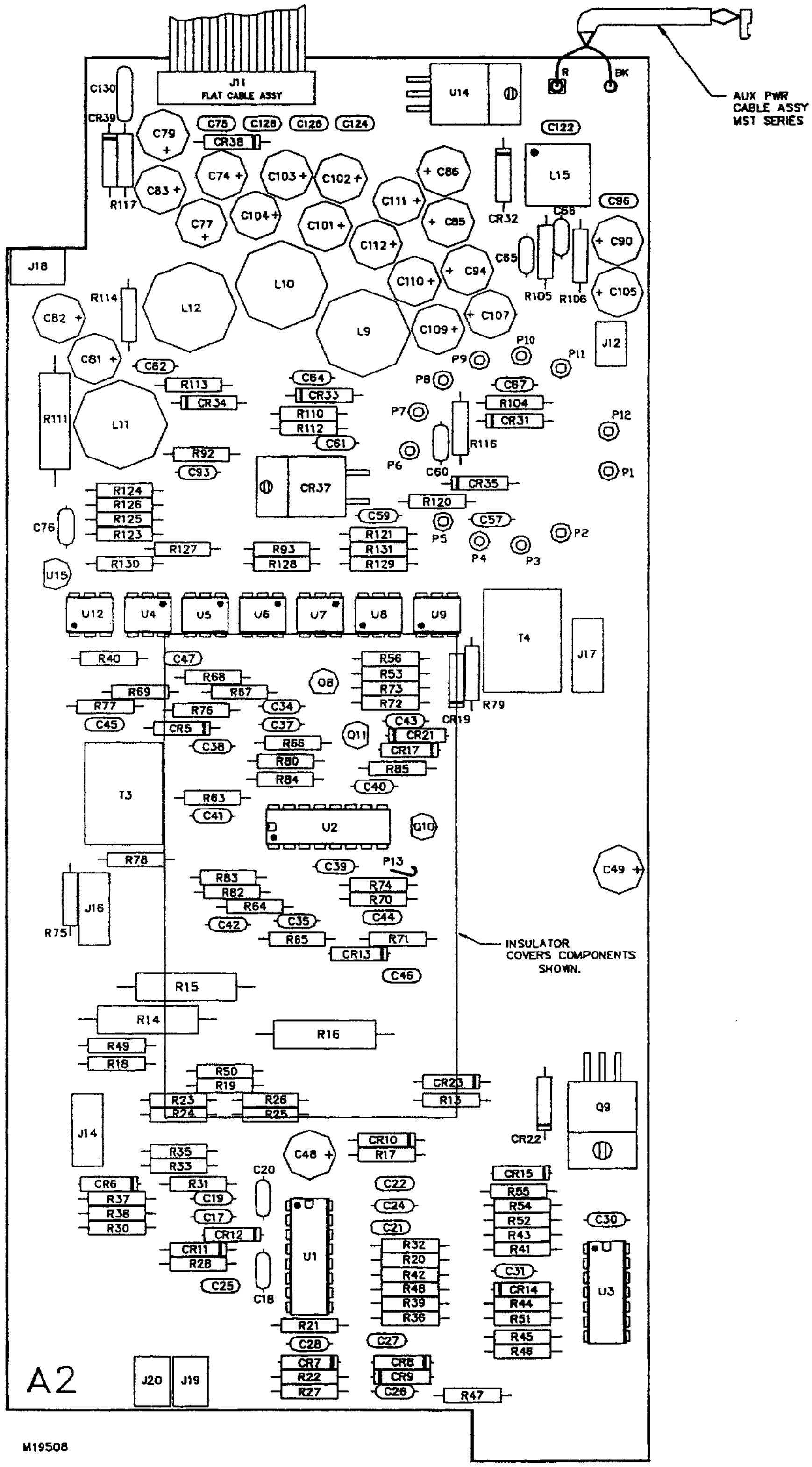

FIGURE 6-3. COMPONENT LOCATION OF MST ASSEMBLY A2

KEPCO REPLACEMENT PARTS LIST

MST SERIES **A2 ASSEMBLY (Figure 6-3)** **CODE: 2351187**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
@P13	1	INSULATOR, EMI SHIELD	KEPCO 189-0606	189-0606	1
@Q8, 9, 10 11	4	INS, TRST MTG PAD TO18	THERMALLOY INC 7717 157M	189-0483	1
C17, C20	2	CAP., CERAMIC, 270PF, 10%, 200V	KEMET C114B271K2X1CA	117-1068	1
C18, C35	2	CAP., CERAMIC, 100PF, 10%, 200V	PHILIPS COMPONE A101K17COGKVVWA	117-1085	1
C19	1	CAP., CERAMIC, 3300PF, 10%, 100V	PHILIPS A332KX7RKVVWA	117-1123	1
C21, C22, C25, C27, C46, C47, C75, C96, C122, C124, C126, C128, C130,	13	CAP., CERAMIC, 1UF, 10%, 50V	MURATA ERIE RPE113X7R105K050V	117-0999	1
C24, C42, C57, C60, C61, C62, C64, C65, C66	9	CAP., CERAMIC, 1000PF, 10%, 200V	PHILIPS A102K17X7RKVVWA	117-1084	1
C26, C28, C30, C37, C93	5	CAP., CERAMIC, 0.1UF, 10%, 50V	PHILIPS COMPONE A104K18X7RFVVWN	117-1052	1
C31, C38, C59, C67	4	CAP., CERAMIC, 0.01UF, 10%, 50V	PHILIPS COMPONE A103K17X7RFVVWA	117-1053	1
C34	1	CAP., CERAMIC, 4700PF, 10%, 100V	CENTRALAB CW15A472K	117-0855	1
C39	1	CAP., CERAMIC, 2200PF, 10%, 100V	AVX SA101C222KAA	117-1121	1
C40, C41, C43	3	CAP., CERAMIC, 470PF, 10%, 100V	PHILIPS COMPONE A471K17X7RHVVWA	117-1055	1
C44, C45	2	CAP., CERAMIC, 0.22UF, 10%, 50V	PHILIPS K224KM30X7RFVCWT	117-1129	1
C48, 49, 74, 77, 79, 81-83, 85, 86, 90, 94, 101-105, 107, 109-112	22	CAP., ELECTRONIC SINGLE END LEADS, 100UF, + 44 -20%, 35V	UNITED CHEMICON LXF35VB12IM8X12LL	117-1074	1
C76	1	CAP., CERAMIC, 0.47UF, 20%, 50V	MEPCO/CENTRALAB K474M30X7RFVCWY	117-1038	1
CR5, CR11, CR22, CR31	4	RECT., SI RECTIFIER, 40V 1 A	MOTOROLA 1N5819	124-0578	1
CR6-9, 13-15, 17, 19, 21,	10	RECT., SWITCHING DIODE, 75V 0.4A	MOTOROLA 1N4148	124-0437	1
CR10	1	DIODE, ZENER, 4.7V 5 %	MOTOROLA 1N4732A	121-0091	1

