MP4300 Series Modular Power System

MP4301A, MP4302A Mainframes
MP4361A, MP4362A SAS Power Modules

KEYSIGHT

OPERATING AND SERVICE GUIDE

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Legal and Safety Information

Legal Notices

Safety and Regulatory Symbols

Safety Notices

Legal Notices

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WARNING A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or DEATH. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

CAUTION A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.


Direct current


Alternating current


Frame or chassis terminal

On supply


Off supply


WARNING risk of electric shock


WARNING refer to accompanying documents


Earth ground terminal

The CE mark is a registered trademark of the European Community.
CAN IECS/NMB-001(A) indicates compliance with the Canadian Interference- Causing Equipment Standard.
ISM GRP 1-A indicates that the instrument is an Industrial Scientific and Medical Group 1 Class A product (CISPER 11, Clause 4)

The ETL mark is a registered trademark of Intertek. The text indicates product compliance with the Canadian Interference- Causing Equipment Standard (ICES-001).


The RCM mark is a registered trademark of the Australian Communications and Media Authority.

Indicates United Kingdom Conformity Assessed.

Contains one or more of the 6 hazardous substances above the maximum concentration value (MCV), 40 Year EPUP.

Safety Notices

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings or instructions elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Keysight Technologies assumes no liability of the customer's failure to comply with the requirements.

The equipment is for industrial use. Equipment operators are subject to all applicable safety regulations. Along with the warning and safety notices in this manual, all relevant safety, accident prevention, and environmental regulations must also be followed. In particular, the operators of the equipment:

- Must be informed of the relevant safety requirements.
- Must have read and understood the operating manual before using the equipment.
- Must use the designated and recommended safety equipment

WARNING General
Do not use this product in any manner not specified by the manufacturer. The protective features of this product may be impaired if it is used in a manner not specified in the operating instructions.

WARNING Environmental Condition
Never use the instrument outside of the specified environmental conditions described in the Environmental Characteristics of the specifications.

WARNING Heavy Weight
Danger to hands and feet. To avoid personal injury and damage to the instrument, always use a sturdy cart or other suitable device to move the instrument. Do not lift the instrument alone; always use two people to lift the instrument.

WARNING SHOCK HAZARD Ground the Instrument
This product is provided with a protective earth terminal. To minimize shock hazard, the instrument must be connected to the ac mains through a grounded power cable, with the ground wire firmly connected to an electrical safety ground at the power outlet. Any interruption of the protective ground conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in injury or death.

WARNING Before Applying Power
Verify that all safety precautions are taken. All connections must be made with the unit turned off, and must be performed by qualified personnel who are aware of the hazards involved. Improper actions can cause fatal injury as well as equipment damage. Note the instrument's external markings described under "Safety Symbols".

WARNING SHOCK HAZARD Lethal Voltages
Some power modules generate voltages up to 160 Vdc
Ensure that instrument connections, load wiring and connections are either insulated or covered so that no accidental contact with lethal output voltages can occur..

WARNING SHOCK HAZARD After Turn-off
Never touch cables or connections immediately after turning off the unit. Depending on the model, lethal voltages can remain at the output terminals for several seconds after turn-off. Verify that there is no dangerous voltage on the output or sense terminals before touching them.

WARNING SHOCK HAZARD from external energy sources.
Because the instrument can be used as a load to sink current, hazardous voltages from an external energy source such as a battery may be present on the output terminals even with the unit turned off. Provision must be made to disconnect the external energy source before touching the output or sense terminals.

WARNING SHOCK HAZARD from module installation or removal.
Never apply power to the instrument without all six module slots occupied with modules and/or filler panels. Never attempt to remove or insert a module or filler panel when power is applied to the instrument. The power switch must be turned off, and ac power must be disconnected from the instrument before removing or installing modules or filler panels.

WARNING Do Not Operate in an Explosive Atmosphere
Do not operate the instrument in the presence of flammable gases or fumes.

WARNING Do Not Remove the Instrument Cover
Only qualified, service-trained personnel who are aware of the hazards involved should remove instrument covers. Always disconnect the power cable and any external circuits before removing the instrument cover.

WARNING Do Not Modify the Instrument
Do not install substitute parts or perform any unauthorized modification to the product. Return the product to a Keysight Sales and Service Office for service and repair to ensure that safety features are maintained.

WARNING Readings and State Reported by the Browser Web Control Page.
Should network communication issues occur, the reported readings and instrument state shown in the Browser Web Control page may not represent the actual readings or instrument state. Do not rely on the reported readings from the Web Control Browser to determine if a circuit that may have hazardous voltages present is safely de-energized. Never modify any connections to the instrument while power is applied.

WARNING Fuses
The instrument contains internal fuses, which are not customer accessible.

WARNING Cleaning
To prevent electric shock, always disconnect the ac mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not use detergent or chemical solvents. Do not attempt to clean internally.

WARNING In Case of Damage
Instruments that are not functioning correctly, appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

1
Quick Reference

Legal and Safety Information

Introduction to the Instrument

Front Panel Reference

Command Quick Reference

Model Features and Options

Specifications and Characteristics

This document includes user, service, and programming information for the Keysight Regenerative Modular Power System (MPS) family.

Documentation, Firmware, and Technical Support

You can download the latest version of this document at www.keysight.com/find/MPS-doc.

If you have questions about your shipment, or if you need information about warranty, service, or technical support, contact Keysight Technologies.

Contacting Keysight Technologies

Use www.keysight.com/find/assist for information on contacting Keysight worldwide, or contact your Keysight Technologies representative.

Introduction to the Instrument

Modular Power System at a Glance

Front Panel at a Glance

Rear Panel at a Glance

Front Panel Display at a Glance

Front Panel Keys at a Glance

Modular Power System at a Glance

The Keysight Modular Power System (MPS) series include 2U rack-mountable mainframe with user-installable power modules with performance and features that are optimized for automated test systems. The output and system features are described as follows. The Models and Options section describes the features that apply to specific modules.

Output features

- Full programming capability for the entire range of output voltage and current
- Output autoranging for greater flexibility
- Output can operate in voltage priority, current priority, or solar array simulator (SAS) modes
- High-speed up and down output programming
- I-V Curve List and Table Mode capability
- Turn-on/turn-off delays allow output on/off sequencing across multiple units
- Protection capability includes over-voltage, over-current, and over-temperature
- Solid-state output disconnect switch for fast protection and smooth turn on/off transitions
- 6 kW rated mainframes
- A variety of single and dual channel modules are planned, covering the following applications
  - Space solar array simulation (SAS)
  - eLoads and 2-quadrant sources
  - High density dc power supplies

Measurement features

- Real-time voltage and current measurements
- External data logger

System features

- Save and recall up to 10 instrument states in non-volatile memory
- LAN and USB programming interfaces are built in; GPIB (IEEE-488) is optional
- Front panel menu setup for LAN and GPIB parameters
- Compliant with 1.5 LXI Device Specification 2016, including a built-in Web server
- SCPI (Standard Commands for Programmable Instruments) compatibility

Regenerative Operation

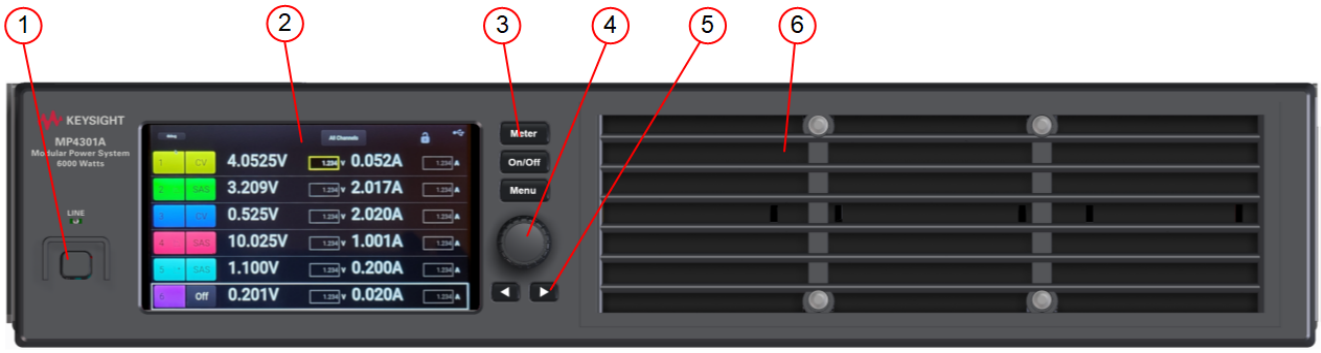
Whenever the MPS is sinking current, either by rapidly down-programming the output, or by discharging an energy source such as a battery, the unit will direct the excess power back to the ac mains. You cannot disable the regenerative operation.

During regenerative operation, the power factor of 0.99 is maintained. Sine wave current distortion is less than 2% at full load. This ensures the quality of the ac signal that is returned to the ac mains.

When an ac mains dropout is sensed, galvanic relays disconnect the ac mains and the unit shuts down.

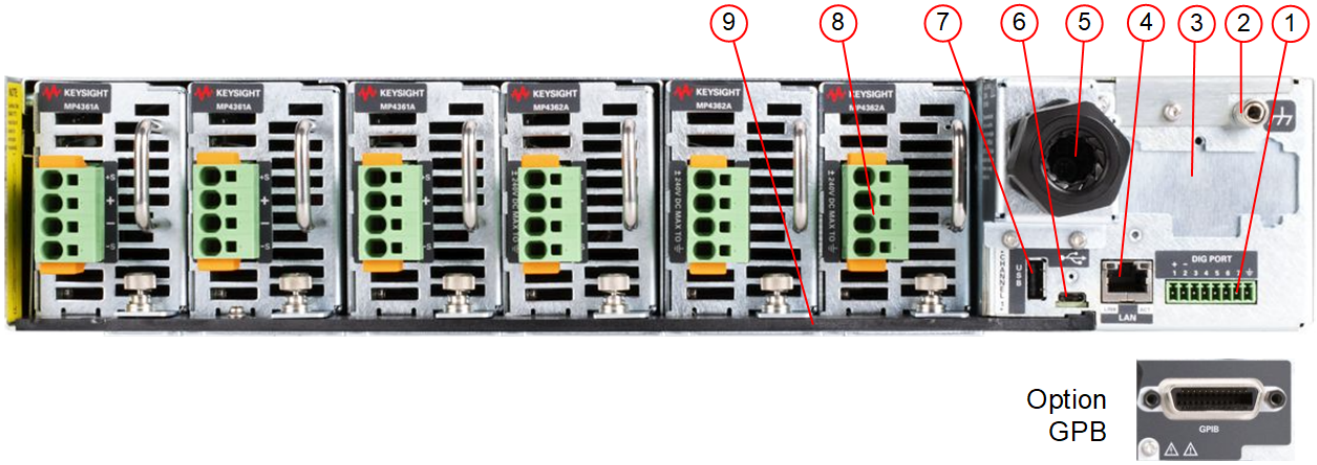
Refer to AC Mains Considerations for additional information.

Front Panel at a Glance



1. On/Off switch - Push this switch to turn the instrument on or off.
2. Display - Turns off after 1 hour of inactivity. Touch the display to restore it.
3. Function keys - Select metering, mode, and command functions.
4. Rotary knob- Scrolls through the display selections. Push to make a selection.
5. Navigation keys - Move horizontally across the selections on the display.
6. Air inlets - Do not block front panel air inlets.

Rear Panel at a Glance

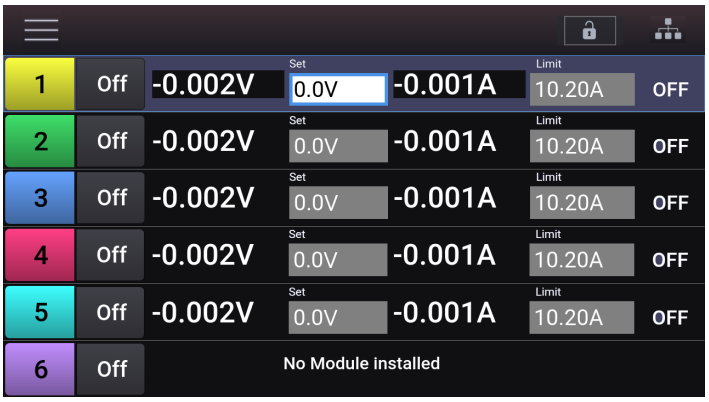


1. Digital IO - Digital IO connector. Pins are user-configurable.
2.  - Auxiliary chassis ground stud. Not for use with ac mains connections.
3. Option cover - Location reserved for Option GPB.
4. LAN - 10/100/1000 Base-T Left LED indicates activity. Right LED indicates link integrity.
5. AC input cover - AC input requires 3-phase L1, L2, L3, connections. A chassis ground stud is located under the cover for the ac mains ground connection. The ac input is bi-directional.
6. USB - C - USB- C interface connector. USB - C cable with locking connector recommended.
7. Memory port - Reserved for future use..
8. Module connectors - Includes sense and output connections for each power module. Up to six single slot modules can be installed in an MPS mainframe.
9. Lockout bar - Must be installed to operate power modules.

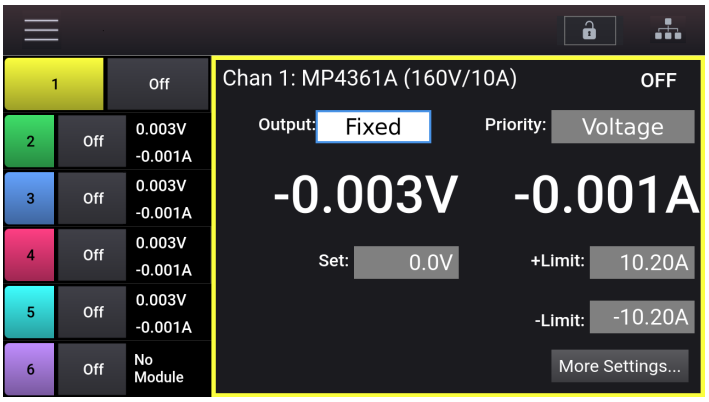
Front Panel Display at a Glance

Channel Overview

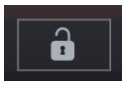
Touch the colored channel to view the channel details. Refer to Using the Front Panel for more information.

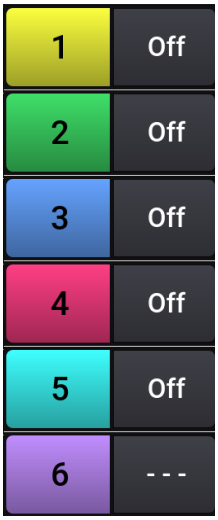


Channel 1 Details



Display Controls

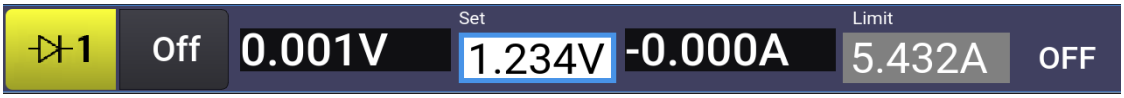
	Accesses the front panel menu. Same as the **Menu** key.
	Locks or unlocks the front panel display.
	Displays the LAN address and hostname. This information is also available under **Menu** + System\ IO\ LAN.



Touch this area of the display to select the channel to control. See **Channel Details**. The status area on the upper right side of the channel detail indicates the channel's status:
OFF = the output is off
ON = the output is on
TRN = the output is transitioning to on
CV = the output is in constant voltage mode
CC = the output is in constant current mode
CP = the output is in constant power mode
CZ = the output is in constant impedance mode
CR = the output is in constant resistance mode
OV+ = the output is in positive over-voltage limit
OV- = the output is in negative over-voltage limit
OC = the output is in over-current limit
OC- = the output is in negative over-current limit
OP = the output is in over-power limit
OP- = the output is in negative over-power limit
OT = the output is disabled by the over-temperature protection
PF = the output is disabled by a power-fail protection
INH = the output is disabled by an external inhibit signal
EDP = the output is disabled by excessive output dynamic protection
UNR = the output is disabled by an unregulated condition
SF = the output is disabled by a sense fault protection
OCF = the output is disabled by internal over-current protection
UV = the output is disabled by under-voltage protection
LFP = the output is disabled by leader/follower fault protection
CSF = the output is disabled by current-sharing fault protection
FLT = the output is disabled by a hardware fault; cycle power to clear

An orange background indicates that the corresponding protection status condition has disabled the output

Channel Information



The colored area on the left identifies the channel. A diode symbol next to the channel indicates that Diode mode has been enabled.

The output voltage and current measurement are displayed in the large fonts.

The voltage and current settings displayed in the Set and Limit fields.

The status area on the right side of the channel information indicates the status of the channel. Touch the status area for a brief description of the status.

Refer to Using the Front Panel for more information.

Front Panel Keys at a Glance

The **Line** switch turns the unit on or off. The green LED indicates power is on.

The **Meter** key returns the display to metering mode. It also toggles between All Channel view and Single Channel view.

The **On/Off** key turns the output of the selected channel on or off.

The **Menu** key accesses the front panel command menu.

The Rotary knob (RPG) lets you navigate around the display. Push on the knob to select an item. When a numeric field is selected, the touch screen numeric keypad will pop up. When a text field is selected, the list will pop up; rotating the knob scrolls through the options. Pushing the knob again will choose the option from the list.

Arrow keys let you navigate around the display in the same manner as the Rotary knob.

Front Panel Menu Reference

Press the **Menu** key to access the front panel menus. Touch the menu item to navigate the menu. Touch **<Back** to back out of the menu. Press the **Menu** key to exit the menu.

For a brief tutorial, refer to Using the Front Panel.

1st Menu Level	2nd Level	3rd Level	Description
System	Back		Back to previous level
	Lock Font Panel		Locks and unlocks the front panel menu
	IO	Back	Back to previous level
		LAN	Displays the LAN configuration
		GPIB/USB	Displays the GPIB/USB configuration
States	Back		Back to previous level
	Reset		Resets the instrument to its default state
	Save/Recall		Saves and recalls an instrument state (from 0 to 9)
	Power-On		Specifies the power-on state (either Reset or State 0)
Help	Back		Back to previous level
	Error Queue		Displays the error messages Reading the messages deletes them
	About Instrument		Displays Mainframe serial number and firmware version Displays power module information

Command Quick Reference

Some [optional] commands have been included for clarity. All settings commands have a corresponding query. See the Syntax Conventions for SCPI.

CALibrate

:COUNt?	Returns the number of times the unit has been calibrated.
:CURRent	
[:LEVel] <range> , (@<channel>)	Calibrates the current; the value selects the range.
:DATA <*value*>	Enters the calibration value read by the external meter.
:DATE <*"date"*>, (@<channel>)	Enters the calibration date in nonvolatile memory.
:LEVel P1|P2|P3	Selects the calibration step.
:PASSword <*value*>	Sets a numeric password to prevent unauthorized calibration.
:SAVE	Saves the calibration constants in non-volatile memory.
:STATe 0|OFF|1|ON	Enables or disables calibration mode.
:VOLTage	
[:LEVel] <range>, (@<channel>)	Calibrates the voltage; the value selects the range.

FETCh

[:SCALar]	
:CURRent	
[:DC]? (@<chanlist>)	Returns the averaged measurement.
:VOLTage	
[:DC]? (@<chanlist>)	Returns the averaged measurement.

HCOPy

:SDUMp	
:DATA? [JPG|PNG]	Returns an image of the front panel display.
:DATA	
:FORMat JPG|PNG	Specifies the format for front panel images returned.

IEEE-488 Common Commands

*CLS	Clear status command.
*ESE <*value*>	Event status enable command and query.
*ESR?	Event status event query.
*IDN?	Identification Query.
*OPC	Sets the OPC (operation complete) bit in the standard event register.
*OPC?	Returns a 1 to the output buffer when all pending operations complete.
*OPT?	Returns a string identifying any installed options.
*RCL <*value*>	Recalls a saved instrument state.
*RDT?	Returns a description of all installed output modules.
*RST	Resets the instrument to pre-defined values that are either typical or safe.
*SAV <*value*>	Saves the instrument state to one of ten non-volatile memory locations.
*SRE <*value*>	Service request enable command and query.
*STB?	Status byte query.
*TRG	Trigger command.
*TST?	Self-test query.
*WAI	Pauses additional command processing until all pending operations are complete.

LXI

:IDENtify	
[:STATe] 0|OFF|1|ON	Turns the front panel LXI identify indicator on or off.
:MDNS	
[:STATe] 0|OFF|1|ON	Sets the MDNS state

MEASure

[:SCALar]	
:CURRent	
[:DC]? (@<chanlist>)	Takes a measurement; returns the averaged current.
:VOLTage	
[:DC]? (@<chanlist>)	Takes a measurement; returns the averaged voltage.

MEMory

:COPY	
:TABLe <"*name*">	Copies the specified table to non-volatile memory.
:DELete	
[:NAME] <"*name*">	Deletes the specified table in both volatile and non-volatile memory.
:ALL	Deletes all tables in both volatile and non-volatile memory.
:TABLe	
:CATalog?	Returns the names of all tables in volatile and non-volatile memory.
:CURRent	
[:MAGNitude] <current>{,<current>}	Programs a list of current points for a new table.
:POINts?	Returns the number of current points in the active table.
:SELect <"*name*">	Creates a new table in volatile memory.
:VOLTage	
[:MAGNitude] <current>{,<current>}	Programs a list of voltage points for a new table.
:POINts?	Returns the number of voltage points in the active table.

OUTPut

[:STATe] 0|OFF|1|ON, (@<chanlist>)	Enables or disables the output.
:INHibit	
:MODE LATChing|OFF	Sets the operating mode of the remote inhibit digital pin.
:MODe BIDirectional|DIODe, <@chanlist>	Enables or disables the internal reverse-current protection diode
:PON	
:STATe RST|RCL0	Sets the output power-on state.
:PROTection	
:CLEar (@<chanlist>)	Resets the latched protection.
:COUPle 0|OFF|1|ON	Enables or disables channel coupling for protection faults.
:OT	
:AMBient:MARGin?	Returns the difference between over-temp and ambient temp.
:TUNNel:MARGin? (@<chanlist>)	Returns the difference between heatsink over-temp and temp.

[SOURce:]
CURRent
[:LEVel]
[:IMMediate]
[:AMPLitude] <*value*>, (@<chanlist>) Sets the output current when in current priority mode.
:LIMit
[:POSitive]
[:IMMediate]
[:AMPLitude] <*value*>, (@<chanlist>) Sets the positive current limit when in voltage priority mode.
:NEGative
[:IMMediate]
[:AMPLitude] <*value*>, (@<chanlist>) Sets the negative current limit when in voltage priority mode.
:DTABle
[:IMMediate]? (@<chanlist>) Returns the table currently being used by the channel.
:SASimulator
[:IMMediate]? (@<chanlist>) Returns the DAC table based on the SAS parameter settings.
:IMP? (@<chanlist>) Returns the calculated Imp of the internal DAC table.
:ISC? (@<chanlist>) Returns the calculated Isc of the internal DAC table.
:TABLe (@<chanlist>)
[:IMMediate]? <"*name*">, (@<chanlist>) Returns the DAC table based on the SAS parameter table settings.
:IMP? <"*name*">, (@<chanlist>) Returns the calculated Imp of the internal DAC table.
:ISC? <"*name*">, (@<chanlist>) Returns the calculated Isc of the internal DAC table.
:MODE FIXed|SASimulator|TABLe, (@<chanlist>) Selects the output mode of the instrument.
:PROTection
[:LEVel] <*value*>, (@<chanlist>) Sets the over-current protection level in SAS mode.
:STATe 0|OFF|1|ON, (@<chanlist>) Enables or disables over-current protection.
:SASimulator
:BWIDth "DEFAULT"|"DCDC_20UF"|"LT_VMP"|"SHUNTSW" (@<chanlist>) Specifies the compensation in SAS mode.
:IMP <*value*>, (@<chanlist>) Sets the current at the Imp point of the curve in SAS mode.
:ISC <*value*>, (@<chanlist>) Sets the Isc current of the curve in SAS mode.
:SCALe <*percent*>, (@<chanlist>) Specifies the current scale in SAS mode.
:TABLe
:NAME <*name*, (@<chanlist> Activates a table when operating in Table mode.

[SOURce:]
DIGital
:INPut
:DATA? Reads the state of the digital control port.
:OUTPut
:DATA <*value*> Sets the state of the digital control port.
:PIN<1-7>
:FUNCtion <*function*> Sets pin function. DIO|DINPut|FAULt|INHibit|ONCouple|OFFCouple
:POLarity POSitive|NEGative Sets the pin polarity.

[SOURce:]
FUNCtion
CURRent|VOLTage, (@<chanlist>) Sets the output regulation - voltage priority or current priority.

[SOURce:]
VOLTage
[:LEVel]
[:IMMediate]
[:AMPLitude] <*value*>, (@<chanlist>) Sets the output voltage when in voltage priority mode.
:LIMit
[:POSitive]
[:IMMediate]
[:AMPLitude] <*value*>, (@<chanlist>) Sets the positive voltage limit when in current priority mode.
:LOW <*value*>, (@<chanlist>) Sets the low voltage limit when in current priority mode.
:DTABle
[:IMMediate]? (@<chanlist>) Returns the table currently being used by the channel.
:SASimulator
[:IMMediate]? (@<chanlist>) Returns the DAC table based on the SAS parameter settings.
:VMP? (@<chanlist>) Returns the calculated Vmp of the internal DAC table.
:VOC? (@<chanlist>) Returns the calculated Voc of the internal DAC table.
:TABLe
[:IMMediate]? <"*name*">, (@<chanlist>) Returns the DAC table based on the SAS parameter table settings.
:VMP? <"*name*">, (@<chanlist>) Returns the calculated Vmp of the internal DAC table.
:VOC? <"*name*">, (@<chanlist>) Returns the calculated Voc of the internal DAC table.
:PROTection
[:LEVel] <*value*>, (@<chanlist>) Sets the over-voltage protection level
:DELay <*value*>, (@<chanlist>) Sets the over-voltage protection delay
:SASimulator
:SCALe <*percent*>, (@<chanlist>) Specifies the voltage scale in SAS mode.
:VMP <*value*> Sets the voltage at the Vmp point of the curve in SAS mode.
:VOC <*value*> Sets the Voc voltage of the curve in SAS mode.

STATus

:EDP	
:CONDition? (@<chanlist>)	Queries the EDP condition register.
:FRAMe	
[:EVENt]?	Queries the operation event register.
:CONDition?	Queries the operation condition register.
:ENABle <*value*>	Sets the operation enable register.
:NTRansiton <*value*>	Sets the Negative transition filter.
:PTRansiton <*value*>	Sets the Positive transition filter.
:OPERation	
[:EVENt]? (@<chanlist>)	Queries the operation event register.
:CONDition? (@<chanlist>)	Queries the operation condition register.
:ENABle <*value*>, (@<chanlist>)	Sets the operation enable register.
:NTRansiton <*value*>, (@<chanlist>)	Sets the Negative transition filter.
:PTRansiton <*value*>, (@<chanlist>)	Sets the Positive transition filter.
:PRESet	Presets all Enable, PTR, and NTR registers.
:QUESt<1|2>	
[:EVENt]? (@<chanlist>)	Queries the questionable event register.
:CONDition? (@<chanlist>)	Queries the questionable condition register.
:ENABle <*value*>, (@<chanlist>)	Sets the questionable enable register.
:NTRansiton <*value*>, (@<chanlist>)	Sets the Negative transition filter.
:PTRansiton <*value*>, (@<chanlist>)	Sets the Positive transition filter.
:UNR	
:CONDition? (@<chanlist>)	Queries the UNR condition register.

SYSTem

:CHANnel	
[:COUNt]?	Returns the number of output channels in a mainframe.
:MODel? (@<chanlist>)	Returns the model numbers of the selected channels.
:OPTion? (@<chanlist>)	Returns the options of the selected channels.
:SERial? (@<chanlist>)	Returns the serial numbers of the selected channels.
:COMMunicate	
:LAN|TCPip:CONTrol?	Returns the initial socket control connection port number.
:DATE <*yyyy*>, <*mm*>, <*dd*>	Sets the date of the system clock.
:ERRor?	Reads and clears one error from the error queue.
:REBoot	Reboots the instrument to its power-on state.
:TIME <*hh*>, <*mm*>, <*ss*>	Sets the time of the system clock.
:VERSion?	Returns the SCPI version that the instrument complies with.

Model Features and Options

Model Features

Mainframe Feature	MP4301A	MP4302A
Input voltage range	200-208 Vac	400-480 Vac
Power rating	6 kW	6 kW
Power Module Feature	**MP4361A**	**MP4362A**
Voltage, current, & power ratings	160 V, 10 A, 1 kW	130 V, 8 A, 1 kW
2-quadrant source/sink operation	Yes	No
Output autoranging	Yes	No
Solar array simulator operation	Yes	Yes
Adjustable bandwidth	SAS mode	SAS mode
Voltage & current programming	Yes	Yes
Voltage & current measurement	Yes	Yes
Array readback	Yes	Yes
Solid-state output disconnect	Yes	Yes

Options/Accessories

Option/Accessory	Description
Option UK6	Commercial calibration with test results data
Option GPB	Includes GPIB card and connector
Keysight MP4309A	Filler module kit (contains 5 filler modules for installing in unused slots)
Keysight 1CP104A	Rack mount kit with handles - for use with MP4301A and MP4302A
Keysight RP7908A	Rack rails for Keysight racks or similar designs

Specifications and Characteristics

Power Module Specifications and Characteristics

Mainframe Characteristics

Power Module Output Quadrants

Outline Diagram

NOTE

Unless otherwise noted, specifications are warranted over the ambient temperature range of 0 to 40°C after a 30-minute warm-up period. Specifications apply at the output terminals, with the sense terminals connected to the output terminals (local sensing).

Power Module Specifications and Characteristics

Specifications

Parameter	Keysight MP4361A	Keysight MP4362A
Output Ratings in Fixed mode		
Voltage source:	0 to 160 V	0 to 130 V
Current source:	0 to 10 A	0 to 8 A
Maximum Power:	1000 W	1000 W
Output Ratings in SAS and Table mode		
Maximum Voc and Vmp:	160 V	130 V
Maximum Isc and Imp:	10 A	8 A
Maximum Power:	1000 W	1000 W
Current sink capability		
Fixed mode:	0 to -10 A	0 to -0.5 A
SAS/Table mode:	0 to -0.5 A	0 to -0.5 A
Output ripple & noise		
CV peak-to-peak:[1]	500 mV	500 mV
CV rms:[2]	50 mV	50 mV
Programming accuracy [3]		
Voltage:	0.05% + 25 mV	0.075% + 25 mV
Current:	0.1% + 7 mA	0.2% + 10 mA
Measurement accuracy [3]		
Voltage:	0.05% + 25 mV	0.08% + 20 mV
Current:	0.1% + 7 mA	0.2% + 25 mA

[1] From 20 Hz to 20 MHz with 10 ohms in parallel with ≥100nF, or either terminal grounded

[2] From 20 Hz to 10 MHz with 10 ohms in parallel with ≥100nF, terminals ungrounded, or either terminal grounded

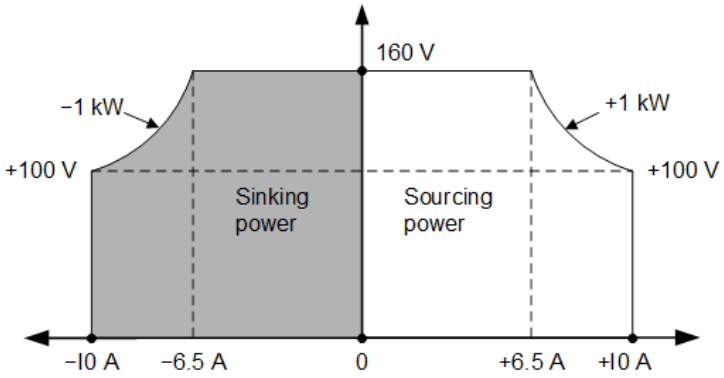
[3] @ 23°C ±5°C ≥

Characteristics

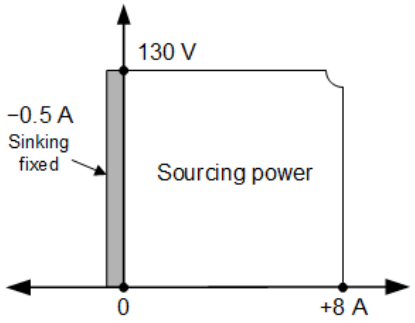
Parameter	Keysight MP4361A	Keysight MP4362A
Programming range & resolution		
Voltage:	0 - 163.2 V; 1.8 mV	0 - 132.6 V; 1.8 mV
Current:	0 -10.2 A; 0.12 mA	0 - 8.2 A; 0.12 mA
Overvoltage:	0 - 172.5 V; 1.8 mV	0 - 142.5 V; 1.8 mV
Overcurrent:	0 -12.5 A; 0.12 mA	0 -10 A; 0.127 mA
Programming accuracy		
Overvoltageprotection:	0.05% + 25 mV	0.075% + 25 mV
Overcurrent limit/protection:	0.1% + 7 mA	0.2% + 10 mA
Output settling time: [1]		
Voltage:	35 ms	35 ms
Current:	< 12.5 µs	< 12.5 µs
Temperature Coefficients - output change per °C		
Voltage:	0.01% + 1.5 mV	0.01% + 1.5 mV
Current:	0.01% + 500 µA	0.01% + 500 µA
Programming rise/fall time [2]		
Voltage:	< 8 ms	< 8 ms
Current:	10 µs	10 µs
Maximum shunt switching frequency:	20 kHz	20 kHz
Maximum MPPT tracking frequency:	200 Hz	200 Hz
SAS curve and table resolution:	1024 points	1024 points
Output capacitance:	80 nF	80 nF
Minimum impedance (Δ V/Δ I) - in SAS mode:	0.25 Ω	0.25 Ω
Maximum capacitive load: [3]	2000 µF	2000 µF
Maximum lead inductance: [3]	50 µH	50 µH
Output current noise [4]		
CC peak-to-peak:	48 mA	48 mA
CC rms:	6 mA	6 mA
Remote sense capability		
Fixed mode:	up to 2 V total	up to 2 V total
SAS/Table mode:	up to 2 V + (Voc - Vmp)	up to 2 V + (Voc - Vmp)
Load [5] & Line [6] regulation		
CV:	4 mV	4 mV
CC:	1 mA	1 mA

[1] Output recovery to within 1.5 A of an operating point on the I-V curve (V < 90% of VMP) after switching from a short circuit to a fixed load
[2] Time for output to change from 90% to 10% or 10% to 90% of its total excursion
[3] Simulator, Table, and Fixed Modes
[4] From 20 Hz to 20 MHz with 10 ohms in parallel with ≥100nF, or either terminal grounded
[5] Change in output voltage or current for any load change within ratings
[6] Change in output voltage or current for any line voltage change within ratings

Power Module Output Quadrants



MP4361A



MP4362A

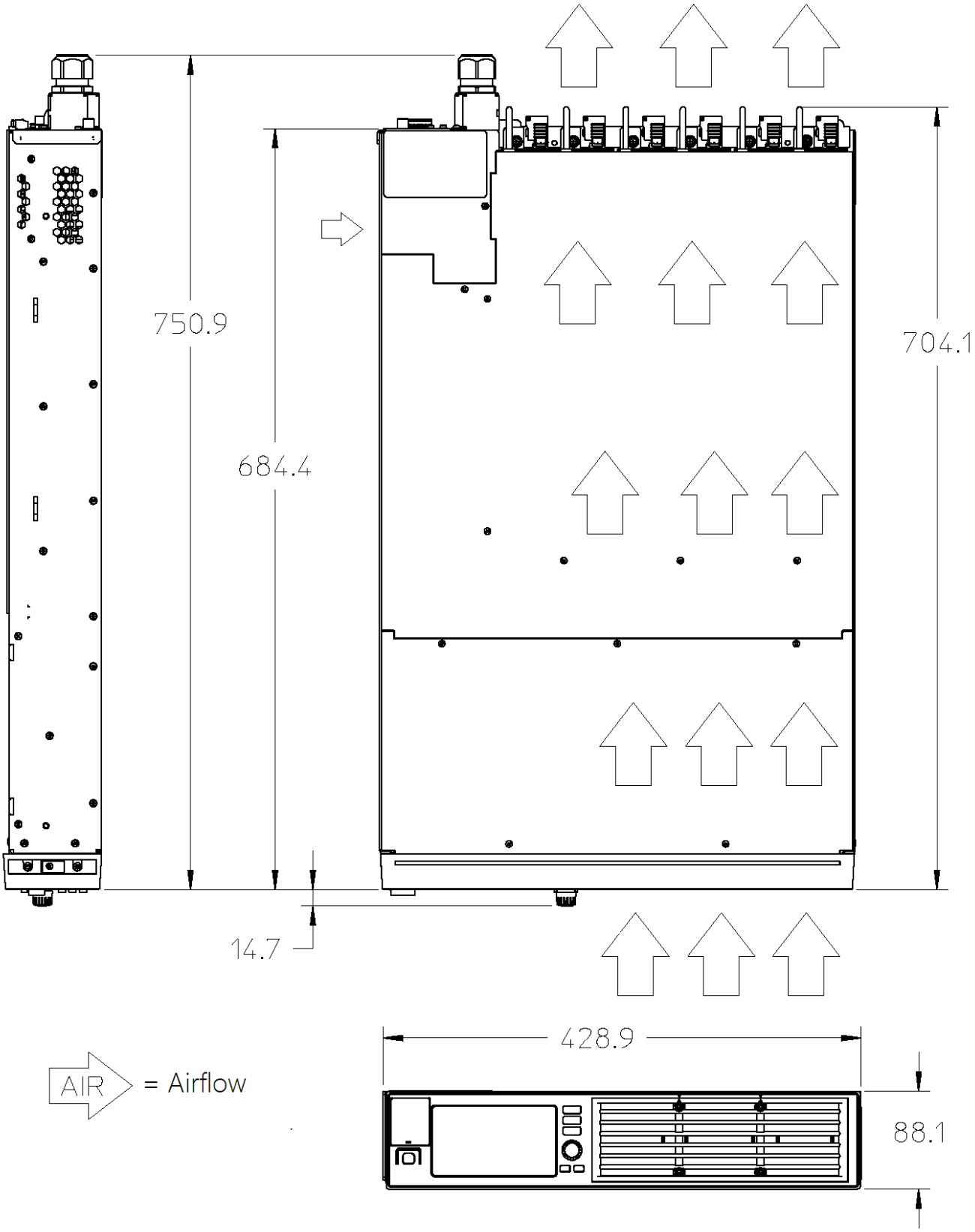
Mainframe Characteristics

Common Characteristic	Keysight MP4301A & MP4302A
Command Processing Time	≤ 1 ms from receipt of command to start of output change. Applies for simple output settings commands.
Computer Interfaces	
LXI version:	1.5 LXI Device Specification 2016
LAN:	10 Mb, 100 Mb, 1 Gb LAN
USB:	USB 2.0 (USB-TMC488 protocol)
GPIB (Option GPB):	SCPI - 1995, IEEE 488.2 compliant interface
Digital Port	
Max voltage rating:	+16.5 VDC/- 5 VDC between pins
Pins 1 & 2 as FLT:	Maximum low-level output voltage = 0.5 V @ 4 mA Maximum low-level sink current = 4 mA Typical high-level leakage current = 1 mA @ 16.5 VDC
Pins 1-7 as outputs:	Maximum low-level output voltage = 0.5 V @ 4 mA; 1 V @ 50 mA; 1.75 V @ 100 mA Maximum low-level sink current = 100 mA Typical high-level leakage current = 0.8 mA @ 16.5 VDC
Pins 1-7 as inputs:	Maximum low-level input voltage = 0.8 V Minimum high-level input voltage = 2 V Typical low-level current = 2 mA @ 0 V (internal 2.2k pull-up) Typical high-level leakage current = 0.12 mA @ 16.5 VDC
Pin 8:	Pin 8 is common (internally connected to chassis ground)
Acoustic statement (European Machinery Directive)	Acoustic noise emission LpA <70 dB at Operator position: LpA <70 dB at Bystander position LpA <55 dB at Idle fan speed Normal operation mode per ISO 7779

Common Characteristic	Keysight MP4301A & MP4302A
Environmental	
Operating environment:	Indoor use, installation category II, pollution degree 2
Temperature range:	0°C to 55°C (Maximum current is derated at 1% per degree C from 40°C to 55°C)
Relative humidity:	Up to 95% RH
Altitude:	Up to 2000 meters
Storage temperature:	-30°C to 70°C
LED statement:	Any LEDs used in this product are Class 1 LEDs as per IEC 825-1
Regulatory Compliance	
EMC:	Complies with European EMC Directive for test and measurement products Complies with Australian standard and carries C-Tick mark This ISM device complies with Canadian ICES-001 Cet appareil ISM est conforme à la norme NMB-001 du Canada
Safety:	Complies with European Low Voltage Directive and carries the CE mark. Conforms to US and Canadian safety regulations. Declarations of Conformity for this product may be downloaded from the Web. Go to http://www.keysight.com/go/conformity and click on “Declarations of Conformity.”
AC Input	
Connections:	L1, L2, L3, and PE (does not require a neutral connection)
Phase and range:	MP4301A - 3 phase; 200 VAC ± 10% and 208 VAC ± 10% MP4302A - 3 phase; 380 VAC ± 10%, 400VAC ± 10% and 480 VAC ± 10%
Frequency:	47 - 63 Hz (400 Hz not supported)
Input VA:	7.2 kW
Input current per phase:	MP4301A - 23.1 A for 200 V models, MP4302A - 12.2A for 400 V models
Efficiency at full power:	85%
Power Factor:	0.99 @ nominal input and rated power
Output Terminal Isolation	No output terminal may be more than ±240 VDC from any other terminal or chassis ground.
Typical Weight	MPS mainframe: 42.4 lbs (19.3 kg) Power module: 3.8 lbs (1.7 kg) Fully loaded mainframe: 65.2 lbs (29.5 kg)
Dimensions	See Outline Diagram for details

Outline Diagram

All dimensions are in millimeters.



