OPERATOR'S MANUAL

MST 488-27HT
POWER MODULE CONTROLLER

INTERACTIVE DIGITALLY CONTROLLED POWER MODULE SYSTEM

KEPCO INC.
An ISO 9001 Company.

CE

MODEL
MST 488-27HT
POWER MODULE CONTROLLER

ORDER NO.	REV. NO

IMPORTANT NOTES:

1) This manual is valid for the following Firmware Versions:

FIRMWARE VERSION	NOTE.
10.35 and higher	

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 firmware version 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 firmware version number.

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KEPCO®
THE POWER SUPPLIER™

P/N 243-1407-r3

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Conditions of Conformance
Programming Module

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 either within an equipment rack or a KEPCO Rack Adapter RA 55 or CA 400.

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

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

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

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

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

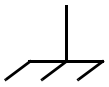
2. Grounding

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

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

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

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



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

3. Electric Shock Hazards

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

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

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

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

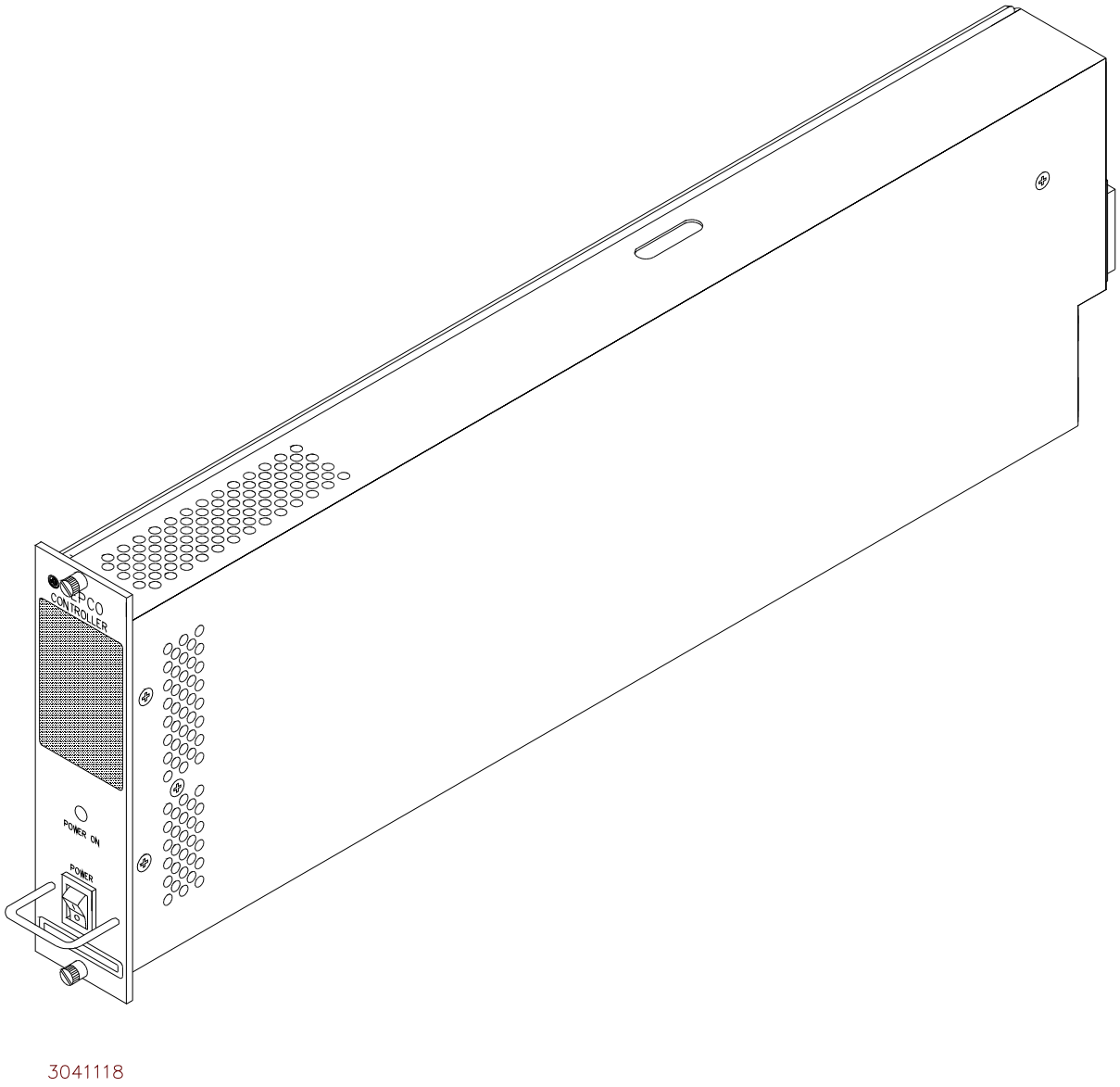


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FIGURE 1-1. MST488-27 POWER MODULE CONTROLLER

SECTION 1 - INTRODUCTION

1.1 SCOPE OF MANUAL

This manual contains the specifications and instructions for the installation and operation of the Model MST 488-27HT Power Module Controller (Figure 1-1), part of the Kepco Model 27553 Mainframe manufactured by Kepco, Inc., Flushing, N.Y. U.S.A.

This controller is designed to control and communicate with both Kepco's MST-MHT and standard MST Series of Power Modules. Information regarding the MST-MHT and standard MST Power Modules can be found in the respective Operator Manuals for MST-MHT Series and MST Series, and can be downloaded from the Kepco web site at

www.kepcopower.com/support/opmanls.htm#mst

1.2 GENERAL DESCRIPTION

NOTE: References to MST power modules in this manual refer to both Kepco's standard MST (non-MHT) power modules as well as the MST-MHT power modules designed to emulate the Keysight 61000© Series unless otherwise specified.

The Kepco Model 27553 Mainframe is a modular power system that is a functional replacement for a Keysight 66000© Mainframe. Model 27553 is comprised of an RA 55H Rack adapter which has nine slots and the MST 488-27HT Controller which is installed in one of the RA 55H slots. The MST 488-27HT Controller is designed to program, control and monitor Kepco MST (non-MHT) and MST-MHT power modules installed in the remaining slots of the RA 55H. Kepco's MST-MHT Series power modules are functional replacements for Keysight 61000© Series power modules,.

The MST-MHT Series, has lower noise specifications than the non-MHT MST units, and has a fixed overvoltage detector in place of the tracking overvoltage detector found in the non-MHT models. This allows the MST-MHT voltage protection logic to emulate Keysight 61000 modules. Non-MHT MST modules can also be used with overvoltage protection but since the overvoltage fault is a tracking detector, if the output is injected with an overvoltage condition, the unit faults, requiring a power cycle to continue operating. Non-MHT MST voltage protection operates normally during voltage changes as overvoltage tracking is disabled during the voltage transition.

The MST 488-27HT Controller power up state allows Kepco's MST-MHT power modules to emulate the Keysight 61000© Series power modules with existing test programs and test requirement documents. The MST 488-27HT Controller can be controlled as an MST 488-27 by sending a command (see PAR. B.8) during software initialization to allow the MST 488-27HT controller and the MST power modules to operate as defined in the MST 488-27 (non HT suffix) Programmer Operator Manual which can be downloaded from the Kepco web site at

www.kepcopower.com/support/opmanls.htm#mst

The MST 488-27 drivers (Labview and IVI) automatically perform this configuration during the KpDCpwrInitalizewithOptions function.

The MST 488-27HT has the capability to program, control and monitor the outputs of up to 27 Kepco MST power supplies (power modules) by adding additional RA 55H Rack Adapters to the bus. The MST 488-27HT communicates with its Host computer over the IEEE 488 bus (GPIB) using SCPI (Standard Commands for Programmable Instruments) Language. A remote terminal program can allow communication via the RS 232-C (EIA 232) standard serial communications bus. The MST 488-27HT communicates with the MST series using the IEEE1118 two-wire serial bus, hereafter referred to as the Control Bus, which allows control over distances up to a maximum of 1000 feet (300 meters) (see Figure 1-2).

The IEEE 488 GPIB interface functions implemented by the MST 488-27HT controller are defined by the IEEE 488 Standard, and described in Table 3-3.

The MST 488-27HT Controller interfaces to MST power modules via the RA 55H Rack Adapter; (part of Kepco's MSP 27553 mainframe). Interconnection to the Host Computer on the GPIB is made via an IEEE 488 standard cable. If a remote terminal program is used for communications between the controller and a computer terminal, a 9 pin null-modem RS 232-C connector/cable is required. Controllers are available in many form factors for RS232, IEEE-488 and VXI; consult factory for availability of the HT type controller.