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MST SERIES **A2 ASSEMBLY (Figure 6-3)** **CODE: 2351187**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
CR12	1	DIODE, ZENER, 7.5V 5 %	MOTOROLA 1N5236B	121-0089	1
CR23, CR39	2	DIODE, ZENER, 15 V	MOTOROLA 1N4744D	121-0103	1
CR32, CR33, CR34, CR35	4	RECT., SI RECTIFIER, 150V 1 A	MOTOROLA MUR115	124-0584	1
CR37	1	RECT., SI RECTIFIER, 45V 7.5A	MOTOROLA MBR745	124-0593	1
CR38	1	DIODE, ZENER, 5.6V 5 %	TRANSITRON 1N752A	121-0066	1
J12	1	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT, 6 PINS	SAMTEC SSW-103-01-SD	143-0608	1
J14, J16, J17	3	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT, 10 PINS	SAMTEC SSW-105-01-SSD	143-0606	1
J18, J19, J20	3	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT, 2 PINS	AMP 175489-2 175489-2	143-0522	1
L9, L10, L12	3	INDUCTOR, CHOKE, OUTPUT FIL-TER, 2 UH 1.5A	KEPCO MB103321-50	100-2321	1
L11	1	INDUCTOR, CHOKE, OUTPUT FIL-TER, 70 UH .25A	KEPCO MB1002320-50	100-2320	1
L15	1	INDUCTOR, CHOKE	BH ELECTRONICS 500-1433	176-0055	1
P1-12,	12	PLUG, SOCKET PIN, 1	ADV INTC 1728-109-T	143-0603	1
Q8	1	TRANSISTOR, SI, PNP, SMALL SIGNAL,	MOTOROLA 2N4403	119-0163	1
Q9	1	TRANSISTOR, SI, NPN, POWER,	MOTOROLA TIP47	119-0182	1
Q10	1	TRANSISTOR, FIELD EFFECT, 60V	MOTOROLA 2N7000	119-0160	1
Q11	1	TRANSISTOR, SI, NPN, SMALL SIGNAL,	MOTOROLA 2N4401	119-0162	1
R4, 18, 19, 23-25, 44-48, 54, 55	12	RES., FIX., PRECISION, METAL FILM, 499 KOHM, 1/8W, 1%	DALE ELECTRONIC TYPE RN55D	115-2309	1
R13, R17, R79, R123	4	RES., FIX., CARBON FILM, 220 OHM, 1/4W, 5%	IRC GBT 1/4	115-2227	1
R14, R15, R16	3	RES., FIX., POWER, AX. LEADS, 20 KOHM, 3W, 5%	TEPRO TS3W	115-2135	1
R20, R32	2	RES., FIX., PRECISION, METAL FILM, 20 KOHM, 1/8W, 1%	PHILIPS SFR55	115-2887	1

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MST SERIES **A2 ASSEMBLY (Figure 6-3)** **CODE: 2351187**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
R21	1	RES., FIX., CARBON FILM, 220 KOHM, 1/4W, 5%	LIBERTY INT'L TYPE R25	115-2870	1
R22	1	RES., FIX., PRECISION, METAL-FILM, 200 KOHM, 1/4W, 1%	PHILIPS 5043ED200K0F	115-2809	1
R26	1	RES., FIX., PRECISION, METAL FILM, 340 KOHM, 1/4W, 1%	PHILIPS TYPE SFR55	115-2822	1
R27	1	RES., FIX., PRECISION, METAL FILM, 88.7 KOHM, 1/4W, 1%	PHILIPS TYPE SFR55	115-2821	1
R28	1	RES., FIX., PRECISION, METAL FILM, 24.3 KOHM, 1/8W, 1%	DALE MMK 1/8	115-2451	1
R30, R33, R43, R46	4	RES., FIX., PRECISION, METAL FILM, 3.74 KOHM, 1/8W, 1%	DALE TYPE MFF 1/8	115-2512	1
R31	1	RES., FIX., CARBON FILM, 15 KOHM, 1/4W, 5%	IRC GBT 1/4	115-2497	1
R35	1	RES., FIX., PRECISION, METAL FILM, 1.5 KOHM, 1/8W, 1%	DALE ELECTRONIC TYPE RN55D	115-2178	1
R36, 39, 64, 65, 69, 129-131	8	RES., FIX., CARBON FILM, 10 KOHM, 1/4W, 5%	IRC/SHALLCROSS CF-1/4	115-2211	1
R37, R71	2	RES., FIX., CARBON FILM, 47 OHM, 1/4W, 5%	IRC/SHALL CROSS CF 1/4	115-2273	1
R38, R78, R106, R114, R117	5	RES., FIX., CARBON FILM, 10 OHM, 1/4W, 5%	IRC GBT 1/4	115-2230	1
R40, R53, R56, R67, R68	5	RES., FIX., CARBON FILM, 2.2 KOHM, 1/4W, 5%	IRC GBT 1/4	115-2382	1
R41, R52	2	RES., FIX., PRECISION, METAL FILM, 49.9 KOHM, 1/8W, 1%	DALE ELECTRONIC TYPE RN55D	115-2755	1
R42	1	RES., FIX., PRECISION, METAL FILM, 10 KOHM, 1/8W, 1%	DALE ELECTRONIC TYPE CCF-55	115-2174	1
R47	1	RES., FIX., PRECISION, METAL-FILM, 6.19 KOHM, 1/4W, 1%	KOA TYPE MF55D	115-1952	1
R48	1	RES., FIX., PRECISION, METAL FILM, 15 KOHM, 1/8W, 1%	DALE MMK 1/8	115-2452	1
R51	1	RES., FIX., PRECISION, METAL-FILM, 5.9 KOHM, 1/4W, 1%	PHILIPS SFR 55	115-2925	1
R63, R73, R92, R93, R126, R128,	6	RES., FIX., CARBON FILM, 1 KOHM, 1/4W, 5%	IRC GBT 1/4	115-2238	1
R70	1	RES., FIX., PRECISION, METAL FILM, 6.98 KOHM, 1/8W, 1%	DALE MFF 1/8	115-2449	1
R72, R75	2	RES., FIX., CARBON FILM, 39 OHM, 1/4W, 5%	IRC GBT 1/4	115-2501	1