2
Installing the Instrument

Before Installation or Use

Installing the Mainframe

AC Mains Connections

Output Connections

Multiple Channel Connections

Interface Connections

WARNING Heavy Weight
Danger to hands and feet. To avoid personal injury and damage to the instrument, always use a sturdy cart or other suitable device to move the instrument. Do not lift the instrument alone; always use two people to lift the instrument.

Before Installation or Use

Inspect the Unit

Upon receipt of the MPS unit, inspect it for any obvious shipping damage. If there is damage, notify the shipping carrier and nearest Keysight Sales and Support Office immediately (www.keysight.com/find/assist). Save the shipping carton and packing materials in case the unit has to be returned.

Check for Items Supplied

Before getting started, check the following list and verify that you have received these items. If anything is missing, please contact your nearest Keysight Sales and Support Office.

Supplied Items	Description	Part Number
MPS Mainframe kit - Includes:		
Digital connector plug	8-pin digital port connector	Keysight 1253-6408 Phoenix Contact 1840421
AC safety cover	Safety cover for ac mains input wires	Keysight 5003-2851
Safety cover screws	Pan-head screw, Torx-T10, M3X0.5, 8 mm, qty 3	Keysight 0515-0372
Strain relief	Strain relief bushing for ac mains input wires	Keysight 1410-1919
Lockout bar	Lockout bare to prevent module removal while energized	Keysight 5040-1771
Lockout bar screws	Slotted/T10 screw, M3X0.5, 6 mm, qty 2	Keysight 0515-5113
Foot	Self-adhesive bumper foot, qty 4	Keysight 0403-1352
Power Module kit - Includes:		Keysight 5066-2126
Output connector plug	4- pin dc output connector, 7.62 mm, 41 A	Keysight 1254-4978 Phoenix Contact 1718504
Sense wire ferrule (qty 2)	Ferrule Sleeve 16.5 mm, 0.8 mm-DIA, 22 AWG, qty 2	Keysight 0362-1830 Phoenix Contact 3200645
Output wire ferrule (qty 2)	Ferrule Sleeve 19 mm, 2.8 mm-DIA, 12 AWG, qty 2	Keysight 0362-1832 Phoenix Contact 3200959
Calibration certificate	Calibration certificate referenced to serial number	None

Review Safety Information

This power supply is a Safety Class 1 instrument - with a protective earth terminal. This terminal must be connected to earth ground through an ac mains equipped with an earth ground. Refer to the Safety Summary page for general safety information. Before installation or operation, always review this guide for specific safety warnings and instructions located at appropriate places throughout the guide.

WARNING LETHAL VOLTAGES - Power modules generate output voltages up to 160 VDC! Ensure that all instrument connections, including load and sense wiring, are insulated.

Observe Environmental Conditions

WARNING Do not operate the instrument in the presence of flammable gases or fumes.

The environmental conditions for the MPS are documented under Common Characteristics. The unit should only be operated indoors in a controlled environment. Do not operate the unit in areas where the ambient temperature exceeds +55 degrees Celsius. This applies for rack-mounting as well as for bench use.

Provide Adequate Air Flow

CAUTION Do not block the air intake at the front, or the exhaust at the rear of the instrument. Refer to the Dimension Diagram for details

The dimensions of the MPS mainframe as well as an outline diagram are given in the Dimension Diagram. Fans cool the power supply by drawing air through the front and side and exhausting it out the back. The unit must be installed in a location that allows sufficient space of at least 3 inches (7.62 cm) at the front and back of the unit, and 1 inch (2.54 cm) along the side for adequate air circulation.

In case of excessive ambient temperature or blockage of airflow at the air inlet or outlet of the instrument, an over-temperature protection will disable the output to protect the mainframe and device under test.

Moving Instruments

CAUTION Fully loaded MPS mainframes weigh as much as 65 lbs (29.5 kg). Always use a sturdy cart or other suitable device to move the instrument. Two people are required for installation. Do not lift or move the unit alone.

Stacking Instruments

CAUTION Never stack more then three mainframes in a free-standing installation.

Rack Mounting Accessories

Keysight MP4300 MPS mainframes can be mounted in a 19-inch EIA rack cabinet. They are designed to fit in two rack-units (2U) of space.

Accessory	Description
Keysight 1CP104A	Rack mount kit with handles - for use with MP4301A and MP4302A
Keysight RP7908A	Rack rails for Keysight racks or similar designs

Installation instructions for the rack mounting accessories are included with each accessory.

Installing the Mainframe

Power Module Installation

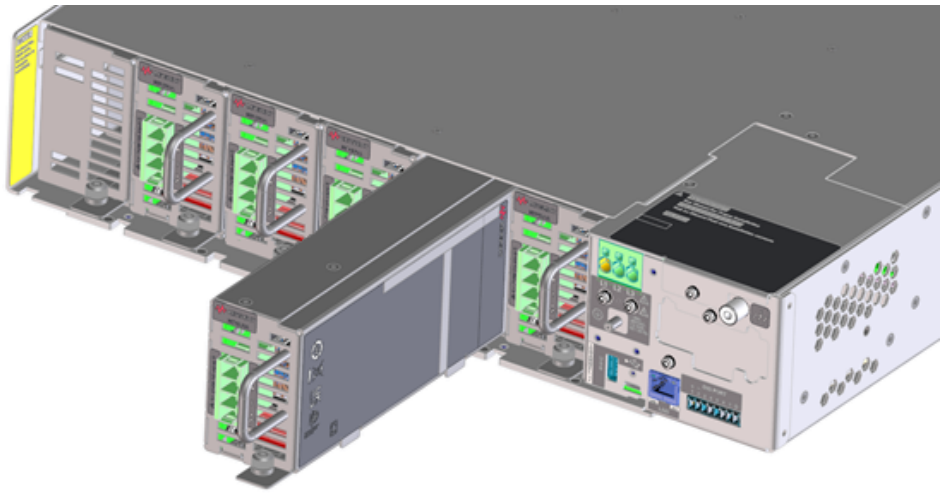
NOTE The information in this section applies if you have purchased an MPS mainframe without the power modules installed, or if you are adding a power module to the mainframe.

CAUTION **Equipment Damage** Turn the mainframe off and disconnect the ac mains before installing or removing power modules. Observe all standard electrostatic discharge precautions before handling electronic components.

Any unused slots **must** have a filler module installed to ensure proper cooling. In the following figures, a filler module is installed in slot 6.

Tools required: #2 Phillips (optional) and T10 Torx driver

Step 1. Power modules can be installed in any slot. Start by sliding the module into the selected slot. In the following figure the module is being installed in Slot 2.

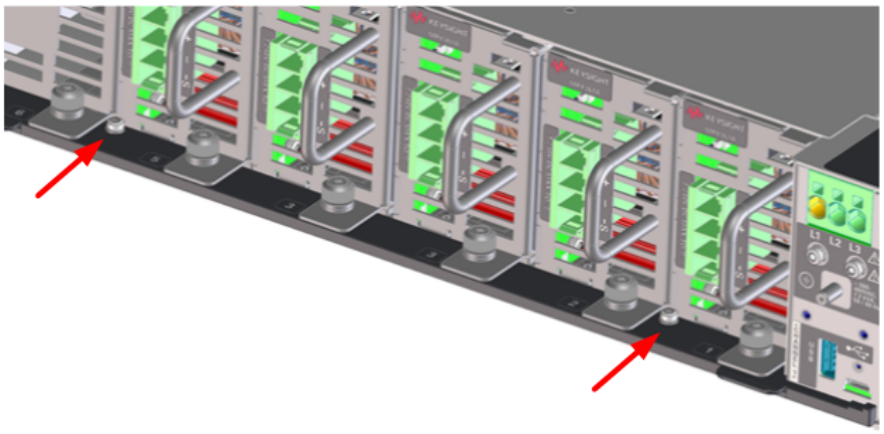


Step 2. Loosely tighten the thumbscrew. If the thumbscrew is tightened all the way you will not be able to install the lockout bar later. Continue installing any other power modules.

Step 3. Install a filler module in any unused slots. In the previous figure, a filler module is shown installed in slot 6. Note that filler modules are an option that must be ordered along with each mainframe. Refer to Model Features and Options for more information.

Step 4. Install the lockout bar after all modules have been installed. Slide the lockout bar under the thumbscrews. The lockout bar ensures that the power modules are not inserted or removed while the internal high voltage rail is active. Without the lockout bar, the module cannot be powered-on. The front panel will indicate "No Module Installed".

Step 5. After the lockout bar is in place, insert and tighten the supplied slotted/T10 screws in the locations shown by the red arrows. Lastly, tighten the module thumbscrews all the way, thus clamping the metal tabs to the lockout bar.



To remove a module, follow the above steps in reverse.

Replacement installation parts can be ordered from Keysight Technologies using the following part numbers:

Part Number	Qty	Description
0515-5113	2	Lockout screw, slotted/T10, M3X0.5, 6mm
5040-1771	1	Lockout Bar
5003-2848	1	Filler Module (MP4309A kit includes 5 modules)

Power Module Channel Assignment

The slot location of a power module in the mainframe determines the channel assignment of the module. When viewed from the rear, the module next to the ac mains connector is always output channel one. Numbering continues sequentially to the left, from 1 up to 6.

Double-wide power modules are assigned the number of the lowest numbered slot in which is installed. For example, if a double-wide module is installed in slots 3 and 4, it is assigned channel number 3. The next adjacent higher numbered module will be assigned channel number 5.

Bench Installation

CAUTION

Do not block the air intake at the front and side, or the exhaust at the rear of the unit. Refer to the dimension diagram for details.

Never stack more then three mainframes on top of one another in a free-standing installation.

The unit must be installed in a location that allows sufficient space of at least 3 inches (7.62 cm) at the front and back, and 1 inch (2.54 cm) along the side of the unit for adequate air circulation.

Four self-adhesive feet are shipped with the mainframe. If desired, install the feet on the bottom of the chassis - one on each corner. Do not install the feet on the front frame.

AC Mains Connections

AC Mains Considerations

Power Cable Connections

AC Mains Considerations

Keysight MPS systems have a fully bi-directional three-phase ac input converter, which allows for seamless bi-directional power flow between the ac mains and dc output terminals.

In a standard power supply, energy only flows from the ac to the dc output terminals. In a regenerative power system, energy also flows from the dc output terminals back to the ac mains whenever the unit is sinking current, either from rapid down-programming of the output or from discharging an energy source such as a battery. This return of energy back to the ac mains is referred to as regenerative operation.

The ac input converter of the MPS system employs firmware algorithms to maintain high power factor and low total harmonic distortion across a wide range of operating conditions. For power factor information, refer to the ac input portion of the Common Characteristics section.

CAUTION Exceeding the ac input voltage rating or miswiring the line connection can create permanent damage in the following devices.

Power Cable Connections

NOTE Compliance to all regulations for the operation of and connection to the public grid of energy back-feeding equipment is required.

AC mains connections must be made by a qualified electrician who is knowledgeable about energy back-feeding equipment to ensure that all applicable safety requirements have been applied and all necessary conditions have been met. Knowledge about 3-phase mains circuits and all applicable safety standards and requirements is also required.

An ac mains power cable is not provided with the unit.

Refer to the following table for the maximum current capacity requirements for each cable conductor. If required by local electrical codes, install a fuse or circuit breaker between the ac mains and the unit. Power cords other than the recommended cords may not fit through the strain relief of the ac cover.

Model	Power cord recommendation	Max input current/ phase L1, L2, and L3
Keysight MP4301A	10/4 SJOOW Cord 300 V UL/CSA	23.1 A
Keysight MP4302A	12/4 SOOW Cord 600 V UL/CSA	12.2 A

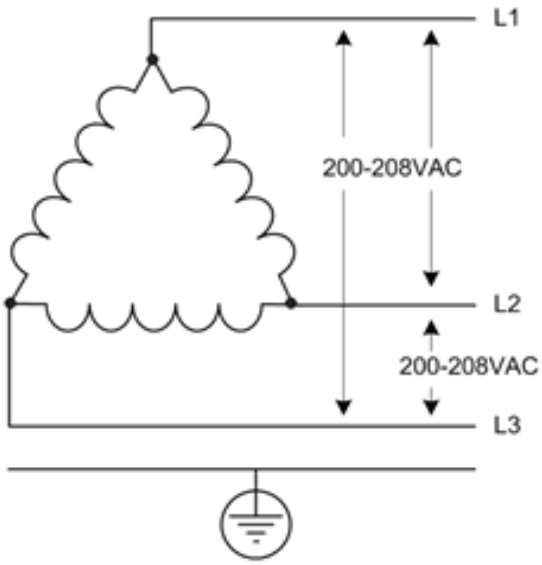
WARNING The cable cross-section must be suitable for the maximum input current of the instrument. The ground cable must have the same cross-section as the phase cable. The power cords recommended above meet these requirements.

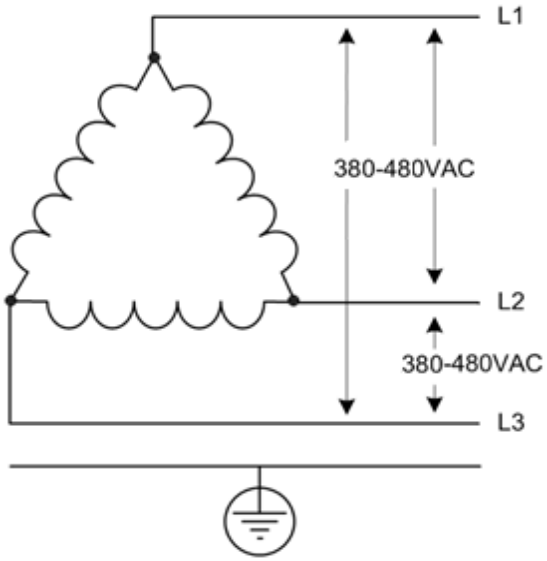
NOTE Safety agency requirements dictate that there must be a way to physically disconnect the ac mains cable from the unit. A disconnect device, either a switch or circuit breaker must be provided in the final installation. The disconnect device must be close to the equipment, be easily accessible, and be marked as the disconnect device for this equipment. It must meet the input ratings requirements listed in the following table.

Keep the ac mains cables as short as possible. The longer the cable, the greater the voltage loss due to cable resistance.

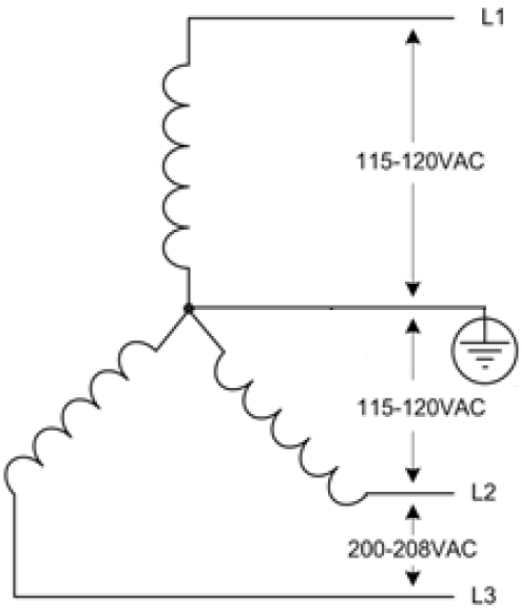
A Wye-type or Delta-type ac mains distribution is required, provided the correct line-to-line voltage is applied. An earth-ground to the PE-ground connection through a separate conductor is also required.

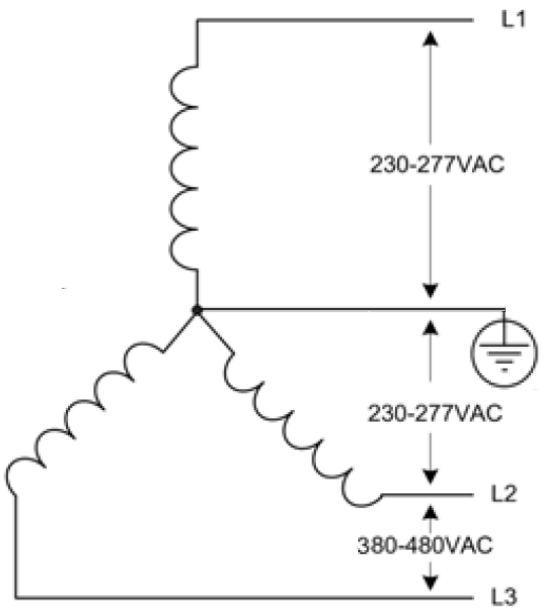
Delta-type





Wye-type



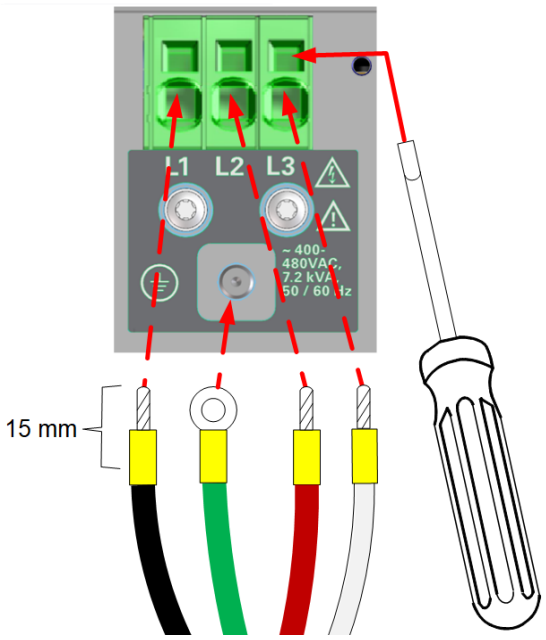


WARNING SHOCK HAZARD The instrument requires a chassis ground connection through a separate conductor. The ac mains must include an earth ground connection.

In cases were the unit is not hardwired to the electrical system, a locking connector scheme should be used such as UL 498, IEC 60309, or equivalent. Consult a local electrician for the connector scheme appropriate for your region.

- The following wire specification and preparation applies (see power cord recommendation)::
  Cable insulation stripping length: 45 - 50 mm
  Wire insulation stripping length: 15 mm
- Recommended ferrules for AWG are:
  10 AWG: Phoenix Contact 3201107
  12 AWG: Phoenix Contact 3200959
  Recommended crimp tool is Hand Tool Crimper, Phoenix Contact p/n CRIMPFOX 6, MPN 1212034.
- Twist and insert the stranded wire completely into the ferrules.
- Crimp the ferrules onto the wires. Ensure that there are no exposed wire strands.
- Crimp an M5 ring lug onto the ground wire (TE Connect p/n 130171).
- Insert the terminated ends of the power cord through the strain relief of the safety cover. The safety cover strain relief is designed to accommodate both a wire cable, or individual wires.
- Do not tighten the strain relief yet.

- Attach the line wires to the L1 - L3 terminals. (U.S. color code shown)
  Always use a flat blade screwdriver to release and fully open the wire clamp when installing stranded wire.
- Connect the ground wire to the chassis stud located *below* the ac mains connector.
  Torque the M5 combination nut to 20 in-lbs.
- Attach the safety cover to the unit using the three T10 screws provided.
  Torque the cover screws to 9 in-lbs.
  Tighten the strain relief.



Output Connections

Wiring Considerations

Single Load Connections

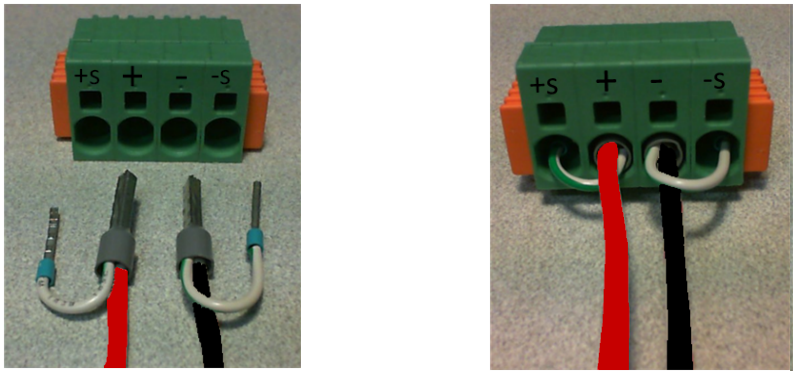
Multiple Load Connections

Remote Sense Connections

Wiring Considerations

Sense Connections

When local sensing, ensure that the sense jumpers are installed on the back of the instrument as shown. The only time the sense jumpers should be disconnected from the output is when remote sensing. Keysight recommends 22 AWG wire used for sense jumpers as well as for remote sensing. Ferrules are recommended for all wiring, especially when using stranded wires (see Items Supplied).



If the sense wires are not installed prior to instrument turn-on or become disconnected, the unit will continue to operate. The open-circuit voltage will now be higher **at the output terminals** than the programmed value because the regulation point is now maintained through internal sense-protect resistors. The actual voltage at the output terminals will be approximately 1% higher than the programmed value. The readback voltage will reflect the programmed value.

Output Connections

WARNING LETHAL VOLTAGES – Power modules generate output voltages up to 160 VDC! Ensure that all instrument connections, including load and sense wiring, are insulated.

The following factors should be considered when wiring the load to the power supply:

- Load wire temperature, current carrying capacity, and voltage drop
- Load and sense wire insulation rating must be at least 300V to ensure adequate insulation due to voltage transients that may occur due to external wiring inductance and/or other disturbances arising from the application.
- Load wire noise and impedance effect

Wire Size

WARNING FIRE HAZARD Select a wire size large enough to carry short-circuit current without overheating (refer to the following table). To satisfy safety requirements, load wires must be heavy enough not to overheat while carrying the short-circuit output current.

Along with conductor temperature, you must also consider voltage drop when selecting wire sizes. The following table lists the resistance for various wire sizes and the maximum lengths to limit the voltage drop to 1.0 V per lead for various currents.

Note that the minimum wire size required to prevent overheating may not be large enough to prevent over-voltage tripping or maintain good regulation. To help prevent nuisance tripping of the over-voltage circuit, select a wire size sufficient to handle the FULL output current of the unit no matter what the intended load current or current limit setting.

Load lead resistance is also an important factor relating to the CV stability of the instrument when remote sensing capacitive loads. If high capacitance loads are expected, you should not use wire gauges heavier than AWG 12 to AWG 14 for long runs of load lead.

Wire Size	Metric size		Resistance	Max length to limit voltage to 1 V/lead	
				for 5 A	for 10 A
AWG[1]	2 wires bundled	4 wires bundled	Ω per foot	Wire length in feet	
18	14.5	12.8	0.0064	30	15
16	18.2	16.1	0.0040	50	25
14	29.3	25.9	0.0025	80	40
12	37.6	33.2	0.0016	125	63
10	51.7	45.7	0.0010	200	100
8	70.5	62.3	0.0006	320	160
Area in mm^2	2 wires bundled	4 wires bundled	Ω per meter	Wire length in meters	
1	12.7	11.2	0.0200	10	5
1.5	15.0	13.3	0.0137	14.6	7.2
2.5	23.5	20.8	0.0082	24.4	12.2
4	30.1	26.6	0.0051	39.2	19.6
6	37.6	33.2	0.0034	58	29
10 (solid wire only)	59.2	52.3	0.0020	102	51

1. Capacity for AWG wires derived from MIL-W-5088B. Maximum ambient temperature: 55°C. Maximum wire temperature: 105°C.
2. Capacity for metric wires are derived from IE Publication 335-1.
3. Capacity of aluminum wire is approximately 84% of that listed for copper wire.
4. Because of wire inductance considerations, it is also recommended that you keep your load leads twisted, tie wrapped, or bundled together and less than 50 feet (14.7 meters) in length per lead.
5. Wire ferrules are included with this product for AWG 12 and 4 mm^2 stranded wires.

Single Load Connections

WARNING SHOCK HAZARD Turn off ac power before making rear panel connections. Verify that any external sources are powered down, and any that capacitance on the MPS output terminals has been fully discharged. The MPS does not automatically down-program external capacitance connected to output terminals.

Disconnect the connector plug to make your wire connections. The 4-pin output connector accepts wires sizes from AWG 8 to AWG 24. Wire sizes smaller than AWG 20 are not recommended. Keysight recommends either using solid wires, or attaching ferrules to the end of stranded wires.

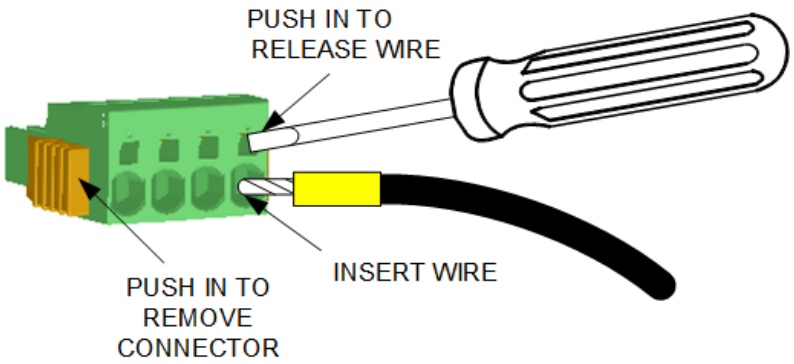
Ferrules are provided for the output and sense wires (see Items Supplied). When using **local** sensing, both sense and output wires can be combined into one ferrule, p/n 0362-1832. When combining the local sense and load wires, the load wires should not exceed AWG 14.

When using **remote** sensing, use ferrule p/n 0362-1830 for the sense wires, and ferrule p/n 0362-1832 for the load wires. Note that when using this ferrule the load wires should not exceed AWG 12.

The recommended crimp tool for the ferrules is:
Hand Tool Crimper, Phoenix Contact p/n CRIMPFOX 6, MPN 1212034.

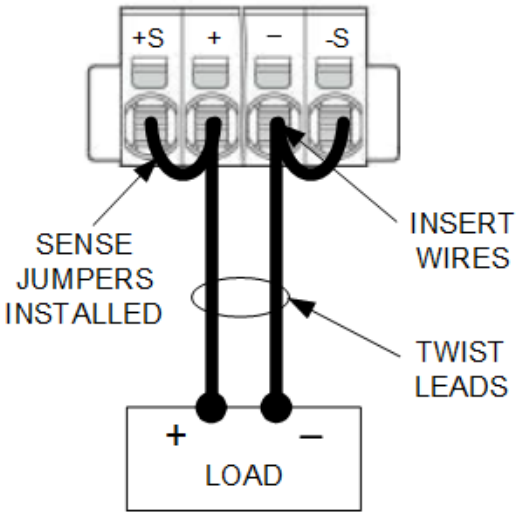
Connect the load wires to the + and - terminals. Connect the sense wires to the +s and -s terminals. As shown in the following illustration, simply push the solid wire or ferrule into the appropriate pin (+/- sense or load). The stripping length for the solid wire insulation is 15 mm.

To remove wires from the connector, use a small flat-blade screwdriver to push in the spring latch to release the wire as shown in the following figure. Note that considerable force is required to release the spring tab. Additionally, if you are using stranded wire without ferrules (not recommended), you must first release the spring latch before inserting the stranded wire.



To install the connector, simply press the connector firmly into the module until you feel or hear a "click", which ensures a secure connection. To remove the connector, simply push in on the two yellow tabs to latch the tabs, and then pull the connector out.

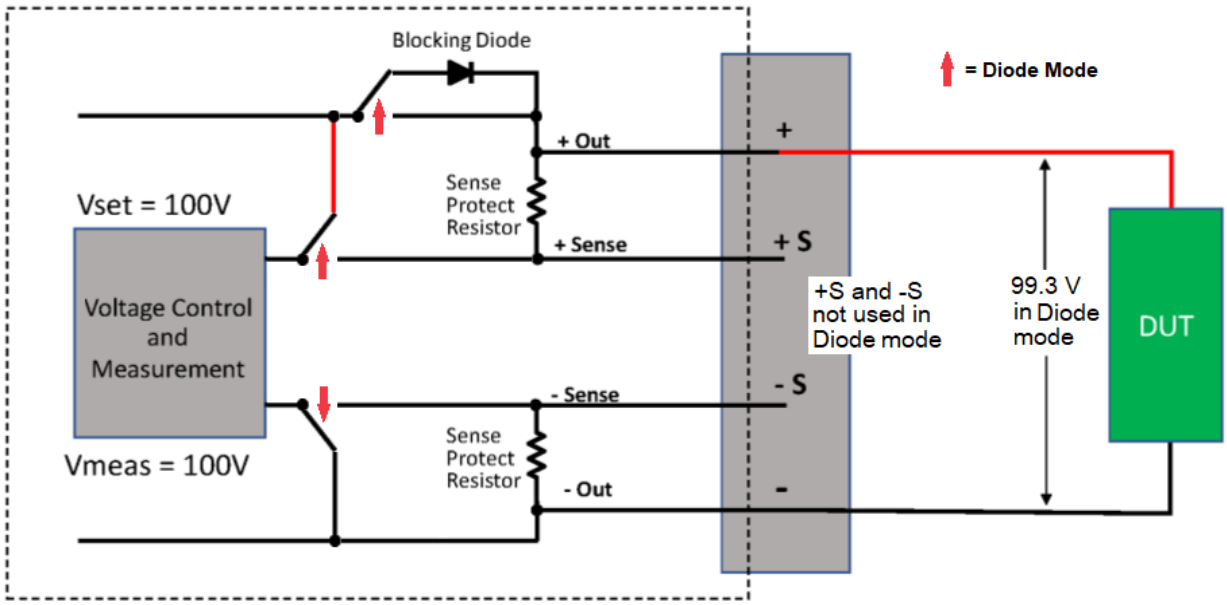
The following illustration shows a single channel connected to the load using local sensing. Keep the wire-pair as short as possible. Twist or bundle the wires to reduce lead inductance and noise pickup.



Reverse-Current Blocking Diode

The MPS has a built-in reverse-current blocking diode. When enabled, the cathode of the diode connects to + out. The diode protects the instrument from reverse currents that can be generated if a paralleled output or a battery is connected to an output and its over-voltage protection trips.

The current blocking diode can be switched in or out using the OUTPut:MODE command. The following figure illustrates the voltage control and measurement path when the diode is switched in.



As shown in the figure, diode mode uses local feedback and readback. Voltages are measured at the anode end of the diode. Therefore there will always be an approximately 0.7 V difference at the DUT compared to the voltage setting and measurement provided by the MPS.

Additionally, when the output is disabled when operating in diode mode, the front panel voltage readback switches from sensing at the anode of the blocking diode, to reading the voltage at the remote sense terminals. This results in a change in the front panel voltage reading.

NOTE

With the current blocking diode switched in, you will not be able to sink current, program negative current limit in voltage priority mode, or program a negative set point in current priority mode.

Also, you will not be able to use the DCDC_20UF or the LT_VMP compensation mode in SAS operation, as this compensation mode requires the use of remote sensing.

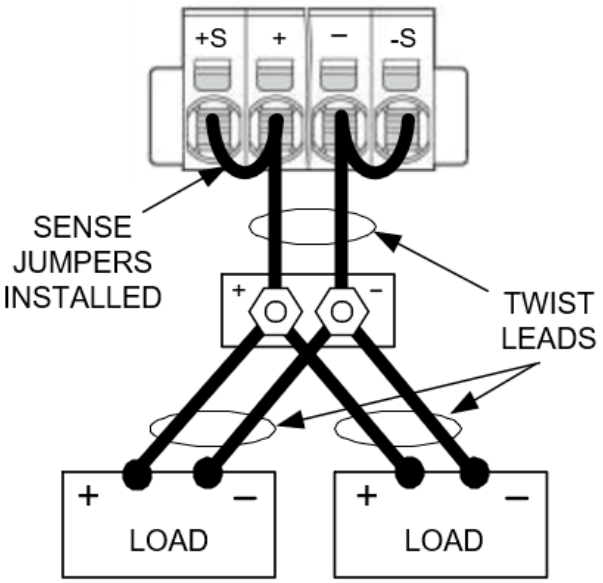
Multiple Load Connections

WARNING

SHOCK HAZARD Turn off ac power before making rear panel connections. Verify that any external sources are powered down, and any that capacitance on the MPS output terminals has been fully discharged. The MPS does not automatically down-program external capacitance connected to output terminals.

If you are using local sensing and are connecting multiple loads to one output, connect only **one** set of wires to the output terminals as shown in the following figure. Use remote distribution terminals as the connection point for both the output and the load wires. Connect each load to the distribution terminals separately.

Keep the wire-pairs as short as possible and twist or bundle each wire pair to reduce lead inductance and noise pickup. The goal is to minimize the loop area or physical space between the + and - output leads from the output to the loads. Remote voltage sensing may be recommended when using remote distribution terminals. Sense either at the remote distribution terminals or, if one load is more sensitive than the others, directly at the critical load.

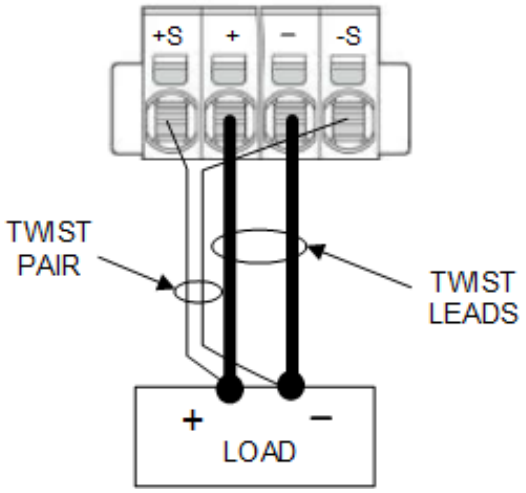


Remote Sense Connections

WARNING LETHAL VOLTAGES - Power modules generate output voltages up to 160 VDC! Ensure that all instrument connections, including load and sense wiring, are insulated.

Remote sensing improves the voltage regulation at the load by regulating the voltage there instead of at the output terminals. This automatically compensates for the load lead voltage drops. Remote sensing is especially useful for CV operation with load impedances that vary or have significant lead resistance. It has no effect during CC operation. Because sensing is independent of other power system functions, remote sensing can be used regardless of how the power system is programmed.