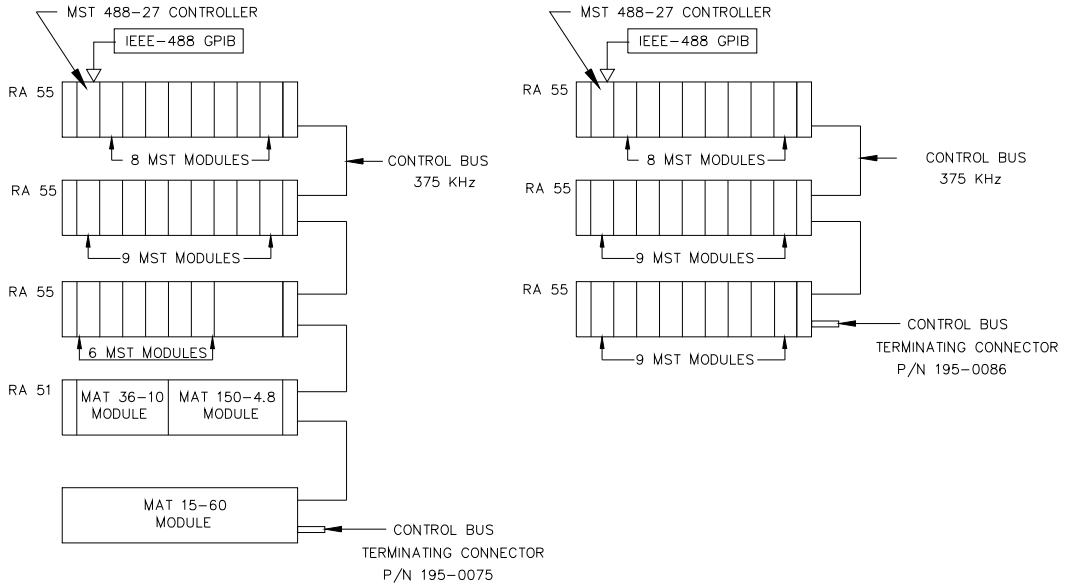
The MST 488-27HT Controller is comprised of a single-board computer (SBC) and power supply housed in a 1/9 Rack (7" high by 1-3/4" wide by 20-1/4" deep) case (see Figure 1-3).

1.3 SPECIFICATIONS (REFER TO FIGURE 1-3)

The Host Computer can set the output voltage with current limit, or the output current with voltage limit. The Host Computer can then have the MST 488-27HT read back the actual output voltage and current delivered by each of the MST power modules to their respective loads. The MST 488-27HT is continually polling all of the power modules on the Control Bus for overvoltage, overcurrent, and other errors. All data transmissions over the GPIB are ASCII encoded. The values for the command parameters can be written in integer, decimal or scientific notation. The responses from the MST 488-27HT are detailed in Section 3 of this manual..

1.4 EQUIPMENT SUPPLIED

A terminator, Kepco P/N 195-0086, is included with each controller to provide proper termination of the IEEE 1118 control bus. In configurations where power modules are daisy chained on the IEEE 1118 control bus (see Figure 1-1), the last power module control bus outlet (in the daisy chain) must be terminated with the IEEE Control Bus Terminator supplied with the controller to reduce spurious noise and provide proper impedance matching.



NOTES: 1. MAXIMUM OF 27 UNITS CAN BE CONTROLLED (ANY COMBINATION)
2. TERMINATOR MUST BE CONNECTED EVEN IF ONLY ONE RACK ADAPTER USED.
3. CONFIGURATIONS OTHER THAN DAISY CHAIN NOT SUPPORTED.

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FIGURE 1-1. CONTROLLER TO POWER MODULE INTERFACE (TYPICAL)

