

# OPERATOR'S MANUAL

## MBT SERIES POWER SUPPLY

### 360 WATT PROGRAMMABLE POWER SUPPLIES

#### MODEL MBT SERIES POWER SUPPLY

ORDER NO.

REV. NO.

#### IMPORTANT NOTES:

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

MODEL	SERIAL NO.	REV. NO.
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- 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.
- 3) The contents of this manual are protected by copyright. Reproduction of any part can be made only with the specific written permission of Kepco, Inc.

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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. 11355 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.11355 USA**

Saul Kupferberg  
(Full Name)

Date: \_\_\_\_\_

VP OF SALES  
(position)

## Conditions of Conformance

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 "built in" applications. 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 detachable power supply cord or via direct wiring to the source power terminal block.
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 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, and which exceed 240 VA at a potential of 2V or more.
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 circuit breaker mounted on the front panel. This circuit breaker 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. 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 factory-wired for the nominal a-c mains voltage indicated on the rating nameplate located adjacent to the source power connection on the product's rear panel. To reconfigure the product input for other nominal mains voltages as listed herein, the product must be modified by a trained service technician.

## 2. Grounding

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



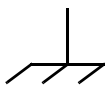
The PROTECTIVE EARTHING CONDUCTOR TERMINAL must be properly connected prior to application of source power to the product (see instructions on installation herein) in order to ensure safety from electric shock.



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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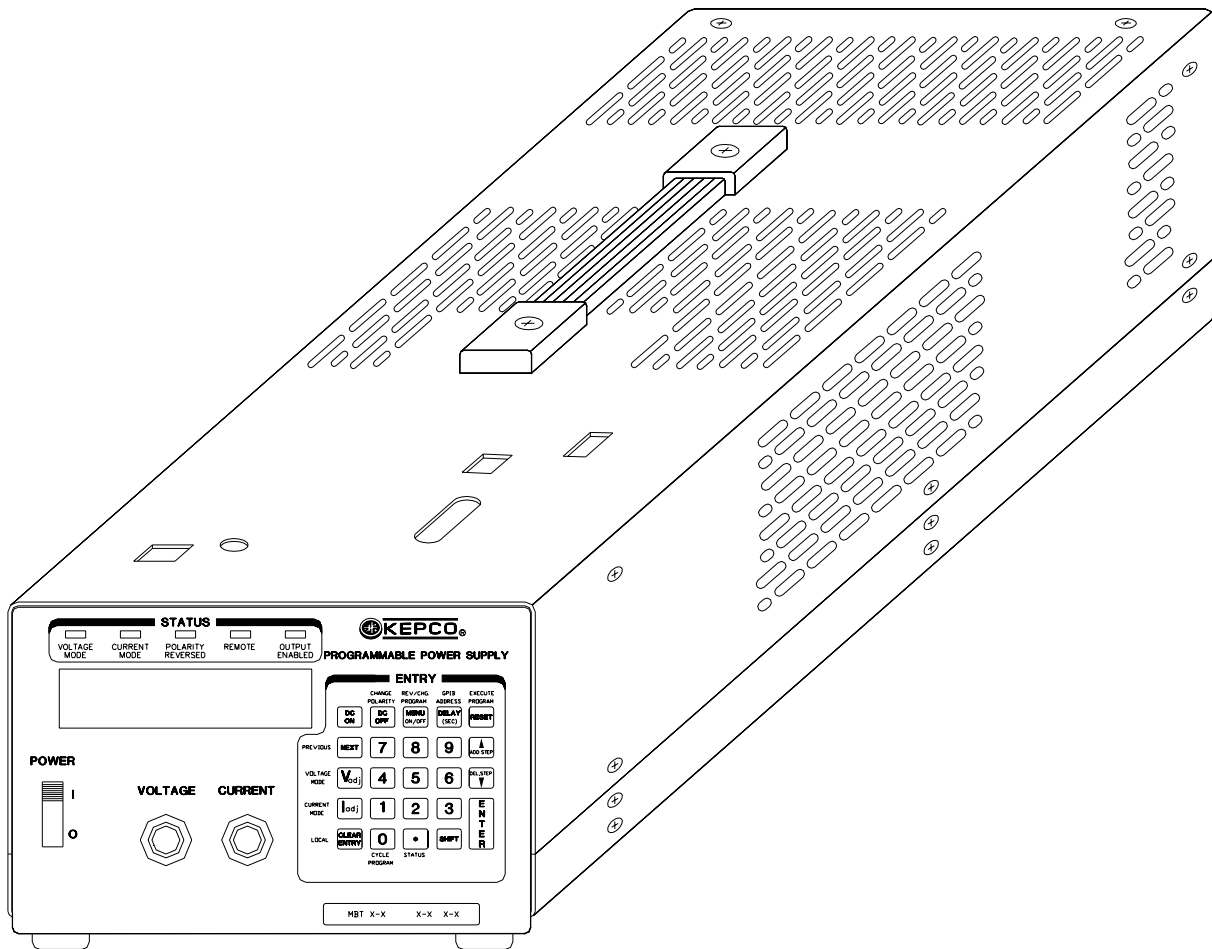
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FIGURE 1-1. MBT SERIES PROGRAMMABLE POWER SUPPLY



## SECTION 1 - INTRODUCTION

### 1.1 SCOPE OF MANUAL

This manual contains instructions for the installation and operation of the MBT series of 360 Watt (half rack), voltage and current stabilized d-c power supplies manufactured by Kepco, Inc., Flushing, New York, U.S.A.

### 1.2 GENERAL DESCRIPTION

The Kepco MBT Power Supply Series (Figure 1-1) consists of eight single-output models as listed in Table 1-1. All models can be delivered with the following options, indicated as a suffix to the Model Number (see PAR. 1.5):

- M- basic unit
- MG- with single board computer
- MR- with output/polarity reversal relays
- MGR- with single board computer and output/polarity reversal relays

MBT Series Power Supplies are of a stand-alone, bench top design whose half-rack cross section permits mounting in a standard Kepco rack adapter (see Table 1-4). MBT Series Power Supplies can be operated with 115V/230V (switch selectable) nominal a-c input power sources (47 - 63Hz).

MBT Series Power Supplies employ linear stabilization for accuracy and resolution. MBT Power Supplies are full-range, automatic-crossover voltage/current stabilizers with a full rectangular output characteristic. The MBT is controlled digitally with 12 bits of resolution over the entire voltage/current range. Voltage and current are displayed on an alphanumeric LCD display. The operational status of the unit is displayed by five front panel LED's: VOLTAGE MODE, CURRENT MODE, REVERSED POLARITY, REMOTE, and OUTPUT ENABLED. Control of the MBT can either be local (via the front panel controls and keypad) or remote (via the IEEE 1118 communication bus, or for option MG and MGR units, via the RS232C and IEEE 488.2 communication buses).

### 1.3 SPECIFICATIONS

Table 1-1 below indicates parameters that vary for different MBT models; Table 1-2 lists general specifications that apply to all MBT models.

**TABLE 1-1. MODEL PARAMETERS**

MODEL NUMBER	OUTPUT VOLTAGE RANGE (VOLTS)	OUTPUT CURRENT RANGE (AMPS)	MAXIMUM OUTPUT POWER (WATTS)
MBT 6-32M	0-6	0-32	192
MBT 15-20M	0-15	0-20	300
MBT 25-14M	0-25	0-14	350
MBT 36-10M	0-36	0-10	360
MBT 55-7M	0-55	0-7	385
MBT 75-5M	0-75	0-5	375
MBT 100-3.6M	0-100	0-3.6	360
MBT 150-2.4M	0-150	0-2.4	360

**TABLE 1-2. GENERAL SPECIFICATIONS**

CHARACTERISTIC	REQUIREMENT		
INPUT			
A-c Voltage (User selectable)	105-125V/210-250V a-c		
A-c Input Frequency Range	47-63 Hz		
A-c Input Current	115V a-c (nominal)	7.5 Amperes	
	230V a-c (nominal)	3.7 Amperes	
OUTPUT			
Voltage/Current Adjustment Range	0 - 100% of rating, either continuously (inherent resolution), by step or by programmed setting.		
Remote Sensing Range	0.5V per lead		
D-C Isolation Voltage	500V d-c		
Enable/Disable Output Power	Using front panel or via the Digital Bus.		
Polarity Reversal (MR and MGR models only)	Built-in polarity reversal power & sense relays.		
Protection	Overvoltage	Tracks programmed voltage, crowbars output & turns off input circuit breaker.	
	Overcurrent	Tracks programmed current, crowbars output & turns off input circuit breaker.	
	Overtemperature	Monitors heatsink temperature, crowbars output & turns off input circuit breaker.	
	External Polarity Reversal	Built-in diode protects unipolar supply output.	
	Power Loss	Detects loss of a-c input power, disables output & turns off input circuit breaker.	
	Overvoltage or interruption between Power and Sensing Leads	MR and MGR Models:	Output voltage and current programmed to zero and output relays opened.
	M and MG Models:	Output voltage and current programmed to zero and/or output crowbar activated and input circuit breaker turned off	
CONTROL-INDICATORS			
Programming Resolution/Accuracy		Programming Resolution	Accuracy
	Voltage	0.024% E <sub>OMAX</sub> (12 Bits)	0.024% E <sub>OMAX</sub>
	Current	0.024% I <sub>OMAX</sub> (12 Bits)	0.1% I <sub>OMAX</sub>
Data Read-back Accuracy	Voltage	0.1% E <sub>OMAX</sub>	
	Current	0.15% I <sub>OMAX</sub>	
Output Display	2X16 Char. Alphanumeric LCD with LED Backlight Indicates Output Voltage, Output Current, Status and Menu. Output voltage displayed by four digits with either three, two, or one decimal(s), depending on Model; output current displayed by either three or four digits (depending on Model) with two decimals.		
Indicators (LED)	VOLTAGE MODE	Green; lit when unit is in voltage mode.	
	CURRENT MODE	Amber; lit when unit is in current mode.	
	POLARITY REVERSED	Red; lit when polarity reversed. (Operational for MR and MGR Models only.)	
	REMOTE	Green; lit when unit is operating in remote mode.	
	OUTPUT ENABLED	Green; lit when output is enabled.	

**TABLE 1-2. GENERAL SPECIFICATIONS (CONTINUED)**

CHARACTERISTIC	REQUIREMENT	
STATIC		
Source Effect	Voltage	0.001% $E_{OMAX}$
	Current	0.005% $I_{OMAX}$
Load Effect	Voltage	0.002% $E_{OMAX}$
	Current	0.024% $I_{OMAX}$ or 4mA (whichever is greater)
Time Effect (8 Hour Drift)	Voltage	0.01% $E_{OMAX}$
	Current	0.02% $I_{OMAX}$
Temperature Coefficient (per °C)	Voltage	0.01% $E_{OMAX}$
	Current	0.02% $I_{OMAX}$
Ripple & Noise (rms/p-p)	Voltage	0.001%/0.01% $E_{OMAX}$ or 0.3mV/3mV (whichever is greater)
	Current	0.03%/0.3% $I_{OMAX}$
MISCELLANEOUS		
Series/Parallel Operation	Consult Kepco applications engineering.	
Leakage Current	Common mode current: 5 $\mu$ A rms or 50 $\mu$ A p-p @ 115V a-c	
Temperature	Storage	-20° C to +70° C
	Operating	0° C to 50° C
Cooling	Built-in fan, exhausts air to rear.	
D-C Output Terminals	Binding posts; barrier strip for remote sensing and monitor connections.	
Local voltage/current control	Output can be controlled by entering the desired value via front panel keypad or continuously (inherent resolution) adjusted via front panel control knobs.	
Remote Error Sensing	Provision for 4-terminal (Kelvin) connection to load; static drop of up to 0.5V/lead may be compensated.	
Voltage Recovery for a Step Load Current	100 $\mu$ sec typical, 150 $\mu$ sec max to recover within 10mV for a 10% to 100% step in rated load current.	
PHYSICAL		
Dimensions	See Figure 1-2.	
Weight (lbs.)	Model M: 35; Models MR, MG: 36; Model MGR:37	
Source Connections	Detachable IEC type 3-wire power entry.	
Load Connections	Binding Post	
Remote Control Signal Connections	IEEE 1118	Two 9-Pin D-type connectors (female) in parallel for input/output daisy chain.
	RS232-C	9-Pin D-type connector (male)
	IEEE 488	24-Pin connector (female)
Sense, Monitor Connections	Barrier strip	

1. KEPCO HAS THE RIGHT TO MAKE ANY CHANGES TO THIS DRAWING WITHOUT NOTICE.

NOTES:

1-MATERIAL:

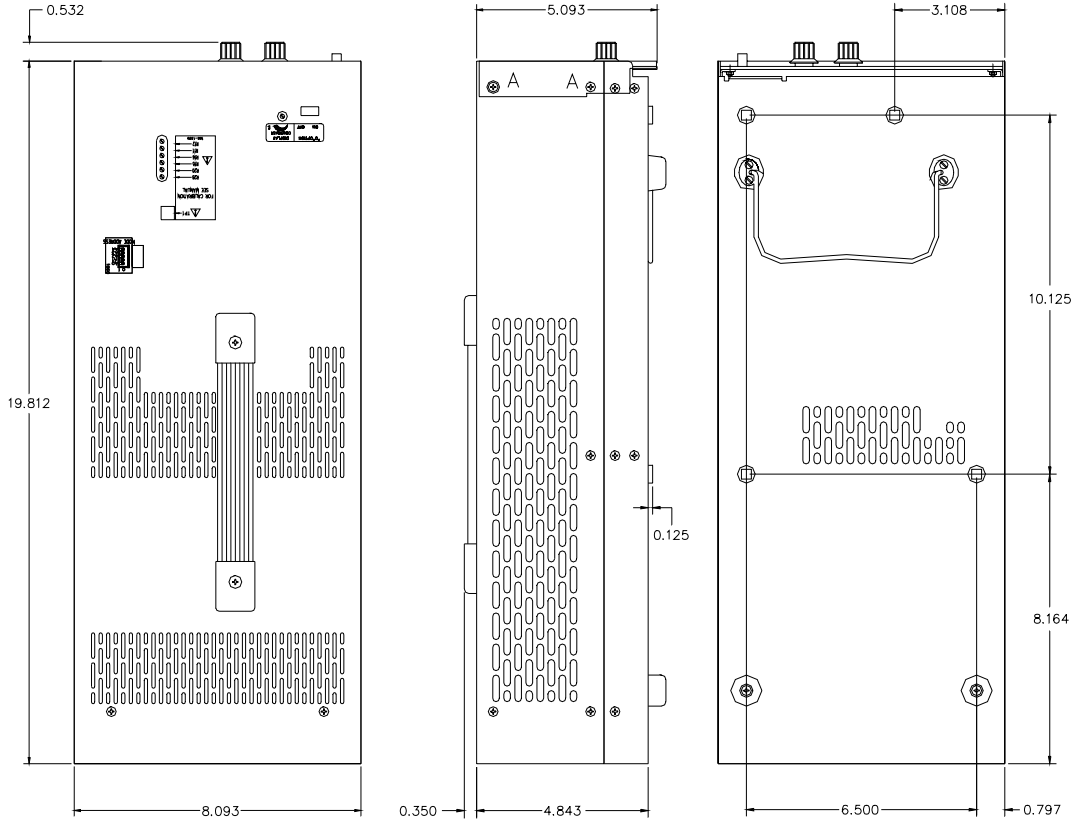
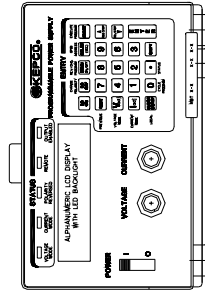
- A-COVER: #16 GAUGE C.R.S
- B-FRONT PANEL: #14 GAUGE C.R.S WITH 0.010" THK. CLEAR HARD COATED POLYCARBONATE OVERLAY
- C-CHASSIS: #16 GAUGE C.R.S

2-FINISH:

- A-COVER & CHASSIS: CHARCOAL GRAY VINYL TEXTURE
- B- FRONT PANEL LIGHT GRAY PER FEDERAL STD 595-26496

3-RACK ADAPTER MOUNTING:

- A-REMOVE BAIL . (4)FEET & HANDLE FROM POWER SUPPLY.
- B-REMOVE (4) 6-32 SCREWS MARKED "A" ( 2 ON EACH SIDE ) AND SET ASIDE. MOUNT (2) FILLER PLATE ( LEFT P/N 12B1773 & RIGHT P/N 12B1774 ) WITH SAME SCREWS.
- C-INSERT (4) SCREW 8-18 X 5/8 KEPCO P/N 101-0421, THROUGH BOTTOM OF RACK ADAPTER AND ALIGN WITH GROMMETS ON BOTTOM OF UNIT.



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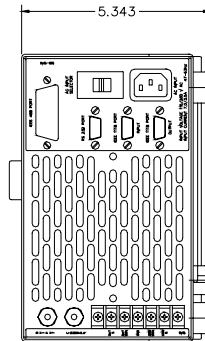


FIGURE 1-2. MBT SERIES POWER SUPPLY, MECHANICAL OUTLINE DRAWING

## **1.4 FEATURES**

### **1.4.1 LOCAL CONTROL**

Two front panel optical encoder controls and/or keypad entries are utilized for setting and adjusting output voltage and current under Local control. The keypad's keys are organized to either directly execute commands, or to introduce a program that can either run once or be cycled. Calibration of the unit is facilitated by a menu-driven procedure.

### **1.4.2 REMOTE CONTROL**

Figure 1-3 shows remotely controlled Power Supply configurations using Kepco products.

All MBT models can be remotely controlled via the IEEE 1118 serial bus using the following Kepco Power Supply Controllers (MG and MGR Models must have the "G" option disabled):

- TMA PC-27 Plugs into a DOS-compatible PC (half-card slot).
- TMA 4882-27 Stand-alone unit, connected to an RS232C or IEEE 488 bus.
- MST 488-27 Module (1/9 rack), plugs in Kepco RA 55 Rack Adapter where it interfaces with an RS232C or IEEE 488 bus.
- TMA VXI-27 Module, plugs into VXI main frame equipped with a GPIB Controller Module; without a GPIB Controller, you must have a VXI-based embedded CPU and a TMA VXI-27 module.

MBT Power Supplies can also be controlled remotely via the keypad of any MBT Series Power Supply connected to the daisy chain as long as there is one Models MG or MGR power supply with the "G" option enabled included in the daisy chain. MBT Models MG and MGR with the "G" option enabled can be controlled directly via the RS232-C bus or the IEEE 488 bus.

## **1.5 OPTIONS**

### **1.5.1 OPTION G - SINGLE BOARD COMPUTER**

The Single Board Computer (SBC) included on "G" option models (MG and MGR) enables the RS232-C and GPIB (IEEE 488) communication buses and permits an MBT power supply to function as a "master" to control other power supplies. A switch accessible through the top cover allows disabling of the "G" Option circuitry to allow a "G" option unit to function as a "slave" and be controlled by another "G" option unit functioning as a "master". In configurations with more than one MBT Series Power Supply, only one unit can have the "G" option enabled; if other "G" option units are used, the "G" option must be disabled.

### **1.5.2 OPTION R - OUTPUT/POLARITY REVERSAL RELAYS**

MBT units with the "R" option (MR and MGR) contain Output/Polarity Reversal relays and associated control circuits, allowing the output to be enabled/disabled, polarity reversed and the local selection of current mode (with the output disabled) by connecting an internal shunt across the output. Disabling the MBT as a voltage source requires opening the connection between the MBT and its load. Disabling the MBT as a current source requires that the MBT output terminals be shorted. The Polarity Reversal relays permit two-quadrant operation of the MBT.

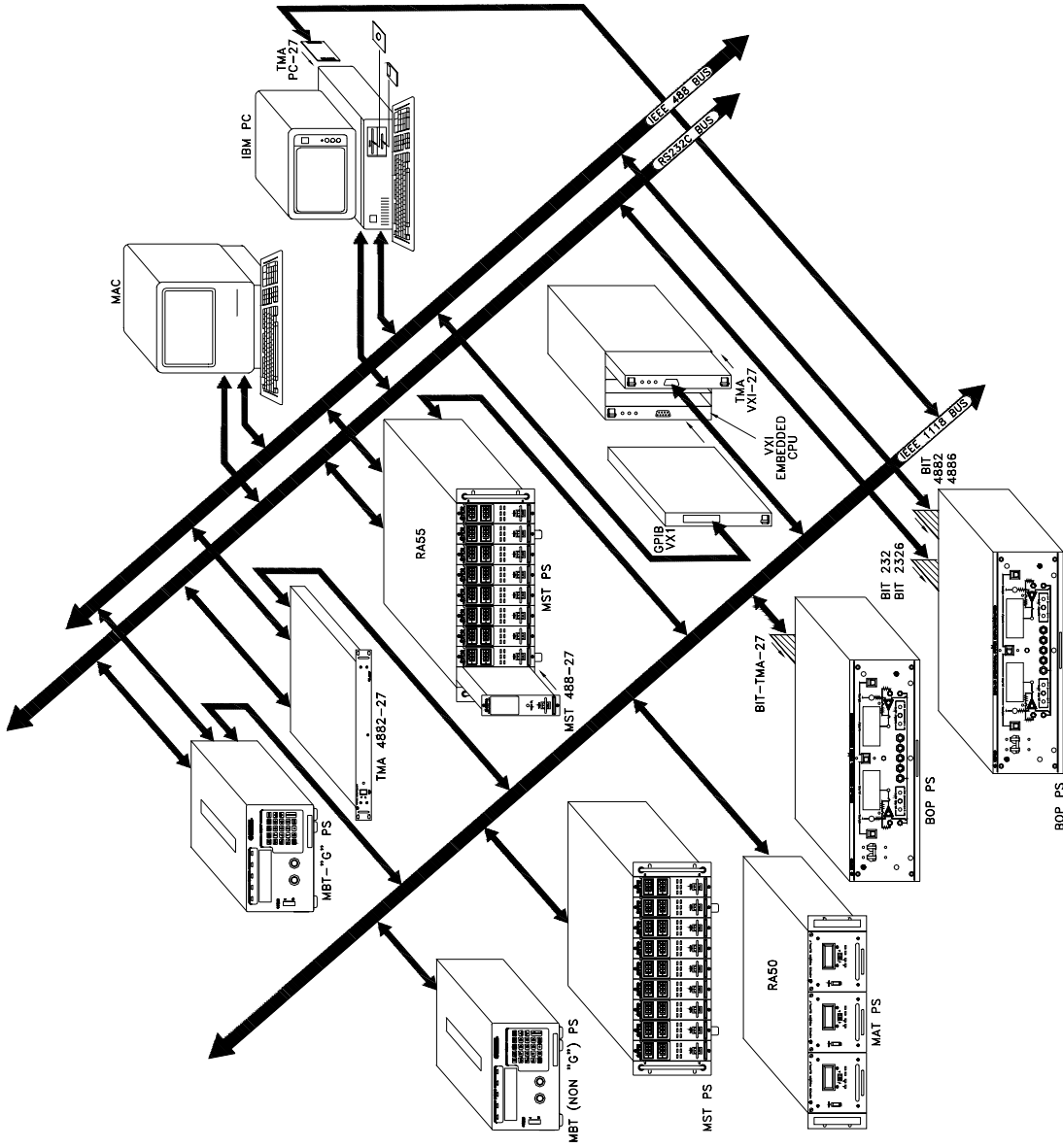


FIGURE 1-3. REMOTELY CONTROLLED POWER SUPPLY CONFIGURATIONS USING KEPSCO PRODUCTS

**1.6 EQUIPMENT SUPPLIED**

Equipment supplied with the unit is listed in Table 1-3.

**TABLE 1-3. EQUIPMENT SUPPLIED**

ITEM	SUPPLIED WITH MODEL	PART NUMBER
Power Cord	All units	118-0557
Cable with two 9-pin connectors for IEEE 1118 bus	All units	118-0844
Terminator for IEEE 1118 bus	All units	195-0086

**1.7 ACCESSORIES**

Accessories for the MBT Power Supply are listed in Table 1-4.

**TABLE 1-4. ACCESSORIES**

ITEM	FUNCTION	PART NUMBER
Cable - two 5-pin connectors	Daisy chain Kepco Power Supplies with 5-pin connectors on IEEE 1118 bus.	118-0699
Cable - one 5-pin and one 9-pin connector, ~6 ft. (2 m)	Daisy chain MBT Power Supply and Kepco Power Supplies with 5-pin connector on IEEE 1118 bus.	118-0749
Cable - one 5-pin and one 9-pin connector, ~12 ft. (4 m)		118-0852
Cable - two 9-pin connectors, ~ 12 ft. (4 m)	Daisy chain MBT Power Supply and Kepco Power Supplies with 9-pin connector on IEEE 1118 bus.	118-0853
Rack Adapter	Allows rack mounting of two MBT Series Power Supplies in a standard 19-inch rack (see Figure 1-2).	RA 37
Filler plate	Facilitate installation of MBT Power Supply in RA 37 Rack Adapter.	128-1773 (left) 128-1774 (right)
Connector	Mating connector for model MBT-G RS323C connector.	143-0296





## 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 Section 2.5. If any indication of damage is found, file an immediate claim with the responsible transport service.

### 2.2 TERMINATIONS AND CONTROLS

- a) Front Panel: Refer to Figure 2-1 and Table 3-1.
- b) Internal Controls: Refer to Figure 2-2 and Table 2-1.
- c) Rear Panel: Refer to Figure 2-3 and Table 2-2.

### 2.3 SOURCE POWER REQUIREMENTS



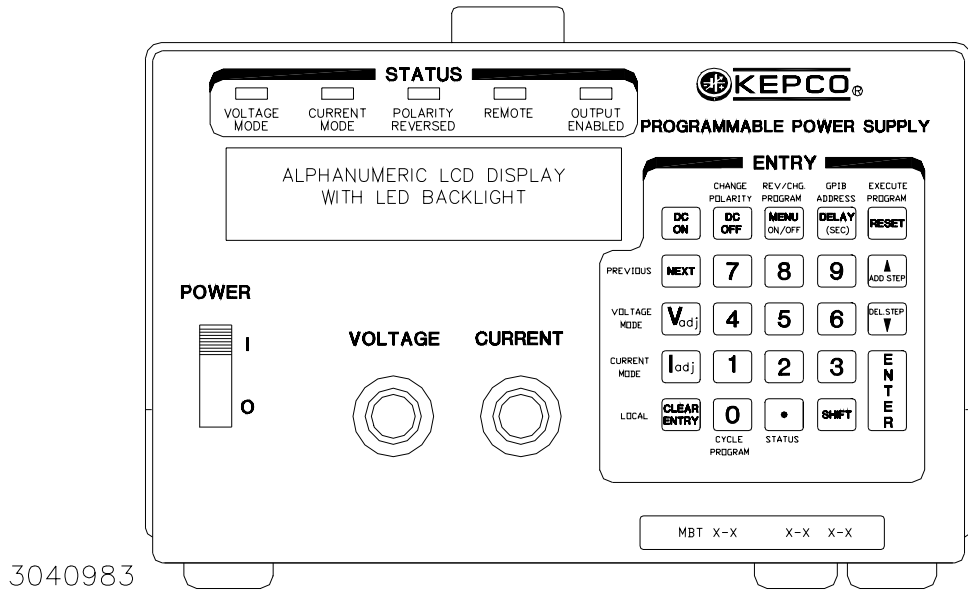
**WARNING**

**BEFORE APPLYING THE A-C SOURCE TO THE POWER SUPPLY, VERIFY THAT THE LINE VOLTAGE TO BE SUPPLIED MATCHES THE POSITION OF THE AC INPUT SELECTOR SWITCH AT THE REAR PANEL (FACTORY DEFAULT IS 115V).**

This power supply operate with the installed circuit breaker from single phase a-c mains power over the specified voltage and frequency ranges without adjustment or modification. The AC INPUT SELECTOR switch located on the rear panel (Figure 2-3) allows selection of either 115V a-c or 230V a-c source power.

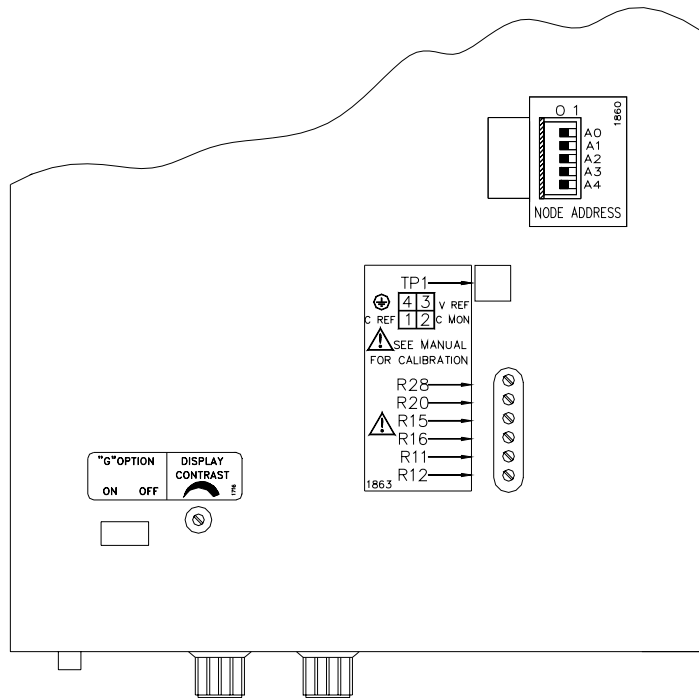
### 2.4 COOLING

The power devices used within the power supply are maintained within their operating temperature range by means of internal heat sink assemblies cooled by an internal cooling fan. The fan operates at low speed for low ambient temperatures and low internal dissipated power, and at high speed for high ambient temperature and/or high internal dissipated power. ALL INLET AND EXHAUST OPENINGS AROUND THE POWER SUPPLY CASE MUST BE KEPT CLEAR OF OBSTRUCTION TO ENSURE PROPER AIR ENTRY AND EXHAUST. Periodic cleaning of the power supply interior is recommended. If the power supply is rack mounted, or installed within a confined space, care must be taken that the ambient temperature, which is the temperature of the air immediately surrounding the power supply, does not rise above the specified limits (see Table 1-2).



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FIGURE 2-1. MBT SERIES FRONT PANEL CONTROLS AND INDICATORS



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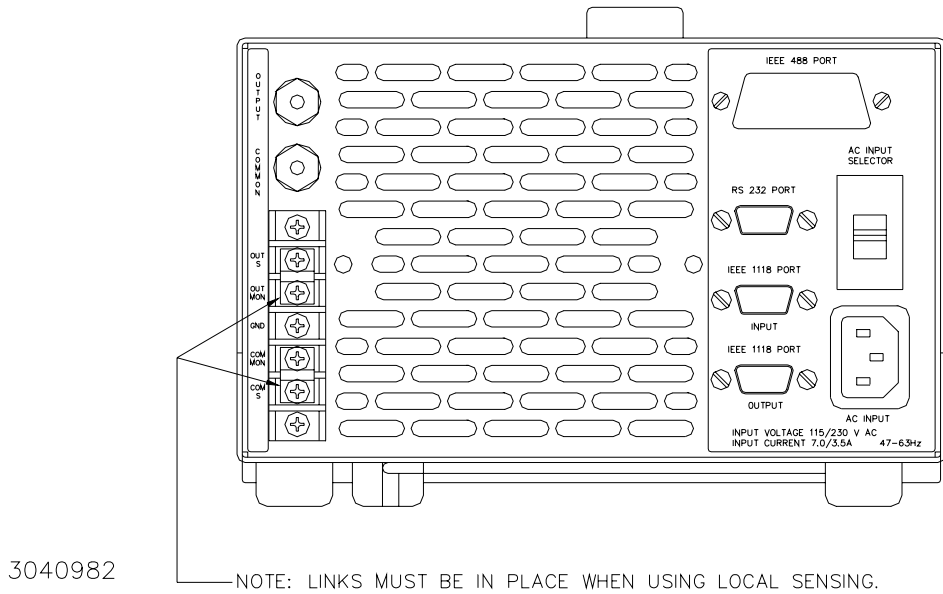
FIGURE 2-2. MBT SERIES INTERNAL CONTROLS ACCESSIBLE THROUGH TOP COVER

**TABLE 2-1. INTERNAL CONTROLS ACCESSIBLE THROUGH TOP COVER**

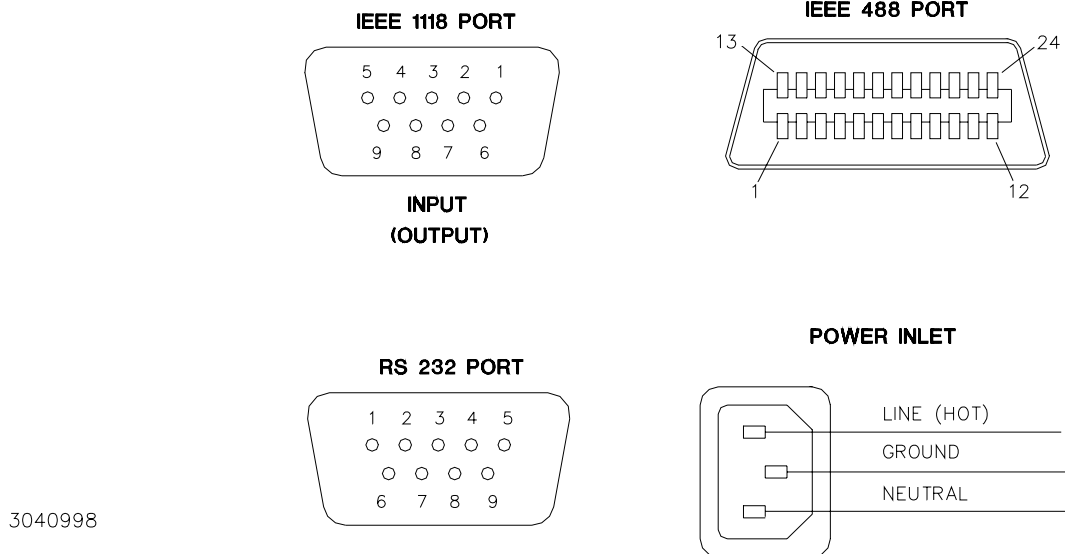
REFERENCE DESIGNATION	CONTROL	PURPOSE
A1R28	$I_{O\ ZERO}$ (NOTE 1)	Used to adjust output current of power supply to initial value. CONDITIONS: current mode, shunt at the output.
A1R20	$E_{O\ ZERO}$ (NOTE 1)	Used to adjust output voltage of power supply to zero. CONDITIONS: voltage mode, no load.
A1R15	$I_{\text{CURRENT SENSING ZERO}}$ (NOTE 1)	Used to adjust current monitor amplifier to zero. CONDITIONS: voltage mode, no load.
A1R16	$I_{\text{FULL SCALE CURRENT ADJUST}}$ (NOTE 1)	Used to calibrate the full scale value of the output current. CONDITIONS: current mode, shunt at the output.
A1R11	$V_{REF}$ (NOTE 1)	Used to calibrate full scale voltage. CONDITIONS: voltage mode, no load.
A1R12	$I_{REF}$ (NOTE 1)	Used to adjust internal full scale current. CONDITIONS: current mode, shunt at the output.
A8S1	"G" Option Selector (NOTE 2)	"G" Option Selector (NOTE 2)"G" option units only: Enables/Disables "G" Option circuits so unit can function as "slave" unit under control of another "G" option unit functioning as a "master." Factory default position is ON: unit functions as a "master."
A8R7	Display Contrast Adjust	Adjusts contrast of front panel alphanumeric display.
A3S1	Node Address (NOTE 3)	Used to select Node address (node number or channel number) of the MBT Power Supply from 1 - 31
A1TP1	Test Points	Provides four test points used for testing/calibration 1 -CURRENT REFERENCE 2 -CURRENT MONITOR 3 - VOLTAGE REFERENCE 4 - COMMON
<p>NOTES:</p> <ol style="list-style-type: none"> <li>These adjustments must be done in accordance with the calibration procedure (see PAR. 5.5 or refer to procedure available at MBT front panel by entering MENU and selecting CALIBRATION (see PAR. 3.2.2.4).</li> <li>This switch is not included on some older models; refer to Kepco applications engineering for assistance in disabling the "G" option.</li> <li>The NODE ADDRESS selector is not accessible through top cover on some older models; it is necessary to remove the top cover to set the node address.</li> </ol>		

**TABLE 2-2. INPUT/OUTPUT PIN ASSIGNMENTS FOR REMOTE CONTROL**

CONNECTOR	PIN	SIGNAL NAME	FUNCTION
RS232-C J4	1	SGND	Signal Ground
	2	RXD	Receive Data
	3	TXD	Transmit Data
	4	DTR	( not used)
	5	SGND	Signal Ground
	6	DSR	See Note.
	7	RTS	See Note.
	8	CTS	Clear To Send (protocol not used)
	9	SGND	Signal Ground
	NOTE: Jumper installed between DSR and RTS allows secondary GPIB addressing if SCPI mode (see Table 2-4) is selected		
IEEE 1118 INPUT/OUTPUT J2, J3	1	Not used	
	2	SHIELD	Shield
	3	IEEE 1118 BUS	Communicate via IEEE 1118 bus
	4	Not used	
	5	Not used	
	6	Not used	
	7	SHIELD	Shield
	8	IEEE 1118 BUS	Communicate via IEEE 1118 bus
	9	Not used	
IEEE 488 PORT J5	1	DI01	I/O Line
	2	DI02	I/O Line
	3	DI03	I/O Line
	4	DI04	I/O Line
	5	EOI	End or Identify
	6	DAV	Data Valid
	7	NRFD	Not Ready for Data
	8	NDAC	Not Data Accepted
	9	IFC	Interface Clear
	10	SRQ	Service Request
	11	ATN	Attention
	12	SHIELD	Shield
	13	DI05	I/O Line
	14	DI06	I/O Line
	15	DI07	I/O Line
	16	DI08	I/O Line
	17	REN	Remote Enable
	18	GND	Ground (signal common)
	19	GND	Ground (signal common)
	20	GND	Ground (signal common)
	21	GND	Ground (signal common)
	22	GND	Ground (signal common)
	23	GND	Ground (signal common)
	24	LOGIC GND	Logic Ground



**FIGURE 2-3. MBT SERIES REAR PANEL CONNECTIONS**



**FIGURE 2-4. CONNECTOR PIN ASSIGNMENTS**

## 2.5 PRELIMINARY OPERATING PROCEDURES

After the unit is unpacked, and before the unit is installed, the following procedure is required to set the node address.

### 2.5.1 NODE ADDRESS (CHANNEL NUMBER) SELECTION

The node address is set by Node Address selector DIP switch A3S1 accessed through the top cover (see Figure 2-2). The address can be set to any number from 1 to 31 by setting the switch positions to the binary value as shown in Table 2-3.

**TABLE 2-3. 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

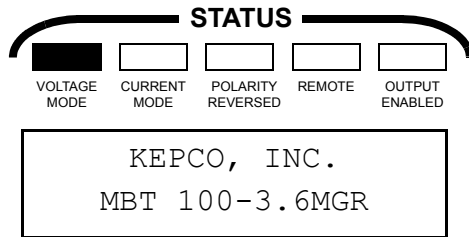
## 2.5.2 PRELIMINARY OPERATIONAL CHECK

A simple operational check after unpacking and before equipment installation is advisable to ascertain whether the power supply has suffered damage resulting from shipping. Refer to Figures 2-1 and 2-3 for location of operating controls and electrical connections. Tables 3-1 and 3-2 explain the functions of operating controls/indicators and keypad keys, respectively.

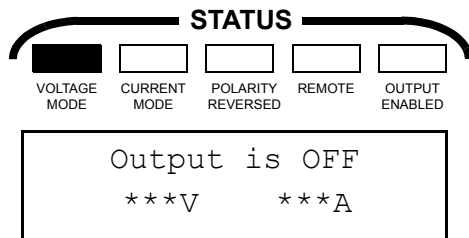
### WARNING

**BEFORE APPLYING THE A-C SOURCE TO THE POWER SUPPLY, VERIFY THAT THE LINE VOLTAGE TO BE SUPPLIED MATCHES THE POSITION OF THE AC INPUT SELECTOR SWITCH AT THE REAR PANEL (FACTORY DEFAULT IS 115V).**

1. With no load connected, set POWER circuit breaker to the ON position. As shown below, the alphanumeric display indicates the model and options; VOLTAGE MODE status indicator is on, all other status indicators are off.



2. After approximately 2 seconds, the display changes to:



NOTE: \*\*\*V and \*\*\*A are the output voltage and current settings in effect at time of last operation (for first time use, the voltage and current are set to 0).

3. Rotate VOLTAGE control first clockwise, then counterclockwise; verify voltage shown on display increases for clockwise rotation and decreases for counterclockwise rotation. If the voltage control has no effect, refer to PAR.s 3.2.2 and 3.2.2.2 to check whether the adjustments are locked; unlock adjustments if necessary.

NOTE: If the voltage (or current) does not increase beyond a certain point, press **SHIFT** then "." keys (STATUS command) to see the overvoltage protection (OVP) and overcurrent protection (OCP) values. Refer to PAR.s 3.2.2 and 3.2.2.5 set new values if necessary.

4. Verify short beeps are audible when VOLTAGE control is rotated. If beeps are not heard refer to PAR.s 3.2.2 and 3.2.2.1 to check whether the speaker is disabled; enable speaker if necessary.
5. Rotate CURRENT control first clockwise, then counterclockwise; verify current shown on display increases for clockwise rotation and decreases for counterclockwise rotation. Verify short beeps are audible when CURRENT control is rotated.

6. Press slew keys, first ▲, then ▼; verify that beeps are heard and displayed programmed voltage increases when ▲, is pressed and decreases when ▼ is pressed.
7. Press **Vadj** key, then enter a numeric value within the voltage range of the power supply and press **ENTER** key. Verify that the display shows the new value for programmed voltage.
8. Press **Iadj** key, then enter a numeric value within the current range of the power supply and press **ENTER** key. Verify that the display shows the new value for programmed current.
9. Connect a digital voltmeter (DVM) (see PAR. 5.5.1.a) to the OUTPUT and COMMON terminals at the rear panel.
10. Program the *nominal* value for current as specified in step 8 above (the *nominal* value refers to the rating of the unit, e.g., for the MBT 100-2.4, *nominal* voltage is 100V and *nominal* current is 2.4A).
11. Press DC ON to enable the output of the unit. The OUTPUT ENABLED status indicator goes on and the display shows the actual output voltage and current (current = 0A) of the power supply.

NOTE: If tolerances specified in the following steps are exceeded, calibration adjustments may have changed during transit; refer to PAR. 5.5 and recalibrate the unit.

12. Compare the voltage shown on the front panel display with the voltage reading of the DVM; the difference between the two should not exceed 0.1% of the nominal voltage of the unit.
13. Repeat step 7 using a different value for programmed voltage and compare the programmed voltage with the voltage reading of the DVM; the difference between the two should not exceed 0.024% of the nominal voltage of the unit.
14. Disable the output by pressing DC OFF key and repeat step 8 above using a different value for output current.
15. Disconnect DVM and connect precision shunt (see PAR. 5.5.1.b) across OUTPUT and COMMON terminals at rear panel; connect DVM across shunt (sensing terminals) and program nominal value for voltage.
16. Press DC ON key to enable the output of the unit. Verify VOLTAGE MODE indicator goes off and CURRENT MODE indicator goes on. Verify that front panel display shows a small value for output voltage ( $R_S \times I_{O\text{prog}}$  where  $R_S$  = resistance of shunt in ohms) and the actual value for current programmed in step 14. Note DVM reading ( $V_{\text{DVM}}$ ) and calculate the output current using the formula  $V_{\text{DVM}}/R_S$ .
17. Compare the output current value shown on the front panel display with the value calculated above (step 16); the difference between the two should not exceed 0.15% of the nominal current of the unit.
18. Repeat step 8 using a different value for programmed current and compare the programmed current. Calculate the output current using the DVM voltage (see step 16), then compare the programmed current with the calculated output current; the difference between the two should not exceed 0.1% of the nominal current of the unit.
19. Disable the output by pressing DC OFF key and turn off power supply.