Connect the unit for remote sensing by first removing the jumpers between sense and load terminals. If you have connected your sense wires as shown under Sense Connections, simply remove the wires and tape then to the side of the corresponding load wire using electrical tape. This will let you reuse them in the future. Make your connections as shown in the following figure. Connect the load to the output terminals using separate connecting wires. Keep the wire-pair as short as possible and twist or bundle it to reduce lead inductance and noise pickup. Keep load leads under 14.7 meters (50 feet) per lead because of inductance effects.



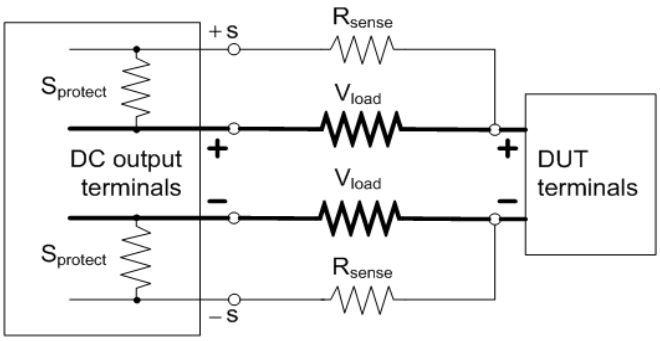
Connect the sense leads as close to the load as possible. Keep the sense wire-pair as short as possible and twist or bundle it to reduce noise pickup. Do NOT bundle the sense wire-pair together with the load wire pair. Sense wires are normally of a lighter gauge than the load wiring.

Note that any voltage drop due to wire resistance in the sense leads can degrade the output voltage regulation. As the voltage drop in the load leads increases, the load voltage regulation error due to sense-lead resistance increases according to the following formula:

$\Delta V_{regulation} = 2(V_{load}(R_{sense}/S_{protect}))$

R_{sense} is the resistance in ohms of each sense lead.
V_{load} is the voltage drop in each load lead.
$S_{protect}$ is the internal sense protect resistor (see following table).

The formula assumes that the voltage drop in the +/- load leads are equal.



Module	$S_{protect}$ resistor
MP4361A , MP4362A	1.6 kΩ

Open Sense Leads

The sense leads are part of the output's feedback path. Connect them in such a way so that they do not inadvertently become open circuited. The power system includes protection resistors that reduce the effect of open sense leads during remote-sensing operation. If the sense leads open during operation, the power system returns to the local sensing mode, with the voltage at the output terminals approximately 1% higher than the programmed value.

Over-Voltage Protection Considerations

You must take into account any voltage drop in the load leads when setting the over-voltage trip point. This is because the OVP circuit senses at the output terminals and not at the sense terminals. Due to the voltage drop in the load leads, the voltage sensed by the OVP circuit could be higher than the voltage being regulated at the load.

Output Noise Considerations

Any noise picked up on the sense leads will appear at the output terminals and may adversely affect CV load regulation. Twist the sense leads to minimize the pickup of external noise. In extremely noisy environments it may be necessary to shield the sense leads. Ground the shield at the power system end only; do not use the shield as one of the sensing conductors.

The documented noise specifications apply at the output terminals when using local sensing. However, voltage transients may be produced at the load by noise induced in the leads or by load current transients acting on the inductance and resistance of the load lead. If it is desirable to keep voltage transient levels to a minimum, place an aluminum or tantalum capacitor, with an approximate value of 10 µF per foot (30.5 cm) of load lead, right across the load.

Paralleled Channel Connections

Parallel Connections

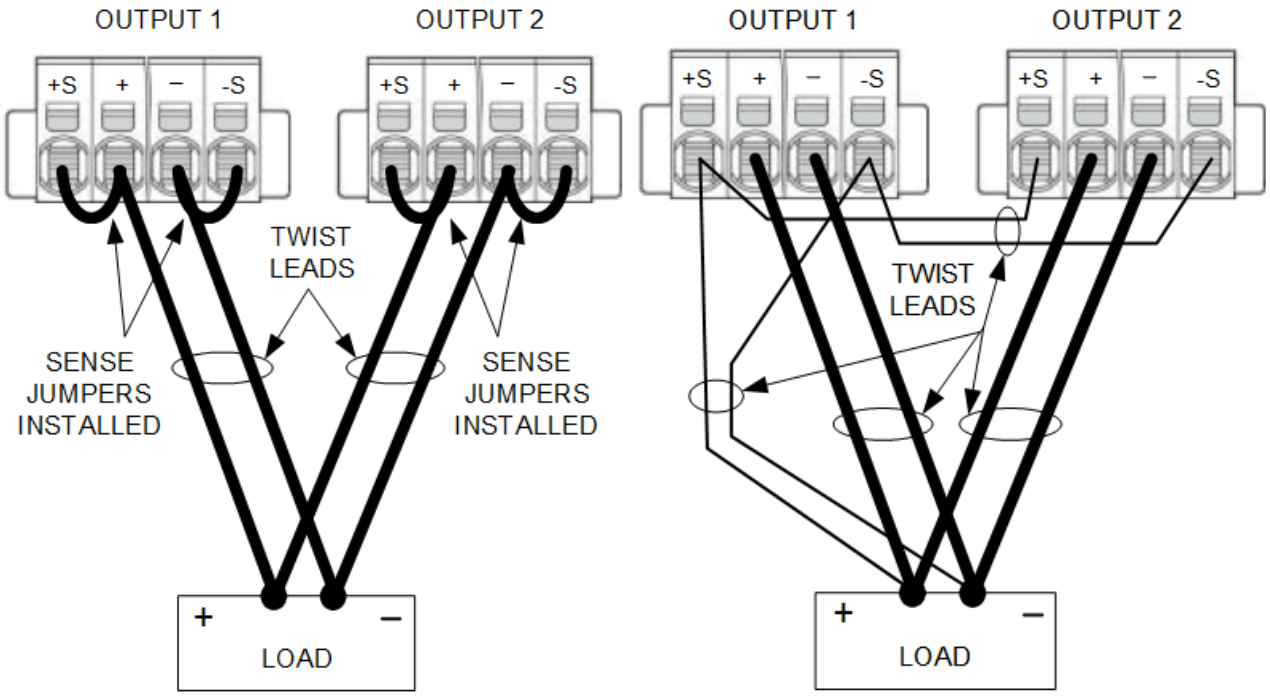
CAUTION

Equipment Damage Only connect power modules that have identical voltage and current ratings.

Connect the parallel wires at the load, not at the output connectors.

Paralleling outputs provides a greater current capability than can be obtained from a single output.

The following figures show how to connect two modules in parallel. The figure on the left illustrates local sensing. If voltage drop in the load leads is a concern, the figure on the right shows how to connect the sense leads directly at the load. Note that in both cases, the remote sense terminals must be connected.



Local sensing

Remote sensing

First program both outputs to the desired output voltage. Then program the current limit of each output. In Current Priority mode, program the output current of each output to one half of the total desired output current. Set the voltage limit to a value higher than the expected output voltage.

Effect on Specifications

Specifications for outputs operating in parallel can be obtained from the specifications for single outputs. Most specifications are expressed as a constant or as a percentage (or ppm) plus a constant. For parallel operation, the percentage portion remains unchanged while constant portions or any

constants are changed as indicated below. For current readback accuracy and temperature coefficient of current readback, use the minus current specifications:

Current: All parallel specifications referring to current are twice the single output specification except for programming resolution, which is the same for both single output and parallel output operation.

Voltage: All parallel specifications referring to voltage are the same as for a single output except for CV load effect, CV load cross regulation, CV source effect, and CV short term drift. These are all twice the voltage programming accuracy (including the percentage portion) at all operating points.

Interface Connections

LAN Connections - site and private

USB Connections

GPIB Connections

Digital Port Connections

This section describes how to connect to the various communication interfaces on your unit. For further information about configuring the remote interfaces, refer to Remote Interface Configuration.

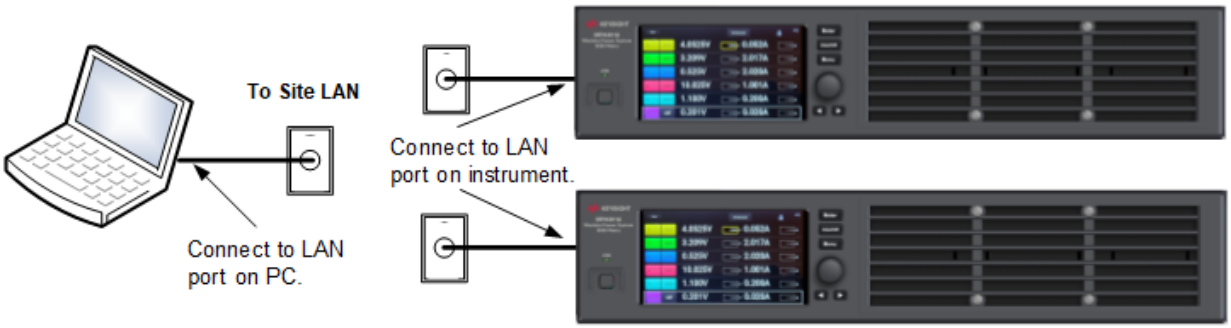
If you have not already done so, install the latest Keysight IO Libraries Suite from www.keysight.com.

NOTE

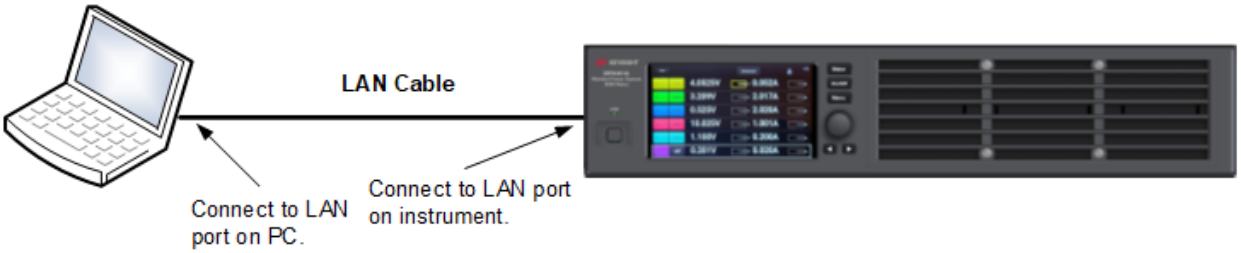
For detailed information about interface connections, refer to the Keysight Technologies USB/LAN/GPIB Interfaces Connectivity Guide, included with the Keysight IO Libraries Suite.

LAN Connections - site and private

A site LAN is a local area network in which LAN-enabled instruments and computers are connected to the network through routers, hubs, and/or switches. They are typically large, centrally-managed networks with services such as DHCP and DNS servers. The following figure illustrates a typical site LAN system.



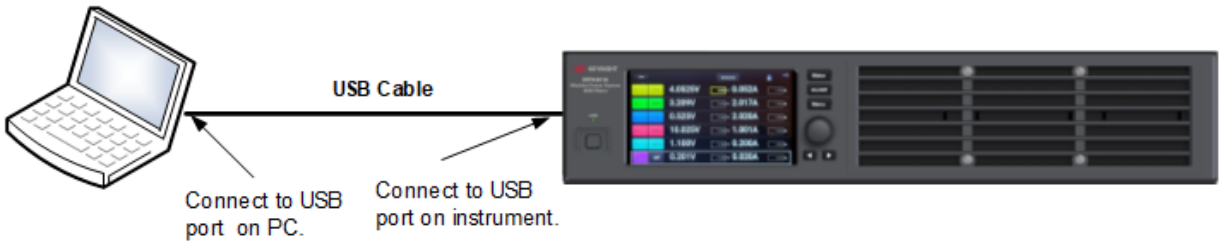
A private LAN is a network in which LAN-enabled instruments and computers are directly connected, and not connected to a site LAN. They are typically small, with no centrally-managed resources. The following figure illustrates a typical private LAN system.



1. Connect the instrument to the site LAN or to your computer using a LAN cable. The as-shipped instrument LAN settings are configured to automatically obtain an IP address from the network using a DHCP server (DHCP is set On). The DHCP server will register the instrument's hostname with the dynamic DNS server. The hostname as well as the IP address can then be used to communicate with the instrument. If you are using a private LAN, you can leave all LAN settings as they are. Most Keysight products and most computers will automatically choose an IP address using auto-IP if a DHCP server is not present. Each assigns itself an IP address from the block 169.254.nnn. The front panel LAN indicator will come on when the LAN port has been configured.
2. Use the Connection Expert utility of the Keysight IO Libraries Suite to add the instrument and verify a connection. To add the instrument, you can request the Connection Expert to discover the instrument. If the instrument cannot be found, add the instrument using the instrument's hostname or IP address.
3. You can now use Interactive IO within the Connection Expert to communicate with your instrument, or you can program your instrument using the various programming environments. You can also use the Web browser on your computer to communicate with the instrument as described under Using the Web Interface.

USB Connections

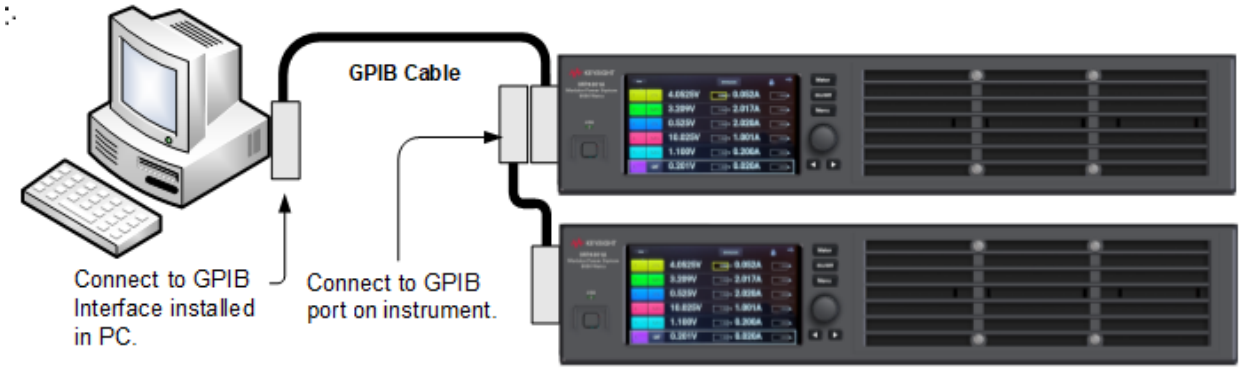
The following figure illustrates a typical USB interface system.



1. Connect your instrument to the USB port on your computer. Note that a USB-C interface cable is required, preferably one with a locking connector.
2. With the Connection Expert utility of the Keysight IO Libraries Suite running, the computer will automatically recognize the instrument. This may take several seconds. When the instrument is recognized, your computer will display the VISA alias, IDN string, and VISA address. This information is located in the USB folder.
3. You can now use Interactive IO within the Connection Expert to communicate with your instrument, or you can program your instrument using the various programming environments.

GPIB Connections

The following figure illustrates a typical GPIB interface system. GPIB connections are only available on units with Option GPB.



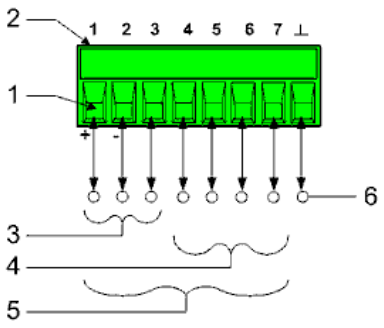
1. Connect your instrument to the GPIB interface card using a GPIB interface cable.
2. Use the Connection Expert utility of the Keysight IO Libraries Suite to configure the GPIB card's parameters.
3. You can now use Interactive IO within the Connection Expert to communicate with your instrument, or you can program your instrument using the various programming environments.

Digital Port Connections

NOTE It is good engineering practice to twist or shield all signal wires to and from the digital connector. If shielded wire is used, connect only one end of the shield to chassis ground to prevent ground loops.

An 8-pin connector and a quick-disconnect connector plug are provided for accessing the digital port functions. Disconnect the connector plug to make your wire connections. The connector plug accepts wires sizes from AWG 14 (1.5 mm^2) to AWG 28 (0.14 mm^2). Wire sizes smaller than AWG 24 (0.25 mm^2) are not recommended. Strip wire insulation back 7 mm.

1. Insert wires
2. Tighten screws
3. Fault/Inhibit configurable pins (observe INH polarity)
4. Output Couple configurable pins
5. Digital IO-configurable pins
6. Signal common



Information on using the digital port is found under Programming the Digital Port. The electrical characteristics are described in the Common Characteristics tables.

3
Getting Started

Using the Front Panel

Remote Interface Configuration

KEYSIGHT TECHNOLOGIES

Using the Front Panel

Turn the Unit On

Set the Output Voltage

Set the Output Current

Enable the Output

Turn the Unit On

WARNING LETHAL VOLTAGES - Power modules generate output voltages up to 160 VDC! Ensure that all instrument connections, including load and sense wiring, are insulated.

Verify that the line cord is connected and plugged in.

Turn the unit on with the front panel power switch. The front panel display will light up after a few seconds. A power-on self-test occurs automatically when you turn the unit on. This test assures you that the power supply is operational.

The Line switch turns the unit on or off.

NOTE It may take about 30 seconds or so for the power system to initialize before it is ready for use.

If the instrument does not turn on, verify that the power cord is firmly connected (power-line voltage is automatically sensed at power-on). Also make sure that the instrument is connected to an energized power source. The green LED above the power switch will illuminate when the power switch is on and the input power is within the ac input rating required by the instrument.

If the front panel indicates "No Module Installed", even though a power module is installed in the designated channel, check to make sure that the lockout bar is in place.

NOTE If a self-test error occurs, the self test error will be noted in the Error queue. Refer to Service and Maintenance for instructions on returning the instrument for service.

Set the Output Voltage

Method 1

Touch any channel's **Set** field directly, or use the rotary knob or arrow keys to select the field you wish to edit.

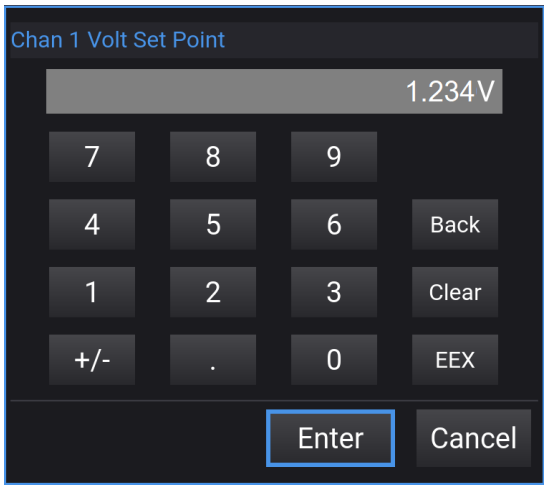
Use the rotary knob (RPG) to navigate around the display. Push on the knob to select an item. When a numeric field is selected, the touch screen numeric keypad will pop up. When a text field is selected, the list will pop up; rotating the knob scrolls through the options. Pushing the knob again will choose the option from the list.

Use the arrow keys to navigate around the display in the same manner as the rotary knob.

When selected, push the rotary knob to enable editing.

Method 2

Touch the channel's **Set** field to display the numeric entry dialog. Enter a value using the numeric entry keypad. Touch **Enter** to enter the value. Values become active when the output is turned on.



Use the numeric keypad to enter a value.

Back backs up one digit.

Clear clears the entry.

EEX adds an exponent to the value.

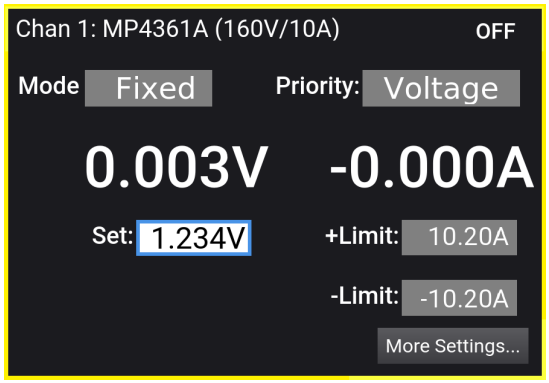
Enter enters the value.

Cancel cancels everything and exits the dialog.

Method 3

Touch Channel 

to display the channel details. Fixed Mode and Voltage Priority is assumed. Touch Channel 1's **Set** field. Repeat Method 1 or Method 2 to enter a value.



Touch Channel 1's **Set** field.

Repeat Method 1 or Method 2 to enter a value.

Set the Output Current

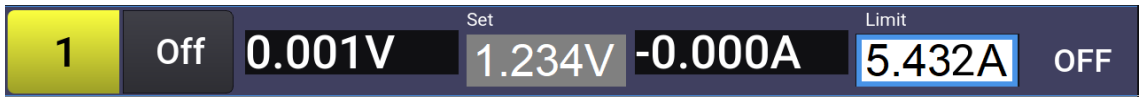
Method 1

Touch any channel's **Limit** field directly, or use the rotary knob or arrow keys to select the field you wish to edit.

Use the rotary knob (RPG) to navigate around the display. Push on the knob to select an item. When a numeric field is selected, the touch screen numeric keypad will pop up. When a text field is selected, the list will pop up; rotating the knob scrolls through the options. Pushing the knob again will choose the option from the list.

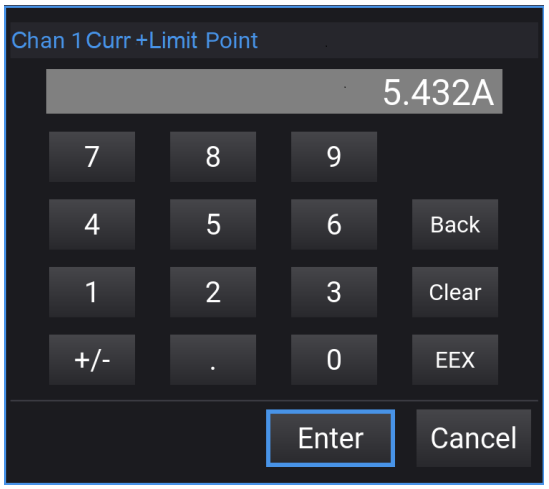
Use the arrow keys to navigate around the display in the same manner as the rotary knob.

When selected, push the rotary knob to enable editing.



Method 2

Touch the channel's **Limit** field to display the numeric entry dialog. Enter a value using the numeric entry keypad. Press **Enter** to enter the value. Values become active when the output is turned on.



Use the numeric keypad to enter a value.

Back backs up one digit.

Clear clears the entry.

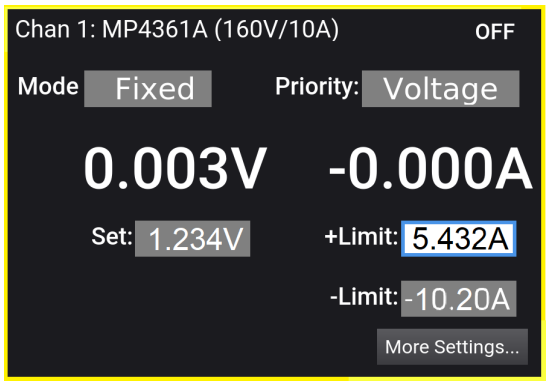
EEX adds an exponent to the value.

Enter enters the value.

Cancel cancels everything and exits the dialog.

Method 3

Touch Channel 1 to display the channel details. Fixed Mode and Voltage Priority is assumed.



Touch Channel 1's **+Limit** field.

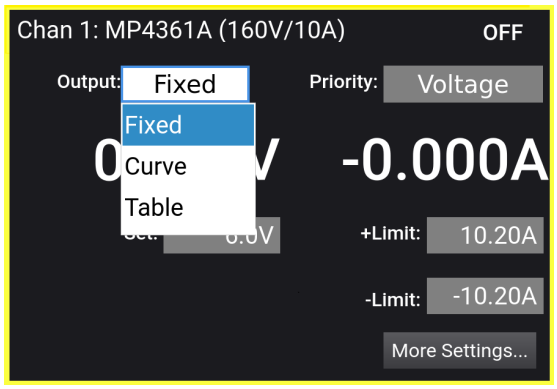
Use the arrow keys to move between the + and - Limit fields.

Repeat Method 1 or Method 2 to enter a value.

Set the Output Mode and Priority

Touch Channel 1 to display the channel setting details.

Touch the **Output** field to specify the output mode of the instrument: Fixed, Curve or Table. Press the rotary knob to select the mode.

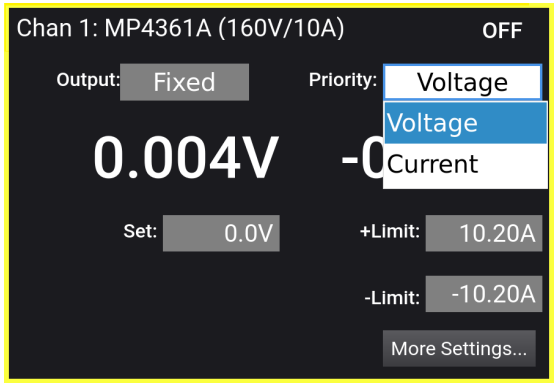


In Fixed mode the power module operates as a standard power supply, in either voltage or current priority mode.

In Curve mode, a solar array characteristic is created from four input parameters and a curve shape

In Table mode, a solar array characteristic is created from three to 1024 voltage and current points.

Touch the **Priority** field to specify the output priority of the instrument: Voltage or Current. Press the rotary knob to select the mode.



In voltage priority mode, the unit will maintain the output voltage at its programmed setting. The unit will limit the output current when it reaches the specified current limit value.

In current priority mode, the unit will maintain the output current at its programmed setting. The unit will limit the output voltage when it reaches the specified voltage limit value. Refer to Set the Output Mode for more information.

Enable the Output

WARNING LETHAL VOLTAGES - Power modules generate output voltages up to 160 VDC! Ensure that all instrument connections, including load and sense wiring, are insulated.

When disabling the output, the MPS does not automatically down-program an external capacitance connected to output terminals. Hazardous voltages may be present on the output terminals even when a channel is off.

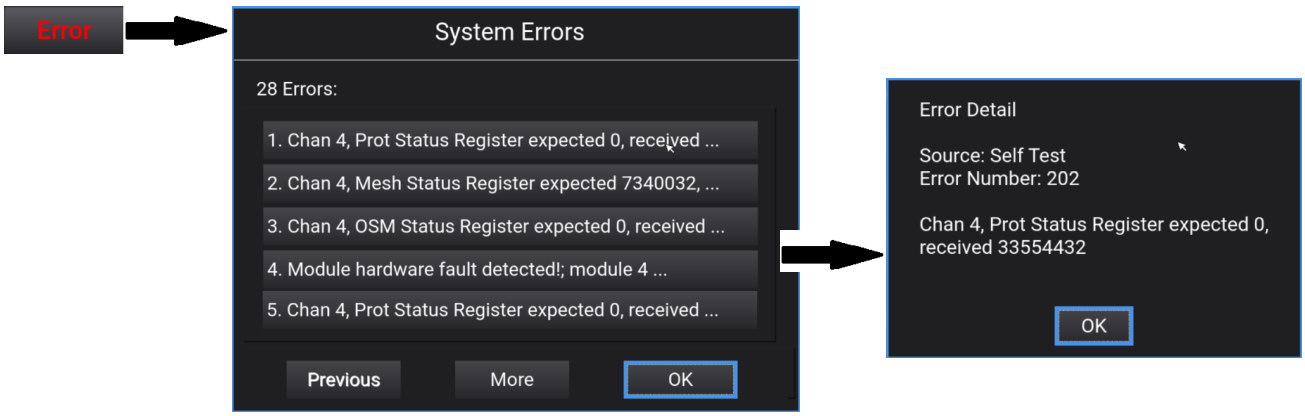
Use the channel [On/Off] key to enable the output. If a load is connected to the output, the front panel display will indicate that it is drawing current. Otherwise, the current reading will be zero. The status indicator shows the output's status. In the case of "CV", the output is in constant voltage mode.

The MPS utilizes a high impedance turn-off mode and does not automatically down-program an external capacitance connected to the output terminals when the output is disabled via the On/Off key, bus command, or a protection event. Hazardous voltages may be present on the output terminals even after a channel is turned off.

In Case of Trouble

Press the Menu key, then select Help to obtain help about any menu level. Press the Menu key again to exit the menu.

An Error status indicator appears at the top of the display if self-test fails or if other operating problems occur with your instrument. Touch the Error indicator to display the list of errors. Touch a specific error message to display details. Refer to SCPI Error Messages for further information.



- Errors are stored in the order they are received. The error at the end of the list is the most recent error.
- If there are more errors than can fit in the queue, the last error stored is replaced with -350,"Error queue overflow". No more errors are stored until you remove errors from the queue. If there are no errors, the instrument responds with +0,"No error".
- Except for selftest errors, errors are cleared when exiting the Error Log menu by touching OK. or when cycling power.

Remote Interface Configuration

LAN Configuration

Modifying the LAN Settings

GPIB/USB Configuration

Using the Web Interface

Using Telnet

Using Sockets

Introduction

This instrument supports three remote interfaces: LAN, USB, and optional GPIB. To use the interfaces, you must first install the latest Keysight IO Libraries Suite from www.keysight.com. Then connect your instrument to your PC.

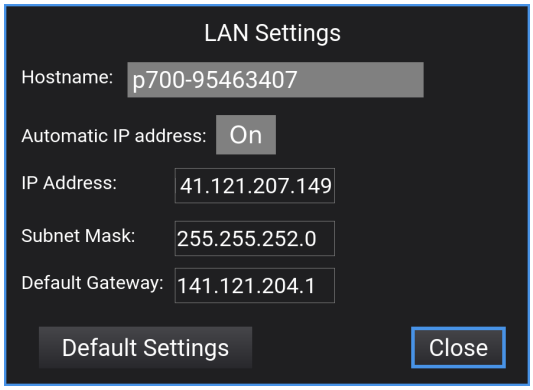
This instrument provides Ethernet connection monitoring. With Ethernet connection monitoring, the instrument's LAN port is continually monitored, and automatically reconfigured when the instrument is unplugged for a minimum of 20 seconds and then reconnected to a network.

LAN Configuration

The following sections describe the primary LAN configuration functions on the front-panel menus. Note that there are no SCPI commands to configure the LAN parameters.

Viewing Active Settings

Touch  to view the hostname and LAN address. Alternatively,

Front Panel Reference	SCPI Command
Press the **[Menu]** key. Select **System\ IO\ LAN\ Settings**. Use the rotary knob to make selections. 	Not available

The currently active settings for the IP Address, Subnet Mask, and Default Gateway may be different from the front panel configuration menu settings - depending on the configuration of the network. If the settings are different, it is because the network has automatically assigned its own settings.

Modifying the LAN Settings

As shipped from the factory, the power system's pre-configured settings should work in most LAN environments. However, you can manually configure these settings as described:

Hostname

A hostname is the host portion of the domain name, which is translated into an IP address. To manually configure the hostname use the rotary knob to select he Hostname field.

Enter values using the numeric keypad. For alpha characters, use the rotary knob to scroll through the list that appears when you use the knob. Use the arrow keys to traverse the text field. Use the Enter field enter the information.

The Hostname field registers the supplied name with the selected naming service. If the field is left blank, no name is registered. A hostname may contain upper and lower case letters, numbers and dashes (-). The maximum length is 15 characters.

Each instrument is shipped with a default hostname with the format: K-modelnumber-serialnumber, where modelnumber is the unit's 7-character model number, and serialnumber is the last five characters of the 10-character serial number located on the label on the top of the unit (e.g. 45678 if the serial number is MY12345678).

Automatic IP address

Turns the automatic IP address function on or off.

On - automatically configures the addressing of the instrument. When selected, the instrument will first try to obtain an IP address from a DHCP server. If a DHCP server is found, the DHCP server will assign an IP address, Subnet Mask, and Default Gateway to the instrument. If a DHCP server is unavailable, the instrument will try to obtain an IP address using AutoIP. AutoIP automatically assigns an IP address, Subnet Mask, and Default Gateway addresses on networks that do not have a DHCP server.
Off - lets you manually configure the addressing of the instrument by entering values in the following three fields. These fields only appear when Manual is selected.

IP Address - This value is the Internet Protocol (IP) address of the instrument. An IP address is required for all IP and TCP/IP communications with the instrument. An IP address consists of 4 decimal numbers separated by periods. Each decimal number ranges from 0 through 255 with no leading zeros (for example, 169.254.2.20).

Subnet Mask - This value is used to enable the instrument to determine if a client IP address is on the same local subnet. The same numbering notation applies as for the IP address. When a client IP address is on a different subnet, all packets must be sent to the Default Gateway.

Default Gateway - This value is the IP address of the default gateway that allows the instrument to communicate with systems that are not on the local subnet, as determined by the subnet mask setting. The same numbering notation applies as for the IP address. A value of 0.0.0.0 indicates that no default gateway is defined.

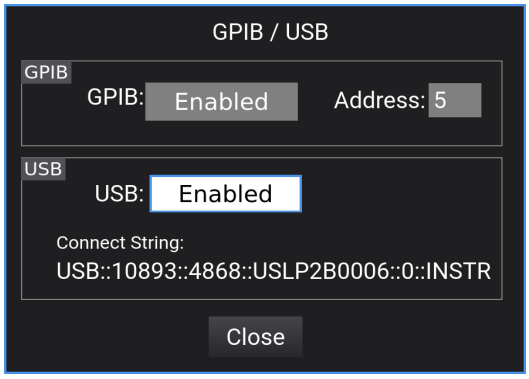
Dot-notation addresses ("nnn.nnn.nnn.nnn" where "nnn" is a byte value from 0 to 255) must be expressed with care, as most PC web software interprets byte values with leading zeros as octal (base 8) numbers. For example, "192.168.020.011" is actually equivalent to decimal "192.168.16.9" because ".020" is interpreted as "16" expressed in octal, and ".011" as "9". To avoid confusion, use only decimal values from 0 to 255, with no leading zeros.

Default Settings

Select Default Settings to reset the LAN to the as-shipped (or default) settings. This returns *ALL* LAN settings to the as-shipped values and restarts networking. All default LAN settings are listed under Non-volatile Settings

GPIB/USB Configuration

You can configure the USB and GPIB interfaces as follows:

Front Panel Reference	SCPI Command
Press the **[Menu]** key. Select **System\ IO\ USB\ Settings** Use the rotary knob to scroll through the list. Select Enabled to enable or disable the GPIB or USB interface. 	Not available

There are no configurable USB parameters. You can retrieve the USB connect string using the front panel menu:

The GPIB configuration is only available on instruments with Option GPB. Each device on the GPIB (IEEE-488) interface must have a unique whole number address between 0 and 30. The instrument ships with the address set to 5. Your computer's GPIB interface card address must not conflict with any instrument on the GPIB interface bus. This setting is non-volatile; it will not be changed by power cycling or *RST.

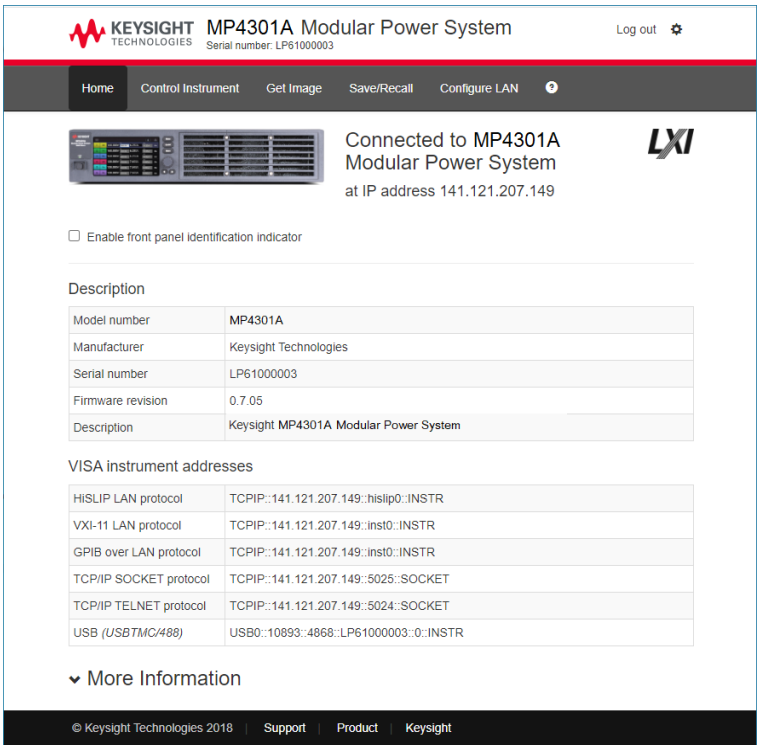
Using the Web Interface

Your instrument has a built-in web interface that lets you control it directly from the web browser on your computer. With the web interface, you can access the front panel control functions including the LAN configuration parameters. Up to six simultaneous connections are allowed. With additional connections, performance will be reduced.

NOTE The built-in web interface only operates over the LAN. A web browser is required to use the web Interface.

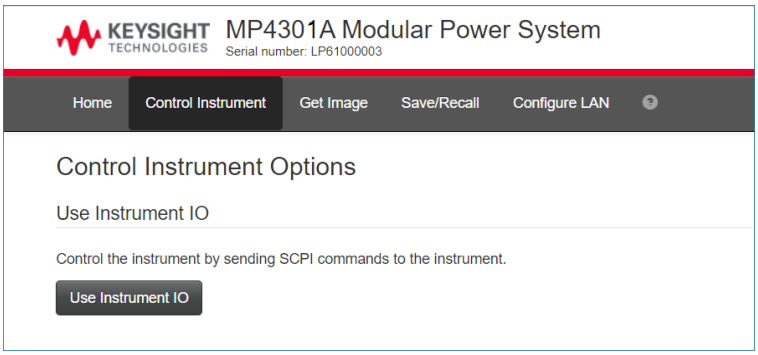
The web interface is enabled when shipped. To launch the web interface:

1. Open the web browser on your computer.
2. Enter the instrument's hostname or IP address into the browser's Address field. The following home page will appear.