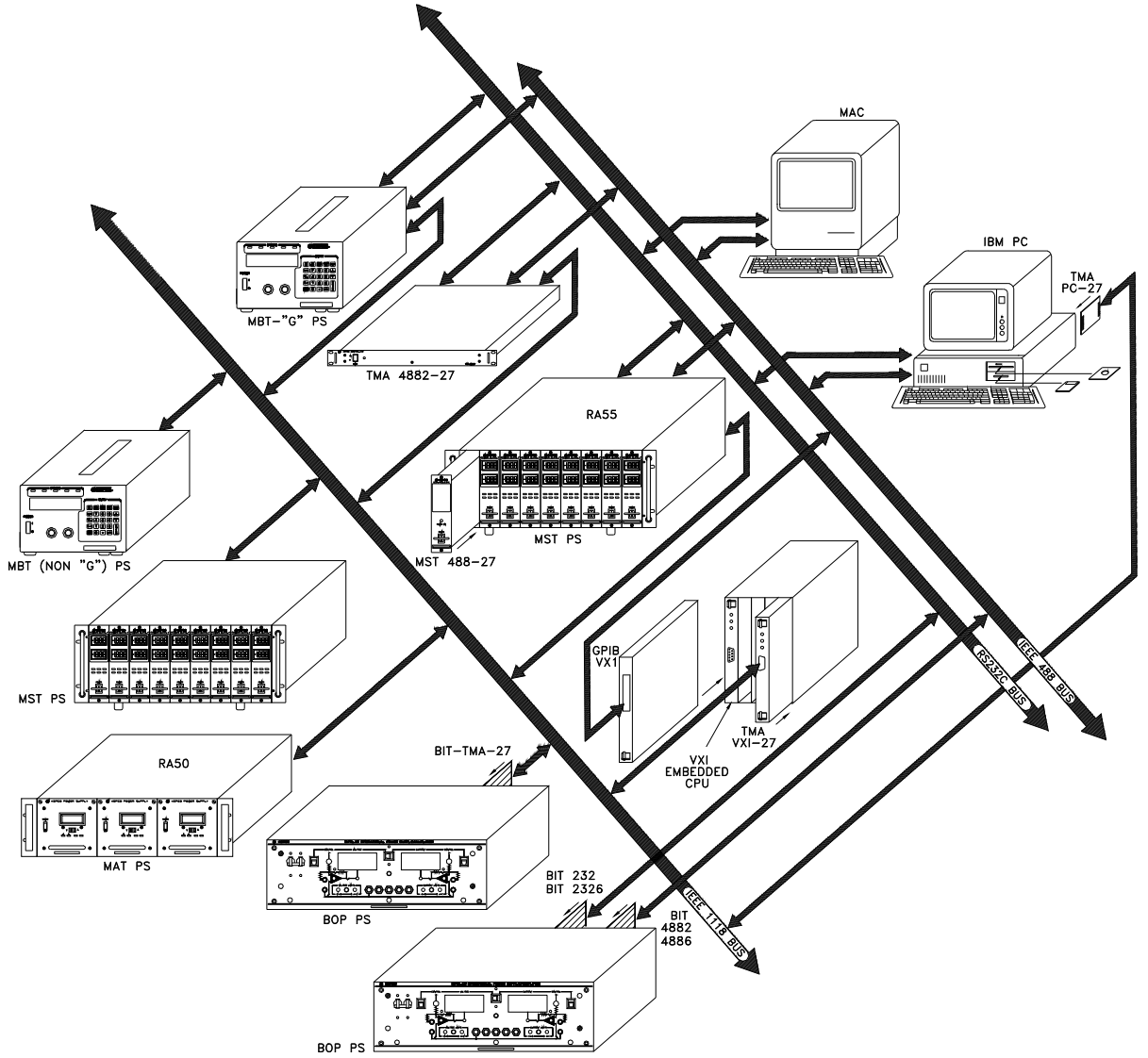


FIGURE 1-2. REMOTELY CONTROLLED POWER SUPPLY CONFIGURATIONS USING KEPCO PRODUCTS

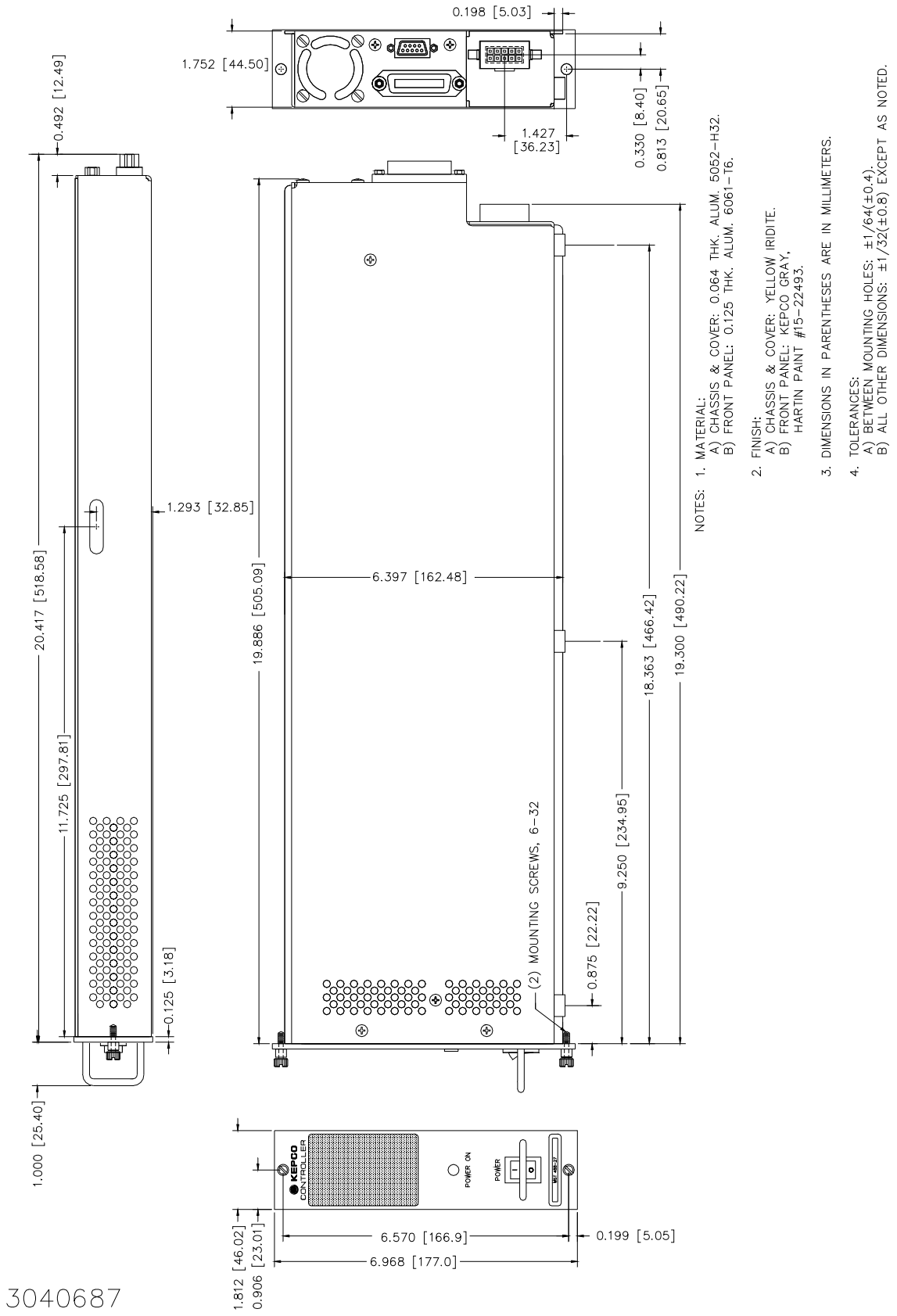


FIGURE 1-3. MST 488-27HT CONTROLLER OUTLINE DRAWING

1.4.1 VOLTAGE PROTECTION

Voltage protection is a feature of the MST 488-27HT and provides the ability to shut down both MST-MHT and MST (non-MHT) power models when an overvoltage exists. A shutdown is not a fault condition; it sets a bit in the questionable register of the MST 488-27HT and causes the power module to set the voltage DAC (Digital-to-Analog Converter) to 0, set the current DAC to 2 and open the relays. There are differences in Overvoltage protection functionality between MST-MHT and MST (non MHT) modules

MST-MHT Power Modules. The MST-MHT Operator manual describes the maximum value of overvoltage protection for each of the MST-MHT models. Overvoltage protection can not be disabled on MST-MHT models.

MST (Non-MHT) Power Modules. MST (non-MHT) models also support overvoltage protection but the maximum protection value is the same as the model's rated (nominal) voltage (e.g., 36V for MST 36-5M). This means that if overvoltage protection is set to maximum, the unit will shut down when the rated voltage is reached (e.g., 36V for MST 36-5M). If it is important that the unit achieve the rated output voltage, do not enable overvoltage protection. Overvoltage protection is disabled upon power up of the non-MHT module, or when an ***RST** command has been issued. For non-MHT models **both** overvoltage and overcurrent protection are enabled by the **CURR:PROT:STAT ON** command. Both protections must be either enabled or disabled; enabling one without the other is not possible. **CURR:PROT:STAT OFF** disables both overcurrent and overvoltage protection.

1.4.2 FUNCTIONAL EQUIVALENCE

The Kepco MST 488-27HT is functionally equivalent but not an exact replacement of the Keysight 66000. If the command string **VOLT:PROT? MAX** is issued to the Keysight 66000 35-volt unit and the Kepco MST 36-volt unit, the response will be slightly different. The Keysight 66000 unit responds with +4.20000E1 while the Kepco unit responds with 4.2E1.

The Kepco MST returns the converted DAC (Digital-to-Analog Converter) value when a **VOLT?** or **CURR?** command is sent to the unit. For this reason when sending **VOLT 10;VOLT?** to the Kepco MST it does not respond with +1,00000E1, but instead responds with 9.9997E0. This response is ±0.015% of the set point due to the rounding of the actual DAC setting.

1.4.3 COMMANDS SUPPORTED.

The MST 488-27HT supports the commands listed in Table A-1 of Appendix A with no modification in performance. Appendix B shows the commands that are supported but provide slightly different outcomes. Some of the commands included in Appendix B are included in the MST 488-27HT to allow proper calibration or provide the ability to switch the MST 48827HT to function as a non-HT MST 488-27 Programmer.

1.5 ACCESSORIES

Accessories for the MST 488-27HT are listed in Table 1-1.

TABLE 1-1. ACCESSORIES

ITEM	FUNCTION	PART NUMBER
Terminator - 5-pin connector	Termination for daisy chain on IEEE 1118 bus.	195-0075
Terminator - 9-pin connector		195-0086
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 MST 488-27HTand 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, ~ 6 ft. (2 m)	Daisy chain MST 488-27HTand Kepco Power Modules with 9-pin connector on IEEE 1118 bus.	118-0844
Cable - two 9-pin connectors, ~ 12 ft. (4 m)		118-0853

SECTION 2 - INSTALLATION

2.1 UNPACKING AND INSPECTION

The Model MST 488-27HT has been carefully inspected and tested prior to packing. Inspect the shipping carton upon receipt for evidence of damage during transit. Save the original packing material. If any indication of damage is found, file a claim immediately with the responsible transport service.

For repairs of a product damaged in shipment, contact the Kepco Factory Representative nearest you or the Kepco Sales Department directly for further instruction.

2.2 INSTALLATION

The installation and set-up procedure for the MST 488-27HT consists of the following steps:

1. Set Device Address (PAR. 2.2.1).

2. Set Shield Ground Jumper (PAR. 2.2.3).

3. Perform final system interconnections (PAR. 2.2.4).

2.2.1 SET (GPIB) DEVICE ADDRESS (SEE FIGURE 2-1)

A single set of DIP switches, accessible through an access hole on the top (see Figure 2-1), are used to set the primary GPIB Device Address (the factory default is 6) as well as enable two Mainframe 66000 functions that are not directly supported by the MST 488-27HT. The following paragraphs explain how to proceed.

NOTE: MST-MHT modules are addressed using secondary addresses. Refer to MST-MHT Operator Manual for configuration details (see PAR. 1.1).

2.2.1.1 USING GPIB

The Device Address is the permanent Listener and Talker address of the MST 488-27HT on the GPIB. It is factory preset to address 6. If a different Device Address is required in your system, proceed as follows. There are 31 (0-30) possible choices (See Table 2-1).

1. Place MST 488-27HT power module controller with the top of the unit facing you, front panel to the right.

2. The Device Address DIP switches are positions 1 through 5 (from right to left, see Figure 2-1). These switches are preset by Kepco to address 6. For other device addresses set them according to Table 2-1.

TABLE 2-1. DEVICE ADDRESS SELECTION

DECIMAL ADDRESS	SELECTOR SWITCH SECTION (SIGNAL LINE)				
	A5	A4	A3	A2	A1
0	0	0	0	0	0
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

2.2.2 ADDITIONAL GPIB ADDRESS SWITCH FUNCTIONS (SEE FIGURE 2-1)

The GPIB address switch has two additional program mode bits P1 (DIP switch position A6, see Figure 2-1) and P2 (position A7). P1 and P2 provide a method to enable two common functions of the Mainframe 66000© that are not directly supported.

The Mainframe 66000© trigger commands are designed to allow a **`*TRG`** from one power module to cause other power modules to also apply trigger values to their outputs. Setting P2 to a 1 creates a functionality which is equivalent to sending **`TRIG:SOUR EXT`** and **`TRIG:LINK TDC`** to all power modules in the system, even though these commands are not supported by the MST 488-27HT controller.