## **2.6 INSTALLATION**

### **2.6.1 BENCH TOP USE**

If the unit is to be used as a bench top instrument, a bail located on the bottom of the unit can be utilized to raise the front of the unit about two inches for ease of accessing the front panel controls, indicators, keypad, and LCD display.

### **2.6.2 RACK MOUNTING**

If the unit is to be rack-mounted, refer to Figure 1-2 for instructions.

### **2.6.3 "G" OPTION SELECTOR (MG AND MGR MODELS)**

If the unit is to be incorporated into a remote-controlled power system (Figure 1-3), certain considerations have to met:

- The Power System can only have one controller; therefor only one MBT Power Supply in the system can have the "G" option enabled. To disable the "G" option on additional MBT units in the Power System, set the "G" option ON/OFF selector switch accessed through the top cover (Figure 2-2) to OFF. For "G" option models without this switch, contact Kepco Inc. or a local representative for assistance. If controller other than an MBT "G" option unit is used, disable the "G" option of all MBT units.
- Control of any MBT Power Supply in the system is possible from any MBT unit's keypad in the "daisy chain" configured Power System.
- A remotely controlled Power System can have as many as 27 units. Each power supply in the system must have a unique node address (see PAR. 2.5.1).

## **2.7 WIRING INSTRUCTIONS**

Interconnections between an a-c power source and a power supply, and between the power supply and its load are as critical as the interface between other types of electronic equipment. If optimum performance is expected, certain rules for the interconnection of source, power supply and load must be observed by the user. These rules are described in detail in the following paragraphs.

### **2.7.1 SAFETY GROUNDING**

Local, national and international safety rules dictate the grounding of the metal cover and case of any instrument connected to the a-c power source, when such grounding is an intrinsic part of the safety aspect of the instrument. The ground terminal of the source power connector (figure 2-4) is connected the the MBT chassis and the instructions below suggest wiring methods which comply with these safety requirements; however, in the event that the specific installation for the power system is different from the recommended wiring, it is the customer's responsibility to ensure that all applicable electric codes for safety grounding requirements are met.

### **2.7.2 SOURCE POWER CONNECTIONS**

Source power is connected to the power supply via the three-wire power input cable supplied.

### **2.7.3 D-C OUTPUT GROUNDING**

Connections between the power supply and the load and sensing connections may, despite all precautions such as shielding, twisting of wire pairs, etc., be influenced by radiated noise, or “pick-up”. To minimize the effects of this radiated noise the user should consider grounding one side of the power supply/load circuit. The success of d-c grounding requires careful analysis of each specific application, however, and this recommendation can only serve as a general guideline.

One of the most important considerations in establishing a successful grounding scheme is to avoid GROUND LOOPS. Ground loops are created when two or more points are grounded at different physical locations along the output circuit. Due to the interconnection impedance between the separated grounding points, a difference voltage and resultant current flow is superimposed on the load. The effect of this ground loop can be anything from an undesirable increase in output noise to disruption of power supply and/or load operation. The only way to avoid ground loops is to ensure that the entire output/load circuit is fully isolated from ground, and only then establish a single point along the output/load circuit as the single-wire ground point.

The exact location of the “best” d-c ground point is entirely dependent upon the specific application, and its selection requires a combination of analysis, good judgement and some amount of empirical testing. If there is a choice in selecting either the positive or negative output of the power supply for the d-c ground point, both sides should be tried, and preference given to the ground point producing the least noise. For single, isolated loads the d-c ground point is often best located directly at one of the output terminals of the power supply; when remote error sensing is employed, d-c ground may be established at the point of sense lead attachment. In the specific case of an internally-grounded load, the d-c ground point is automatically established at the load.

The output binding posts of MBT Power Supplies are d-c isolated (“floating”) from the chassis in order to permit the user maximum flexibility in selecting the best single point ground location. Output ripple specifications as measured at the output are equally valid for either side grounded. Care must be taken in measuring the ripple and noise at the power supply: measuring devices which are a-c line operated can often introduce additional ripple and noise into the circuit.

There is, unfortunately, no “best” method for interconnecting the load and power supply. Individual applications, location and nature of the load require careful analysis in each case. Grounding a single point in the output circuit can be of great importance. It is hoped that the preceding paragraphs will be of some assistance in most cases. For help in special applications or difficult problems, consult directly with Kepco's Application Engineering Department.

### **2.7.4 POWER SUPPLY/LOAD INTERFACE**

The general function of a voltage- or current-stabilized power supply is to deliver the rated output quantities to the connected load. The load may have any conceivable characteristic: it may be fixed or variable, it may have predominantly resistive, capacitive or inductive parameters; it may be located very close to the power supply output terminals or it may be a considerable distance away. The perfect interface between a power supply and its load would mean that the specified performance at the output terminals would be transferred without impairment to any load, regardless of electrical characteristics or proximity to each other.

The stabilized d-c power supply is definitely not an ideal voltage or current source, and practical interfaces definitely fall short of the ideal. All voltage-stabilized power supplies have a finite source impedance which increases with frequency, and all current-stabilized power supplies

have a finite shunt impedance which decreases with frequency. The method of interface between the power supply output and the load must, therefore, take into account not only size with regard to minimum voltage drop, but configuration with regard to minimizing the impedance introduced by practical interconnection techniques (wire, bus bars, etc.). The series inductance of the load wire must be as small as possible as compared to the source inductance of the power supply: error sensing cannot compensate for reactive effects due to this. These dynamic conditions are especially important if the load is constantly modulated or step-programmed, or has primarily reactive characteristics, or where the dynamic output response of the power supply is critical to load performance.

### **2.7.5 LOAD CONNECTION - GENERAL**

Load connections to the MBT power supply are achieved via the OUTPUT and COMMON binding posts located on the rear panel. A barrier strip is provided at the rear panel for connection of error sensing and monitor connections.

**NOTE** REGARDLESS OF OUTPUT CONFIGURATION, OUTPUT SENSE LINES MUST BE CONNECTED FOR OPERATION. OBSERVE POLARITIES: THE **OUTPUT S** SENSING WIRE MUST BE CONNECTED TO THE **OUTPUT** LOAD WIRE, AND THE **COM S** SENSING WIRE MUST BE CONNECTED TO THE **COMMON** LOAD WIRE. IF LOCAL SENSING IS USED, INSTALL LINKS AS SHOWN IN FIGURE 2-3.

For M and MG units (non-“R” option), the OUTPUT binding post is always positive with respect to COMMON. For MR and MGR units, the OUTPUT is positive with respect to COMMON when polarity is nonreversed, negative with respect to COMMON when polarity is reversed.

### **2.7.6 LOAD CONNECTION USING LOCAL SENSING**

Figure 2-5 shows a typical configuration using local sensing and a grounded load; Figure 2-6 shows a typical configuration using local sensing with an isolated (“floating”) load.

### **2.7.7 LOAD CONNECTION USING REMOTE SENSING**

Figure 2-7 shows a typical configuration using remote sensing and a grounded load; Figure 2-8 shows a typical configuration using remote sensing with an isolated (“floating”) load.

## **2.8 OPERATING CONFIGURATION**

The complete operating configuration is defined by

- The Model Number (e.g. MBT 100-3.6M)
- Options included (“G” or “R,” see PAR. 1.5)
- Jumper configuration of internal boards.

Table 2-4 lists the location of the internal jumpers and their function. This information is provided for reference purposes only, to indicate the configuration options available. Do not attempt to alter the jumper configuration. For assistance in changing any jumper-selected parameter contact Kepco applications engineering.

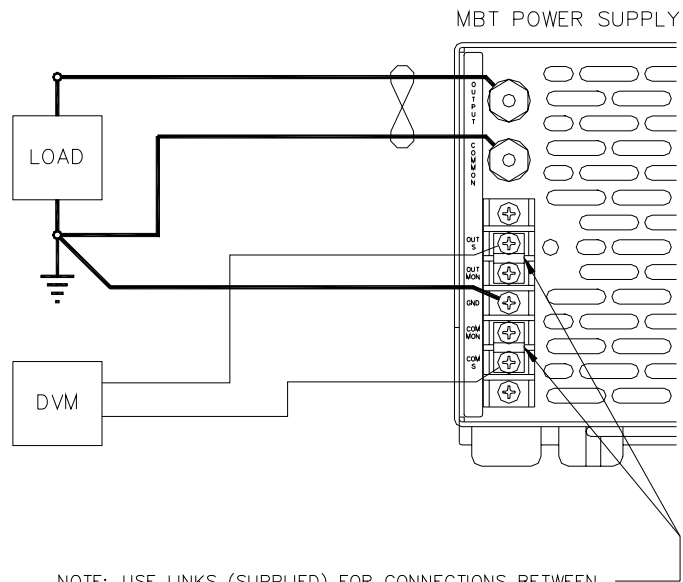
**TABLE 2-4. INTERNAL JUMPER CONFIGURATION**

LOCATION	FUNCTION	JUMPER INSTALLED	JUMPER NOT INSTALLED	DESCRIPTION
A1	Establish the Model	J1-J5		MBT 6-32M (G) (R)
		J1-J4	J5	MBT 15-20M (G) (R)
		J1-J3, J5	J4	MBT 25-14M (G) (R)
		J1-J3	J4, J5	MBT 36-10M (G) (R)
		J1, J2, J4, J5	J3	MBT 55-7M (G) (R)
		J1, J2, J4	J3, J5	MBT 75-5M (G) (R)
		J1, J2, J5	J3, J4	MBT 100-3.6M (G) (R)
		J1, J2	J3-J5	MBT 150-2.4M (G) (R)
	Path Fault Protection	J7 (Default for M, MG)		For M and MG units; enables crowbar protection circuit to trip circuit breaker and shut off unit if path fault detected.
			J7 (Default for MR, MGR)	For MR and MGR units; allows software complete control of path fault protection. Outputs (voltage and current) are programmed to zero and relays opened to isolate load in case of path fault.
A2	Input Power Loss Protection	J5 (Default)		Enables crowbar protection circuit to trip circuit breaker and shut off unit when power loss detected.
			J5	Disables crowbar protection circuit which trips circuit breaker and shuts off unit when power loss detected.
	Control of OUTPUT ENABLED Status Indicator (M, MG Models only)	J4 pins 1-2 (Default)		For M, MG units: front panel OUTPUT ENABLED indicator illuminated only when the output is enabled.
			J4 pins 2-3	For M, MG units: front panel OUTPUT ENABLED indicator illuminated whether or not the output is enabled.
A13	Control of Programming Language	J7 (Default)		Selects SCPI programming language (see PAR. 3.3.5).
			J7	Selects CIIL programming language (see PAR. 3.3.6).
	Permits Selection of Secondary Address	J8 (Default)		Secondary address not allowed.
			J8	Secondary address allowed.
A14	Determines External Cable Shield Connection	J5 (Default)		Connects shield of external IEEE 488 cable to signal common.
			J5	Disconnects shield of external IEEE 488 cable from signal common.

**2.9 RS 232 CONNECTIONS**

Since the MBT uses a 9-pin male connector, it is classified as a Data Terminal Equipment (DTE) in accordance with the RS 232 Standard (equipment using a female connector is classified as Data Communication Equipment, DCE).

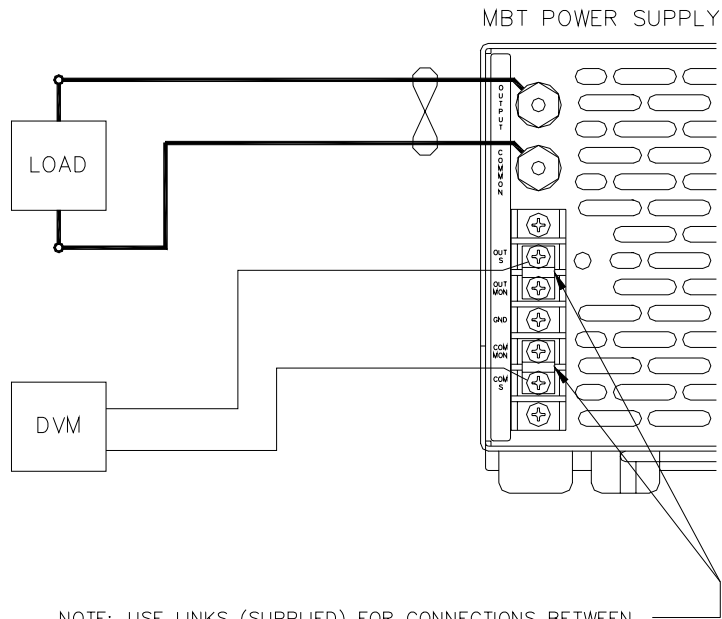
Either a DTE to DTE or a null modem cable is required to connect the MBT-G to an IBM-PC compatible computer. This cable has only three wires and connects RXD at one end to TXD at the other end. The RS232-C port control lines (Table 2-2) are used to activate special feature by means of jumpers, e.g., secondary addressing may be enabled by putting a jumper between DSR and RTS at the RS 232 port (pins 6 and 7. Refer to PAR. 3.3.3.1 for RS 232 operation. NOTE: Be sure the cable used has no unintended internal connections, particularly between RTS and CTS.



NOTE: USE LINKS (SUPPLIED) FOR CONNECTIONS BETWEEN (OUT S) AND (OUT MON) AND BETWEEN (COM S) AND (COM MON) FOR LOCAL SENSING.

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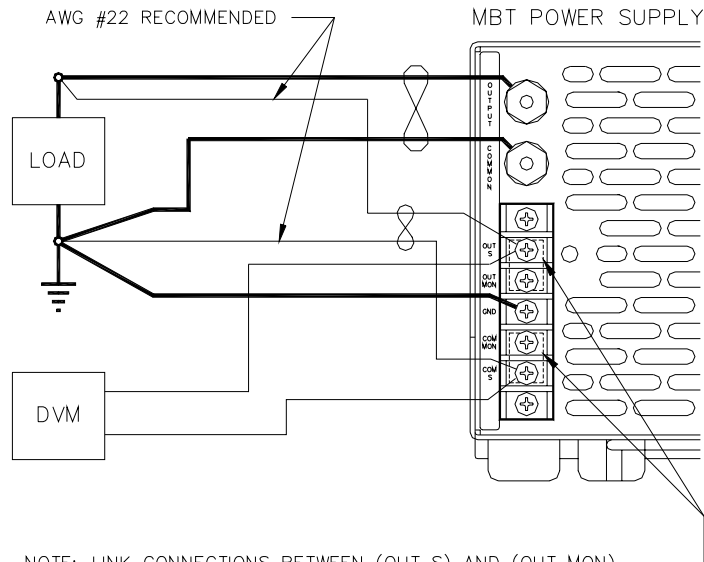
**FIGURE 2-5. GROUNDED LOAD CONNECTIONS, LOCAL SENSING**



NOTE: USE LINKS (SUPPLIED) FOR CONNECTIONS BETWEEN (OUT S) AND (OUT MON) AND BETWEEN (COM S) AND (COM MON) FOR LOCAL SENSING.

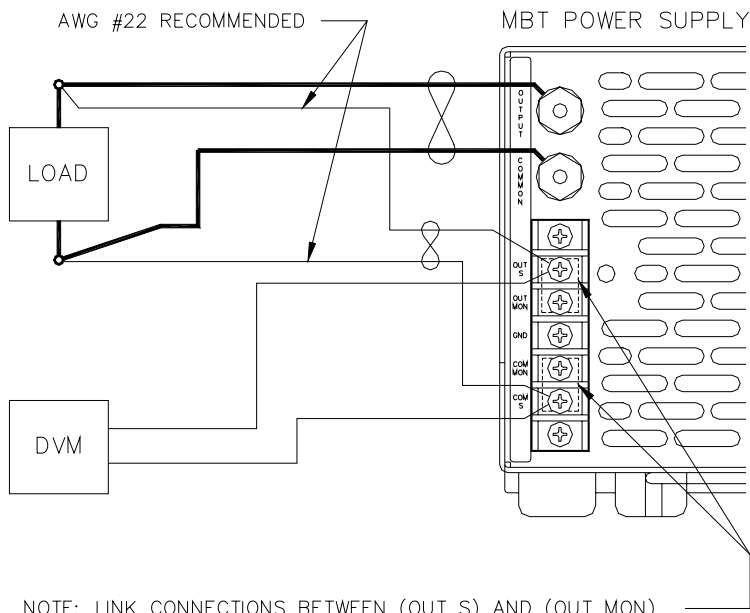
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**FIGURE 2-6. ISOLATED LOAD CONNECTIONS, LOCAL SENSING**



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**FIGURE 2-7. GROUNDED LOAD CONNECTIONS, REMOTE SENSING**



3041007

**FIGURE 2-8. ISOLATED LOAD CONNECTIONS, REMOTE SENSING**

## SECTION 3 - OPERATION

### 3.1 GENERAL

The MBT Power Supply can be operated in either Local or Remote modes. Upon turn on, the Power Supply is in Local mode and restores the settings in place at previous turn off. The factory default settings for Voltage and Current are 0, Voltage Mode selected and, for MR and MGR units, Non-reversed Polarity. MG and MGR (“G” option) units require initialization of the SBC (single board computer), resulting in an additional initial delay.

Operation of the power supply requires an understanding of how the power supply works. The MBT power supply is a linear power supply with an automatic crossover between Voltage mode and Current mode. To avoid confusion, a distinction must be made between *actual* mode (the actual mode the power supply operates in) and the *commanded* mode (the mode the power supply is commanded to enter either by keypad operation (either locally or remotely) or remotely by a command issued by computer via a controller).

#### 3.1.1 ACTUAL MODE

If the output is enabled, the unit will be in *actual* Voltage mode as long as the load is greater than, or equal to, the value of programmed voltage divided by programmed current.

$$\text{VOLTAGE MODE (} V_{\text{OUT}} = V_{\text{PROG}} \text{) when } R_L \geq \frac{V_{\text{PROG}}}{I_{\text{PROG}}}$$

If the output is enabled, the unit will be in *actual* Current mode as long as the load is less than the value of programmed voltage divided by programmed current.

$$\text{CURRENT MODE (} I_{\text{OUT}} = I_{\text{PROG}} \text{) when } R_L < \frac{V_{\text{PROG}}}{I_{\text{PROG}}}$$

If the output is disabled, M and MG Models will always be in actual Voltage mode; for MR and MGR models the actual mode will be the same as the commanded mode.

The STATUS indicators (VOLTAGE MODE and CURRENT MODE) always reflect actual mode.

When the unit operates in actual Voltage mode, the power supply will maintain the output voltage constant at the value programmed for Output Voltage; current will vary in accordance with the value of the load within the limits established by programmed Current Limit. When the unit operates in actual Current mode, the power supply will maintain the output current constant at the value programmed for Output Current; the output voltage will vary in accordance with the value of the load within the limit established by programmed Voltage Limit.

Note that  $V_{\text{PROG}}$  and  $I_{\text{PROG}}$  are either output or limit parameters, depending on the *actual* mode: When the unit is in actual Voltage mode,  $V_{\text{PROG}}$  refers to Output Voltage and  $I_{\text{PROG}}$  refers to Current Limit; when the unit is in actual Current mode,  $V_{\text{PROG}}$  refers to Voltage Limit and  $I_{\text{PROG}}$  refers to Output Current.

### 3.1.2 COMMANDED MODE

Two commands are available from the keypad (either locally or remotely) or, in a different form, from a remote computer: Voltage mode and Current mode. After a Voltage mode command has been issued, the power supply is considered to be in *commanded* Voltage mode; after a Current command, the power supply is in *commanded* Current mode. These commands can *not* change the *actual* mode. This means, for example, that the power supply can be in commanded Voltage mode (Voltage mode command issued) and actual Current mode because  $R_L < V_{PROG}/I_{PROG}$ .

The commanded mode is important during remote operation because it establishes which conditions the internal microcontroller of the power supply will monitor to determine whether an error condition exists. For commanded Voltage mode the power supply reports a “voltage error” if the output voltage exceeds the internal limits established for output voltage, and an “overload” error if the output current reaches the programmed value for Current Limit. For commanded Current mode the power supply reports a “current error” if the output current exceeds the internal limits established for output current, and an “overload” error if the output voltage reaches the value programmed for Voltage Limit. Error messages are not used when operating in Local mode.

When Models MR and MGR are in commanded Voltage mode, the slew keys are assigned to increase/decrease output voltage, and when the output is disabled (DC OFF pressed), the output relays isolate the output from the load by disconnecting the output. Commanded Current mode assigns the slew keys to increase/decrease current, and causes the output relays to isolate the output from the load by short-circuiting the output. This feature fully protects the load regardless of commanded mode. When the output is enabled (DC ON pressed), the output relays either connect the output to the load (commanded Voltage mode) or remove the short-circuit from the output (commanded Current mode).

For Models M and MG, commanded mode has virtually no effect on local operation with one exception: if the unit was commanded to Current mode through remote operation prior to entering Local mode, the slew keys will be assigned to increase/decrease current until the first Voltage mode command is received from the keypad. After receiving a Voltage mode command, the slew keys will be assigned to increase/decrease voltage. Subsequent Voltage and Current mode commands have no effect; “No relay present” is displayed and the slew keys remain allocated to voltage.

### 3.1.3 LOCAL MODE

In local mode, Voltage and Current can be set either via the front panel keypad or the VOLTAGE and CURRENT controls (PAR.s 3.2.1.6 and 3.2.1.7). A pair of up/down slew controls provide an alternate way to control the output incrementally. Selected keys on the keypad serve a dual purpose. These keys are identified by the alternate function labeled in blue; the alternate function is accessed by pressing the **SHIFT** key prior to the dual function key.

A local programming feature (PAR. 3.2.1.11) allows the power supply parameters to be preset and applied for a specified period of time. The Power Supply can be programmed to sequence through as many as 89 steps which may be divided into a maximum of 10 programs.

A menu feature (PAR. 3.2.2) guides the operator through various operational sequences, including power supply calibration and remote operation of another power supply using the local keypad.



### 3.1.4 REMOTE MODE

In Remote Mode the power supply settings are controlled via the IEEE 1118 bus using either a computer with a Kepco controller or by another MBT unit operating in a remote configuration with one MBT unit operating as a controller (“G” option enabled) (see PAR. 1.4.2 and Figure 1-3). MBT Models MG and MGR with the “G” option enabled can also be controlled directly via either the RS232C or IEEE 488 bus.

PAR. 3.2.2.3 provides instructions for using one MBT keypad to control another MBT power supply in remote mode. PAR. 3.3 provides instructions for sending remote commands to an MBT power supply in a computer/controller configuration using SCPI or CIL programming languages.

## 3.2 LOCAL MODE OPERATION

### 3.2.1 LOCAL MODE CONTROLS AND INDICATORS

Local Mode operation is accomplished using the front panel controls, indicators and keypad described in the following paragraphs.

#### 3.2.1.1 FRONT PANEL CONTROLS AND INDICATORS.

Table 3-1 lists and describes the function of the front panel controls and indicators; see Figure 2-1 for the location of operating controls and indicators.

**TABLE 3-1. FRONT PANEL CONTROLS AND INDICATORS**

CONTROL/INDICATOR	FUNCTION	REFERENCE PARAGRAPH
<b>POWER</b> circuit breaker	Applies source power to the MBT Power Supply and shuts off power supply upon detection various error conditions.	3.2.1.2, 4.1.8
<b>VOLTAGE</b> control	Used to increase (clockwise rotation) or decrease (counterclockwise) output voltage (Voltage mode) or voltage limit (Current mode) value.	3.2.1.6.6, 3.2.1.6.7
<b>CURRENT</b> control	Used to increase (clockwise rotation) or decrease (counterclockwise) output current (Current mode) or current limit (Voltage mode) value.	3.2.1.7.6 and 3.2.1.7.7
<b>VOLTAGE MODE</b> status indicator	Illuminates (green) when power supply is in Voltage Mode.	3.2.1.8
<b>CURRENT MODE</b> status indicator	Illuminates (amber) when power supply is in Current Mode.	3.2.1.8
<b>POLARITY REVERSED</b> status indicator	Illuminates (red) when output polarity is reversed (operational only on MR and MGR Models).	3.2.1.9
<b>REMOTE</b> status indicator	Illuminates (green) when power supply is in Remote Mode.	3.2.2.3
<b>OUTPUT ENABLED</b> status indicator	Illuminates (green) when the power supply output is applied to the load.	3.2.1.5
Alphanumeric Display	Displays output voltage and current as well as messages and other information in response to keypad entries.	3.2.1
<b>ENTRY</b> keypad	Used to command output mode, adjust output current and voltage, and program power supply.	3.2.1.2

**TABLE 3-2. KEY FUNCTIONS**

<b>FUNCTION</b>	<b>KEY</b>	<b>DESCRIPTION</b>	<b>REFERENCE PARAGRAPH</b>
<b>ENTER</b>	<b>ENTER</b>	Used to confirm or enter the input data of the parameter setting.	-
<b>Select alternate function</b>	<b>SHIFT</b>	Selects alternate function (screened in blue) of keys with dual function capability. <b>SHIFT</b> key press indicated by blinking "sh" on display; "sh" disappears if valid key (or <b>SHIFT</b> ) pressed. When MBT keypad is used to control another power supply in a remote configuration, the "sh" changes to ■.	-
<b>Numeric entries</b>	<b>0 - 9, .</b>	Numerical keys and "." are used to input all parameter values.	3.2.1.6, 3.2.1.7
<b>CYCLE PROGRAM</b>	<b>SHIFT then 0</b>	Activated by pressing <b>SHIFT</b> , followed by "0" key when program is being created or changed. This key function can be pressed at the end of a local program to indicate that the program is to be recycled continuously, or to change a program from a "cycle" to "single" run.	3.2.1.11.5
<b>STATUS</b>	<b>SHIFT then "."</b>	Displays programmed voltage, current, OVP (overvoltage protection), and OCP (overcurrent protection) on alphanumeric display.	-
<b>Slew voltage or current</b>	<b>▲, ▼</b>	Slews the output voltage or current up or down with an increment which can be set using the menu (see PAR. 3.2.2.6). (Current can be slewed with these keys only on units commanded to enter Current mode.) Can also be used to navigate through the screens of each step of a local program (▲ goes up, ▼ goes down).	3.2.1.6.4, 3.2.1.6.5, 3.2.1.11
<b>ADD STEP</b>	<b>SHIFT then ▲</b>	Utilized to add steps to program being reviewed, changed, or created. Refer to Table 3-16 for default values of new steps.	3.2.1.11.1
<b>DEL (Delete) STEP</b>	<b>SHIFT then ▼</b>	Utilized to delete displayed step from program being reviewed/ changed. After the step has been deleted, the previous step will be displayed.	3.2.1.11.4
<b>Display/Adjust Voltage</b>	<b>Vadj</b>	Utilized to display or adjust either output voltage (Voltage Mode) or voltage limit (Current Mode).	3.2.1.6.1, 3.2.1.6.2, 3.2.1.6.3,
<b>Command VOLTAGE MODE</b>	<b>SHIFT then Vadj</b>	MR, MGR Models: If the unit is commanded to operate in Voltage mode and the output is disabled, the output relays open (output disabled).  M, MG Models: Unavailable function ("No Relay present" message displayed).	3.2.1.8
<b>Display/Adjust Current</b>	<b>ladj</b>	Utilized to display or adjust current limit (Voltage Mode) or output current (Current Mode).	3.2.1.7.1, 3.2.1.7.2, 3.2.1.7.3
<b>Command CURRENT MODE</b>	<b>SHIFT then ladj</b>	MR, MGR Models: If the unit is commanded to operate in Current mode and the output is disabled, the output relays close, short-circuiting the output (output disabled).  M, MG Models: Unavailable function ("No Relay present" message displayed).	3.2.1.8
<b>CLEAR ENTRY</b>	<b>CLEAR ENTRY</b>	Clears the previous keypad entry and is effective if pressed prior to the ENTER key being pressed. In addition, this key is used to stop a running program at a step.	3.2.1.11.6 3.2.1.11.7

**TABLE 3-2. KEY FUNCTIONS (CONTINUED)**

<b>FUNCTION</b>	<b>KEY</b>	<b>DESCRIPTION</b>	<b>REFERENCE PARAGRAPH</b>
<b>Command LOCAL mode</b>	<b>SHIFT then CLEAR ENTRY</b>	Places power supply in Local Mode (front panel control) if the unit is being operated remotely, otherwise this function is not operational. In Remote Lock mode (power supply controlled remotely), all Local Mode functions, including Local Mode selection are inhibited (see PAR. 3.2.2.2).	3.2.1.11.2
<b>RESET</b>	<b>RESET</b>	M, MG Models: Programs output voltage and current to 0. In addition, this key is used to stop a local program in progress.  MR, MGR Models: In addition to above functions, sets the unit to Voltage Mode and Positive polarity and isolate the power supply from the load.	3.2.1.11.6 3.2.1.11.7
<b>EXECUTE PROGRAM</b>	<b>SHIFT then RESET</b>	Runs the program selected with the REV/CHG PROGRAM function.	3.2.1.11.3
<b>Enable Output</b>	<b>DC ON</b>	MR, MGR Models: Enables d-c output power, connecting the unit to the load.  M, MG Models: Enables output values to be applied to the load.	3.2.1.5
<b>Disable Output</b>	<b>DC OFF</b>	MR, MGR Models: Disables d-c output power, disconnecting the unit from the load.  M, MG Models: Programs output voltage and current to zero; the unit will still display the previous output settings	3.2.1.5
<b>CHANGE POLARITY</b>	<b>SHIFT then DC OFF</b>	MR, MGR Models: Reverses output polarity.  M, MG Models: Unavailable function ("No Relay present" message displayed).	3.2.1.9
<b>Enter MENU mode</b>	<b>MENU ON/OFF</b>	Toggles the MENU on and off.	3.2.2
<b>REV/CHG. (Review/Change) PROGRAM</b>	<b>SHIFT then MENU ON/OFF</b>	Displays program on alphanumeric display (see NEXT and PREVIOUS, below). Used to review/change existing programs or enter new programs into memory.	3.2.1.11.1
<b>Set time duration of program steps</b>	<b>DELAY (SEC)</b>	Utilized to program the time duration for each step of a program entered via the keypad. Values are in seconds - 0.1 minimum to 9999 maximum (4 digits + decimal point allowed).	3.2.1.11
<b>GPIB ADDRESS</b>	<b>SHIFT then DELAY (SEC)</b>	Displays unit's GPIB address on alphanumeric display and allows change of unit's GPIB address via keypad entry.	3.2.1.10
<b>NEXT</b>	<b>NEXT</b>	Allows next step of program or new menu item to be displayed. Operates only when REV/CHG PROGRAM or MENU function selected.	3.2.1.11.2
<b>PREVIOUS</b>	<b>SHIFT then NEXT</b>	Allows previous step of program to be displayed. Operates only when REV/CHG PROGRAM or MENU functions selected.	-

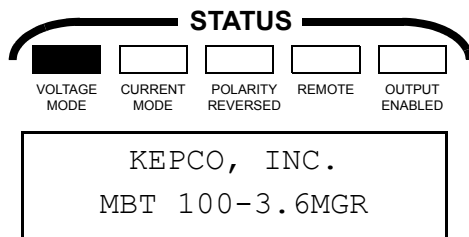
### 3.2.1.2 KEYPAD OPERATION

In Local mode, all parameter settings and operations are via a 24-key front panel keypad and two controls. Alternate key functions, screened in blue on the keypad, are represented in italics in the listing below. These alternate key functions require that the *SHIFT* key be pressed prior to depressing the alternate function key. Valid key entries will be indicated with a quarter-second beep; in most cases invalid entries will be indicated with a half-second (louder) beep. Table 3-2 lists the functions of the keys on the front panel keypad. LOCAL MODE PROCEDURES

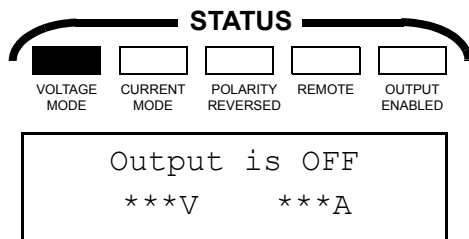
### 3.2.1.3 TURNING THE POWER SUPPLY ON

**CAUTION: DO NOT repeatedly toggle the circuit breaker/switch as this may cause unit to fault.**

1. Set Power ON/OFF circuit breaker/switch on front panel to ON. If actuator does not lock when released, wait a few seconds before trying again. The circuit breaker is "trip-free" design; if overload exists or the protection is activated, contacts cannot be held closed by actuator.



2. After approximately 2 seconds, the display changes to:



NOTE: \*\*\*V and \*\*\*A are the output voltage and current settings in effect at time of last operation (for first time use, the voltage and current are set to 0).

3. The unit is now in Local mode.

### 3.2.1.4 SETTING LOCAL MODE


If the unit is being operated remotely (REMOTE indicator is on.), use the following procedure to set the unit into LOCAL mode

NOTE: In Remote Lock mode, all Local Mode functions, including Local Mode selection, are inhibited. To enter Local mode it will be necessary turn MBT power off for approximately 10 seconds, then on.

1. Press **SHIFT** (blinking "sh" appears on alphanumeric display). Depending on the model, and whether the output is enabled or disabled, one of the following displays (A-D) will appear:

NOTES: A blinking “.” is represented by “\*” to indicate that the values displayed on the bottom line of the alphanumeric display are “live,” i.e., actual values at the power supply output.

A blinking “sh” is represented by *sh* to indicate that the SHIFT key has been pressed, and the next key that is pressed will be interpreted with the alternate meaning.

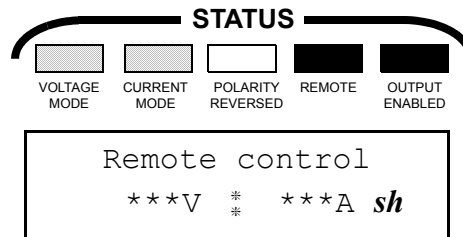
 indicates STATUS LED may be on or off, depending on the actual status of the power supply.

\*\*\* indicates the values displayed are actual values for output voltage and current.

### indicates that the values displayed for voltage and current are the actual internal values prior to passing through the output relays. For commanded voltage mode the display will show the programmed value for output voltage and 0 A for current. For commanded current mode the display will show 0 V for voltage and the programmed value for output current.

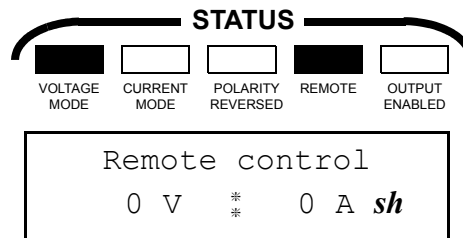
**A**

M, MG models with Output Enabled



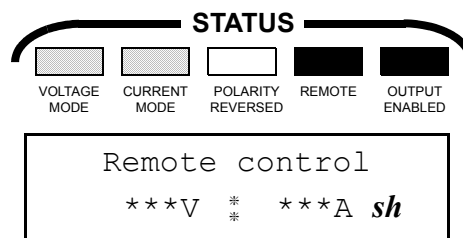
**B**

M, MG models with Output disabled



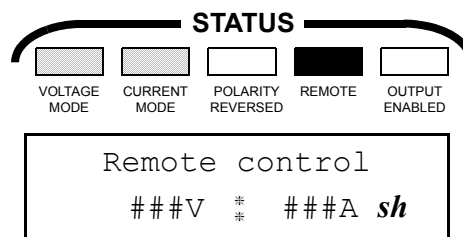
**C**

MR, MGR models with Output enabled



**D**

MR, MGR models with Output disabled

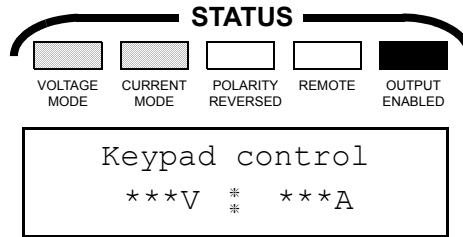


2. Press **CLEAR ENTRY** (LOCAL). Depending on the model, and whether the output is enabled or disabled, one of the following displays (A-D) will appear:

NOTE: For explanation of symbols, see step 1 above.

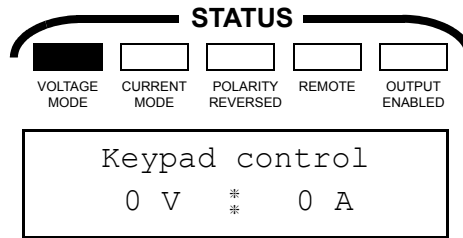
**A**

M, MG models with Output Enabled



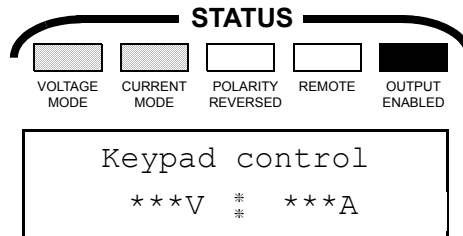
**B**

M, MG models with Output disabled



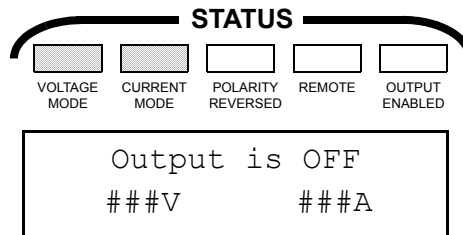
**C**

MR, MGR models with Output enabled



**D**

MR, MGR models with Output disabled

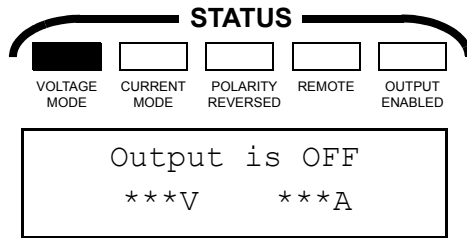


### 3.2.1.5 ENABLING/DISABLING DC OUTPUT POWER

#### 3.2.1.5.1 M AND MG MODELS

The **DC OFF** key will change the output voltage and current values to zero. The **DC ON** key restores the previous output voltage and current values if these settings were not changed via the keypad and/or **VOLTAGE/CURRENT** controls.

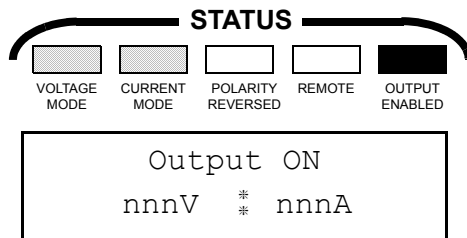
1. With the output disabled, the display reads:



NOTE: This screen indicates the power supply is in local mode with output disabled and is waiting for some instruction (e.g., setting output voltage, current, running or changing a program, etc.).

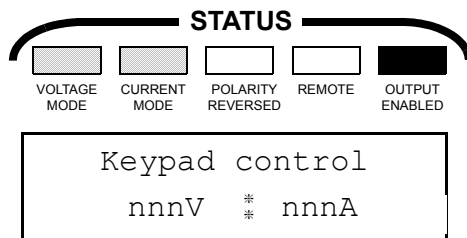
\*\*\* Represents programmed values.

2. To enable the output, press **DC ON**; the display briefly changes to:



NOTE: nnnV and nnnA represent the actual output voltage and current of the power supply.

then the display reads:



NOTE: This screen indicates the power supply is in local mode with output enabled and is waiting for some instruction (e.g., setting output voltage, current, running or changing a program, etc.).

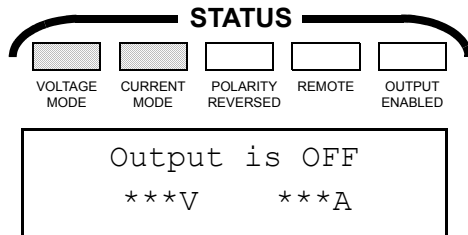
If the value of the load is less than the programmed voltage divided by the programmed current ( $R_L < V_{Prog} / I_{Prog}$ ), the MBT power supply will be forced into Current mode and the VOLTAGE MODE indicator will be off and the CURRENT MODE indicator will be on.

Pressing the **DC OFF** key causes the *actual* output voltage and current to go to zero; the display shows the *programmed* values for voltage and current.

### 3.2.1.5.2 MR AND MGR MODELS

If the unit is in commanded Voltage mode, the **DC OFF** key electrically disconnects the output from the load; if the unit is in commanded Current mode, the **DC OFF** key short circuits the output. The **DC ON** key restores the previous status if these settings were not changed by the keypad and/or **VOLTAGE/CURRENT** controls.

1. With the output disabled, the display reads:



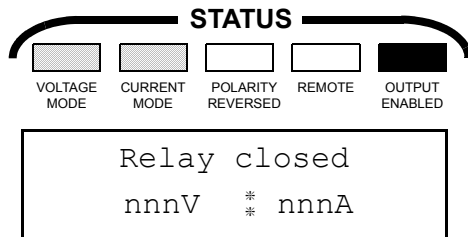
NOTE: This screen indicates the power supply is in local mode with output disabled and is waiting for some instruction (e.g., setting output voltage, current, mode, running/changing a program, etc.).

\*\*\* Represents programmed values.

Status LEDs show the commanded mode (Voltage or Current).

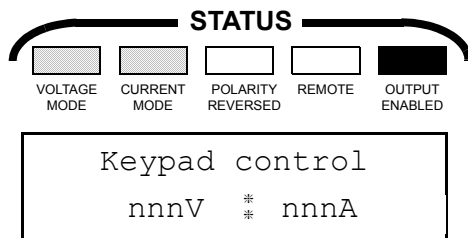
\*\*\* Represents programmed values.

2. To enable the output, press **DC ON**; the display briefly changes to:



NOTE: nnnV and nnnA represent the actual output voltage and current of the power supply.

then the display reads:



NOTE: This screen indicates the power supply is in local mode with output enabled and is waiting for some instruction (e.g., setting output voltage, current, mode, running/changing a program, etc.).

Status LEDs now show the actual mode (Voltage or Current).

If the value of the load is less than the programmed voltage divided by the programmed current ( $R_L < V_{Prog} / I_{Prog}$ ), the MBT power supply will be forced into Current mode and the VOLTAGE MODE indicator will go off and the CURRENT MODE indicator will go on.

Pressing the DC OFF key causes the relays to disconnect the load from the power supply output; the display shows the programmed values for voltage and current.



### 3.2.1.6 SETTING OUTPUT VOLTAGE OR VOLTAGE LIMIT

There are three ways to set output voltage or voltage limit: 1) **Vadj** and numeric keys, 2) slew keys, and 3) the **VOLTAGE** control. The display should be reading either “Output is off” if the output is disabled, or “Keypad control” if the output is enabled.

#### 3.2.1.6.1 USING VADJ AND NUMERIC KEYS — M, MG MODELS

The Vadj and numeric keys can be used to adjust either output voltage or voltage limit (either the actual value or the programmed value). The effect of the numeric keypad entries is dependent upon the model, the previously commanded mode, whether the output is enabled or disabled, and the load value.