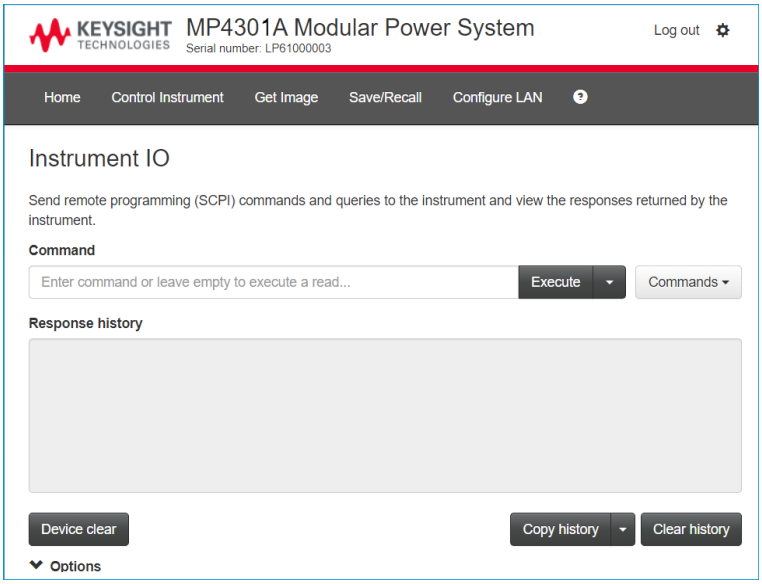


Tip: Check the Enable front panel identification indicator to cause the LAN indicator  on the front of the addressed unit to turn on. This identifies the unit being addressed:

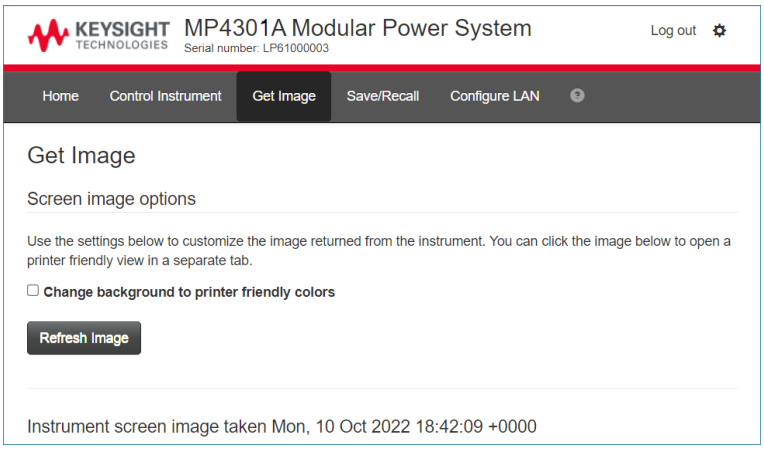
3. Click on the Control Instrument tab on the top of the page to begin controlling your instrument.
4. Click on Use Instrument IO to send SCPI commands to the instrument. You an also select from Use RDP to launch a remote desktop session, or Use VNC to launch a remote display session. Selecting Use Tablet Optimized lets you access the GUI on most mobile devices



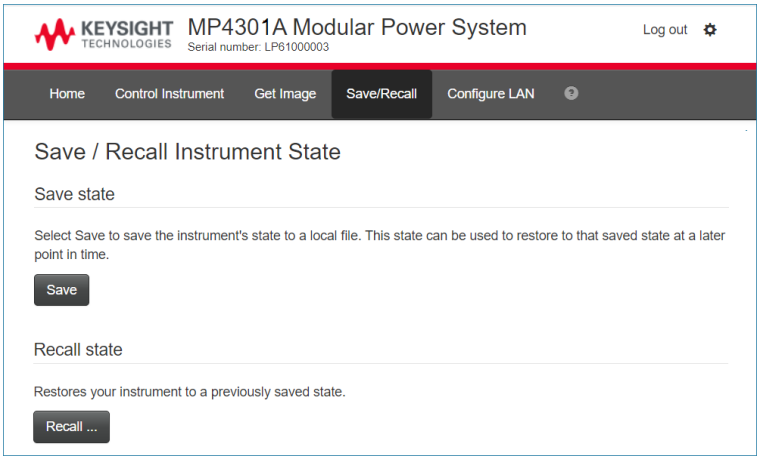
5. You need to enter a password to continue. As shipped, the default password is Keysight. To set a different password, click on the Settings (gear) icon.
6. Enter the SCPI command in the Command field and click the Execute button. The command and response will display in the Response History area.



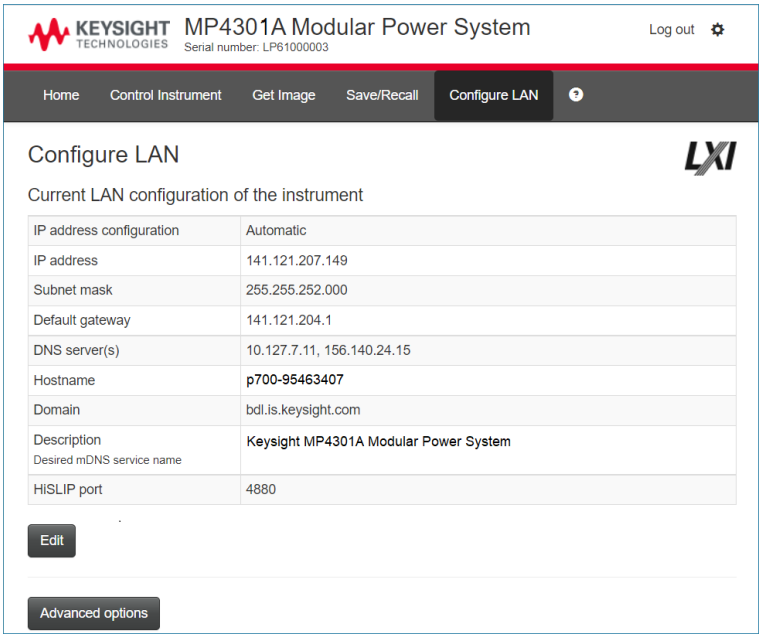
7. You can also capture an image of the field that appears on the GUI by selecting the Get Image tab. Click on the image to print or save it. Click Refresh image to refresh it.



8. You can also save and recall an instrument state by clicking on the Save/Recall tab. Then click on the Save or Recall buttons.



9. Click the Configure LAN tab to configure the LAN settings. This page provides an overview of the current LAN settings and lets you change those settings. The initial page displays the current LAN configuration of your instrument. The Edit button opens the Edit Network Configuration page, which lets you set a unique host name and description. The Advanced options button accesses the reset network configuration option. You will need to reboot your instrument after you have changed the LAN configuration



For additional help about any of the pages, click on the ? button.

Using Telnet

NOTE Power supplies allow any combination of up to six simultaneous telnet, data socket, and control socket connections to be made.

In an MS-DOS Command Prompt box type: telnet hostname 5024 where hostname is the unit's hostname or IP address, and 5024 is the instrument's telnet port.

You should get a Telnet session box with a title indicating that you are connected to the power supply. Type the SCPI commands at the prompt.

Using Sockets

Keysight instruments have standardized on using port 5025 for SCPI socket services. A data socket on this port can be used to send and receive ASCII/SCPI commands, queries, and query responses. All commands must be terminated with a newline for the message to be parsed. All query responses will also be terminated with a newline.

The socket programming interface also allows a control socket connection. The control socket can be used by a client to send device clear and to receive service requests. Unlike the data socket, which uses a fixed port number, the port number for a control socket varies and must be obtained by sending the following SCPI query to the data socket: SYSTem:COMMunicate:TCPip:CONTrol?

After the port number is obtained, a control socket connection can be opened. As with the data socket, all commands to the control socket must be terminated with a newline, and all query responses returned on the control socket will be terminated with a newline.

To send a device clear, send the string "DCL" to the control socket. When the power supply has finished performing the device clear it echoes the string "DCL" back to the control socket.

Service requests are enabled for control sockets using the Service Request Enable register. Once service requests have been enabled, the client program listens on the control connection. When SRQ goes true the instrument will send the string "SRQ +nn" to the client. The "nn" is the status byte value, which the client can use to determine the source of the service request.

4
Using the Modular Power System

Fixed Mode Operation

SAS Operation

Current Sinking Operation

Programming Output Protection

Making Measurements

Programming the Digital Port

System-Related Operations

KEYSIGHT TECHNOLOGIES

Fixed Mode Operation

Set the Operating Mode

Set the Output Priority Mode

Set the Output Voltage

Set the Output Current

Set the Diode Mode

Enable the Output

Priority Mode Tutorial

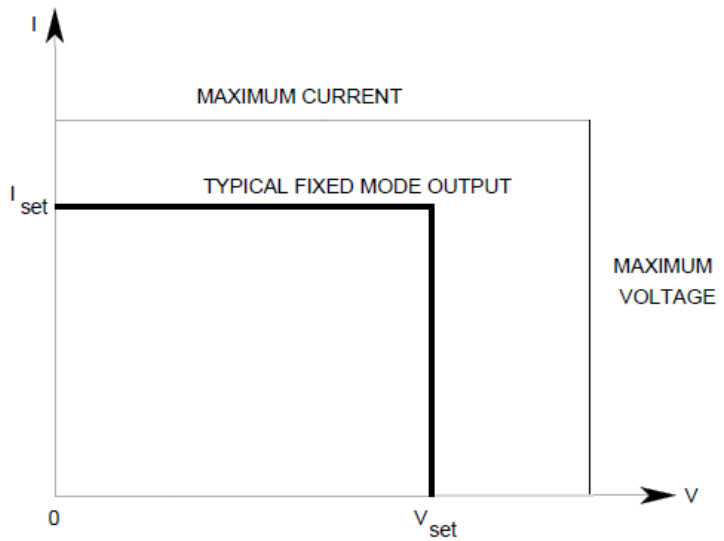
WARNING LETHAL VOLTAGES - Power modules generate output voltages up to 160 VDC! Ensure that all instrument connections, including load and sense wiring, are insulated.

NOTE When the unit is first turned on, it may take about 30 seconds or so to initialize before it is ready for use.

Set the Operating Mode

Select either FIXed, CURVe, or TABLe mode. This section describes Fixed mode operation.

Fixed mode - The Fixed mode output characteristic is similar to that of a standard power supply. The output behavior is determined by the priority setting - either Voltage priority or Current priority. Refer to Output Quadrants for details.



Curve mode - selects solar array simulator operation in which an exponential model is used to approximate the I-V curve. Refer to Programming a Curve for details.

Table mode - selects table mode operation, in which a user-defined table of points is ued to generate the I-V curve. Refer to Programming a Table for details.

Front Panel Reference	SCPI Command
Touch a channel to display the channel details.. In the Output field, select Fixed mode. Touch the selection or press the rotary knob to select.	To specify FIXed mode: CURR:MODE FIX, (@1)

NOTE The output is turned off when switching from Fixed mode to Curve or Table modes, and all output settings revert to their power-on or RST values (see *RST).

Set the Output Priority Mode

Select either voltage priority or current priority operating mode. Refer to Priority Mode Tutorial for more information.

Voltage priority - this mode keeps the output voltage constant. The output voltage remains at its programmed setting, provided the load current remains within the + or - current limit setting.

Current priority - this mode keeps the output current constant. The output current remains at its programmed setting, provided the load voltage remains within the voltage limit setting.

Front Panel Reference	SCPI Command
Touch a channel to display the channel details. In the Priority field, Select Voltage or Current. Touch the selection or press the rotary knob to select.	To specify current or voltage priority mode: FUNC CURR|VOLT, (@1)

NOTE When switching between modes, the output is turned off and the output settings revert to their power-on or RST values.

Set the Output Voltage

When the unit is in voltage priority mode, the output voltage remains at its programmed setting provided the load current remains within its programmed positive or negative limit.

Front Panel Reference	SCPI Command
Touch a channel to display the channel details. Touch the Set field to display the Numeric Entry dialog for the voltage setting. Enter a value and press Enter.	To set the output voltage: VOLT 100, (@1)

In voltage priority mode, you can specify a positive and negative current limit, which limits the output current at the specified value.

Front Panel Reference	SCPI Command
Touch the +Limit or -Limit field to display the Numeric Entry dialog for the current limit settings. Enter a value and press Enter.	To set the positive current limit: CURR:LIM 12, (@1) To set the negative current limit: CURR:LIM:NEG -5, (@1)

Set the Output Current

When the unit is in current priority mode, the output current remains at its programmed setting provided the load voltage remains within the voltage limit setting.

Front Panel Reference	SCPI Command
Touch a channel to display the channel details. Touch the Set field to display the Numeric Entry dialog for the current setting. Enter a positive or negative value and press Enter.	To set the positive output current: CURR 10, (@1) To set the negative output current: CURR –4, (@1)

When the unit is in current priority mode, you can specify a voltage limit which limits the output voltage at the specified value.

Front Panel Reference	SCPI Command
Touch the Limit field to display the Numeric Entry dialog for the voltage limit setting. Enter a value and press Enter.	To set the voltage limit: VOLT:LIM 110, (@1)

Set the Diode Mode

NOTE Diode mode is only available on units with firmware revision 1.1.09 and up.

An internal diode protects the instrument from reverse currents that can be generated if a paralleled output or a battery is connected to an output and its over-voltage protection trips.

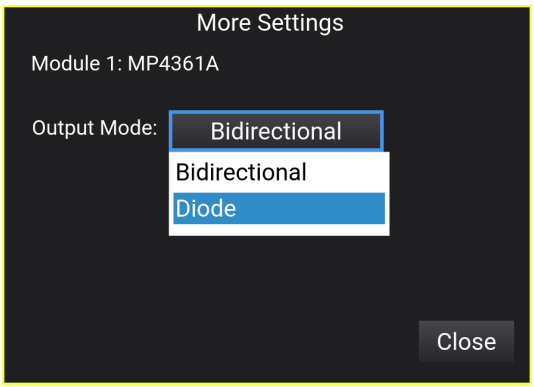
Diode - the protection diode is enabled (the output operates as a source only).

Bidirectional - the protection diode is disabled (the output operates bi-directionally).

The following conditions apply when enabling the internal protection diode:

- The diode setting is stored in the mainframe's non-volatile memory for the specified slot. Any power module installed in that slot will inherit the diode setting for that slot.
- Changing the diode mode resets the module settings.
- You will not be able to sink current in diode mode.

- You will not be able to program negative current limit in voltage priority mode.
- You will not be able to program a negative set point in current priority mode.

Front Panel Reference	SCPI Command
Touch a channel to display the channel details.Then touch More Settings. Then select Diode in the Output Mode dropdown.  Then select Apply to apply the diode mode.	To enable the internal reverse-current protection diode: OUTP:MODE DIOD, (@1) To disable the internal reverse-current protection diode: OUTP:MODE BID, (@1)

A diode symbol will appear in the channel icon  to indicate that the protection diode is enabled. Refer to Blocking Diode for connection information.

Enable the Output

WARNING LETHAL VOLTAGES - Power modules generate output voltages up to 160 VDC! Ensure that all instrument connections, including load and sense wiring, are insulated.

When disabling the output, the MPS does not automatically down-program an external capacitance connected to output terminals. Hazardous voltages may be present on the output terminals even when a channel is off.

Enable the output as follows:

Front Panel Reference	SCPI Command
Touch Channel 1's Off field directly. The field will indicate On when the output is enabled. - or - Press the Output **On/Off** key.	To enable the output: OUTP ON|OFF, (@1)

The MPS utilizes a high impedance turn-off mode and does not automatically down-program an external capacitance connected to the output terminals when the output is disabled via the On/Off key, bus command, or a protection event. Hazardous voltages may be present on the output terminals even after a channel is turned off.

NOTE During a 1-cycle ac line dropout the unit may reboot. The output remains off after reboot until the previous settings are reinstated either by the front panel controls or using a computer program. This is consistent with safe operating procedures.

Priority Mode Tutorial

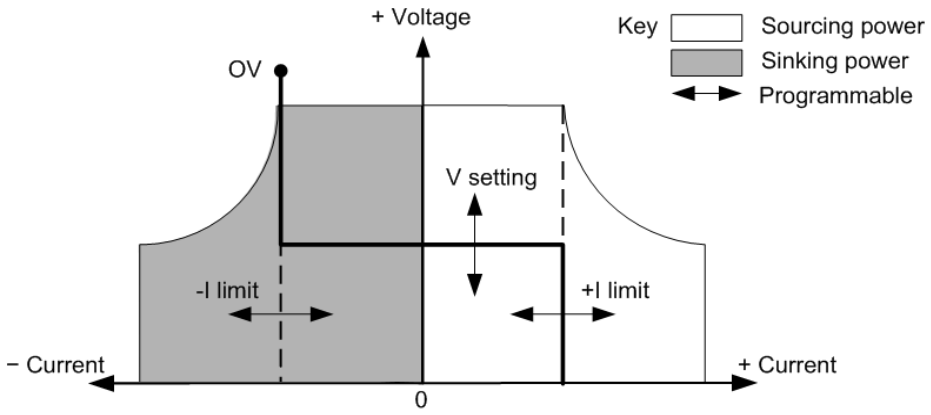
NOTE

Keysight MP4362A power modules have a fixed sinking current limit of 0.5 A. They also have a rectangular output characteristic. Refer to Output Quadrants for details.

Voltage Priority

In voltage priority mode, the output is controlled by a constant-voltage feedback loop, which maintains the output voltage at its programmed setting provided the load current remains within the positive or negative current limit settings. Voltage priority mode is best suited for use with resistive or high impedance loads, and loads that are sensitive to voltage overshoots. Do not use voltage priority mode with low-impedance sources such as batteries, power supplies, or large charged capacitors.

In voltage priority mode, the output voltage should be programmed to the desired value. A positive and negative current limit value should also be set. The current limit should always be set to a value that is greater than the actual output current requirement of the external load. The following figure shows the voltage priority operating locus of the output. The area in the white quadrants shows the output as a source (sourcing power). The shaded quadrants show the output as a load (sinking power).



The heavy solid line illustrates the locus of possible operating points as a function of the output load. As shown by the horizontal portion of the line, the output voltage remains regulated at its programmed setting provided the load current remains within the positive or negative current limit setting. A CV (constant voltage) status indicates that the output voltage is being regulated and the output current is within its limit settings.

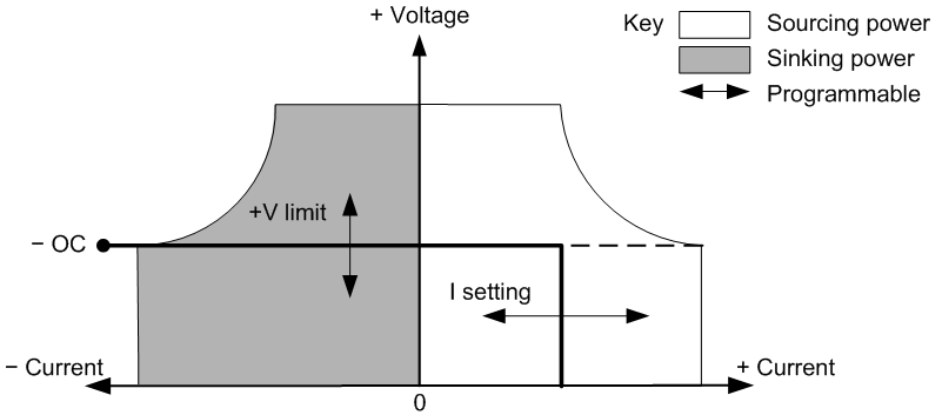
Note that when the output current reaches the positive or negative current limit, the unit no longer operates in constant voltage mode and the output voltage is no longer held constant. Instead, the power supply will now regulate the output current at its current limit setting. A LIM+ (positive current limit), or LIM– (negative current limit) status is set to indicate that a current limit has been reached. These conditions are annunciated by CL+ or CL- on the front panel.

The vertical portions of the load line shows the output voltage either increasing or decreasing, as current is either forced into or pulled out of the unit. When the output voltage exceeds the over-voltage protection setting, the output shuts down and the OV status bit will be set.

Current Priority

In current priority mode, the output is controlled by a bi-polar constant current feedback loop, which maintains the output source or sink current at its programmed setting. The output current remains at its programmed setting, provided the load voltage remains within the voltage limit setting. Current priority mode is best suited for use with batteries, power supplies, large charged capacitors, and loads that are sensitive to current overshoots. It minimizes current overshoots during programming, turn-on, and turn-off transitions and seamlessly transitions between positive and negative currents.

In current priority mode, the output current should be programmed to the desired value. A positive voltage limit value should also be set. The voltage limit should always be set to a value that is greater than the actual output voltage requirement of the external load. The following figure shows the current priority operating locus of the output. The area in the white quadrants shows the output as a source (sourcing power). The shaded quadrants show the output as a load (sinking power).



The heavy solid line illustrates the locus of possible operating points as a function of the output load. The vertical portion of the line shows the output current being regulated at its programmed setting, provided the output voltage remains within its limit setting. A CC (constant current) status indicates that the output current is being regulated and the output voltage is within its limit settings.

Note that when the output voltage reaches the voltage limit, the unit no longer operates in constant current mode and the output current is no longer held constant. Instead, the power supply will now regulate the output voltage at its voltage limit setting. A LIM+ (positive voltage limit) status is set to indicate that the voltage limit has been reached. This condition is annunciated by VL+ on the front panel.

When the unit is sinking power, the horizontal portion of the line shows the output current increasing in the negative direction as more current is forced into the unit. This can happen when the load is a power source such as a battery, and its output voltage is higher than the voltage limit setting of the power supply. Once the current exceeds the built-in negative over-current limit, the output will shut down, the output relays will open, and the OCF status bits will be set. In such a case, it is important to set the voltage limit properly in order prevent this protection shutdown.

SAS Operation

Introduction

Compensation Modes

Programming a Curve

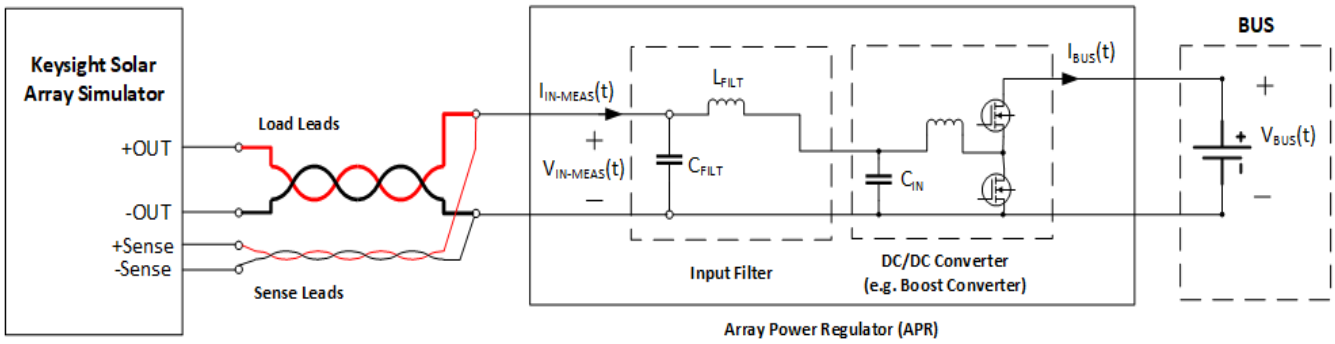
Programming a Table

Reference Information

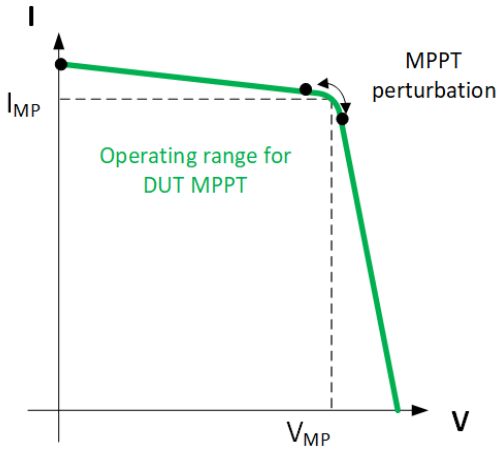
Introduction

Keysight MPS instruments operate as a solar array simulator when the SAS:MODE command specifies either Curve or Table mode. The two primary SAS applications for which the MP4361A and MP4362A power modules are designed for are: dc to dc converter devices, and shunt switching devices.

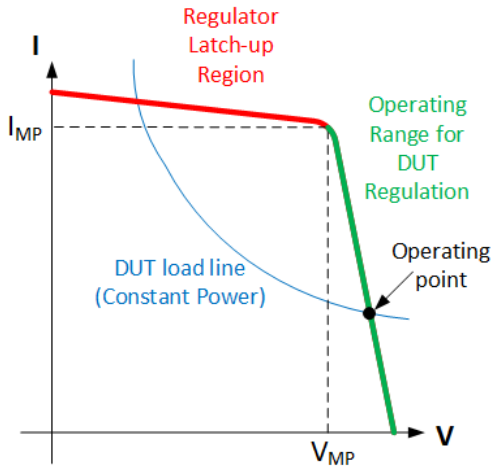
For dc to dc converter applications, operation generally falls under either maximum power point tracking (the default), bus regulation, or fixed load. The following diagram illustrates a typical circuit used for dc to dc converter applications:



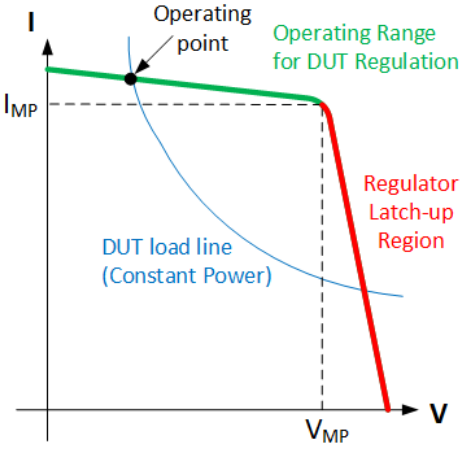
MPPT Application (default)



Bus Regulation Applications

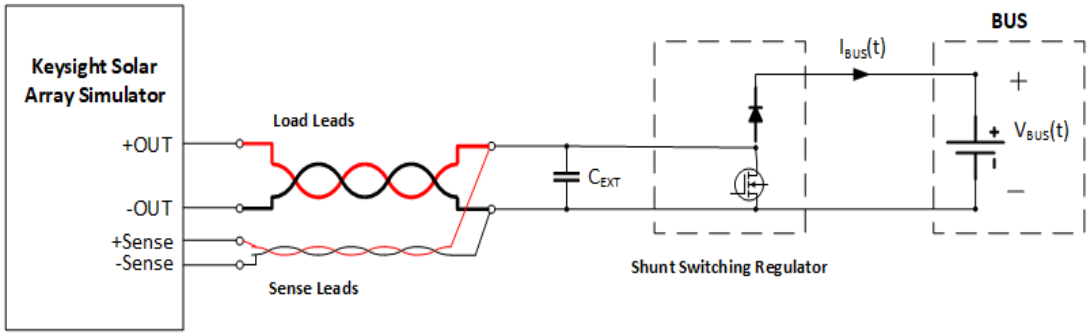


Regulation DUTs operating above Vmp

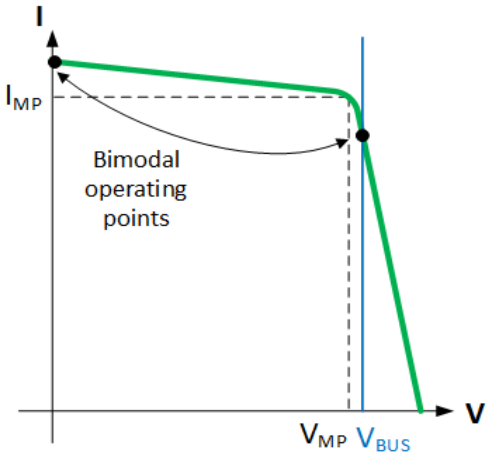


Regulation DUTs operating below Vmp

For shunt switching applications, the output typically alternates between two states: as a shunt circuit, and as a diode coupled to a bus voltage. The following diagram illustrates a typical circuit used for shunt switching:



Shunt Switching Application



For applications not described in this section, please consult the factory.

Compensation Modes

The digital control capability of the SAS module allows for flexible, firmware-based, compensation modes that can be tailored for different applications to achieve optimal performance. The compensation modes are described in detail as follows.

NOTE When the reverse-current blocking diode is enabled, the only available compensation modes are DEFAULT and SHUNTSW.

DEFAULT Mode

Default mode is intended for initial turn-on and debug when operating in solar array simulation mode. It is a low performance mode available for initial confirmation of system hardware interconnections to the DUT and verification of basic SAS mode operation with a static load. The following are the key operating characteristics:

- Not recommended for evaluating DC/DC converters, MPPT trackers, or shunt switching control.
- Will not provide stable operation with an active DC/DC converter in regulation mode.
- Recommended for initial verification of hardware configuration with a static load.
- No minimum external capacitance requirement.
- Supports local or remote sensing.

DCDC_20UF Mode

DCDC_20UF mode applies to DC/DC converter applications where there is a minimum of 20µF. It serves applications with regulation DUTs operating at voltages above Vmp, but it can also accommodate MPPT and fixed load applications at any operating voltage on the SAS curve provided the minimum 20µF is met. The following are the key operating characteristics:

- Recommended for DC/DC converter and MPPT applications.
- Optimized for operation above Vmp when the DUT has a constant power input impedance characteristic, such as converters providing bus regulation.
- Also recommended for DUTs with constant voltage, current, or resistance input impedance characteristics, such as converters providing MPPT tracking at any voltage on the SAS curve. For these characteristics, operation is allowed at any voltage on the SAS curve.
- Requires a minimum of 20µF external capacitance at the sense point.
- If the DUT is a constant power load, Vmp/Imp must be greater than or equal to 5 ohms.
- Require remote sensing. Capacitance that is separated from the sense point by a series diode does not contribute to the 20 µF minimum.
- This mode cannot be used when the reverse-current blocking diode is enabled.

LT_VMP Mode (only available on units with with firmware revision 1.1.09 and up)

LT_Vmp mode (less than Vmp) applies to DC/DC converter applications where there is a range of 1uF-20uF. It serves applications with regulation DUTs operating at voltages below Vmp, but it can also accommodate MPPT and fixed load applications at any operating voltage provided the 1µF-20µF requirement is met. The following are the key operating characteristics:

- Recommended for DC/DC converter applications only.
- Optimized for operation below Vmp when the DUT has a constant power input impedance characteristic, such as converters providing bus regulation.
- Requires a minimum of 1µF and maximum 20µF capacitance.
- Require remote sensing.
- This mode cannot be used when the reverse-current blocking diode is enabled.

SHUNTSW Mode

The following are the key operating characteristics of SHUNTSW mode:

- Recommended for shunt switching applications only.
- Optimized for shunt switching operation where the output terminal voltage alternates between two steady levels, one of which is around zero volts.
- No minimum external capacitance requirement.
- Supports local or remote sensing.

Compensation Applications

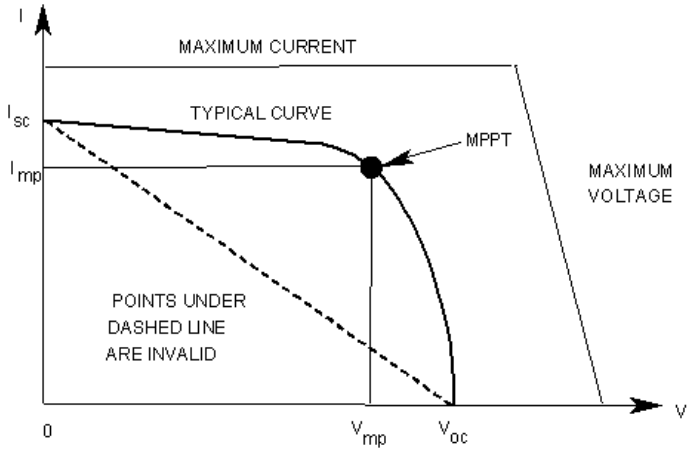
The recommended compensation mode application summary is as follows:

Application *	DEFAULT	DCDC_20UF	LT_Vmp	SHUNTSW
Initial turn-on/debug of MPPT and shunt switching DUTs with no external capacitance required	Recommended	Not recommended	Not recommended	Not recommended
Performance testing of MPPT DUTs with a minimum 20µF capacitance	Not recommended	Recommended	Not recommended	Not recommended
Performance testing DC to DC regulation DUTs operating at >Vmp with a minimum 20µF capacitance	Not recommended	Recommended	Not recommended	Not recommended
Performance testing DC to DC regulation DUTs operating at <Vmp with a 1uF- 20µF capacitance	Not recommended	Not recommended	Recommended	Not recommended
Performance testing of shunt switching DUTs	Not recommended	Not recommended	Not recommended	Recommended

* Please contact the factory for any applications not covered in this section.

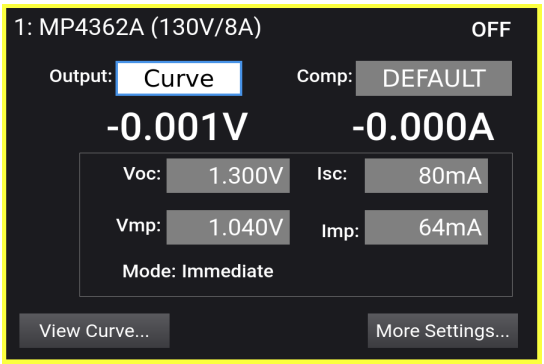
Programming a Curve

Curve mode uses an exponential model to approximate the I-V curve as illustrated in the following figure. It is programmed in terms of its open circuit voltage (Voc), short circuit current (Isc), maximum voltage point (Vmp), and maximum current point (Imp) at the approximate peak power point (MPPT). SAS operation is achieved by sampling the output voltage, applying a low-pass filter, and continually adjusting the constant current loop using the filtered voltage as an index into the exponential model.



In Curve mode, a solar array characteristic is created from four input parameters and a curve shape:
Imp – the current at the maximum power point
Isc – the short-circuit current
Vmp - the voltage at the maximum power point
Voc – the open-circuit voltage

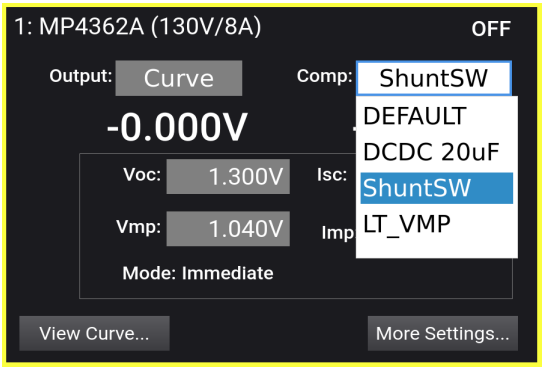
Specify Curve Operation

Front Panel Menu Reference	SCPI Command
Touch a channel to display the channel details. **In the Output dropdown, select Curve mode.** Touch the selection or press the rotary knob to select. 	To specify Curve mode: CURR:MODE SAS, (@1)

- The settings shown on the display are the true Vmp and Imp values. These values are calculated based on the running curve parameters or table points.

Specify the Compensation

Refer to Compensation Modes for details.

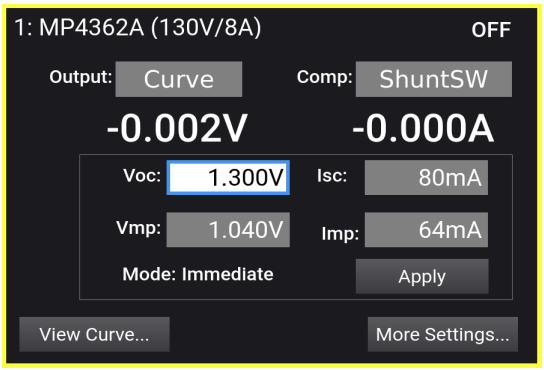
Front Panel Menu Reference	SCPI Command
After Curve mode is selected, specify a compensation mode in the Comp dropdown. Touch the selection or press the rotary knob to select. 	For initial turn-on and debug of SAS operation: CURR:SAS:BWID "DEFAULT", (@1) For DC to DC converter and MPPT applications with ≥20 µF external capacitance: CURR:SAS:BWID "DCDC_20UF", (@1) For DC to DC converter applications with 1 µF to 20 µF capacitance: CURR:SAS:BWID "LT_Vmp", (@1) For Shunt Switching applications: CURR:SAS:BWID "SHUNTSW", (@1)

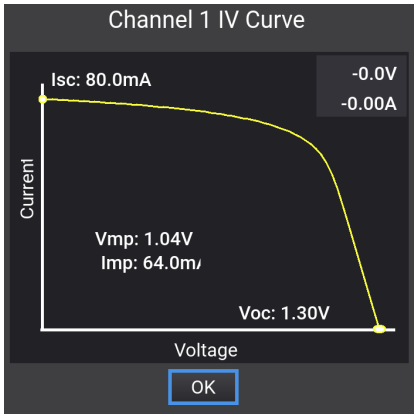
- The output is turned off when switching from Curve or Table modes to Fixed mode, and all output settings revert to their power-on or RST values (see *RST).
- When switching between Curve and Table modes, solar array settings will be preserved.
- When the reverse-current blocking diode is enabled, the only available compensation modes are DEFAULT and SHUNTSW.

Specify the Curve Parameters

Specify the I-V characteristic of the curve using Imp, Isc, Vmp, and Voc. These can be programmed individually, but when programming a new curve, it is best to send all of the parameters on the same line. This method effects an instant curve change.

The curve parameters can be entered in any order - the instrument determines if all parameters are within acceptable limits. Any parameter not programmed retains the value of the previously programmed curve.