The Mainframe 66000© **OUTP:TTLT** command allows an overvoltage shutdown or current mode shutdown of one power supply to also shutdown (reset) the other selected power modules, or for an *RST command sent to one power supply to cause all power modules in the mainframe to be reset. Setting P1 switch to 1 provides this functionality.

P1- ***RST** sent to any secondary address will apply ***RST** functionality to all power modules connected to the controller. Also causes detection of overvoltage or current mode to reset all power modules connected to the controller.

P2 - ***TRG** sent to any secondary address will apply ***TRG** to all power modules connected to the controller.

2.2.3 SET SHIELD GROUND JUMPER (SEE FIGURE 2-1)

The jumper sets the Shield Ground state for the AC/control bus connector and is accessible after the cover is removed:

- JUMPER INSTALLED = shield grounded (factory default)
- JUMPER REMOVED = shield not grounded

2.2.4 INSERTION

To insert the MST 488-27HT Controller in the RA 55 Rack Adapter, proceed as follows:

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

CAUTION

When inserting the Controller into a Rack Adapter under power, the Controller POWER switch must be placed in the OFF position prior to insertion.

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

2.2.5 REMOVAL

To remove the Controller from the RA 55 Rack Adapter, proceed as follows:

CAUTION

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

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

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

2.2.6 FINAL SYSTEM INTERCONNECTIONS

1. Install the MST 488-27HT in the left-most slot of the RA 55 Rack Adapter (see PAR. 2.2.4). If the rack adapter has a plate used for mounting a power module connector in slot 9, the plate must first be removed to accommodate the MST 488-27HT controller by removing four screws securing the plate to the rack adapter chassis.

2. Install all power modules in the RA 55 Rack Adapter.

3. Connect the MST 488-27HT to the GPIB.

4. All power module outputs should be connected to their respective loads. For MST Power Module Calibration see the MST Operator's Manual.

5. Connect input power to the RA 55 Rack Adapter in accordance with the RA 55 Rack Adapter manual.

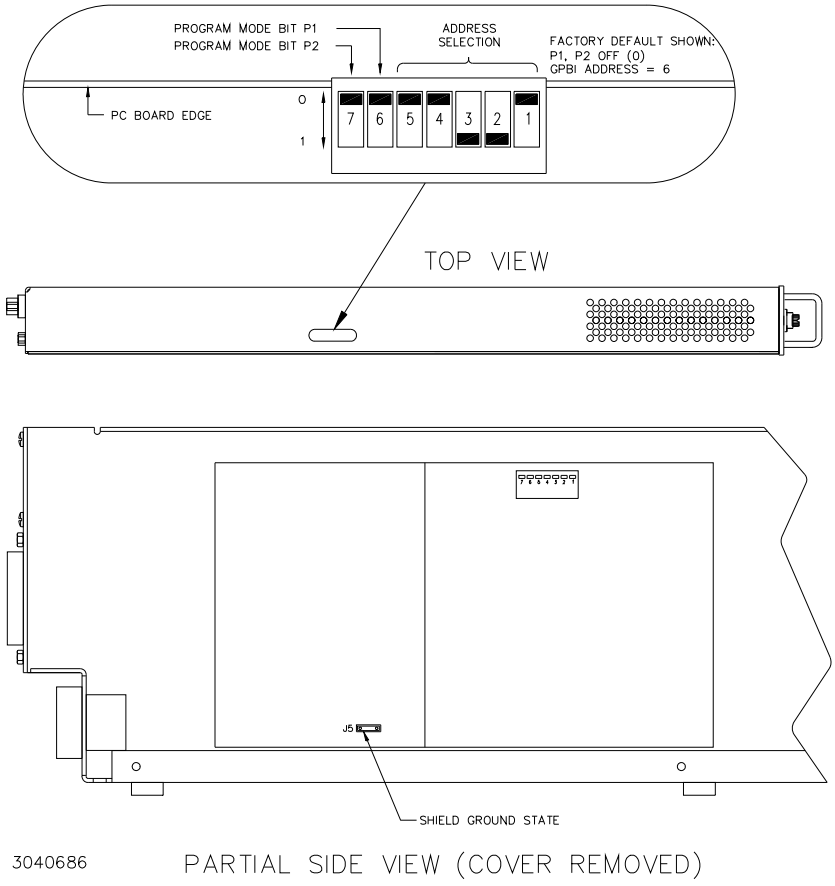


FIGURE 2-1. CONFIGURATION CONTROLS

2.3 REAR TERMINATIONS ON THE MST 488-27HT (SEE FIGURE 2-2)

a. AC INPUT. The MST 488-27HT draws power from the same source used to power the MST power modules. Power is applied through the Rack Adapter via the AC/control bus connector.

b. IEEE 488 BUS. This port is a 24 pin IEEE 488 connector and conforms mechanically and electrically to the IEEE 488 standard. Refer to Table 2-2 for pin assignments.

c. RS 232-C PORT. This port is a standard 9 pin RS 232-C (male) connector). Refer to Table 2-2 for pin assignments.

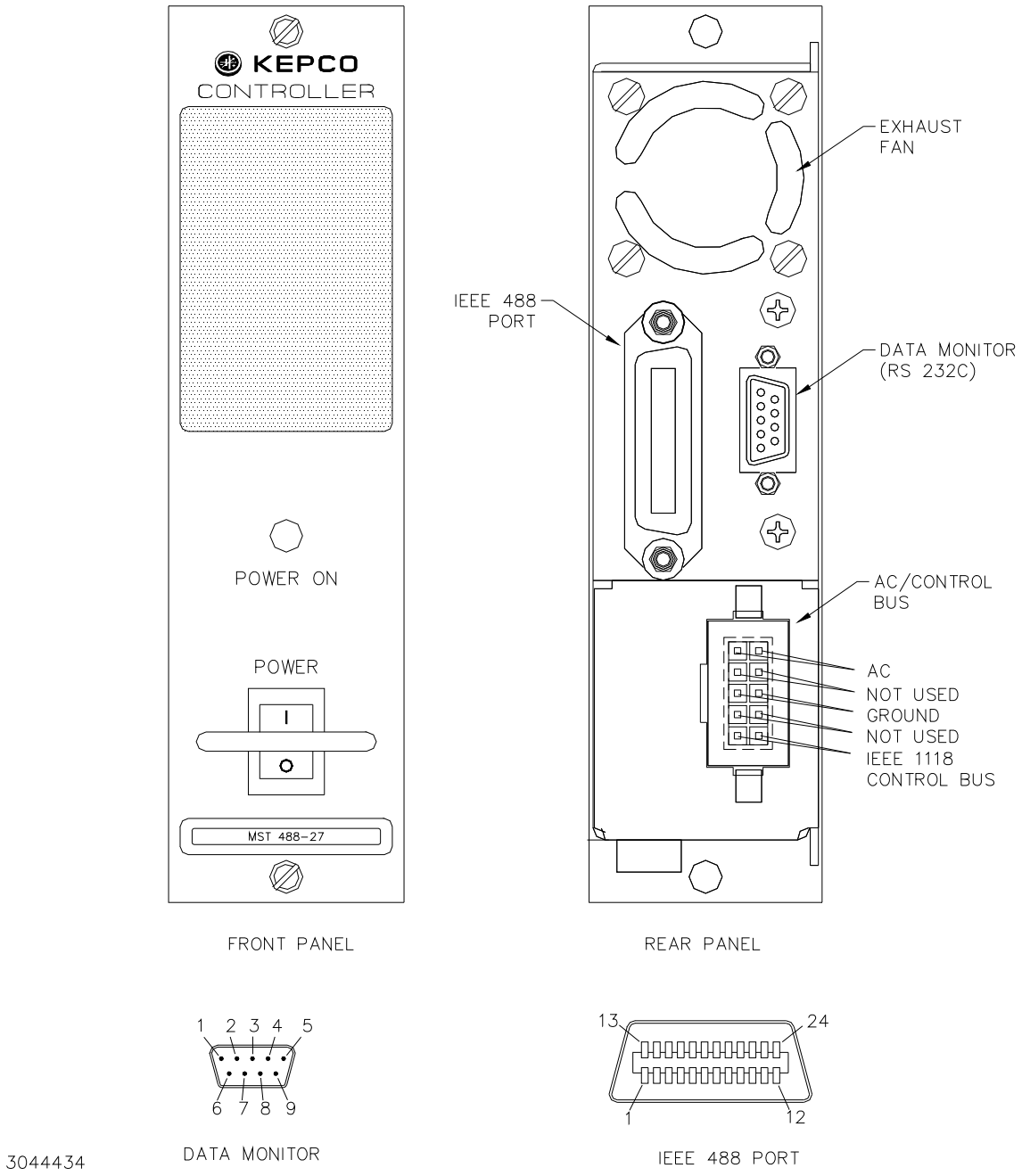


FIGURE 2-2. FRONT AND REAR PANELS OF MST 488-27HT POWER MODULE CONTROLLER

2.4 PROPER TURN-ON SEQUENCE

The MST 488-27HT and the power modules to be controlled each have individual POWER switches. Turn on power to the power modules first, then turn on power to the MST 488-27HT Controller last.