For M and MG models, when the output is disabled, the output voltage and current are programmed to zero, and the power supply remains in actual voltage mode. If the output is enabled, the power supply will operate in voltage mode except for the case where the value of the load is less than the programmed voltage divided by the programmed current ( $R_L < V_{Prog} / I_{Prog}$ ). In this case the MBT power supply will be forced into Current mode.

Table 3-3 summarizes the effect of the **Vadj** adjustment. The first three columns reflect the status of the unit before the **Vadj** command is issued. The fourth column shows the message on the front panel display after the Vadj is pressed and the fifth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s 3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

If the output is enabled and the value of the load is greater than or equal to the value of programmed voltage divided by programmed current ( $R_L \geq V_{Prog} / I_{Prog}$ ), the power supply operates in voltage mode and the keypad entries adjust actual output voltage, contrary to the display indication.

If the output is enabled and the value of the load is less than the value of programmed voltage divided by programmed current ( $R_L < V_{Prog} / I_{Prog}$ ), the power supply is forced to operate in current mode and the keypad entries adjust actual voltage limit.

If the power supply was operating in a remote configuration, setting output voltage or voltage limit can also be influenced by the last command issued to the power supply before the unit is put into Local Mode. If the power supply was commanded to operate in Current mode before being set into Local mode, Table 3-3 indicates that if the load allows the power supply to operate in voltage mode, **Vadj** and the keypad entries adjust either actual output voltage or programmed voltage limit, depending on whether the load is enabled or disabled. If the load forces the power supply to operate in current mode, **Vadj** and keypad entries will adjust actual voltage limit, contrary to the display indication.

Refer to PAR. 3.2.1.6.3 for procedure.

**TABLE 3-3. USING VADJ AND KEYPAD ENTRIES TO SET OUTPUT VOLTAGE/VOLTAGE LIMIT — MODELS M, MG**

POWER SUPPLY STATUS BEFORE Vadj PRESSED			EFFECT AFTER Vadj PRESSED	
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE *** (DICTATED BY LOAD)	DISPLAY INDICATION	NUMERIC VALUE SET BY KEYPAD ADJUSTS:
VOLTAGE	DISABLED	VOLTAGE*****	CONST VOLT =	Programmed output voltage
VOLTAGE	ENABLED	VOLTAGE	CONST VOLT =	Actual output voltage
VOLTAGE	ENABLED	CURRENT****	CONST VOLT =	Actual Voltage limit **
CURRENT *	DISABLED	VOLTAGE*****	VOLT LIMIT =	Programmed voltage limit
CURRENT *	ENABLED	CURRENT	VOLT LIMIT =	Actual Voltage limit
CURRENT *	ENABLED	VOLTAGE****	VOLT LIMIT =	Actual output voltage **

\* If the unit was programmed to Current mode remotely before being set to Local Mode, the unit will stay in commanded current mode until a Voltage Mode command is received.  
 \*\* "Overload" error message placed in error buffer (for use when operating in Remote mode).  
 \*\*\* Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's.  
 \*\*\*\* Condition where load forces power supply mode.  
 \*\*\*\*\* Forced internally by the power supply.

**3.2.1.6.2 USING VADJ AND NUMERIC KEYS — MR, MGR MODELS**

The Vadj and numeric keys can be used to adjust either output voltage or voltage limit (either the actual value or the programmed value). The effect of the numeric keypad entries is dependent upon the model, the previously commanded mode, whether the output is enabled or disabled, and the load value.

For MR and MGR models, when the output is disabled, the load is disconnected from the power supply if the power supply is operating in Voltage mode, or the power supply output is short circuited if the unit is operating in Current mode.

If the output is enabled, the power supply can operate either in voltage mode or current mode, as determined by both the programmed output values (Voltage or Current) and the value of the load. If the power supply is commanded to be in Voltage mode, the power supply will actually operate in voltage mode when  $R_L \geq V_{Prog} / I_{Prog}$ , and current mode (forced) when  $R_L < V_{Prog} / I_{Prog}$ . Similarly if the power supply is commanded to be in Current mode, the power supply will actually operate in Current mode when  $R_L < V_{Prog} / I_{Prog}$ , and in Voltage mode (forced) when  $R_L \geq V_{Prog} / I_{Prog}$ .

Table 3-4 summarizes the effect of the **Vadj** adjustment. The first three columns reflect the status of the unit before the **Vadj** command is issued. The fourth column shows the message on the front panel display after the **Vadj** key is pressed and the fifth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s 3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

If the output is enabled, and the power supply is commanded to operate in Voltage mode, but  $R_L < V_{Prog} / I_{Prog}$  forces the power supply to operate in current mode, the keypad entries adjust the actual voltage limit, contrary to the display indication.

If the output is enabled, and the power supply is commanded to operate in Current mode, but  $R_L \geq V_{Prog} / I_{Prog}$  forces the power supply to operate in Voltage mode, the keypad entries adjust the actual output voltage, contrary to the display indication.

Refer to PAR. 3.2.1.6.3 for procedure.

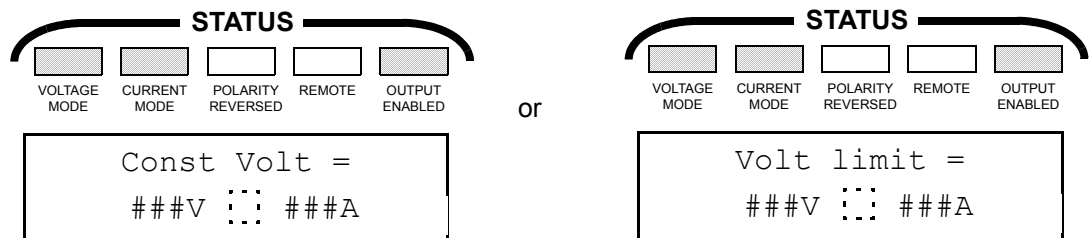
**TABLE 3-4. USING VADJ AND KEYPAD ENTRIES TO SET OUTPUT VOLTAGE/VOLTAGE LIMIT — MODELS MR, MGR**

POWER SUPPLY STATUS BEFORE Vadj PRESSED			EFFECT AFTER Vadj PRESSED	
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE *** (DICTATED BY LOAD)	DISPLAY INDICATION	NUMERIC VALUE SET BY KEYPAD ADJUSTS:
VOLTAGE	DISABLED	VOLTAGE****	CONST VOLT =	Programmed output voltage
CURRENT	DISABLED	CURRENT****	VOLT LIMIT =	Programmed voltage limit
VOLTAGE	ENABLED	VOLTAGE	CONST VOLT =	Actual output voltage
VOLTAGE	ENABLED	CURRENT *	CONST VOLT =	Actual voltage limit **
CURRENT	ENABLED	CURRENT	VOLT LIMIT =	Actual voltage limit
CURRENT	ENABLED	VOLTAGE *	VOLT LIMIT =	Actual output voltage **

\* Condition where load forces power supply mode.  
 \*\* "Overload" error message placed in error buffer (for use when operating in Remote mode).  
 \*\*\* Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's.  
 \*\*\*\* Forced internally by the power supply.

**3.2.1.6.3 PROCEDURE USING VADJ AND NUMERIC KEYPAD**

1. Press **Vadj**.

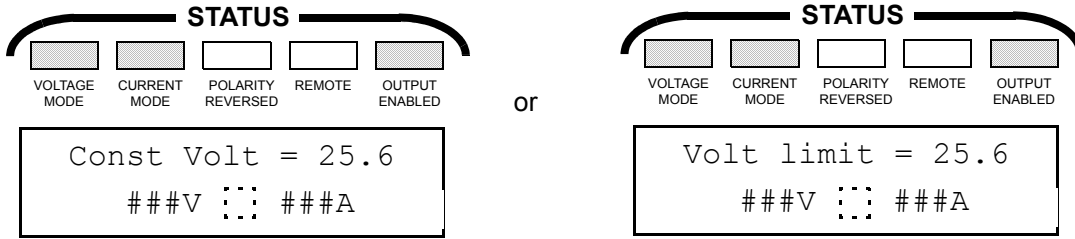


NOTES:  indicates LED may be either on or off.

###V and ##A will either be actual or programmed values of output voltage/voltage limit and output current/current limit (see Tables 3-3 and 3-4).

: indicates that blinking “:” appears only for OUTPUT ENABLED status.

- Enter voltage value via key pad, e.g., 25.6.



- Press **ENTER** to confirm or **CLEAR ENTRY** to correct. Display will return to “Output is OFF” or “Keypad control” display with either the new setting (**ENTER**) or the old setting (**CLEAR ENTRY**). If the entered value is too high, the display will indicate “Value too high,” then return to either “Output is OFF” or “Keypad control” display, showing the previous value.

NOTE: The display time for momentary messages, such as “Value too high,” can be reduced by pressing any key until the message concludes; the ENTER key is convenient for this purpose.

#### 3.2.1.6.4 SLEW (▲ AND ▼) KEYS — M, MG MODELS

As described in PAR. 3.2.1.6.1 (M, MG Models) for the **Vadj** and numeric keys, the effect of the slew keys is dependent upon model, commanded mode, output enabled/disabled, actual mode, and the load.

Table 3-5 summarizes the effect of the slew key adjustment. The first three columns reflect the status of the unit before the slew key is pressed. The fourth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s 3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

The slew keys are not operational when the power supply is in Remote mode, when you enter the MENU (PAR. 3.2.2), or PROGRAM REV/CHG (PAR. 3.2.1.11.1) functions, or when a program is running (PAR.s 3.2.1.11.3 and 3.2.1.11.5).

Table 3-5 shows that with the power supply commanded to operate in voltage mode, with the output disabled, the slew keys adjust the programmed output voltage.

If the output is enabled and the value of the load is greater than or equal to the value of programmed voltage divided by programmed current ( $R_L \geq V_{Prog} / I_{Prog}$ ), the power supply operates in Voltage mode and the slew keys adjust actual output voltage.

If the output is enabled and the value of the load is less than the value of programmed voltage divided by programmed current ( $R_L < V_{Prog} / I_{Prog}$ ), the power supply will be forced to operate in Current mode and the slew keys will adjust actual voltage limit. This will not be apparent from the display indication; to see the revised voltage limit it is necessary to view status by pressing **SHIFT** then (.) on the keypad.

**TABLE 3-5. USING SLEW KEYS (▲ AND ▼) TO SET OUTPUT VOLTAGE/VOLTAGE LIMIT — MODELS M, MG**

POWER SUPPLY STATUS BEFORE SLEW KEY PRESSED			SLEW KEYS ADJUST:
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE *** (DICTATED BY LOAD)	
VOLTAGE	DISABLED	VOLTAGE*****	Programmed output voltage
VOLTAGE	ENABLED	VOLTAGE	Actual output voltage
VOLTAGE	ENABLED	CURRENT****	Actual Voltage limit **
CURRENT *	Either DISABLED or ENABLED	Either VOLTAGE or CURRENT	No effect on voltage. (Refer to table 3-9 for effect on current/current limit.)
* If the unit was programmed to Current mode remotely before being set to Local Mode, the unit will stay in commanded current mode until a Voltage Mode command is received. ** Overload" error message placed in error buffer (for use when operating in Remote mode). *** Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's. **** Condition where load forces power supply mode. ***** Forced internally by power supply.			

If the power supply was operating in a remote configuration, and the slew keys will be used to locally adjust voltage/voltage limit, it is advisable to press **SHIFT** and **Vadj** to ensure that the power supply has been commanded to operate in Voltage mode. If the power supply was commanded to operate in current mode before being set into Local mode, the slew keys will have no effect on output voltage or voltage limit.

Pressing the ▲ key increases the output voltage/voltage limit (see Table 3-5) by the slew key V range value which was previously set using the MENU (see PAR. 3.2.2). For example, if the output voltage is 25.6V (Voltage mode, output enabled), and the slew key V range value is 0.10V, pressing the ▲ key twice changes the output voltage to 25.8V. The ▼ key operates similarly to decrease output voltage by the slew key V range value.

### 3.2.1.6.5 SLEW (▲ AND ▼) KEYS — MR, MGR MODELS

As described in PAR. 3.2.1.6.2 (MR, MGR Models) for the **Vadj** and numeric keys, the effect of the slew keys is dependent upon model, commanded mode, output enabled/disabled, actual mode, and the load.

Table 3-6 (MR, MGR Models) summarizes the effect of the slew key adjustments for different conditions. The first three columns reflect the status of the unit before the slew key is pressed. The fourth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s 3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

**TABLE 3-6. USING SLEW KEYS (▲ AND ▼) TO SET OUTPUT VOLTAGE/VOLTAGE LIMIT — MODELS MR, MGR**

POWER SUPPLY STATUS BEFORE SLEW KEY PRESSED			SLEW KEYS ADJUST:
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE ** (DICTATED BY LOAD)	
VOLTAGE	DISABLED	VOLTAGE****	Programmed output voltage
CURRENT	Either DISABLED or ENABLED	Either CURRENT or VOLTAGE	No effect on voltage. (Refer to table 3-11 for effect on current/current limit.)
VOLTAGE	ENABLED	VOLTAGE	Actual output voltage
VOLTAGE	ENABLED	CURRENT***	Actual voltage limit *
* "Overload" error message placed in error buffer (for use when operating in Remote mode). ** Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's. *** Condition where load forces power supply mode. **** Forced internally by power supply.			

The slew keys are not operational when the power supply is in Remote mode, when you enter the MENU (PAR. 3.2.2), or PROGRAM REV/CHG (PAR. 3.2.1.11.1) functions, or when a program is running (PAR.s 3.2.1.11.3 and 3.2.1.11.5).

Table 3-6 shows that with the power supply commanded to operate in Voltage mode, with the output disabled, the slew keys adjust the programmed output voltage.

If the output is enabled and the value of the load is greater than or equal to the value of programmed voltage divided by programmed current ( $R_L \geq V_{Prog} / I_{Prog}$ ), the power supply operates in Voltage mode and the slew keys adjust actual output voltage.

If the output is enabled and the value of the load is less than the value of programmed voltage divided by programmed current ( $R_L < V_{Prog} / I_{Prog}$ ), the power supply will be forced to operate in Current mode and the slew keys will adjust actual voltage limit. This will not be apparent from the display indication; to see the revised voltage limit it is necessary to view status by pressing **SHIFT** then (.) on the keypad.

If the power supply was operating in a remote configuration, and the slew keys will be used to locally adjust voltage/voltage limit, it is advisable to press **SHIFT** and **Vadj** to ensure that the power supply has been commanded to operate in Voltage mode. If the power supply was commanded to operate in current mode before being set into Local mode, the slew keys will have no effect on output voltage or voltage limit.

Pressing the ▲ key increases the output voltage/voltage limit (see Table 3-6) by the slew key V range value which was previously set using the MENU (see PAR. 3.2.2). For example, if the output voltage is 25.6V (Voltage mode, output enabled), and the slew key V range value is 0.10V, pressing the ▲ key twice changes the output voltage to 25.8V. The ▼ key operates similarly to decrease output voltage by the slew key V range value.

### 3.2.1.6.6 VOLTAGE CONTROL — M, MG MODELS

As described in PAR. 3.2.1.6.1 (M, MG Models) for the **Vadj** and numeric keys, the effect of the **VOLTAGE** control is dependent upon model, commanded mode, output enabled/disabled, actual mode, and the load.

Table 3-7 (M, MG Models) summarizes the effect of the **VOLTAGE** control adjustments for different conditions. The first three columns reflect the status of the unit before the **VOLTAGE** control is adjusted. The fourth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s 3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

**TABLE 3-7. USING VOLTAGE CONTROL TO SET OUTPUT VOLTAGE/VOLTAGE LIMIT — MODELS M, MG**

POWER SUPPLY STATUS BEFORE VOLTAGE CONTROL ADJUSTED			VOLTAGE CONTROL ADJUSTS:
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE *** (DICTATED BY LOAD)	
VOLTAGE	DISABLED	VOLTAGE*****	Programmed output voltage
VOLTAGE	ENABLED	VOLTAGE	Actual output voltage
VOLTAGE	ENABLED	CURRENT****	Actual voltage limit **
CURRENT *	DISABLED	Either VOLTAGE or CURRENT	Programmed voltage limit
CURRENT *	ENABLED	CURRENT	Actual voltage limit
CURRENT *	ENABLED	VOLTAGE	Actual output voltage

\* If the unit was programmed to Current mode remotely before being set to Local Mode, the unit will stay in commanded current mode until a Voltage Mode command is received.  
 \*\* Overload" error message placed in error buffer (for use when operating in Remote mode).  
 \*\*\* Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's.  
 \*\*\*\* Condition where load forces power supply mode.  
 \*\*\*\*\* Forced internally by the power supply.

The **VOLTAGE** control is not operational when the power supply is in Remote mode or when you enter the MENU (PAR. 3.2.2), PROGRAM REV/CHG (PAR. 3.2.1.11.1) functions, or when a program is running (PAR.s 3.2.1.11.3 and 3.2.1.11.5).

Rotating the **VOLTAGE** control clockwise increases output voltage/voltage limit; counterclockwise decreases output voltage/voltage limit.

Table 3-7 shows that with the power supply commanded to be in Voltage mode and the load disabled, the **VOLTAGE** control adjusts the programmed output voltage.

If the output is enabled and the value of the load is greater than or equal to the value of programmed voltage divided by programmed current ( $R_L \geq V_{Prog} / I_{Prog}$ ), the power supply operates in Voltage mode and the **VOLTAGE** control adjusts actual output voltage.

If the output is enabled and the value of the load is less than the value of programmed voltage divided by programmed current ( $R_L < V_{Prog} / I_{Prog}$ ), the power supply will be forced to operate in

Current mode and the **VOLTAGE** control will adjust actual voltage limit. This will not be apparent from the display indication; to see the revised voltage limit it is necessary to view status by pressing **SHIFT** then (.) on the keypad.

### 3.2.1.6.7 VOLTAGE CONTROL — MR, MGR MODELS

As described in PAR. 3.2.1.6.2 (MR, MGR Models) for the **Vadj** and numeric keys, the effect of the **VOLTAGE** control is dependent upon model, commanded mode, output enabled/disabled, actual mode, and the load.

Table 3-8 (MR, MGR Models) summarizes the effect of the **VOLTAGE** control adjustments for different conditions. The first three columns reflect the status of the unit before the **VOLTAGE** control is adjusted. The fourth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s 3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

**TABLE 3-8. USING VOLTAGE CONTROL TO SET OUTPUT VOLTAGE/VOLTAGE LIMIT — MODELS MR, MGR**

POWER SUPPLY STATUS BEFORE VOLTAGE CONTROL ADJUSTED			VOLTAGE CONTROL ADJUSTS:
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE ** (DICTATED BY LOAD)	
VOLTAGE	DISABLED	VOLTAGE****	Programmed output voltage
CURRENT	DISABLED	CURRENT****	Programmed voltage limit
VOLTAGE	ENABLED	VOLTAGE	Actual output voltage
VOLTAGE	ENABLED	CURRENT ***	Actual Voltage limit *
CURRENT	ENABLED	CURRENT	Actual Voltage limit
CURRENT	ENABLED	VOLTAGE	Actual output voltage

\* Overload" error message placed in error buffer (for use when operating in Remote mode).  
 \*\* Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's.  
 \*\*\* Condition where load forces power supply mode.  
 \*\*\*\* Forced internally by the power supply

The **VOLTAGE** control is not operational when the power supply is in Remote mode or when you enter the MENU (PAR. 3.2.2), PROGRAM REV/CHG (PAR. 3.2.1.11.1) functions, or when a program is running (PAR.s 3.2.1.11.3 and 3.2.1.11.5).

Rotating the **VOLTAGE** control clockwise increases output voltage/voltage limit; counterclockwise decreases output voltage/voltage limit.

Table 3-8 shows that if the output is disabled, with the power supply commanded to be in Voltage mode the **VOLTAGE** control adjusts the programmed output voltage, with the power supply commanded to be in Current mode the **VOLTAGE** control adjusts programmed voltage limit.

If the output is enabled and the value of the load is greater than or equal to the value of programmed voltage divided by programmed current ( $R_L \geq V_{Prog} / I_{Prog}$ ), the power supply operates in Voltage mode and the **VOLTAGE** control adjusts actual output voltage.



If the output is enabled and the value of the load is less than the value of programmed voltage divided by programmed current ( $R_L < V_{Prog} / I_{Prog}$ ), the power supply operates in Current mode and the **VOLTAGE** control adjusts actual voltage limit. This will not be apparent from the display indication; to see the revised voltage limit it is necessary to view status by pressing **SHIFT** then (.) on the keypad.

### 3.2.1.7 SETTING OUTPUT CURRENT OR CURRENT LIMIT

There are three ways to set output current or current limit: 1) **ladj** and numeric keys, 2) slew keys, 3) the **CURRENT** control. The display should be reading either “Output is off” (PAR. 3.2.1.5.2, step 1) if the output is disabled, or “Keypad control” (PAR. 3.2.1.5.1, step 2) if the output is enabled.

NOTE: If the power supply is operating in a remote configuration, the operation of Local controls can be influenced by the last mode command sent via remote mode before the unit was set to Local mode. For this reason it is advisable to set the power supply mode locally using **SHIFT** then **Vadj** (commanded Voltage mode) or **SHIFT** then **ladj** (commanded Current mode) before setting current/current limit values

#### 3.2.1.7.1 USING IADJ AND NUMERIC KEYS — M, MG MODELS

The **ladj** and numeric keys can be used to adjust either output current or current limit (either the actual value or the programmed value). The effect of the numeric keypad entries is dependent upon the model, commanded mode, whether the output is enabled or disabled, and the load.

For M and MG models, when the output is disabled, the load is disconnected from the power supply. If the load is enabled, the power supply will operate in voltage mode except for the case where the value of the load is less than the programmed voltage divided by the programmed current ( $R_L < V_{Prog} / I_{Prog}$ ). In this case the MBT power supply will be forced into Current mode.

Table 3-9 (M, MG Models) summarizes the effect of the **ladj** and numeric keys for different conditions. The first three columns reflect the status of the unit before the **ladj** command is issued. The fourth column shows the message on the front panel display after the **ladj** key is pressed and the fifth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s 3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

Table 3-9 shows that with the power supply operating in Voltage mode, with the output disabled, **ladj** and keypad entries adjust the programmed current limit.

If the load is enabled and the value of the load is greater than or equal to the value of programmed voltage divided by programmed current ( $R_L \geq V_{Prog} / I_{Prog}$ ), the power supply operates in Voltage mode and the **ladj** and keypad entries adjust actual current limit.

If the load is enabled and the value of the load is less than the value of programmed voltage divided by programmed current ( $R_L < V_{Prog} / I_{Prog}$ ), the power supply is forced to operate in current mode and the **ladj** and keypad entries adjust actual output current.

**TABLE 3-9. USING IADJ AND KEYPAD ENTRIES TO SET OUTPUT CURRENT/CURRENT LIMIT — MODELS M, MG**

POWER SUPPLY STATUS BEFORE Iadj PRESSED			EFFECT AFTER Iadj PRESSED	
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE *** (DICTATED BY LOAD)	DISPLAY INDICATION	NUMERIC VALUE SET BY KEYPAD ADJUSTS:
CURRENT *	DISABLED	CURRENT	CONST CURR =	Programmed output current
CURRENT *	ENABLED	CURRENT	CONST CURR =	Actual output current
CURRENT *	ENABLED	VOLTAGE ****	CONST CURR =	Actual current limit **
VOLTAGE	DISABLED	VOLTAGE	CURR LIMIT =	Programmed current limit
VOLTAGE	ENABLED	VOLTAGE	CURR LIMIT =	Actual current limit
VOLTAGE	ENABLED	CURRENT ****	CURR LIMIT =	Actual output current **

\* If the unit was programmed to Current mode remotely before being set to Local Mode, the unit will stay in current mode until a Voltage Mode command is received.  
 \*\* "Overload" error message placed in error buffer (for use when operating in Remote mode).  
 \*\*\* Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's.  
 \*\*\*\* Condition where load forces power supply mode.

If the power supply is operating in a remote configuration, setting output current or current limit can also be influenced by the last command issued to the power supply before the unit is put into Local Mode. If the power supply was commanded to operate in Current mode before being set into Local mode, Table 3-9 indicates that if the load allows the power supply to operate in current mode, **Iadj** and the keypad entries adjust either programmed or actual output current depending on whether the load is disabled or enabled. If the load forces the power supply to operate in voltage mode, **Iadj** and keypad entries will adjust actual current limit, contrary to the display indication.

Refer to PAR. 3.2.1.7.3 for procedure.

**3.2.1.7.2 USING IADJ AND NUMERIC KEYS — MR, MGR MODELS**

The **Iadj** and numeric keys can be used to adjust either output current or current limit (either the actual value or the programmed value). The effect of the numeric keypad entries is dependent upon the model, commanded mode, whether the output is enabled or disabled, and the load.

For MR and MGR models, when the output is disabled, the load is disconnected from the power supply if the power supply is operating in Voltage mode, or the power supply output is short circuited if the unit is operating in Current mode.

If the output is enabled, the power supply can operate either in voltage mode or current mode, as determined by both the programmed output values (Voltage or Current) and the value of the load. If the power supply is commanded to be in Voltage mode, the power supply will actually operate in voltage mode when  $R_L \geq V_{Prog} / I_{Prog}$ , and current mode (forced) when  $R_L < V_{Prog} / I_{Prog}$ . Similarly if the power supply is commanded to be in Current mode, the power supply will actually operate in Current mode when  $R_L < V_{Prog} / I_{Prog}$ , and in Voltage mode (forced) when  $R_L \geq V_{Prog} / I_{Prog}$ .

Table 3-10 (MR, MGR Models) summarizes the effect of the **ladj** and numeric keys for different conditions. The first three columns reflect the status of the unit before the **ladj** command is issued. The fourth column shows the message on the front panel display after the **ladj** key is pressed and the fifth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s 3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

Table 3-10 shows that with the power supply output disabled, the **ladj** and keypad entries adjust the programmed output current (Current mode) or current limit (Voltage mode). The **ladj** and keypad entries operate similarly to control actual output current/current limit if the power supply output is enabled, and the value of the load permits the power supply to operate in the commanded mode, Current/Voltage.

**TABLE 3-10. USING IADJ AND KEYPAD ENTRIES TO SET OUTPUT CURRENT/CURRENT LIMIT — MODELS MR, MGR**

POWER SUPPLY STATUS BEFORE ladj PRESSED			EFFECT AFTER ladj PRESSED	
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE *** (DICTATED BY LOAD)	DISPLAY INDICATION	NUMERIC VALUE SET BY KEYPAD ADJUSTS:
CURRENT	DISABLED	CURRENT*****	CONST CURR =	Programmed output current
VOLTAGE	DISABLED	VOLTAGE*****	CURR LIMIT =	Programmed current limit
CURRENT	ENABLED	CURRENT	CONST CURR =	Actual output current
CURRENT	ENABLED	VOLTAGE ****	CONST CURR =	Actual current limit **
VOLTAGE	ENABLED	VOLTAGE	CURR LIMIT =	Actual current limit
VOLTAGE	ENABLED	CURRENT ****	CURR LIMIT =	Actual output current **

\* If the unit was programmed to Current mode remotely before being set to Local Mode, the unit will stay in current mode until a Voltage Mode command is received.  
 \*\* "Overload" error message placed in error buffer (for use when operating in Remote mode).  
 \*\*\* Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's.  
 \*\*\*\* Condition where load forces power supply mode  
 \*\*\*\*\* Forced by the power supply.

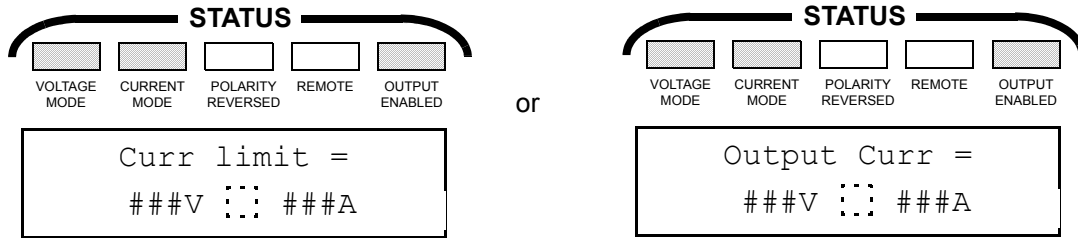
If the load is enabled, and the power supply is commanded to operate in Current mode, but  $R_L \geq V_{Prog} / I_{Prog}$  forces the power supply to operate in voltage mode, the keypad entries adjust the actual current limit, contrary to the display indication.

If the load is enabled, and the power supply is commanded to operate in Voltage mode, but  $R_L < V_{Prog} / I_{Prog}$  forces the power supply to operate in Current mode, the keypad entries adjust the actual output current, contrary to the display indication.

Refer to PAR. 3.2.1.7.3 for procedure.

### 3.2.1.7.3 PROCEDURE USING IADJ AND NUMERIC KEYPAD

1. Press **ladj**.

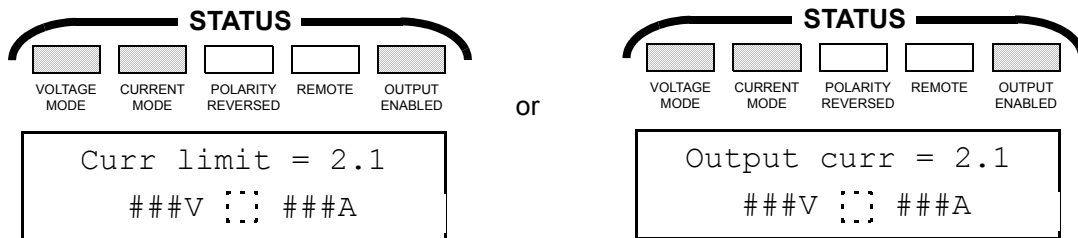


NOTES:  indicates LED may be either on or off.

###V and ###A will either be actual or programmed values of output voltage/voltage limit and output current/current limit (see Tables 3-9 and 3-10).

⋮ indicates that blinking “:” appears only for OUTPUT ENABLED status.

2. Enter current value via key pad, e.g., 2.1.



3. Press **ENTER** to confirm or **CLEAR ENTRY** to correct. Display will return to “Output is OFF” or “Keypad control” display with either the new current value (**ENTER**) if the unit is in current mode, or the old current value (**CLEAR ENTRY**). If the entered value is too high, the display will indicate “Value too high,” then return to either “Output is OFF” or “Keypad control” display, showing the previous value.

### 3.2.1.7.4 SLEW (▲ AND ▼) KEYS — M, MG MODELS

As described in PAR. 3.2.1.7.1 (M, MG Models) for the **ladj** and numeric keys, the effect of the slew keys is dependent upon model, commanded mode, output enabled/disabled, actual mode, and the load.

Table 3-11 (M, MG Models) summarizes the effect of the slew keys for different conditions. The first three columns reflect the status of the unit before the slew key is pressed. The fourth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s 3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

**TABLE 3-11. USING SLEW KEYS (▲ AND ▼) TO SET OUTPUT CURRENT/CURRENT LIMIT — MODELS M, MG**

POWER SUPPLY STATUS BEFORE SLEW KEY ADJUSTED			SLEW KEYS ADJUST:
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE ** (DICTATED BY LOAD)	
CURRENT *	DISABLED	VOLTAGE*****	Programmed output current
CURRENT *	ENABLED	CURRENT	Actual output current
CURRENT *	ENABLED	VOLTAGE ****	Actual current limit **
VOLTAGE	Either DISABLED or ENABLED	Either VOLTAGE or CURRENT	No effect on current

\* If the unit was programmed to Current mode remotely before being set to Local Mode, the unit will stay in current mode until a Voltage Mode command is received.  
 \*\* Overload" error message placed in error buffer (for use when operating in Remote mode).  
 \*\*\* Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's.  
 \*\*\*\* Condition where load forces power supply mode.  
 \*\*\*\*\* Forced by the power supply

The slew keys are not operational when the power supply is in Remote mode, when you enter the MENU (PAR. 3.2.2), or PROGRAM REV/CHG (PAR. 3.2.1.11.1) functions, or when a program is running (PAR.s 3.2.1.11.3 and 3.2.1.11.5).

Table 3-11 shows that with the power supply commanded to operate in voltage mode, the slew keys have no effect on current.

If the power supply was operating in a remote configuration, it is possible to use the slew keys to locally adjust current/current limit only if the power supply was commanded to operate in Current mode before being set into Local mode. If the output is disabled, the slew keys adjust programmed output current. If the output is enabled and the load permits the power supply to operate in Current mode, the slew keys adjust actual output current; If the load forces the power supply to operate in Voltage mode, the slew keys adjust actual current limit.

Pressing the ▲ key increases the output current/current limit (see Table 3-11) by the slew key I range value which was previously set using the MENU (see PAR. 3.2.2). For example, if the current limit is 1.0A (Current mode, output enabled), and the slew key I range value is 0.10A, pressing the ▲ key twice changes the output current to 1.2A. The ▼ key operates similarly to decrease current limit by the slew key I range value.

**3.2.1.7.5 SLEW (▲ AND ▼) KEYS — MR, MGR MODELS**

As described in PAR. 3.2.1.7.2 (MR, MGR Models) for the Iadj and numeric keys, the effect of the slew keys is dependent upon model, commanded mode, output enabled/disabled, actual mode, and the load.

Table 3-12 (MR, MGR Models) summarizes the effect of the slew keys for different conditions. The first three columns reflect the status of the unit before the slew key is pressed. The fourth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s

3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

**TABLE 3-12. USING SLEW KEYS (▲ AND ▼) TO SET OUTPUT CURRENT/CURRENT LIMIT — MODELS MR, MGR**

POWER SUPPLY STATUS BEFORE SLEW KEY ADJUSTED			SLEW KEYS ADJUST:
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE ** (DICTATED BY LOAD)	
VOLTAGE	Either DISABLED or ENABLED	Either VOLTAGE or CURRENT	No effect on current
CURRENT	DISABLED	CURRENT****	Programmed output current
CURRENT	ENABLED	CURRENT	Actual output current
CURRENT	ENABLED	VOLTAGE ***	Actual Current limit *

\* Overload" error message placed in error buffer (for use when operating in Remote mode).  
 \*\* Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's.  
 \*\*\* Condition where load forces power supply mode.  
 \*\*\*\* Forced by the power supply.

The slew keys are not operational when the power supply is in Remote mode, when you enter the MENU (PAR. 3.2.2), or PROGRAM REV/CHG (PAR. 3.2.1.11.1) functions, or when a program is running (PAR.s 3.2.1.11.3 and 3.2.1.11.5).

Table 3-12 shows that with the power supply commanded to operate in Voltage mode, the slew keys have no effect on current or current limit.

If the power supply is commanded to operate in a Current mode and the output is disabled, the slew keys adjust programmed output current. If the output is enabled and the load permits the power supply to operate in Current mode, the slew keys adjust actual output current; if the load forces the power supply to operate in Voltage mode, the slew keys adjust actual current limit.

Pressing the ▲ key increases the output current/current limit (see Table 3-12) by the slew key I range value which was previously set using the MENU (see PAR. 3.2.2). For example, if the current limit is 1.0A (Current mode, output enabled), and the slew key I range value is 0.10A, pressing the ▲ key twice changes the output current to 1.2A. The ▼ key operates similarly to decrease current limit by the slew key I range value.

**3.2.1.7.6 CURRENT CONTROL — M, MG MODELS**

As described in PAR. 3.2.1.7.1 above for the **ladj** and numeric keys, the effect of the **CURRENT** control is dependent upon model, commanded mode, output enabled, actual mode, and the load.

Table 3-13 (M, MG Models) summarizes the effect of the **CURRENT** control adjustments for different conditions. The first three columns reflect the status of the unit before the **CURRENT** control is adjusted. The fourth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s 3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

The **CURRENT** control is not operational when the power supply is in Remote mode or when you enter the MENU (PAR. 3.2.2), PROGRAM REV/CHG (PAR. 3.2.1.11.1) functions, or when a program is running (PAR.s 3.2.1.11.3 and 3.2.1.11.5).

Rotating the **CURRENT** control clockwise increases output current/current limit; counterclockwise decreases output current/current limit.

**TABLE 3-13. USING CURRENT CONTROL TO SET OUTPUT CURRENT/CURRENT LIMIT — MODELS M, MG**

POWER SUPPLY STATUS BEFORE CURENT CONTROL ADJUSTED			CURRENT CONTROL ADJUSTS:
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE *** (DICTATED BY LOAD)	
VOLTAGE	DISABLED	VOLTAGE*****	Programmed current limit
VOLTAGE	ENABLED	VOLTAGE	Actual current limit
VOLTAGE	ENABLED	CURRENT ***	Actual output current **
CURRENT *	DISABLED	VOLTAGE*****	Programmed output current
CURRENT *	ENABLED	CURRENT	Actual output current
CURRENT *	ENABLED	VOLTAGE ****	Programmed current limit **

\* If the unit was programmed to Current mode remotely before being set to Local Mode, the unit will stay in current mode until a Voltage Mode command is received.  
 \*\* "Overload" error message placed in error buffer (for use when operating in Remote mode).  
 \*\*\* Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's.  
 \*\*\*\* Condition where load forces power supply mode.  
 \*\*\*\*\* Forced by the power supply.

Table 3-13 shows that with the power supply commanded to be in Voltage mode and the output disabled, the **VOLTAGE** control adjusts the programmed output voltage.

If the output is enabled and the value of the load is greater than or equal to the value of programmed voltage divided by programmed current ( $R_L \geq V_{Prog} / I_{Prog}$ ), the power supply operates in Voltage mode and the **CURRENT** control adjusts actual current limit. This will not be apparent from the display indication; to see the revised current limit it is necessary to view status by pressing **SHIFT** then (.) on the keypad.

If the output is enabled and the value of the load is less than the value of programmed voltage divided by programmed current ( $R_L < V_{Prog} / I_{Prog}$ ), the power supply will be forced to operate in Current mode and the **CURRENT** control will adjust actual output current.

When conditions dictate that the **CURRENT** control adjusts current limit, it will not be apparent from the display indication; to see the revised current limit it is necessary to view status by pressing **SHIFT** then (.) on the keypad

### 3.2.1.7.7 CURRENT CONTROL — MR, MGR MODELS

As described in PAR. 3.2.1.7.1 above for the **ladj** and numeric keys, the effect of the **CURRENT** control is dependent upon model, commanded mode, output enabled, actual mode, and the load.

Table 3-14 (MR, MGR Models) summarizes the effect of the **CURRENT** control adjustments for different conditions. The first three columns reflect the status of the unit before the **CURRENT** control is adjusted. The fourth column shows how the adjustment will affect the status of the power supply. Refer to PAR.s 3.1.1 and 3.1.2 for more details regarding *commanded* and *actual* mode of operation (either voltage or current).

The **CURRENT** control is not operational when the power supply is in Remote mode or when you enter the MENU (PAR. 3.2.2), PROGRAM REV/CHG (PAR. 3.2.1.11.1) functions, or when a program is running (PAR.s 3.2.1.11.3 and 3.2.1.11.5).

Rotating the **CURRENT** control clockwise increases output current/current limit; counterclockwise decreases output current/current limit.

**TABLE 3-14. USING CURRENT CONTROL TO SET OUTPUT CURRENT/CURRENT LIMIT — MODELS MR, MGR**

POWER SUPPLY STATUS BEFORE CURENT CONTROL ADJUSTED			CURRENT CONTROL ADJUSTS:
COMMANDED MODE	OUTPUT ENABLED/DISABLED	ACTUAL MODE *** (DICTATED BY LOAD)	
CURRENT	DISABLED	CURRENT****	Programmed output current
VOLTAGE	DISABLED	VOLTAGE****	Programmed current limit
CURRENT	ENABLED	CURRENT	Actual output current
CURRENT	ENABLED	VOLTAGE ****	Actual Current limit **
VOLTAGE	ENABLED	VOLTAGE	Actual Current limit
VOLTAGE	ENABLED	CURRENT ****	Actual output current **

\* If the unit was programmed to Current mode remotely before being set to Local Mode, the unit will stay in current mode until a Voltage Mode command is received.  
 \*\* "Overload" error message placed in error buffer (for use when operating in Remote mode).  
 \*\*\* Actual mode is indicated by the VOLTAGE MODE and CURRENT MODE status LED's.  
 \*\*\*\* Condition where load forces power supply mode.  
 \*\*\*\*\* Forced by the power supply.

Table 3-14 shows that if the output is disabled, with the power supply commanded to be in Current mode, the **CURRENT** control adjusts the programmed output current; with the power supply commanded to be in Voltage mode, the **CURRENT** control adjusts programmed current limit.

With the power supply commanded to be in Current mode, if the output is enabled and the value of the load is less than the value of programmed voltage divided by programmed current ( $R_L < V_{Prog} / I_{Prog}$ ), the power supply operates in Current mode and the **CURRENT** control adjusts actual output current. If the output is enabled and the value of the load is greater than or equal to the value of programmed voltage divided by programmed current ( $R_L \geq V_{Prog} / I_{Prog}$ ), the power supply will be forced to operate in Voltage mode and the **CURRENT** control will adjust actual current limit (this will not be apparent from the display indication; to see the revised current limit it is necessary to view status by pressing **SHIFT** then (.) on the keypad).

If the power supply is commanded to be in Voltage mode with the load enabled and the load permits the power supply to operate in Voltage mode, the **CURRENT** control adjusts the actual current limit (this will not be apparent from the display indication; to see the revised current limit



it is necessary to view status by pressing **SHIFT** then (.) on the keypad). If the load forces the power supply to operate in Current mode, the **CURRENT** control adjusts actual output current.

### 3.2.1.8 SETTING VOLTAGE MODE OR CURRENT MODE

Although all MBT Power Supplies automatically switch between Voltage mode and Current mode depending upon the programmed values for output voltage/current, the voltage/current limit values, and the value of the load (see PAR. 3.2.1.7.1), commanding the power supply to go into Voltage mode or Current Mode causes the internal microcontroller to monitor either voltage or current, respectively, for fault and overload error conditions. If an error condition is detected, an error message is stored in the error buffer (this has no effect when operating in Local mode).

#### 3.2.1.8.1 M, MG MODELS

The M and MG models can be commanded to Voltage mode from the front panel. Current mode can not be set from the front panel, but units installed in a remote configuration can be commanded to go into Current mode using remote commands. If the power supply was commanded to be in Current mode before being set to Local mode, the slew keys will adjust current (see PAR.s 3.2.1.6.4 and 3.2.1.7.4). For the slew keys to adjust voltage it is necessary to command the unit to be in Voltage mode as follows:

1. The display should be reading either "Output is off" (PAR. 3.2.1.5.1, step 1) if the output is disabled, or "Keypad control" (PAR. 3.2.1.5.1, step 2) if the output is enabled.
2. To ensure that the power supply is set to Voltage mode, press **SHIFT** then **Vadj** keys. The message "No relay present" appears briefly, then the display will revert back to either "Output is off" if the output is disabled, or "Keypad control" if the output is enabled. (Pressing **SHIFT** then **ladj** will cause the same messages to appear, but will have no other effect.)

#### 3.2.1.8.2 MR, MGR MODELS

The MR and MGR models can be commanded to either Voltage Mode or Current mode from the front panel. Internal relays within the power supply act to establish the commanded mode. For Voltage mode the relays will either connect (output enabled) or disconnect (output disabled) the load. For Current mode the relays either short the output internally with the load connected (output disabled) or remove the short with the load connected (output enabled); refer to PAR.s 4.1.11 and 4.1.13 for details regarding enabling and switching sequences.