Front Panel Menu Reference	SCPI Command
In the Curve dialog, enter a value for each of the four I-V curve parameters. Then press **View Curve**. 	Specify the Imp, Isc, Vmp, and Voc on the same line: CURR:SAS:ISC 5, (@1);IMP 4.5, (@1);: VOLT:SAS:VOC 100, (@1);VMP 90, (@1)

Front Panel Menu Reference	SCPI Command
Select View Curve to view the curve. 	Not available

- If the curve parameters are sent individually, an error can occur if the parameter value is outside the allowable curve characteristic determined by the three existing parameters. Additionally, it may take up to four curve changes to obtain the final curve.

Output the Curve

To output the curve that was previously programmed:

Front Panel Menu Reference	SCPI Command
With the correct channel selected, press the **On/Off** key.	To run the curve on output 1: OUTP ON, (@1)

When the unit detects invalid equation parameters, it will generate an error, light the ERR annunciator on the front panel, and will not use the new parameters. Instead, it will operate with the last valid settings. Therefore, although it may seem that the unit is operating correctly, it will NOT be using the values that you have programmed for SAS mode.

Curve Restrictions

Under certain conditions, such as if Imp is significantly less than Isc, the model equations will exhibit a certain degree of inaccuracy in that the actual maximum power point (Pmp) and value may be somewhat different from the expected value of Pmp (Imp x Vmp). Thus the actual Pmp point may not occur at exactly the Imp x Vmp. This can be corrected by entering new values for Imp and Vmp.

Note that the accuracy specifications in SAS mode are relative to the values given in the exponential equations, and not necessarily to the input parameters Imp and Vmp. However, the Isc and Voc values are always accurately given by the exponential equations.

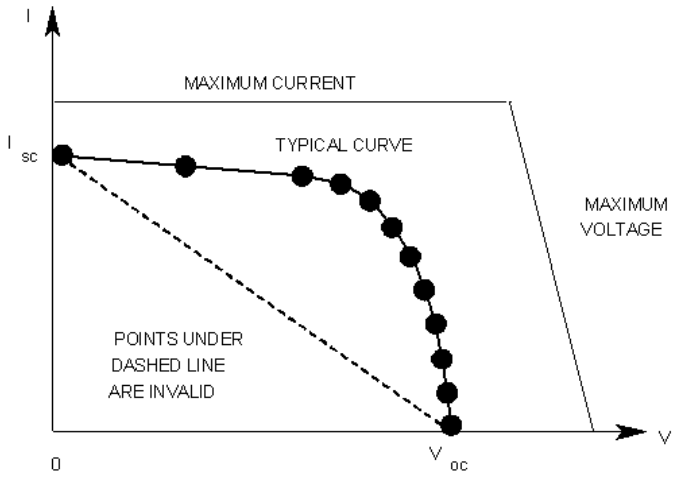
Programming a Table

NOTE

Output synchronization is NOT provided in Table mode; this means that the output will activate a table as soon as the command is received. You cannot synchronize table changes between outputs or mainframes. There is also no list support for table changes

In Table mode, the output characteristic is determined by a user-defined table of I-V points as illustrated in the following figure. Table mode operation is achieved by sampling the output voltage, applying a low-pass filter, and continually adjusting the constant current loop by using the filtered voltage as an index into the stored table of points.

Linear interpolation is used to set the current when the filtered voltage does not have an exactly matching table entry. What this means is that the I-V curve is generated by connecting the points in the table by straight lines. The more points that you provide, the more accurate the curve will be when the points are connected.



Tables are initially created using the MEM:TABL:SEL command. Up to 30 tables can be created and stored in volatile memory per mainframe. To save the tables when the instrument is turned off, copy them to non-volatile memory using MEM:TABL:COPY. Up to 30 tables can be stored in non-volatile memory per mainframe. The number of voltage or current points per table returned is set at 1024.

Programming a New Table

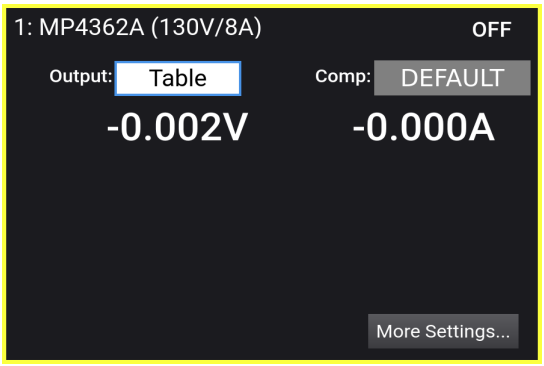
If a table does not exist, you must program a new table. Programming a table consists of entering voltage data and current data to create the desired number of I-V coordinate-pairs. The number of voltage values must match the number of current values.

Front Panel Menu Reference	SCPI Command
Not available	To create a new a table for output 1: MEM:TABL:SEL <"name"> To enter voltage and current data for the table: MEM:TABL:VOLT 0,5,10,50,55,60 MEM:TABL:CURR 4,4,3.5,3,2.5,0

Select the Table

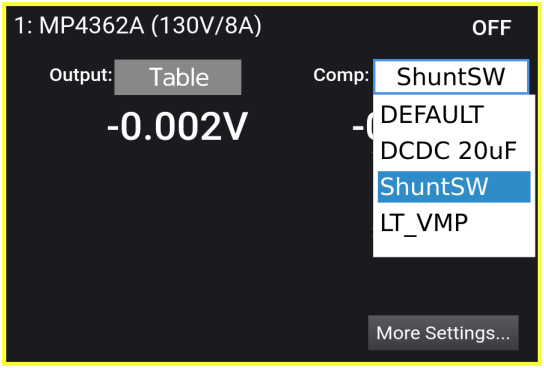
Front Panel Menu Reference	SCPI Command
Not available	To select a table for output 1: CURR:TABL:NAME <"name">, (@1)

Enable Table Mode

Front Panel Reference	SCPI Command
Touch a channel to display the channel details. 	To enable Table mode: CURR:MODE TABL, (@1)

Specify the Compensation

Refer to Compensation Modes for details.

Front Panel Menu Reference	SCPI Command
Specify a compensation mode for the table in the Comp dropdown. Touch the selection or press the rotary knob to select. 	For initial turn-on and debug of SAS operation: CURR:SAS:BWID "DEFAULT", (@1) For DC to DC converter and MPPT applications with ≥20 µF external capacitance: CURR:SAS:BWID "DCDC_20UF", (@1) For DC to DC converter applications with 1 µF to 20 µF capacitance: CURR:SAS:BWID "LT_Vmp", (@1) For Shunt Switching applications: CURR:SAS:BWID "SHUNTSW", (@1)

- The output is turned off when switching from Curve or Table modes to Fixed mode, and all output settings revert to their power-on or RST values (see *RST).
- When switching between Curve and Table modes, solar array settings will be preserved.
- When the reverse-current blocking diode is enabled, the only available compensation modes are DEFAULT and SHUNTSW.

Output the Table

To output the table that was previously selected:

Front Panel Reference	SCPI Command
With the correct channel selected, press the **On/Off**key.	To run the table on output 1: OUTP ON, (@1)

- Note that the front panel displays the table measurements. Touch a channel to display the channel details. Under Output, select Table.
- When an invalid I-V point is detected, an error is generated, and the unit will light the ERR annunciator on the front panel, and the table will not be used. Instead, the unit will operate with the last valid table settings. Therefore, although it may seem that the unit is operating correctly, it will NOT be using the values that you have programmed for Table mode.

Table Restrictions

In this mode, a table of I-V points specifies the curve. A table can be programmed with a maximum of 1024 I-V points per table. Table values are not saved as part of the instrument state. The table must satisfy the following requirements.

For both current and voltage tables:

- The number of points in each list can range from 3 to 1024.
- Both lists must contain the same number of points.

For the voltage table:

- The first value must be 0 (a range of ±10 mV is allowed).
- The point values must be strictly monotonically increasing. Adjacent values cannot be equal.

For the current table:

- The point values must be monotonically decreasing. Adjacent values can be equal.
- The last value must be 0 (a range of ±0.3 mA is allowed).

Reference Information

SAS Command Details

The following SCPI commands are not supported in SAS mode:

`CALibrate:STATe`	Enable calibration mode
`CURRent[:LEVel]`	all CURR[:LEV] commands
`CURRent:LIMit`	all CURR:LIM commands
`FUNCtion CURR|VOLT`	Priority mode setting
`VOLTage[:LEVel]`	all VOLT[:LEV] commands
`VOLTage:LIMit`	all VOLT:LIM commands

Troubleshooting

In normal solar array operation, the front panel status annunciator reports CC (constant-current) status. If the solar array curve operates outside the normal operating boundaries, the front panel status annunciator reports either VL+ (positive voltage limit) or CL- (negative current limit) status.

Most SAS errors involve curve and table parameters being outside of the acceptable parameter limits. For example:

Error 335, VMP must be less than VOC

Other errors can occur if the VMP or IMP is less than the allowable range of values, if the computed (or true) VOC exceeds the maximum voltage setting of the instrument, or if the slope of the curve is greater than the allowable maximum dI/dV of 4.154.

Error 339, VMP and/or IMP too small
Error 315, Settings conflict error; dI/dV is <calculated value>, maximum is 4.154

If oscillations occur when using the DCDC20uF compensation range, verify that you are using a minimum capacitance of 20uF on the input to the DUT. Also verify that you are using the remote sense inputs. The sense inputs must be attached as closely as possible to the >=20uF capacitor.

Model Equations

The following equations describe the solar array simulator space model using the parameters Rs, N, and a, which are defined as functions of the four input parameters Voc, Vmp, Isc, and Imp. See Note 1.

$$R_s = \frac{V_{oc} - V_{mp}}{I_{mp}}$$

$$N = \frac{\ln\left(2 - 2^a\right)}{\ln\left(\frac{I_{mp}}{I_{sc}}\right)}$$

$$a = \frac{V_{mp}\left(1 + \frac{R_s I_{sc}}{V_{oc}}\right) + R_s\left(I_{mp} - I_{sc}\right)}{V_{oc}}$$

$$V = \frac{\frac{V_{oc}\ln\left(2 - \left(\frac{I}{I_{sc}}\right)^N\right)}{\ln(2)} - R_s(I - I_{sc})}{1 + \frac{R_s I_{sc}}{V_{oc}}}$$

Note 1 This model is described in the paper: Britton, Lunscher, and Tanju, "A 9 KW High-Performance Solar Array Simulator", Proceedings of the European Space Power Conference, August 1993 (ESA WPP-054, August 1993)

Current Sinking Operation

Current Sinking

Regenerative Operation

NOTE Keysight MP4362A power modules have a fixed sinking current limit of 0.5 A. Refer to Output Quadrants for details.

Current Sinking

Current sinking, also referred to as down-programming, is the ability to pull current into the positive terminal of the power supply. For example, the power supply pulls or sinks current into the positive terminal whenever a lower output voltage is programmed. This is necessary because stored energy from the power supply's output capacitor and external capacitance from the load, including the wiring, must be discharged to lower the voltage at the output terminals.

The ability to rapidly transition from a higher to a lower constant voltage level greatly improves the output response time. At some point, some of this energy may be returned to the ac mains by the power supply. This is the most commonly used application of the regenerative function of the unit, which is automatic and completely transparent to the user.

The MP4361A power module can continuously sink up to 100% of its rated current. This two quadrant sourcing and sinking capability allows for seamless transitions between sourcing and sinking current without changing the power supply’s output characteristics or introducing any disruptive behavior. The following controls are provided to fully utilize the two-quadrant output capability of the supply. These controls apply when the MP4361A is operating in Fixed mode.

Current Limit control in voltage priority mode

When operating in voltage priority mode, you can program a negative and positive current limit. This will limit any current overshoots that may occur during rapid up- or down-programming.

Current setting control in current priority mode

When operating in current priority mode, you can program the output current to seamlessly cross the zero point when transitioning from positive to negative or negative to positive. Additionally, when operating in the negative current quadrant, you can program a negative current setting that will hold the sink current at the specified value. This is useful, for example, for discharging a battery at a constant current rate.

Regenerative Operation

Regenerative operation is automatic and requires no programming on the part of the user. Whenever the unit is sinking current, either by rapidly down-programming the output, or by discharging an energy source such as a battery, the unit will return the excess energy to the ac mains. Refer to AC Mains Considerations for additional information.

Programming Output Protection

Clear Output Protection

Introduction

Keysight MPS models have many protection functions. These functions disable the channel output to protect the device under test (DUT) as well as the channel. A front panel status indicator will turn on when a protection function has been set. Most protection functions are latching, which means that they must be cleared once they have been set.

CAUTION All protections cause a high impedance output disconnect. The output is disconnected without actively sinking current, so any voltage discharge of the DUT depends on the DUT characteristics. The DUT and load lead inductance must be within the specified hardware limits to safely absorb any stored energy. Refer to the Specifications for more information.

Of the following protection functions, the OV, OC, PROT and INH are user-programmable.

OV = Over-voltage protection compares the voltage measured by the sense leads to the user-programmed positive OVP level. If the sense voltage exceeds this level the channel goes into a latched protection state. OV protection is always enabled.

OV- = Negative over-voltage protection trips if the remote sense leads are accidentally reversed. This protection minimizes the resulting rise in output voltage by comparing the voltage measured by the sense leads to a fixed negative voltage level of 20% of the unit's rated voltage. If the sense voltage exceeds this level the unit goes into a latched protection state. OV- protection is always enabled.

OC = Over-current protection can be enabled or disabled. When enabled, the channel goes into a latched protection state when the output current reaches the current limit setting. This prevents persistent operation in current limit when operating in voltage priority mode.

OC- = Same as OC, except that it protects against negative over-current.

OP+ = Positive over-power protection compares the output power to the rated sourcing power. A OP+ protection occurs when the rated power threshold is exceeded. OP+ protection is always enabled.

OP- = Negative over-power protection compares the sinking power to the rated sinking power. A OP- protection occurs when the rated power threshold is exceeded. OP- protection is always enabled.

OT = Over-temperature protection monitors a number of internal temperatures and compares them to pre-defined temperature limits. If an internal temperature exceeds the pre-defined limit, the channel goes into a latched protection state. Use OUTP:PROT:OT:AMB:MARG? to return the margin remaining between the temperature reading and the OT trip level. OT protection is always enabled.

Note that If an over-temperature condition occurs on the ac input converter of the instrument, the unit will shut down immediately without warning and will not generate an OT status.

PF = Power-fail protection detects ac line disturbances that might cause a malfunction. If an ac line disturbance occurs, the unit goes into a latched protection state. PF protection is always enabled.

PROT = The output is disabled by a protection event

EDP = Excessive dynamic protection protects the instrument from damage in the event of over-switching (switching frequency >50 kHz), excessive large repetitive voltage swings (or oscillation), and persistent pulse-width modulator current saturation. When tripped, the unit will go into a latched protection. EDP should not engage under normal conditions. EDP protection is always enabled.

INH = The Inhibit input (pin 3) on the rear panel digital connector can be programmed to act as an external shutdown signal. Refer to Inhibit Input for details.

LFP = A Leader/Follower Protection fault has occurred in the paralleled group. All outputs of all paralleled units are disabled. LFP is always enabled.

LIM_PROT = Limit Protection indicates the output is disabled by high limit protection; which is triggered when the output operates in high limit for longer than the specified maximum duration.

LIM_PROT- = Limit Protection - indicates the output is disabled by low limit protection; which is triggered when the output operates in low limit for longer than the specified maximum duration.

UV = Under-voltage protection is a user-programmable function that can be enabled or disabled. When enabled, it provides an under-voltage shutdown that prevents the output voltage from going below the programmed setting. If the voltage measured at the remote sense leads falls below the programmed under-voltage level, the unit will go into a latched protection state.

OCF = An internal over-current fault has occurred which caused a latched protection fault.

LOV = An internal over-voltage fault has occurred which caused a latched protection fault.

DOV = An externally applied over-voltage fault has occurred which caused a latched protection fault.

Set the Over-Voltage Protection

The over-voltage protection will turn the output off if the output voltage reaches the programmed over-voltage limit. The OVP circuit monitors the voltage at the + and – sense terminals. A negative OVP shutdown will occur if the + and – sense leads are accidentally reversed.

Note that you can specify a delay to prevent momentary over-voltage excursions from tripping the over-voltage protection. Delay values can range from 10 microseconds to 65 milliseconds.

SCPI Command
To set the OVP level to 120 volts: VOLT:PROT 120, (@1)
To enter a delay value of 10 ms: VOLT:PROT:DEL 0.01, (@1)

Making Measurements

Average Measurements

Each output channel has its own measurement capability. Measurements are performed by digitizing the instantaneous output voltage or current for a specified measurement time, storing the results in a buffer, and calculating the value for the specified measurement type.

Front Panel Reference	SCPI Command
Press the **[Meter]** key. Each channel has its own voltage and current measurement capability. Press the **[Meter]** key again to display a single channel view. If dashes are displayed, the front panel measurement is interrupted because a remote interface measurement is taking place.	To measure average (DC) output voltage or current: MEAS:VOLT? MEAS:CURR? To return the other parameter from the simultaneous measurement: FETC:VOLT? FETC:CURR?

Programming the Digital Port

Bi-Directional Digital I/O

Digital Input only

Fault Output

Inhibit Input

Digital Control Port

A Digital Control Port consisting of seven I/O pins is provided to access various control functions. Each pin is user-configurable. The following control functions are available for the I/O pins. See the Digital Subsystem for details on the SCPI commands to program the Digital Port.

The following table describes the possible pin configuration for the digital port functions. For a complete description of the electrical characteristics of the digital control port, refer to the Specifications section.

Function	Description
DIO	General-purpose ground-referenced digital input/output function. The output can be set with [SOURce:]DIGital:OUTPut:DATA.
DINPut	Digital input-only mode. The digital output data of the pin is ignored.
FAULt	Applies only to pin 1. Pin 1 functions as an isolated fault output. The fault signal is true when any output is in a protected state. Pin 2 serves as the isolated common for pin 1. When pin 1 is set to the FAULt function, the instrument ignores any commands to program pin 2. Queries of pin 2 will return FAULt. If pin 1 is changed from FAULt to another function, pin 2 is set to DINPut.
INHibit	Applies only to pin 3. When pin 3 is configured as an inhibit input; a true signal at the pin will disable the output.
Common	Applies only to pin 8. Connected to ground.

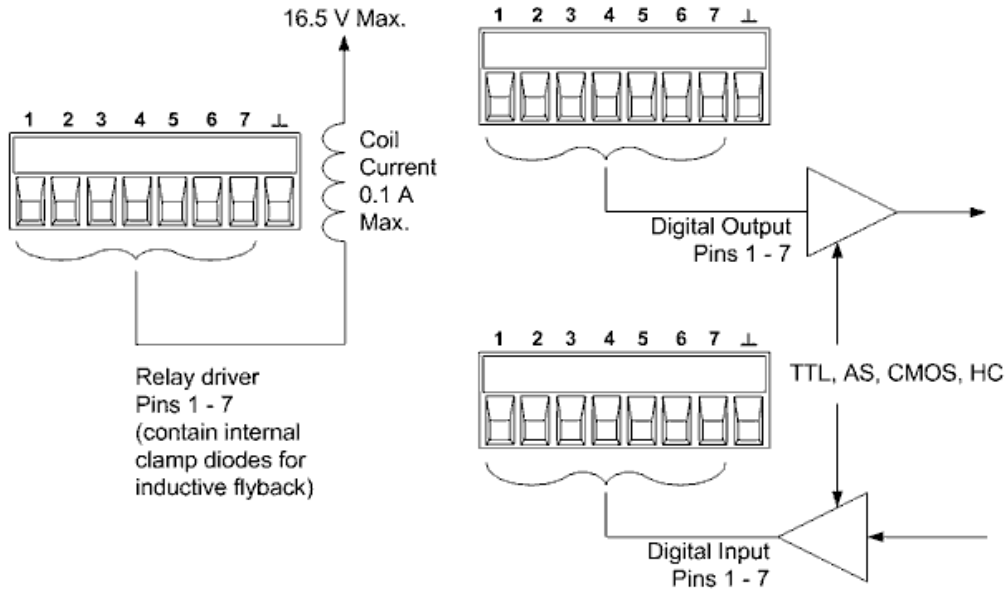
In addition to the configurable pin functions, the signal polarity (Positive or Negative) for each pin is also configurable. For level signals, POSitive indicates a voltage high at the pin. NEGative indicates a voltage low at the pin. For edge signals, POSitive means a rising edge and NEGative means a falling edge.

Bi-Directional Digital I/O

Each of the seven pins can be configured as general purpose bi-directional digital inputs and outputs. The polarity of the pins can also be configured. Pin 8 is the signal common for the digital I/O pins. Data is programmed according to the following bit assignments:

Pin	7	6	5	4	3	2	1
Bit Weight	6 (MSB)	5	4	3	2	1	0 (LSB)

The digital I/O pin can be used to control both relay circuits as well as digital interface circuits. The following figure illustrates typical relay circuits as well as digital interface circuit connections using the digital I/O functions



To configure the pins for digital I/O:

SCPI Command
To select the pin function: DIG:PIN<1-7>:FUNC DIO
To select the pin polarity: DIG:PIN<1-7>:POL POS
To configure pins 1 through 7 as “0000111”: DIG:OUTP:DATA 7

Digital Input

Each of the seven pins can be configured as digital input only. The polarity of the pins can also be configured. Pin 8 is the signal common for the digital input pins. The pin status reflects the true condition of the external signal that is applied to the pin. The pin state is not affected by the setting of DIGital:OUTPut:DATA. To configure the pins for digital input only:

SCPI Command
To select the pin function: DIG:PIN<1-7>:FUNC DINP
To select the pin polarity: DIG:PIN<1-7>:POL POS
To read the data on the pins: DIG:INP:DATA?

Fault Output

Pins 1 and 2 can be configured as a fault-output pair. The Fault Output function enables a fault condition to generate a protection fault signal on the digital port. Refer to Programming Output Protection for a list of protection signals.

Both pins 1 and 2 are dedicated to this function. Pin 1 is the Fault output; pin 2 is the common for pin 1. This provides for an optically-isolated output. The polarity of pin 1 can also be configured. When the pin polarity is POSitive, a fault condition causes the isolated output to conduct. Note that the Fault output signal remains latched until the fault condition is removed and the protection circuit is cleared. as explained under Clear Output Protection.

NOTE Pin 2's selected function is ignored. Pin 2 should be connected to the ground of the external circuit.

SCPI Command
To configure the Fault function: DIG:PIN1:FUNC FAUL
To select the pin polarity: DIG:PIN1:POL POS

Inhibit Input

Pin 3 can be configured as a remote inhibit input. The Inhibit Input function lets an external input signal control the output state of instrument. The input is level triggered. The signal latency is 5 microseconds. Pin 8 is the common for pin 3. The following non-volatile inhibit input modes can be programmed:

LIVE - allows the enabled output to follow the state of the Inhibit input. When the Inhibit input is true, the output is disabled. When the Inhibit input is false, the output is re-enabled.

OFF - The Inhibit input is ignored.

To configure the Inhibit Input function:

SCPI Command
To select the Inhibit function: DIG:PIN3:FUNC INH
To select the pin polarity: DIG:PIN3:POL POS
To specify the Inhibit mode: OUTP:INH:MODE LATC OUTP:INH:MODE OFF

System-Related Operations

Instrument Identification

Error Queue

Instrument State Storage

Password Protection

Instrument Identification

You can query the model number, serial number, options, and firmware revision. SCPI commands return information with the *IDN? and *OPT? queries.

Front Panel Reference	SCPI Command
Press the **[Menu]** key. Select **Help\ \About Instrument**. Press the **[Meter]** key to exit.	To return manufacturer, model number, serial number, and firmware revision: IDN? To return the installed options: *OPT?

Error Queue

You can view the list of errors that have accumulated in the Error Queue.

Front Panel Reference	SCPI Command
Press the **[Menu]** key. Select **Help\ \Error Queue**. Displaying errors clears the queue. Press the **[Meter]** key to exit.	Read and clear one error from the queue: SYST:ERR?

Instrument State Storage

The power supply has ten instrument state storage locations (numbered 0 through 9) available in non-volatile memory. Any state previously stored in the same location will be overwritten.

Front Panel Reference	SCPI Command
Press the **[Menu]** key. Select **System\ States\ SaveRecall**. Select the Save field and enter a location from 0 to 9. Turn the rotary knob to select; press the knob to Save. Select the Recall field and enter a location from 0 to 9. Turn the rotary knob to select; press the knob to Recall.	To save a state in location 1: *SAV 1 To recall a state from location 1: *RCL 1

Specifying a power-on state

When shipped, the power supply is configured to automatically recall the Reset (*RST) settings at power-on. However, you can configure the power supply to use the settings you have stored in State location 0 at power-on.

Front Panel Reference	SCPI Command
Press the **[Menu]** key.Select **System\ States\ Power On**. In the dropdown, select Reset State, or Recall State 0. Touch the selection or press the rotary knob to select.	To recall the reset state (*RST): OUTP:PON:STAT RST To recall the settings in state 0: OUTP:PON:STAT RCL0

NOTE

Password Protection

You can password-protect instrument calibration. As shipped, the calibration password is 0 (zero).

Front Panel Reference	SCPI Command
Not available	Enter calibration mode using the original password CAL:STAT ON, <password> To change the password: CAL:PASS <password> To exit calibration mode and activate the password: CAL:STAT OFF

If the password is lost, access can be restored by setting an internal switch to reset the password to 0. If the message “Locked out by internal switch setting” or “Calibration is inhibited by switch setting” appears, the internal switch is set to prevent the password from being changed. Refer to Calibration Switches for more information.

5 SCPI Programming Reference

Related Software

SCPI Introduction

Commands by Subsystem

Status Tutorial

E4360A Compatibility

KEYSIGHT TECHNOLOGIES

Related Software

IO Libraries and Instrument Drivers

You can download the Keysight IO Libraries Suite software, along with IVI-COM and LabVIEW drivers from the Keysight Developer Network at www.keysight.com/find/adn.

Interface Documentation

For detailed information about interface connections, refer to the Keysight Technologies USB/LAN/GPIB Interfaces Connectivity Guide, included with the Keysight IO Libraries Suite. Or you can download the guide from the Web at www.keysight.com/find/connectivity.

Web Interface

The Keysight MPS provides a Web interface that is built into the instrument. You can use this interface over LAN for remote access and control of the instrument via a Web browser. See Using the Web Interface for details.

SCPI Introduction

Keywords

Queries

Command Separators and Terminators

Syntax Conventions

Parameter Types

Device Clear

Introduction

This instrument complies with the rules and conventions of the present SCPI version (see SYSTem:VERSion?).

SCPI (Standard Commands for Programmable Instruments) is an ASCII-based instrument command language designed for test and measurement instruments. SCPI has two types of commands, common and subsystem.

IEEE-488.2 Common Commands

The IEEE-488.2 standard defines a set of common commands that perform functions such as reset, self-test, and status operations. Common commands always begin with an asterisk (*****), are three characters in length, and may include one or more parameters. The command keyword is separated from the first parameter by a blank space. Use a semicolon (**;**) to separate multiple commands as shown below:

Subsystem Commands

Subsystem commands perform specific instrument functions. They are comprised of alphabetically arranged commands that extend one or more levels below the root in a hierarchical structure, also known as a *tree system*. In this structure, associated commands are grouped together under a common node or root, thus forming *subsystems*. A portion of the OUTPut subsystem is shown below to illustrate the tree system. Note that some [optional] commands have been included for clarity.

```
OUTPut
     [:STATe] OFF|0|ON|1, (@<chanlist>)
     :INHibit
            :MODE OFF
     :PROTection
            :CLEar (@<chanlist>)
```

Keywords

Keywords, also referred to as headers, are instructions recognized by the instrument. Common commands are also keywords.

OUTPut is the root keyword, INhibit is a second-level keyword, CLEar is a third-level keywords. Colons (**:**) separate the keyword levels.

The command syntax shows most commands (and some parameters) as a mixture of upper- and lower-case letters. The upper-case letters indicate the abbreviated spelling for the command. For shorter program lines, you can send the abbreviated form. For better program readability, you can send the long form.

In the above examples, OUTP and OUTPUT are both acceptable forms. You can use upper- or lower-case letters. Therefore, OUTPUT, outp, and Outp are all acceptable. Other forms such as OUT, are not valid and will generate an error.

Queries

Following a keyword with a question mark (**?**) turns it into a query (Example: VOLTage?, CURRent?). If a query contains parameters, place the query indicator at the end of the last keyword, before the parameters. Insert a space between the query indicator and the first parameter.

You can query the programmed value of most parameters. For example, you can query the voltage setting by sending:

```
VOLTage?
```

You can also query the minimum or maximum allowable voltage settings as follows:

```
VOLTage? MIN, (@<chanlist>)
VOLTage? MAX, (@<chanlist>)
```

You must read back all the results of a query before sending another command to the instrument. Otherwise, a *Query Interrupted* error will occur and the unreturned data will be lost.

Command Separators and Terminators

Separators

Colons (**:**) separate keyword levels. Blank spaces must be used to separate command parameters from their corresponding keyword. If a command requires more than one parameter, use a comma to separate adjacent parameters. In the following example, the <current>{,<current} values must be separated with a comma.

```
MEMory:TABle:CURRent[:MAGNitude] <current>{,<current>}
```

Semicolons (**;**) separate commands and can be used to separate commands within the same subsystem. This lets you send several subsystem commands within the same message string. For example, sending the following command string:

```
OUTPut:STATe ON, (@<chanlist>);PROTection:CLEar (@<chanlist>);COUPle ON
```

is the same as sending the following commands:

```
OUTPut ON, (@<chanlist>)
OUTPut:PROTection:CLEar (@<chanlist>)
OUTPut:PROTection:COUPle ON
```

Note that the semicolon follows the implied path of the hierarchical tree structure. In the above example, the optional :STATe keyword must follow the OUTput keyword to place the command parser at the second level in the hierarchy. This allows the use of the PROTection keyword after the semicolon, since PROTection is a second-level keyword. Next, the command parser is placed at the third level in the hierarchy by the :CLEAR keyword. This allows the use of the COUPle keyword after the second semicolon, since COUPle is a third-level keyword.

You can also combine commands of different subsystems within the same message string. In this case, you must use a colon to return the command parser to the root level in order to access another subsystem. For example, you could clear the output protection and check the status of the Operation Condition register in one message by using a root specifier as follows:

```
OUTPut:PROTection:CLEar (@<chanlist>);:STATus:OPERation:CONDition?
(@<chanlist>)
```

Note the use of the colon *after* the semicolon in order to return the command parser to the root.

Terminators

A command string sent to the instrument must terminate with a new line (<NL>) character. The IEEE-488 EOI (End-Or-Identify) message is interpreted as a <NL> character and can be used to terminate a command string in place of an <NL>. A carriage return followed by a new line (<CR><NL>) is also accepted. Command string termination will always reset the current SCPI command path to the root level.

Syntax Conventions

- Triangle brackets (< >) indicate that you must specify a value for the enclosed parameter. For example, in the VOLTage <value>, (@<chanlist>) command syntax, the <*value*> and <chanlist> parameters are enclosed in triangle brackets. The brackets are not sent with the command string. You must specify a value for the parameters (Example: "VOLTage 50, (@1)".
- A vertical bar (|) separates multiple parameter choices for a given command string. For example, LATChing|OFF in the OUTPut:INHibit command indicates that you can specify "LATChing" or "OFF". The bar is not sent with the command string.
- Square brackets ([ ]) enclose some syntax elements - nodes and parameters for example. This indicates that the element is optional and can be omitted. The brackets are not sent with the command string. In the case of an optional parameter, if you do not specify a value for an optional parameter the instrument will ignore the parameter. Any keyword enclosed in brackets is optional and can be omitted. However, if you are combining several commands within the same message string as previously described, you must include the optional commands to place the command parser at the correct level in the hierarchy.

- Braces (**{}**) indicate parameters that may be repeated zero or more times. The notation <value> {,<value>} shows that the first value must be entered, while additional values may be omitted or may be entered one or more times.

Parameter Types

The SCPI language defines several data formats to be used in commands and queries.

Channel Parameter

The channel parameter <chanlist> is required to address one or more channels as follows:

(@<channel> {,<channel>}) - up to six channels

You can also specify a range of sequential channels as follows:

(@<start_channel>:<end_channel>)

For example, (@2) specifies channel 2 and (@1:3) specifies channels 1 through 3. The channel list, shown as <chanlist> throughout this document, must be preceded with the @ symbol and must be enclosed in parentheses (). A maximum of 6 channels may be specified through a combination of single channels and ranges. Query results are channel list order-sensitive. Results are returned in the order they are specified in the list.

NOTE When adding a <chanlist> to a query, you must include a space character between the query indicator (?) and the channel list parameter. Otherwise error –103, Invalid separator will occur.

Numeric Parameters

Commands that require numeric parameters will accept all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation. If a command accepts only certain specific values, the instrument will automatically round the input numeric parameters to the accepted values. The following command requires a numeric parameter for the voltage value:

```
[SOURce:]VOLTage 50|MIN|MAX, (@1)
```

Note that special values for numeric parameters such as MINimum, MAXimum, and INFinity are also accepted. Instead of selecting a specific value for the voltage parameter, you can substitute MIN to set the voltage to its minimum allowable value, MAX to set it to its maximum allowable value.

You can also send engineering unit suffixes with numeric parameters (e.g., V for volts, A for amperes, W for Watts). All parameters values are in base units.

Discrete Parameters

Discrete parameters are used to program settings that have a limited number of values (like IMMediate, EXTernal, or BUS). They may have a short form and a long form just like command keywords. You can use upper- or lower-case letters. Query responses will always return the short form in all upper-case letters. The following command requires a discrete parameter for the Function:

```
FUNCtion VOLTage|CURRent, (@1)
```

Boolean Parameters

Boolean parameters represent a single binary condition that is either true or false. For a false condition, the instrument will accept "OFF" or "0". For a true condition, the instrument will accept "ON" or "1". When you query a Boolean setting, the instrument will always return "0" or "1". The following command requires a Boolean parameter:

```
OUTPut OFF|0|ON|1,(@1)
```

ASCII String Parameters

String parameters can contain virtually any set of ASCII characters. A string must begin and end with matching quotes; either with a single quote or a double quote. You can include the quote delimiter as part of the string by typing it twice without any characters in between. The following command uses a string parameter:

```
CALibrate:DATE "10/12/22"
```

Arbitrary Block Program or Response Data

Definite-length block data <Block> allows any type of device-dependent data to be programmed or returned as a series of 8-bit binary data bytes. This is particularly useful for transferring large quantities of data or 8-bit extended ASCII codes.

Device Clear

Device Clear is an IEEE-488 low-level bus message that you can use to return the instrument to a responsive state. Different programming languages and IEEE-488 interface cards provide access to this capability through their own unique commands. The status registers, the error queue, and all configuration states are left unchanged when a Device Clear message is received.

Device Clear performs the following actions:

- If a measurement is in progress, it is aborted.
- The instrument returns to the trigger idle state.
- The instrument's input and output buffers are cleared.
- The instrument is prepared to accept a new command string.

Commands by Subsystem

CALibrate

FETCh

HCOPy

IEEE-488 Common

LXI

MEASure

MEMory

OUTPut

[SOURce:]

- **CURRent**
- **DIGital**
- **FUNCtion**
- **VOLTage**

STATus

SYSTem

CALibrate Subsystem

Calibrate commands calibrate the instrument.

NOTE Read the calibration section before calibrating. Improper calibration reduces accuracy and reliability.

CALibrate:COUNt?

Returns the number of times the unit has been calibrated. The count is incremented whenever the calibration (and date) is saved, the password is changed or reset, or the firmware is updated.

Parameter	Typical Return
(none)	<count>
Return the calibration count: CAL:COUN?	

CALibrate:CURRent[:LEVel] <*value*>, (@<channel>)

Calibrates the output current. The value entered selects the range that is being calibrated.

Parameter	Typical Return
<value> the maximum current rating of the range	(none)
<channel> the channel to calibrate	
Calibrates the 10 A range: CAL:CURR 10, (@1)	

CALibrate:DATA <*value*>

Enters the calibration value read by the external meter. You must first select a calibration level for the value being entered. Data values are expressed in base units - either volts or amperes

Parameter	Typical Return
<value> the numeric value	(none)
Enter the calibration value 10.02: CAL:DATA 10.02	

CALibrate:DATE <*"date"*>, (@<channel>)
CALibrate:DATE? (@<channel>)

Enters the calibration date in nonvolatile memory. Enter any ASCII string up to 15 characters. The query returns the date.

Parameter	Typical Return
<*"date"*> string program data Enclose string parameters in single or double quotes.	<last cal date>
<channel> the calibrated channel	
Enters the calibration date for channel 2: `CAL:DATE "10/12/22", (@2)`	

CALibrate:LEVel P1|P2|P3

Advances to the next level in the calibration. P1 is the first level; P2 is the second; P3 is the third.

Parameter	Typical Return
P1 | P2 | P3	(none)
Selects the minimum calibration point of channel 1: `CAL:LEV P1`	

CALibrate:PASSword <*password*>

Sets a numeric password to prevent unauthorized calibration.

Parameter	Typical Return
<*password*> a numeric value of up to 15 digits	(none)
Set a new password to a value of 1234: `CAL:PASS 1234`	

- If the password is set to 0, password protection is removed and the ability to enter calibration mode is unrestricted. The as-shipped setting is 0 (zero).
- To change the password: unsecure calibration memory with old code, then set the new code.
- If you forget your password, refer to Calibration Switches.
- This setting is non-volatile; it will not be changed by power cycling or *RST.

CALibrate:SAVE

Saves the calibration constants in non-volatile memory. Do this at the end of the calibration to avoid losing changes.

Parameter	Typical Return
(none)	(none)
Store calibration constants into non-volatile memory: CAL:SAVE	

CALibrate:STATe 0\|OFF\|1\|ON [,<password>]
CALibrate:STATe?

Enables or disables calibration mode. Calibration mode must be enabled for the instrument to accept any calibration commands. The first parameter specifies the state. The second optional parameter is the password.