If the units were powered up out of sequence, there are two ways to recover (besides cycling power to all units off, then on, in the proper sequence). 1) send two SDC (Selected Device Clear [0x4]) commands to the MST 488-27HT Controller (secondary address 30). 2) perform a **Scan for Instruments** as described in PAR. 2.5.1 which sends multiple DCL (Device Clear [0x14]) commands which are acted on by all devices during the scanning process.

NOTE: Sending SDC and DCL commands rediscovers units powered up out of sequence, however this also clears the status register system, similar to the *CLS command.

If all components (power modules plus controller) are to be powered up using a remote switch, one of the two recovery methods described above must be used since it is unlikely that the Controller will be the last to power up.

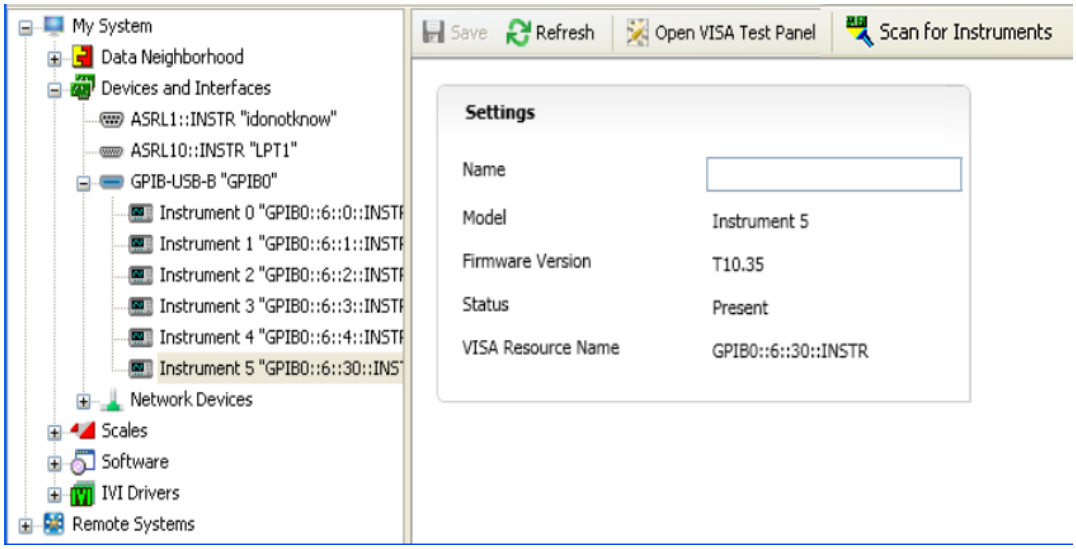
2.5 CHECKOUT

The following paragraphs provide instructions for connecting the MST 488-27HT Controller to the GPIB (PAR. 2.5.1), verifying the controller is working (PAR. 2.5.2) and verifying that the controller is properly communicating with a power module.

2.5.1 DISCOVERY (CONNECTING TO THE GPIB)

The MST 488-27HT requires a GPIB connection to operate. Kepco recommends using a connection tool such as the National Instruments (NI) GPIB controller tool and its program Measurement and Automation Explorer to connect to the GPIB.

Start up the connection tool, select **Devices and Interfaces**, then **GPIB**, then **Scan For Instruments**. The result should be similar to the following:

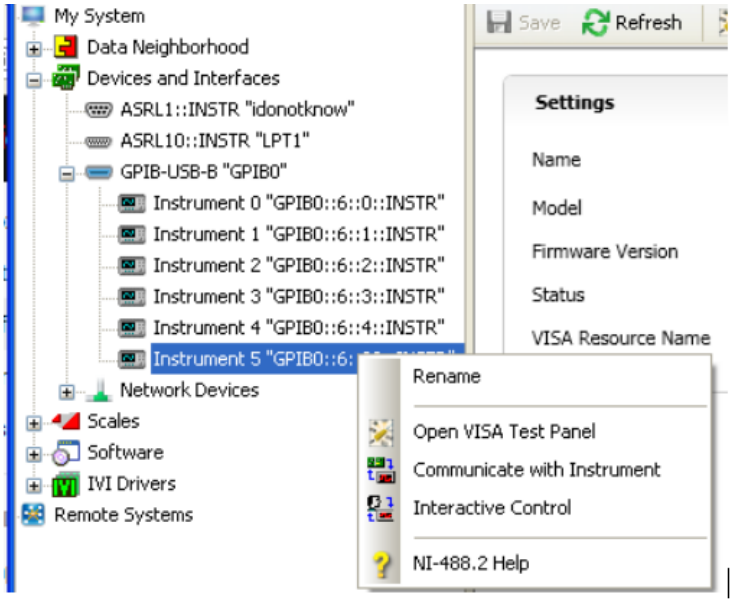


You may only see the highlighted instrument at address 30; this is the MST 488-27HT controller. The other instruments are the power modules that are installed in the RA 55H mainframe, powered up, and connected to the GPIB.

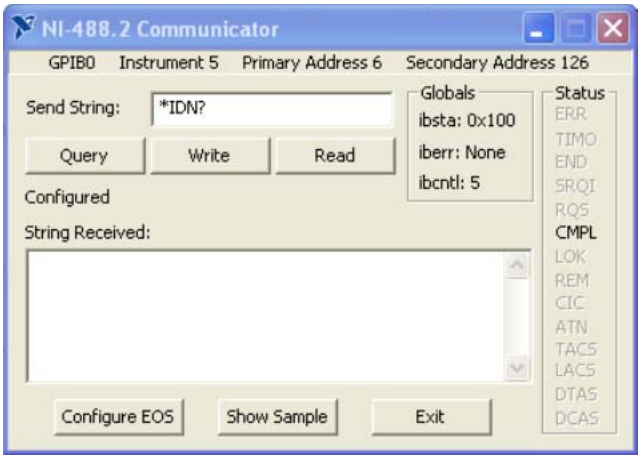
2.5.2 CONTROLLER CHECKOUT

The following procedure details how to verify the controller is working.

1. After discovery (PAR. 2.5.1), right click on the controller instrument at address 30.



2. Highlight **Interactive Control** and click. The following pop-up window is displayed.



3. Click **Query**. The string received should be **`KEPCO,MST 488-27,1,x.x`** where **`x.x`** is the firmware version; e.g., **`KEPCO,MST 488-27,1,10.35`** shows Version 10.35, the initial release. This indicates the controller is communicating wit the computer. Firmware Versions below 9 indicate a non-HT MST 488-27 Programmer. Firmware Versions of 10 and higher indicate an MST 488-27HT Controller.

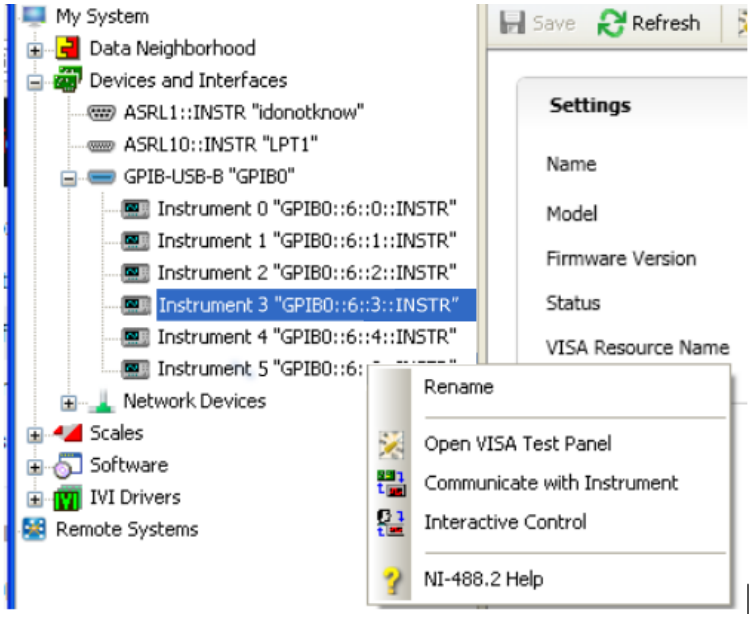
4. The MST 488-27HT supports commands found in the MST 488-27 (non-HT) Programmer (refer to MST 488-27 (non-HT) Programmer Operator Manual for details; see PAR. 1.1 of this manual for download instructions). Replace **`*IDN?`** with **`INST:CAT?`** then click **Query** again. The unit will either time-out, indicating no power modules are connected, or it will provide a comma separated list that indicates the power modules that are connected and powered up.