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REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
R74	1	RES., FIX., PRECISION, METAL FILM, 12.1 KOHM, 1/8W, 1%	DALE MMK 1/8	115-2453	1
R76, R77	2	RES., FIX., CARBON FILM, 27 OHM, 1/4W, 5%	IRC GBT 1/4	115-2317	1
R80	1	RES., FIX., PRECISION, METAL-FILM, 332 OHM, 1/4W, 1%	PHILIPS SFR 55	115-2923	1
R82-84, 104 -106, 110, 112, 113, 116, 120, 121,	12	RES., FIX., CARBON FILM, 100 OHM, 1/4W, 5%	IRC GBT 1/4	115-2231	1
R85	1	RES., FIX., PRECISION, METAL FILM, 2 KOHM, 1/8W, 1%	DALE ELECTRONIC TYPE RN55D	115-2334	1
R111	1	RES., FIX., POWER, AX. LEADS, 5 OHM, 3W, 5%	TEPRO TS2B	115-0700	1
R124	1	RES., FIX., PRECISION, METAL FILM, 1 KOHM, 1/8W, 1%	DALE ELECTRONIC TYPE CCF-55	115-2180	1
R125	1	RES., FIX., PRECISION, METAL FILM, 953 OHM, 1/8W, 1%	IRC GBT 1/4	115-2479	1
T3, T4	2	TRANSFORMER, DRIVER, TRF DRIVER-TOROID MOS SER.	KEPCO 100-2319	100-2319	1
U1	1	I.C. HI-PWR FACTOR PREREGULATOR	UNITRODE UC3854N	250-0237	1
U2	1	I.C. CMOS SINGLE-CHIP 8-BIT MICROCONTROLLER	INTEL P80C32	250-0307	1
U3	1	I.C.QUADVOLTAGECOMPARATOR	NAT. LM339AN	250-0120	1
U4, U5, U6, U7, U8, U9, U12	7	OPTO-COUPLER(PHOTOTRST),	MOTOROLA MOC8102	119-0156	1
U14	1	I.C. 5V-1A LOW DROP-OUT VOLTAGE REGULATOR	NAT. LM2940CT-5.0	250-0279	1
U84	1	I.C. ADJ. REFERENCE (2.5-37V) 600uA-100mA	MOTOROLA. TL431AILP	250-0239	1

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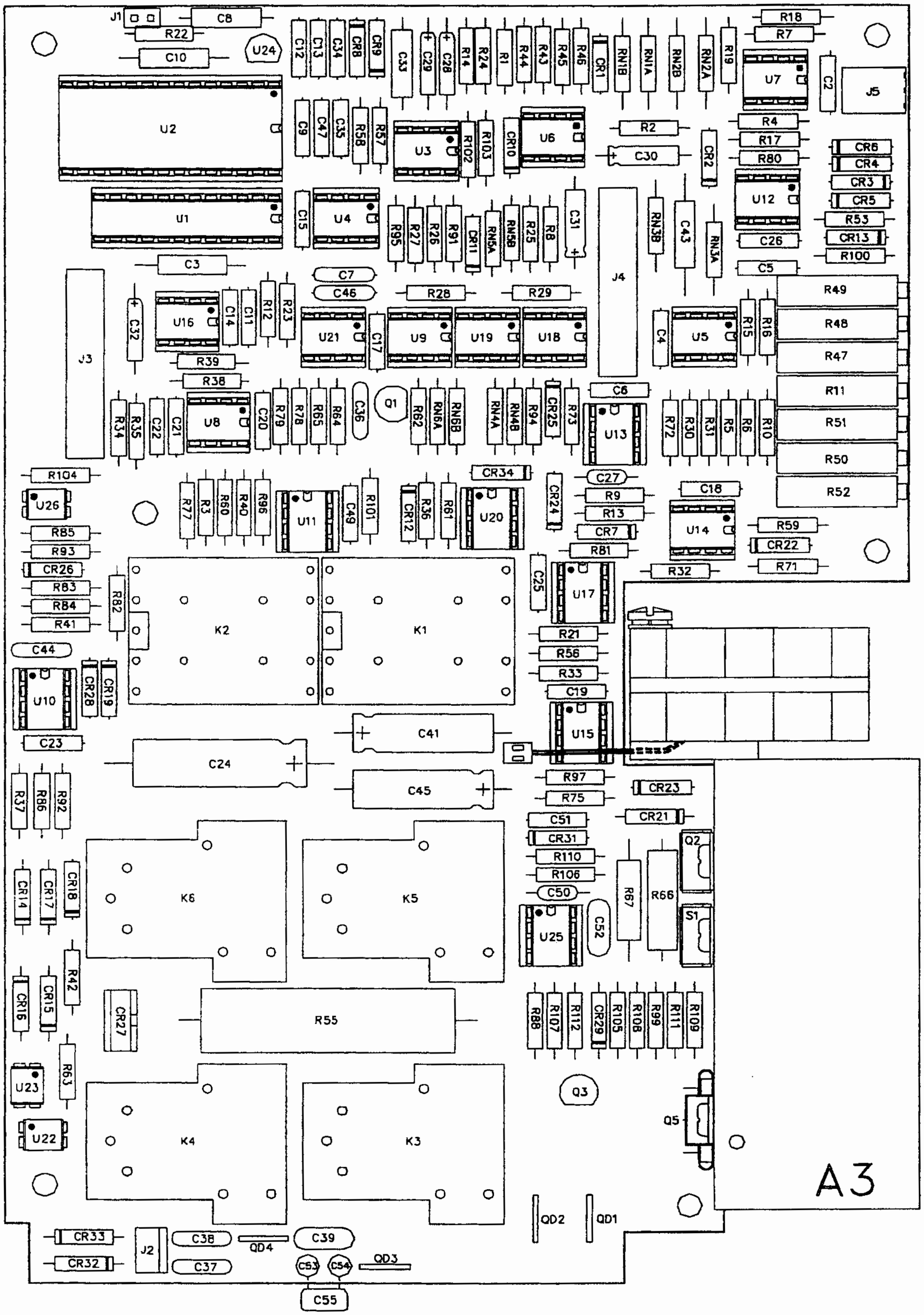