Parameter	Typical Return
0|OFF|1|ON, *RST OFF	0 or 1
<*password*> a numeric value up to 15 digits	
Disable calibration: CAL:STAT OFF Enable calibration with optional password: CAL:STAT ON, 1234	

A password is required if <*password*> has been set to a non-zero value.

CALibrate:VOLTage[:LEVel] <*value*>, (@<channel>)

Calibrates the output voltage. The value entered selects the range that is being calibrated.

Parameter	Typical Return
<value> the maximum voltage rating of the range	(none)
<channel> the channel to calibrate	
Calibrates the 160 V range: CAL:VOLT 160, (@1)	

CURRent Subsystem

Current commands program the output current of the instrument.

[SOURce:]CURRent[:LEVel][:IMMediate][:AMPLitude] <*value*>|MIN|MAX, (@<chanlist>)
[SOURce:]CURRent[:LEVel][:IMMediate][:AMPLitude]? [MIN|MAX,] (@<chanlist>)

Sets the immediate current level when the output is operating in current priority mode. Units are in amperes. The maximum value depends on the current rating of the unit. The minimum value is the most negative value.

Parameter	Typical Return
-102% to 102% of rating (MP4361A), *RST 0 -0.51 to 102% of rating (MP4362A), *RST 0	<current level>
<chanlist> one or more channels	
Sets the positive current on channel 1 to 2 A: CURR 2, (@1)	

[SOURce:]CURRent:LIMit[:POSitive][:IMMediate][:AMPLitude] <*value*>|MIN|MAX, (@<chanlist>)
[SOURce:]CURRent:LIMit[:POSitive][:IMMediate][:AMPLitude]? [MIN|MAX,] (@<chanlist>)
[SOURce:]CURRent:LIMit:NEGative[:IMMediate][:AMPLitude]<*value*>|MIN|MAX, (@<chanlist>)
[SOURce:]CURRent:LIMit:NEGative[:IMMediate][:AMPLitude]? [MIN|MAX,] (@<chanlist>)

Sets the current limit when in voltage priority mode. Units are in amperes. The maximum value depends on the current rating of the module. The minimum value is the most negative value.

Parameter	Typical Return
Positive: 0 to 102% of rating, *RST 102% of rating Negative: -102% of rating to 0 (MP4361A), *RST -102% of rating Negative: -0.51 to 0 (MP4362A), *RST -0.51	<+current limit> <–current limit>
<chanlist> one or more channels	
Sets the positive current limit on channel 1 to 2 A: CURR:LIM 2, (@1) Sets the negative current limit on channel 1 to -2 A: CURR:LIM:NEG -2, (@1)	

- If current protection is enabled with CURRent:PROTection:STATe ON and the output goes into current limit, the output is disabled and the Questionable Condition status' OCP bit is set.

[SOURce:]CURRent:DTABle[:IMMediate]? (@<chanlist>)

Returns the table that is currently being used by the specified channel.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<chanlist> one or more channels	<4.8,4.9,5.0,5.1,5.2,5.3, ...>
Returns the DAC table settings on channel 2: CURR:DTAB? (@2)	

[SOURce:]CURRent:DTABle:SASimulator[:IMMediate]? (@<chanlist>)

Returns the DAC table that was calculated based on the SAS parameter settings. The number of current points returned is set at 1024.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<chanlist> one or more channels	<4.8,4.9,5.0,5.1,5.2,5.3, ...>
Returns the DAC table settings on channel 2: CURR:DTAB:SAS? (@2)	

[SOURce:]CURRent:DTABle:SASimulator[:IMMediate]:IMP? (@<chanlist>)

Returns the calculated Imp (maximum power current) of the internal DAC table.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<chanlist> one or more channels	+3.620843E+00
Returns the calculated Imp of the DAC table settings on channel 2: CURR:DTAB:SAS:IMP? (@2)	

[SOURce:]CURRent:DTABle:SASimulator[:IMMediate]:ISC? (@<chanlist>)

Returns the calculated Isc (short-circuit current) of the internal DAC table.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<chanlist> one or more channels	+5.100000E+00
Returns the calculated Isc of the DAC table settings on channel 2: CURR:DTAB:SAS:ISC? (@2)	

[SOURce:]CURRent:DTABle:TABLe[:IMMediate]? <"*name*">, (@<chanlist>)

Returns the DAC table that was calculated based on the values from the specified table. The number of current points returned is set at 1024.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<"name"> the table name	<4.8,4.9,5.0,5.1,5.2,5.3, ...>
<chanlist> one or more channels	
Returns the DAC table on channel 2: CURR:DTAB:TABL? "table1", (@2)	

[SOURce:]CURRent:DTABle:TABLe[:IMMediate]:IMP? <"*name*">, (@<chanlist>)

Returns the calculated Imp (maximum power current) of the internal DAC table for the specified table.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<"name"> the table name	+3.620843E+00
<chanlist> one or more channels	
Returns the calculated Imp of the DAC table on channel 2: `CURR:DTAB:TABL:IMP? "table1", (@2)`	

[SOURce:]CURRent:DTABle:TABLe[:IMMediate]:ISC? <"*name*">, (@<chanlist>)

Returns the calculated Isc (short-circuit current) of the internal DAC table for the specified table.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<"name"> the table name	+5.10000E+00
<chanlist> one or more channels	
Returns the calculated Isc of the DAC table on channel 2: `CURR:DTAB:TABL:ISC? "table1", (@2)`	

[SOURce:]CURRent:MODE FIXed|SASimulator|TABLe, (@<chanlist>)
[SOURce:]CURRent:MODE? (@<chanlist>)

Selects the output mode of the instrument.

FIXed - In Fixed mode, the output is a fixed rectangular I-V characteristic.

SASimulator - Simulator mode uses an exponential model to approximate the I-V curve. It is programmed in terms of its open circuit voltage (Voc), short circuit current (Isc), voltage point (Vmp), and current point (Imp) at approximately the peak power point.

TABLe - Table mode sets the output characteristics by a user-defined table of voltage/current points. A curve is generated by connecting the points by straight lines. Therefore, the more points that are provided, the more the connected points will resemble a curve.

Parameter	Typical Return
FIXed|SASimulator|TABLe *RST: FIXed	FIX|SAS|TABL
<chanlist> one or more channels	
Set channel 2 to operate in SAS mode: `CURR:MODE SAS, (@2)`	

- When selecting Table mode, you must first activate a table using the CURRent:TABLe:NAME command. Otherwise Error 103 is generated if no table has been activated. When a table has been selected, the combination of table values and scale factors for the voltage and current points are checked to not exceed any maximum. If the validity check passes, the table will be used.

[SOURce:]CURRent:PROTection[:LEVel] <*value*>|MIN|MAX,(@<chanlist>)
[SOURce:]CURRent:PROTection[:LEVel]? [MIN|MAX,] (@<chanlist>)

Sets the over-current protection level in SAS and Table modes. Units are in amperes. This single-sided limit is applied to the positive current. If the output current exceeds the protection level, the output is disabled and the Questionable Condition status OC bit is set.

In Fixed mode, this command is ignored, as the CURRent:LIMit:POSitive and CURRent:LIMit:NEGative commands determine the level at which the OCP occurs.

Parameter	Typical Return
0 – 12.5 (MP4361A), *RST 12.5 0 – 10 (MP4362A), *RST 10	<protection level>
<chanlist> one or more channels	
Sets the current protection 5 A on channel 2: CURR:PROT 5, (@2)	

- An over-current condition can be cleared with the OUTPut:PROTection:CLEar command after the condition that caused the OCP trip is removed.

[SOURce:]CURRent:PROTection:STATe 0|OFF|1|ON, (@<chanlist>)
[SOURce:]CURRent:PROTection:STATe? (@<chanlist>)

Enables or disables over-current protection. In Fixed mode, if the over-current protection is enabled and the output goes into current limit, the output is disabled and the Questionable Condition status' OCP bit is set. In SAS and Table modes this occurs when the output current exceeds the CURRent:PROTection:LEVel setting.

Parameter	Typical Return
0|OFF|1|ON, *RST OFF	0 or 1
<chanlist> one or more channels	
Enable the current protection state: CURR:PROT:STAT ON, (@2)	

[SOURce:]CURRent:SAS:BWIDth "DEFAULT"|"DCDC_20UF"|"SHUNTSW", (@<chanlist>)
[SOURce:]CURRent:SAS:BWIDth? (@<chanlist>)

Specifies the compensation of the curve parameters when operating in SAS mode. The parameters must be sent in quotes. Refer to SAS Compensation Modes for details.

DEFAULT - Used for initial turn-on and debug of SAS operation.

DCDC_20UF - Used for DC to DC converter and MPPT applications with ≥20 µF external capacitance.

LT_VMP - (less than Vmp) Used for for DC/DC converter applications with a 1 µF to 20 µF external capacitance (only available on units with with firmware revision 1.1.09 and up).

SHUNTSW - Used for shunt switching applications.

Parameter	Typical Return
"DEFAULT"|"DCDC_20UF"|"LT_VMP"|"SHUNTSW" *RST DEFAULT	DEFAULT|DCDC_20UF|LT_VMP|SHUNTSW
<chanlist> one or more channels	
Sets the compensation to shunt switching on channel 2: CURR:SAS:BWID "SHUNTSW", (@2)	

- Changing the curve compensation turns the channel's output off.

[SOURce:]CURRent:SAS:IMP <*value*>, (@<chanlist>)
[SOURce:]CURRent:SAS:IMP? (@<chanlist>)

Sets the Imp (maximum power current) of the curve in SAS mode. This must be less than or equal to the Isc value. Units are in amperes.

Parameter	Typical Return
0 – 10 (MP4361A), *RST 0.8% of nominal rating 0 – 8 (MP4362A), *RST 0.8% of nominal rating	<0.8 X max value>
<chanlist> one or more channels	
Sets the maximum power current to 4.5 A on channels 1 and 2: CURR:SAS:IMP 4.5,(@1,2)	

- When a single Isc, Imp, Voc, or Vmp parameter is sent, it is checked along with the unchanged parameters to determine if all parameters and the resulting curve are within acceptable limits. If a parameter is outside the limits, an error occurs and no new curve is programmed. If all four parameters are programmed individually, four curves are produced as each parameter is programmed.
- When programming an entirely new curve, it is best to send all parameters on the same program line. In this case, the instrument checks that all parameters are acceptable. The parameters can be sent in any order. Any parameter not programmed takes on the value of the previous curve.

[SOURce:]CURRent:SAS:ISC <*value*>, (@<chanlist>)
[SOURce:]CURRent:SAS:ISC? (@<chanlist>)

Sets the Isc (short-circuit current) in SAS mode. Units are in amperes.

Parameter	Typical Return
0 – 10 (MP4361A), *RST 1% of nominal rating 0 – 8 (MP4362A), *RST 1% of nominal rating	<max value>
<chanlist> one or more channels	
Sets the short-circuit current to 4.5 A on channels 1 and 2: CURR:SAS:ISC 5, (@1,2)	

- When a single Isc, Imp, Voc, or Vmp parameter is sent, it is checked along with the unchanged parameters to determine if all parameters and the resulting curve are within acceptable limits. If a parameter is outside the limits, an error occurs and no new curve is programmed. If all four parameters are programmed individually, four curves are produced as each parameter is programmed.
- When programming an entirely new curve, it is best to send all parameters on the same program line. In this case, the instrument checks that all parameters are acceptable. The parameters can be sent in any order. Any parameter not programmed takes on the value of the previous curve.

[SOURce:]CURRent:SAS:SCALe <percent>|MIN|MAX, (@<chanlist>)
[SOURce:]CURRent:SAS:SCALe? [MIN|MAX,] (@<chanlist>)

Set a scale factor for the curve in both Curve and Table modes. The output current will be equal to this percentage multiplied by the current computed from the SAS curve or table. This is often used to simulate variations in solar cell irradiance.

Parameter	Typical Return
<percent> 1 to 100, *RST 100	100
<chanlist> one or more channels	
Sets the scale factor for the current to 90%: CURR:SAS:SCAL 90, (@2)	

- When on, the output will respond immediately to any change in this setting.

[SOURce:]CURRent:TABLe:NAME <"*name*">, (@<chanlist>)
[SOURce:]CURRent::TABLe:NAME? (@<chanlist>)

Activates a user-defined table when the unit is operating in Table mode. If the unit is not in Table mode, the specified table becomes the active table when Table mode is invoked.

If you send the command without specifying a table name, it de-selects the active table. This allows the MEMory:DELete:ALL command to delete all tables in both volatile and non-volatile memory. When operating in Table mode, an error is generated if this command is sent without a table name.

Parameter	Typical Return
<"name"> the table name	<table name>
<chanlist> one or more channels	
Activates the table named curve1 on channel 1: `CURR:TABL:NAME "curve1", (@1)` De-selects the active table: `CURR:TABL:NAME (@1)`	

DIGital Subsystem

Digital commands program the digital control port on the rear panel of the instrument.

[SOURce:]DIGital:INPut:DATA?

Reads the state of the digital control port. Returns the binary-weighted value of the state of pins 1 through 7 in bits 0 through 6 respectively.

Parameter	Typical Return
(none)	<bit value>
Reads the state of the digital control port: DIG:INP:DATA?	

[SOURce:]DIGital:OUTPut:DATA <*value*>
[SOURce:]DIGital:OUTPut:DATA?

Sets the state of the digital control port. This only affects the pins whose function has been set to Digital IO operation. The port has seven signal pins and a digital ground pin. In the binary-weighted value that is written to the port, the pins are controlled according to the following bit assignments:

Pin	1	2	3	4	5	6	7
Bit number	0	1	2	3	4	5	6
Decimal value	1	2	4	8	16	32	64

Bit values corresponding to digital port pins that are not configured as DIO are ignored.

Parameter	Typical Return
0 – 127, *RST 0	<bit value>
Programs pins 1, 3, and 5 on: DIG:OUTP:DATA?	

[SOURce:]DIGital:PIN<1-7>:FUNCtion <*function*>
[SOURce:]DIGital:PIN<1-7>:FUNCtion?

Sets the pin function. The functions are saved in non-volatile memory.

DIO	Pins 1-7 function as a ground-referenced digital input/output.
DINPut	Pins 1-7 function as a ground-referenced digital input-only.
FAULt	Pin 1 functions as an isolated fault output. Pin 2 is common for pin 1
INHibit	Pin 3 functions as an inhibit input.

Parameter	Typical Return
DIO | DINPut | FAULt | INHibit	DIO, DINP, FAUL, INH
Sets pin 1 to FAULt mode: DIG:PIN1:FUNC FAUL	

[SOURce:]DIGital:PIN<1-7>:POLarity POSitive|NEGative
[SOURce:]DIGital:PIN<1-7>:POLarity?

Sets the pin polarity.

POSitive means a logical true signal is a voltage high at the pin. For trigger inputs and outputs, POSitive means a rising edge.

NEGative means a logical true signal is a voltage low at the pin. For trigger inputs and outputs, NEGative means a falling edge. The pin polarities are saved in non-volatile memory.

Parameter	Typical Return
POSitive|NEGative	POS or NEG
Sets pin 1 to POSitive polarity: DIG:PIN1:POL POS	

FETCh Subsystem

Fetch commands return measurement data that has been previously acquired. FETCh queries do not generate new measurements, but allow additional measurement calculations from the same acquired data. The data is valid until the next MEASure command occurs.

FETCh[:SCALar]:CURRent[:DC]? (@<chanlist>)
FETCh[:SCALar]:VOLTage[:DC]? (@<chanlist>)

This query returns the DC output current in amperes or DC output voltage in volts. The data returned is the result of the last measurement command or triggered acquisition. The data is valid until the next MEASure command occurs.

Parameter	Typical Return
<chanlist> one or more channels	+1.000000E+01
Returns the measured DC current FETC:CURR? (@1 Returns the measured DC voltage FETC:VOLT? (@1	

FUNCtion Command

NOTE

The Function command to set voltage or current priority only applies in Fixed mode operation. It is not available in SAS and Table modes. Refer to the SOUR:CURR:MODE command to specify the operating mode.

[SOURce:]FUNCtion CURRent|VOLTage, (@<chanlist>)
[SOURce:]FUNCtion? (@<chanlist>)

Sets the output regulation - voltage priority or current priority. In voltage priority mode, the output is controlled by a constant voltage feedback loop, which maintains the output voltage at its programmed setting. In current priority mode, the output is controlled by a constant current feedback loop, which maintains the output current at its positive or negative programmed setting.

Refer to Priority Mode Tutorial for more information.

Parameter	Typical Return
CURRent|VOLTage, *RST VOLTage	CURR or VOLT
<chanlist> one or more channels	
Sets the output regulation to current priority on channel 2: FUNC CURR, (@2)	

HCOPy Subsystem

HCOPy commands return the display image.

HCOPy:SDUMp:DATA? [JPG|PNG]

Returns an image of the front panel display. The format may be specified by the optional parameter. If no format is specified, the format is determined by HCOPy:SDUMp:DATA:FORMat.

The response is a SCPI 488.2 definite length binary block of the form: #<nonzero digit><digits><8 bit data-bytes> where:
<nonzero digit> specifies the number of digits to follow,
<digits> specify the number of 8 bit data bytes to follow, and
<8 bit data bytes> contain the data to be transferred.

Parameter	Typical Return
[JPG|PNG]	<Block>
Returns the image in PNG format: HCOP:SDUM:DATA? PNG	

HCOPy:SDUMp:DATA:FORMat JPG|PNG
HCOPy:SDUMp:DATA:FORMat?

Specifies the format for front panel images returned.

Parameter	Typical Return
BMP|JPG|PNG, *RST PNG	JPG, or PNG
Specify JPG as the image format: HCOP:SDUM:DATA:FORM JPG	

IEEE-488 Common Commands

IEEE-488 Common commands generally control overall instrument functions, such as reset, status, and synchronization. All common commands consist of a three-letter mnemonic preceded by an asterisk: *RST *IDN? *SRE 8.

*CLS

Clear status command. Clear Status Command. Clears the event registers in all register groups. Also clears the status byte and error queue. If *CLS immediately follows a program message terminator (<NL>), then the output queue and the MAV bit are also cleared. Refer to Status Tutorial for more information.

Parameter	Typical Return
(none)	(none)
Clear event registers, status byte, and error queue: *CLS	

*ESE <*value*>
*ESE?

Event status enable command and query. Sets the value in the enable register for the Standard Event Status group. Each set bit of the register enables a corresponding event. All enabled events are logically ORed into the ESB bit of the status byte. The query reads the enable register. Refer to Status Tutorial for more information.

Parameter	Typical Return
A decimal value corresponding to the binary-weighted sum of the register's bits.	<bit value>
Enable bits 3 and 4 in the enable register: *ESE 24	

- The value returned is the binary-weighted sum of all enabled bits in the register. For example, with bit 2 (value 4) and bit 4 (value 16) set, the query returns +20.
- Any or all conditions can be reported to the ESB bit through the enable register. To set the enable register mask, write a decimal value to the register using *ESE.
- *CLS does not clear the enable register, but does clear the event register.

*ESR?

Event status event query. Reads and clears the event register for the Standard Event Status group. The event register is a read-only register, which latches all standard events. Refer to Status Tutorial for more information.

Parameter	Typical Return
(none)	<bit value>
Read event status enable register: *ESR?	

- The value returned is the binary-weighted sum of all enabled bits in the register.
- Any or all conditions can be reported to the ESB bit through the enable register. To set the enable register mask, write a decimal value to the register using *ESE.
- Once a bit is set, it remains set until cleared by this query or *CLS.

*IDN?

Identification Query. Returns instrument's identification string, which contains four comma-separated fields. The first field is the manufacturer's name, the second field is the instrument model number, the third field is the serial number, and the fourth field is the firmware revision.

Parameter	Typical Return
(none)	Keysight Technologies,MP4300,MY12345678,A.01.01
Return the instrument's identification string: *IDN?	

*OPC
*OPC?

Sets the OPC (operation complete) bit in the standard event register. This occurs at the completion of the pending operation. Refer to Status Tutorial for more information. The query returns a 1 to the output buffer when all pending operations complete. The response is delayed until all pending operations complete.

Parameter	Typical Return
(none)	1
Set the Operation Complete bit: *OPC Return a 1 when commands complete: *OPC?	

- The purpose of this command is to synchronize your application with the instrument.
- Used in conjunction with initiated acquisitions, transients, output state changes, and output settling time to provide a way to poll or interrupt the computer when these pending operations complete.
- Other commands may be executed before the operation complete bit is set. However, other commands cannot be executed until the query completes.
- The difference between *OPC and *OPC? is that *OPC? returns "1" to the output buffer when the current operation completes.

*OPT?

Returns a string identifying any installed options. A 0 (zero) indicates no options are installed.

Parameter	Typical Return
(none)	OPT 760
Returns installed options `*OPT?`	

*RCL <0-9>

Recalls a saved instrument state. This restores the instrument to a state that was previously stored in locations 0 through 9 with the *SAV command. All instrument states are recalled except: (1) the output state is set to OFF, (2) the trigger systems are set to the Idle state, (3) calibration is disabled, (4) all lists are set to their *RST values, and (5) the non-volatile settings are not affected.

Parameter	Typical Return
0 - 9	(none)
Recall state from location 1: `*RCL 1`	

- Location 0 is automatically recalled at power turn-on when the Power-On state is set to RCL0.
- Stored instrument states are not affected by *RST.

*RDT?

Returns a description of all the output modules (channels) installed in a mainframe. Semicolons separate multiple channel descriptions.

An arbitrary ASCII string with up to six semicolon-separated fields can be returned. To read the string, be sure to dimension a string variable with at least 75 characters

Parameter	Typical Return
(none)	CHAN1:xxxxxA;CHAN2:xxxxxA
Reset the instrument: `*RDT?`	

*RST

Resets the instrument to pre-defined values that are either typical or safe. These settings are described in Reset State.

Parameter	Typical Return
(none)	(none)
Reset the instrument: `*RST`	

- This cancels any measurement or transient actions in process. It resets the WTG-meas, WTG-tran, and WTG-dlog bits in the Operation Status registers.

*SAV <0-9>

Saves the instrument state to one of ten non-volatile memory locations. For safety reasons, when a saved state is recalled, the output state will be set to OFF.

Parameter	Typical Return
0 - 9	(none)
Save state to location 1: *SAV 1	

- If a particular state is desired at power-on, it should be stored in location 0. Location 0 is automatically recalled at power turn-on when the Power-On state is set to RCL0.
- Output state, List data, and the calibration state is NOT saved as part of the *SAV operation.
- Data in non-volatile memory, described under Non-Volatile Settings, is not affected by *SAV.
- When shipped, locations 0 through 9 are empty.

*SRE <*value*>
*SRE?

Service request enable command and query. This sets the value of the Service Request Enable register. This determines which bits from the Status Byte Register are summed to set the Master Status Summary (MSS) bit and the Request for Service (RQS) summary bit. A 1 in any Service Request Enable register bit position enables the corresponding Status Byte register bit. All such enabled bits are then logically OR-ed to cause the MSS bit of the Status Byte register to be set. Refer to Status Tutorial for more information.

Parameter	Typical Return
A decimal value corresponding to the binary-weighted sum of the register's bits.	<bit value>
Enable bit 3 and bit 4 in the enable register: *SRE 24	

- When a serial poll is conducted in response to SRQ, the RQS bit is cleared, but the MSS bit is not. When *SRE is cleared (by programming it with 0), the power supply cannot generate an SRQ.

*STB?

Status byte query. Reads the Status Byte Register, which contains the status summary bits and the Output Queue MAV bit. The Status Byte is a read-only register and the bits are not cleared when it is read. Refer to Status Tutorial for more information.

Parameter	Typical Return
(none)	<bit value>
Read status byte: *STB?	

*TST?

Self-test query. Performs a instrument self-test. If self-test fails, one or more error messages will provide additional information. Use SYSTem:ERRor? to read error queue. See SCPI Error Messages for more information.

Parameter	Typical Return
(none)	0 (pass) or +1 (failed)
Perform self-test: *TST?	

- The power-on self-test is the same self-test performed by *TST.
- *TST? also forces an *RST command.

*WAI

Pauses additional command processing until all pending operations are complete. See OPC for more information.

Parameter	Typical Return
(none)	(none)
Wait until all pending operations complete. *WAI	

- *WAI can only be aborted by sending the instrument a Device Clear command.

LXI Subsystem

LXI:IDENtify[:STATe] 0|OFF|1|ON
LXI:IDENtify[:STATe]?

Turns the front panel LAN indicator  on or off. When on, the LAN indicator identifies the unit being addressed.

Parameter	Typical Return
0|OFF|1|ON, *RST OFF	0 or 1
To blink the front panel LXI indicator: LXI:IDENT ON	

LXI:MDNS[:STATe] 0|OFF|1|ON
LXI:MDNS[:STATe]?

Sets the MDNS state on or off.

Parameter	Typical Return
0|OFF|1|ON, *RST OFF	0 or 1
To set the MDNS state on: LXI:MDNS ON	

MEASure Subsystem

Measure commands measure the output voltage or current. They trigger the acquisition of new data before returning the reading. Measurements are performed by digitizing the instantaneous output voltage or current for a specified measurement time, storing the results in a buffer, and calculating the value for the specified measurement type.

MEASure[:SCALar]:CURRent[:DC]? (@<chanlist>)
MEASure[:SCALar]:VOLTage[:DC]? (@<chanlist>)

initiates and triggers a measurement, and returns the DC output voltage in amperes or volts.

Output current and voltage is measured simultaneously. You can use FETCh:CURRent? to return the voltage data that was collected along with the current measurement and vice-versa.

Parameter	Typical Return
(none)	<DC value>
Returns the measured DC current on channel 1: MEAS:CURR? (@1) Returns the measured DC voltage on channel 2: MEAS:VOLT? (@2)	

- The MEASure query starts a new measurement immediately. It is not synchronized to any trigger event. Use the INITiate, TRIGger, and FETCh sequence for synchronized measurements.
- The default measurement time interval is 1.7 milliseconds.

MEMory Subsystem

MEMory commands provide mass storage capability for output measurement data. The mass storage may be either internal or external to the instrument. The mass storage device is selected using the full path embedded within the filename. The filename parameter is a string.

MEMory:COPY:TABLe <"*name*">

Copies the table that was selected with MEMory:TABLe:SELect to non-volatile memory. You can use the same name or a different name. Table names cannot be longer than 12 alphanumeric characters and must start with an alpha character. A maximum of 30 tables can be stored in non-volatile memory. Tables can have from 3 to 1024 points.

Parameter	Typical Return
<"name"> the table name	(none)
Copies the table named curve1: `MEM:COPY:TABL "curve1"`	

- The query returns an ASCII string enclosed in double quotes containing the value of the specified attribute, or a blank string if the name of the attribute is not valid or an error has occurred.
- After many writes to non-volatile memory, the time it takes to write to memory may increase up to one second per write operation. If you are copying many tables, this may take up to 10 seconds..

MEMory:DELete[:NAME] <"*name*">

Deletes the specified table in both volatile and non-volatile memory. This command will delete one table per execution. If a table is stored in volatile memory and also stored in non-volatile memory with the same name, the volatile copy will be deleted first. A second MEM:DEL[:NAME] must be sent to remove the table from non-volatile memory.

Parameter	Typical Return
<"name"> the table name	(none)
Deletes the table named curve1: `MEM:DEL "curve1"`	

MEMory:DELete:ALL

Deletes all tables in both volatile and non-volatile mass memory. The command fails if a table is currently selected or activated with the MEMory:TABLe:SELect or CURRent:TABLe:NAME command. If the command fails, no tables are deleted.

Parameter	Typical Return
(none)	(none)
Deletes all tables in volatile and non-volatile memory: `MEM:DEL:ALL`	

MEMory:TABLe:CATalog?

Returns the names of all user-defined tables in both volatile and non-volatile memory. The table names are enclosed in quotes. Multiple responses are separated by commas. ("") indicates the end of the list.

Parameter	Typical Return
(none)	"Table1","Table2","Table3",""
Returns all tables in volatile and non-volatile memory: MEM:TABL:CAT?	

MEMory:TABLe:CURRent[:MAGNitude] <current>{,<current>}
MEMory:TABLe:CURRent[:MAGNitude]?

Programs a list of current points for a new table. A table must have at least 3 points. You may, but are not required to send all the table points in one command. Repeatedly sending this command will append additional points to the end of the table, up to a maximum of 1024 points. A maximum of 30 tables can be stored in volatile memory.

The query returns the current points in the active table.

Parameter	Typical Return
<current> 0 to the rated current. *RST 0 Values must be in equal or descending order, or an error will occur.	<+7.800000E+00,+7.700000E+00,+7.500000E+00, +7.000000E+00,+6.000000E+00>
Programs five data points in a new table: MEM:TABL:CURR 7.8,7.7,7.5,7,6	

- To copy a table from volatile to non-volatile memory, use MEMory:TABLe:SELect and MEMory:COPY:TABLe.
- Querying values from a table where no values have been set will return NAN (9.91E37).

MEMory:TABLe:CURRent[:MAGNitude] :POINts?

The query returns the number of current points in the active table.

Parameter	Typical Return
(none)	<# of points>
Return the number of points in the active table: MEM:TABL:CURR:POIN?	

MEMory:TABLe:SELect <"*name*">
MEMory:TABLe:SELect?

Creates a new table in volatile memory to be programmed with a list of voltage and current points. Table names cannot be longer than 12 alphanumeric characters and must start with an alpha character. Table names are converted to upper case. If you send this command without specifying a table name, it will de-select the selected table.

This command is also used to select an existing table in non-volatile memory to be copied into volatile memory for appending additional voltage and current points. A selected table can be copied into non-volatile memory using MEMory:COPY:TABLe.

Parameter	Typical Return
<"name"> the table name	<"curve1">
Selects or creates the table named curve1:MEM:TABL:SEL "curve1" Queries the selected table: MEM:TABL?	

- To activate a table in Table mode, use [SOURce:]CURRent:TABLe:NAME.

MEMory:TABLe:VOLTage[:MAGNitude] <voltage>{,<voltage>}
MEMory:TABLe:VOLTage[:MAGNitude]?

Programs a list of voltage points for a new table. A table must have at least 3 points. You may, but are not required to send all the table points in one command. Repeatedly sending this command will append additional points to the end of the table, up to a maximum of 4000 points. A maximum of 30 tables can be stored in volatile memory.

The query returns the voltage points in the active table.

Parameter	Typical Return
<voltage> 0 to the rated voltage. *RST 0 Values must be in equal or ascending order, or an error will occur.	<+5.400000E+01,+5.600000E+01,+5.700000E+01, +5.800000E+01,+5.900000E+01>
Programs five data points in a new table: MEM:TABL:VOLT 54,56,57,58,59	

- To copy a table from volatile to non-volatile memory, use MEMory:TABLe:SELect and MEMory:COPY:TABLe.
- Querying values from a table where no values have been set will return NAN (9.91E37).

MEMory:TABLe:VOLTage[:MAGNitude] :POINts?

The query returns the number of voltage points in the active table.

Parameter	Typical Return
(none)	<# of points>
Return the number of points in the active table: MEM:TABL:VOLT:POIN?	

OUTPut Subsystem

The Output subsystem controls the output state, power-on, protection, and relay functions.

OUTPut[:STATe] 0|OFF|1|ON, (@<chanlist>)
OUTPut[:STATe]? (@<chanlist>)

This command enables or disables the specified output. The enabled state is ON (1); the disabled state is OFF (0). The state of a disabled output is a condition of zero output voltage and zero source current. The state of a disabled output is a condition of zero output voltage and zero source current.

Parameter	Typical Return
0|OFF|1|ON, *RST OFF	0 or 1
<chanlist> one or more channels	
Turns the output off on channel 2: OUTP OFF (@2)	

- When output is enabled, the front-panel status indicator changes from OFF to indicate the operating status of the instrument (CV, CC, etc.).
- Because of internal circuit start-up procedures, Output On may take up to 75 milliseconds to complete its function. Conversely, Output Off may take up to 75 milliseconds to complete its function. To mitigate these built-in delays, you can program the output to zero volts rather than using the output on/off function.
- The MPS utilizes a high impedance turn-off mode and does not automatically down-program an external capacitance connected to output terminals when the output is disabled via the On/Off key, bus command, or a protection event. Hazardous voltages may be present on the output terminals even after a channel is turned off.

OUTPut:INHibit:MODE LATChing|OFF
OUTPut:INHibit:MODE?

Sets the operating mode of the remote inhibit digital pin. The inhibit function shuts down the output in response to an external signal on the Inhibit input pin. The Inhibit mode is stored in non-volatile memory. See Programming the Digital Port.

LATChing - a logic-true signal on the Inhibit input causes the output state to latch OFF. The output remains disabled until the Inhibit input is returned to logic-false and the latched INH status bit is cleared by sending the OUTPut:PROTection:CLEar command or a protection clear command from the front panel.

OFF - The Inhibit input is ignored.

Parameter	Typical Return
LATChing|OFF	LATC or OFF
Sets the Inhibit Input to Latching mode: OUTP:INH:MODE LATC	

OUTPut:MODE BIDirectional|DIODe, (@<chanlist>)
OUTPut:MODE?

NOTE Diode mode is only available on units with with firmware revision 1.1.09 and up.

Configures the module's output to only source current, or operate bi-directionally. The diode setting is stored in the mainframe's non-volatile memory for the specified slot. Any module installed in that slot will inherit the diode setting for that slot.

DIODe - the protection diode is enabled (the output operates as a source only). Refer to Blocking Diode for connection information.

BIDirectional - the protection diode is disabled (the output operates bi-directionally).

Parameter	Typical Return
BIDirectional|DIODe	BID or DIOD
<chanlist> one or more channels	
Enables the internal reverse-current protection diode: OUTP:MODE DIOD	

- The diode setting is not affected by *RST or power cycling.
- Changing the diode setting resets the module settings.

OUTPut:PON:STATe RST|RCL0
OUTPut:PON:STATe?

Sets the output power-on state. This determines whether the power-on state is set to the *RST state (RST) or the state stored in memory location 0 (RCL0).Instrument states can be stored using the *SAV command. This parameter is saved in non-volatile memory.

Parameter	Typical Return
RST | RCL0	RST or RCL0
Sets the power-on state to the *RST state: OUTP:PON:STAT RST	

- If the power-on state is set to 0 with no state stored, a self-test error "file not found; 0 state" is generated and the instrument is set to the *RST state.

OUTPut:PROTection:CLEar (@<chanlist>)

Resets the latched protection. This clears the latched protection status that disables the output when a protection condition occurs (see Programming Output Protection).

Parameter	Typical Return
<chanlist> one or more channels	(none)
Clears the latched protection status on channel 1: OUTP:PROT:CLE (@1	

- All conditions that generate the fault must be removed before the latched status can be cleared. The output is restored to the state it was in before the fault condition occurred.

OUTPut:PROTection:COUPle[:STATe] 0|OFF|1|ON
OUTPut:PROTection:COUPle[:STATe]?

Enables or disables channel coupling for protection faults. When enabled, ALL output channels are disabled when a protection fault occurs on any output channel. When disabled, only the affected output channel is disabled when a protection fault is triggered.

Parameter	Typical Return
0|OFF|1|ON, *RST OFF	0 or 1
Turns the output coupling protection on: `OUTP:PROT:COUP ON`	

OUTPut:PROTection:OT:AMBient:MARGin?

Returns the difference between the factory ambient over-temperature setting and the ambient temperature at the front panel air inlet. The margin is returned in degrees Celsius.

Parameter	Typical Return
(none)	(none)
Returns the temperature margin: `OUTP:PROT:OT:AMB:MARG?`	

- The factory over-temperature setting is 55° C and the ambient temperature is 25° C.

OUTPut:PROTection:OT:TUNNel:MARGin? (@<chanlist>)

Returns the difference between the factory heatsink over-temperature setting and the power module heatsink temperature. The margin is returned in degrees Celsius.

Parameter	Typical Return
<chanlist> one or more channels	(none)
Returns the temperature margin for channel 1: `OUTP:PROT:OT:TUNN:MARG? (@1)`	

- The factory over-temperature setting is 100° C and the ambient temperature is 25° C.

[SOURce] Subsystem

The SOURce keyword is optional in many commands that set parameters for a source or output, such as [SOURce:]CURRent <value>.

Because SOURce subsystem commands are often used without the optional SOURce keyword, these commands are listed by their individual subsystems, below:

Subsystems and Commands Using the Optional [SOURce:] Keyword

CURRent

DIGital

FUNCtion

VOLTage

STATus Subsystem

Status register programming lets you determine the operating condition of the instrument at any time. The instrument has three groups of status registers; EDP, Operation, Questionable, UNR, and Standard Event. The Operation and Questionable status groups each consist of the Condition, Enable, and Event registers as well as NTR and PTR filters.

The Status subsystem is also programmed using Common commands. Common commands control additional status functions such as the Service Request Enable and the Status Byte registers. Refer to Status Tutorial for more information.

STATus:EDP:CONDition? (@<chanlist>)

Queries the condition register for the EDP Status group. This is a read-only register, which holds the live (unlatched) Excessive Dynamic Protection status. Reading the EDP Status Condition register does not clear it.

Parameter	Typical Return
<chanlist> one or more channels	<bit value>
Read the EDP status condition register: STAT:EDP:COND? (@1	

- The value returned is the binary-weighted sum of all enabled bits in the register. For example, with bit 3 (value 8) and bit 5 (value 32) set and enabled, the query returns +40.
- The condition register bits reflect the current condition. If a condition goes away, the corresponding bit is cleared.
- *RST clears this register, other than those bits where the condition still exists after *RST.

STATus:FRAMe[:EVENt]

Queries the event register for the Frame Status group. This is a read-only register, which stores (latches) all events that are passed by the Frame NTR and/or PTR filter. Reading the Frame Status Event register clears it.

Parameter	Typical Return
<chanlist> one or more channels	<bit value>
Read the Frame status event register: STAT:FRAM?	

- The value returned is the binary-weighted sum of all enabled bits in the register. For example, with bit 3 (value 8) and bit 5 (value 32) set and enabled, the query returns +40.
- *RST has no effect on this register.