5. Click **Query** again. If the list is different than returned in step 4, the power up sequence was not followed. Refer to PAR. 2.4 to power up the units correctly or recover without powering off the units.

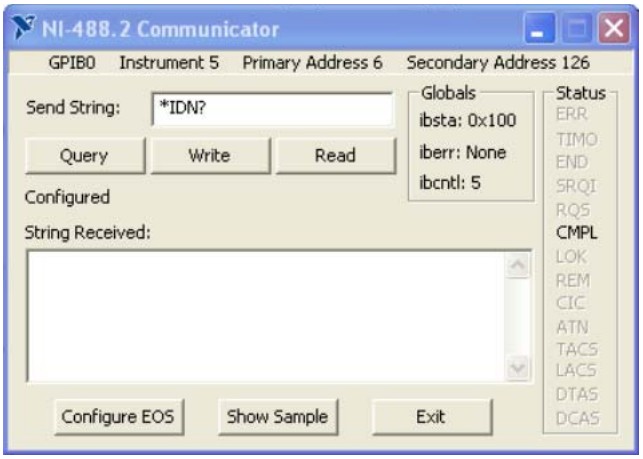
2.5.3 POWER MODULE COMMUNICATION CHECKOUT.

This procedure checks communication between controller and power module.

1. After discovery (PAR. 2.5.1), right click on an instrument at an address other than 30.



2. Highlight **Interactive Control** and click.. The following pop-up window is displayed.



3. Click **Query**. the string received is formatted as follows:
   <manufacturer>,<model>,0,x.x-y.y
   where **<manufacturer>** is the manufacturer of the power module, **<model>** is the power module model, **x.x** is the controller Firmware Version and **y.y** is the power module Firmware Version. E.g., **KEPCO,MST 36-5MHT ,0,10.35-5.6** is returned for a Kepco model MST-MHT 36-5 of firmware version 5.6 accessed through a controller at firmware version 10.35. This indicates the controller is successfully communicating with the power module.

4. Enter the following string in the **Send String** box
   VOLT 5;CURR 1;:MEAS:VOLT?

5. Click **Query**. After changing a parameter, the measurement takes some time to reflect the change, so the unit should respond with **0.00000E0**. Pressing Query a second or possibly a third time should result in a returned value of **4.9992E0** to indicate 5V. If not, the power module is defective and should be returned to Kepco, for service.

6. Enter the following string in the **Send String** box
   VOLT? MAX

7. Click **Query**. The unit should respond with the maximum voltage of the power module, e.g., for MST 36-5MHT the returned value is **m3.60000E1**.

.

TABLE 2-2. INPUT/OUTPUT PIN ASSIGNMENTS

CONNECTOR	PIN	SIGNAL NAME	FUNCTION
DATA MONITOR (RS232-C)	1	SGND	Signal Ground
	2	RXD	Receive Data
	3	TXD	Transmit Data
	4	DTR	Data Terminal Ready (not used)
	5	SGND	Signal Ground
	6	DSR	Data Set Ready (not used)
	7	RTS	Request to Send (not used)
	8	CTS	Clear to Send (not used)
	9	SGND	Signal Ground

TABLE 2-2. INPUT/OUTPUT PIN ASSIGNMENTS

CONNECTOR	PIN	SIGNAL NAME	FUNCTION
IEEE 488 PORT	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

SECTION 3 - OPERATION

3.1 GENERAL

Kepco MST 488-27HT Power Module Controller is programmed over a control bus using SCPI (Standard Commands for Programmable Instruments) commands as defined for the Keysight 66000© Mainframe. Communication with the Controller requires that at least one MST power module be installed and turned on.

The commands supported by the MST 488-27HT are shown in tree format in Figure 3-1. Appendix C lists all commands supported by the Keysight 66000© Mainframe that are not supported by the MST 488-27HT. Appendix B provides information on commands that are supported differently than the Keysight 66000 implementation.

The control bus is the IEEE-488 standard communications bus (General Purpose Interface Bus (GPIB) with each power module having a secondary address corresponding to the settings of the address DIP switch found on both MST-MHT Series and MST (non-MHT) Series power modules. .

Upon power up, the MST 488-27HT Controller looks for power modules connected to the bus. See PAR. 2.4 for proper turn-on sequence and recovery methods if needed

NOTE: The MST 488-27HT does not have non-volatile RAM. Upon power loss, all programmed values/configurations are lost and must be reprogrammed.

3.1.1 OPERATING STATUS REGISTERS

The bits in the Operating status registers are defined in Table 3-1. The MSTP and CAL bits are always a zero and are reserved for future enhancements.

TABLE 3-1. OPERATION CONDITION REGISTER, OPERATION ENABLE REGISTER, AND OPERATION EVENT REGISTER BITS

CONDITION	MSTP	NU	CC	NU	CV	NU	NU	WTG	NU	NU	NU	NU	CAL
BIT	12	11	10	9	8	7	6	5	4	3	2	1	0
VALUE	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

CAL CALIBRATION
CC CONSTANT CURRENT
CV CONSTANT VOLTAGE
NU NOT USED
MSTP MASTER STEP COMPLETE
WTG WAITING FOR TRIGGER

The CV bit is set to 1 when the auto-switch control of the MST power module is in voltage-stabilized mode, indicating that the current setting is greater than the load requirements. When the CV bit is 1, the CC bit will be 0.

The CC bit is set to 1 when the power module is in current stabilized mode, indicating that the voltage setting is greater than the load requirements.

3.1.2 QUESTIONABLE STATUS REGISTERS

The bits in the Questionable status registers are defined in Table 3-2. The OV and OC bits function the same way as in the Keysight 66000 mainframe. The CAL and MSTP bits are reserved for future use. The Overtemperature bit (bit 4) of the Keysight 66000 is the Power Supply Fault bit and is used to report overtemperature and other advanced load protection features of Kepco's MST power Supplies.

TABLE 3-2. QUESTIONABLE EVENT REGISTER, QUESTIONABLE CONDITION REGISTER AND QUESTIONABLE CONDITION ENABLE REGISTER BITS

CONDITION	NU	UNR	RI	NU	NU	NU	NU	PSF	NU	NU	OC	OV
BIT	11-15	10	9	8	7	6	5	4	3	2	1	0
VALUE		1024	512	256	128	64	32	16	8	4	2	1

NU NOT USED
OC OVERCURRENT PROTECT
PSF POWER SUPPLY FAULT
OV OVERVOLTAGE PROTECT
RI REMOTE INHIBIT
UNR OUTPUT UNREGULATED

MST power modules have hardware protections that are designed to prevent a defective power module from causing damage to the load. These faults are handled as redundant circuits to the control circuits and they cause the d-c output switcher to shut down and the PSF bit (bit 4). to be set to one.

MST power modules also have an open sense link detector; this error causes the power supply to open the relay and disconnect the unit from the load. If this occurs, the UNR bit (bit 10) is set. Depending upon the load connected to the MST, either the OV or PSF bit will also be set.

The OV bit is set to indicate the power module relay has disconnected the load and is setting the voltage DAC (Digital-to-Analog Converter) to 0 and the current DAC to a few LSBs. The OV bit is set when the measured power module voltage exceeds the **VOLT:PROT** setting. Sending ***RST** sets the **VOLT:PROT** setting to the power module's maximum value.

The OC bit is set to indicate the power module relay has disconnected the load and is setting the voltage DAC to 0 and the current DAC to a few LSBs. The OC bit is set when the power supply is in CC mode for a period greater than the **OUTP:PROT DEL** time and **CURR:PROT:STAT** is set to ON.

When the OC or OV bit is set, changes to the voltage setting, current setting and output on-off setting can occur, but settings are not applied until the bits are cleared. The previous setting can be restored by sending **OUTP:PROT:CLE** to the power module which clears the bits and restores the power supply to the previous state. The bits can also be cleared by sending ***RST**, which sets: voltage setting to 0, current setting to a few LSBs, voltage protection to maximum and output to off.

NOTE: The Overvoltage Protection function is different for MST-MHT and MST (non-MHT) models. See PAR. 1.4.1 for details.

3.1.3 COMPATIBLE POWER SUPPLIES

The MST 488-27HT is designed to operate with the MST-MHT Series power modules but can also accommodate non-MHT MST models. MST-MHT power modules incorporate improved noise reduction, current mode control and readback over the MST (non-MHT) Series. MST-MHT Series also incorporate a change in the measurement readback to support Keysight 66000 power modules over their voltage range.