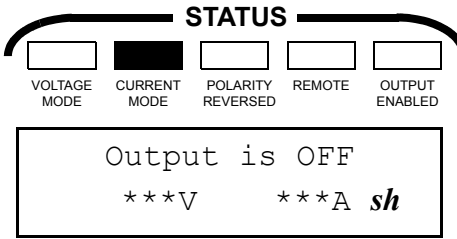
**VOLTAGE MODE** — Commanding the power supply to go into Voltage mode causes the internal microprocessor to compare the output voltage to the programmed voltage and the output current to the current limit to determine when an error condition has occurred. While the power supply is in Voltage mode with the load enabled, the output voltage will remain constant at the programmed value, while the current will vary depending on the value of the load. If the load is less than the programmed voltage divided by programmed current, the power supply will operate in Current mode (forced).

Commanding the power supply to go into Voltage mode (with output disabled) from Current mode causes the output relays to disconnect the load and remove the internal short across the power supply output. With the output disabled the VOLTAGE MODE indicator will go on and the CURRENT MODE indicator will go off. If the output is enabled, the actual mode will be determined by the programmed voltage and current values relative to the load (see PAR. 3.2.1.7.1). To command the power supply to go into Voltage mode, proceed as follows:

1. Press **SHIFT** key; display resembles A or B below.

**A**

MR, MGR models with Output disabled (commanded) Current Mode



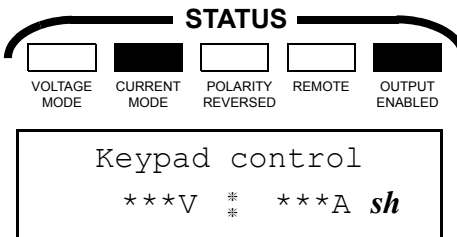
NOTE: A blinking “sh” is represented by *sh* to indicate that the SHIFT key has been pressed, and the next key that is pressed will be interpreted with the alternate meaning.

NOTE:

\*\*\*V and \*\*\*A are the output voltage and current settings in effect at time of last operation (for first time use, the voltage and current are set to 0).

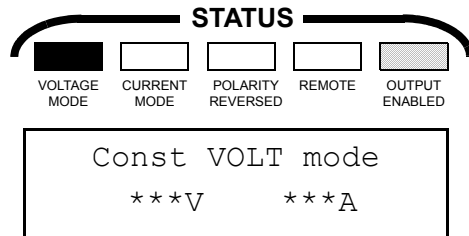
**B**

MR, MGR models with Output enabled (actual) Voltage Mode



NOTE: Although Current mode is shown above, the actual mode is dependent upon the value of the load relative to programmed voltage and current.

2. Press **Vadj** key to command the power supply to go into Voltage mode.; the display will briefly display the message shown below.; then return to the “Output is OFF” or “Keypad Control” message displayed before the SHIFT key was pressed.



NOTE: If output is enabled, a blinking “.” appears at the center of the bottom line of the display and the VOLTAGE MODE and CURRENT MODE indicators reflect the actual mode of the power supply as determined by the load

**CURRENT MODE** — Commanding the power supply to go into Current mode causes the internal microprocessor to compare the output current to the programmed current and the output voltage to the voltage limit to determine when an error condition has occurred. While the power supply is in Current mode with the output enabled, the output current will remain constant at the programmed value, while the voltage will vary depending on the value of the load. If the load is

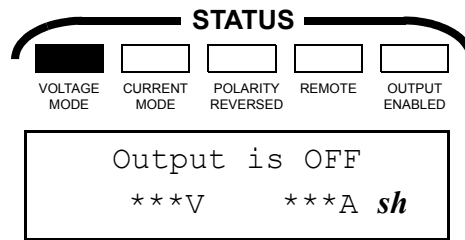
greater than or equal to the programmed voltage divided by programmed current, the power supply will operate in Voltage mode (forced).

Commanding the power supply to go into Current mode (with output disabled) from Voltage mode causes the output relays to put an internal short across the power supply output (allowing the load to be connected/disconnected). With the output disabled the CURRENT indicator will go on and the VOLTAGE indicator will go off. If the output is enabled, the actual mode will be determined by the programmed voltage and current values relative to the load (see PAR. 3.2.1.7.1). To command the power supply to enter Current mode, proceed as follows:

1. Press **SHIFT** key; display resembles A or B below.

**A**

MR, MGR models with Output disabled (commanded) Voltage Mode



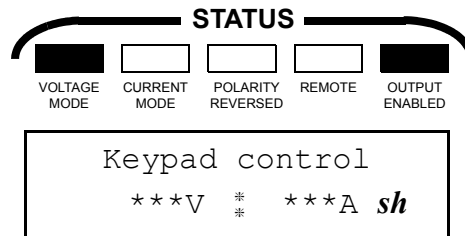
NOTE: (If previously set to Current mode, VOLTAGE MODE indicator is off and CURRENT MODE indicator is on (internally relays short the output).)

NOTE:

\*\*\*V and \*\*\*A are the output voltage and current settings in effect at time of last operation (for first time use, the voltage and current are set to 0).

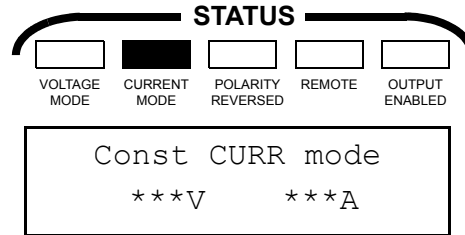
**B**

MR, MGR models with Output enabled (actual) Voltage Mode



NOTE: Although Voltage mode is shown above, the actual mode is dependent upon the value of the load relative to programmed voltage and current.

2. Press **ladj** key to command the power supply to go into Current mode.; the display will briefly display the message shown below., then return to the “Output is OFF” or “Keypad Control” message displayed before the **SHIFT** key was pressed.

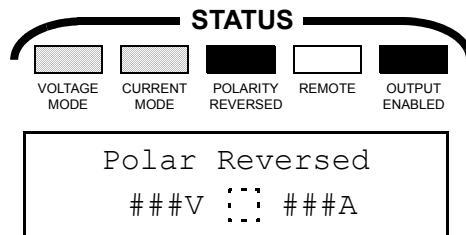


NOTE: If output is enabled, a blinking “.” appears at the center of the bottom line of the display and the VOLTAGE MODE and CURRENT MODE indicators reflect the actual mode of the power supply as determined by the load.

### 3.2.1.9 REVERSING DC OUTPUT POLARITY — MR, MGR MODELS

The display should be reading either “Output is off” (PAR. 3.2.1.5.1, step 1) if the output is disabled, or “Keypad control” (PAR. 3.2.1.5.1, step 2) if the output is enabled.

1. Press **SHIFT** key. (Blinking “sh” appears on display.)
2. Press **DC OFF (CHANGE POLARITY)** key.
  - a. If changing from non-reversed to reversed, the display briefly shows:



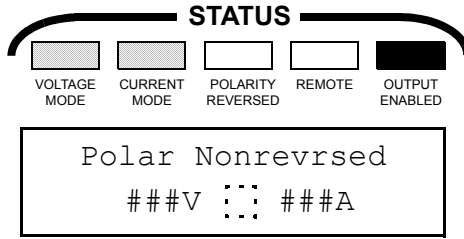
NOTE: ###V and ###A represent either actual power supply output voltage and current (output enabled) or programmed output and limit values (output disabled).

NOTES: :.:. indicates that blinking “.” appears only for OUTPUT ENABLED status.

The POLARITY REVERSED indicator will only go on when the output is enabled.

A blinking “sh” is represented by *sh* to indicate that the SHIFT key has been pressed, and the next key that is pressed will be interpreted with the alternate meaning.

b. If changing from reversed to non-reversed, the display briefly shows



NOTE: ###V and ###A represent either actual power supply output voltage and current (output enabled) or programmed output and limit values (output disabled).

NOTE: :.:. indicates that blinking “.” appears only for OUTPUT ENABLED status.

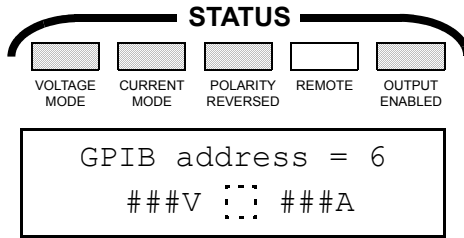
c. Display returns to “Output is OFF” or “Keypad control” display.

3. To go back to previous polarity, press **SHIFT** then **DC OFF**.

### 3.2.1.10 CHANGING THE GPIB ADDRESS

The display should be reading either “Output is off” (PAR. 3.2.1.5.1, step 1) if the output is disabled, or “Keypad control” (PAR. 3.2.1.5.1, step 2) if the output is enabled.

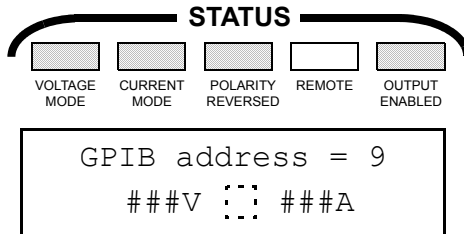
1. Press **SHIFT** key. (Blinking “sh” appears on display.)
2. Press **DELAY (GPIB ADDRESS key)**.



NOTE: ###V and ###A represent either actual power supply output voltage and current (output enabled) or programmed output and limit values (output disabled).

NOTE: The factory default address is 6.

3. If the GPIB Address is correct, press **ENTER** or **CLEAR ENTRY** to accept the GPIB address displayed. Display returns to either “Output is off” (PAR. 3.2.1.5.1, step 1) if the output is disabled, or “Keypad control” (PAR. 3.2.1.5.1, step 2) if the output is enabled.
4. Enter new GPIB address — valid addresses are 0 to 30 (e.g., for address 9, enter 9).



5. Press ENTER to confirm the new GPIB address or CLEAR ENTRY to accept previous setting. In either case the display returns to either "Output is off" (PAR. 3.2.1.5.1, step 1) if the output is disabled, or "Keypad control" (PAR. 3.2.1.5.1, step 2) if the output is enabled.

NOTE: The new GPIB address will be in effect the next time the unit is turned on; to make it effective immediately, turn power to the MBT off, then on again.

### 3.2.1.11 LOCAL MODE PROGRAMMING OF THE POWER SUPPLY

The Local mode programming feature of the MBT Series Power Supply allows up to ten separate programs (0 to 9) to be set up via the keypad. Each program is a series of commands (steps) which are set up prior to execution. A total of 99 steps are available, and since each program uses at least one step, this leaves 89 steps which can be split, as desired, among a maximum of ten programs; a single program may contain a maximum of 90 steps. Each step of a program allows the MBT to be set to specific parameters for a specified period of time. Table 3-15 defines the five screens used to program each step.

Once a program is entered into the power supply, it remains in non-volatile memory, so that the program can be recalled and executed again even if the unit was previously turned off.

For M and MG Models, each step allows the unit to select:

- Values for output voltage and current limit (Screen 0)
- the active time period for these values (screen 1)

NOTE: If the unit is forced into Current mode by the value of the load relative to programmed current and voltage, the values programmed for output voltage and current limit will be used for voltage limit and output current, respectively

For MR and MGR Models, each step allows the user to select:

- output voltage and current limit or output current or voltage limit values (Screen 0)
- the active time period for these values (Screen 1)
- voltage mode or current mode (Screen 2)
- polarity non-reversed or reversed
- output enabled or disabled.

**TABLE 3-15. PROGRAMMING MODE SCREENS**

SCREEN	FUNCTION	DISPLAY
<p>Screen 0 (Sc: 0)</p> <p>Voltage and Current Settings</p>	<p>Displays voltage and current settings.</p> <p>Pr# Program number selected</p> <p>Stp: Step number</p> <p>Sc: Screen number</p> <p>***V Programmed voltage value</p> <p>Voltage Mode: output voltage Current mode: voltage limit</p> <p>***A Programmed current value</p> <p>Voltage Mode: current limit Current mode: output current</p>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p>Pr#2      Stp: 0      Sc:0 ***V                      ***A</p> </div> <p>NOTE: While the programming mode screens are active (creating, changing, or observing screens 0 through 4) the status LEDs above the display reflect the actual status of the power supply, not the settings that are displayed for the programming mode screens. (These settings are active only when the program is executed.)</p>
<p>Screen 1 (Sc: 1)</p> <p>Delay</p>	<p>Displays delay time.</p> <p>***s Time duration (in seconds) for which programmed values of displayed step will be active</p>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p>Pr#2      Stp: 0      Sc:1 Delay = ***s</p> </div>
<p>Screen 2 (Sc: 2)</p> <p>Voltage/Current Mode Select</p> <p>(Models MR, MGR only)</p>	<p>Displays selected mode.</p>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p>Pr#2      Stp: 0      Sc:2 Const VOLT mode</p> </div> <p style="text-align: center;">or</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p>Pr#2      Stp: 0      Sc:2 Const CURR mode</p> </div>
<p>Screen 3 (Sc: 3)</p> <p>Polarity Select</p> <p>(Models MR, MGR only)</p>	<p>Displays selected polarity.</p>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p>Pr#2      Stp: 0      Sc:3 Polar Nonreversed</p> </div> <p style="text-align: center;">or</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p>Pr#2      Stp: 0      Sc:3 Polar Reversed</p> </div>
<p>Screen 4 (Sc: 4)</p> <p>Output Enabled/Dis- abled</p> <p>(Models MR, MGR only)</p>	<p>Displays status of output.</p>	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p>Pr#2      Stp: 0      Sc:4 Output Enabled</p> </div> <p style="text-align: center;">or</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p>Pr#2      Stp: 0      Sc:4 Output Disabled</p> </div>

### 3.2.1.11.1 ENTERING PROGRAM MODE

1. Press **SHIFT** key. (Blinking *sh* appears on display.)
2. Press **MENU ON/OFF (REV/CHG PROGRAM)** key

```

Rev/change PRG #
***V  [::]  ***A
    
```

NOTE: [::] indicates that a blinking “:” will appear if output is enabled.

3. Select a Program # (0 to 9) by pressing the corresponding number key. (It is not necessary to press **ENTER**.)
  - a. If the program is new (empty - no programmed steps stored), the display changes to:

```

Stp 0
End of program
    
```

Proceed to PAR. 3.2.1.11.2 to create a program.

- b. If the Program # selected (e.g., 2) has been previously stored, the display changes to one of the screens shown in Table 3-15. (The screen displayed is related to the last screen displayed during a prior programming session.)

Proceed to PAR. 3.2.1.11.3 to execute the program, or PAR. 3.2.1.11.4 to modify the program.

### 3.2.1.11.2 CREATING A NEW PROGRAM

To create a new program (display appears as shown in PAR. 3.2.1.11.1, step 3, above) it is necessary to insert “blank” steps using the **ADD STEP** function. These “blank” steps have the following default values listed in Table 3-4. Once the desired number of steps have been added, programming the values is the same as described for reviewing/changing an existing program.

**TABLE 3-16. DEFAULT PARAMETERS FOR NEW ADDED STEPS**

PARAMETER	VALUE
VOLTAGE	0 V
CURRENT	0 A
DELAY	0.1 SEC
MODE	VOLTAGE
POLARITY	NON-REVERSED
OUTPUT	ENABLED

NOTE: The default values shown above are only for a completely new step. If the step was previously programmed, deleted, and then added again, the previous values will appear.



The following step-by-step procedure explains how to enter a simple program to illustrate the programming technique. The program to be entered is shown in Table 3-17; the values are arbitrary, for instructional purposes only.

**TABLE 3-17. SAMPLE PROGRAM (ASSIGNED PROGRAM #2)**

PROGRAM STEP (Stp: )	SCREEN 0		SCREEN 1	SCREEN 2 *	SCREEN 3 *	SCREEN 4 *
	VOLTAGE	CURRENT	DELAY	MODE *	POLARITY *	OUTPUT *
0	1.0V	2.1A	20s	VOLTAGE	NON-REVERSED	ENABLED
1	2.0V	1.3A	15s	VOLTAGE	REVERSED	ENABLED
2	5.2V	3.3A	10s	CURRENT	NON-REVERSED	DISABLED

\* MR and MGR Models only.

NOTE: It is recommended that programs be entered either by first adding the "blank" steps, then programming the values for each screen of each step, or alternatively, by adding step 0, programming the values for each screen of step 0, then adding step 1, programming the values for step 1, etc. There are, however, no restrictions on the sequence of programming steps other than "blank" steps must be added before they can be assigned values.

1. Press **SHIFT**, then press **▲ (ADD STEP)** to add step 0. The display shows one of the screen listed in Table 3-15 (depending upon the last screen displayed during a prior programming session).

NOTE: The screens may be programmed in any order. It is not necessary to change values if the default values are correct, however it is recommended that all screens be checked.

2. Repeat step 1 above twice to add steps 1 and 2 to the program.
3. Press **NEXT**

```
Stp 3
End of program
```

4. Press **NEXT** again to display step 0.

```
Pr#2    Stp: 0    Sc:0
***V          ***A
```

NOTE: If Sc: 0 is not displayed, use **▲** or **▼** to cycle through the screens until Sc:0 is displayed. (Remember, even though we are programming screen 0 first, the screens and steps may be programmed in any order.)

5. You are ready to begin changing the default values of the added steps to new values. Press **Vadj**

```
Const VOLT =
0.0V          0.00A
```

6. Enter **1** (it is not necessary to key in insignificant zeroes, e.g., for 0.010, key in .01).

```
Const VOLT = 1
0.0V          0.00A
```

NOTE: If you make a mistake entering the value, press **ENTER** to confirm the incorrect value, then repeat steps 5 and 6 to correct the voltage. This applies any time the wrong value is keyed. If you press **CLEAR ENTRY** you will exit the Program mode, and the display will return to either "Output is OFF" or "Keyboard control."

7. Press **ENTER**.

```
Pr#2   Stp: 0   Sc:0
1.0V   0.00A
```

8. Press **ladj**.

```
Curr limit =
1.0V        0.00A
```

9. Enter **2.1** and press **ENTER**.

```
Pr#2   Stp: 0   Sc:0
1.0V   2.10A
```

10. Press **▲** to display Sc: 1.

```
Pr#2   Stp: 0   Sc:1
Delay = 0.1s
```

11. Press **DELAY (SEC)**.

```
Delay =
Delay = 0.1s
```

12. Enter **20** and press **ENTER**.

```
Pr#2   Stp: 0   Sc:1
Delay = 20s
```

NOTE: Steps 13 through 19 apply only to MR and MGR Models.

13. Press **▲** to display Sc: 2.

```
Pr#2   Stp: 0   Sc:2
Voltage mode
```

or

```
Pr#2   Stp: 0   Sc:2
Current mode
```

14. If Voltage mode is already selected, proceed to step 15. To set Voltage mode, press **SHIFT**, then **Vadj.** (When Current mode is desired, press **SHIFT**, then **Iadj.**)

15. Press **▲** to display Sc: 3.

Pr#2      Stp: 0      Sc:3 Polar nonrevrsd	or	Pr#2      Stp: 0      Sc:3 Polar reversed
---	----	--

16. If Polarity is already set to non-reversed, proceed to step 17. To set Polarity to non-reversed, press **SHIFT**, then **DC OFF**. (Pressing **SHIFT** then **DC OFF** will toggle Polarity between reversed and non-reversed.)

17. Press **▲** to display Sc: 4.

Pr#2      Stp: 0      Sc:4 Output enabled	or	Pr#2      Stp: 0      Sc:4 Output disabled
--	----	---

18. If Output is already set to Enabled, proceed to step 19. To set Output to Enabled, press **DC ON**. (To select Output disabled press **DC OFF**.)

19. Press **▲** to display Sc: 0.

Pr#2      Stp: 0      Sc:0 1.0V      2.10A
---

20. Press **NEXT** to display Sc: 0 for program step 1 (Stp: 1).

Pr#2      Stp: 1      Sc:0 0.0V      0.00A
---

21. Repeat procedural steps 5 through 12 (steps 5 through 19 for MR and MGR Models) above to load the values for the screens (0 and 1, or 0 through 4) for program steps 1 and 2 (Stp: 1 and Stp: 2) as specified in Table 3-17.

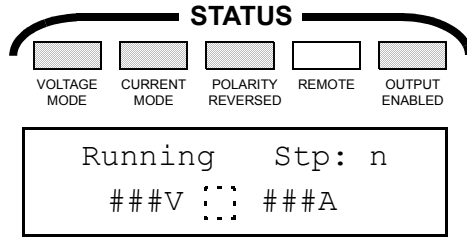
22. Press **NEXT** to display Stp: 3

Stp 3 End of program
-------------------------

### 3.2.1.11.3 RUNNING A PROGRAM

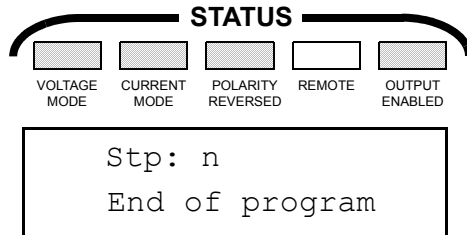
To run a program you must first enter Program mode (PAR. 3.2.1.11.1). Press **SHIFT** and **RESET** (**EXECUTE PROGRAM** function) to execute the program once you have selected a program, created a new program (PAR. 3.2.1.11.2) or modified a program (PAR. 3.2.1.11.4). While

the program is running, the display indicates the output voltage and current for each step (n) while it is being executed:



NOTE: ###V and ###A represent either actual power supply output voltage and current (output enabled), or programmed output and limit values (output disabled).

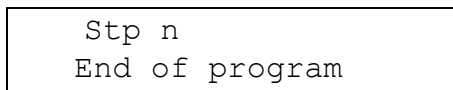
The program will execute all steps once, and stop with the display reading:



NOTE: For the sample program (PAR. 3.2.1.11.2), n = 2.

#### 3.2.1.11.4 MODIFYING A PROGRAM

1. To modify a program, you must first enter program mode and select the program (PAR. 3.2.1.11.1).
2. Press **NEXT** or **PREVIOUS** (**SHIFT** then **NEXT**) to display the step(s) that require modification.
3. Press **▲** or **▼** to display the Screen(s) that require modification.
4. Change the parameters by pressing the appropriate key(s) and changing the value (e.g., to change the time duration for a step, display Screen 1 and press **DELAY**, enter the new value, and press **ENTER**; this value has now been modified). After all parameters selected for modification have been changed, press **SHIFT** then **RESET** to execute the program. Once a parameter has been modified, the new value is stored, even if the unit is turned off.
5. To delete a step (with the exception of step 0), go to the step using **NEXT** (or **SHIFT** then **NEXT**); press **SHIFT** then **▼** (DEL STEP function). The step is deleted and the display shows the previous step.
6. To delete step 0, all the other steps must be deleted first. Use **NEXT** until display shows the last step of the program.



NOTE: n = the last step of the program selected

Then press SHIFT then ▼ (DEL STEP function), until display reads:

```
Stp 0
End of program
```

NOTE: If step 0 is deleted, the initial values for step 0 of a new program will be the same as the deleted step 0.

### 3.2.1.11.5 CYCLING A PROGRAM

1. To cycle a program, first enter program mode and select a program. Press **NEXT** until the display reaches the end of the program:

```
Stp n
End of program
```

NOTE: n = the last step of the program selected

2. Press SHIFT and 0. The display changes to:

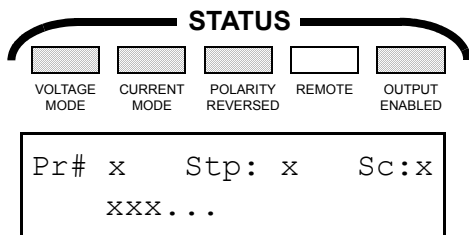
```
Stp n   Cycle On
End of program
```

3. Press **SHIFT** then **RESET** to execute the program. The program will run continuously, proceeding to execute step 0 after the last step is executed.

### 3.2.1.11.6 STOPPING A PROGRAM

There are two ways to stop a program:

1. Press **CLEAR ENTRY** key. The program will stop at the step in progress when **CLEAR ENTRY** is pressed. The values programmed by that step will remain at the power supply output. The display will be as shown below:



NOTE: xxx = the message will depend on which screen is displayed. The screen displayed prior to running the program will be displayed when the program stops.

2. Press **RESET** key. Operation of **RESET** is similar to **CLEAR ENTRY** above, with the following exception: pressing **RESET** forces the power supply output voltage and current to zero. (For MR and MGR Models, the output is also disconnected from the load.)

To restart the program, press **SHIFT** then **RESET** to execute the program; the program will restart from step 0 (Stp: 0).

### 3.2.1.11.7 EXITING PROGRAM MODE

To exit Program Mode press **CLEAR ENTRY** after the program has been stopped (see PAR. 3.2.1.11.6).

1. If the output is enabled when **CLEAR ENTRY** is pressed, the display reverts to "Keypad control" (PAR. 3.2.1.5.1, step 2).
2. If the output is disabled when **CLEAR ENTRY** is pressed, the display reverts to "Output is off" (PAR. 3.2.1.5.2, step 1), except for Models M and MG where the program was stopped with **RESET**: the display reverts to "Keypad control."

### 3.2.1.11.8 SAMPLE PROGRAM OPERATION - MODELS M, MG

The following paragraphs describes how the MBT power supply operates, using the Sample Program (3-17) for illustration. Figures 3-1 (M and MG Models) and 3-2 (MR and MGR Models) show output voltage and current for the sample program (PAR. 3.2.1.11.2) when  $R_L = 2$  ohms, and when  $R_L = 1$  ohm

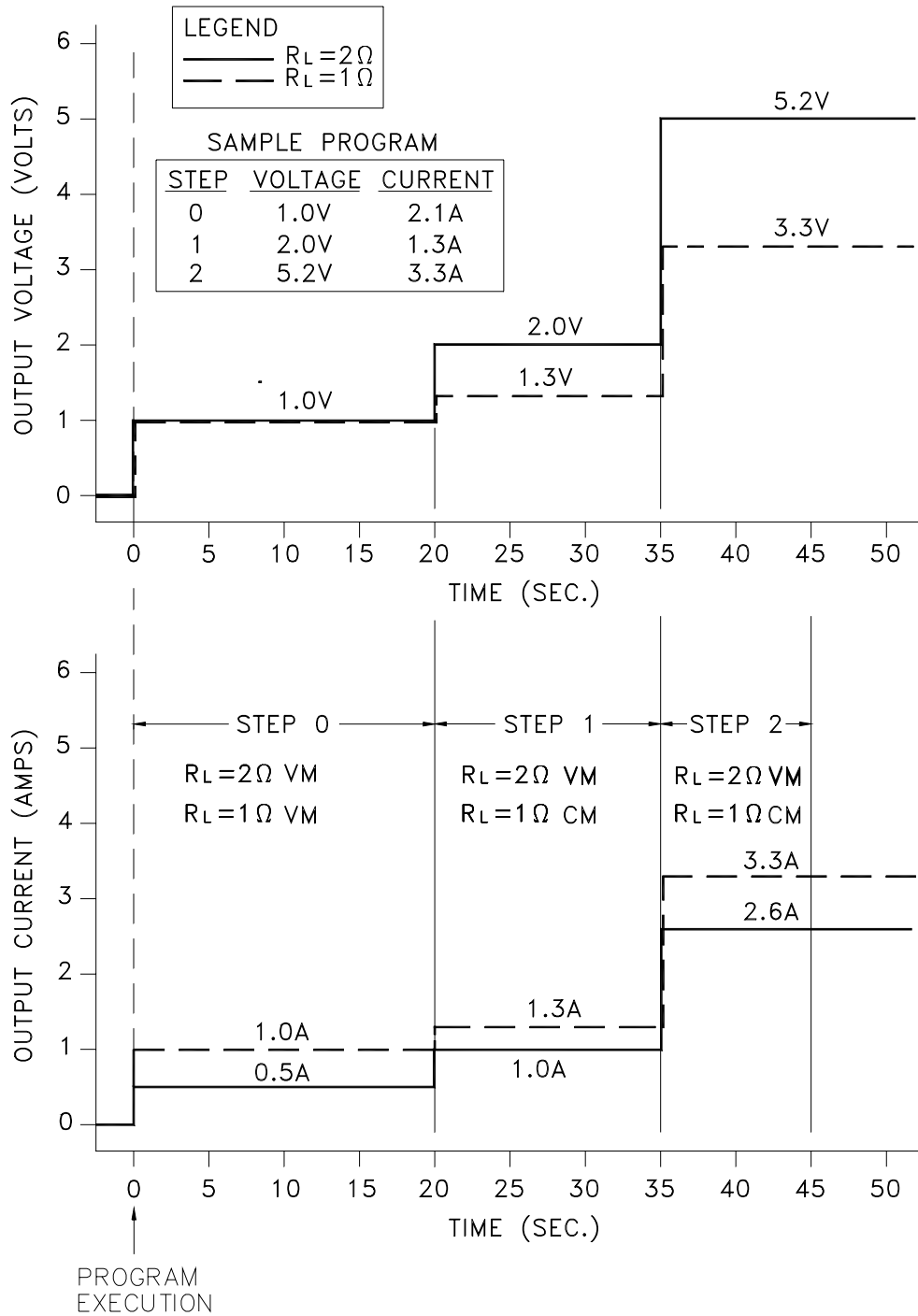
NOTE: Whenever a program is running, the STATUS indicators on the front panel represent the actual condition of the power supply regarding Voltage or Current mode of operation, the polarity of the output, and whether the output is enabled or disabled.

During step 1, the programmed values of voltage/current with a load of either 1 ohm or 2 ohms allow the power supply to operate in Voltage mode (current drawn by the load is within the current limit of 2.1A).

During step 2, the power supply continues to operate in voltage mode with the 2 ohm load, however with a 1 ohm load, the power supply is forced into Current mode (even though the commanded mode is Voltage mode) since 2V into a load of 1 ohm would produce a current (2A) greater than the current limit (1.3A). Current is limited to 1.3A and voltage is at 1.3V (1.3A into a 1 ohm load). For MR and MGR Models, since polarity is reversed for this step, Figure 3-2 shows negative values for voltage and current.

For M and MG models, during step 3 the power supply continues to operate in voltage mode for the 2 ohm load. For the 1 ohm load, however, current is limited to 3.3A, so the power supply is forced into Current mode with the voltage at 3.3V (3.3A into a 1 ohm load).

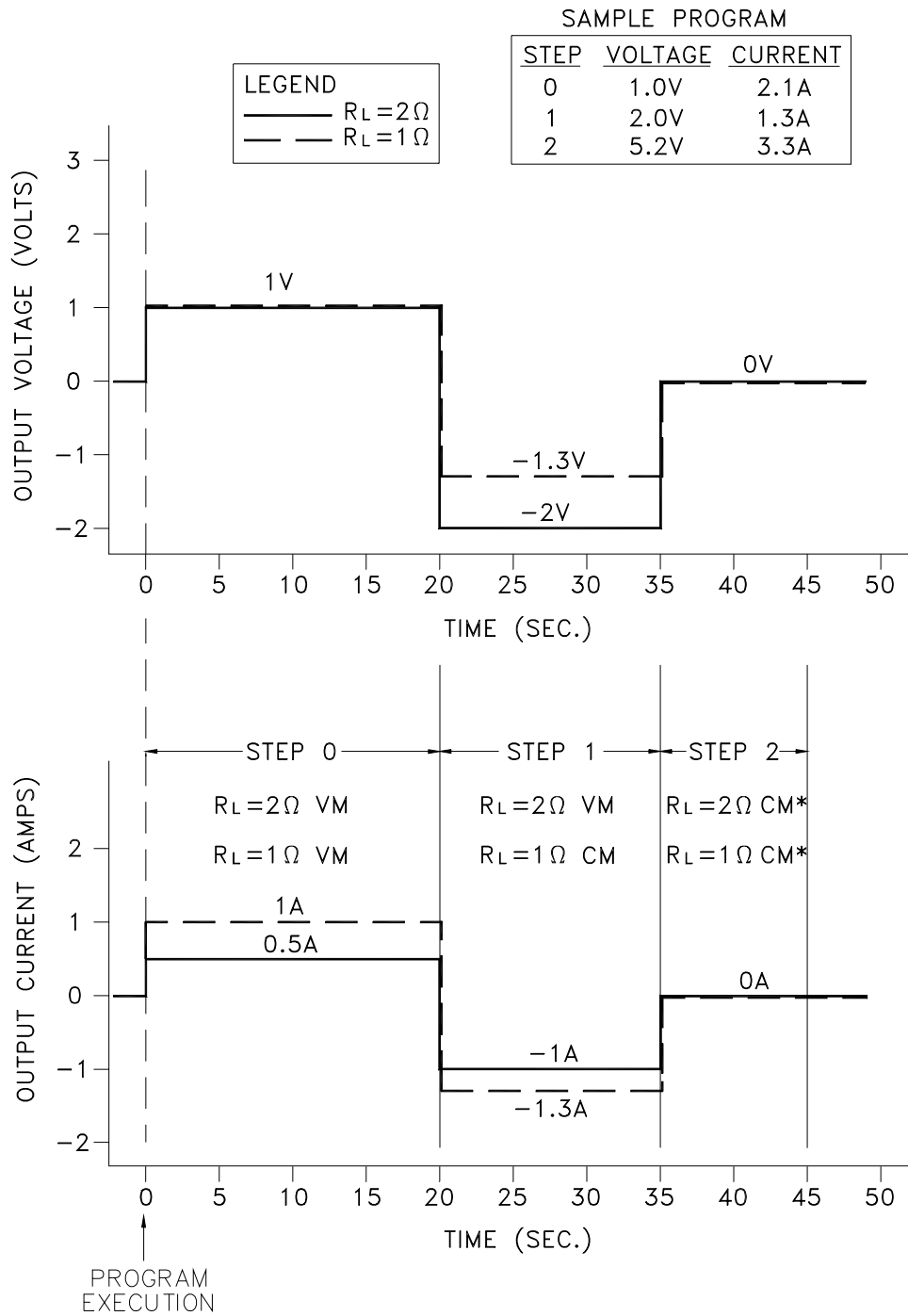
For MR and MGR models, during step 3 the power supply is commanded to operate in Current mode with the output disabled, so the output/polarity reversal relays short the output, forcing output voltage and current to zero.



VM = VOLTAGE MODE DICTATED BY PROGRAMMED VALUES AND LOAD  
 CM = CURENT MODE DICTATED BY PROGRAMMED VALUES AND LOAD

3041014

**FIGURE 3-1. SAMPLE PROGRAM OPERATION FOR M, MG MODELS**



VM = VOLTAGE MODE DICTATED BY PROGRAMMED VALUES AND LOAD  
 CM = CURRENT MODE DICTATED BY PROGRAMMED VALUES AND LOAD  
 CM\* = CURRENT MODE SET INTERNALLY BY THE CURRENT MODE COMMAND

3041013

**FIGURE 3-2. SAMPLE PROGRAM OPERATION FOR MR, MGR MODELS**



### 3.2.2 USING THE MENU SYSTEM

To enter the Menu, press the **MENU ON/OFF** Key. The functions listed in Table 3-18 are available and can be displayed one at a time by pressing **NEXT**, or **SHIFT** then **NEXT (PREVIOUS)**, to “navigate” through the Menu options. To select the displayed option, press **ENTER** key.

**TABLE 3-18. MENU FUNCTIONS**

DISPLAY	FUNCTION
Speaker On/Off	Enables or disables audible beep heard when keypad keys are pressed (factory default = speaker on).
Control lockout	Disables VOLTAGE and CURRENT controls (factory default = controls unlocked).
Remote channel	Enter Remote mode to control another power supply from keypad.
Calibration	Provides procedure for calibrating the power supply.
OVP, OCP setup	Establishes Overvoltage and Overcurrent protection values.
Slew key set-up	Establishes the increment for voltage/current increase/decrease produced by one press of a slew key.
Rem Dsp Blanking	Disables display updateing during remote operation
GPIB addressing	Allows selection of primary or secondary GPIB addressing
Compatible Mode	Allows selection of Compatibility mode for certain features
Command Language	Allows selection of SCPI or CIL for remote programming

#### 3.2.2.1 SPEAKER ON/OFF

1. Press **MENU ON/OFF** to enter the Menu, then press **NEXT** until “Speaker On/Off” is displayed:

Speaker On/Off Next/Enter
------------------------------

press **ENTER** to select this function.

2. Screen displays either “Speaker Enabled” or “Speaker Disabled”. Use the slew keys to toggle between the two options.
3. Once the unit is set to the desired option, press **MENU ON/OFF** key to return to menu level; press it again to exit the menu system.

#### 3.2.2.2 CONTROLS LOCK-OUT

This option is used to lock-up (disable) the **VOLTAGE** and **CURRENT** controls and the slew keys. When locked, the voltage and current parameters can only be modified by numeric keypad entry using **Vadj** and **Iadj** keys.

1. Press **MENU ON/OFF** to enter the Menu, then press **NEXT** until “Control lockout” message is displayed; press **ENTER** to select this function.

2. The display shows either "Controls unlocked" or "Controls locked;" use the slew keys to toggle between the two options.
3. Press **MENU ON/OFF** to return to menu level; press it again to exit the menu system.

### 3.2.2.3 REMOTE CHANNEL

This function is used to remotely control other power supplies from the front panel of an MBT power supply included in the remote configuration (see PAR. 1.4.1 and 1.4.2).

#### 3.2.2.3.1 GENERAL NOTES FOR REMOTE CONFIGURATIONS USING IEEE 1118 BUS

1. The remote configuration must have one (and only one) MBT configured as a controller ("G" option enabled) on the IEEE 1118 bus.
2. Each power supply in the configuration must be preset with unique node addresses.
3. No more than 27 units can be connected to a remote configuration.
4. The units must remain powered down for approximately 10 seconds before power is restored to allow the internal memory chips to stabilize.
5. When applying power to units in a remote configuration, the unit with the "G" option enabled must be the last unit powered up.
6. Any MBT front panel (keypad and display) can be used to control any other power supply in the configuration (regardless of which power supply has the "G" option enabled).
7. Upon initiating remote operation, it is necessary to send commands for output status, polarity (MR and MGR Models) and mode, for the display to be updated.
8. Status LEDs of the controlling power supply reflect the controlling power supply status, not the controlled power supply.
9. It is possible for an MG or MGR Model to be remote controlled using its own keypad, thus a single unit with "G" option enabled could be operated in remote mode using its own keypad. As an example, an MG Model could be commanded to enter Current mode by remote control even though a Current mode command will not be accepted through Local mode **SHIFT** then **ladj** command.
10. Remote control only affects the controlled power supply after the first command is issued. Once the first command is issued, the display of the controlled power supply reads "Remote control" and its Local keypad is disabled.
11. The controlled power supply remains in "Remote control" status even after the controlling power supply exits remote control operation. To put the controlled power supply into Local mode, press **SHIFT** then **CLEAR ENTRY**.

12. The functions available from the controlling power supply keypad are:

Voltage Mode	<b>SHIFT</b> then <b>Vadj</b>
Current Mode	<b>SHIFT</b> then <b>ladj</b>
Change Polarity	<b>SHIFT</b> then <b>DC OFF</b> (for MR, MGR Models only)
Output Enable	<b>DC ON</b>
Output Disable	<b>DC OFF</b>
Voltage Adjust	<b>Vadj</b> , numeric, then <b>ENTER</b>
Current Adjust	<b>ladj</b> , numeric, then <b>ENTER</b>
Reset	<b>RESET</b>

### 3.2.2.3.2 REMOTE OPERATION USING KEYPAD TO CONTROL ANOTHER MBT POWER SUPPLY

The following steps are performed at the controlling power supply.

1. Press **MENU ON/OFF** to enter the Menu, then press **NEXT** until "Remote Channel" is displayed; press **ENTER** to select this function.

```
Enter Node #
```

2. Enter the node number (address) of the power supply to be controlled. This is a number between 1 and 31 (the node address is set via DIP switch A3S1 accessed through the top cover; see PAR. 2.6.1). MBT power supplies are shipped with the node address set to a default value of 1. Enter the node number and press **ENTER**.

- a. If the node address does not exist, or the connection through the IEEE 1118 bus is not valid, the display will briefly read:

```
Communication  
ERROR
```

then the unit will return to Menu level with the display reading "Remote Channel." Press **MENU ON/OFF** again to exit the Menu.

- b. If the selected unit (node) is present and the control lines operational, the display reads:

```
wait...
```

followed by

```
MDL X - Y
```

NOTE: MDL X-Y refers to the MBT Model, of the power supply to be controlled (e.g., MBT 100-3.6), where X is the nominal voltage rating (100) and Y is the nominal current rating (3.6).

followed by

#n M1; M2; M3
***V * **A

NOTE: A blinking “.” is represented by “.” to indicate that the values displayed on the bottom line of the alphanumeric display are “live,” i.e., actual values at the power supply output.

NOTE: the status LEDs above the display reflect the actual status of the controlling power supply, not the settings of the controlled power supply.

n = node address of the controlled power supply

M1 = message showing the commanded mode of operation for the controlled power supply:

VM — Voltage Mode

CM — Current Mode

VL — Voltage Limit: indicates that the controlled power supply was commanded to be in Current mode but the load is forcing it to operate in Voltage mode.

CL — Current Limit: indicates that the controlled power supply was commanded to be in Voltage mode, but the load is forcing it to operate in Current mode.

M2 = message showing the commanded polarity of the controlled power supply:

P+ — Polarity plus (non-reversed)

P- — Polarity minus (reversed) (available on MR and MGR Models only)

M3 = message showing the commanded output status of the controlled power supply:

OD — Output Disabled

OE — Output Enabled

\*\*\*V and \*\*\*A indicate the output values of the controlled power supply:

If the controlled MBT power supply is an M or MG Model, this represents actual output values of the controlled power supply. (When output is disabled, 0V and 0A are the true outputs.)

If the controlled MBT power supply is an MR or MGR Model, this represents actual output values of the controlled power supply if the output is enabled; if the output is disabled, this represents the **internal** output of the controlled power supply since the load will either be isolated (commanded Voltage mode) or short-circuited (commanded Current mode). The display will show programmed voltage and 0A for commanded Voltage mode, and 0V and programmed current for commanded Current mode.

NOTE: You can now use the keypad of the controlling power supply to set parameters for the controlled power supply. However, the messages and values displayed in step 2 above are not valid at this time. These messages/values are stored in the buffer of the controlling power supply; they are updated with valid information from the controlled power supply only by executing the commands indicated in steps 3 through 5 below.

3. Ensure that the controlled power supply output is disabled by pressing DC OFF. Message M3 in the upper right corner of the display reads OD. (Remember, this command must be executed even if the display already reads OD to begin with.)
4. If the controlled power supply is a Model MR or MGR unit, press **SHIFT** then DC OFF. Read Message M2 on the display to establish the existing polarity of the controlled power supply (P+, non-reversed or P-, reversed). To toggle the polarity press **SHIFT** then **DC OFF**. (Again, this command must be executed even if the original polarity displayed is the desired polarity.)
5. Set the commanded mode of the controlled power supply by pressing **SHIFT** and either **Vadj** (for commanded Voltage mode) or **Iadj** (for commanded Current mode). Message M1 on the display will verify that the controlled power supply is commanded to Voltage mode (VM) or Current mode (CM). (Again, this command must be executed even if the display originally showed the correct mode.)
6. If the controlled power supply is an M or MG Model, it is recommended that the voltage and current values be reintroduced, even if the values shown are correct (If these values are not set at this time and the output is disabled, then enabled, the output values will stay at zero when the output is enabled.)