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NOTES:
1. NOT ALL COMPONENTS USED IN ALL MODELS, SEE PARTS LIST.
2. R109 MOUNTED ON END IN MODELS WITH SUFFIX "F".

FIGURE 6-4. COMPONENT LOCATION OF MST ASSEMBLY A3

MST SERIES **A3 COMMON PARTS ASSEMBLY (Figure 6-4)** **CODE: 2671155**

NOTE: SEE A3 ASSEMBLY PARTS LIST (FOLLOWING THIS COMMON PARTS LIST) FOR PARTS NOT INCLUDED ON THE A3 COMMON PARTS LIST SHOWN BELOW.

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
B1	1	DC FAN 12V, 0.23A	PANASONIC FBK04F12U	148-0048	1
C2, 4, 5, 6, 9, 11-15, 17-23, 25, 33, 47, 51	21	CAP., CERAMIC, 0.1UF, 10%, 50V	PHILIPS COMPONENT A104K18X7RFVVWN	117-1052	1
C3, 10	2	CAP., CERAMIC, 0.47UF, 10%, 50V	KEMET C202C474K5R5CA	117-1064	1
C7, 36, 46	3	CAP., CERAMIC, 0.47UF, 20%, 50V	MEPCO/CENTRALAB K474M30X7RFVCWY	117-1038	1
C8	1	CAP., CERAMIC, 3900PF, 2%, 50V	KEMET C430C392J5G5CA	117-1071	1
C28, 29	2	CAP., TANTALUM, 1UF, 20%, 50V	G. E. 62F105	117-0815	1
C30, 31	2	CAP., TANTALUM, 6.8UF, 20%, 35V	PHILIPS COMPONENT 40MSL85D035M0A	117-0968	1
C32	1	CAP., TANTALUM, 10UF, 20%, 15V	MEPCO/ELECTRA 40CS106L020M1A	117-0969	1
C33	1	CAP., MYLAR, METALLIZED, 2200PF, 10%, 200V	SPRAGUE 192P22292	117-0659	1
C34	1	CAP., CERAMIC, 560PF, 2%, 50V	KEMET C114G561G5CA	117-1070	1
C37, 39	3	CAP., CERAMIC, 0.1UF, 10%, 200V	KEMET C340C104K2R5CA	117-1099	1
CR1-13, 18, 19, 22-26, 28, 31, 34	23	RECT., SWITCHING DIODE, 75V 0.4A	MOTOROLA 1N4148	124-0437	1
CR14-17	4	DIODE, CURRENT REGULATOR, 1.0M, 100 V	MOTOROLA 1N5297	121-0083	1
CR21	1	DIODE, ZENERS, 3.3V 5 %	TRANSITRON 1N746A	121-0060	1
CR27	1	RECT., SI RECTIFIER, 600V, 24 A	MOTOROLA MR2406	124-0589	1
CR29, 32, 33	3	RECT., SI RECTIFIER, SI-4 400V 1A	VISHAY 1N5395	124-0028	1
J1	1	JACK, PLUG, PCB MOUNT (STRAIGHT PINS), 2 PIN	SAMTEC TSW-101-07-TD	142-0262	1
J2	1	JACK, PLUG, PCB MOUNT (STRAIGHT PINS), 3 PIN	AMP 640456-3	142-0330	1

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MST SERIES **A3 COMMON PARTS ASSEMBLY (Figure 6-4)** **CODE: 2671155**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
J3, 4	2	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT, 12	SAMTEC DW12-09-SD400	143-0558	1
J5	1	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT,	AMP 6-535512-2	143-0470	1
K1, 2	2	RELAY, GENERAL PURPOSE, 5 VDC 4PDT	AROMAT NF4GB	140-0094	1
K3, 4, 5, 6	4	RELAY, GENERAL PURPOSE, 5 VDC SPDT	AROMAT JTIEDC5V	140-0122	1
QD1, 2	2	QUICK CONNECT (MALE), QC 90DEGREE	KEPCO 1070332 168	107-0332	1
QD3, 4	2	QUICK CONNECT (MALE), QC PCB MT	ZIERICK 1021	107-0281	1
Q1	1	TRANSISTOR, SI, PNP, SMALL SIGNAL,	MOTOROLA 2N4403	119-0163	1
Q3	1	TRANSISTOR, SI, NPN, SMALL SIGNAL,	FAIRCHILD 2N5450	119-0093	1
RN4A, B	1	RES. NETWORK 10K/10K	PRECISION RESISTIVE PROD PRP-8451	234-0006	1
RN5A, B	1	RES. NET 10K/4.99K	DALE PTF56	234-0071	1
R1, 2, 8, 9, 21, 25, 28, 33, 56, 102	10	RES., FIX., MOLDED, CARBON, 1 KOHM, 1/4W, 10%	IRC/SHALLCROSS CF-1/4	115-2238	1
R3, 36, 40, 60, 61, 62, 77-79, 96, 100, 104	13	RES., FIX., MOLDED, CARBON, 10 KOHM, 1/4W, 10%	IRC/SHALLCROSS CF-1/4	115-2211	1
R4, 23, 27	3	RES., FIX., PRECISION, METAL FILM, 2 KOHM, 1/8W, 1%	DALE ELECTRONIC TYPE RN55D	115-2334	1
R5, 6, 94	3	RES., FIX., MOLDED, CARBON, 1.1 MOHM, 1/4W, 5%	IRC/SHALLCROSS CF-1/4	115-2657	1
R7, 10, 29, 30, 42, 63, 65, 81, 97,	9	RES., FIX., MOLDED, CARBON, 3.3 KOHM, 1/4W, 10%	IRC/SHALLCROSS CF-1/4	115-2257	1
R11, 51	2	RES., VAR., MULTITURN, TRIMMER, COMP. OR CERM., 100 KOHM, 3/4W, 10%	BOURNS 3009P-1-104	115-2399	1
R12	1	RES., FIX., PRECISION, METAL FILM, 7.32 KOHM, 1/8W, 1%	IRC CEA	115-2335	1
R14, 24	2	RES., FIX., MOLDED, CARBON, 2.2 MOHM, 1/4W, 5%	IRC/SHALLCROSS CF-1/4	115-2602	1