STATus:FRAMe:CONDition?

Queries the condition register for the Frame Status group. This is a read-only register, which holds the live (unlatched) Frame status. Reading the Frame Status Condition register does not clear it.

Parameter	Typical Return
<chanlist> one or more channels	<bit value>
Read the Frame status condition register: STAT:FRAM:COND?	

- The value returned is the binary-weighted sum of all enabled bits in the register. For example, with bit 3 (value 8) and bit 5 (value 32) set and enabled, the query returns +40.
- The condition register bits reflect the current condition. If a condition goes away, the corresponding bit is cleared.
- *RST clears this register, other than those bits where the condition still exists after *RST.

STATus:FRAMe:ENABle <*value*>
STATus:FRAMe:ENABle?

Sets the value of the enable register for the Frame Status group. The enable register is a mask for enabling specific bits from the Frame Event register to set the FRAME bit of the Status Byte register. STATus:PRESet clears all bits in the enable register.

Parameter	Typical Return
A decimal value corresponding to the binary-weighted sum of the register's bits.	<bit value>
<chanlist> one or more channels	
Enable bit 2 and 4 in the enable register: STAT:FRAM:ENAB 20	

- For example, with bit 3 (value 8) and bit 5 (value 32) set and enabled, the query returns +40.
- *CLS does not clear the enable register, but does clear the event register.

STATus:FRAMe:NTRansition <*value*>
STATus:FRAMe:NTRansition?
STATus:FRAMe:PTRansition <*value*>
STATus:FRAMe:PTRansition?

Sets and queries the value of the NTR (Negative-Transition) and PTR (Positive-Transition) registers. These serve as a polarity filter between the Frame Condition and Frame Event registers.

When a bit in the NTR register is set to 1, then a 1-to-0 transition of the corresponding bit in the Frame Condition register causes that bit in the Frame Event register to be set.

When a bit in the PTR register is set to 1, then a 0-to-1 transition of the corresponding bit in the Frame Condition register causes that bit in the Frame Event register to be set.

STATus:PRESet sets all bits in the PTR registers and clears all bits in the NTR registers.

Parameter	Typical Return
A decimal value corresponding to the binary-weighted sum of the register's bits.	<bit value>
<chanlist> one or more channels	
Enable bit 2 and 4 in the NTR register: STAT:FRAM:NTR 20 Enable bit 2 and 4 in the PTR register: STAT:FRAM:PTR 20	

- If the same bits in both NTR and PTR registers are set to 1, then any transition of that bit at the Frame Condition register sets the corresponding bit in the Frame Event register.
- If the same bits in both NTR and PTR registers are set to 0, then no transition of that bit at the Frame Condition register can set the corresponding bit in the Frame Event register.
- The value returned is the binary-weighted sum of all enabled bits in the register.

STATus:OPERation[:EVENt]? (@<chanlist>)

Queries the event register for the Operation Status group. This is a read-only register, which stores (latches) all events that are passed by the Operation NTR and/or PTR filter. Reading the Operation Status Event register clears it.

Parameter	Typical Return
<chanlist> one or more channels	<bit value>
Read the operation status event register: STAT:OPER? (@1	

- The value returned is the binary-weighted sum of all enabled bits in the register. For example, with bit 3 (value 8) and bit 5 (value 32) set and enabled, the query returns +40.
- *RST has no effect on this register.

STATus:OPERation:CONDition? (@<chanlist>)

Queries the condition register for the Operation Status group. This is a read-only register, which holds the live (unlatched) Operation status. Reading the Operation Status Condition register does not clear it.

Parameter	Typical Return
<chanlist> one or more channels	<bit value>
Read the operation status condition register: STAT:OPER:COND? (@1	

- The value returned is the binary-weighted sum of all enabled bits in the register. For example, with bit 3 (value 8) and bit 5 (value 32) set and enabled, the query returns +40.
- The condition register bits reflect the current condition. If a condition goes away, the corresponding bit is cleared.
- *RST clears this register, other than those bits where the condition still exists after *RST.

STATus:OPERation:ENABle <*value*>, (@<chanlist>)
STATus:OPERation:ENABle? (@<chanlist>)

Sets the value of the enable register for the Operation Status group. The enable register is a mask for enabling specific bits from the Operation Event register to set the OPER (operation summary) bit of the Status Byte register. STATus:PRESet clears all bits in the enable register.

Parameter	Typical Return
A decimal value corresponding to the binary-weighted sum of the register's bits.	<bit value>
<chanlist> one or more channels	
Enable bit 3 and 4 in the enable register: STAT:OPER:ENAB 24, (@1	

- For example, with bit 3 (value 8) and bit 5 (value 32) set and enabled, the query returns +40.
- *CLS does not clear the enable register, but does clear the event register.

STATus:OPERation:NTRansition <*value*>, (@<chanlist>)
STATus:OPERation:NTRansition? (@<chanlist>)
STATus:OPERation:PTRansition <*value*>, (@<chanlist>)
STATus:OPERation:PTRansition? (@<chanlist>)

Sets and queries the value of the NTR (Negative-Transition) and PTR (Positive-Transition) registers. These serve as a polarity filter between the Operation Condition and Operation Event registers.

When a bit in the NTR register is set to 1, then a 1-to-0 transition of the corresponding bit in the Operation Condition register causes that bit in the Operation Event register to be set.

When a bit in the PTR register is set to 1, then a 0-to-1 transition of the corresponding bit in the Operation Condition register causes that bit in the Operation Event register to be set.

STATus:PRESet sets all bits in the PTR registers and clears all bits in the NTR registers.

Parameter	Typical Return
A decimal value corresponding to the binary-weighted sum of the register's bits.	<bit value>
<chanlist> one or more channels	
Enable bit 3 and 4 in the NTR register: STAT:OPER:NTR 24, (@1 Enable bit 3 and 4 in the PTR register: STAT:OPER:PTR 24, (@1	

- If the same bits in both NTR and PTR registers are set to 1, then any transition of that bit at the Operation Condition register sets the corresponding bit in the Operation Event register.
- If the same bits in both NTR and PTR registers are set to 0, then no transition of that bit at the Operation Condition register can set the corresponding bit in the Operation Event register.
- The value returned is the binary-weighted sum of all enabled bits in the register.

STATus:PRESet

Presets all Enable, PTR, and NTR registers.

Operation register	Questionable register	Preset setting
STAT:OPER:ENAB	STAT:QUES<1|2>:ENAB	all defined bits are disabled
STAT:OPER:NTR	STAT:QUES<1|2>:NTR	all defined bits are disabled
STAT:OPER:PTR	**STAT:QUES<1|2>:PTR**	all defined bits are enabled

Parameter	Typical Return
(none)	(none)
Preset the Operation and Questionable registers: STAT:PRES	

STATus:QUESt<1|2>[:EVENt]? (@<chanlist>)

Queries the event register for the Questionable Status group. This is a read-only register, which stores (latches) all events that are passed by the Operation NTR and/or PTR filter. Reading the Questionable Status Event register clears it.

Parameter	Typical Return
<chanlist> one or more channels	<bit value>
Read questionable status event register #1: STAT:QUES1? (@1	

- The value returned is the binary-weighted sum of all enabled bits in the register. For example, with bit 2 (value 4) and bit 4 (value 16) set, the query returns +20.
- *RST has no effect on this register.

STATus:QUESt<1|2>:CONDition? (@<chanlist>)

Queries the condition register for the Questionable Status group. This is a read-only register, which holds the live (unlatched) Questionable status. Reading the Questionable Status Condition register does not clear it.

Parameter	Typical Return
<chanlist> one or more channels	<bit value>
Read questionable status condition register #1: STAT:QUES1:COND? (@1	

- The value returned is the binary-weighted sum of all enabled bits in the register. For example, with bit 2 (value 4) and bit 4 (value 16) set, the query returns +20.
- The condition register bits reflect the current condition. If a condition goes away, the corresponding bit is cleared.
- *RST clears this register, other than those bits where the condition still exists after *RST.

STATus:QUESt<1|2>:ENABle <*value*>, (@<chanlist>)
STATus:QUESt<1|2>:ENABle? (@<chanlist>)

Sets the value of the enable register for the Questionable Status group. The enable register is a mask for enabling specific bits from the Operation Event register to set the QUES (questionable summary) bit of the Status Byte register. STATus:PRESet clears all bits in the enable register.

Parameter	Typical Return
A decimal value corresponding to the binary-weighted sum of the register's bits.	<bit value>
<chanlist> one or more channels	
Enable bit 2 and 4 in the questionable enable register #1: STAT:QUES1:ENAB 20, (@1	

- For example, with bit 2 (value 4) and bit 4 (value 16) set, the query returns +20.
- *CLS does not clear the enable register, but does clear the event register.

STATus:QUESt<1|2>:NTRansition <*value*>, (@<chanlist>)
STATus:QUESt<1|2>:NTRansition? (@<chanlist>)
STATus:QUESt<1|2>:PTRansition <*value*>, (@<chanlist>)
STATus:QUESt<1|2>:PTRansition? (@<chanlist>)

Sets and queries the value of the NTR (Negative-Transition) and PTR (Positive-Transition) registers. These serve as a polarity filter between the Questionable Condition and Questionable Event registers.

When a bit in the NTR register is set to 1, then a 1-to-0 transition of the corresponding bit in the Questionable Condition register causes that bit in the Questionable Event register to be set.

When a bit in the PTR register is set to 1, then a 0-to-1 transition of the corresponding bit in the Questionable Condition register causes that bit in the Questionable Event register to be set.

STATus:PRESet sets all bits in the PTR registers and clears all bits in the NTR registers.

Parameter	Typical Return
A decimal value corresponding to the binary-weighted sum of the register's bits.	<bit value>
<chanlist> one or more channels	
Enable bit 3 and 4 in the questionable NTR register #1: STAT:QUES1:NTR 24, (@1 Enable bit 3 and 4 in the questionable PTR register #1: STAT:QUES1:PTR 24, (@1	

- If the same bits in both NTR and PTR registers are set to 1, then any transition of that bit at the Questionable Condition register sets the corresponding bit in the Questionable Event register.
- If the same bits in both NTR and PTR registers are set to 0, then no transition of that bit at the Questionable Condition register can set the corresponding bit in the Questionable Event register.
- The value returned is the binary-weighted sum of all enabled bits in the register.

STATus:UNR:CONDition? (@<chanlist>)

Queries the condition register for the UNR Status group. This is a read-only register, which holds the live (unlatched) Unregulated status. Reading the UNR Status Condition register does not clear it.

Parameter	Typical Return
<chanlist> one or more channels	<bit value>
Read the UNR status condition register: STAT:UNR:COND? (@1	

- The value returned is the binary-weighted sum of all enabled bits in the register. For example, with bit 2 (value 4) and bit 4 (value 16) set, the query returns +20.
- The condition register bits reflect the current condition. If a condition goes away, the corresponding bit is cleared.
- *RST clears this register, other than those bits where the condition still exists after *RST.

SYSTem Subsystem

System commands control system functions that are not directly related to output control, measurement, or status functions. Note that IEEE-488 Common commands also control system functions such as self-test, saving and recalling states, and others.

SYSTem:CHANnel[:COUNt]?

Returns the number of output channels in a mainframe.

Parameter	Typical Return
(none)	4
Returns the number of channels: SYST:CHAN?	

SYSTem:CHANnel:MODel? (@<chanlist>)

Returns the model numbers of the selected channels. Multiple responses are separated by commas.

Parameter	Typical Return
<channel list>	MP4361A, MP4361A
Returns the model numbers in channels 3 and 4: SYST:CHAN:MOD? (@3,4)	

SYSTem:CHANnel:OPTion? (@<chanlist>)

Returns the options installed in the selected channels. The query returns an ASCII string enclosed in double quotes. If no option is installed, an empty quoted string ("") is returned. Multiple responses are separated by commas.

Parameter	Typical Return
<channel> the specified channel	""
Returns the options in channels 1 through 3: SYST:CHAN:OPT? (@1:3)	

SYSTem:CHANnel:SERial? (@<chanlist>)

Returns the serial numbers of the selected channels. Multiple responses are separated by semicolons.

Parameter	Typical Return
<channel list>	MY00123456; MY00234567
Returns the serial numbers in channels 3 and 4: SYST:CHAN:SER? (@3,4)	

SYSTem:COMMunicate:LAN:CONTrol?
SYSTem:COMMunicate:TCPip:CONTrol?

Returns the initial socket control connection port number. This connection is used to send and receive commands and queries. Unlike the data socket, which uses a fixed port number, the control socket port number varies and must be obtained using these queries.

Parameter	Typical Return
(none)	<port #> (0 if sockets not supported)
Query the Control connection port: SYST:COMM:LAN:CONT? or SYST:COMM:TCP:CONT?	

SYSTem:DATE <*yyyy*>, <*mm*>, <*dd*>
SYSTem:DATE?

Sets the date of the system clock. Specify the year (2000 to 2099), month (1 to 12), and day (1 to 31). The system clock is only used in conjunction with the BenchVue Power Control and Analysis software.

Parameter	Typical Return
<yyyy,<mm>,<dd>	+2018,+04,+30
Set the date to June 30, 2018: SYST:DATE 2018,06,30	

- The system clock does not adjust itself for time zone changes or daylight savings time.

SYSTem:ERRor?

Reads and clears one error from the error queue.

Parameter	Typical Return
(none)	<+0,"No error">
Reads and clears the first error in error queue: SYST:ERR?	

- The front-panel ERR annunciator turns on when one or more errors are currently stored in the error queue. Error retrieval is first-in-first-out (FIFO), and errors are cleared as you read them. When you have read all errors from the error queue, the ERR annunciator turns off.
- If more than 30 errors have occurred, the last error stored in the queue (the most recent error) is replaced with -350,"Error queue overflow". No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the instrument responds with +0,"No error".
- The error queue is cleared by the *CLS and when power is cycled. It is not cleared by a *RST.
- Errors have the following format <*error code*>,<*error string*>. The error string may contain up to 255 characters. For a list of error codes and message strings, see SCPI Error Messages.

SYSTem:REBoot

Reboots the instrument to its power-on state.

Parameter	Typical Return
(none)	(none)
Reboots the instrument: SYST:REB	

SYSTem:TIME <hh>, <mm>, <ss>
SYSTem:TIME?

Sets the time of the system clock. Specify hours (0 to 23), minutes (0 to 59), and seconds (0 to 59). The real time clock is only used in conjunction with the BenchVue Power Control and Analysis software.

Parameter	Typical Return
<hh>,<mm>,<ss>	<hh,mm,ss>
Set the clock to 8:30 PM: SYST:TIME 20,30,0	

SYSTem:VERSion?

Returns the SCPI version that the instrument complies with. Cannot be determined from front panel.

Parameter	Typical Return
(none)	<"version">
Return the SCPI version: SYST:VERS?	

- The command returns a string in the form "YYYY.V", where YYYY represents the year of the version and V represents a version for that year.

VOLTage Subsystem

Voltage commands program the output voltage of the instrument.

[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*value*>|MIN|MAX, (@<chanlist>)
[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]? [MIN|MAX,] (@<chanlist>)

Sets the immediate voltage level when the output is operating in voltage priority mode. Units are in volts. The maximum value depends on the voltage rating of the unit.

Parameter	Typical Return
0% to 102% of rating, *RST 0	<voltage level>
<chanlist> one or more channels	
Sets the output voltage to 20 V on channel 1: VOLT 20, (@1)	

[SOURce:]VOLTage:LIMit[:POSitive][:IMMediate][:AMPLitude] <*value*>|MIN|MAX, (@<chanlist>)
[SOURce:]VOLTage:LIMit[:POSitive][:IMMediate][:AMPLitude]? [MIN|MAX,] (@<chanlist>)
[SOURce:]VOLTage:LIMit:LOW <*value*>|MIN|MAX, (@<chanlist>)
[SOURce:]VOLTage:LIMit:LOW? [MIN|MAX,] (@<chanlist>)

Sets the voltage limit when in current priority mode. Units are in volts. The maximum value depends on the voltage rating of the module. VOLTage:LIMit:LOW sets the low voltage limit in current priority mode. This prevents the output from turning on when the output voltage is below the programmed low voltage limit.

Parameter	Typical Return
0.1% to 102% of rating, *RST 102% LOW: 0.1% to 101.8% of rating, *RST 0%	<+voltage limit>
<chanlist> one or more channels	
Sets the positive voltage limit to 120 V on channel 1: VOLT:LIM 120, (@1) Sets the low voltage limit to 10 V on channel 1: VOLT:LIM:LOW 10, (@1)	

- These commands only apply in Fixed mode operation (see CURRent:MODE). An error is generated if these commands are sent when the instrument is operating in SAS or in Table mode.

[SOURce:]VOLTage:DTABle[:IMMediate]? (@<chanlist>)

Returns the table that is currently being used by the specified channel.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<chanlist> one or more channels	<49.8,49.9,50.0,50.1,50.2,50.3, ...>
Returns the DAC table settings on channel 2: VOLT:DTAB? (@2)	

[SOURce:]VOLTage:DTABle:SASimulator[:IMMediate]? (@<chanlist>)

Returns the DAC table that was calculated based on the SAS parameter settings. The number of voltage points returned is set at 1024.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<chanlist> one or more channels	<49.8,49.9,50.0,50.1,50.2,50.3, ...>
Returns the DAC table settings on channel 2: VOLT:DTAB:SAS? (@2)	

[SOURce:]VOLTage:DTABle:SASimulator[:IMMediate]:VMP? (@<chanlist>)

Returns the calculated Vmp (maximum power voltage) of the internal DAC table.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<chanlist> one or more channels	+5.389988E+01
Returns the calculated VMP of the DAC table on channel 2: VOLT:DTAB:SAS:VMP? (@2)	

[SOURce:]VOLTage:DTABle:SASimulator[:IMMediate]:VOC? (@<chanlist>)

Returns the calculated Voc (open-circuit voltage) of the internal DAC table.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<chanlist> one or more channels	+6.000000E+01
Returns the calculated VOC of the DAC table on channel 2: VOLT:DTAB:SAS:VOC? (@2)	

[SOURce:]VOLTage:DTABle:TABLe[:IMMediate]? <"*name*">, (@<chanlist>)

Returns the DAC table that was calculated based on the values from the specified table. The number of voltage points returned is set at 1024.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<"name"> the table name	None
<chanlist> one or more channels	<4.8,4.9,5.0,5.1,5.2,5.3, ...>
Returns the DAC table settings on channel 2: VOLT:DTAB:TABL? "table1", (@2)	

[SOURce:]VOLTage:DTABle:TABLe[:IMMediate]:VMP? <"*name*">, (@<chanlist>)

Returns the calculated Vmp (maximum power voltage) of the internal DAC table for the specified table.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<"name"> the table name	None
<chanlist> one or more channels	+3.620843E+00
Returns the calculated Vmp of the DAC table on channel 2: VOLT:DTAB:TABL:VMP? " table1", (@2)	

[SOURce:]VOLTage:DTABle:TABLe[:IMMediate]:VOC? <"*name*">, (@<chanlist>)

Returns the calculated Voc (open-circuit voltage) of the internal DAC table for the specified table.

Multiple responses are separated by commas. If more than one channel has been queried, all the DAC values for the first channel are returned, followed immediately by the DAC values of the next channel.

Parameter	Typical Return
<"name"> the table name	None
<chanlist> one or more channels	+5.10000E+00
Returns the calculated Voc of the DAC table on channel 2: VOLT:DTAB:TABL:VOC? "table1", (@2)	

[SOURce:]VOLTage:PROTection[:LEVel] <*value*>|MIN|MAX, (@<chanlist>)
[SOURce:]VOLTage:PROTection[:LEVel]? [MIN|MAX,], (@<chanlist>)

Sets the over-voltage protection level. Units are in volts. If the output voltage exceeds the OVP level, the output is disabled and the Questionable Condition status register OV bit is set.

Parameter	Typical Return
0 to 120% of rating, *RST 120% of rating	<protect level>
<chanlist> one or more channels	
Sets the over-voltage protection to 24 V: VOLT:PROT 24, (@2)	

- An over-voltage condition can be cleared with the OUTPut:PROTection:CLEar command after the cause of the over-voltage condition has been removed
- The operation of over-voltage protection is affected by the setting of the voltage protection delay, which is specified by VOLTage:PROTection:DELay.

[SOURce:]VOLTage:PROTection:DELay <*value*>|MIN|MAX, (@<chanlist>)
[SOURce:]VOLTage:PROTection:DELay? [MIN|MAX,] (@<chanlist>)

Sets the over-voltage protection delay. The over-voltage protection function will not be triggered during the delay time. After the delay time has expired, the over-voltage protection function will be active. This prevents momentary changes in output status from triggering the over-voltage protection function.

Programmed values can range from 10 microseconds to 65 milliseconds with a resolution of 1 microsecond.

Parameter	Typical Return
60 µs - 5 ms | MIN | MAX, *RST 0	<delay value>
<chanlist> one or more channels	
Sets the over-voltage protection delay to 10 millisecond: VOLT:PROT:DEL 0.01, (@2)	

[SOURce:]VOLTage:SAS:SCALe <percent>|MIN|MAX, (@<chanlist>)
[SOURce:]VOLTage:SAS:SCALe? [MIN|MAX,] (@<chanlist>)

Set a scale factor for the curve in both Curve and Table modes.

The output voltage will be equal to this percentage multiplied by the voltage computed from the SAS curve or table. This is often used to simulate variations in solar cell temperature.

Parameter	Typical Return
<percent> 1 to 100, *RST 100	100
<chanlist> one or more channels	
Sets the scale factor for the voltage to 90%: VOLT:SAS:SCAL 90, (@2)	

- When on, the output will respond immediately to any change in this setting.

[SOURce:]VOLTage:SAS:VMP <*value*>, (@<chanlist>)
[SOURce:]VOLTage:SAS:VMP? (@<chanlist>)

Sets the voltage at the Vmp (maximum power voltage) of the curve when operating in SAS mode. The value must be less than or equal to Voc. The values are programmed in volts.

Parameter	Typical Return
0 – 160 (MP4361A), *RST 0.8% of nominal rating 0 – 130 (MP4362A), *RST 0.8% of nominal rating	<0.8 X max value>

Parameter	Typical Return
<chanlist> one or more channels	
Sets the peak power voltage to 90 V on channels 1 and 2: CURR:SAS:VMP 90, (@1,2)	

- When a single Isc, Imp, Voc, or Vmp parameter is sent, it is checked along with the unchanged parameters to determine if all parameters and the resulting curve are within acceptable limits. If a parameter is outside the limits, an error occurs and no new curve is programmed. If all four parameters are programmed individually, four curves are produced as each parameter is programmed.
- When programming an entirely new curve, it is best to send all parameters on the same program line. In this case, the instrument checks that all parameters are acceptable. The parameters can be sent in any order. Any parameter not programmed takes on the value of the previous curve.

[SOURce:]VOLTage:SAS:VOC <*value*>, (@<chanlist>)
[SOURce:]VOLTage:SAS:VOC? (@<chanlist>)

Sets the Voc (open-circuit voltage) when operating in SAS mode. The values are programmed in volts.

Parameter	Typical Return
0 – 160 (MP4361A), *RST 1% of nominal rating 0 – 130 (MP4362A), *RST 1% of nominal rating	<max value>
<chanlist> one or more channels	
Sets the short-circuit current to 4.5 A on channels 1 and 2: CURR:SAS:ISC 5, (@1,2)	

- When a single Isc, Imp, Voc, or Vmp parameter is sent, it is checked along with the unchanged parameters to determine if all parameters and the resulting curve are within acceptable limits. If a parameter is outside the limits, an error occurs and no new curve is programmed. If all four parameters are programmed individually, four curves are produced as each parameter is programmed.
- When programming an entirely new curve, it is best to send all parameters on the same program line. In this case, the instrument checks that all parameters are acceptable. The parameters can be sent in any order. Any parameter not programmed takes on the value of the previous curve.

Status Tutorial

Status Registers

EDP Status Register

UNR Status Register

Standard Event Status Group

Questionable Status Groups

Operation Status Group

Frame Status Group

Status Byte Register

Error and Output Queues

Status Diagram

Status Registers

The status groups use up to four types of registers to track, qualify, flag, and enable status events.

- A Condition register continuously monitors the state of the instrument. The bits in the condition register are updated in real time and the bits are not latched.
- A PTR/NTR register qualifies the signal that passes to the event register. When a PTR bit is set, signals with positive edge transition pass to the event register. When an NTR bit is set, signals with a negative edge transition pass to the event register. When both bits are set, all signal pass.
- An Event register latches transitions that pass through the PTR and NTR registers. When an event bit is set, it remains set until the Event register is read. Reading the Event register clears it.
- An Enable register defines which bits in the event register will be reported to the Status Byte register. You can write to or read from an enable register.

EDP Status Register

The EDP (excessive dynamic protection) status register maps into the EDP bit of the Questionable Status registers. It queries the EDP status. The following table describes the bit assignments.

Bit	Bit Name	Decimal Value	Definition
0	OS	1	Channel is disabled by over-switching protection (freq > 50kHz).
1	OSC	2	Channel is disabled by oscillation protection.
2	PWM_SAT_HI	4	Channel is disabled by persistent PWM high saturation protection
3	PWM_SAT_LO	8	Channel is disabled by persistent PWM low saturation protection
4	PWM_SAT_EITHER	16	Channel is disabled by persistent PWM saturation protection

5	DYN_CURR	32	Channel is disabled by excessive dynamic current
6	DYN_POW	64	Channel is disabled by excessive dynamic power

UNR Status Register

The UNR (unregulated) status register maps into the UNR bit of the Questionable Status registers. It queries the UNR status. The following table describes the bit assignments.

Bit	Bit Name	Decimal Value	Definition
0	IPK+	1	Output is in positive peak current limit
1	IPK-	2	Output is in negative peak current limit
2	PWMhi	4	PWM high saturation detected
3	PWMlo	8	PWM low saturation detected
4	PPK+	16	Output is in positive peak power limit
5	PPK-	32	Output is in negative peak power limit
6	VPK+	64	Output is in positive peak voltage limit
7	VPK-	128	Output is in negative peak voltage limit
8	BOR	256	Bottom out resistance - for future use

Standard Event Status Group

These registers are programmed by Common commands. The group consists of an Event and Enable register. The Standard Event event register latches events relating to communication status. It is a read-only register that is cleared when read. The Standard Event enable register functions similarly to the enable registers of the Operation and Questionable status groups. Refer to Status Diagram.

The following table describes the Standard Event Status register bit assignments.

Bit	Bit Name	Decimal Value	Definition
0	Operation Complete	1	All commands before and including *OPC have been executed.
1	not used	not used	0 is returned
2	Query Error	4	The output buffer was read, but was empty; a new command was received before the previous query was read; or both input and output buffers are full.
3	Device- specific Error	8	A device-specific error, including a self-test error, calibration error or other device-specific error occurred.
4	Execution Error	16	An execution error occurred.
5	Command Error	32	A command syntax error occurred.
6	not used	not used	0 is returned
7	Power On	128	Power has been cycled since the last time the event register was read or cleared.

Questionable Status Groups

These registers record signals that indicate abnormal operation. The groups consist of a Condition, PTR/NTR, Event, and Enable register. The outputs of the Questionable Status groups are logically-ORed into the QUEStionable summary (bit 3) of the Status Byte register. When bit 3 of the Status Byte is asserted, you must query the Questionable **and** the Questionable2 status registers to determine which one asserted bit 3. Refer to Status Diagram.

The following table describes the Questionable1 Status register bit assignments.

Bit	Bit Name	Decimal Value	Definition
0	OV	1	Output is disabled by the over-voltage protection
1	OC	2	Output is disabled by the over-current protection
2	PF	4	Output is disabled by a power-fail (ac low-line or brownout)
3	OP+	8	Output is disabled by the positive over-power protection
4	OT	16	Output is disabled by the over-temperature protection
5	OP-	32	Output is disabled by the negative over-power protection
6	OV-	64	Output is disabled by the negative over-voltage protection
7	LIM+	128	Output is in positive voltage or current limit
8	EDP	256	Output is disabled by excessive output dynamic protection
9	INH	512	Output is disabled by an external INHibit signal
10	UNR	1024	Output is unregulated
11	LIM_PROT-	2048	Output is disabled because low limit protection time expired
12	OC-	4096	Output is disabled by the negative over-current protection
13	LIM-	8192	Output is in negative voltage or current limit
14	LIM_PROT	16384	Output is disabled because high limit protection time expired
15	not used	not used	0 is returned

The following table describes the Questionable2 Status register bit assignments.

Bit	Bit Name	Decimal Value	Definition
0	MC	1	Output is disabled because module communication failed
1, 2	not used	not used	0 is returned
3	CSF	8	Output is disabled by current sharing fault protection
4	LFP	16	Output is disabled by leader/follower protection
5	not used	not used	0 is returned
6	UV	64	Output is disabled by under-voltage protection
7	OCF	128	Output is disabled by internal over-current protection

8	LOV	256	Output is disabled by internal over-voltage protection
9	DOV	512	Output is disabled by external over-voltage protection
10	SF	1024	Output is disabled by a sense fault
11	OCF-	2048	Output is disabled by internal negative over-current protection
12	LOV-	4096	Output is disabled by internal negative over-voltage protection
13	DOV-	8192	Output is disabled by external negative over-voltage protection
14	FLT	16384	Hardware fault has occurred
15	not used	not used	0 is returned

Operation Status Group

These registers record signals that occur during normal operation. The groups consist of a Condition, PTR/NTR, Event, and Enable register. The outputs of the Operation Status register group are logically-ORed into the OPERation summary bit (7) of the Status Byte register. Refer to Status Diagram.

The following table describes the Operation Status register bit assignments.

Bit	Bit Name	Decimal Value	Definition
0, 1	not used	not used	0 is returned
2	OFF	4	Output is programmed off or is in protection state
3	WTG-meas	8	Measurement system is waiting for a trigger
4	MEAS-active	16	Measurement is initiated or in progress
5	WTG-tran	32	Transient system is waiting for a trigger
6, 7	not used	not used	0 is returned
8	CV	256	Output is in constant voltage
9	TRAN-active	512	Transient system is initiated or in progress
10	CC	1024	Output is in constant current
11	CP	2048	Output is in constant power
12	CR	4096	Output is in constant resistance
13	CZ	8192	Output is in constant impedance
14, 15	not used	not used	0 is returned

Frame Status Group

This register summarizes the status information from the MPS mainframe. The groups consist of a Condition, PTR/NTR, Event, and Enable register.

The following table describes the Frame status register bit assignments. Refer to Status Diagram.

Bit	Bit Name	Decimal Value	Definition
0	OT_PFC	1	An over-temperature occurred in the PFC
1	OT_FPGA	2	An over-temperature occurred in the main FPGA
2	OT_CPU	4	An over-temperature occurred in the main processor
3	FAN	8	The fans have either stopped running or are running too slow
4	LOB	16	The Lockout bar is not installed in the mainframe
5	POW_FAIL	32	The input power is outside the specified operating range
6 - 8	not used	not used	0 is returned

Status Byte Register

This register summarizes the information from all other status groups as defined in the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. Refer to Status Diagram.

The following table describes the Status Byte register bit assignments.

Bit	Bit Name	Decimal Value	Definition
0	Questionable2 Status Summary	1	One or more bits are set in the Questionable2 Data Register. Bits must be enabled, see STATus:QUEStionable:ENABle
1	not used	not used	0 is returned
2	Error Queue	4	One or more errors in the Error Queue. Use SYSTem:ERRor? to read and delete errors.
3	Questionable Status Summary	8	One or more bits are set in the Questionable Data Register. Bits must be enabled, see STATus:QUEStionable:ENABle.
4	Message Available	16	Data is available in the instrument's output buffer.
5	Event Status Summary	32	One or more bits are set in the Standard Event Register. Bits must be enabled, see *ESE.
6	Master Status Summary	64	One or more bits are set in the Status Byte Register and may generate a Request for Service. Bits must be enabled, see *SRE.
7	Operation Status Summary	128	One or more bits are set in the Operation Status Register. Bits must be enabled, see STATus:OPERation:ENABle.

Master Status Summary and Request for Service Bits

MSS is a real-time (unlatched) summary of all Status Byte register bits that are enabled by the Service Request Enable register. MSS is set whenever the instrument has one or more reasons for requesting service. *STB? reads the MSS in bit position 6 of the response but does not clear any of the bits in the Status Byte register.

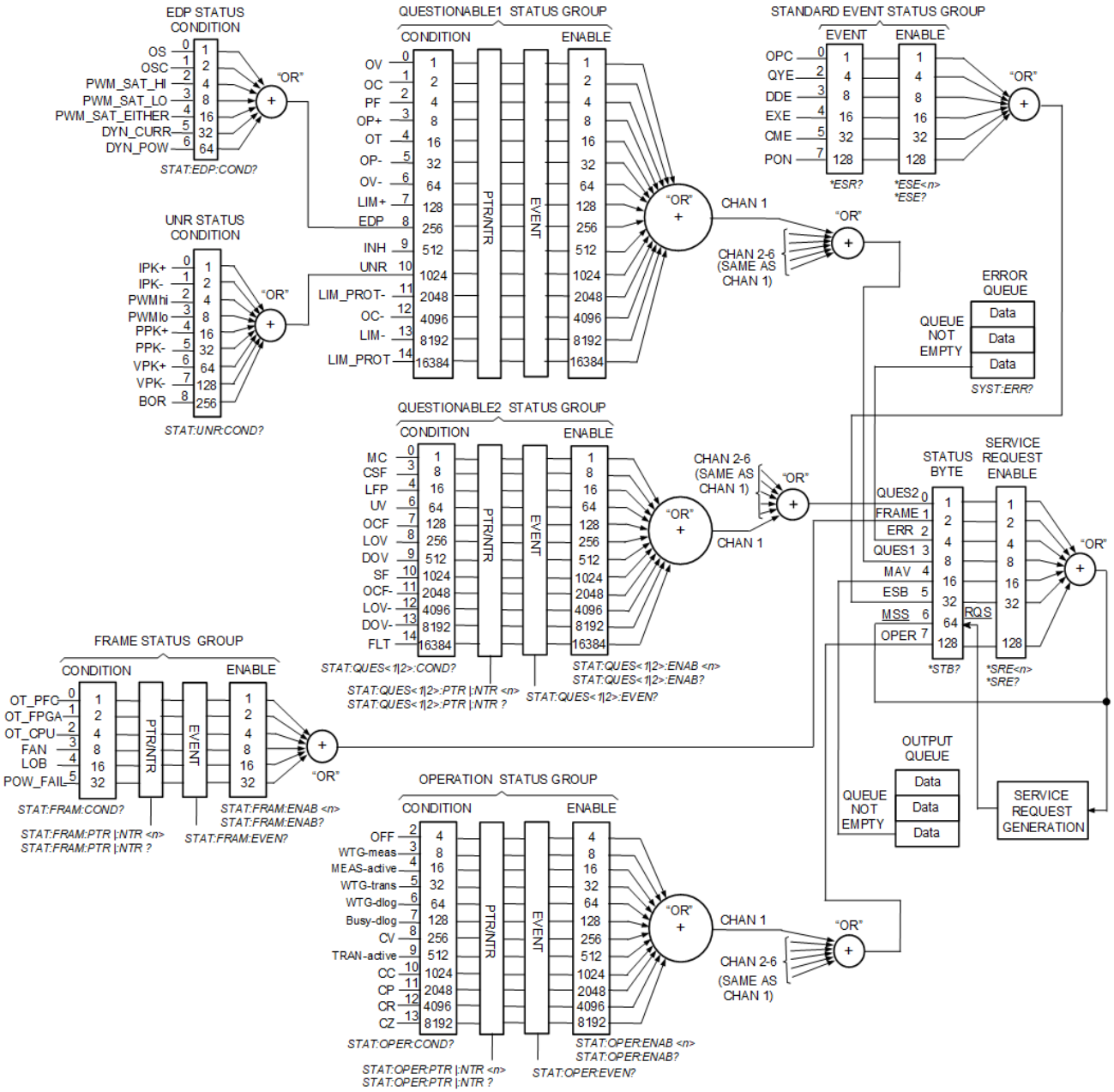
The RQS bit is a latched version of the MSS bit. Whenever the instrument requests service, it sets the SRQ interrupt line true and latches RQS into bit 6 of the Status Byte register. When the controller does a serial poll, RQS is cleared inside the register and returned in bit position 6 of the response. The remaining bits of the Status Byte register are not disturbed.

Error and Output Queues

The Error Queue is a first-in, first-out (FIFO) data register that stores numerical and textual description of an error or event. Error messages are stored until they are read with SYSTem:ERRor? If the queue overflows, the last error/event in the queue is replaced with error -350,"Queue overflow".

The Output Queue is a first-in, first-out (FIFO) data register that stores messages until the controller reads them. Whenever the queue holds messages, it sets the MAV bit (4) of the Status Byte register.

Status Diagram



Reset State (*RST)

NOTE The power-on/reset state may differ from that shown below if you have enabled power-on state recall mode from the **States** menu (see Instrument State Storage)..

Reset Settings

The following table shows the reset state. These parameters are reset to the indicated values at power-on or after *RST.

SCPI Command	*RST Settings
CALibrate:STATe	OFF
CURRent	0
CURRent:LIMit	1.02% of rating
CURRent:LIMit:NEGative	-1.02% of rating (MP4361A) -0.51A (MP4362A)
CURRent:MODE	FIXed
CURRent:PROTection	12.5 A (MP4361A) 10 A (MP4362A)
CURRent:PROTection:STATe	OFF
CURRent:SASimulator:BWIDth:RANGe	DEFAULT
CURRent:SASimulator:IMP	0.8% of nominal rating
CURRent:SASimulator:ISC	1% of nominal rating
CURRent:SAS:SCALe	100%
DIGital:OUTPut:DATA	0
FUNCtion	VOLTage
LXI:IDENtify	OFF
LXI:MDNS	ON
OUTPut	OFF
VOLTage	0
VOLTage:LIMit	102% of rating
VOLTage:LIMit:LOW	0
VOLTage:PROTection	120% of rating
VOLTage:SASimulator:VMP	0.8% of nominal rating

SCPI Command	*RST Settings
VOLTage:SASimulator:VOC	1% of nominal rating
VOLTage:SAS:SCALe	100%

Non-Volatile Settings

The following table shows the as-shipped settings of the non-volatile parameters. These are not affected by power cycling or *RST.