NOTE: When the controlled power supply is an M or MG Model, sending an output voltage or output current parameter will cause the output to be enabled.

Set output voltage or voltage limit by pressing **Vadj**, entering the numeric value, and pressing **ENTER**; set output current or current limit by pressing **Iadj**, entering the numeric value, and pressing **ENTER**.

7. To end the remote controlling operation press **MENU ON/OFF**; the unit will return to Menu level with the display reading "Remote Channel." Press **MENU ON/OFF** again to exit the Menu.

#### 3.2.2.4 CALIBRATION

1. Press **MENU ON/OFF** to enter the Menu, then press **NEXT** until "Calibration" is displayed; press **ENTER** to select this function.
2. The steps on the display guide you through the calibration procedure (refer to PAR. 5.5 for details). Press **NEXT** to advance to the next step of the procedure.
3. Once "End of Calibration" screen is reached, press either **NEXT** or **MENU ON/OFF** keys to return to menu. Press **MENU ON/OFF** again to exit the menu system.

#### 3.2.2.5 OVP, OCP SET-UP

This function is used to set Over-Voltage (OVP) and Over-Current (OCP) protection values. The unit will not allow programmed values or actual outputs above these limits.

NOTE: The OVP and OCP function is inoperative when the power supply is being controlled remotely (Remote mode). Remote operation automatically establishes the nominal values of the power supply as the OVP and OCP values. When the power supply is subsequently placed in Local mode, the nominal values for OVP and OCP remain. (For example, the MBT 100-3.6 will be programmed to OVP value of 100V and OCP value of 3.6A when placed into Local mode after remote operation.

1. Press **MENU ON/OFF** to enter the Menu, then press **NEXT** until “OVP, OCP Set-up” is displayed; press **ENTER** to select this function.

OVP = ***
OCP = ***

NOTE: \*\*\* indicates values set for overvoltage and over-current protection.

2. Unit displays the actual programmed values. Factory default values are the nominal output Voltage and Current. (e.g., for Model MBT 15-20MG, factory default values are OVP=15.00 V and OCP=20.00 A).
3. To set different values press **Vadj** key and enter new OVP value and/or **Iadj** key and enter new OCP value.

OVP = ***
Max Volt =

OCP = ***
Max Curr =

4. Press **ENTER** to accept new value; the display will be similar to step 1 above, with the new value.

NOTE: If the programmed value is larger than the nominal value for the power supply (e.g., setting OVP on a Model 100-3.6 to 120V), the OVP will be set to the nominal value (in this case 100V) instead of the programmed value without any warning message. Repeat step 3 if readjustment is desired.

5. Press **MENU ON/OFF** to return to menu level. Press it again to exit the menu system.

### 3.2.2.6 SLEW KEY INCREMENTS SET-UP

The slew keys can be adjusted to increment/decrement voltage/current by a specific value. The slew key values range from a minimum of one digit above the resolution of the unit adjustment to a maximum of 1V for voltage and 1A for current. The resolution of the slew key adjustment is 1 LSB (least significant bit, equal to 0.024% of nominal value).

1. Press **MENU ON/OFF** to enter the Menu, then press **NEXT** until “Slew key Set-up” is displayed; press **ENTER** to select this function.
2. The unit displays the actual programmed values. Factory default values are: 0.1V for voltage and 0.1A for current.
3. To set different values, press **Vadj** key and enter the new value for voltage increment. Similarly, press **Iadj** key and enter the new value for current increment.

NOTE: When entering the slew key increment value, notice that the display allocates room for a figure of four decimal places (maximum). After pressing **ENTER** (step 4. below), the

displayed value for slew key increment will only show two decimal places, however the true four-decimal place value is stored internally and is the actual value added/subtracted when a slew key is pressed. (For example, entering an increment of “.0055” will result in a displayed value of “0.00;” pressing the slew key continuously for a period of time in “Output is OFF” or Keypad control” status will verify that the programmed or actual value is changing.)

4. Press **ENTER** to accept the new value; the display shows the new slew key increment values.

NOTE: If a value greater than 1 (V or A) is entered, the adjustment will be set to 1 (maximum value) without any warning message. Repeat step 3. to readjust, as desired.

5. Press **MENU ON/OFF** to return to the menu level. Press it again to exit the menu system.

### 3.2.2.7 REMOTE DISPLAY BLANKING

The front panel display may be blanked or disabled during remote operation. This may improve the response time of the MBT unit during quick, successive remote operations. The display may be disabled either temporarily for a selected number of seconds, or continuously once a remote command is received, until the unit is powered off. While the display is disabled, it will show the message "REMOTE CONTROL".

1. Press **MENU ON/OFF** to enter the menu, then **NEXT** until "Rem Dsp Blanking" is displayed; press **ENTER** to select this function.
2. The unit will display "Don't Blank," "Stay Blank," or the number of seconds (1, 3, or 10) to keep the display disabled. Use the slew keys to select the mode that you prefer.
3. Press **MENU ON/OFF** to return to menu level. Press it again to exit menu system.

### 3.2.2.8 GPIB ADDRESSING MODE

The MBT-G supports either Primary or Secondary addressing mode for GPIB remote programming. In the Secondary addressing mode, the secondary address is the channel number to which the command will be sent. Otherwise, the channel number is selected by use of the "INSTR" command, or by appending the channel number to the command itself.

1. Press **MENU ON/OFF** to enter the menu, then **NEXT** until "GPIB addressing" is displayed; press **ENTER** to select this function.
2. The display shows either "Pri.Addressing" or "Sec.Addressing." Use the slew keys to toggle between the two modes.
3. Press **MENU ON/OFF** to return to menu level. Press it again to exit menu system.

### 3.2.2.9 COMPATIBILITY MODE

The MBT-G has 2 compatibility modes, Off and ON. When selected to be ON, the unit is backward compatible with older Kepco products. When OFF, the unit is completely compatible with the 488.2 and SCPI standards. Table 3-19 below describes the differences.

**TABLE 3-19. MBT-G COMPATIBILITY MODES**

Function	MODE 0 (OFF)	MODE 1 (ON)
Device Clear	Does not reset power modules	Resets all power modules
Status	Uses Status Instrument Registers	Does not use Status Instrument Registers
PON enable	All status register enables are set to 0	All status register enables are set to 32767
sys:vers?	returns 1997.0	returns blank string

1. Press **MENU ON/OFF** to enter the menu, then **NEXT** until "Compatible Mode" is displayed; press **ENTER** to select this function.
2. The display shows either "Compatibility ON" or "Compatibility OFF." Use the slew keys to toggle between the 2 modes.
3. Press **MENU ON/OFF** to return to menu level. Press it again to exit menu system.

### 3.2.2.10 COMMAND LANGUAGE

The MBT-G allows selection of either SCPI or CIIL command languages for remote programming.

1. Press **MENU ON/OFF** to enter the menu, then **NEXT** until "Command Language" is displayed; press **ENTER** to select this function.
2. The display shows either "SCPI Programming" or "CIIL Programming." Use the slew keys to toggle between the 2 modes.
3. Press **MENU ON/OFF** to return to menu level. Press it again to exit menu system.

### 3.3 REMOTE MODE PROGRAMMING

**NOTE:** The VISA query function (included in the latest versions of the VISA libraries) is not supported by the MBT Power Supply. In newer XP and Vista computers a delay is needed to insure the MBT Power Supply has time to return the response to the query. The VISA query has no provisions to add a delay, nor can it issue a series of read strobes between sending the request and receiving data from the device. Instead of the VISA query, use one of the two methods described below. Method 2 is recommended.

1. Use a VISA Write followed by VISA Read with a small delay between the functions. The delay is determined by computer speed. A 2 millisecond delay between the Write and Read functions will be sufficient to insure that there is enough time to receive a response for all valid queries.
2. Follow the VISA Write with a series of VISA Read strobes while waiting for the data available bit to be true, followed by the VISA Read function when data is available. This method provides the highest throughput.



### 3.3.1 GENERAL

Kepeco MBT Power Supplies (Models MG and MGR, with the “G” option enabled) may be programmed over a control bus using either SCPI (Standard Commands for Programmable Instruments) or CIL (Control Interface Intermediate Language) commands. SCPI and CIL provide a common language conforming to IEEE488.2 for instruments used in an automatic test system. The control bus can be either the IEEE 488 standard communication bus (General Purpose Interface Bus, GPIB), or the RS232C communication bus. (Refer to Table 2-2 for input/output signal allocations.) Most power supply functions available from the keypad can be programmed via Remote command.

### 3.3.2 IEEE 488 (GPIB) BUS PROTOCOL

Table 3-20 defines the interface capabilities of the MBT power supply (Talker/Listener) relative to the IEEE 488 (GPIB) bus (reference document *ANSI/IEEE Std 488: IEEE Standard Digital Interface for Programmable Instrumentation*) communicating with a Host Computer—Controller (Talker/Listener).

**TABLE 3-20. IEEE 488 (GPIB) BUS INTERFACE FUNCTIONS**

FUNCTION	SUBSET SYMBOL	COMMENTS
Source Handshake	SH1	Complete Capability (Interface can receive multiline messages)
Acceptor Handshake	AH1	Complete Capability (Interface can receive multiline messages)
Talker	T6	Basic talker, serial poll, unaddress if MLA (My Listen Address) (one-byte address)
Listener	L4	Basic listener, unaddress if MTA (My Talk Address) (one-byte address).
Service Request	SR1	Complete Capability. The interface sets the SRQ line true if there is an enabled service request condition.
Remote/Local	RL1	Complete capability. Interface selects either local or remote information. In local mode the MBT executes front panel commands, but can be set to remote mode via IEEE 488 bus. When in Remote mode (REMOTE status indicator on) all front panel keys except LOCAL function (SHIFT then CLEAR ENTRY) are disabled. LOCAL function can be disabled using programmed local lockout command so that only the controller or a power on condition can restore Local mode.
Parallel Poll	PP0	No Capability
Device Clear	DC1	Complete Capability. MBT accepts DCL (Device Clear) and SDC (Selected Device Clear).
Device Trigger	DT0	No Capability
Controller	C0	No Capability

Tables 3-21 and 3-22 define the messages sent to the MBT, or received by the MBT, via the IEEE 488 bus in IEEE 488 command mode and IEEE 488 data mode, respectively. These messages are enabled during the “handshake” cycle, with the MBT power supply operating is either a Talker or a Listener.

### 3.3.2.1 STRING PARSING

When the MBT power supply is in listen mode, strings are accepted. When the host controller sends the last byte it can assert the EOI line to indicate the string is complete. The GPIB listener function automatically adds a LF to terminate the string input. The parsing software then processes the string and if there are valid commands, the power supply is updated with the new control input. Some GPIB host controllers do not have the ability to assert the EOI control line, however the GPIB listener function will also terminate the string input when either a carriage return (0d<sub>H</sub>) or Line Feed (0A<sub>H</sub>) character is received.

**TABLE 3-21. IEEE 488 (GPIB) BUS COMMAND MODE MESSAGES**

MNEMONIC	MESSAGE DESCRIPTION	COMMENTS
ATN	Attention	Received
DAC	Data accepted	Received or Sent
DAV	Data Valid	Received or Sent
DCL	Device Clear	Received
IFC	Interface Clear	Received
MLA	My Listen Address	Received
MTA	My Talk Address	Received
OTA	Other Talk Address	Received
RFD	Ready for Data	Received or Sent
SDC	Selected Device Clear	Received
SPD	Serial Poll Disable	Received
SPE	Serial Poll Enable	Received
SRQ	Service Request	Sent
UNL	Unlisten	Received
UNT	Untalk	Received

**TABLE 3-22. IEEE 488 (GPIB) BUS DATA MODE MESSAGES**

MNEMONIC	MESSAGE DESCRIPTION	COMMENTS
DAB	Data Byte	Received or Sent
END	End	Received or Sent
EOS	End of String	Received or Sent
RQS	Request Service	Sent
STB	Status Byte	Sent

### 3.3.3 RS232-C BUS PROTOCOL

The MBT power supply may be operated remotely via an RS232-C terminal, or from a PC using a terminal emulation program. The following settings must be observed:

- Baud rate: 9600
- Parity: None
- Data Bits 8
- Stop Bits 1
- Echo ON
- XON OFF

The above settings are established by the firmware and cannot be changed by the user although firmware with alternate settings can be ordered. It is recommended that the user program the computer's serial interface to match the above setting. Refer to Figure 2-4 and Table 2-2 for RS232 connections. See PAR. 3.3.3.1 for a description of RS 232 implementation.

Upon power-up, the RS 232 port provides the following message:

**KEPCO POWER SUPPLY CONTROLLER V.4.6;MBTG=6;PROGMODE=2**

where

**V4.6** indicates the software Version number

**MBTG=6** indicates the first device is an MBT G Option with the GPIB address set to 6

**PROGMODE=x** is defined as follows:

x = 0 = CIL

x = 1 = SCPI (secondary addressing enabled)

x = 2 = SCPI (standard)

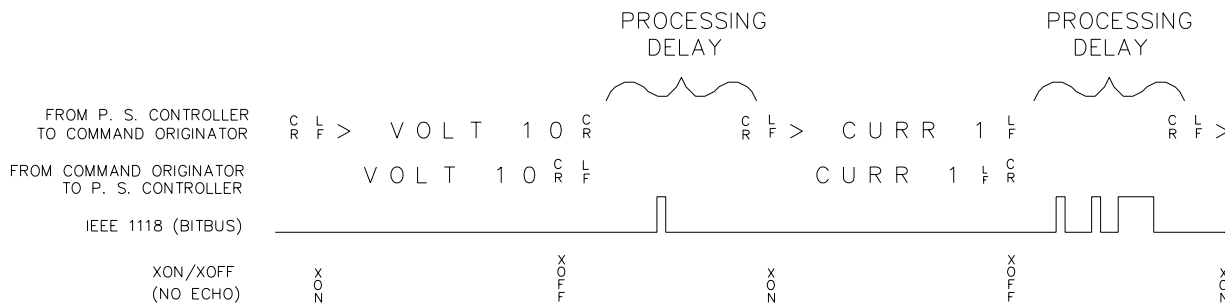
x = 3 = SCPI (compability mode enabled)

#### 3.3.3.1 RS 232 IMPLEMENTATION

The following paragraphs are provided to help the user understand how the RS 232 serial interface is implemented in the MBT-G option. Since the RS 232 protocol does not use a parity bit, the echo mode is the default method used to ensure reliable communication between the command originator (computer) and the MBT power supply controller, thus avoiding a more complex "handshake" protocol.

When the MBT-G power supply is in the RS 232 echo mode it returns all data sent to the host controller. The MBT-G power supply provides two additional options that allow handshake communication: the Prompt method and the XON XOFF method. In standard echo mode the controller must verify that each character is echoed back by the MBT-G power supply. As shown in Figure 3-3, there are times when the MBT-G power supply does not echo back the character from the controller, requiring that the controller resend the character. By using the handshake options (prompt and XON XOFF) the host controller can ensure that serial data interrupts occurring after parsing of the incoming message do not result in lost data.

Figure 3-3 illustrates the default echo mode, the prompt method and the XON XOFF method described in the following paragraphs.



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**FIGURE 3-3. RS 232 IMPLEMENTATION**

Only four control characters (characters between 00<sub>H</sub> and 1F<sub>H</sub>) are acknowledged by the power supply:

- Carriage Return (CR, 0D<sub>H</sub>)
- Line Feed (LF, 0A<sub>H</sub>)
- Back Space (BS, 08<sub>H</sub>)
- Escape (ESC, 01B<sub>H</sub>)

BS deletes the last character entered, with the exception of CR or LF characters. Either the CR or LF character acts as the line terminator, initiating parsing of the ASCII data sent to the MBT-G power supply by the command originator. When the line is parsed and the commands are sent to the individual power supplies via the IEEE 1118 bus, the MBT-G power supply sends the line terminator sequence CR LF to the command originator.

The ESC character is used for synchronization, causing the MBT-G to reset its input buffer and return a CR LF sequence.

All non-control characters are sent via the serial port of the command originator. The control character BS is echoed as BS Space BS. Only the first control character is returned in response to either a CR LF or LF CR character sequence (see Figure 3-3).

### 3.3.3.2 ECHO MODE

Echo mode is the default method of ensuring data is transferred without errors. Each byte (character) is echoed back to the sender where it is verified as the same character that was just sent. If the character is incorrect or missing, the sender sends the character again until the correct character is verified as having been received.

All non-control characters are sent via the serial port of the command originator. The control character BS is echoed as BS Space BS. Only the first control character is returned in response to either a CR LF or LF CR character sequence (see Figure 3-3).

### 3.3.3.3 PROMPT METHOD

The command originator sends a message line (command) to the MBT-G and waits until the prompt sequence CR LF > (3E<sub>H</sub>, 62<sub>10</sub>) is received. The MBT-G sends the prompt sequence CR LF > to the command originator indicating the power supply is ready to receive the next com-

mand and data will not be lost. The prompt method is similar to the echo method described above, except that the command originator does not have to compare each character and repeat any characters dropped while the IEEE 1118 bus (BITBUS) is active. The operation of the MBT-G is identical for echo mode and prompt mode; implementation of prompt mode is at the command originator.

### 3.3.3.4 XON XOFF METHOD

The XON XOFF method allows the MBT-G to control when the command originator is allowed to send data. The command originator can only send data after the XON (transmission on) character (011<sub>H</sub>) has been received; the command originator stops sending data after receiving the XOFF (transmission off) character (013<sub>H</sub>), and waits until the XON character is received before sending additional data. The XON XOFF method can be implemented independently of the echo method using the special commands described below (PAR 3.3.3.5).

Control characters, either CR or LF, are returned as XOFF CR if echo mode is on, and as XOFF if echo mode is off. XOFF stops data from the command originator and the MBT-G returns the normal sequence of CR LF (if echo mode is enabled).

### 3.3.3.5 SPECIAL COMMANDS

The serial parser supports the command RSMODE to allow quick changes to RS 232 protocol.

**RSMODEn** This command is used to implement the XON XOFF method and control whether echo mode is on or off. The **RSMODE** sequence is followed by a number **n**: 0, through 5, defined in Table 3-23. This command must be the first command on a line.

**TABLE 3-23. XON XOFF CONTROL**

VALUE OF n	ECHO	PROMPT	XON XOFF
0	OFF	OFF	DISABLED
1	ON	ON	DISABLED
2	OFF	ON	DISABLED
3	OFF	OFF	ENABLED
4	ON	ON	ENABLED
5	OFF	ON	ENABLED

## 3.3.4 PROGRAMMING TECHNIQUES TO OPTIMIZE POWER SUPPLY PERFORMANCE

Kepco's auto-crossover digital supplies can operate in either voltage mode with current limit, or current mode with voltage limit. The operating mode is determined by the voltage and current commands received, as well as the load. Each time voltage and current commands are received, the unit must evaluate the commands and the load conditions to determine the proper operating mode. Reducing the number of times this evaluation must be made is desirable because Kepco's digital auto-crossover supplies employ two separate feedback loops. Each time there is a potential mode change, there is always an uncontrolled period of a few milliseconds while the two feedback loops compete for control of the output. By changing only the active parameter (e.g., voltage for voltage mode), there is no doubt as to what the operating mode will be, so the unit is never uncontrolled, response is quick and no transients are possible. Recommended programming techniques are:

1. Minimize programmed mode (voltage or current) changes. Unless absolutely required by the test parameters, allow the power supply to automatically switch modes as determined by the load. This will improve response time and reduce undesirable transients. For those power supplies that employ relays (Kepeco's MBT with "R" option, MAT and MST) this will also increase the life of the relay.
2. Once the mode (voltage or current) is programmed, program the active parameter to zero and the complementary limit parameter to the maximum anticipated for application. Then program only the active parameter. The active parameter is the parameter that controls the output, e.g., voltage controls the output in voltage mode.
3. Never program both the active and complementary limit parameter to zero. This can result in long response times. Set the active parameter to zero and the complementary limit parameter to a minimum, e.g., 10% of maximum, to ensure that the active mode is defined.

### **3.3.5 SCPI PROGRAMMING**

SCPI (Standard Commands for Programmable Instruments) is a programming language conforming to the protocols and standards established by IEEE 488.2 (reference document *ANSI/IEEE Std 488.2, IEEE Standard Codes, Formats, Protocols, and Common Commands*). SCPI commands are sent to the MBT-G Power Supply as output strings within the selected programming language (PASCAL, BASIC, etc.) in accordance with the manufacturer's requirements for the particular GPIB interface card used.

Different programming languages (e.g., BASIC, C, PASCAL, etc.) have different ways of representing data that is to be put on the IEEE 488 bus. It is up to the programmer to determine how to output the character sequence required for the programming language used. Address information (GPIB address) must be included before the command sequence. (See PAR. 3.2.1.10 to establish the MBT-G power supply GPIB address.)

#### **3.3.5.1 SCPI MESSAGES**

There are two kinds of SCPI messages: program messages from controller to power supply, and response messages from the power supply to the controller. Program messages consist of one or more properly formatted commands/queries and instruct the power supply to perform an action; the controller may send a program message at any time. Response messages consist of formatted data; the data can contain information regarding operating parameters, power supply state, status, or error conditions.

#### **3.3.5.2 COMMON COMMANDS/QUERIES**

Common commands and queries are defined by the IEEE 488.2 standard to perform overall power supply functions (such as identification, status, or synchronization) unrelated to specific power supply operation (such as setting voltage/current). Common commands and queries are preceded by an asterisk (\*) and are defined and explained in APPENDIX A (see Table 3-24). Refer also to syntax considerations (PAR.s 3.3.5.3 through 3.3.5.8).

#### **3.3.5.3 SCPI SUBSYSTEM COMMAND/QUERY STRUCTURE**

Subsystem commands/queries are related to specific power supply functions (such as setting output voltage, current limit, etc.) Figure 3-4 is a tree diagram illustrating the structure of SCPI subsystem commands used in MBT-G power supplies with the "root" at the left side, and specific commands forming the branches. The subsystem commands are defined and explained in Appendix B (see Table 3-24).

**TABLE 3-24. SCPI COMMAND INDEX**

COMMAND	PAR. REFERENCE	COMMAND	PAR. REFERENCE	COMMAND	PAR. REFERENCE
*CLS	A.2	MEAS:VOLT?	B.11	STAT:QUES:ENAB?	B.31
*ESE	A.3	OUTP:[STAT]	B.12	STAT:QUES:INST?	B.32
*ESE?	A.4	OUTP:[STAT]?	B.13	STAT:QUES:INST1?	B.33
*ESR?	A.5	[SOUR]:CURR	B.14	STAT:QUES:INST2?	B.34
*IDN?	A.6	[SOUR]:CURR?	B.15	STAT:QUES:INST:ENAB, ?	B.35, B.36
*OPC, *OPC?	A.7,	[SOUR]:CURR:TRIG	B.16	STAT:QUES:INST1:ENAB, ?	B.37, B.38
OPT?	A.9	[SOUR]:CURR:TRIG?	B.17	STAT:QUES:INST2:ENAB, ?	B.39, B.40
*RST	A.10	[SOUR]:VOLT	B.18	STAT:QUES:INST:ISUM?	B.41
*SRE	A.11	[SOUR]:VOLT?	B.19	STAT:QUES:INST:ISUM:ENAB, ?	B.42, B.43
*SRE?	A.12	[SOUR]:VOLT:TRIG	B.20	SYS:COMM:GPIB:ADDR	B.44
*STB?	A.13	[SOUR]:VOLT:TRIG?	B.21	SYST:COMM:SER:BAUD	B.45
*TRG	A.14	[SOUR]:FUNC:MODE	B.22	SYST:COMM:SER:ECHO	B.46
*TST	A.15	STAT:OPER:COND?	B.23	SYST:COMM:SER:PACE	B.47
*WAI	A.16	STAT:OPER:ENAB	B.24	SYST:COMM:SER:PROM	B.48
INIT[:IMM]	B.2	STAT:OPER:ENAB?	B.25	SYST:ERR	B.49
INIT:CONT	B.3	STAT:OPER?	B.26	SYST:ERR:CODE?	B.50
INIT:CONT?	B.4	STAT:PRES	B.27	SYST:ERR:CODE:ALL?	B.51
INST:CAT	B.5	STAT:QUES?	B.28	SYST:LANG	B.52
INST, INST?	B.6, B.7, B.8	STAT:QUES:COND?	B.29	SYST:SET	B.53
INST:STAT	B.9	STAT:QUES:ENAB	B.30	SYST:VERS?	B.54
MEAS:CURR?	B.10				

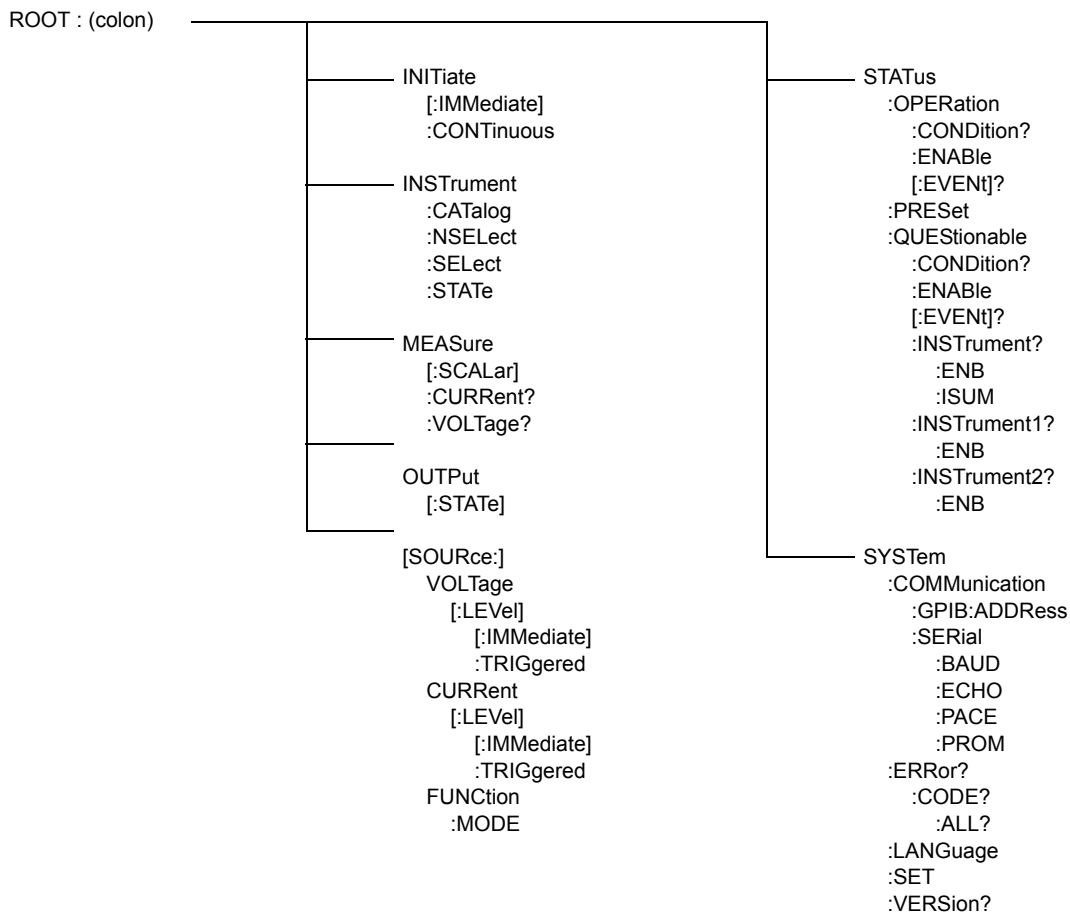


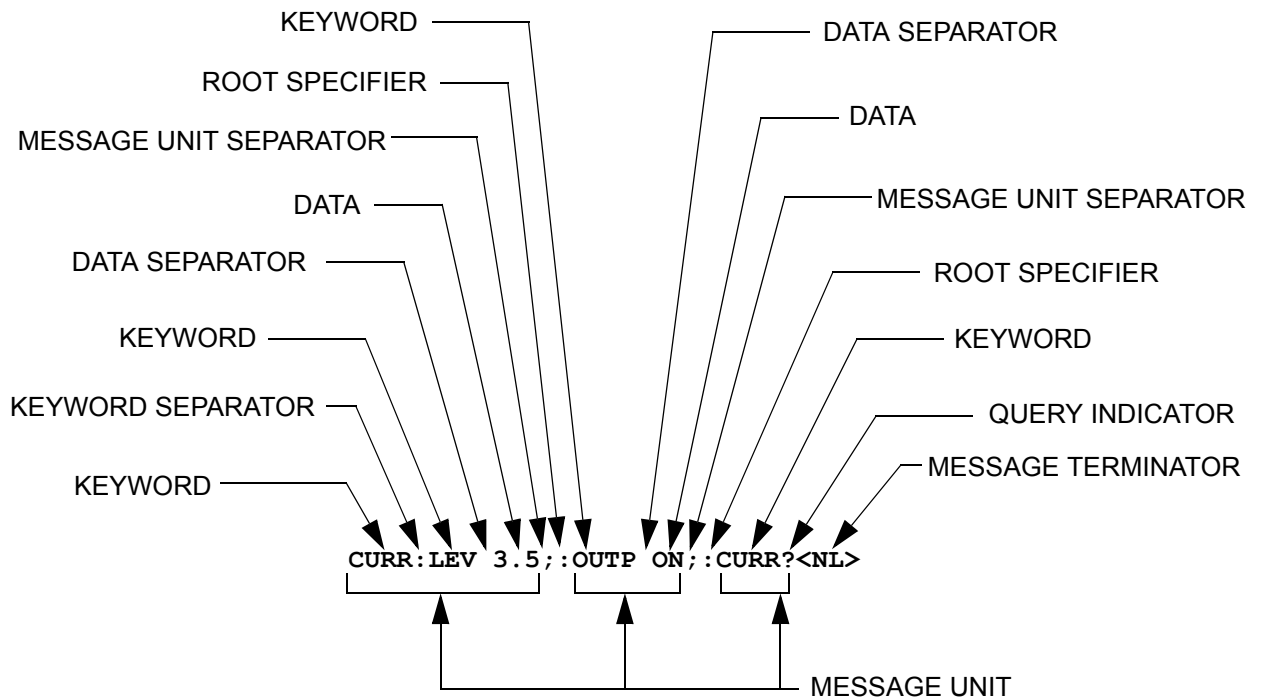
FIGURE 3-4. TREE DIAGRAM OF SCPI COMMANDS USED WITH MBT-G POWER SUPPLIES

### 3.3.5.4 PROGRAM MESSAGE STRUCTURE

SCPI program messages (commands from controller to power supply) consist of one or more *message units* ending in a *message terminator*. The message terminator is not part of the syntax; it is defined by the way your programming language indicates the end of a line (such as a “new-line” or “end-of-line” character). The message unit is a keyword consisting of a single command or query word followed by a message terminator (e.g., CURR?<newline> or TRIG<end-of-line>). The message unit may include a data parameter after the keyword separated by a space; the parameter is usually numeric (e.g., CURR 5<newline>), but may also be a string (e.g., OUTP ON<newline>). Figure 3-5 illustrates the message structure, showing how message units are combined. The following subparagraphs explain each component of the message structure.

NOTE: An alternative to using the message structure for multiple messages defined in the following paragraphs is to send each command as a separate line. In this case each command must use the full syntax shown in Appendix B.





**FIGURE 3-5. MESSAGE STRUCTURE**

### 3.3.5.4.1 KEYWORD

Keywords are instructions recognized by a decoder within the MBT-G Power Supply, referred to as a “parser.” Each keyword describes a command function; all keywords used by the MBT-G Power Supply are listed in Figure 3-4.

Each keyword has a long form and a short form. For the long form the word is spelled out completely (e.g., STATUS, OUTPUT, VOLTAGE, and TRIGGER are long form keywords). For the short form only the first three or four letters of the long form are used (e.g., STAT, VOLT, OUTP, and TRIG). The rules governing short form keywords are presented in Table 3-25.

**TABLE 3-25. RULES GOVERNING SHORTFORM KEYWORDS**

IF NUMBER OF LETTERS IN LONGFORM KEYWORD IS:	AND FOURTH LETTER IS A VOWEL?	THEN SHORT FORM CONSISTS OF:	EXAMPLES
4 OR FEWER	(DOES NOT MATTER)	ALL LONG FORM LETTERS	MODE
5 OR MORE	NO	THE FIRST FOUR LONG FORM LETTERS	MEASure, OUTPut, EVEnt
5 OR MORE	YES	THE FIRST THREE LONG FORM LETTERS	LEVel, IMMEDIATE, ERRor

You must use the rules above when using keywords. Using an arbitrary short form such as ENABL for ENAB (ENABLE) or IMME for IMM (IMMEDIATE) will result in an error. Regardless of which form chosen, you must include all the letters required by that form.

To identify the short form and long form in this manual, keywords are written in upper case letters to represent the short form, followed by lower case letters indicating the long form (e.g.,

IMMediate, EVENt, and OUTPut). The parser, however, is not sensitive to case (e.g., outp, OutP, OUTPUT, ouTPut, or OUTp are all valid).

#### **3.3.5.4.2 KEYWORD SEPARATOR**

If a command has two or more keywords, adjacent keywords must be separated by a colon (:) which acts as the keyword separator (e.g., CURR:LEV:TRIG). The colon can also act as a root specifier (PAR. 3.3.5.4.7).

#### **3.3.5.4.3 QUERY INDICATOR**

The question mark (?) following a keyword is a query indicator. This changes the command into a query. If there is more than one keyword in the command, the query indicator follows the last keyword. (e.g., VOLT? and MEAS:CURR?).

#### **3.3.5.4.4 DATA**

Some commands require data to accompany the keyword either in the form of a numeric value or character string. Data always follows the last keyword of a command or query (e.g., VOLT:LEV:TRIG 14 or SOUR:VOLT? MAX

#### **3.3.5.4.5 DATA SEPARATOR**

Data must be separated from the last keyword by a space (e.g., VOLT:LEV:TRIG 14 or SOUR:VOLT? MAX

#### **3.3.5.4.6 MESSAGE UNIT SEPARATOR**

When two or more message units are combined in a program message, they must be separated by a semicolon (;) (e.g., VOLT 15;MEAS:VOLT? and CURR 12; CURR:TRIG 12.5).

#### **3.3.5.4.7 ROOT SPECIFIER**

The root specifier is a colon (:) that precedes the first keyword of a program message. This places the parser at the root (top left, Figure 3-4) of the command tree. Note the difference between using the colon as a keyword separator and a root specifier in the following examples:

VOLT:LEV:IMM 16 Both colons are keyword separators.

:CURR:LEV:IMM 4 The first colon is the root specifier, the other two are keyword separators.

VOLT:LEV 6;:CURR:LEV 15 The second colon is the root specifier, the first and third are keyword separators

:INIT ON;:TRIG;:MEAS:CURR?:VOLT? The first three colons are root specifiers.

#### **3.3.5.4.8 MESSAGE TERMINATOR**

The message terminator defines the end of a message. Three message terminators are permitted:

- new line (<NL>), ASCII 10 (decimal) or 0A (hex)
- (<CR>), ASCII 13 (decimal) or 0D (hex)
- both of the above (<CR> <NL>)

Your GPIB interface card software will automatically send a message terminator. For example, the HP BASIC OUTPUT statement inserts <NL> after the last data byte. When binary data is exchanged, <END> must be used. The combination <NL><END> terminator can be used for all data except binary data.

NOTE: Kepco power modules *require* a message terminator at the end of each program message. The examples shown in this manual assume a message terminator will be added at the end of each message. Where a message terminator is shown it is represented as <NL> regardless of the actual terminator character.

### 3.3.5.5 UNDERSTANDING THE COMMAND STRUCTURE

Understanding the command structure requires an understanding of the subsystem command tree illustrated in Figure 3-4. The “root” is located at the top left corner of the diagram. The parser goes to the root if:

- a message terminator is recognized by the parser
- a root specifier is recognized by the parser

*Optional keywords* are enclosed in brackets [ ] for identification; optional keywords can be omitted and the power supply will respond as if they were included in the message. The root level keyword [SOURce] is an optional keyword. Starting at the root, there are various branches or paths corresponding to the subsystems. The root keywords for the MBT-G power supply are :INITiate, :MEASure, :OUTPut, [:SOURce], :STATus, and :SYSTem. Because the [SOURce] keyword is optional, the parser moves the path to the next level, so that VOLTage, CURRent, and FUNCtion commands are at the root level.

Each time the parser encounters a keyword separator, the parser moves to the next indented level of the tree diagram. As an example, the STATus branch is a root level branch that has three sub-branches: OPERation, PRESet, and QUEStionable. The following illustrates how SCPI code is interpreted by the parser:

**STAT:PRES<NL>**

The parser returns to the root due to the message terminator.

**STAT:OPER?;PRES<NL>**

The parser moves one level in from STAT. The next command is expected at the level defined by the colon in front of OPER?. Thus you can combine the following message units STAT:OPER? and STAT:PRES;

**STAT:OPER:COND?;ENAB 16<NL>**

After the OPER:COND? message unit, the parser moves in one level from OPER, allowing the abbreviated notation for STAT:OPER:ENAB.

### 3.3.5.6 ADDRESSING MULTIPLE POWER SUPPLIES

Power supplies on the IEEE 118 bus are selected by node address, also referred to as node number or channel number. Refer to the applicable manuals for the power modules connected to the IEEE 118 bus to set each power module to a unique node number, from 1 to 31 (a maximum of 27 power modules may be connected to the bus).

The node number may follow any part of a SCPI command. Note that there must be no space preceding the node number

e.g., `meas2:volt?` or `meas:volt2?` both measure output voltage of the power supply at node number 2.

e.g., `func3:mode volt` or `func:mode3 volt` both set the power supply at node number 3 to commanded voltage mode.

e.g., `stat1:ques?` or `stat:ques1?` or `stat:ques:cond1?` all read Questionable Register status of the power supply at node number 1.

Upon power turn-on, commands sent without a node (channel) number will go to the default node address (1) until another node number is specified. Once another node number is specified, the new number becomes the default until another is specified.

NOTE: An alternate means of selecting the node, is to use IEEE 488 secondary addressing, where the secondary address is the power supply node address (refer to PAR. 2.9 to enable this feature).

The node selected can also be changed using the `INSTRument:SElect <N>` command. This allows subsequent commands to operate on the specified node (e.g. `INST:SEL 10` causes node 10 to be selected).

### 3.3.5.7 UNDERSTANDING THE COMMAND STRUCTURE

Understanding the command structure requires an understanding of the subsystem command tree illustrated in Figure 3-4. The “root” is located at the top left corner of the diagram. The parser goes to the root if:

- a message terminator is recognized by the parser
- a root specifier is recognized by the parser

*Optional keywords* are enclosed in brackets [ ] for identification; optional keywords can be omitted and the power supply will respond as if they were included in the message. The root level keyword [SOURCE] is an optional keyword. Starting at the root, there are various branches or paths corresponding to the subsystems. The root keywords for the MBT-G power supply controller are :INITiate, :MEASure, :OUTPut, [:SOURce], :STATus, and :SYSTem. Because the [SOURCE] keyword is optional, the parser moves the path to the next level, so that VOLTage, CURRent, and FUNCtion commands are at the root level.

Each time the parser encounters a keyword separator, the parser moves to the next indented level of the tree diagram. As an example, the STATus branch is a root level branch that has three sub-branches: OPERation, PRESet, and QUEStionable. The following illustrates how SCPI code is interpreted by the parser:

**STAT:PRES<NL>**

The parser returns to the root due to the message terminator.

**STAT:OPER?;PRES<NL>**

The parser moves one level in from STAT. The next command is expected at the level defined by the colon in front of OPER?. Thus you can combine the following message units `STAT:OPER?` and `STAT:PRES;`

**STAT:OPER:COND?;ENAB 16<NL>**

After the `OPER:COND?` message unit, the parser moves in one level from OPER, allowing the abbreviated notation for `STAT:OPER:ENAB`.

### 3.3.5.8 PROGRAM MESSAGE SYNTAX SUMMARY

- Common commands begin with an asterisk (\*).
- Queries end with a question mark (?).
- Program messages consist of a root keyword and, in some cases, one or more message units separated by a colon (:) followed by a message terminator. Several message units of a program message may be separated by a semicolon (;) without repeating the root keyword.
- If a program message has more than one message unit, then a colon (:) must precede the next keyword in order to set the parser back to the root (otherwise the next keyword will be taken as a subunit of the previous message unit).

e.g., the command `meas:volt?;curr?` will read output voltage and output current since both `volt?` and `curr?` are interpreted as subunits of the `meas` command.

- Several commands may be sent as one message; a line feed terminates the message. Commands sent together are separated by a semicolon (;). The first command in a message starts at the root, therefore a colon (:) at the beginning is not mandatory.

e.g., the command `meas:volt?;:curr?` will read output voltage and programmed current since the colon preceding `curr?` indicates that `curr?` is not part of the `meas` command and starts at the root.

- UPPER case letters in mnemonics are mandatory (short form). Lower case letters may either be omitted, or must be specified completely (long form)  
e.g., **INST** (short form) has the same effect as **INSTRUMENT** (long form).
- Commands/queries may be given in upper/lower case (long form)  
e.g., **SoURce** is allowed.
- Text shown between brackets [] is optional.  
e.g., **:[SOUR]VOLT:[LEV] TRIG** has the same effect as **:VOLT TRIG**

### 3.3.5.9 STATUS REPORTING

The status reporting of the MBT-G power supply follows the SCPI and IEEE 488.2 requirements. The serial poll response of the MBT-G power supply provides summary bits of the status and error reporting system. The simplest status report is the command valid reporting and data availability. This successful decoding of a command string generates no error and is indicated by the bit 3 of the serial poll response being a zero. The setting of bit 4 in the status byte indicates data is available to the controller in response a command query message.

#### 3.3.5.9.1 STATUS REPORTING STRUCTURE

The status reporting of the MBT-G power supply uses four status registers, illustrated in Figure 3-6. These registers are the Questionable, Operation, Standard Event and Service Request registers. The Questionable and Operation registers are 16 bit registers and the Standard Event and Service Request registers are 8 bits. These four registers are referred to as condition registers. Each of the four condition registers is associated with two related registers: an event register which holds unlatched events reported in realtime by the instrument and is cleared by

reading the register, and an enable register which allows the contents of the event register to be passed through to set the associated condition register.

A zero to one transition of a condition register is added to the event register if the specific bit in the enable register is also a 1. Reading an event register clears all of the bits found in the event register. If any bits are set in an event register, the following condition register bit is then set. For example, if the STAT:QUES:ENB (enable) register has bit 0 set and a voltage error is detected, the event registers bit 0 is set. The 1 in the event register causes bit 3 of the status byte to be asserted. The Service Request register is ANDed with its enable register for all bits except bit 6. The result is placed in bit 6 of the Service Request register. If bit 6 is a 1 (true), it causes the MBT-G power supply to assert the SRQ line to the host controller.

Figure 3-6 also shows that if the error/event queue is not empty, bit 3 is set in the Service Request register and bit 4 indicates that a message is available in the output buffer.