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MST SERIES | **A3 COMMON PARTS ASSEMBLY (Figure 6-4)** | **CODE: 2671155**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
R15, 16, 18, 91	4	RES., FIX., PRECISION, METAL FILM, 221 OHM, 1/8W, 1%	IRC CEA	115-2311	1
R17, 26, 35, 39	4	RES., FIX., PRECISION, METAL FILM, 4.75 KOHM, 1/8W, 1%	DALE MMF-1/8	115-2490	1
R19, 72, 80, 82, 95	5	RES., FIX., MOLDED, CARBON, 4.7 KOHM, 1/4W, 10%	IRC/SHALLCROSS CF-1/4	115-2383	1
R22	1	RES., FIX., PRECISION, METAL FILM, 56.2 KOHM, 1/8W, 1%	IRC CEA	115-2358	1
R34, 38	2	RES., FIX., PRECISION, METAL FILM, 9.09 KOHM, 1/8W, 1%	DALE RN60D	115-2678	1
R37, 103	2	RES., FIX., PRECISION, METAL-FILM, 100 KOHM, 1/4W, 1%	IRC CEA	115-2753	1
R43-46, 85, 86, 92, 93	8	RES., FIX., PRECISION, METAL FILM, 10 KOHM, 1/8W, 1%	IRC CEA	115-2174	1
R47, 48, 49	3	RES., VAR., MULTITURN, TRIMMER, COMP. OR CERM., 1 KOHM, 3/4W, 10%	BOURNS 3009P-1-102	115-2456	1
R50	1	RES., VAR., MULTITURN, TRIMMER, COMP. OR CERM., 20 KOHM, 3/4W, 10%	BOURNS 3009P-203	115-2393	1
R57, 58, 107	3	RES., FIX., PRECISION, METAL FILM, 1 KOHM, 1/8W, 1%	IRC CEA	115-2180	1
R64, 84, 88	3	RES., FIX., MOLDED, CARBON, 560 OHM, 1/4W, 10%	IRC/SHALLCROSS CF-1/4	115-2210	1
R73	1	RES., FIX., MOLDED, CARBON, 100 OHM, 1/4W, 10%	IRC/SHALLCROSS CF-1/4	115-2231	1
R75	1	RES., FIX., MOLDED, CARBON, 150 OHM, 1/2W, 5%	IRC/SHALLCROSS CF-1/2	115-2165	1
R83	1	RES., FIX., PRECISION, METAL FILM, 1.24 KOHM, 1/8W, 1%	DALE MMF 1/8	115-2507	1
R99	1	RES., FIX., MOLDED, CARBON, 10 OHM, 1/4W, 10%	IRC/SHALLCROSS CF-1/4	115-2230	1
S1	1	SWITCH, THERMOSTAT (N.O.), SP ST 1A	AIRPAX 67F100	127-0431	1
U1	1	IC. DUAL 12-BIT DAC	ANALOG DEV. AD7537K	250-0175	1
U2	1	IC 12-BIT SUCCESSIVE APPROX. ADC W/FOUR INPUTS	ANALOG DEV. AD7582KN	250-0174	1
U3, 5, 11	3	IC DUAL DIFFERENTIAL COMPARATORS	T.I. LM393N	250-0098	1

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KEPCO REPLACEMENT PARTS LIST

MST SERIES | **A3 COMMON PARTS ASSEMBLY (Figure 6-4)** | **CODE: 2671155**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
U4, 7, 8, 9, 25	5	IC DUAL PRECISION OP.AMP	LINEAR TECH. LT1013CN8	250-0198	1
U6, 10	2	IC, I.C. DUAL JFET-INPUT OP.AMP INT. COMPENSATED	T.I. TL082CP	250-0107	1
U12, 13	2	IC J FET INPUT OP.AMP	T.I. TL081CP	250-0100	1
U14	1	IC LOW INPUT OFFSET VOLTAGE OP. AMP	PRECISN MONO OP-07CP	250-0146	1
U15	1	IC PRECISION FIXED GAIN DIFFER-ENTIAL AMP.	BURR-BROWN INA106KP	250-0230	1
U16	1	ICPRECISION VOLTAGE REFER-ENCE +5V +/-1%	PMI REF02CP	250-0177	1
U17	1	IC OPTO-COUPLER (PHOTO TRST	NEC PS2502-2	119-0151	1
U18, 19, 20	3	IC DUAL PERIPHERAL NAND DRIVER, OUTPUT CLAMP	T.I. SN75477P	250-0194	1
U21	1	IC OVERVOLTAGE SENSING CIR-CUIT	MOTOROLA MC3423	250-0193	1
U22, 23, 26	3	IC OPTO-COUPLER (PHOTO TRST)	NEC PS2502-1	119-0152	1
U24	1	IC 3-TERMINAL NEGATIVE VOLT-AGE REGULATOR	NATIONAL LM79L05ACP	250-0178	1