The MST 488-27HT can also be programmed to behave as a standard MST 488-27 Programmer by sending **SYST:SET SA0**. See PAR. B.8 for further details.

3.2 IEEE 488 (GPIB) BUS PROTOCOL

Table 3-3 defines the interface capabilities of the MST 488-27HT controller (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 3-3. 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	RL2	No Local lock-out.
Parallel Poll	PP0	No Capability
Device Clear	DC1	Complete Capability. DCL (Device Clear) and SDC (Selected Device Clear) supported.
Device Trigger	DT1	GET supported.
Controller	C0	No Capability

Tables 3-4 and 3-5 define the messages sent to the MST 488-27HT, or received by the MST 488-27HT, 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 MST 488-27HT controller operating as either a Talker or a Listener. The MST 488-27HT requires the use of secondary addressing: the address of an MST-H or MST-HT power module will be the secondary address.

3.2.1 STRING PARSING

When the MST 488-27HT 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 ($0d_H$) or Line Feed ($0A_H$) character is received.

TABLE 3-4. 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 3-5. 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 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 MST 488-27HT controller 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.

The MST 488-27HT uses SCPI messages that were defined by the Keysight 61000© Series power modules with operation of the commands in accordance with SCPI 1990 rules.

3.3.1 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.

3.3.2 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 (*).

3.3.3 SCPI SUBSYSTEM COMMAND/QUERY STRUCTURE

Subsystem commands/queries are related to specific power supply functions (such as setting output voltage, current limit, etc.) Figure 3-1 is a tree diagram illustrating the structure of SCPI subsystem commands used in the MST 488-27HT controller with the “root” at the left side, and specific commands forming the branches. The subsystem commands that behave exactly the same as they do in the Keysight 66000© Mainframe are listed in Appendix A. Subsystem commands that are supported but are different in some way from the same commands in the Keysight 66000© Mainframe are explained in Appendix B. 66000© Mainframe Subsystem commands that are not supported in the MST 488-27HT are listed in Appendix C.

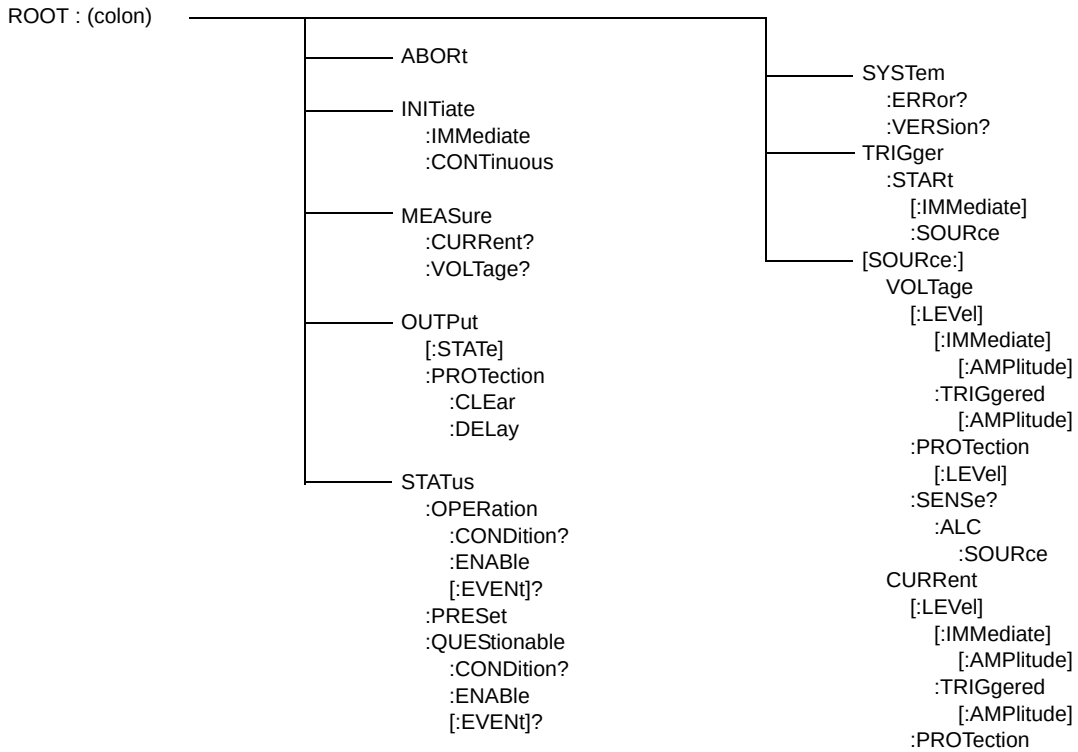


FIGURE 3-1. TREE DIAGRAM OF SCPI COMMANDS USED WITH MST 488-27HT CONTROLLER

APPENDIX A - MAINFRAME 66000© COMMANDS IDENTICAL TO MST 488-27HT

A.1 INTRODUCTION

This appendix lists the SCPI/IEEE 488.2 commands and queries used with the MST 488-27HT Controller whose function and behavior is identical to the corresponding commands and queries used in the Keysight 66000© Mainframe.

TABLE A-1. SUPPORTED SCPI/IEEE 488.2 COMMAND/QUERY INDEX

COMMAND/QUERY	COMMAND/QUERY	COMMAND/QUERY	COMMAND/QUERY
ABOR	[SOUR]:CURR[:LEV][:IMM][:AMPL]	STAT:OPER:COND?	*CLS
INIT[:IMM]	[SOUR]:CURR[:LEV][:IMM][:AMPL]?	STAT:OPER:ENAB	*ESE
INIT:CONT	[SOUR]:CURR[:LEV][:TRIG][:AMPL]	STAT:OPER:ENAB?	*ESE?
INIT:CONT?	[SOUR]:CURR[:LEV][:TRIG][:AMPL]?	STAT:OPER[:EVEN]?	*ESR?
MEAS:CURR[:DC]?	[SOUR]:CURR:PROT:STAT	STAT:PRES	*OPC
MEAS:VOLT[:DC]?	[SOUR]:CURR:PROT:STAT?	STAT:QUES[:EVEN]?	*OPC?
OUTP[:STAT]	[SOUR]:VOLT[:LEV][:IMM][:AMPL)	STAT:QUES:COND?	*OPT?
OUTP[:STAT?]	[SOUR]:VOLT[:LEV][:IMM][:AMPL)?	STAT:QUES:ENAB	*RST
OUTP:PROT:CLE	[SOUR]:VOLT[:LEV][:TRIG][:AMPL)	STAT:QUES:ENAB?	*SRE
	[SOUR]:VOLT[:LEV][:TRIG][:AMPL)?	SYST:VERS?	*SRE?
	[SOUR]:VOLT:PROT[:LEV]	TRIG:IMM	*STB?
	[SOUR]:VOLT:PROT[:LEV]?		*TRG
			*TST?

APPENDIX B - MAINFRAME 66000© COMMANDS SUPPORTED BY MST 488-27HT WITH DIFFERENCES

B.1 INTRODUCTION

This appendix describes the SCPI/IEEE 488.2 commands and queries used with the MST 488-27HT Controller whose function and behavior is similar to the corresponding commands and queries used in the Keysight 66000© Mainframe, but with some differences. The differences are described in the following paragraphs.

NOTE: The MST 488-27HT has no NVRAM (non-volatile memory). Upon power loss, all programmed values/configurations are lost and must be reprogrammed.

TABLE B-1. MAINFRAME 66000© COMMANDS SUPPORTED BY MST 488-27HT WITH DIFFERENCES

COMMAND	PAR.	COMMAND	PAR.
CURR:PROT?	B.2	STAT register	B.6
CURR:PROT:DEL ?	B.3	SYST:ERR?	B.7
FUNC:MODE	B.4	SYST:SET	B.8
*IDN?	B.5	TRIG:SOUR	B.9

B.2 CURR:PROT? QUERY **CURR:PROT?**

Description**:** CURR:PROT? returns 0.0000E0. Although this query exists, changing the CURR:PROT value is not supported at this time; it is always reported as 0.

B.3 .CURRent:PROTect:DELay, ? COMMAND, QUERY **CURR:PROT:DEL, ?**

Syntax**:** Short Form: CURR:PROT;DEL n Long Form: CURRent:PROTect;DELay n
Where n = shutdown delay in Seconds. Accepts values from 0 to 10 in 0.1 increments.
NOTE: Power up default set to 1

Description**:** When OUTP:PROT;STAT is on, any overcurrent event can cause the unit to shutdown. CURR:PROT:DEL allows the user to delay shutdown for up to 10 seconds. This command has no effect when OUTP:PROT;STAT is off. A setting below 1.1 second causes the unit to shutdown in less than 100 milliseconds if OUTP;PROT;STAT is on and overcurrent detected

The query OUTP:PROT;DEL? returns value <n> representing the delay setting in seconds.