### 3.3.5.9.2 OPERATIONAL STATUS REGISTER

The OPERational condition register contains conditions which are a part of the instrument's normal operation. The definition of each of these bits (condition register) is as follows:

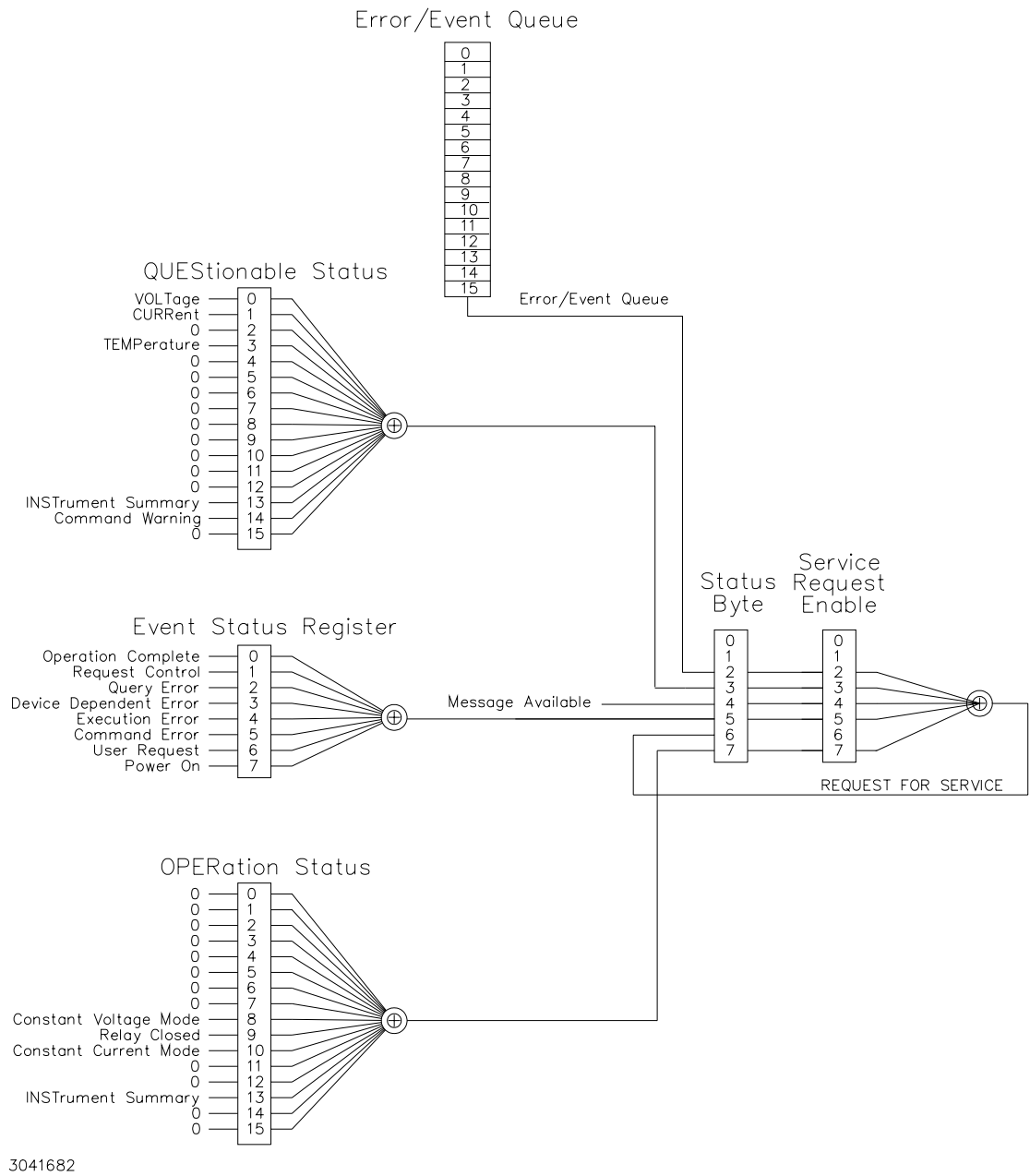
- 1 through 7 - Not Used — always zero.
- 8 - Constant Voltage — 1 indicates the instrument is in constant voltage mode.
- 9 - Relay — 1 indicates the power supply output relay is closed.
- 10 - Constant Current — 1 indicates the instrument is in constant current mode.
- 11 through 15 - Not Used — always zero.

### 3.3.5.9.3 QUESTIONABLE STATUS REGISTER

The QUEStionable condition register (see Figure 3-6) contains status bits representing data/signals which give an indication of the quality of various aspects of the signal.

A bit set in the QUEStionable condition register indicates that the data currently being acquired or generated is of questionable quality due to some condition affecting the parameter associated with that bit.

- 8 - Voltage Mode — 1 indicates the instrument is in Voltage mode.
- 9 - Relay — 1 indicates the power supply output relay is closed, unit is supplying power at output terminals.
- 10 - Current Mode — 1 indicates the Power Supply is in Current mode. Changes in this bit do not affect the event register.
- 14 - Command warning — This bit indicates a non-fatal warning that relates to the instrument's interpretation of a command, query, or on or more parameters of a specific command or query. The power supply sets this bit for
  - MEAS:VOLT? 10,1 — The 10 is the number of digits and the 1 is the range. Since this capability is not implemented in Kepco power supplies, the Command Warning bit is set.
  - INST:SEL 2 sent to a single power supply. Trying to select unit 2 when only one power supply is connected causes the Command Warning bit to be set.



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**FIGURE 3-6. STATUS REPORTING STRUCTURE**

### 3.3.5.9.4 MULTIPLE LOGICAL INSTRUMENTS

The MBT-G power supply is a SCPI device that supports multiple logical instruments; it allows a choice between two methods of status reporting. The status reporting default upon powerup treats the unit as a single channel instrument. When multiple channels are in use, a SCPI compliant status structure can be selected which provides an INSTRument summary status register and an individual INSTRument summary for each logical instrument. These registers are equivalent to the Status Questionable register of a single channel instrument and are also found in the

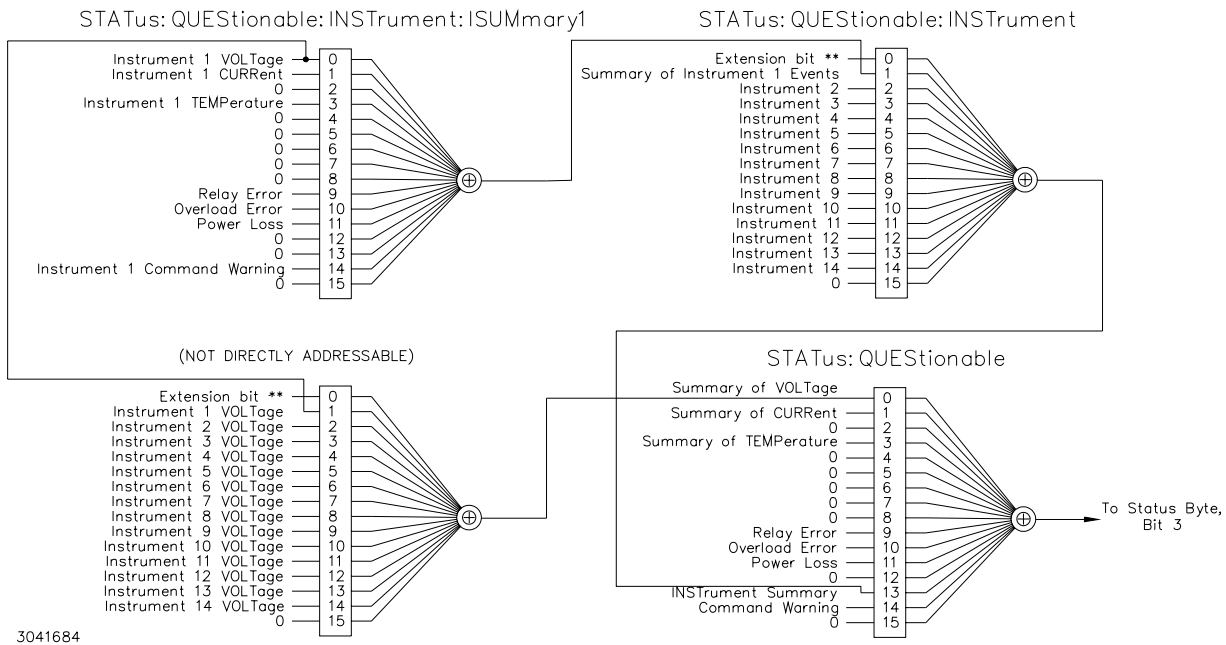
STATUS Questionable register for the selected channel. The contents of the STATUS Questionable register can also contain the summary of all instruments as shown in Figure 3-7.

The selection of the status reporting structure is controlled by the `SYSTEM:SET SI` (Instrument Structure) command, either `SI0` (off) or `SI1` (on). The power-up default is the off condition. To enable the SCPI compliant mode of operation for multiple logical instruments the user must send `SYSTEM:SET SI1` to the MBT-G power supply during initialization. The `SI1` state is not remembered when the unit is turned off. To return to the standard method of reporting the selected device's status without turning the unit off, send `SYSTEM:SET SI0`.

When the MBT-G power supply is set up for SCPI compliant status reporting for multiple channels, the specific instrument's Questionable register is found in the `STAT:QUES:INST:ISUM<n>` register. This register has the same bit structure as the single channel Questionable register. The ISUM enable register is ANDed with the bits of the channel's ISUM register and its bit is placed in the INST register. The Questionable register bits are the logical ORing of all channels' Questionable ISUM register. This is shown in figure 3-7.

The ISUMmary registers set the INSTRument register, which in turn sets bit 13 of the QUESTIONable or OPERAtion status register. This is shown pictorially in Figure 3-7.

The STATUS:QUESTIONABLE and STATUS:QUESTIONABLE:CONDITION registers are the same in this mode of status reporting. The condition register indicates the status of the various event registers and bits set are only cleared if the source of the bit is cleared.



**FIGURE 3-7. EXPANSION OF QUESTIONABLE REGISTER FOR MULTIPLE LOGICAL INSTRUMENTS**



### 3.3.5.10 SCPI PROGRAM EXAMPLE

Figure 3-8 is an example of a program using SCPI commands to program the MBT-G Power Supply. The program illustrated is for a configuration using an IBM PC or compatible with a National Instruments GPIB interface card. (It will be necessary to consult the manufacturer's data to achieve comparable functions with an interface card from a different manufacturer.) This program sets output voltage (Voltage mode) or voltage limit (Current mode) to 5V, and current limit (Voltage mode) or output current (Current mode) to 1A, then reads the measured (actual) voltage and current, then prints the measurements.

```

/*****
/*   Sample Program For KEPCO power supply, using National Instruments   */
/*   GPIB interface card and IBM PC or compatible computer               */
/*****

#include <stdio.h>
#include "decl.h"

char rd_str[80];           // Input buffer
char dat_str[80];         // Output buffer
int  bd,adr;

main() {
    adr = ibfind("DEV6");   // Open DEV6 (defined by IBCONF)
    bd = ibfind ("GPIB0"); // Open GPIB card
    ibsic (bd);            // Send Interface Clear
    ibsre(bd,1);          // Set remote line true

    strcpy(dat_str,"VOLT 5;CURR 1"); // Define a set command
    strcat(dat_str,"\r\n");         // Append delimiter
    ibwrt(adr,dat_str,strlen(dat_str)); // Send string to power supply

    strcpy(dat_str,"MEAS:VOLT?;CURR?"); // Define a measure command
    strcat(dat_str,"\r\n");         // Append delimiter
    ibwrt(adr,dat_str,strlen(dat_str)); // Send string to power supply

    strset(rd_str,'\0'); // Clear input buffer
    ibrd(adr,rd_str,64); // Read result of measure
    printf("received : %s\n",rd_str); // Print voltage and current
}

```

FIGURE 3-8. TYPICAL EXAMPLE OF MBT-G POWER SUPPLY PROGRAM USING SCPI COMMANDS

### 3.3.6 CIIL PROGRAMMING

The CIIL command language is used on early models of Kepco power supplies and controllers. The command functions are included here for compatibility with other equipment programmed with CIIL commands. The CIIL command set for the MBT-G Power Supply is defined and explained in Appendix C.



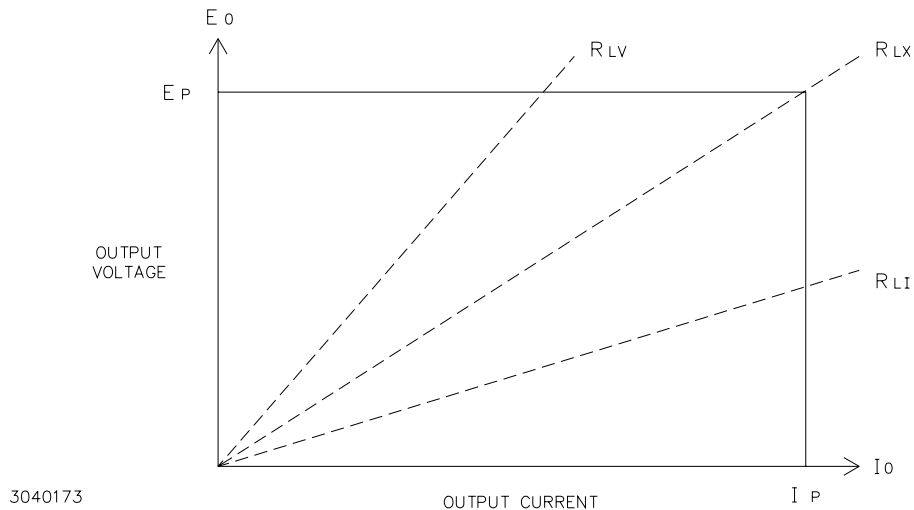
## SECTION 4 - THEORY OF OPERATION

### 4.1 INTRODUCTION

The MBT Power Supply is a digitally controlled voltage and current stabilized d-c source with an automatic sharp crossover between the voltage and current mode of operation. The values for output voltage and current are set digitally (12-bit resolution), either locally using the front panel optical encoders and/or keypad entries, or remotely using an external computer interfaced through the IEEE 1118 digital bus. MBT option MG and MGR units can also use either the IEEE 488 bus or RS232-C bus.

The output voltage  $E_o$  and output current  $I_o$  of the MBT Power Supply is determined by their programmed values and by the magnitude of the load resistance ( $R_L$ ). The crossover resistance ( $R_{LX}$ ) is the load value at which, for given values of programmed voltage and current, the power supply will switch from voltage mode (see PAR.s 4.1.1 and 4.1.3) to current mode (see PAR.s 4.1.2 and 4.1.4) or vice versa;  $R_{LX}$  is given by Ohm's Law:

$$E_p = I_p R_{LX} \text{ (see Figure 4-1)}$$



**FIGURE 4-1. CROSSOVER CHARACTERISTICS OF THE MBT POWER SUPPLY SHOWING THE CRITICAL OR CROSSOVER VALUE OF LOAD RESISTANCE  $R_{LX}$**

#### 4.1.1 VOLTAGE SOURCE.

When the Power Supply 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 MBT Power Supply 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 MBT Power Supply 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:

$$E_o = I_o R_L$$

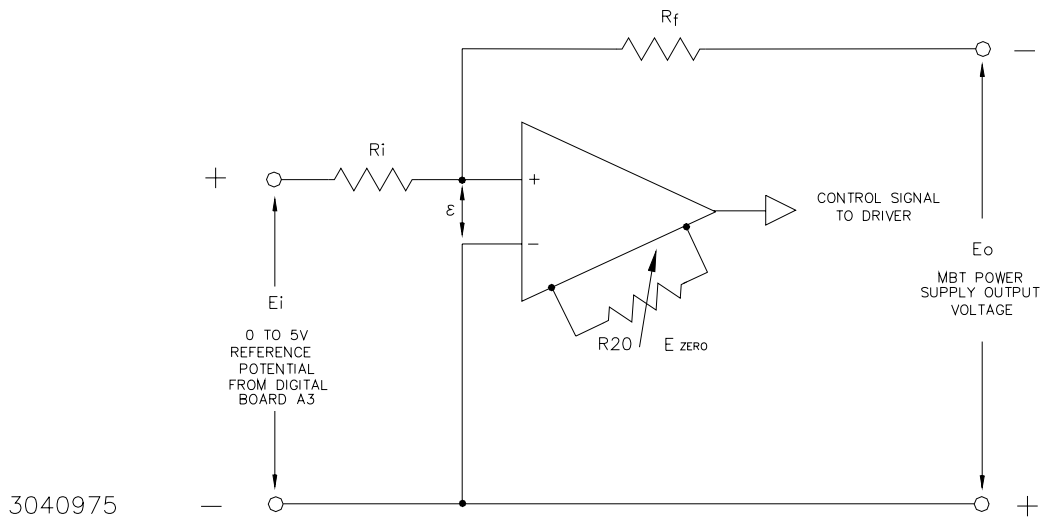
### 4.1.2 CURRENT SOURCE

Similarly, if the Power Supply 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 MBT Power Supply 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 MBT Power Supply 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 the Ohm's Law:

$$E_o = I_o R_L$$

### 4.1.3 VOLTAGE MODE

In the voltage mode of operation, a voltage comparison amplifier compares the feedback signal from the output voltage with a 0 to +5V Reference Potential generated from a Digital to Analog Converter (DAC) from the Digital Board A3 (see Figure 4-2).

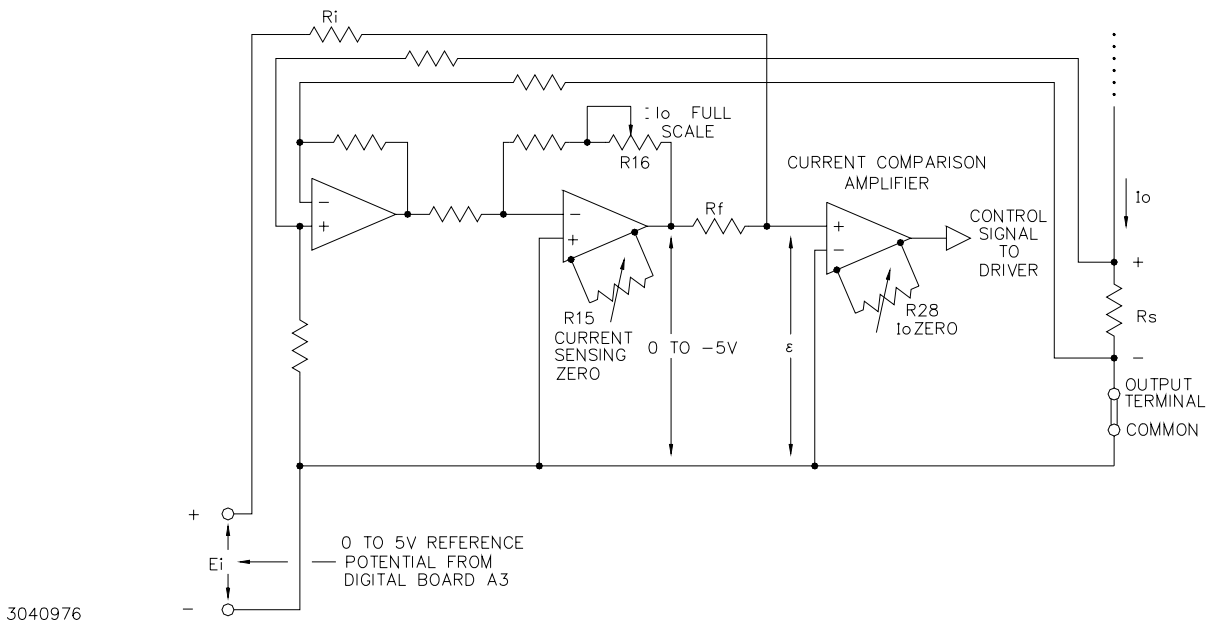


**FIGURE 4-2. VOLTAGE COMPARISON EQUIVALENT CIRCUIT**

A condition of balance exists if:  $E_o/R_f = E_i/R_i$  and  $\epsilon$  approaches zero. A change in either  $E_i$  or  $E_o$  in the balance equation produces an error signal that, when amplified by the voltage comparison amplifier, becomes a control signal for the MBT Power Supply driver stage. The control signal is then applied to the pass element (power transistors) to increase or decrease its conductance so as to maintain a desired value of output voltage.

### 4.1.4 CURRENT MODE

In the current mode of operation, a current comparison amplifier compares a feedback signal proportional to the output current, to a 0 to +5V Reference Potential. The Reference Potential is generated by another channel of the Digital to Analog Converter on the Digital Board A3 (see Figure 4-3).



**FIGURE 4-3. CURRENT COMPARISON EQUIVALENT CIRCUIT**

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 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 a voltage signal of 0 to -5V. The later signal being proportional to the output current.

A condition of balance exists if:  $G I_o R_s/R_f = E_i/R_i$  and  $\epsilon$  approaches zero, where  $G$  is the gain of the current sensing amplifier chain. 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 transistors) to increase or decrease its conductance so as to maintain a desired value of output current.

#### 4.1.5 VOLTAGE/CURRENT REFERENCE

The internal feedback components in the voltage and current control channel of each MBT Power Supply are selected to control the voltage and current full scale output range. This is made possible by the 0 to +5V d-c signal applied to either the voltage comparison amplifier or current comparison amplifier. These two 0 to +5V d-c Reference Potential signals are generated by the A3 Digital Board in response to a command received either from local controls, or remotely through the IEEE 1118 bus via the A3 Digital Control Board.

#### 4.1.6 A/D CONVERSION

The output voltage and current are continuously monitored by the voltage and current sensing amplifiers. Two channels of an Analog 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 two milliseconds. On demand from the remote Controller, the contents of the output volt-

age or current buffer are sent over the IEEE 1118 bus by the Digital Control Board. These digital signals are also sent to the front panel display to refresh the displayed values of voltage and current.

#### **4.1.7 VOLTAGE/CURRENT COMPARISON ERRORS**

The digital contents of the output voltage and current buffer are also used to make decisions regarding the dynamic time-out delay and issuing the corresponding error message. The end of the dynamic time-out is determined by three consecutive “within specified limit window” determinations of the output parameter (voltage or current) that is being programmed. This time-out has a maximum duration of approximately 20 milliseconds (ten cycles of the main program loop). Any voltage or current reading at the end of the time-out that differs from the programmed value (voltage in commanded Voltage mode, current in commanded Current mode) by more than 0.6% of full scale value will trigger a Voltage or Current comparison error message. (For example, if Full scale = 100V and Programmed voltage is 20V, 0.6% of 100 = 0.6V; errors occur if the actual voltage is lower than 19.4V or higher than 20.6V.)

#### **4.1.8 PROTECTIVE CIRCUITS**

Error conditions that turn-off the MBT Power Supply generate flags that act on the High Priority Interrupt line of the microcontroller on Digital Control Board A3. This will result in an immediate reporting and storing of error messages in the Controller before the MBT DC power is completely lost. These flags are:

- Crowbar
- Overtemperature
- Power loss
- Path Fault

**4.1.8.1 OVERVOLTAGE/OVERCURRENT PROTECTION** Among the protective circuits designed for the MBT Power Supply are overvoltage and overcurrent tracking circuits on the A1 Analog Control Board. 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 PAR.s 4.1.3 and 4.1.4 which are used for error signal generation. If the voltage or current exceeds the programmed value by the above established limit for longer than approximately 6 milliseconds, a Crowbar and Turn-off circuit is activated.

**4.1.8.2 OVERTEMPERATURE PROTECTION** Another protective circuit allows the MBT Power Supply to detect a temperature increase on the power transistor Heat Sink or on the output capacitor discharge transistor. An Overtemperature error message is generated if the temperature is beyond an established limit. If an overtemperature condition persists for 6 milliseconds, the Crowbar and Turn-off circuit causes an error message to be sent to the controller and shuts off the MBT Power Supply.

**4.1.8.3 POWER LOSS PROTECTION** The MBT Power Supply detects a loss of source power after 8 milliseconds. If the power loss continues for more the 6 milliseconds, a signal is provided to the Crowbar and Turn-off circuit which generates an error message and turns the unit off. This feature can be disabled by removing Jumper J5 from the A2 board (see PAR. 2.8 and Table 2-4).

**4.1.8.4 PATH FAULT PROTECTION** The path fault protection circuit is activated if the connection between a power lead and corresponding sensing lead is interrupted or if the power and sensing leads are too long. The path fault detector monitors the voltage drop between the Power Supply output terminals (OUTPUT and COMMON) and the corresponding sense leads (OUT S and COM S). When this voltage drop reaches some point in excess of 0.5V per lead for longer than approximately 6 milliseconds for M and MG Models, or longer than 20 milliseconds for MR and MGR Models, the path fault detector operates as follows:

(MR, MGR MODELS) The output voltage and current are programmed to zero, and the relays are commanded to Open, disengaging the load from the power supply.

(M, MG MODELS) The output voltage and current are programmed to zero and/or the Crowbar and Turn-off circuit is activated, shutting the power supply down.

In any case, activation of the path fault detector generates a corresponding error message which is supplied to the controller before MBT power is shut off.

This feature also ensures that current through the sense leads cannot exceed a small value (1mA) so that the load can not be supplied through the sensing leads, and the load is protected against an uncontrolled voltage at the output when the sense leads are interrupted.

**4.1.8.5 CROWBAR AND TURN-OFF CIRCUIT** Activation of the Crowbar and Turn-off circuit causes a Crowbar error message to be issued, stored in the error buffer, and sent to the remote controller. This circuit short-circuits the output terminals of the Power Supply to protect the load (rapidly discharging the output capacitor), and sends a signal to turn off the POWER front panel circuit breaker.

#### **4.1.9 RESPONSE TIME**

An important feature of MBT programmable Power Supplies is a fast response to input commands. The programming speed is determined primarily by the size of the output capacitor. For fast programming speed it appears that the output capacitor should be removed or 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 as a result of a SET command, the output capacitor will charge up. The charging time is determined by the Power Supply current limit setting. The larger the current limit setting the shorter the charging time.

For a SET command calling for a reduction in output voltage, the output capacitor will discharge. The discharge time is determined by the load resistance and not by the Power Supply current-limit setting. Even if the output capacitor has a small value, for light loads the discharge time will be very long.

The MBT Power Supply is designed with a special output capacitor discharge circuit that will discharge the output capacitor to zero within approximately 25 milliseconds. The circuit is automatically activated anytime the power transistors are being cut-off. To limit the power dissipation in the discharge circuit, a maximum rate of two discharges per second is permitted. This rate is established at no load (worst case); at maximum load a faster rate may be obtained.

#### 4.1.10 RETENTION OF PROGRAMMED VALUES

A non-volatile RAM located on the A3 Digital Control Board allows the MBT Power Supply to retain the last programmed values for voltage and current when the unit is turned off. When the unit is turned on, the last programmed values of voltage and current will be displayed on the front panel, along with the message **Output is OFF**. For the M and MG option units, this means that output voltage and current are set to zero; for MR and MRG option units, the output relays disconnect the power supply output from the load. This allows the operator to readjust the previously programmed values as desired, followed by the DC ON command to make the output active. The non-volatile RAM also stores the data related to local programs.

#### 4.1.11 OUTPUT ENABLE/DISABLE AND POLARITY REVERSAL RELAYS — MR, MGR MODELS

An important feature of “R” Option MBT Power Supplies is the output enable, disable and polarity reverse functions. These are achieved by activating two power relays and two signal relays. The two power relays connect, disconnect or reverse the power supply output at the Power Supply rear panel OUTPUT and COMMON terminals (one relay for connect/disconnect, the other for polarity reversal). The signal relays perform the same functions as the power relays but they act on the sense leads (OUT S and COM S) instead of the 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.

To increase the reliability of the MBT Power Supply, a “Dry” switching technique is used. Anytime a command is received from a Controller to Close, Open, or Reverse Polarity of relays, or change the operating mode (voltage or current), the MBT software implements a special sequence:

- 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.
- 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).

#### 4.1.12 OUTPUT ENABLE/DISABLE

NOTE: For both voltage or current modes of operation, the command to Enable the output at the load is Close, and to Disable the output from the load is Open. These definitions for Enable and Disable apply specifically to MBT Power Supplies.

**4.1.12.1 M, MG MODELS** The non- “R” option units operate locally only as a *commanded* voltage source. The *actual* mode, voltage or current, will depend on the programmed values for output voltage and current and the value of the load. The output is disabled by setting the output voltage and current to zero.

NOTE: Refer to PAR.s 3.1.1 and 3.1.2 for an explanation of *actual* and *commanded* modes.



**4.1.12.2 MR, MGR MODELS** The “R” option units operate either as a *commanded* voltage source or a *commanded* current source. The *actual* mode, voltage or current, will depend on the programmed values for output voltage and current and the value of the load (see NOTE above). Enabling or disabling the output differs from the voltage mode to the current mode. When considering a voltage source, a no-load condition (infinite resistance) is ideal. This is equivalent to a disabled voltage source since no output current flows to the load and a set output voltage is maintained. Enabling the voltage source is followed by energizing the power relay that connects the power supply to the load.

For a current source to operate properly there must be a load at the output terminals. A current source without a load will transfer itself into a voltage limit source. The ideal load for a current source is a direct short at the output terminals. This is achieved by energizing both power relays and is equivalent to a disabled current source. No output voltage will be present, no current will flow into the load and the set current will flow freely through the short.

Enabling the current source is achieved by deenergizing the power relays to remove the short across the Power Supply output terminals and to permit a current flow through the load.

#### **4.1.13 LOCAL CONTROL**

The local controls consist of the POWER circuit breaker which applies source power to the unit. VOLTAGE and CURRENT controls are used to increment output voltage/voltage limit in Voltage mode/Current mode, and output current/current limit in Current mode/Voltage mode, or programmed values for voltage and current when the output is Disabled. A numeric keypad with additional dedicated keys can also be used to program the MBT. Five STATUS LEDs provide direct indications for operating mode (Voltage or Current), polarity reversed, remote mode, and output enabled; an alphanumeric LCD display provides status messages and programming instructions in response to keypad entries. The following paragraphs indicate the functions available.

**4.1.13.1 SET OUTPUT VOLTAGE/CURRENT LIMIT (VOLTAGE MODE)** When operating in the Voltage mode, output voltage can be set in three different ways:

NOTE When the output is Disabled, the following controls affect the programmed output and limit values for voltage and current.

1. The **VOLTAGE** control is an optical encoder that digitally increments (clockwise rotation) or decrements (counterclockwise rotation) the programmed voltage value, which will be displayed on the LCD display.
2. The slew keys (**▲**, **▼**) on the keypad also increment the voltage value displayed on the LCD display; the increment is programmable (see PAR. 3.2.2.6).
3. Pressing the **Vadj** key, then using the numeric keypad to enter the precise numeric value for output voltage.

Current limit can be set in two ways:

1. The **CURRENT** control is an optical encoder that digitally increments (clockwise rotation) or decrements (counterclockwise rotation) the programmed current limit value which will *not* be displayed on the LCD display. The new current limit can be viewed by using the STATUS function (**SHIFT** then “.” key).
2. Pressing the **Iadj** key, then using the numeric keypad to enter the precise numeric value for current limit.

**4.1.13.2 SET OUTPUT CURRENT/VOLTAGE LIMIT (CURRENT MODE)** When operating in the Current mode, output current can be set in three different ways:

NOTE When the output is Disabled, the following controls affect the programmed output and limit values for voltage and current.

1. The **CURRENT** control is an optical encoder that digitally increments (clockwise rotation) or decrements (counterclockwise rotation) the programmed current value, which will be displayed on the LCD display.
2. For MR and MGR models in the *commanded* current mode, the slew keys (**▲**, **▼**) on the keypad also increment the current value displayed on the LCD display; the increment is programmable (see PAR. 3.2.2.6).
3. Pressing the  $I_{adj}$  key, then using the numeric keypad to enter the precise numeric value for output voltage.

Voltage limit can be set in two ways:

1. The **VOLTAGE** control is an optical encoder that digitally increments (clockwise rotation) or decrements (counterclockwise rotation) the programmed voltage limit value which will not be displayed on the LCD display. The new voltage limit can be viewed by using the STATUS function (**SHIFT** then “.” key).
2. Pressing the  $V_{adj}$  key, then using the numeric keypad to enter the precise numeric value for voltage limit.

**4.1.13.3 SET VOLTAGE/CURRENT MODE** M and MG Models cannot be set to *commanded* Current mode from the front panel.

For MR and MGR Models, pressing the **SHIFT** key then either the **Vadj** or **Iadj** key allows selection of *commanded* Voltage or *commanded* Current Mode, respectively.

NOTE: Refer to PAR.s 3.1.1 and 3.1.2 for an explanation of *actual* and *commanded* modes.

**4.1.13.4 OUTPUT ENABLE/DISABLE** Separate DC ON and DC OFF keys are used to enable/disable the output (see PAR. 4.1.12).

**4.1.13.5 PROGRAMMABLE PARAMETERS** The MBT Power Supply keyboard offers a means of defining the operating mode and establishing specific operating parameters for specific intervals of time. The keypad is used to create up to ten separate programs. Each program consists of a series of steps that define the following:

(M, MG):

1. Output voltage and current limit or output current and voltage limit
2. The active time period for the step.

(MR, MGR):

1. Output voltage and current limit or output current and voltage limit
2. The active time period for the step
3. Commanded mode (voltage/current)
4. Polarity reversed or non-reversed
5. Output enabled/disabled.

A total of 99 steps are available, and since each program uses at least one step, this leaves 89 steps which can be split, as desired, among a maximum of ten programs; a single program may contain a maximum of 90 steps. Programs can be entered or modified from the keypad without changing the current status of the power supply; status will only change when the program is executed. The MBT Power Supply can execute one program at a time; programs can be set up either cycle indefinitely or stop after one complete execution cycle. (Refer to PAR. 3.2.2.9.)

**4.1.13.6 STATUS** In addition to the five LEDs (see PAR. 4.1.13), the keypad allows on-line observation of actual output voltage and current, as well as programmed overcurrent and overvoltage values. Pressing the SHIFT and “.” (decimal point) keys causes these parameters to be displayed on the LCD display.

**4.1.13.7 MENU-SELECTABLE PARAMETERS** The keypad also allows selection of additional miscellaneous features through a menu selection. Menu selections allow the operator to:

- Enable/disable the MBT speaker which provides audible beeps for each keypad entry.
- Enable/disable the VOLTAGE and CURRENT controls and slew keys, requiring the exact output value to be entered on the numeric keypad.
- Use the front panel to control the operating parameters of another Kepco Power Supply connected to the IEEE 1118 bus by entering the node address of the power supply to be controlled at the keypad. (One of the Power Supplies connected to the bus must be an MBT "G" option unit.)
- Calibrate the MBT Power Supply. Step-by-step instructions for calibrating the unit are displayed on the LCD display.
- Establish values for overvoltage and overcurrent protection.
- Establish the increment value for operation of the Slew keys.

#### **4.1.14 REMOTE CONTROL**

Remote control of the MBT power supply is accomplished using either SCPI or CIIIL programming languages (see PAR.s 3.3.5 or 3.3.6, respectively). The following functions can be performed via remote control of the MBT Power Supply:

- Set values for output voltage and current limit (Voltage Mode).
- Set values for output current and voltage limit (Current Mode).
- Reset output to zero.
- Set Mode (Voltage or Current).
- Enable or disable the output.
- Measure actual values of output voltage and current.
- Read error messages.

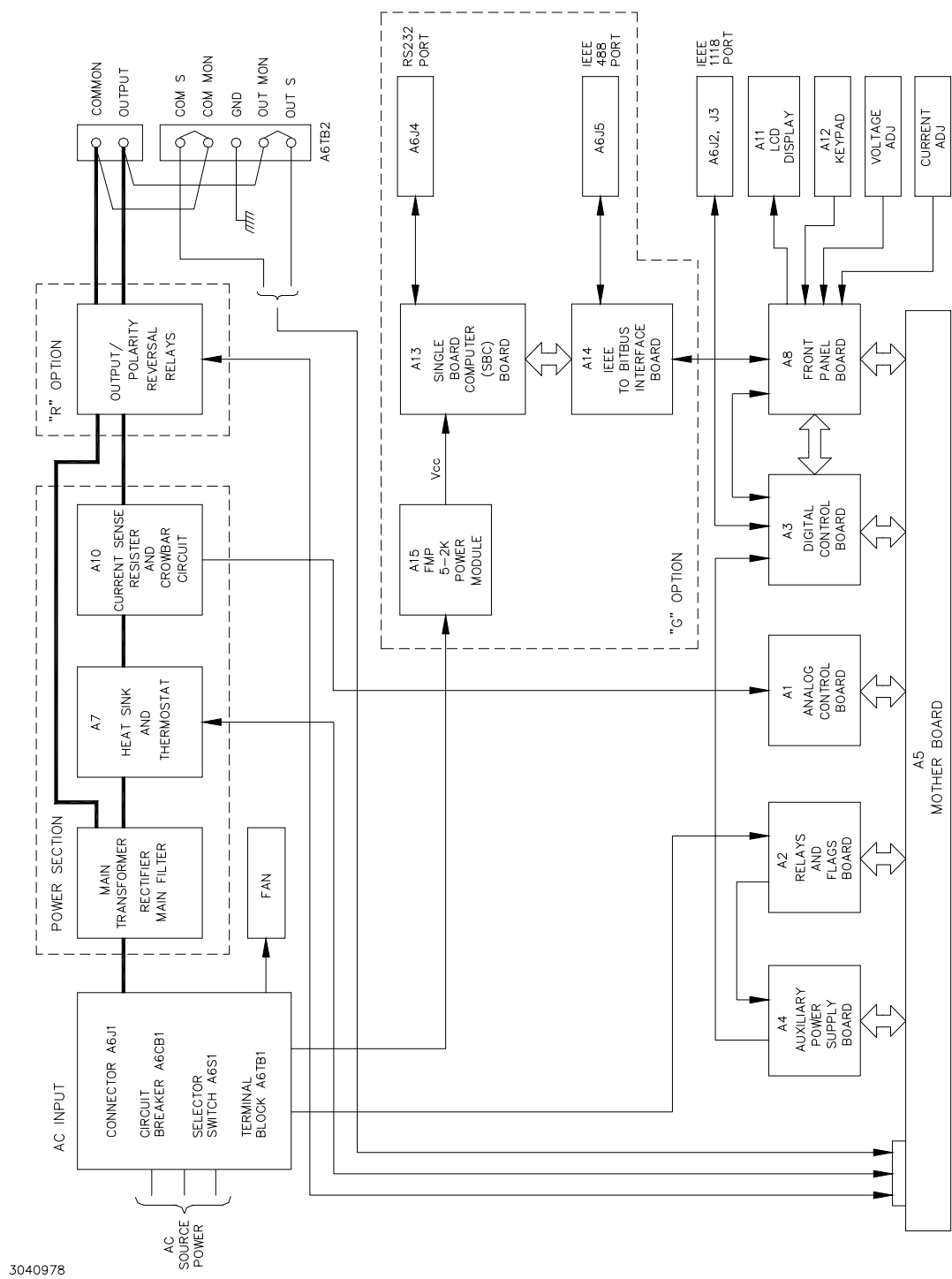
## 4.2 MBT SERIES BLOCK DIAGRAM CIRCUIT DESCRIPTION

Figure 4-4 is a block diagram of the MBT Series Power Supply; Figure 4-5 provides the location of internal power supply components.

Source power is routed through the rear panel AC INPUT connector A6J1, front panel POWER circuit breaker A6CB1 and rear panel AC INPUT SELECTOR switch A6S1 and distributed via terminal block A6TB1 to the cooling fan A6B1, the main power transformer A6T1, and Relays and Flag Board A2. For MG and MGR option units, source power is also applied to an integral FMP-5K a-c to d-c power module used to provide  $V_{CC}$  for digital logic on Single Board Computer (SBC) Board A13 and Interface Board A14. The AC INPUT SELECTOR allows the MBT to operate with either 115V a-c or 230V a-c source power.

Main transformer A6T1, bridge rectifier A6CR1 and main filter elements A6C1 and A6C2 provide d-c voltage to heat sink assembly A7. The heat sink assembly provide the current-amplified output voltage to the output terminals at the rear panel via the current sensing resistor A10R1 on Board A10 (and, for MR and MGR option units, via output/polarity reversal relays located on a chassis-mounted bracket). The heat sink also provides thermostat outputs to terminal block A6TB1 and to Mother Board A5 which interconnects Auxiliary Power Supply Board A4, Relays and Flags Board A2, Analog Control Board A1, Digital Control Board A3, and Front Panel Board A8.

Analog Control Board A1 compares the Reference Voltages derived from Digital Control Board A3 with the feedback signals from the Power Section. Analog Control Board A1 then provides control signals for the Power Section which determine the output of the power supply. This board also contains some of the protection and shutdown circuits (see PAR. 4.3.1).



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FIGURE 4-4. MBT SERIES POWER SUPPLY, OVERALL BLOCK DIAGRAM

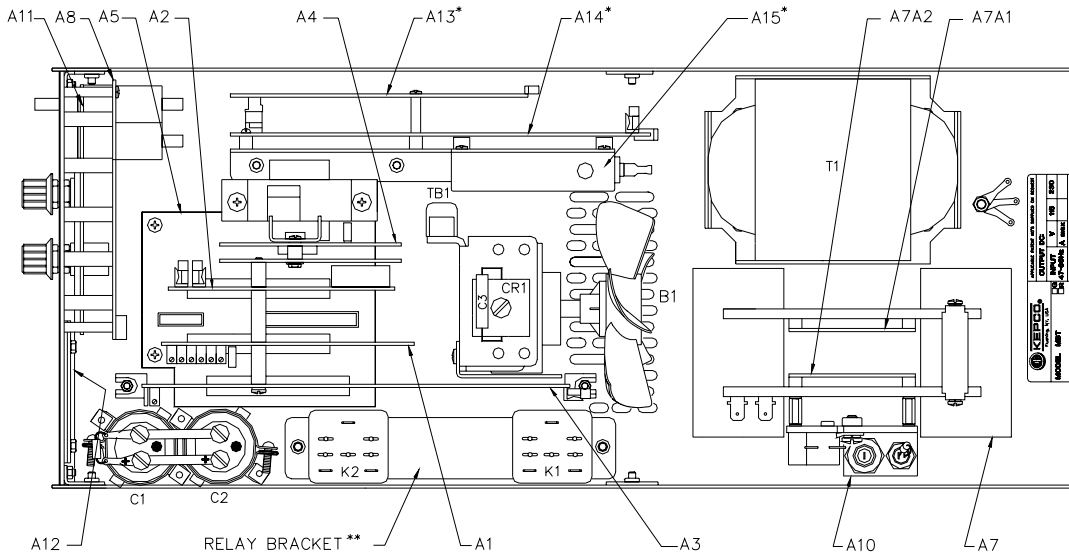
The main function of Relays and Flags Board A2 is to deliver all the flags necessary for Digital Control Board A3 via Mother board A5. For MR and MGR option units, this board also contains the circuitry to control the opening and closing sequence of the output/polarity reversal relays and the sensing leads relays.

Digital Control Board A3 receives digital commands from either the front panel (via Front Panel Board A8) for local operation, or from either an internal "G" option or an external controller over the two-wire IEEE 1118 bus for remote operation. This board generates the voltage and current Reference Voltage signals which are sent to Analog Control Board A1 to control the power supply output. This board also converts the analog output current and voltage into digital signals for transmission to a controller via the IEEE 1118 bus. In addition, this board controls Front Panel Board A8 which provides the interface between the front panel VOLTAGE and CURRENT controls, keypad, status indicator LEDs and LCD display.