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MST 75-2.5M **ASSEMBLY (Figure 6-4.)** **CODE: 2361456**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
C24	1	CAP., ELECTROLYTIC, AX. LEADS, 220UF, 20%, 100V	GE 43F9347AA1	117-0598	1
C26, 43	2	CAP., CERAMIC, 1000PF, 10%, 200V	PHILIPS A102K17X7RKVVWA	117-1084	1
C27, C50	2	CAP., CERAMIC 0.01UF, 10%, 50V	PHILIPS COMPONE A103K17X7RFVVWA	117-1053	1
C41, C45	2	CAP., ELECTROLYTIC, AX. LEADS, 22UF, 20% , 100V	UNITED CHEMICON SME100T22M8X16LL	117-1103	1
C44	1	CAP., CERAMIC, 0.1UF, 10%, 50V	PHILIPS COMPONE A104K18X7RFVVWN	117-1052	1
C49	1	CAP., MYLAR, METALLIZED, 0.022UF, 10%, 200V	ITW PAKTRON PT485	117-0377	1
C52	1	CAP., CERAMIC, 1UF, 10% , 50V	MURATA ERIE RPE113X7R105K050V	117-0999	1
Q2	1	TRANSISTOR, SI, NPN, POWER,	MOTOROLA MJF122	119-0168	1
Q5	1	TRANSISTOR, FIELD EFFECT,	INTER. RECT. P450	119-0158	1
RN1A, RN1B	1	RESIS., , SET 1K/100K 1/4W	DALE PTF65	234-0072	1
RN2A, RN2B	1	RESIS., NET 75K/4.99K RATIO 15:1	DALE PTF56	234-0040	1
RN3A, RN3B	1	RESIS. , NET.75K/10K	PRP INC. PR1/8	234-0014	1
RN6A, RN6B	1	RESIS., MATCHED SET 1K/10K	VISHAY DAALE SPTF-AR0-2	234-0007	1
R13, R53, R41	3	RES., FIX., CARBON FILM, 10 OHM, 1/4W, 5%	IRC GBT 1/4	115-2230	1
R31	1	RES., FIX., PRECISION, METAL FILM, 22.1 KOHM, 1/8W, 1%	DALE ELECTRONIC TYPE CFF-552212F	115-2857	1
R32	1	RES., FIX., PRECISION, METAL FILM, 16.5 KOHM, 1/4W, 1%	DALE CCF-55	115-2898	1
R52	1	RES., VAR., MULTITURN, TRIM-MER, COMP. OR CERM., 10 KOHM, 3/4W, 10%	BOURNS 3009P-1-103	115-2481	1
R55	1	RES., FIX., POWER, SHUNT (4 TERMINAL), 0.1 OHM, 15W, 1%	VISHAY DALE CPSL-15-5 .1 1%	115-2917	1
R59	1	RES., FIX., PRECISION, METAL FILM, 61.9 KOHM, 1/8W, 1%	VISHAY DALE MFF1/8 RN55E6192F	115-1653	1

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MST 75-2.5M **ASSEMBLY (Figure 6-4.)** **CODE: 2361456**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
R66	1	RES., FIX., POWER, AX. LEADS, 6.8 KOHM, 3W, 5%	TEPRO TS2B	1151284	1
R67	1	RES., FIX., CARBON FILM, 43 OHM, 1/2W, 5%	BALDWIN COMP. CR50	115-2123	1
R101	1	RES., FIX., CARBON FILM, 330 OHM, 1/4W, 5%	IRC GBT 1/4	115-2233	1
R105	1	RES., FIX., PRECISION, METAL-FILM, 3.7 KOHM, , 1/8W, 1%	DALE MMF 1/8	115-2512	1
R106	1	RES., FIX., PRECISION, METAL FILM, 150 KOHM, 1/8W, 1%	DALE RN55D	115-2597	1
R108, 111	2	RES., FIX., PRECISION, METAL FILM, 20 KOHM, 1/8W, 1%	PHILIPS SFR55	115-2887	1
R109	1	RES., FIX., PRECISION, METAL FILM, 10 KOHM, 1/8W, 1%	DALE ELECTRONIC TYPE CCF-55	115-2174	1
R110	1	RES., FIX., PRECISION, METAL FILM, 1.5 KOHM, 1/8W, 1%	DALE ELECTRONIC TYPE RN55D	115-2178	1
R112	1	RES., FIX., PRECISION, METAL FILM, 12.1 KOHM, 1/8W, 1%	DALE MMK 1/8	115-2453	1

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MST SERIES **A4 ASSEMBLY (Figure 6-5)** **CODE: 2361439**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.