B.4 FUNC:MODE, FUNC:MODE? - FUNCTION MODE COMMAND, QUERY **FUNC:MODE, ?**

Description**:** FUNC:MODE 0 / 1 is used to calibrate the MST MHT power modules and is provided for this purpose only. The query returns 0 as the power up default and after *RST is issued.

B.5 *IDN? — IDENTIFICATION QUERY *IDN?

Syntax**:** *IDN?
Return value: Character string

Description: **Identifies the instrument.** This query requests identification. A power module must be installed and turned on for communication. The string contains the manufacturer name, model, SN, firmware revs. The SN field is normally used for the serial #, but since the MST 488-27HT has no NVRAM, serial #s are not stored in memory; the power module current rating 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 an error occurs. . The character string contains the following fields: <Manufacturer>, <Model>, <Serial Number>, <Firmware revision> where:
<Manufacturer> = KEPCO,
<Model> = MSTH xx where MSTH represents the MST-HT power module and xx indicates the voltage rating of the MST-H power module. Supported models include MAT, MBT, MST and MST-H,
<Serial Number> = yy where yy = the current rating of the MST-H power module,
<Firmware revision> = Returns the firmware version of the MST 488-27HT controller and the firmware version of the selected power module, separated by '-'. Prefix of T indicates the MST 488-27HT supports only the subset of commands required by Teledyne/Boeing.

B.6 STATUS REGISTER OPERATION

The MST-488-27HT does not support the NPR nor PTR registers for Status Questionable and Status Operation commands. The Default setting in the Mainframe 66000© was for the NPR register to be 0 and the PTR register to have all bits set. This causes all positive transitions in the condition register to set the corresponding EVENT register bit whenever the bit becomes a 1.

An example of how the STATus:OPERation register functions is as follows:
Sending STAT:OPER? followed by INIT:IMM will cause the WTG bit to be set. Sending STAT:OPER:Even? will return 32, indicating that the WTG bit is set.

B.7 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.** Error messages are defined in Table B-2.

TABLE B-2. ERROR MESSAGES

ERROR MESSAGE	ESR ERROR BIT SET	EXPLANATION
0,"No error"	None	No error
-100,"Command error"	Command Error bit 5	Command and data understood, but more information included which is not recognized.
-102,"Syntax error"	Command Error bit 5	First 4 characters recognized, subsequent characters not recognized.
-103,"Invalid separator"	Command Error bit 5	For example, VOLT.10 received instead of VOLT:10
-108,"Parameter Not Allowed Error"	Command Error bit 5	Volt12 sequence, channel number is invalid
-109,"Missing parameter"	Command Error bit 5	For example, VOLT instead of VOLT 21.
-111,"Header separator error"	Command Error bit 5	Missing space between volt and value or ; missing
-113,"Undefined header"	Command Error bit 5	First 4 characters could not be identified as legal command.For example, command VLT instead of VOLT
-120,"Numeric data error"	Command Error bit 5	Expected number but other characters were detected
-121,"Invalid character in number"	Command Error bit 5	Volt 1,500 (comma not allowed)
-123,"Exponent too large"	Command Error bit 5	Exponent E+3 or greater is invalid.

TABLE B-2. ERROR MESSAGES (CONTINUED)

ERROR MESSAGE	ESR ERROR BIT SET	EXPLANATION
-141,"Invalid character data"	Command Error bit 5	For example OUTP OFD or OUTP STOP instead of OUTP OFF
-150,"String data error"	Command Error bit 5	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"	Execution error bit 4	Value exceeds power supply rating
-223,"Data format error"	Execution error bit 4	Multiple decimals in digit, Multiple E, etc.
-224,"Illegal parameter value"	Execution error bit 4	For example, OUTP 2 instead of OUTP 1
-240,"Hardware error"	Execution error bit 4	If overvoltage is triggered, sending VOLT commands (e.g., VOLT 5) will cause this error until OVP is cleared.
-241,"Hardware missing"	Execution error bit 4	Requesting device 2 status (INST:NSEL 2)
-350,"Queue overflow"	Device Error bit 3 (1)	More than 15 errors are in queue.
-410,"Query interrupted"	Query Error bit 2	New command sent before data from previous query read. Previous query data lost.
-430,"Query Deadlocked"	Query Error bit 2	Over 255 characters received in single input string
(1) The Device error bit may be set when the status monitoring functions of the power supply detect an overvoltage/under-voltage condition.		

B.8 SYSTem:SET COMMAND

SYST:SET

Syntax**:** Short Form: SYST:SET {SA0 | SA1 | CM0 | CM1 | SI0 |}
LONG Form: SYSTem:SET {SA0 | SA1 | CM0 | CM1 | SI0 |}

Description: **Allows the unit to behave as a standard Kepco MST 488-27 Controller (programmer).** Sending SYST:SET SA0 disables the default secondary address mode of the MST 488HT controller and causes the unit to revert to the command syntax of the non-HT suffix MST 488-27 Controller (Programmer).

To return the unit to secondary addressing send SYST:SET SA1

After sending SYST:SET SA0, SCPI commands and queries behave as documented in Appendices A and B of MST 488-27 Programmer Operator Manual except as noted below. The MST 488-27 Programmer Operator Manual can be downloaded from the Kepco website at

https://www.kepcopower.com/support/opmanls.htm#mst

After sending SA0 the following exceptions apply:

- Status reporting bits for STAT:OPER registers and STAT QUES registers follow the assignments listed in Tables 3-1 and 3-2 respectively.
- The unit does not support SYST:SET SI1 which enables the STAT:INST register status reporting capability of the non-HT MST 488-27 unit.
- Some MST 488-27HT commands are still supported.
  - — VOLT:PROT to allow for over voltage protection setting
  - — OUTP:PROT:DEL current mode timing delay
  - — OUTP:PROT:CLE protection reset

B.9 TRIGger[:SEQuence]:SOURce COMMAND

TRIG:SOUR

Syntax**:** Short Form: TRIG[:SEQ]:SOUR {HOLD | BUS | IMM}
Long Form: TRIGger[:SEQuence]:SOURce {HOLD | BUS | IMM}

Description: **Selects the active trigger source.** Only BUS, HOLD and IMM are supported in the MST48-27HT. EXT LINK and TTLT are not supported.

APPENDIX C - MAINFRAME 66000© COMMANDS NOT SUPPORTED BY MST 488-27HT

C.1 INTRODUCTION

This appendix lists the SCPI/IEEE 488.2 commands and queries used with the Keysight 66000© Mainframe that are not supported by the MST 488-27HT Controller.

TABLE C-1. NON-SUPPORTED SCPI/IEEE 488.2 COMMAND/QUERY INDEX

COMMAND/QUERY	COMMAND/QUERY	COMMAND/QUERY	COMMAND/QUERY
CAL:AUT	OUTP:TTLT[:STAT]?	[SOUR]:VOLT:MODE	*PSC
CAL:STAT	OUTP:TTLT:LINK	[SOUR]:VOLT:MODE?	*PSC?
DISP[:WIND][:STAT]	OUTP:TTLT:LINK?	[SOUR]:VOLT:PROT:DEL?	*RCL
DISP[:WIND][:STAT]?	OUTP:TTLT:SOUR	STAT:OPER:NTR	*SAV
OUTP:DFI	[SOUR]:CURR:MODE	STAT:OPER:NTR?	*WAI
OUTP:DFI?	[SOUR]:CURR:MODE?	STAT:OPER:PTR	
OUTP:DFI:LINK	[SOUR]:LIST:COUN	STAT:OPER:PTR	
OUTP:DFI:LINK?	[SOUR]:LIST:COUN?	STAT:QUEST:NPR	
OUTP:DFI:SOUR	[SOUR]:LIST:CURR	STAT:QUEST:NPR?	
OUTP:DFI:SOUR?	[SOUR]:LIST:CURR:POIN?	STAT:QUES:PTR	
OUTP:PROT:DEL	[SOUR]:LIST:DWEL?	STAT:QUES:PTR?	
OUTP:REL	[SOUR]:LIST:DWEL:POIN?	TRIG:DEL	
OUTP:REL?	[SOUR]:LIST:STEP	TRIG:DEL?	
OUTP:REL:POL	[SOUR]:LIST:STEP?	TRIG:LINK	
OUTP:REL:POL?	[SOUR]:LIST:STEP:POIN	TRIG:LINK?	
OUTP:TTLT[:STAT]	[SOUR]:LIST:VOLT		