Auxiliary Power Supply Board A4 contains an auxiliary transformer, five bridge rectifiers, and two +5V IC power supplies used to generate supply voltages ( $\pm 21V$ , +10.5V, +5V (2), and +12.5V) for the circuitry on Boards A1, A2, A3 and A8. These voltages are provided via Mother Board A5 which serves to interconnect boards A1, A2, A3, A4, and A8, except for the isolated +5V sent directly to A3 for isolated input/output circuits.

### 4.3 DETAILED CIRCUIT DESCRIPTIONS

The following paragraphs provide detailed circuit descriptions of the MBT Series Power Supply Circuits. Figure 4-5 shows the location of major components within the power supply; note that the chassis is designated A6, therefore reference designations for chassis-mounted components other than major assemblies (A1-A5, A7-A14) are prefixed by A6.



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\* USED ONLY ON MODELS MG AND MGR  
 \*\* USED ONLY ON MODELS MR AND MGR

**FIGURE 4-5. MBT SERIES POWER SUPPLY, LOCATION OF MAJOR COMPONENTS**

#### 4.3.1 ANALOG CONTROL BOARD A1 (See Schematic Diagram, Figure 6-18)

The main function of Analog Control Board A1 is to compare Reference Voltages derived from Digital Control Board A3 with the voltage and current feedback signals from the power section. This board also contains the detection portion of the protection circuits incorporated into the MBT Series Power Supply.

This board is identical for all options of a particular model, however it differs between models due to a few components — such as voltage and current channel feedback resistors, scaling resistors, feedback capacitors — and the position of the jumpers used to establish Model (see PAR. 2.8). The principal circuits of the board are:

- Voltage and current reference amplifiers (U2A and U2B)
- Voltage and current comparison amplifiers (U7 and U6)
- Voltage and current monitor amplifiers (U3A and U3B)
- Overvoltage and overcurrent tracking circuits (U9C/D and U9A/B)
- Overvoltage and overcurrent comparators (U8B and U8C)
- Voltage and current over-range comparators (U1B and U1A)
- Operating mode comparator (U8A)
- Current sensing and scaling circuit (U5 and U4)
- Analog gate and predriver circuit (CR7, CR8, Q1)
- Constant current return supply circuit (Q2)
- Output capacitor discharge circuit (Q3)
- Path fault detector circuit (U10A)

The A1 Board is connected to Mother Board A5 via A1P1, and to the sensing resistor A10R1 via two twisted wires connected to A1J6.

The path fault detector detects when the voltage drop between the power and sense terminals exceeds 0.5V; this condition can be caused by an interruption of continuity between power and sense terminals, or when the power leads are too long. The /PATH FAULT signal is applied to Digital Control Board A3, where it is monitored by the software for 10 program cycles (maximum 20 milliseconds). If the path fault condition still exists at the end of this delay, Digital Board A3 programs the output voltage and current to zero.

(MR, MGR MODELS) For "R" option units, Digital Control Board A3 programs the output to DISABLED, causing the output relays to open and isolate the power supply from the load upon detection of a path fault condition.

(M, MG MODELS) Units without the "R" option relays are configured with jumper A1J7 installed. This allows U10B to act on the /Overvoltage/Overcurrent line applied to Flags/Relays Board A2 via Mother Board A5. If the path fault condition persists longer than 6 milliseconds, this activates

the crowbar protection circuit which trips the main POWER circuit breaker, shutting off the MBT Power Supply.

#### **4.3.2 RELAY AND FLAGS BOARD A2 (See Schematic Diagram, Figure 6-19 for Models M, MG, Figure 6-20 for Models MR, MGR)**

The main function of this board is to deliver all the flags necessary for Digital Control Board A3. On units with the "R" option installed, this board also contains the circuits which control the opening and closing sequences of the output/polarity reversal relays. The principal circuits of this board are as follows:

- $\pm 15V$  D-C Regulators (U1, U2)
- Logic Flag Circuits (U3D, U4)
- Status LED Drivers (U3A, U3B, U3C, U3E)
- A-C Power Loss Circuit (LC1)
- Crowbar and Circuit Breaker Command Circuit (U3F, U4, U8A, LC3)

For MR and MGR Models the A2 board also incorporates the following additional circuits:

- Logic Circuit for Open/Close Command Sequencing (U5A, U5B, U5C, U5D, U8B, U8C, U8D, U6A, U6B)
- Power Relay Drivers (K1, K2, CR3, CR4)
- Relays for switching the Sensing Leads (K3, K4)

This board differs between options of a particular model (as noted above), as well as between models (due to a few components (decoupling capacitors between power and sensing leads).

The A2 board is connected to the A5 Mother Board via connector A2P1; two twisted-wire cables connected to A2J1, A2J2, and A2J3, provide interconnections between the A2 board and Auxiliary Power Supply Board A4, terminal block A6TB1, and POWER circuit breaker A6CB1, respectively. Jumper A2J5 permits circuit breaker A6CB1 to either trip upon detection of input power loss (J5 installed) or not trip upon detection of power loss (J5 not installed).

(M, MG) Header A2J4 is incorporated on the A2 board for units without the "R" option. If the jumper is installed between A2J4 pins 1 and 2, illumination of the front panel OUTPUT ENABLED indicator is controlled by the software in response to the DC ON/DC OFF commands. If the jumper is installed between A2J4 pins 2 and 3, the OUTPUT ENABLED indicator is on and cannot be controlled by MBT software in response to DC ON/DC OFF commands.

#### **4.3.3 DIGITAL CONTROL BOARD A3 (See Schematic Diagram, Figure 6-21)**

The Digital Control Board A3 receives digital commands over the two-wire IEEE 1118 bus (remote mode) or through connector J5 from the front panel controls (local mode). These commands cause the A3 board to generate the two analog reference signals (voltage and current) used by Analog Control Board A1 to control the output of the power supply. The analog signals reflecting the output values are converted to digital signals for transmission to the external controller via the IEEE 1118 bus. Digital Control Board A3 also controls Front Panel Board A8, accepting the digital commands from the keypad and front panel VOLTAGE and CURRENT



optical encoders and providing digital signals for the front panel alphanumeric display. Digital Control Board A3 contains the following circuits:

- Microprocessor (U6)
- EPROM Memory (32K x 8) containing proprietary software (U12)
- Non-volatile RAM (8K x 8) (U16)
- D/A and A/D Converters (U18, U17)
- Reference Voltage Circuit (+5V) (U23)
- Peripheral Circuit for controlling LCD and keypad (U27)
- Isolated two-wire Digital Control Bus circuit (U1)

Component locations for Digital Control Board A3 are shown in Figure 6-5. Connector A3P1 connects the A3 board to Mother Board A5. Header-connector A3J1 is split between three two-wire cables: pins 5 and 6 carry +5V Isolated used by the Digital Control Bus Circuit, pins 3 and 4 carry the IEEE 1118 bus signals and interface the A3 board with the IEEE 1118 Input/Output Ports (A6J2 and A6J3), and pins 1 and 2 provide IEEE 1118 bus signals to Interface Board A14 via "G" option selector switch A8S1 on Front Panel Board A8. Connector A3J5 provides the interface for Front Panel Board A8. Jumpers A3J3 and A3J4 must be installed for normal operation of the A3 board.

Microswitch A3S1 (accessible via the top cover) is used to set the node address of the MBT power supply (see PAR. 2.5.1). Five binary bits (A0 through A4) allow selection of addresses between 1 and 31, with A0 the least significant bit. Moving the switch towards the right forces a "1" on that line.

#### **4.3.4 AUXILIARY SUPPLY BOARD A4 (See Schematic Diagram, Figure 6-22)**

Auxiliary Supply Board A4 generates voltages used by other circuits of the MBT Series Power Supply. This board is identical for all MBT models and options, and contains the following circuits:

- Auxiliary Line Transformer (T1)
- Rectifier and Filter Circuit for  $\pm 15V$  (CR1, C1, C2)
- Rectifier and Filter Circuit for Driver Supply (CR2, C3)
- Rectifier and Filter Circuit for Return Supply (CR4, C5)
- +5V Regulated Supply for Logic Circuits (CR3, C4, U1, C7)
- +5V Isolated Regulated Supply for BIT bus (IEEE 1118 bus) (CR5, C6, U2, C8)

This board is identical for all MBT Series Power Supplies, regardless of option. Auxiliary Supply Board A4 is connected to Mother Board A5 via connector A4P1.

Figure 6-6 shows component locations for Auxiliary Supply Board A4. Connector A4J1 connects +5V (isolated) via a twisted pair cable to Digital Control Board A3 (A3J1, pins 5 and 6).

#### **4.3.5 MOTHER BOARD A5 (See Schematic Diagram, Figure 6-23)**

Mother Board A5 provides interconnections between various power supply components and is identical for all MBT models and options. Boards A1, A2, A3, and A4 plug directly into connectors A5J3, A5J2, A5J1, and A5J4, respectively (see Figure 6-7 for component locations). Connector A5J5 provides connections to/from heat sink assemblies A7, A10 and (for MR and MGR units) the Relays Assembly; connector J6 provides interconnections for Front Panel Board A8.

#### **4.3.6 A-C INPUT CIRCUIT AND MAIN D-C SUPPLY (CHASSIS A6) (See Main Schematic Diagram, Figure 6-17)**

A-C source power is received via the rear panel-mounted 3-pin AC INPUT connector A6J1, routed to the front panel POWER circuit breaker A6CB1, and applied to distribution terminal block A6TB1. Circuit breaker A6CB1 functions to protect the MBT Power Supply by opening if either an overcurrent condition in the primary a-c circuit appears, or if the voltage circuit breaker coil is activated by the Crowbar and Circuit Breaker Command circuit (see PAR. 4.3.2).

The two primary windings of main line transformer A6T1 are connected either in parallel for 115V a-c nominal line voltage, or in series for 230V a-c nominal line voltage, using rear panel-mounted AC INPUT SELECTOR switch A6S1. Terminal block A6TB1 also distributes source power (115V a-c) to the fan, the auxiliary line transformer on Auxiliary Power Supply Board A4 via Relay and Flags Board A2, and, for MG and MGR option units, the separate FMP 5-2K auxiliary "G" option power module, A15.

The fan is powered through power resistor A6R2; when the heatsink temperature is high enough to close thermostat A6S2, but not high enough to close overtemperature thermostat A6S1, resistor A6R2 is shorted. This effectively allows the fan to operate at two speeds: low speed for low power dissipation by the heat sink and low ambient temperature, or high speed for high power dissipation by the heat sink and/or high ambient temperature conditions.

The main d-c voltage is obtained by rectifying the main transformer A6T1 secondary winding voltage using silicon diodes configured as either a full wave bridge or, for MBT 6-32, a full wave center-tapped rectifier circuit (A6CR1). This voltage is filtered by the parallel-connected main filter capacitors A6C1 and A6C2.

#### **4.3.7 HEAT SINK ASSEMBLY A7 (See Main Schematic Diagram, Figure 6-17)**

The heat sink assembly or pass element is equivalent to a bipolar NPN transistor working in an emitter follower configuration having a very high d-c current amplification factor. There are two different configurations of heat sink assembly A7: one for the six low voltage models and one for the two high voltage models and some slight differences between models of each configuration. The low voltage configuration (MBT 6-32M, 15-20M, 25-14M, 36-10M, 55-7M, 75-5M) has 13 NPN transistors cascaded on three levels, with the 11 output transistors in parallel.

The high voltage configuration (MBT 100-3.6M, 150-2.4M) employs two series branches of transistors that divide the voltage across them. Each branch is cascaded on two levels and has the final five transistors in parallel.

The pass element is connected in series with the unregulated main d-c supply and the output. The series equivalent resistance of the pass element, and therefore the voltage across it, is changed to keep either the output voltage (in Voltage Mode) or output current (in Current Mode) constant.

The pass element transistors and associated circuits are electrically connected to two printed circuit board subassemblies; the transistors are also physically mounted on the heat sink for heat dissipation (see Figure 6-8). Low voltage model heat sink assemblies are interconnected with chassis-mounted components, Mother Board A5, and Sensing Resistor and Crowbar assembly A10 by means of one 9-pin connector on printed circuit subassembly A7A1. High voltage models use two 12-pin connectors, one on each printed circuit board subassembly, to interconnect the two subassemblies, the chassis-mounted components, Mother Board A5, and assembly A10. High current models (MBT 6-32M and 15-20M) use a heavy duty cable mounted between the two printed circuit board subassemblies to deliver the pass element output to the Sensing Resistor and Crowbar assembly A10.

#### 4.3.8 FRONT PANEL BOARD A8 (See Schematic Diagram, Figures 6-24)

Front Panel Board A8, Alphanumeric Display (LCD) A11 and Keypad A12 provide an interface between the operator and the MBT power supply. Operator inputs from the keypad and from the VOLTAGE and CURRENT optical encoders is sent to Digital Control Board A3 in order to initiate a program or modify a value; display information from Digital Control Board A3 is sent to LCD A11 by the Front Panel Board A8. Front panel board A8 is identical for all MBT models and options, and contains the following circuits:

- VOLTAGE and CURRENT controls (optical encoders) and interface circuits (U5, U4, U2, U3, U1C)
- Buffers (for “beeper” device and REMOTE status LED) (U1B, U1A)
- Status LEDs (DS1 through DS5)
- “G” Option selector switch (S1)

Transition type connector A8J1 connects the front panel board to Digital Control Board A3 via a 26-conductor flat cable (see Figure 6-11 for component locations). Connector A8J6 interconnects Front Panel Board A8 with Mother Board A5 via a 9-pin flat cable. Connector A8J4 interconnects Front Panel Board A8 with the keypad via a 10-conductor flat cable. Alphanumeric display A11 is plugged directly into connector A8J5.

Connector A8J7 provides the backlight diode voltage for LCD A11 via a twisted pair; however, on some models this connector is not used: the backlight voltage is provided directly to the LCD via connector A8J5.

Potentiometer R7, accessible through the top cover (see Figure 2-2), adjusts the contrast of LCD A11.

The status indicator LEDs, DS1 through DS5 are visible from the front panel to display status: VOLTAGE MODE, CURRENT MODE, POLARITY REVERSED, REMOTE, and OUTPUT ENABLED, respectively. Indicators DS1 through DS4 are driven by signals from Relay and Flags Board A2 via Mother Board A5; indicator DS5 is driven directly by Digital Control Board A3, buffered by U1A.

Operation of the VOLTAGE and CURRENT control optical encoders is identical. Rotating VOLTAGE control in either direction produces clock pulses which trigger D-type flip-flops U3A and U3B. U3B is always triggered set, indicating to Digital Control Board A3 that voltage is to be decremented or incremented. Flip-flop U3A is either set or reset, indicating to Digital Control Board A3 that voltage is to be incremented (clockwise rotation) or decremented (counterclock-

wise rotation). Digital Control Board A3 then resets U3B to prepare for further movement of the control.

“G” Option selector switch S1 routes IEEE1118 bus signals to/from the rear panel connector via Digital Control Board A3 (A3J1 to A8J9) to/from Interface Board A14 (A8J8 to A14J2) when the “G” option is enabled. This switch also provides a flag to the Digital Control Board to indicate whether the “G” option is enabled or disabled. On models without the “G” option selector switch, the IEEE 1118 bus is connected directly from A3J1 to A14J2.

#### **4.3.9 SENSING RESISTOR AND CROWBAR CIRCUIT A10 (See Main Schematic Diagram, Figure 6-17)**

The A10 assembly contains current sensing resistor A10R1, and the crowbar circuit, consisting of triac A10CR1 which is controlled by Relay and Flags Board A2. Blocking diode A10CR2 protects the power supply against the possibility that a voltage of opposite polarity to the programmed polarity is applied to the output terminals. The A10 assembly is mounted on Heat Sink Assembly A7, but is electrically isolated from the heat sink. The value of the sensing resistor differs between models, but is identical for all options of a particular model.

#### **4.3.10 ALPHANUMERIC DISPLAY (LCD) A11 (See Schematic Diagram, Figure 6-25)**

The alphanumeric display is a liquid crystal display used to display status, operational parameters, calibration instructions, and programming information. Alphanumeric characters are sent from Digital Control Board A3 via Front Panel Board A8 in the form of eight parallel data bits along with control signals. Operating voltage and backlight LED voltage are provided by Front Panel Board A8. The alphanumeric display is identical for all MBT models and options.

#### **4.3.11 KEYPAD A12 (See Schematic Diagram, Figure 6-26)**

The keypad consists of 24 momentary action switches which provide a combination of ten signals (KPAD1 through KPAD5 and D0 through D4) to Digital Control Board A3 via Front Panel Board A8 to indicate which switch is pressed. Switch functions are completely determined by the software. Keypad A12 is identical for all MBT models and options.

#### **4.3.12 "G" OPTION COMPONENTS — MG, MGR MODELS**

The “G” Option components function as built-in controller to permit the MBT power supply to a remotely control up to 26 additional power supplies (see Figure 1-3) via the IEEE 1118 bus. The “G” option components also allow the MBT to communicate with either a personal computer (PC) or a PC-assisted controller via the IEEE 488 bus or RS232 bus, receiving commands and transmitting status and error messages. The “G” option components are identical for all MG and MGR models and consist of the following:

- Single Board Computer A13
- Interface Board A14
- +5V Power Supply A15
- 2-wire cable between A6TB1 and the line input of +5V Power Supply
- 9-conductor flat cable between A13J2 and A6J4 (RS232 port)

- 24-conductor flat cable between A14J1 and A6J5 (IEEE 488 port)
- 2-wire cable between A14J2 and A8J8 (between A14J2 and A3J1 on models without the "G" option selector switch)

#### **4.3.12.1 SINGLE BOARD COMPUTER (SBC) A13 — MG, MGR MODELS (See Schematic Diagram, Figure 6-27)**

The Single Board Computer is a microcomputer built around the I80188 microprocessor and contains the interface for the RS232 bus. The following circuits are located on this board (see Figure 6-15 for component locations):

- I80188 Microprocessor (U1)
- S-RAM type Memory, 32K x 8 (U14)
- EPROM type Memory, 64K x 8, with proprietary software (U9)
- RS232C Interface Circuit (U10 and U11)

Refer to PAR. 2.8 and Table 2-4 for information regarding options offered by Jumpers J7 and J8.

#### **4.3.12.2 INTERFACE BOARD A14 — MG, MGR MODELS (See Schematic diagram, Figure 6-28)**

Interface Board A14 provides separate circuits which interface SBC A13 with both the IEEE 488 bus and the IEEE 1118 bus. See Figure 6-16 for component locations; the following circuits are contained on this board:

- IEEE 1118 Interface Circuit (U7 through U21)
- IEEE 488 Interface Circuit (U1 through U6, U23)

The IEEE 1118 interface circuits uses an independent microprocessor to control "handshake," assembling data received, and stretching data for serial transmission via the two-wire IEEE 1118 bus. SBC circuits are connected to the IEEE 1118 bus via buffer/driver U7 and isolated by opto-isolators U8 and U9.

#### **4.3.13 "R" OPTION COMPONENTS — MR, MGR MODELS (See Schematic Diagram, Figure 6-20)**

MBT Series Power Supplies with the "R" option include a special Relay and Flags Board A2, and a Power Relay Assembly. These components function to allow the load to be electrically isolated from the power supply output (output disabled status), and permit reversing the polarity of the voltage applied to the load (refer also to PAR.s 4.1.11 through 4.1.13).

To preserve the power relays on the power relay assembly, a "dry switching" technique is used. Each time the relays are operated, the following sequence is executed under control of Relay and Flags Board A2:

- 1) If the unit is operating in Voltage mode, the output voltage and current limit parameters are stored. If the unit is operating in Current mode, the output current and voltage limit parameters are stored.
- 2) The parameters stored in step 1 above are programmed to zero.

- 3) When output voltage (Voltage mode) or output current (Current mode) reach zero, the relays are switched to the new position.
- 4) When the switching action is complete, the parameters stored in step 1 are restored.

NOTE: The switching time of the output relays is approximately 500 microseconds; this must be taken into account when setting up a program which exercises the output relays.

The commands DC ON and DC OFF have a different effect, depending on whether the unit is operating in commanded Voltage mode or commanded Current mode. In commanded Voltage mode the load is either connected (DC ON) or disconnected (DC OFF) by the output relays. In commanded Current mode the load is either released, allowing current to flow to the load (DC ON) or shorted (DC OFF). This feature protects the load against overload shocks.

Upon initial power up of the MR or MGR suffix power supply, the unit will be in Voltage mode, Polarity nonreversed, with the load disconnected (DC OFF). The display will show the programmed value for output voltage and current limit.

## APPENDIX A - SCPI COMMON COMMAND/QUERY DEFINITIONS

### A.1 INTRODUCTION

This appendix defines the IEEE 488.2 common commands and queries used with the MBT Power Supply controller. Common commands and queries are preceded by an asterisk (\*) and are defined and explained in Figures A-1 through A-14, arranged in alphabetical order. Table A-1 provides a quick reference of all IEEE 488.2 common commands and queries used in the MBT power supply controller.

**TABLE A-1. IEEE 488.2 COMMAND/QUERY INDEX**

COMMAND	PAR.	COMMAND	PAR.
*CLS	A.2	*RST	A.10
*ESE, ?	A.3, A.4	*SRE, ?	A.11, A.12
*ESR?	A.5	*STB?	A.13
*IDN?	A.6	*TRG	A.14
*OPC, ?	A.7,	*TST?	A.15
*OPT	A.9	*WAI	A.16

### A.2 \*CLS — CLEAR STATUS COMMAND

**\*CLS**

Syntax: \*CLS

Description: **Clears status data.** Clears the error queue of the instrument. It also clears the following registers without affecting the corresponding Enable Registers: Standard Event Status Register (ESR), Operation Status Event Register, Questionable Status Event Register, and Status Byte Register (STB).  
 Related commands: \*OPC \*OPC?. (See example, Figure A-1.)

### A.3 \*ESE — STANDARD EVENT STATUS ENABLE COMMAND

**\*ESE**

Syntax: \*ESE <integer> where <integer> = positive whole number: 0 to 255 per Table A-2.  
 Default Value: 0

Description: **This command programs the standard Event Status Enable register bits.** The contents function as a mask to determine which events of the Event Status Register (ESR) are allowed to set the ESB (Event Summary Bit) of the Status Byte Register. Enables the Standard events to be summarized in the Status Byte register (1 = set = enable function, 0 = reset = disable function). All of the enabled events of the standard Event Status Enable register are logically ORed to cause ESB (bit 5) of the Status Byte Register to be set (1 = set = enable, 0 = reset = disable). (See example, Figure A-1.)

**TABLE A-2. STANDARD EVENT STATUS ENABLE REGISTER AND STANDARD EVENT STATUS REGISTER BITS**

CONDITION	PON	NU	CME	EXE	DDE	QUE	NU	OPC
BIT	7	6	5	4	3	2	1	0
VALUE	128	64	32	16	8	4	2	1

PON Power On  
 NU (Not Used)  
 CME Command Error  
 EXE Execution Error  
 DDE Device Dependent Error  
 QUE Query Error  
 OPC Operation Complete

#### A.4 \*ESE? — STANDARD EVENT STATUS ENABLE QUERY

### \*ESE?

Syntax: \*ESE? Return value: Integer> value per Table A-2.

Description: **Returns the mask stored in the Standard Event Status Enable Register.** Contents of Standard Event Status Enable register (\*ESE) determine which bits of Standard Event Status register (\*ESR) are enabled, allowing them to be summarized in the Status Byte register (\*STB). All of the enabled events of the Standard Event Status Enable Register are logically ORed to cause ESB (bit 5) of the Status Byte Register to be set (1 = set = enable function, 0 = reset = disable function). (See example, Figure A-1.)

#### A.5 \*ESR? — EVENT STATUS REGISTER QUERY

### \*ESR?

Syntax: \*ESR?  
Return value: <integer> (Value = contents of Event Status register as defined in Table A-2.)

Description: **Causes the power supply to return the contents of the Standard Event Status register. After it has been read, the register is cleared.** The Standard Event Status register bit configuration is defined in Table A-2(1 = set, 0 = reset). Related Commands: \*CLS, \*ESE, \*OPC. (See example, Figure A-1.)

#### A.6 \*IDN? — IDENTIFICATION QUERY

### \*IDN?

Syntax: \*IDN?  
Return value: Character string

Description: **Identifies the instrument.** This query requests identification. The string contains the manufacturer name, model, SN, firmware revs. The SN field is normally used for the serial #, but since serial #s are not stored in memory, the channel # is given instead. The firmware revision consists of the controller rev. and power module rev. separated by a '-'. If no module is present at the selected channel, PSC (Power Supply Controller) is given as the model. Supported models include MAT, MBT, and MST The character string contains the following fields: <Manufacturer>, <Model>, <Serial Number>, <Firmware revision> where: <Manufacturer> = KEPCO, <Model> = BOP, <Serial Number> = MM,DD,YY-SSS (MM - month, DD - day, YY - year, SSS - serial number in that day) <Firmware revision>=n.m (n.m revision, e.g. 1.0) (See example, Figure A-1.)

The model identified in the \*IDN? query after power up of the controller is the device connected to the BITBUS with an address of 1. If no device is set to be address 1 then the power up IDN string returned will contain the model identifier of PSC. The model identifier reflects the type of power supply at a specific BITBUS address. figure B-3 shows an example of the model identifier after specifying any device.

#### A.7 \*OPC — OPERATION COMPLETE COMMAND

### \*OPC

Syntax: \*OPC

Description: **Causes power supply to set status bit 0 (Operation Complete) when pending operations are complete** This command sets Standard Event Status Register bit 0 (see Table A-2) to "1" when all previous commands have been executed and changes in output level have been completed. This command does not prevent processing of subsequent commands, but bit 0 will not be set until all pending operations are completed. (1 = set = enable function, 0 = reset = disable function). (See example, Figure A-1.) As an example, the controller sends command(s), then sends \*OPC. If controller then sends \*ESR?, the power supply responds with either a "0" (if the power supply is busy executing the programmed commands), or a "1" (if the previously programmed commands are complete). (See example, Figure A-1.)



*CLS	Power supply clears status data.
*ESE 60	Power supply enables bits 5, 4, 3 and 2, allowing command error, execution error, device dependent error and query error to set the Event Status Summary bit when an STB command is executed.
*ESE?	Returns 60, (value of the mask) verifying that bits 5, 4, 3 and 2 are enabled.
*ES	Unknown command will set command error (Bit 5).
*ESR?	Returns 32 (bit 5 set), indicating Command Error has occurred since the last time the register was read.
*IDN?	Controller returns character string: "KEPCO,MBT,1,V3.0-3.0"
*OPC	Allows status bit 0 to be set when pending operations complete
VOLT 21;CURR 3	Sets output voltage to 21V, output current to 3A
*ESR	Returns 129 (128 + 1, power on, bit 7 = 1, operation complete, bit 1 = 1)
*ESR	Returns 0 (event status register cleared by prior *ESR?)
VOLT 15;CURR 5;*OPC?	Sets output voltage to 15V, output current to 5A, puts "1" on output bus when command operations are complete.
*RST	Power supply reset to power on default state.
*SRE 40	When ESB or QUES bits are set (Table A-3), the Request for Service bit will be set.
*SRE?	Returns the value of the mask (40).
*STB?	For example, the Power supply responds with 96 (64 + 32) if MSS and the Event Status Byte (Table A-3) summary bit have been set. The power supply returns 00 if no bits have been set.
VOLT 25	Power supply voltage commanded to 25V.
VOLT:TRIG 12	Programs power supply voltage to 12V when *TRG received.
INIT	Trigger event is initialized.
*TRG	Power supply reverts to commanded output voltage of 12V.
*TST?	Power supply executes self test and responds with 0 if test completed successfully, with 1 if test failed.

FIGURE A-1. GPIB COMMANDS

**A.8 \*OPC? — OPERATION COMPLETE QUERY**

**\*OPC?**

Syntax: \*OPC?  
Return value: <1> (ASCII) placed in output queue when power supply has completed operation.

Description: **Indicates when pending operations have been completed.** When all pending operations are complete (all previous commands have been executed and changes in output level have been completed) a "1" is placed in the Output Queue. Subsequent commands are inhibited until the pending operations are completed. \*OPC? is intended to be used at the end of a command line so that the application program can monitor the bus for data until it receives the "1" from the power supply Output Queue. (See example, Figure A-1.)

**A.9 \*OPT? — Options Query**

# \*OPT?

Syntax: \*OPT?  
Returns string determined by power supply model.

Description: **Causes the power supply to return an ASCII string which defines the functionality of the power supply.** The functionality is defined as follows:

STRING DATA	MEANING
RI1	Indicates unit has the ability to modify the DCL response.
CHN	Indicates multiple channel device is enabled
DS0	Display present, no text capability.
CIIL	Unit supports CIIL commands

# \*RST

## A.10 \*RST — RESET COMMAND

Syntax: \*RST

Description: **Resets power supply to the power on default state.** The power supply is programmed to the power on values of the following parameters: CURR[:LEV][:IMM] = 0, VOLT[:LEV][:IMM] = 0, OUTP[:STAT] = OFF. If the power supply is in either an overvoltage or overcurrent state, this condition is reset by \*RST. (See example, Figure A-1.)

# \*SRE

## A.11 \*SRE — SERVICE REQUEST ENABLE COMMAND

Syntax: \*SRE<integer> where <integer> = value from 0 - 255 per Table A-3, except bit 6 cannot be programmed.

Description: **Sets the condition of the Service Request Enable register.** The Service Request Enable register determines which events of the Status Byte Register are summed into the MSS (Master Status Summary) and RQS (Request for Service) bits. RQS is the service request bit that is cleared by a serial poll, while MSS is not cleared when read. A "1" (1 = set = enable, 0 = reset = disable) in any Service Request Enable register bit position enables the corresponding Status Byte bit to set the RQS and MSS bits. All the enabled Service Request Enable register bits then are logically ORed to cause Bit 6 of the Status Byte Register (MSS/RQS) to be set. Related Commands: \*SRE?, \*STB?. (See example, Figure A-1.)

**TABLE A-3. SERVICE REQUEST ENABLE AND STATUS BYTE REGISTER BITS**

CONDITION	OPER	MSS RQS	ESB	MAV	QUES	ERR QUE	NU	NU
BIT	7	6	5	4	3	2	1	0
VALUE	128	64	32	16	8	4	2	1

OPER      Operation Status Summary  
MSS        Master Status Summary  
RQS        Request for Service  
ESB        Event Status Byte summary  
MAV        Message available  
QUES      QUESTIONable Status Summary  
ERR QUE   1 or more errors occurred (see PAR. B.49)  
NU         (Not Used)

# \*SRE?

## A.12 \*SRE? — SERVICE REQUEST ENABLE QUERY

Syntax: \*SRE?                      Response: <integer> = value from 0 - 255 per Table A-3.

Description: **Reads the Service Enable Register.** Used to determine which events of the Status Byte Register are programmed to cause the power supply to generate a service request (1 = set = function enabled, 0 = reset = function disabled). Related Commands: \*SRE, \*STB? (See example, Figure A-1.)

### A.13 \*STB? — STATUS BYTE REGISTER QUERY

## \*STB?

Syntax: \*STB? Response: <integer> value from 0 to 255 per Table A-3.

Description: **Reads Status Byte Register without clearing it.** This Query reads the Status Byte Register (bit 6 = MSS) without clearing it (1 = set = function enabled, 0 = reset = function disabled). The register is cleared only when subsequent action clears all set bits. MSS is set when the power supply has one or more reasons for requesting service. (A serial poll also reads the Status Byte Register, except that bit 6 = RQS, not MSS; and RQS will be reset.) Related Commands: \*SRE, \*SRE?. (See example, Figure A-1.)

### A.14 \*TRG — TRIGGER COMMAND

## \*TRG

Syntax: \*TRG

Description: **Triggers the power supply to be commanded to preprogrammed values of output current and voltage.** When the trigger is armed (checked by examining WTG bit in Status Operational Condition register) \*TRG generates a trigger signal. The trigger will change the output of the power supply to the output voltage and current levels specified by VOLT:TRIG and CURR:TRIG commands and clear the WTG bit in the Status Operation Condition register. If INIT:CONT has been issued, the trigger subsystem is immediately rearmed for subsequent triggers, and the WTG bit is again set to 1. \*TRG or GET are both addressed commands (only devices selected as listeners will execute the command). Related Commands: ABOR, INIT, TRIG, CURR:TRIG, VOLT:TRIG. (See example, Figure A-1.)

# \*TST?

## A.15 \*TST? — SELF TEST QUERY

Syntax: \*TST?                      Returned value: 0 or n (0 = pass test, n = fail test )where n = address of failed unit(s)

Description: **Power Supply test.**This query causes the power supply to do a self test and provide the controller with pass/fail results. The \*TST? command performs the following tasks on relay equipped units:

- Sets output off (for units with relays, disconnects relays).
- Sets the output to a max positive level, measures the voltage reported to the A to D converter.
- Sets the output to 0, measures the output.
- Swaps the output relays to make the output negative.
- Sets the output to max negative level and measures the output.
- Set output to 0 and sets output relays to positive value.

For power supplies which do not have relays (e.g, MBT and BOP), the levels indicated above will actually appear at the power supply output.

Errors (e.g., voltage error or relay error) are reported over the Bit bus. These errors update flags in the status Questionable register in the controller. If the power supply's questionable register is 0, it is considered to have passed and if it is non-zero it has failed. An error on any power supply connected to the controller is reported as the address of the power supply. If, for example, there are three power supplies connected and \*TST? is executed, all power supplies perform the test and the response will be 0 if all pass. If device 2 fails, the response would be 2. If devices 2 and 3 fail the response would be 2,3.

The user can determine if there was a Relay error or a voltage setting error by sending STAT:QUESn? to the device, replacing n with the number returned in response to \*TST?. For example, STAT:QUES1? should be sent if the \*TST? response was a 1. A voltage error is reported in the questionable register if there is a problem in setting an output.

If the unit fails, it is recommended that the test be executed a second time after reading the STAT:QUES register. This is recommended because if the error was already set in the status questionable register It is possible that a unit which failed \*TST? may pass when retested.

# \*WAI?

## A.16 \*WAI — WAIT-TO-CONTINUE COMMAND

Syntax: \*WAI                      Response:

Description: **Causes the power supply to wait until all previously issued commands and queries are complete before executing subsequent commands or queries.** This command can be used to guarantee sequential execution of commands and queries. When all pending operations are complete (all previous commands have been executed, changes in output level have been completed), the WAI command is completed and execution of subsequent commands can continue.

Example:

VOLT 10;:*WAI;:volt 15	The *WAI command ensures that the power supply output actually goes to 10V before being set to 15V
------------------------	--

FIGURE A-2. USING THE \*WAIT-TO-CONTINUE COMMAND

## APPENDIX B - SCPI COMMAND/QUERY DEFINITIONS

### B.1 INTRODUCTION

This appendix defines the SCPI subsystem commands and queries used with the MBT Power Supply controller. Subsystem commands are defined in PAR. B.2 through B.54, arranged in groups as they appear in the tree diagram, Figure 3-4. Table B-1 provides a quick reference of all SCPI subsystem commands and queries used in the Interface Card.

**TABLE B-1. SCPI SUBSYSTEM COMMAND/QUERY INDEX**

COMMAND	PAR.	COMMAND	PAR.
INIT[:IMM]	B.2	STAT:QUES:ENAB, ?	B.30, B.31
INIT:CONT, ?	B.3, B.4	STAT:QUES:INST?	B.32
INST:CAT?	B.5	STAT:QUES:INST1?	B.33
INST:NSEL	B.6	STAT:QUES:INST 2?	B.34
INST:SEL	B.7, B.8	STAT:QUES:INST:ENAB, ?	B.35, B.36
INST:STAT	B.9	STAT:QUES:INST1:ENAB, ?	B.37, B.38
MEAS:CURR?	B.10	STAT:QUES:INST2:ENAB, ?	B.39, B.40
MEAS:VOLT?	B.11	STAT:QUES:INST:ISUM?	B.41
OUTP[:STAT], ?	B.12, B.13	STAT:QUES:INST:ISUM:ENAB, ?	B.42, B.43
[SOUR:]CURR[:LEV][:IMM][:AMP], ?	B.14, B.15	SYST:COMM:GPIB:ADDR	B.44
[SOUR:]CURR[:LEV]:TRIG[:AMP], ?	B.16, B.17	SYST:COMM:SER:BAUD	B.45
[SOUR:]VOLT[:LEV][:IMM][:AMP], ?	B.18, B.19	SYST:COMM:SER:ECHO	B.46
[SOUR:]VOLT[:LEV]:TRIG[:AMP]?	B.20, B.21	SYST:COMM:SER:PACE	B.47
[SOUR:]FUNC:MODE	B.22	SYST:COMM:SER:PROM	B.48
STAT:OPER:COND?	B.23	SYST:ERR?	B.49
STAT:OPER:ENAB, ?	B.24, B.25	SYST:ERR:CODE?	B.50, B.51
STAT:OPER[:EVENT]?	B.26	SYST:LANG	B.52
STAT:PRES	B.27	SYST:SET	B.53
STAT:QUES[:EVENT]?	B.28	SYST:VERS?	B.54
STAT:QUES:COND?	B.29		

### B.2 INITiate[:IMMEDIATE] COMMAND

### INIT[:IMM]

Syntax: Short Form: INIT[:IMM] Long Form: INITiate[:IMMEDIATE]

Description: **Enables a single trigger.** If INIT:CONT is OFF, then INIT[:IMM] arms the trigger system for a single trigger. If INIT:CONT is ON, then the trigger system is continuously armed and INIT[:IMM] is redundant. This command enables a single trigger. A GPIB <GET>, \*TRG or command completes the sequence. Upon receipt of the <GET> or \*TRG command, the power supply will return to the programmed values of voltage and current established by the VOLT:TRIG and CURR:TRIG commands. After a GPIB <GET> or \*TRG command has been received, subsequent GPIB <GET>, \*TRG commands have no effect unless preceded by INIT or INIT:CONT ON. Related Commands: <GET>, \*RST, \*TRG. (See example, Figure B-3.)

### B.3 INITiate:CONTInuous COMMAND

## INIT:CONT

Syntax: Short Form: INIT:CONT {ON | OFF} or {1 | 0} ( 1 = on, 0 = off)  
Long Form: INITiate:CONTInuous {ON | OFF} or {1 | 0} ( 1 = on, 0 = off)

Description: **INIT:CONT ON enables continuous triggers.; INIT:CONT OFF disables continuous triggers.** If INIT:CONT is OFF, then INIT[:IMM] arms the trigger system for a single trigger. If INIT:CONT is ON, then the trigger system is continuously armed and INIT[:IMM] is redundant. Executing \*RST command sets INIT:CONT to OFF. (See example, Figure B-3.)

### B.4 INITiate:CONTInuous? QUERY

## INIT:CONT?

Syntax: Short Form: INIT:CONT? Long Form: :INITiate:CONTInuous?  
Return Value: 1 or 0

Description: **Determines whether continuous triggers are enabled or disabled.** Power supply returns value of INIT:CONT flag: "1" = continuous triggers are enabled (INIT:CONT ON); "0" = continuous triggers disabled (INIT:CONT OFF). (See example, Figure B-3.)

### B.5 INSTrument:CATalog? QUERY

## INST:CAT?

Syntax: Short Form: INST:CAT? Long Form: :INSTrument:CATalog?  
Return Value: comma separated string with the instrument numbers found on the bitbus.

Description: Allows the host computer to determine what instruments are on the bitbus. Unlike the \*RST command, this command does not scan possible bitbus addresses to determine if the device is present. The list contains all channel numbers found and allows the host computer to determine if the power supplies are connected and powered-up (see Figure B-1).

*RST	Bitbus is scanned and all supplies are set to 0v, 0c, and Voltage mode
INST:CAT?	With three power supplies connected to the MBT Power Supply controller the MBT returns 1,2,3 if their addresses are set to 1, 2 and 3. *** User turns off supply 2.
INST:CAT?	MBT returns 1,3 *** User turns on supply 2
INST:CAT?	MBT returns 1,3
INST2	Channel 2 restored
INST:CAT?	MBT returns 1,2,3 *** User turns off supply 3
INST:CAT?	MBT returns 1,2
VOLT3 4;:SYST:ERR?	MBT returns "0240, Hardware not found" *** User turns on supply 3
VOLT3 4;:SYST:ERR?	Channel 3 restored
INST:CAT?	MBT returns 1,2,3

FIGURE B-1. USE OF INSTrument:CATalog QUERY

### B.6 INSTrument[:NSElect] COMMAND

## INST:NSEL

Syntax: Short Form :INST:NSEL <val> Long Form: INSTrument:NSElect <val>

Description: **Selects power supply connected to channel number <VAL>; also brings off-line or "locked out" power supply to on-line status.** selects the instrument to which subsequent commands will be addressed until another channel is selected. Identical to INST:SEL command (see Figure B-2).

## B.7 INSTRUMENT[:SElect] COMMAND

**INST:SEL**

Syntax: Short Form :INST:SEL <val> Long Form: INSTRUMENT:SElect <val>

Description: **Selects power supply connected to channel number <VAL>; also brings off-line or “locked out” power supply to on-line status.** selects the instrument to which subsequent commands will be addressed until another channel is selected. The <value> following the command is the channel (node) number, from 1 to 31. This command is also used to bring a power supply on-line (i.e., the controller recognizes a power supply assigned to a selected channel). In cases where a fault has “locked out” a power supply (the controller no longer recognizes the power supply assigned to a channel), this command restores the power supply to the system. (See example, Figure B-2.)

## B.8 INSTRUMENT[:SElect]? QUERY

**INST:SEL?**

Syntax: Short Form :INST:SEL? Long Form: INSTRUMENT:SElect ?  
Return value: <VAL> 1 to 31

Description: **Used to determine which channel selected.**

## B.9 INSTRUMENT:STATe COMMAND

**INST:STAT**

Syntax: Short Form :INST:STAT <val> Long Form: INSTRUMENT:STATe <val>

Description: 0 (off) sets output to 0; 1 (on) restores output voltage and current. (see Figure B-2)

Note: Power Supply at address 1 is an MBT 25-14, address 2 is an MST 6-12, and address 4 is a BOP 100-1.

*RST	Devices are located on the BITBUS (IEEE 1118) as noted above.
INST:SEL 1;*IDN?	Controller returns KEPCO,MBT,1,V4.2-3.0 (Channel 1 selected; device connected to BITBUS channel 1 is MBT 25-14, firmware version 3.0; MBT firmware version is 4.2).
INST:NSEL 2;*IDN?	Controller returns KEPCO,MST,2,V4.2-2.6 (Channel 2 selected; device connected to BITBUS channel 2 is MST 6-12, firmware version 2.6; MBT firmware version is 4.2).
VOLT? MAX	Controller returns 6.0E0 indicating a 6 volt unit (MST 6-12 at connected to channel 2).
VOLT4? MAX::INST:SEL?	Controller returns 1.0E2,4 indicating address 4 is selected and the device connected to BITBUS channel 4 (BOP 100-1) is a 100 volt unit.
*IDN?	Controller returns KEPCO,BOP,4,V4.2-1.1 (Device connected to BITBUS channel 4 is a BOP with BIT card firmware version 1.1; MBT firmware version is 4.2).
*RST;*IDN?	Controller returns KEPCO,MBT,V4.2-3.0 (Channel 1 selected; device connected to BITBUS channel 1 is MBT 25-14, firmware version 3.0; MBT firmware version is 4.2).
INST:SEL 3;*IDN?	Controller returns KEPCO,PSC,1,V4.2 (Channel 3 selected; unknown device connected to channel 3; MBT firmware version is 4.2).