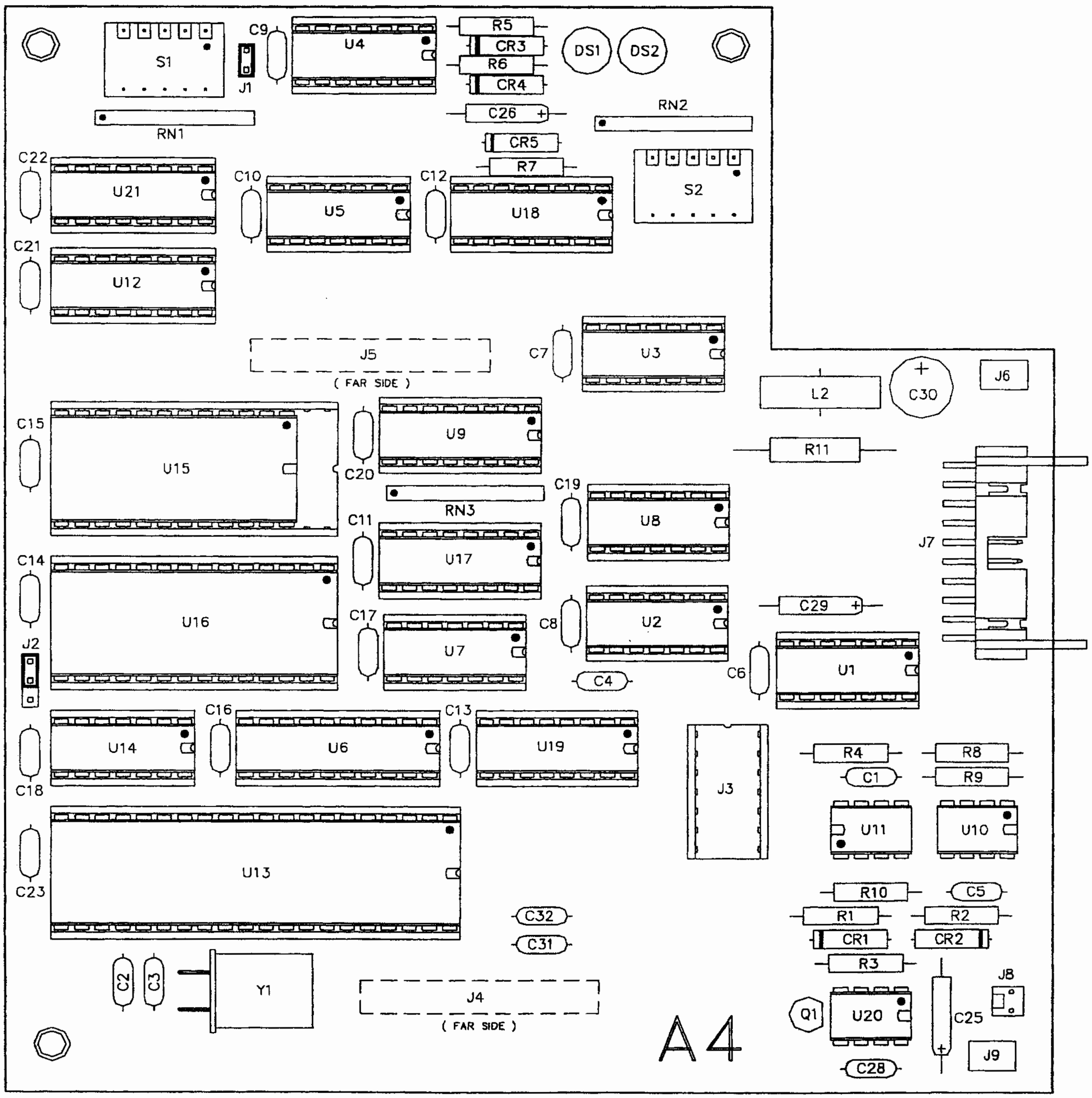

FIGURE 6-5. COMPONENT LOCATION OF MST ASSEMBLY A4

NOTE: REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO, INC. ORDERS SHOULD INCLUDE KEPCO PART NUMBER AND DESCRIPTION.

PLEASE NOTE: THE MANUFACTURER'S NAME AND PART NUMBER LISTED FOR EACH ITEM ON REPLACEMENT PARTS LISTS REPRESENTS AT LEAST ONE SOURCE FOR THAT ITEM AND IS LISTED SOLELY FOR THE CONVENIENCE OF KEPCO EQUIPMENT OWNERS IN OBTAINING REPLACEMENT PARTS LOCALLY. WE RESERVE THE RIGHT TO USE EQUIVALENT ITEMS FROM ALTERNATE SOURCES. KEPCO, INC.

KEPCO REPLACEMENT PARTS LIST

MST SERIES | **A4 ASSEMBLY (Figure 6-5)** | **CODE: 2361439**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
@J1, @J2	2	SHUNT 2 POSITION,	AMP 531220-1	172-0382	1
@J3, @U1-U5 @U14, @U7, @U8	9	TRANSISTOR OR I.C. SOCKET, 14 PINS	AMP 2-641599-3	143-0424	1
@U9, @U12, @U17-U19, @U21,	6	TRANSISTOR OR I.C. SOCKET, 16 PINS	AMP 2-641600-3	143-0425	1
@U13	1	TRANSISTOR OR I.C. SOCKET, 40 PINS	AMP 2-640379-3	143-0442	1
@U15, @U16	2	TRANSISTOR OR I.C. SOCKET, 28 PINS	AMP 2-640362-3	143-0441	1
@U6	1	TRANSISTOR OR I.C. SOCKET, 20 PINS	AMP 2-641602-3	143-0428	1
C1, C4-C23, C28,	22	CAP., CERAMIC, 0.1UF, + 10%, 50V	PHILIPS COMPONE A104K18X7RFVVWN	117-1052	1
C2, C3	2	CAP., CERAMIC, 10PF, 5%, 50V	PHILIPS COMPONE A100J17C0GHVVWA	117-1051	1
C25, C26, C29	3	CAP., TANTALUM, 22UF, 20%, 15V	SPRAGUE 162D226X0015EE2	117-0966	1
C30	1	CAP., ELECTRONIC SINGLE END LEADS, 100UF, + 44 -20%, 35V	UNITED CHEMICON LXF35VB12IM8X12LL	117-1074	1
C31, C32	2	CAP., CERAMIC, 470PF, 10%, 100V	PHILIPS COMPONE A471K17X7RHVVWA	117-1055	1
CR1, CR2, CR3, CR4, CR5	5	RECT., SWITCHING DIODE, 75V 0.4A	MOTOROLA 1N4148	124-0437	1
DS1	1	DEVICE, SIGNALING, LED RD 1.7V	LEECRAFT L131DR	153-0078	1
DS2	1	DEVICE, SIGNALING , LED YE 2.1V	LEECRAFT L131DY	153-0079	1
J1	1	JACK, PLUG, PCB MOUNT (STRAIGHT PINS), 2	SAMTEC TSW-101-07-TD	142-0262	1
J2	1	JACK, PLUG, PCB MOUNT (STRAIGHT PINS),	AMP 102943-3	142-0309	1
J4, J5	2	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT, 24	SAMTEC SSW-112-01-S--D	143-0557	1
J6, J9	2	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT, 2	AMP 175489-2	143-0522	1
J7	1	JACK, SOCKET, CONNECTOR PRINTED CIRCUIT, 20	AMP 104130-4	143-0446	1
J8	1	JACK, PLUG, PCB MOUNT (STRAIGHT PINS),	AMP 640456-2	142-0329	1

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KEPCO **REPLACEMENT PARTS LIST**

MST SERIES **A4 ASSEMBLY (Figure 6-5)** **CODE: 2361439**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
L2	1	INDUCTOR, CHOKE, OUTPUT FILTER, INDUCTOR, FILTER 40 TURNS MST	KEPCO 1002329	100-2329	1
Q1	1	TRANSISTOR, SI, NPN, SMALL SIGNAL,	MOTOROLA 2N4401	119-0093	1
RN1, RN2, RN3	3	NET (7)10K	DALE MSP08A01 103G	234-0021	1
R1, R3, R4, R8, R9, R10	6	RES., FIX., CARBON FILM, 390 OHM, 1/4W, 5%	IRC GBT 1/4	115-2234	1
R2	1	RES., FIX., CARBON FILM, 1.8 KOHM, 1/4W, 5%	IRC GBT 1/4	115-2470	1
R5, R6	2	RES., FIX., CARBON FILM, 1.5 KOHM, 1/4W, 5%	IRC GBT 1/4	115-2229	1
R7	1	RES., FIX., CARBON FILM, 100 KOHM, 1/4W, 5%	IRC GBT 1/4	115-2641	1
R11	1	RES., FIX., CARBON FILM, 20 OHM, 1W, 5%	RCD TYPE CF 100	115-0505	1
S1, S2	2	SWITCH, PRINTED CIRCUIT, SW-DIP 5 POS SP ST 50DVC 2A	AMP 1-435802-6	127-0406	1
U1	1	I.C. QUAD 3-STATE BUFFER	T.I SN174LS125AN	250-0164	1
U2	1	I.C. HEX INVERTER, HIGH SPEED CMOS LSTTL INP-COM	SIG. 74HCT04N	250-0165	1
U9	1	I.C. 4 D-TYPE EDGE-TRIGGERED FLIP-FLOP	T.I. SN74LS175N	250-0067	1
U10	1	OPTO-COUPLER(PHOTOTRST),	AVNET ELECTRONICS HCPL2631	119-0146	1
U11	1	OPTO-COUPLER(PHOTOTRST),	WYLE ELE I HCPL2601	119-0143	1
U12, U21	2	I.C. QUAD 2 TO 1 MULTIPLEXER (3-STATE) HI-SP CMOS	SIGNETICS 74HCT257N	250-0172	1
U13	1	I.C. MICROCONTROLLER W/ON-CHIP COMMUNICATION	INTEL P8044AH	250-0166	1
U15	1	I.C. 2K X 8 SRAM 120nS SECONDS	S-MOS SYS SRM1016C-12	250-0173	1
U16	1	IC, PROGRAMMED	KEPCO, INC. 250-0478	250-0478	1
U17, U18	2	I.C. QUAD 2 TO 1 MULTIPLEXER (3-STATE)	T.I. SN74LS257BN	250-0176	1

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MST SERIES **A4 ASSEMBLY (Figure 6-5)** **CODE: 2361439**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.
U19	1	I.C. 3 T0 8 DECODER/DEMULTI-PLEXER, HI-SP, CMOS	SIG. 74HCT138N	250-0170	1
U20	1	I.C. DIFFERENTIAL BUS TRANS-CEIVER	T.I. SN75176BP	250-0163	1
Y1	1	CRYSTAL 12 MHZ 0.005%	ECLIPTIC EC 1209S 12	253-0001	1

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MST SERIES **A5 ASSEMBLY (Figure 6-6)** **CODE: 2361258**

REFERENCE DESIGNATOR	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (SEE BOTTOM NOTE)	KEPCO PART NO.	REC. SPARE PART QTY.

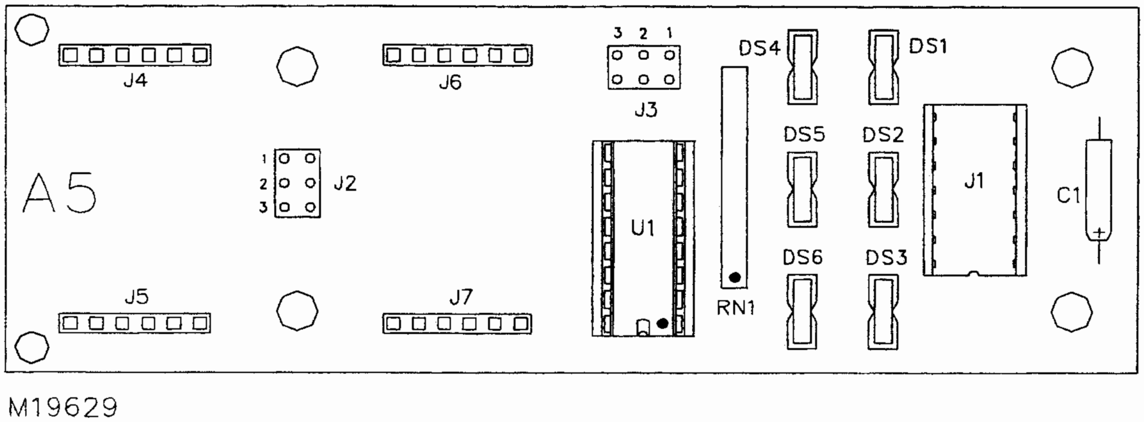

FIGURE 6-6. COMPONENT LOCATION OF MST ASSEMBLY A5

C1	1	CAP., TANTALUM 22UF,+ 20 -20%,15V	SPRAGUE 162D226X0015EE2	117-0966	1
DS1,DS3,DS5	3	DEVICE, SIGNALING, LED GN 2.3V	IND DEV 4306R5	153-0085	1
DS2	1	DEVICE, SIGNALING,, LED RD 2.3V	IND DEV 4306R1~	153-0087	1
DS4,DS6	2	DEVICE, SIGNALING LED YE 2.2V	IND DEV 4306R7	153-0086	1
J1	1	JACK,TRANSISTOR OR I.C. SOCKET, 14	AMP 2-641599-3	143-0424	1
J2,J3	2	JACK,PLUG, PCB MOUNT (STRAIGHT PINS), 6 PINS	SAMTEC TSW-103-07-TD~	142-0325	1
J4,J5,J6,J7	4	JACK,SOCKET, CONNECTOR PRINTED CIRCUIT, 6 PINS	AMP 534237-4	143-0547	1
RN1	1	RES. NET .120K	DALE MSP08A-01-121G	234-0073	1
U1	1	I.C. TRI-STATE BUFFER	SIG. N74LS365	250-0072	1
@U1	1	TRANSISTOR OR I.C. SOCKET, 16 PINS	AMP 2-641600-3	143-0425	1
@J2-3, @J3-2	2	SHUNT, TWO-POSITION	AMP INCORP. 382511-5	172-0382	1

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