**FIGURE B-2. IDENTIFYING AND SELECTING DEVICES ON BITBUS**

## B.10 MEASure[:SCALar]:CURRent[:DC]? QUERY

**MEAS:CURR?**

Syntax: Short Form: MEAS[:SCALar]:CURR[:DC]? <boolean>  
Long Form: MEASure[:SCALar]:CURRent[:DC]? <boolean>  
<boolean> = 0 or 1  
Return Value: <num\_value> (digits with decimal point and Exponent)

Description: **Measures actual current.** This query returns the actual value of output current (measured at the output terminals) as determined by the programmed value of voltage and current and load conditions. NOTE: The SCPI convention for this command allows the controller to establish the range and accuracy of the measurement if nn,nn is added after the question mark; the power supply accepts this format but sets the command warning bit (13) in the status questionable register and ignores the extra characters. (See example, Figure B-3.)

### B.11 MEASure[:SCALar][:VOLTage][:DC]? QUERY

## MEAS:VOLT?

Syntax: Short Form: MEAS[:SCAL]:VOLT[:DC]? <boolean>  
Long Form: MEASure[:SCALar]:VOLTage[:DC]? <boolean>  
<boolean> = 0 or 1  
Return Value: <num\_value> (digits with decimal point and Exponent)

Description: **Measures actual voltage.** This query returns the actual value of output voltage (measured at the output terminals) as determined by the programmed value of voltage and current and load conditions. NOTE: The SCPI convention for this command allows the controller to establish the range and accuracy of the measurement if nn,nn is added after the question mark; the power supply accepts this format but sets the command warning bit (13) in the status questionable register and ignores the extra characters. (See example, Figure B-3.)

### B.12 OUTPut[:STATe] COMMAND

## OUTP

Syntax: Short Form: OUTP[:STAT] <boolean> Long Form: OUTPut[:STATe] <boolean>  
<boolean>=(0 or OFF, 1 or ON)  
OUTP <boolean>(@n1,n2,n3) Open or close multiple channels, n1, n2, n3 = channel numbers  
OUTP <boolean>(@n1:n2) Open or close a range of channels, n1 = low, , n2 = high channel number

Description: **Enables or disables the power supply output.** Upon power up the output is enabled (OUTP ON). When OUTP OFF is executed, the programmed values of voltage and current are saved, then voltage and current are programmed to 0. When OUTP ON is executed, the power supply output is restored to the previously saved programmed values. The saved values of voltage and current can be viewed by VOLT? and CURR? queries. Related Commands: OUTP?. (See example, Figure B-3. Multiple channel examples: OUTP OFF(@5,7) closes channels 5 and 7, OUTP ON(@4:7) opens channels 4, 5, 6, and 7.

### B.13 OUTPut[:STATe] QUERY

## OUTP?

Syntax: Short Form: OUTP[:STAT]? Long Form: OUTPut[:STATe]?  
Return Value: <int\_value> (0 or 1)

Description: **Indicates whether power supply output is enabled or disabled.** Returns 0 if output disabled, returns 1 if output enabled. Related Commands: OUTP. (See example, Figure B-3.)

### B.14 [SOURce:]CURRent[:LEVel][:IMMEDIATE][:AMPLitude] COMMAND

## CURR

Syntax: Short Form: [SOUR:]CURR[:LEV][:IMM][:AMP] <exp\_value>  
Long Form: [SOURce:]CURRent[:LEVel][:IMMEDIATE][:AMPLitude] <exp\_value>  
<exp\_value> = digits with decimal point and Exponent, e.g., 2.71E+1 for 27.1

Description: **Sets programmed current level at power supply output.** This command programs output current to a specific value; actual output current will depend on load conditions. If the value exceeds the maximum for the model being programmed, error message -222,"Data out of range" is posted in output queue. (See example, Figure B-3.)

### B.15 [SOURce:]CURRent[:LEVel][:IMMEDIATE][:AMPLitude]? QUERY

## CURR?

Syntax: Short Form: [SOUR:]CURR[:LEV][:IMM][:AMP]? MIN, MAX  
Long Form: [SOURce:]CURRent[:LEVel][:IMMEDIATE][:AMPLitude]? MIN, MAX  
Return Value:<exp\_value> = digits with decimal point and Exponent, e.g., 2.71E+1 for 27.1

Description: **Returns either the programmed value, maximum value, or minimum value of current.** The CURR? query returns the programmed value of current. Actual output current will depend on load conditions. The CURR?MAX query returns the maximum current allowed for a particular model. CURR? Returns programmed current value. CURR? MAX returns maximum current allowed for power supply. CURR? MIN returns minimum current allowed for power supply (always 0). Related Commands: CURR. (See example, Figure B-3.)



- NOTES: 1. The power supply is assumed to be operating in constant voltage (CV) mode.  
 2. Examples below are intended only to illustrate command functions. Refer to PAR. 3.3.4 for programming techniques to optimize performance.

OUTP ON	Output enabled.
OUTP?	Power supply returns "1" (output enabled).
VOLT 21; CURR 1.5	Power supply output programmed to go to 21V, current limit 1.5A
INIT:CONT ON	Continuous triggers enabled.
INIT:CONT?	Power supply returns "1."
VOLT:TRIG 15;CURR:TRIG 3	Power supply output programmed to return to 15V, current limit 3A upon receipt of trigger.
*TRG	Power supply output returns to 15V,current limit 3A.
VOLT 21; CURR 5E-2	Power supply output programmed to go to 21V, current limit 0.05A
MEAS:VOLT?	If actual value of output voltage is 20.9V, power supply returns 2.09E+1.
MEAS:CURR?	If actual value of output current is 0.0483A, power supply returns 4.83E-2.
FUNC:MODE?	Returns VOLT if power supply operating in constant voltage mode, CURR for constant current mode.
CURR:TRIG?	Returns 3 (current value established by CURR:TRIG.
VOLT:TRIG?	Returns 15 (voltage value established by VOLT:TRIG.
*TRG	Power supply output returns to 21V, current limit 0.05A.
INIT:CONT 0	Triggers disabled.
INIT:CONT?	Power supply returns "0."
OUTP OFF	Output disabled.
OUTP?	Returns 0 (output disabled).
MEAS:VOLT?	Returns 0. (measured output voltage).
VOLT?	Returns 17.(programmed output voltage)/
CURR?	Returns 1.5 (programmed current)
CURR? MAX	Returns 4 (assuming maximum allowable current for power supply being addressed is 4A, e.g., MBT 25-14).
CURR? MIN	Returns 0 (minimum allowable current).
CURR?	Returns 1.5, indicating programmed current value = 1.5A.
SYST:VERS?	Returns 1997.0.

**FIGURE B-3. PROGRAMMING THE OUTPUT**

**B.16 [SOURce:]CURRent[:LEVel]TRIGgered[:AMPlitude] COMMAND**

**CURR:TRIG**

Syntax: Short Form: [SOUR:]CURR[:LEV]:TRIG[:AMP] <exp\_value>  
 Long Form: [SOURce:]CURRent[:LEVel]:TRIGgered[:AMPlitude] <exp\_value>  
 <exp\_value> = digits with decimal point and Exponent, e.g., 2.71E+1 for 27.1

Description: **Programs current value to be transferred to output by \*TRG commands.** Actual output current will depend on load conditions. If the value exceeds the maximum for the model being programmed, error message -222,"Data out of range" is posted in output queue. Related Commands: CURR. (See example, Figure B-3.)

**B.17 [SOURce:]CURRent[:LEVel]TRIGgered[:AMPlitude]? QUERY**

**CURR:TRIG?**

Syntax: Short Form: [SOUR:]CURR[:LEV]:TRIG[:AMP]?  
 Long Form: [SOURce:]CURRent[:LEVel]:TRIGgered[:AMPlitude]?  
 Return Value: <exp\_value> = digits with decimal point and Exponent, e.g., 2.71E+1 for 27.1

Description: **Returns the current value established by CURR:TRIG command.** (See example, Figure B-3.)

- NOTES: 1. The power supply is assumed to be operating in constant voltage (CV) mode.  
 2. Examples below are intended only to illustrate command functions. Refer to PAR. 3.3.4 for programming techniques to optimize performance.

VOLT 21; CURR 1.1	Power supply programmed to voltage limit 21V, 1.1A.
CURR?	Returns 1.1.
CURR 4.2	Power supply output current programmed to 3.3A, error message
	-301 posted.
CURR?	Returns 3.3.
	--- OVERCURRENT CONDITION (1 SECOND) OCCURS.
CURR?	Returns small value (approx. 1% of full scale current rating).
CURR 2.5	Power supply output current programmed to 2.5A
	--- OVERCURRENT CONDITION (1 SECOND) OCCURS.
(After 10 seconds)	
CURR?	Returns 2.5.

FIGURE B-4. PROGRAMMING CURRENT

**B.18 [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPlitude] COMMAND**

**VOLT**

Syntax: Short Form: [SOUR:]VOLT[:LEV][:IMM][:AMP] <exp\_value>  
 Long Form: [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPlitude] <exp\_value>  
 <exp\_value> = digits with decimal point and Exponent, e.g., 2.71E+1 for 27.1

Description: **Sets programmed voltage level at power supply output.** This command programs output voltage to a specific value; actual output voltage will depend on load conditions. If the value exceeds the maximum for the model being programmed, error message -222, "Data out of range" is posted in output queue. (See example, Figure B-3.)

**B.19 [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPlitude]? QUERY**

**VOLT?**

Syntax: Short Form: [SOUR:]VOLT[:LEV][:IMM][:AMP]? {MIN | MAX}  
 Long Form: [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPlitude]? {MIN | MAX}

Description: **Identifies programmed voltage, maximum allowable voltage, or minimum voltage (always 0).** The VOLT? query returns the programmed value of voltage. Actual output voltage will depend on load conditions. The VOLT?MAX query returns the maximum voltage allowed for a particular model (e.g., 25V for Kepeco's MST25-8DM). VOLT? MINReturns minimum voltage allowed for power supply (always 0). Related Commands: VOLT. (See example, Figure B-3)

**B.20 [SOURce:]VOLTage[:LEVel]TRIGgered[:AMPlitude] COMMAND**

**VOLT:TRIG**

Syntax: Short Form: [SOUR:]VOLT[:LEV]:TRIG[:AMP] <exp\_value>  
 Long Form: [SOURce:]VOLTage[:LEVel]:TRIGgered[:AMPlitude] <exp\_value>  
 <exp\_value> = digits with decimal point and Exponent, e.g., 2.71E+1 for 27.1

Description: **Programs voltage value to be transferred to output by \*TRG commands.** Actual output voltage will depend on load conditions. If the value exceeds the maximum for the model being programmed, error message -222, "Data out of range" is posted in output queue. (See example, Figure B-3.)

**B.21 [SOURce:]VOLTage[:LEVel]TRIGgered[:AMPlitude]? QUERY**

**VOLT:TRIG?**

Syntax: Short Form: [SOUR:]VOLT[:LEV]:TRIG[:AMP]?  
 Long Form: [SOURce:]VOLTage[:LEVel]:TRIGgered[:AMPlitude]?  
 Return Value: <exp\_value> = digits with decimal point and Exponent, e.g., 2.71E+1 for 27.1

Description: **Returns value representing voltage value to be programmed by \*TRG command established by VOLT:TRIG command).** (See example, Figure B-3.)

## B.22 [SOURCE:]FUNCTION:MODE COMMAND

## FUNC:MODE

Syntax: Short Form: FUNC:MODE {VOLT | CURR}  
 Long Form: FUNCTION:MODE {VOLT | CURR}

Description: **Establishes the operating mode of the power supply.** VOLT = Constant Voltage mode (CV).  
 CURR = Constant Current mode (CC).

## B.23 STATus:OPERation:CONDition? QUERY

## STAT:OPER:COND?

Syntax: Short Form: STAT:OPER:COND? Long Form: STATus:OPERation:CONDition?  
 Return Value: <int\_value> 0 to 1313 (256 + 512 + 1024).

Description: **Returns the value of the Operation Condition Register (see Table B-2).** The Operation Condition Register contains unlatched real-time information about the operating conditions of the power supply. Bit set to 1 = function enabled (active, true); bit reset to 0 = function disabled (inactive, false). (See example, Figure B-5.)

**TABLE B-2. OPERATION CONDITION REGISTER, OPERATION ENABLE REGISTER, AND OPERATION EVENT REGISTER BITS**

CONDITION	NU	CC	RLY	CV	NU	NU	NU	NU	
BIT	15-11	10	9	8	7 - 6	5	4 - 1	0	
VALUE	32,768 - 2048	1024	512	256	128 - 64	32	16 - 2	1	

CC - POWER SUPPLY IN CONSTANT CURRENT MODE  
 CV - POWER SUPPLY IN CONSTANT VOLTAGE MODE  
 NU - NOT USED  
 RLY - POWER SUPPLY RELAY IS CLOSED

## B.24 STATus:OPERation:ENABLE COMMAND

## STAT:OPER:ENAB

Syntax: Short Form: STAT:OPER:ENAB <int\_value> 0 to 1313 (1 + 32 + 256 + 1024)  
 Long Form: STATus:OPERation:ENABLE <int\_value> 0 to 1313 (1 + 32 + 256 + 1024)

Description: **Sets Operation Enable Register.** The Operation Enable Register is a mask for enabling specific bits in the Operation Event Register which will cause the operation summary bit (bit 7) of the Status Byte register to be set Bit set to 1 = function enabled (active, true); bit reset to 0 = function disabled (inactive, false). The operation summary bit is the logical OR of all the enabled bits in the Operation Event register. (See example, Figure B-5.)

## B.25 STATus:OPERation:ENABLE? QUERY

## STAT:OPER:ENAB?

Syntax: Short Form: STAT:OPER:ENAB? Long Form: STATus:OPERation:ENABLE?  
 Return Value: <int\_value> 0 to 1313 (1 + 32 + 256 + 1024).

Description: **Reads Operation Enable Register (see Table B-2).** Returns value of Operation Enable Register bits. Bit set to 1 = function enabled (active, true); bit reset to 0 = function disabled (inactive, false). (See example, Figure B-5.)

## B.26 STATus:OPERation[:EVENT]? QUERY

## STAT:OPER?

Syntax: Short Form: STAT:OPER[:EVENT]? Long Form: STATus:OPERation[:EVENT]?  
 Return Value: <int\_value> 0 to 1313 (1 + 32 + 256 + 1024).

Description: **Indicates changes in conditions monitored by Operational Event Register.** Returns the value of the Operation Event register. The Operation Event register is a read-only register which holds (latches) all events that occur. Reading the Operation Event register clears it. (See example, Figure B-5.)

## B.27 STATus:PRESet COMMAND

## STAT:PRES

Syntax: Short Form: STAT:PRES Long Form: STATus:PRESet

Description: **Disables reporting of all status events.** This command sets all bits of the Operation Condition (Table B-2) and Questionable Condition Registers to 0, preventing all status events from being reported. (See example, Figure B-5.)

NOTE: The selected power supply is assumed to be operating in cV (constant voltage) mode.

STAT:OPER:ENAB 1056	Mask enabled for CC, WTG and bits.
STAT:OPER:ENAB?	Returns 1056 (32 + 1024) (CC, WTG bits set).
STAT:QUES:ENAB 3	Mask enabled for OV and OC bits (1 + 2).
STAT:QUES:ENAB?	Returns 3 (1 + 2) indicating OV and OC bits are enabled.
STAT:PRES	Operation Condition and Questionable Condition registers are reset.
INIT:CONT ON	Continuous triggers enabled.
STAT:OPER:COND?	Power supply returns 288 (256 + 32) to indicate that power supply is constant voltage mode and Wait For Trigger is true.
STAT:OPER?	Returns 1057, e.g., indicating that since the last reading of the Operation Event Register the power supply has entered Constant Current mode, the Wait Trigger was set.
STAT:OPER?	Returns 0 indicating no changes since previous reading of the Operation Event register.
STAT:QUES?	Returns 0 (no questionable conditions occurred since previous reading
	--- OVERCURRENT CONDITION OCCURS
STAT:QUES?	Returns 2 (overcurrent protection tripped since the last STAT:QUES? query).
STAT:QUES:COND?	Returns 2, (Power supply still in overcurrent protection state).
STAT:QUES?	Returns 0, (Register cleared by previous STAT:QUES?).
STAT:QUES:COND?	Returns 2, (Power supply still in overcurrent protection state).
SYST:ERR?	Power supply returns 0, "No error" message.
INST:SEL 1	Select instrument 1
STAT:QUES?	MBT responds 4 indicating instrument 1 in current mode
INST:SEL 2	Select instrument 2
STAT:QUES?	MBT responds 8 indicating instrument 2 in voltage mode
STAT:QUES:INST:ISUM1?	MBT responds 4 indicating instrument 1 in current mode
STAT:QUES:INST:ISUM2?	MBT responds 8 indicating instrument 2 in voltage mode

FIGURE B-5. USING STATUS COMMANDS AND QUERIES

**B.28 STATus:QUESTIONable[:EVENT]? QUERY**

**STAT:QUES?**

Syntax: Short Form: STAT:QUES[EVEN]? Long Form: STATus:QUESTIONable[EVENT]?  
 Return Value: <int\_value> actual register value

Description: **Indicates questionable events that occurred since previous STAT:QUES? query.** Returns the value of the Questionable Event register (see Table B-3). The Questionable Event register is a read-only register which holds (latches) all events. Reading the Questionable Event register clears it. (See example, Figure B-5.)

**B.29 STATus:QUESTIONable:CONDition? QUERY**

**STAT:QUES:COND?**

Syntax: Short Form: STAT:QUES:COND? Long Form: STATus:QUESTIONable:CONDition?  
 Return Value: <int\_value> actual register value

Description: **Returns the value of the Questionable Condition Register (see Table B-3).** The Questionable Condition Register contains unlatched real-time information about questionable conditions of the power supply. Bit set to 1 = condition (active, true); bit reset to 0 = condition (inactive, false). (See example, Figure B-5.)

**TABLE B-3. QUESTIONABLE EVENT REGISTER, QUESTIONABLE CONDITION REGISTER AND QUESTIONABLE CONDITION ENABLE REGISTER BITS**

CONDITION	PL	OL	RE	NU	NU	NU	NU	NU	OT	NU	CE	VE
BIT	11	10	9	8	7	6	5	4	3	2	1	0
VALUE	2048	1024	512	256	128	64	32	16	8	4	2	1

PL POWER LOSS  
 OL OVERLOAD  
 RE RELAY ERROR  
 OT OVERTEMPERATURE  
 CE CURRENT ERROR  
 VE VOLTAGE ERROR  
 NU NOT USED

**B.30 STATus:QUESTIONable:ENABLE COMMAND** **STAT:QUES:ENAB**

Syntax: Short Form: STAT:QUES:ENAB <int\_value> Long Form: STATus:QUESionable:ENABLE <int\_value>

Description: **Programs Questionable Condition Enable Register (see Table B-3).** The Questionable Condition Enable Register determines which conditions are allowed to set the Questionable Condition Register; it is a mask for enabling specific bits in the Questionable Event register that can cause the questionable summary bit (bit 3) of the Status Byte register to be set. The questionable summary bit is the logical OR of all the enabled bits in the Questionable Event register. Bit set to 1 = function enabled (active, true); bit reset to 0 = function disabled (inactive, false). (See example, Figure B-5.)

**B.31 STATus:QUESTIONable:ENABLE? QUERY** **STAT:QUES:ENAB?**

Syntax: Short Form: STAT:QUES:ENAB? Long Form: STATus:QUESionable:ENABLE?  
 Return Value: <int\_value> actual register value

Description: **Reads Questionable Condition Enable Register (see Table B-3).** Power supply returns value of Questionable Condition Enable Register, indicating which conditions are being monitored. Bit set to 1 = function enabled (active, true); bit reset to 0 = function disabled (inactive, false). Related Commands: STAT:QUES?. (See example, Figure B-5.)

**B.32 STATus:QUESTIONable:INSTrument? QUERY** **STAT:QUES:INST?**

Syntax: Short Form: STAT:QUES:INST? Long Form: STATus:QUESionable:INSTrument?  
 Return Value: <int\_value> actual register value

Description: **Reads Questionable Instrument Register 0 (see Table B-4).** Unit returns value of Instrument Register 0 (inst register). The bits of this register are set when at least one bit in the specified channel's ISUM register was set previously and the specific enable bit was also set. When this register is read, bits 1 - 14 are cleared. Bit 0 which indicates the summary of the bits in Instrument Register 1 (inst1 register) remains set until the inst1 register is read.

**TABLE B-4. QUESTIONABLE INSTRUMENT REGISTER 0 BITS**

CONDITION	NU	CH 14	CH 13	CH 12	CH 11	CH 10	CH 9	CH 8	CH 7	CH 6	CH 5	CH 4	CH 3	CH 2	CH 1	INST1
BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
VALUE	32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

CH CHANNEL  
 NU NOT USED  
 INST1 INSTRUMENT REGISTER 1

**B.33 STATus:QUESTIONable:INSTrument1? QUERY** **STAT:QUES:INST1?**

Syntax: Short Form: STAT:QUES:INST1? Long Form: STATus:QUESionable:INSTrument1?  
 Return Value: <int\_value> actual register value

Description: **Reads Questionable Instrument Register 1 (see Table B-5).** Unit returns value of Instrument Register 1 (inst1 register). The bits of this register are set when at least one bit in the specified channel's ISUM register was set previously and the specific enable bit was also set. When this register is read, bits 1 - 14 are cleared. Bit 0 which indicates the summary of the bits in Instrument Register 2 (inst2 register) remains set until the inst2 register is read.

**TABLE B-5. QUESTIONABLE INSTRUMENT REGISTER 1 BITS**

CONDITION	NU	CH 28	CH 27	CH 26	CH 25	CH 24	CH 23	CH 22	CH 21	CH 20	CH 19	CH 18	CH 17	CH 16	CH 15	INST2
BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
VALUE	32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

CH CHANNEL  
 NU NOT USED  
 INST1 INSTRUMENT REGISTER 1

**B.34 STATus:QUESTionable:INSTrument2? QUERY**

**STAT:QUES:INST2?**

Syntax: Short Form: STAT:QUES:INST2? Long Form: STATus:QUESTionable:INSTrument2?  
 Return Value: <int\_value> actual register value

Description: **Reads Questionable Instrument Register 2 (see Table B-6).** Unit returns value of Instrument Register 2 (inst2 register). The bits of this register are set when at least one bit in the specified channel's ISUM register was set previously and the specific enable bit was also set. When this register is read, bits 1 - 14 are cleared.

**TABLE B-6. QUESTIONABLE INSTRUMENT REGISTER 2 BITS**

CONDITION	NU	CH 31	CH 30	CH 29	NU
BIT	15-4	3	2	1	0
VALUE	32768-16	8	4	2	1

CH CHANNEL  
 NU NOT USED

**STAT:QUES:INST:ENAB**

**B.35 STATus:QUESTionable:INSTrument:ENABle COMMAND**

Syntax: Short Form: STAT:QUES:INST:ENAB <int\_value>  
 Long Form: STATus:QUESTionable:INSTrument:ENABle <int\_value>

Description: **Programs Questionable Instrument Register 0 Enable Register (see Table B-3).** The Questionable Instrument Register 0 Enable Register is a mask which determines which channels are allowed to set Questionable Instrument Register 0.

**STAT:QUES:INST:ENAB?**

**B.36 STATus:QUESTionable:INSTrument:ENABle? QUERY**

Syntax: Short Form: STAT:QUES:INST:ENAB?  
 Long Form: STATus:QUESTionable:INSTrument:ENABle?  
 Return Value: <int\_value> actual register value.

Description: **Reads Questionable Instrument Register 0 Enable Register (see Table B-3).** Unit returns value of Questionable Instrument Register 0 Enable Register.

**STAT:QUES:INST1:ENAB**

**B.37 STATus:QUESTionable:INSTrument1:ENABle COMMAND**

Syntax: Short Form: STAT:QUES:INST1:ENAB <int\_value>  
 Long Form: STATus:QUESTionable:INSTrument1:ENABle <int\_value>

Description: **Programs Questionable Instrument Register 1 Enable Register (see Table B-3).** The Questionable Instrument Register 1 Enable Register is a mask which determines which channels are allowed to set Questionable Instrument Register 1.

## STAT:QUES:INST1:ENAB?

### B.38 STATus:QUESTIONable:INSTrument1:ENABLE? QUERY

Syntax: Short Form: STAT:QUES:INST1:ENAB? Long Form: STATus:QUESionable:INSTrument1:ENABLE?  
Return Value: <int\_value> actual register value.

Description: **Reads Questionable Instrument Register 1 Enable Register (see Table B-3).** Unit returns value of Questionable Instrument Register 1 Enable Register.

## STAT:QUES:INST2:ENAB

### B.39 STATus:QUESTIONable:INSTrument2:ENABLE COMMAND

Syntax: Short Form: STAT:QUES:INST2:ENAB <int\_value>  
Long Form: STATus:QUESionable:INSTrument2:ENABLE <int\_value>

Description: **Programs Questionable Instrument Register 2 Enable Register (see Table B-6).**The Questionable Instrument Register 2 Enable Register is a mask which determines which channels are allowed to set Questionable Instrument Register 2.

## STAT:QUES:INST2:ENAB?

### B.40 STATus:QUESTIONable:INSTrument2:ENABLE? QUERY

Syntax: Short Form: STAT:QUES:INST2:ENAB? Long Form: STATus:QUESionable:INSTrument2:ENABLE?  
Return Value: <int\_value> actual register value.

Description: **Reads Questionable Instrument Register 2 Enable Register (see Table B-3).** Unit returns value of Questionable Instrument Register 2 Enable Register.

### B.41 STATus:QUESTIONable:INSTrument:ISUM? QUERY

## STAT:QUES:INST:ISUM?

Syntax: Short Form: STAT:QUES:INST:ISUM? Long Form: STATus:QUESionable:INSTrument:ISUM?  
Return Value: <int\_value> actual register value

Description: **Reads ISUM Register (see Table B-3).** Unit returns value of ISUM Register for selected channel This register is identical in function to the QUESTIONable register for the selected channel

## STAT:QUES:INST:ISUM:ENAB

### B.42 STATus:QUESTIONable:INSTrument:ISUM:ENABLE COMMAND

Syntax: Short Form: STAT:QUES:INST:ISUM:ENAB <int\_value>  
Long Form: STATus:QUESionable:INSTrument:ISUM:ENABLE <int\_value>

Description: **Programs Questionable Instrument ISUM Enable Register (see Table B-3).**The Questionable Instrument ISUM Enable Register is a mask which determines which conditions are allowed to set the Questionable Instrument ISUM Register for the selected channel.

## STAT:QUES:INST:ISUM:ENAB?

### B.43 STATus:QUESTIONable:INSTrument:ISUM:ENABLE? QUERY

Syntax: Short Form: STAT:QUES:INST:ISUM:ENAB?  
Long Form: STATus:QUESionable:INSTrument:ISUM:ENABLE?  
Return Value: <int\_value> actual register value

Description: **Reads ISUM Enable Register (see Table B-3).** Unit returns value of ISUM Enable Register for selected channel.

### B.44 SYSTem:COMMunication:GPIB:ADDRess COMMAND

## SYST:COMM:GPIB:ADDR

Syntax: Short Form: SYST:COMM:GPIB:ADDR<INT VAL> 1 to 30  
Long Form: SYSTem:COMMunication:GPIB:ADDRess<INT VAL> 1 to 30

Description: **Sets selected power supply GPIB address.**

#### **B.45 SYSTem:COMMunication:SERial:BAUD COMMAND      SYST:COMM:SER:BAUD**

Syntax:      Short Form: SYST:COMM:SER:BAUD {19200 | 9600 | 4800 | 2400}  
              Long Form: SYSTem:COMMunication:SERial:BAUD {19200 | 9600 | 4800 | 2400}

Description: **Sets the unit to operate at the specified baud rate.**

#### **B.46 SYSTem:COMMunication:SERial:ECHO COMMAND      SYST:COMM:SER:ECHO**

Syntax:      Short Form: SYST:COMM:SER:ECHO {ON | OFF}  
              Long Form: SYSTem:COMMunication:SERial:ECHO {ON | OFF}

Description: **Enables (ON) or disables (OFF) echo mode** (see PAR. 3.3.3.2) Sending ON causes all subsequent characters to be echoed back. Sending OFF turns off the character echo after the next line terminator character. The \*RST command has no effect on echo status

#### **B.47 SYSTem:COMMunication:SERial:PACE COMMAND      SYST:COMM:SER:PACE**

Syntax:      Short Form: SYST:COMM:SER:PACE {NONE | XON}  
              Long Form: SYSTem:COMMunication:SERial:PACE {NONE | XON}

Description: **Enables (XON) or disables (NONE) data flow control via the serial interface** (see PAR. 3.3.3.4)

#### **B.48 SYSTem:COMMunication:SERial::PROMpt COMMAND      SYST:COMM:SER:PROM**

Syntax:      Short Form: SYST:COMM:SER:PROM {ON | OFF}  
              Long Form: SYSTem:COMMunication:SERial:PROMpt {ON | OFF}

Description: **Enables (ON) or disables (OFF) prompt** (see PAR. 3.3.3.3). Sending ON causes the unit to return > character after the command is parsed.

#### **B.49 SYSTem:ERRor[:NEXT]? QUERY      SYST:ERR?**

Syntax:      Short Form: SYST:ERR[:NEXT]?                      Long Form: SYSTem:ERRor[:NEXT]?  
              Return Value: <int\_value,string>

Description: **Posts error messages to the output queue.** Returns the next error number followed by its corresponding error message string from the instrument error queue. The error queue is a FIFO (first in first out) buffer that stores errors as they occur. As it is read, each error is removed from the queue and the next error message is made available. When all errors have been read, the query returns 0,"No error". If more than 15 errors are accumulated, it will overflow. The oldest errors stay in the queue but the most recent errors are discarded. The last error in the queue will be -350,"Too many errors." Error messages are defined in Table B-7.

#### **B.50 SYSTem:ERRor:CODE? QUERY      SYST:ERR:CODE?**

Syntax:      Short Form: SYST:ERR:CODE?                      Long Form: SYSTem:ERRor:CODE?

Description: Returns the three character error code without the ASCII definition string. The error codes are defined in table B-7 (See example, Figure B-3.)

#### **B.51 SYSTem:ERRor:CODE:ALL? QUERY      SYST:ERR:CODE:ALL?**

Syntax:      Short Form: SYST:ERR:CODE:ALL?                  Long Form: SYSTem:ERRor:CODE:ALL?  
              Return Value:

Description: Returns a comma-separated list of all error codes. A maximum of 15 codes will be returned; if the queue is empty, the power supply returns 0. The error codes are defined in table B-7

#### **B.52 SYSTem:LANGuage COMMAND      SYST:LANG**

Syntax:      Short Form: SYST:LANG CIIL                      Long Form: SYSTem:LANGuage CIIL

Description: **This command allows the CIIL command language to be used to program the power supply.** (CIIL is included to provide compatibility with earlier Kepco equipment.) Once CIIL is selected, the CIIL command 'GAL' followed by the command 'SCPI' must be sent for the power supply to respond to SCPI commands.



**TABLE B-7. ERROR MESSAGES**

ERROR MESSAGE	EXPLANATION
0, "No error"	No error
-100, "Command error"	Command and data understood, but more information included which is not recognized.
-102, "Syntax error"	First 4 characters recognized, subsequent characters not recognized.
-103, "Invalid separator"	For example, VOLT.10 received instead of VOLT:10
-108, "Parameter Not Allowed Error"	Volt12 sequence, channel number is invalid
-109, "Missing parameter"	For example, VOLT instead of VOLT 21.
-111, "Header separator error"	Missing space between volt and value or ; missing
-113, "Undefined header"	First 4 characters could not be identified as legal command. For example, command VLT instead of VOLT
-120, "Numeric data error"	Expected number but other characters were detected
-121, "Invalid character in number"	Volt 1,500 ( comma not allowed)
-123, "Exponent too large"	Exponent E+3 or greater is invalid.
-141, "Invalid character data"	For example OUTP OFD or OUTP STOP instead of OUTP OFF
-150, "String data error"	Invalid characters were detected in numeric entry. For example E.1 instead of E+1 or 4d3 instead of 4.3.
-222, "Data out of range"	Value exceeds power supply rating
-223, "Data format error"	Multiple decimals in digit, Multiple E, etc.
-224, "Illegal parameter value"	For example, OUTP 2 instead of OUTP 1
-241, "Hardware missing"	Requesting device 2 status (INST:NSEL 2)
-350, "Queue overflow"	More than 15 errors are in queue.
-410, "Query interrupted"	New command sent before data from previous query read. Previous query data lost.
-430, "Query Deadlocked"	Over 255 characters received in single input string"

**B.53 SYSTem:SET COMMAND**

**SYST:SET**

Syntax: Short Form: SYSTem:SET {CM0 | CM1} Long Form: SYSTem:SET {CM0 | CM1}

Description: Sending SYST:SET CM1 sets the unit to operate in compatible mode and have all GPIB functions compatible with software version 1.2 and lower units. Sending SYST:SET CM0 sets the unit to be fully SCPI 1997 compliant.

**B.54 SYSTem:VERSion QUERY**

**SYST:VERS?**

Syntax: Short Form: SYST:VERS? Long Form: SYSTem:VERSion?  
Return Value: <int\_value>.<int\_value> (YYYY.V)

Description: **Identifies SCPI Version implemented.** Returns SCPI Version number: YYYY = year, V = Revision number for specified year (e.g 1997,0.).



## APPENDIX C - CIIL COMMAND DEFINITIONS

### C.1 INTRODUCTION

This appendix defines the CIIL commands used with the MBT Power Supply. Table C-1 provides a quick reference of all CIIL commands used in the MBT Power Supply.

**TABLE C-1. CIIL SUBSYSTEM COMMAND/QUERY INDEX**

COMMAND	PAGE	COMMAND	PAGE
CLS	C-4	OPN	C-4
CNF	C-4	RST	C-4
FNC	C-1	SET	C-3
FTH	C-2	SRN	C-3
GAL	C-6	SRX	C-3
INX	C-2	STA	C-5
IST	C-4		

FNC

- Syntax:** Stimulus mode: FNC DCS :CHnn <SET Command>  
 Sensor mode: FNC DCS <VOLT or CURR command> :CHnn
- Function:** This operator is used with either the SET command to program a power supply's output (stimulus mode), or with the VOLT and CURR commands to read its output settings (sensor mode).
- Description:** The first operand contains the three (3) letter mnemonic pertaining to the device on the control bus, in this case DCS (Direct Current Source). If a reading is being set up, the modifier VOLT or CURR follows. The next operand is used to select the specific channel of the device being programmed or read from. The MBT can control up to 27 power supplies/power modules with control bus addresses in the range of 1 to 31.
- Example:**
- |   |  |
|---|--|
| FNC DCS :CH12 SET VOLT 15<br>FNC DCS :CH12 SET CURR 3<br>FNC DCS VOLT :CH03<br><br>FNC DCS CURR :CH21 | Power supply at node address 12 commanded to 15V<br>Power supply at node address 12 commanded to 3A<br>Power supply at node address 3 returns value which represents actual output voltage<br>Power supply at node address 21 returns value which represents actual output current |
|---|--|

NOTE: Actual output voltage and current depends on whether output is enabled or disabled and load conditions

**FIGURE C-1. FNC — FUNCTION COMMAND**

# INX

**Syntax:** INX VOLT (initiate voltage reading)  
INX CURR (initiate current reading)

**Function:** Commences a data acquisition process in accordance with the preceding FNC command.

**Description:** The response to the INX command is a dynamic time-out value, unless a catastrophic error condition exists, in which case an error message will be returned. If the time-out value returned is not zero, this indicates the power supply's output voltage or current has not yet settled. A time delay should be observed before proceeding with the FTH command, or the command may be repeated until a zero value is returned, but the preceding FTH command must also be repeated.

**Example:** INX VOLT                      Power supply initiates voltage reading)  
FTH VOLT                      Power supply sends voltage reading to controller)

**FIGURE C-2. INX — INITIATE OP CODE COMMAND**

# FTH

**Syntax:** FTH VOLT (fetch voltage reading)  
FTH CURR (fetch current reading)

**Function:** Commands the previously designated power supply to return the requested data reading.

**Description:** This command must immediately follow an INX command. The value returned is the value of the output voltage or current, whichever was requested, unless a catastrophic error condition exists, in which case an error message will be returned. The value observed will be in scientific notation.

**Example:** INX VOLT                      Power supply initiates voltage reading)  
FTH VOLT                      Power supply sends voltage reading to controller)

**FIGURE C-3. FTH — FETCH COMMAND**

# SET, SRX, SRN

**Syntax:** FNC DCS :CHnn SET VOLT <value> CURL <value>  
FNC DCS :CHnn SET CURR <value> VLTL <value>  
SRX               Set Range Maximum  
SRN               Set Range Minimum

**Function:** This operator is used in conjunction with FNC (in stimulus mode) to specify the output mode of the power supply being programmed.

**Description:** The first operand is the noun modifier and the second operand specifies the value. The first operand field of the command contains the four(4) letter mnemonic for the output mode of the power supply. The choices are:

VOLT	VOLTAGE MODE OPERATION
VLTL	VOLTAGE LIMIT
CURR	CURRENT MODE OPERATION
CURL	CURRENT LIMIT

The second operand field of the command contains the value assigned to the chosen output mode. This value may be specified as accurately as the resolution of the power supply allows. It can be directly specified in ASCII integer, decimal, or in scientific notation.

There may be two (2) set commands, separated by a space (ASCII 32), for each power supply being programmed. The following are the only allowable combinations:

VOLT with CURL  
CURR with VLTL

The limit parameter (CURL or VLTL) may not be set without the main parameter. A polarity sign may precede the VOLT or CURR value so that the power supply's polarity may be selected.

In the case of Kepco's MBT power supplies, the two related Op Codes, SRX and SRN are functionally identical to the SET command, since there is only one range, 0 - maximum. The commands are included only for compatibility.

**Example:** FNC DCS :CH12 SET VOLT 5 CURL 3 Power supply at node address 12 commanded to 5V  
(Voltage mode) with current limit of 3A.  
FNC DCS :CH08 SET CURR 2 VLTL 17 Power supply at node address 8 commanded to 2A  
(Current mode) with voltage limit of 17V

FIGURE C-4. SET COMMAND

## OPN, CLS

<b>Syntax:</b>	OPN :CHnn CLS :CHnn
<b>Function:</b>	These commands are used to connect or disconnect the power supply from the load (effective for MR and MGR options only).
<b>Description:</b>	OPN                 Disconnects the load from the power supply specified by the operand. CLS                 Connects the load to the power supply specified by the operand.
<b>Example:</b>	OPN :CH22         Opens the relay of the power supply at node address 22. CLS :CH14         Closes the relay of the power supply at node address 14.

**FIGURE C-5. OPN, CLS — OPEN, CLOSE RELAY COMMANDS**

## RST

<b>Syntax:</b>	RST DCS :CHnn
<b>Function:</b>	This operator is used to return a power supply to its power-on state. The output voltage and current are programmed to zero and the output relay of MR and MGR models is opened.
<b>Example:</b>	RST DCS :CH13         The power supply at node address 13 is reset.

**FIGURE C-6. RST — RESET COMMAND**

## CNF, IST

<b>Syntax:</b>	CNF or IST
<b>Function:</b>	Causes power supply to execute confidence test.
<b>Description:</b>	The CNF operator commands the MBT to execute the confidence test procedure defined for the MBT power supplies (IST is functionally identical to CNF for MBT power supplies. The procedure consists of opening all power relays, programming voltage and current to their maximum values, switching polarity, checking for error flags, then programming voltage and current to zero. The results of CNF are obtained through the STA command.
<b>Example:</b>	CNF                     All power supplies in the daisy chain execute confidence test. IST                     All power supplies in the daisy chain execute self test.

**FIGURE C-7. CNF, IST — CONFIDENCE TEST, INTERNAL SELF TEST COMMANDS**

# STA

**Syntax:** STA

**Function:** Causes power supply to return operating status to controller.

**Description:** This operator commands the power supply to report its present operating status. Status is reported in the form of a message (character string) as defined below. Any catastrophic error conditions (indicated by \* in the table below) which exist will be reported, until the error condition is corrected. As required by CIIL, all error messages begin with an ASCII "F" (Fault) followed by a 2 digit code, "07" (Halt). The code that follows (SCSnn) indicates the type of device and the channel number. The next 3 digit code describes the nature of the fault: "DEV" for device related errors or "MOD" for non-device errors, such as syntax.

**TABLE C-2. CIIL ERROR MESSAGES**

ERROR MESSAGE	EXPLANATION
F07 DCSnn DEV Power Loss	The power supply has lost its input power. *
F07 DCSnn DEV Crowbarred (MAT, MBT)	A shutdown occurred due to overvoltage or overcurrent. *
F07 DCSnn DEV Device Turned Off (BOP)	
F07 DCSnn DEV Output Fault (MST)	
F07 DCSnn DEV Over Temperature	A shutdown occurred due to thermal causes. *
F07 DCSnn DEV Overload	The voltage or current limit point was exceeded. *
F07 DCSnn DEV Voltage Fault	The output voltage is not within limits (voltage mode). *
F07 DCSnn DEV Current Fault	The output current is not within limits (current mode). *
F07 DCSnn DEV Relay Not Opened	The power relay failed to open. *
F07 DCSnn DEV Relay Not Closed	The power relay failed to close. *
F07 DCSnn DEV Polarity Error	The output polarity is not correct. *
F07 DCSnn DEV Load Path Fault	Open or miswired load or error sense leads detected. *
F07 DCSnn MOD Invalid Command	Improper syntax was used. **
F07 DCSnn DEV Not Ready	The output voltage or current has not settled. **
F07 DCSnn DEV Device Not Present	The specified power supply was not present during power up or during the last DCL. **
F07 DCSnn DEV Device Not Responding	The power supply has failed to communicate to the controller. **
F07 DCSnn DEV Invalid Voltage Range	The programmed voltage is outside the power supply's range. **
F07 DCSnn DEV Invalid Current Range	The programmed current is outside the power supply's range. **
F07 DCSnn DEV Set Modifier Error	An improper SET command was sent. **
F07 DCSnn DEV Invalid Device ID	The selected channel was not between 1-31. **
*Catastrophic error	
**Non-Catastrophic error	

**FIGURE C-8. STA — STATUS COMMAND**

# GAL

**Syntax:** GAL

**Function:** Enables utility commands which change error handling defaults.

**Description:** This command enables the utility commands listed below. If no GAL command is issued, the default conditions are T0, F1, and P1. Once the GAL command is issued, the appropriate utility command may be sent to change the default condition.

**TABLE C-3. CIIL ERROR HANDLING UTILITY COMMANDS**

UTILITY COMMAND	DESCRIPTION
T0	Instructs non-catastrophic error messages to be erased from memory if any command is sent prior to STA command.
T1	Instructs non-catastrophic error messages to be stacked in memory until STA command is sent.
F0	Fetch Mode 0. Ignores error conditions when performing FTH command.
F1	Fetch Mode 1. Reports any error conditions which are present during FTH command.
P0	Power Loss Mode 0. Reports a power loss message only once until power is restored to the power module.
P1	Power Loss Mode 1. Continuously reports a power loss message until power is restored to the power module.

Note: The defaults are T0, F1 and P1

**Example:** GAL Enables utility commands.  
F0 Causes controller to ignore error conditions during FTH command.

**FIGURE C-9. GAL — GO TO ALTERNATE LANGUAGE COMMAND**