SCPI Command	As-shipped Settings
CALibrate:DATE	empty string
CALibrate:PASSword	0
DIGital:PIN<all>:FUNCtion	DINPut
DIGital:PIN<all>:POLarity	POSitive
OUTPut:INHibit:MODE	OFF
OUTPut:PON:STATe	RST
Front Panel as-shipped settings	
Front panel lockout password	Disabled
Firmware update password protected	Disabled
GPIB address	5
GPIB interface	Enabled
LAN interface	Enabled
USB interface	Enabled
Wake on I/O	Enabled
Interface as-shipped settings	
Get GPIB Address	Automatic
Subnet mask	255.255.0.0
Default gateway	0.0.0.0
Host name	K-<modelname>-<last 5 digits of serial number>
mDNS service name	Keysight MP4300 Modular Power System <serial number>
LAN service - VXI-11	Enabled
LAN service - Telnet	Enabled

SCPI Command	As-shipped Settings
LAN service - mDNS	Enabled
LAN service - Web server	Enabled
LAN service - sockets	Enabled
Web password	Blank (web password is disabled)

SCPI Error Messages

The Keysight instrument returns error messages in accord with the SCPI standard.

- Up to 30 errors can be stored in each interface-specific error queue (one each for GPIB, USB, VXI-11, and Telnet/Sockets.) Errors appear in the error queue of the I/O session that caused the error.
- The front-panel ERR annunciator turns on when there are one or more errors in the error queue.
- A special global error queue holds all power-on and hardware-related errors (i.e. power-fail).
- Error retrieval is first-in-first-out (FIFO), and errors are cleared as you read them. Once you have read all interface-specific errors, the errors in the global error queue are retrieved. When you have read all errors from the error queue, the ERR annunciator turns off.
- If more than 30 errors have occurred, the last error stored in the queue (the most recent error) is replaced with -350,"Error queue overflow". No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the instrument responds with +0,"No error".
- The front panel reports errors from all I/O sessions and the global error queue. To display the error queue on the front panel, press the Menu key, then select Help, then Error Queue. This lists all of the errors in the error queue. Touch any of the errors in the list to display additional details.
- Error conditions are also summarized in the Status Byte Register. See Status Subsystem for details.
- The interface-specific error queues are cleared by power cycles and *CLS. The error queue is not cleared by *RST.
- SCPI: SYSTem:ERRor? *Read and clear one error from the queue*

Errors have the following format (the error string may contain up to 255 characters):
-113, "Undefined header".

Error Device-dependent Errors (these errors set Standard Event Status register bit #3)

0 No error

This is the response to the ERR? query when there are no errors.

101 Calibration state is off

Calibration is not enabled. The instrument will not accept calibration commands.

102 Calibration password is incorrect

The calibration password is incorrect.

103 Calibration is inhibited by switch setting

Calibration mode is locked out by the calibration switch.

104 Bad sequence of calibration commands

Calibration commands have not been entered in the proper sequence.

105 Unexpected output current

The measured output current is outside the acceptable range.

106 Zero measurement out of range error

The “zero” measurement value is outside the acceptable range.

107 Programming cal constants out of range

The programmed calibration constant is outside the acceptable range.

108 Measurement cal constants out of range

The measurement calibration constant is outside the acceptable range.

109 Over voltage cal constants out of range

The over voltage calibration constant is outside the acceptable range.

110 Wrong V+I

The instrument was unable to set the correct voltage or current value.

114 Wrong status

An incorrect status function has been reported.

116 Locked out by internal switch setting

This function has been locked out by an internal switch.

117 Calibration error

A calibration error has occurred. Do not save calibration constants. Try re-calibrating the unit.

200 Hardware error channel <1>

A hardware error has occurred on the output.

201 Invalid configuration

An invalid parallel configuration is not allowed.

202 Selftest Fail

A selftest failure has occurred. See selftest failure list for details.

203 Compatibility function not implemented

The requested compatibility function is not available.

204 NVRAM checksum error

A checksum error has occurred in the instrument’s nonvolatile random access memory.

205 NVRAM full

The nonvolatile random access memory of the instrument is full.

206 File not found

The internal calibration file or the internal channel attribute file was not found in NVRAM.

207 Cal file version error

The calibration file was written or read using old firmware. Firmware must be updated.

208 Running backup firmware

The instrument is presently running the backup (previous) version of the firmware.

210 Frame NVRAM error

A non-volatile RAM error has occurred in the instrument.

212 State file not loaded

A previously saved output state file has failed to load.

214 Line frequency error

A discrepancy has occurred between the line frequency and the line frequency setting.

215 Hardware failure

A hardware failure has occurred on the power supply

302 Option not installed

The option that is programmed by this command is not installed.

303 There is not a valid acquisition to fetch from

There is no valid data in the measurement buffer.

304 Volt and curr in incompatible transient modes

Voltage and current cannot be in Step and List mode at the same time.

305 A triggered value is on a different range

A triggered value is on a different range than the one that is presently set.

306 Too many list points

Too many list points have been specified.

307 List lengths are not equivalent

One or more lists are not the same length.

308 This setting cannot be changed while transient trigger is initiated

Setting cannot be changed while the instrument is waiting for or executing a trigger sequence.

309 Cannot initiate, voltage and current in fixed mode

Cannot initiate transient generator. Either the voltage or current function is set to Fixed mode.

310 The command is not supported by this model

This instrument does not have either the hardware or options required to support this command.

315 Settings conflict error

A data element could not be programmed because of the present instrument state.

316 Mass storage error

The mass storage memory has been exceeded.

317 Invalid format

An invalid data format was found in the command string.

320 Firmware update error

This may be due to the instrument hardware not being able to support the firmware version.

324 Inconsistent arb settings

The arb settings are inconsistent; most likely a mismatch in the arb lengths.

327 Initiated with no sense function enabled

A measurement has been initiated without specifying the measurement (sense) function.

328 Too many measurement points

Too many measurement points have been specified.

331 Illegal parameter value

The parameter value is out of range or does not exist.

334 Table number is invalid

The table number must be either 1 or 2.

335 VMP must be less than VOC; VMP setting is <setting>, VOC setting is <setting>

The VMP curve parameter is equal to or greater than the VOC parameter

337 IMP must be less than or equal to ISC

The IMP curve parameter is greater than the ISC parameter

339 VMP and/or IMP too small

The VMP and/or IMP are less than the allowable range of values

Command Errors (these errors set Standard Event Status register bit #5)

-100 Command error

Generic syntax error.

-101 Invalid character

An invalid character was found in the command string.

-102 Syntax error

Invalid syntax was found in the command string. Check for blank spaces.

-103 Invalid separator

An invalid separator was found in the command string. Check for proper use of , ; :

-104 Data type error

A different data type than the one allowed was found in the command string.

-105 GET not allowed

A group execute trigger is not allowed in a command string.

-108 Parameter not allowed

More parameters were received than were expected.

-109 Missing parameter

Fewer parameters were received than were expected.

-110 Command header error

An error was detected in the header.

-111 Header separator error

A character that was not a valid header separator was found in the command string.

-112 Program mnemonic too long

The header contains more than 12 characters.

-113 Undefined header

A command was received that was not valid for this instrument.

-114 Header suffix out of range

The value of the numeric suffix is not valid.

-120 Numeric data error

Generic numeric data error.

-121 Invalid character in number

An invalid character for the data type was found in the command string.

-123 Exponent too large

The magnitude of the exponent was larger than 32000.

-124 Too many digits

The mantissa of a numeric parameter contained more than 255 digits, excluding leading zeros.

-128 Numeric data not allowed

A numeric parameter was received but a character string was expected.

-130 Suffix error

Generic suffix error

-131 Invalid suffix

A suffix was incorrectly specified for a numeric parameter.

-134 Suffix too long

The suffix contains more than 12 characters.

-138 Suffix not allowed

A suffix is not supported for this command.

-140 Character data error

Generic character data error

-141 Invalid character data

Either the character data element contains an invalid character, or the element is not valid.

-144 Character data too long

The character data element contains more than 12 characters.

-148 Character data not allowed

A discrete parameter was received, but a string or numeric parameter was expected.

-150 String data error

Generic string data error

-151 Invalid string data

An invalid character string was received. Check that the string is enclosed in quotation marks.

-158 String data not allowed

A character string was received, but is not allowed for this command.

-160 Block data error

Generic block data error

-161 Invalid block data

The number of data bytes sent does not match the number of bytes specified in the header.

-168 Block data not allowed

Data was sent in arbitrary block format but is not allowed for this command.

Execution Errors (these errors set Standard Event Status register bit #4)

-200 Execution error

Generic syntax error

-220 Parameter error

A data element related error occurred.

-221 Settings conflict

A data element could not be executed because of the present instrument state.

-222 Data out of range

A data element could not be executed because the value was outside the valid range.

-223 Too much data

A data element was received that contains more data than the instrument can handle.

-224 Illegal parameter value

An exact value was expected but not received.

-225 Out of memory

The device has insufficient memory to perform the requested operation.

-226 Lists not same length

One or more lists are not the same length.

-230 Data corrupt or stale

Possible invalid data. A new reading was started but not completed.

-231 Data questionable

The measurement accuracy is suspect.

-232 Invalid format

The data format or structure is inappropriate.

-233 Invalid version

The version of the data format is incorrect to the instrument.

-240 Hardware error

The command could not be executed because of a hardware problem with the instrument.

-241 Hardware missing

The command could not be executed because of missing hardware, such as an option.

Query Errors (these errors set Standard Event Status register bit #2)

-400 Query Error

Generic error query

-410 Query INTERRUPTED

A condition causing an interrupted query error occurred.

-420 Query UNTERMINATED

A condition causing an unterminated query error occurred.

-430 Query DEADLOCKED

A condition causing a deadlocked query error occurred.

-440 Query UNTERMINATED after indefinite response

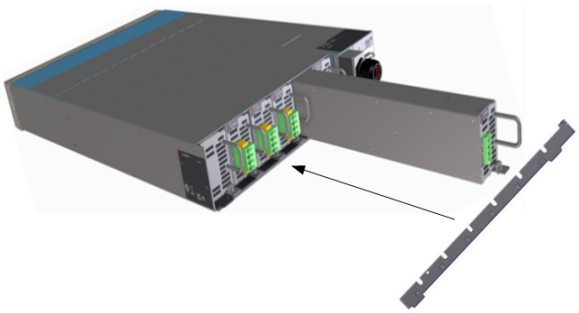
A query was received in the same program message after a query indicating an indefinite response was executed.

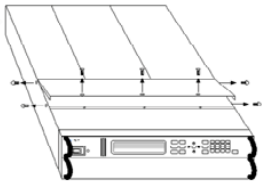
E4360A Compatibility

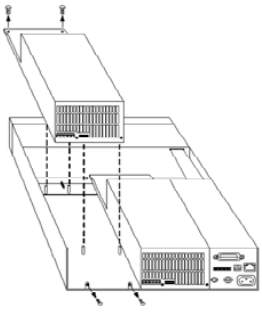
This section describes the primary features of the Keysight MP4360A Modular SAS Power System and how they compare with the primary features of the Keysight E4360A Modular Solar Array Simulator.

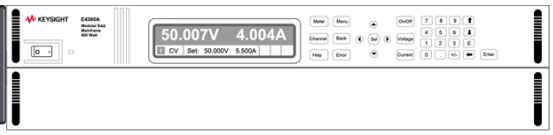
Differences in General

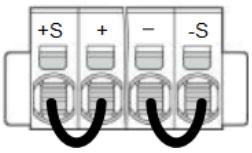
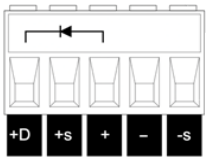
Items	MP4360A Modular Power System	E4360A Modular SAS
Description:	MP4301A 6000 W Modular SAS; 200-208 VAC MP4302A 6000 W Modular SAS; 380-480 VAC	E4360A 1200 W Modular SAS
Power:	Up to 6000 W with six modules installed	Up to 1200 W with two modules installed
Dimensions:	2 U Height 88.1mm, Width 428.9mm, Depth 765.6 mm	2 U Height 88.9mm, Width 432.5mm, Depth 608.5 mm
Rack mounting:	Standard support rails and ears	Custom rack mount kit
Weight:	29.5 kg with six modules installed	18.6 kg with two modules installed
AC input:	200-208 VAC nominal, 3-phase or 380-480 VAC nominal, 3-phase	100, 120, 220, 240 VAC nominal Universal input; no switch setting At 100/120 VAC nominal, max current is derated by half
Power cord:	Supplied by customer	Supplied with mainframe
Power dissipation:	Directs excess power at the output back to the AC mains	Not available
Interfaces:	GPIB (optional), LAN, USB, USB-C, built-in Web server	GPIB, LAN, USB, built-in Web server
Module installation:	Modules install through the back of the mainframe After installation, the lockout bar must be installed	Modules install through the top of the mainframe after first removing the blower cover
Front panel controls:	Minimal font panel buttons High-resolution display with built-in touch controls	Individual keys for main functions Extensive menu controls
Output ratings:	6 outputs; up to 1 kW per output 10 A or 8 A (module dependent)	2 outputs; up to 600 W per output 8.5 A or 5 A (module dependent)









Items	MP4360A Modular Power System	E4360A Modular SAS
+/- Output & sense connections:	Part of 4-pin connector including +s, –s Side tabs lock the connector into place 	Part of 5-pin connector including +s, –s, +D Has no locking mechanism 
Diode terminal:	Must be enabled programmatically	Connects internal diode in series with +output
Auto-parallel:	Not available - coming soon	Up to 4 outputs (in 2 mainframes)
Analog connections:	Not available	Connect external current monitors and programming sources

SCPI Compatibility

E4360A commands not listed below are accepted on the MP4360A series. Note that E4360A commands that have an optional <channel> parameter must include this parameter to be compatible with the MP4360A series.

E4360A Command	Effect on MP4360A series	E4360A Command	Effect on MP4360A series
ABORt commands	Not available	LIST commands	Not available
DISPlay commands	Not available	OUTPut:COUPle commands	Not available
CURRent:DTABle:SAS:LIST? queries	Not available	POWer:LIMit?	Not available
CURRent:MODE:DTABle 256|4096	Ignored. Resolution is 1024	SENse:DLOG commands	Not available
CURRent::MODE:PROGramming	Not available	SYSTem:GROup commands	Not available - coming soon
CURRent:SAS:MODE IMM|LIST	Ignored. Mode is IMMediate	SYSTem:MMEMory commands	Not available - coming soon
CURRent:SLIMit:HIGH <NRf>	Not available	SYSTem:PASSword commands	Not available
CURRent:TABLe:OFFSet <NRf>	Not available	TRIGger commands	Not available
FETCh:DLOG	Not available	VOLTage:DTABle:SAS:LIST? queries	Not available
FORMat commands	Not available	VOLTage:SLIMit:HIGH <NRf>	Not available
INITiate commands	Not available	VOLTage:TABLe:OFFSet <NRf>	Not available

6
Verification and Calibration

Test Equipment and Setups

Performance Verification

Instrument Calibration

Test Record Forms

KEYSIGHT TECHNOLOGIES

Test Equipment and Setups

Test Equipment

Measurement Setups

Test Equipment

The test equipment recommended for the performance verification and adjustment procedures is listed below. If the exact instrument is not available, substitute calibration standards of equivalent accuracy.

Instrument	Requirements	Recommended Model	Use [1]
Digital Multimeter	Resolution: 10 nV @ 1V Readout: 8 1/2 digits Accuracy: 20 ppm	Keysight 3458A	V, C
Film capacitor	0.1 µF, 10%, 400 Vdc (for voltage ripple and noise)	B32520E6104K000 or equivalent	V
Current Shunt	15 A (0.1 Ω), 0.01%, TC=4ppm/ΩC	Guildline 9230A/15R	V, C
DC power supply	160 V, 10 A (for current sink verification)	Keysight MP4361A or equivalent	V
Load resistors	10 Ω, 1 kW, 1 % (for voltage ripple and noise)	4 x NH25010R00FE01, 250 W or equivalent 10 Ω 1kW	V
Electronic load	160 V, 10 A, 1 kW minimum	Keysight MP4361A module or equivalent	V
GPIB controller	Full GPIB capabilities	Keysight 82350B or equivalent	V, C
Oscilloscope	Sensitivity: 1 mV Bandwidth: 20 MHz	Keysight DSO6054A or equivalent	V
RMS Voltmeter	Bandwidth: 10 MHz	Rhode and Schwartz URE3, Keysight 3458A, or equivalent	V
Differential Amplifier	Bandwidth: 20 MHz	LeCroy DA1855A, DA1850A, or equivalent	V
Terminations	50 Ω BNC termination		V

[1]V=Verification; C=Calibration

Measurement Setups

Voltmeter

To ensure that the values read by the voltmeter during both the verification procedure and the calibration procedure are not affected by the instantaneous measurement of the ac peaks of the output current ripple, make several dc measurements and average them.

If you are using a Keysight 3458A DMM, you can set up the voltmeter to do this automatically. From the instrument's front panel, program 100 power line cycles per measurement. Press NPLC 100 ENTER. Additionally, turn on auto-calibration (ACAL) and the autorange function (ARANGE).

Current Shunt

The 4-terminal current shunt is used to eliminate output current measurement error caused by voltage drops in the load leads and connections. It has special current-monitoring terminals inside the load connection terminals. Connect the voltmeter directly to these current-monitoring terminals.

Electronic Load

Many of the test procedures require the use of a variable load capable of dissipating the required power. For all tests, a Keysight MP4300 mainframe, with MP4361A modules can be used as a load. The electronic load unit is considerably easier to use than load resistors.

Fixed load resistors may be used in place of a variable load, with minor changes to the test procedures. To avoid contact with any high voltages during operation, use switches to connect, disconnect, or short the load resistors.

Also, if computer controlled test setups are used, the relatively slow (compared to computers and system voltmeters) settling times and slew rates of the unit under test may have to be taken into account. "Wait" statements can be used in the test program if the test system is faster than the unit under test.

Performance Verification

Introduction

Verification Setups

Test Considerations

Voltage Programming and Readback Accuracy

Constant Voltage Ripple and Noise

Current Programming and Readback Accuracy

Current Sink Capability Verification

Test Record Forms

Introduction

Use the performance verification tests to verify that the unit under test (UUT) is operating normally and meets its published specifications. Two different levels of performance verification tests are available:

- Performance Verification Tests An extensive set of tests that are recommended as an acceptance test when you first receive the instrument or after performing adjustments.
- Calibration Tests These tests verify that the instrument is operating within its calibration limits.

The performance verification tests are recommended as acceptance tests when you first receive the instrument. The acceptance test results should be compared against the instrument specifications.

Keysight Technologies recommends that you repeat the performance verification tests at every calibration interval. This ensures that the instrument will remain within specifications for the next calibration interval and provides the best long-term stability. Performance data measured using this method may be used to extend future calibration intervals.

Perform the verification tests before calibrating your power supply. If the instrument passes the verification tests, the unit is operating within its calibration limits and does not need to be calibrated.

If the instrument fails any of the tests or if abnormal test results are obtained, try calibrating the unit. If calibration is unsuccessful, return the unit to a Keysight Technologies Service Center.

Refer to the Test Equipment and Setups section for a list of the equipment and test setups required for verification. Also refer to the Measurement Setups section for information about connecting the voltmeter, current shunt, and load.

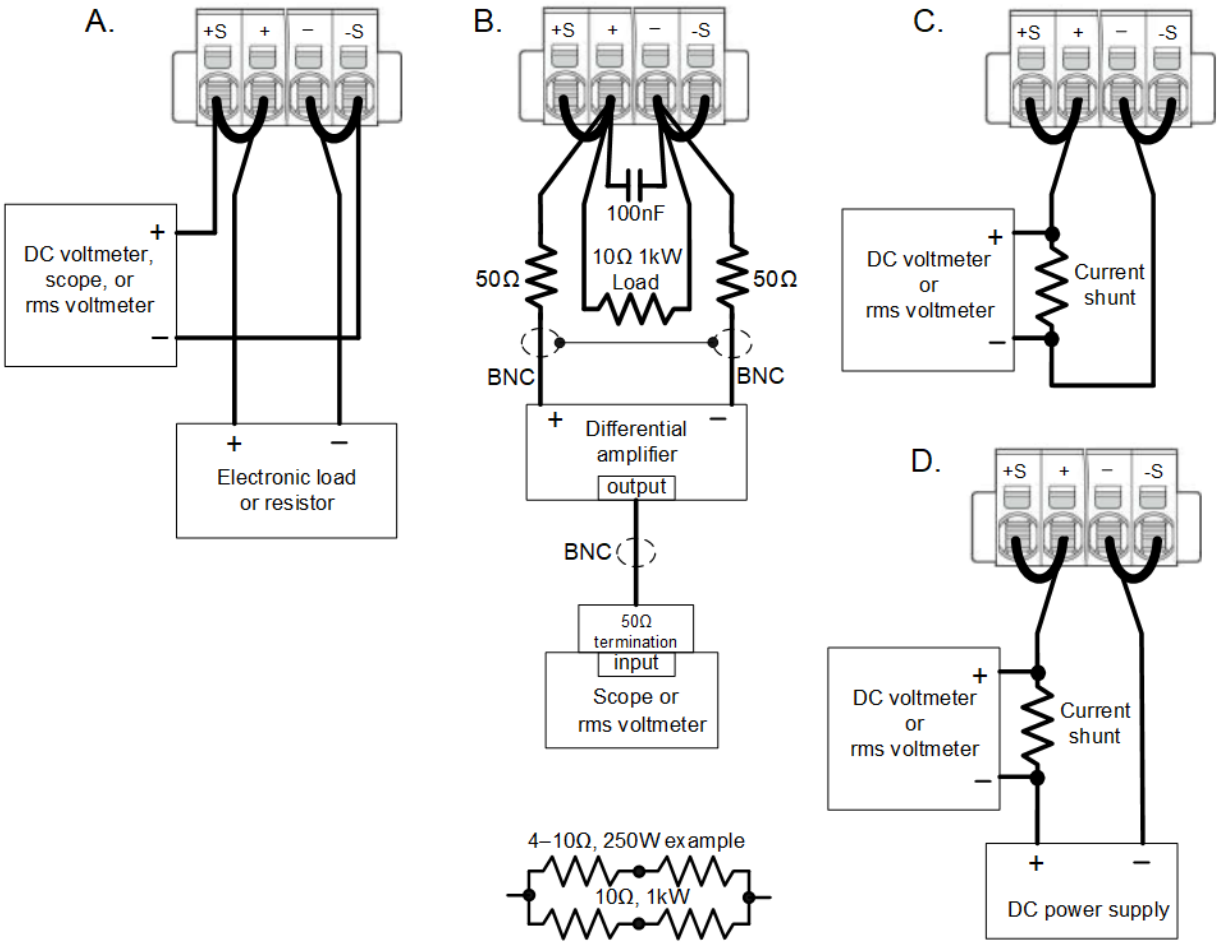
WARNING LETHAL VOLTAGES – Power modules generate output voltages up to 160 VDC! Ensure that all instrument connections, including load and sense wiring, are insulated. Always turn off ac power when connecting or disconnecting any equipment on the sense or output terminals of the unit.

Verify that any external sources are powered down, and any that capacitance on the MPS output terminals has been fully discharged. The MPS does not automatically down-program external capacitance connected to output terminals.

CAUTION Equipment Damage It is recommended to set the over-voltage protection function of the instrument slightly higher than its operating point during the verification procedure. This will prevent damage to any external equipment (electronic load, differential amplifier) that may occur if the output voltage is accidentally programmed higher than the prescribed voltage setting.

NOTE Turn the unit off or send a Reset command after completing the verification procedure to return all instrument settings to their default values.

Verification Setups



Test Considerations

For optimum performance, all verification procedures should comply with the following:

- Fixed mode operation is required for all verification procedures.
- Ambient temperature is stable, within 23 °C ±2 °C.
- Ambient relative humidity is less than 80%.
- 30 minute warm-up period before verification or adjustment.
- Cables as short as possible, twisted or shielded to reduce noise.
- The UUT is allowed to be off for up to 5 minutes after the initial 30 minute warmup period to reconfigure the output without observing the 30 minute warm-up period again.

Verification Procedure

Voltage Programming and Readback Accuracy

This test verifies that the voltage programming and measurement functions are within specifications.

Step 1. Turn off the unit under test. Verify that any external sources are powered down, and any that capacitance on the MPS output terminals has been fully discharged. The MPS does not automatically down-program external capacitance connected to output terminals. Only connect the DMM to the sense screws (see Test Setup A). Do NOT connect the load unit.

Step 2. Turn on the unit under test and program the instrument settings as described in the test record form under “Voltage Programming & Readback Min”. Turn the output on. The output status should be “CV”, with the output current close to zero.

Step 3. Record the output voltage reading from the DMM (Vout) and the voltage measured by the instrument over the interface. The readings should be within the limits specified in the test record form for the appropriate model under “Voltage Programming & Readback, Minimum voltage (Vout)”.

WARNING The next step applies the full output voltage of the unit under test to the output.

Step 4. Program the instrument settings as described in the test record form under “Voltage Programming & Readback High”.

Step 5. Record the output voltage reading from the DMM (Vout) and the voltage measured by the instrument over the interface. The readings should be within the limits specified in the test record form for the appropriate model under “Voltage Programming & Readback, High voltage (Vout)”.

Constant Voltage Ripple and Noise

Periodic and random deviations in the output combine to produce a residual ac voltage superimposed on the dc output voltage. This residual voltage is specified as the rms or peak-to-peak noise in the indicated frequency range (refer to the Mainframe Characteristics section).

Step 1. Turn off the unit under test. Verify that any external sources are powered down, and any that capacitance on the MPS output terminals has been fully discharged. The MPS does not automatically down-program external capacitance connected to output terminals. Connect the load resistors, differential amplifier, and an oscilloscope (ac coupled) to the output (see Test Setup B).

Step 2. As shown in the diagram, use the differential probes to connect the differential amplifier to the + and - output terminals. Connect the shields of the two probes together. Connect the output of the differential amplifier to the oscilloscope with an external 50 Ω termination at the input of the oscilloscope.

Step 3. Set the probe to 1:1 and set the inputs of the differential amplifier to match the probe setting. Set the inputs to ac coupling. Set the input resistance to 1 MΩ. Set the oscilloscope's time base to 5 ms/div, and set the vertical scale to the maximum sensitivity without clipping the waveform. Turn the bandwidth limit on (usually 20 MHz), and set the sampling mode to peak detect.

Step 4. Turn on the unit under test and program the instrument settings as described in the in the test record form under "CV Ripple and Noise". Turn the output on. Let the oscilloscope run for a few seconds to generate enough measurement points. On the Keysight Infiniium scope, the maximum peak-to-peak voltage measurement is indicated at the bottom of the screen on the right side. The result should not exceed the peak-to-peak limits in the test record form under "CV Ripple and Noise, peak-to-peak".

NOTE If the measurement contains any question marks, clear the measurement and try again. This means that some of the scope data received was questionable.

Step 5. Disconnect the oscilloscope and connect an rms voltmeter in its place. Do not disconnect the 50 ohm termination. Divide the reading of the rms voltmeter according to the differential amplifier setting. The result should not exceed the rms limits in the test record form for the appropriate model under "CV Ripple and Noise, rms".

Current Programming and Readback Accuracy

This test verifies that the current programming and measurement functions are within specifications.

Step 1. Turn off the unit under test. Verify that any external sources are powered down, and any that capacitance on the MPS output terminals has been fully discharged. The MPS does not automatically down-program external capacitance connected to output terminals. Connect the current shunt directly across the output terminals. Connect the DMM directly across the current shunt (see Test Setup C).

Step 2. Turn on the unit under test and program the instrument settings as described in the test record form under "Current Programming & Readback Min". Turn the output on. The output status should be "CC", with the output voltage close to zero. Wait 5 minutes for the temperature to settle.

Step 3. Divide the voltage drop (DMM reading) across the current shunt by the shunt resistance to convert to amps and record this value (Iout). Also, record the current measured by the instrument over the interface. The readings should be within the limits specified in the test record form under "Current Programming & Readback, Minimum Current (Iout)".

Step 4. Program the instrument settings as described in the test record form under “Current Programming & Readback, High”. Wait 5 minutes for the temperature to settle.

Step 5. Divide the voltage drop (DMM reading) across the current shunt by the shunt resistance to convert to amps and record this value (Iout). Also, record the current reading measured by the instrument over the interface. The readings should be within the limits specified in the test record form under “Current Programming & Readback, High Current (Iout)”.

Current Sink Capability Verification

This test checks the ability of the power supply to sink its rated negative current.

Step 1. Turn off the unit under test. Verify that any external sources are powered down, and any that capacitance on the MPS output terminals has been fully discharged. The MPS does not automatically down-program external capacitance connected to output terminals. Connect an external source to the + and - output terminals (see Test Setup D).

Step 2. Set the external source for voltage priority mode and program it as described in the test record under “Current Rating (Isink)”. Turn the output of the external source on.

Step 3. Turn on the unit under test. Set the operating mode to current priority. Program the instrument settings as described in the test record under “ Current Rating (Isink)”. Turn the output on.

Step 4. Check the front panel display of the unit under test and verify that it is sinking its rated current and has a CC status. Divide the voltage drop (DMM reading) across the current shunt by the shunt resistance to convert to amps and record this value. The readings should be within the limits specified in the test record form under “Current Sink Test”.

Instrument Calibration

Introduction

Calibration Interval

Calibration Setups

Test Considerations

Voltage Programming and Measurement Calibration

Current Programming and Measurement Calibration

Enter a Calibration Date

Save Calibration and Exit

Introduction

The instrument features closed-case electronic calibration; no internal mechanical adjustments are required. The instrument calculates correction factors based on input reference values that you set and stores correction factors in non-volatile memory until the next calibration adjustment is performed. This EEPROM calibration memory is not changed by cycling power or *RST.

Refer to the Test Equipment and Setups section for a list of the equipment and test setups required for calibration. Also refer to the Measurement Setups section for information about connecting the voltmeter, current shunt, and load. Additional information about calibration follows.

- The correct password is required to enter the calibration function. The password is pre-set to 0 (zero). You can change the password once calibration mode is entered to prevent unauthorized access to the calibration mode. Refer to Password Protection for more information.
- When calibrating the unit using SCPI commands, most steps involve sending a *OPC? query to synchronize with the power supply's command completion before proceeding. The response from the instrument must be read each time *OPC? is given. In some steps, it may take up to 30 seconds for *OPC? to respond.
- Once started, you must complete each calibration section in its entirety. As each calibration section is completed, the instrument calculates new calibration constants and begins using them. These constants are not saved in nonvolatile memory until a SAVE command is explicitly given.
- Exit the calibration mode by sending CAL:STAT OFF. Note that any calibration section that was calibrated but not saved will revert to its previous calibration constants.

Calibration Interval

One Year Calibration Interval

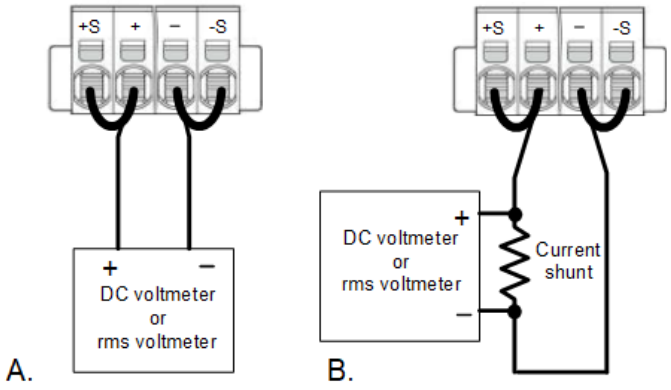
The instrument should be calibrated on a regular interval determined by the accuracy requirements of your application. A **one-year** interval is adequate for most applications. Accuracy specifications are warranted only if adjustment is made at regular calibration intervals. Published accuracy specifications are not warranted beyond the one-year calibration interval. Keysight MP4301A and MP4302A mainframes do not require calibration.

Voltage and current programming and measurement accuracy specifications can be extended to a three-year period calibration interval by multiplying (or increasing) the one-year calibration accuracy specifications shown in the verification Test Record Forms by a factor of three.

WARNING LETHAL VOLTAGES - Power modules generate output voltages up to 160 VDC! Ensure that all instrument connections, including load and sense wiring, are insulated. Always turn off ac power when connecting or disconnecting any equipment on the sense or output terminals of the unit.

Verify that any external sources are powered down, and any that capacitance on the MPS output terminals has been fully discharged. The MPS does not automatically down-program external capacitance connected to output terminals.

Calibration Setups



Test Considerations

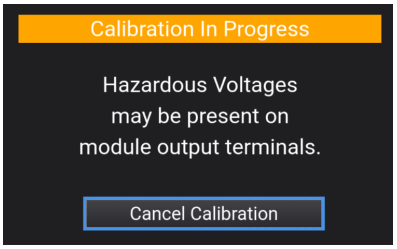
For optimum performance, all calibration procedures should comply with the following:

- Fixed mode operation is required for all verification procedures.
- Ambient temperature is stable, within 23 °C ±2 °C.
- Ambient relative humidity is less than 80%.
- 30 minute warm-up period before verification or adjustment.

- Cables as short as possible, twisted or shielded to reduce noise.
- The UUT is allowed to be off for up to 5 minutes after the initial 30 minute warmup period to reconfigure the output without observing the 30 minute warm-up period again.

Calibration Procedure

Calibration can only be accomplished remotely using SCPI commands. Once calibration has started, the following dialog will appear on the front panel. Touching **Cancel Calibration** terminates the calibration process and resets the instrument.



Voltage Programming and Measurement Calibration

Step 1. Connect the voltage input of the Keysight 3458A DMM to an output channel. Connect the +sense terminal to the +output and the -sense terminal to the -output (see Test Setup A).

Step 2. Turn the unit on.

Step 3. Enter Calibration mode.

SCPI Command
CAL:STAT ON, [<password>]

Step 4. Select the voltage programming and measurement calibration.

SCPI Command
Specify the full-scale voltage range. Full scale ranges vary by model. This selects the 160 V range: CAL:VOLT 160, (@1)

Step 5. Select the first voltage calibration point.

SCPI Command
CAL:LEV P1 *OPC?

WARNING The next step applies the full rated output voltage of the unit to the output.

Step 6. Select the second voltage calibration point. Measure the output voltage with the DMM and enter the data.

SCPI Command
CAL:LEV P2 *OPC? CAL:DATA <data>

Step 7.Save Calibration and Exit

SCPI Command
To save calibration data: CAL:SAVE To exit calibration mode: CAL:STAT OFF

Step 8. Turn the unit off.

NOTE lif the mainframe is off for under 5 minutes when reconfiguring the current connections the 30-minute warmup period doesn't need to be repeated.

Current Programming and Measurement Calibration

Step 1. Connect a precision shunt resistor to the output. Connect the DMM directly across the current shunt (see Test Setup B).

Step 2. Turn the unit on.

Step 3. Enter Calibration mode.

SCPI Command
CAL:STAT ON, [<password>]

Step 4. Select the current programming and measurement calibration.

SCPI Command
Specify the full-scale current range. Full scale ranges vary by model. This selects the 10 A range: CAL:CURR 10, (@1)

Step 5. Select the first current calibration point. Calculate the shunt current (I=V/R) and enter the data.

SCPI Command
CAL:LEV P1 *OPC?

Step 6. Select the second current calibration point. Wait 5 minutes for the temperature to settle. Calculate the shunt current (I=V/R) and enter the data.

SCPI Command
CAL:LEV P2 *OPC? CAL:DATA <data>

Step 7. Select the third current calibration point. Calculate the shunt current (I=V/R) and enter the data. Observe positive current polarity.

SCPI Command
CAL:LEV P3 *OPC? CAL:DATA <data>

Step 8. Enter a Calibration date.

SCPI Command
CAL:DATE <"date">, (@1)

Step 9. Save Calibration and Exit.

SCPI Command
To save calibration data: CAL:SAVE To exit calibration mode: CAL:STAT OFF

Step 10. Turn the unit off.

Test Record Forms – MPS family

Keysight MP4361A

MP4361A Test Record	Report Number _____		Date_____
Test Description	**Min. Specs**	**Results**	**Max. Specs**
Voltage Programming & Readback			
Minimum voltage (Vout):	-0.025	_____	0.025
Voltage measured over interface:	Vout - 0.025	_____	Vout + 0.025
High voltage (Vout):	159.895	_____	160.105
Voltage measured over interface:	Vout - 0.105	_____	Vout + 0.105
CV Ripple and Noise			
peak-to-peak:	N/A	_____	0.5
rms:	N/A	_____	0.05
Current Programming & Readback			
Minimum current (Iout):	- 0.007	_____	0.007
Current measured over interface:	Iout - 0.007	_____	Iout + 0.007
High current (Iout):	9.983	_____	10.017
Current measured over interface:	Iout - 0.017	_____	Iout + 0.017
Current Sink Test			
Negative current rating:	- 10.017	_____	- 9.983

	MP4361A UUT Settings	Programmed Source Settings
Voltage Programming & Readback Min:	Voltage priority: 0 V, 1 A	not used
Voltage Programming & Readback High:	Voltage priority: 160 V, 1 A	not used
CV Ripple and Noise:	Voltage priority: 100 V, 10.2 A	not used
Current Programming & Readback Min:	Current priority: 100 V, 0 A	not used
Current Programming & Readback High:	Current priority: 100 V, 10 A	not used
Current Rating (Isink):	Current priority: 102 V, -10 A	Voltage priority: 100 V, 10.2 A

Keysight MP4362A

MP4362A Test Record	Report Number _____		Date_____
Test Description	**Min. Specs**	**Results**	**Max. Specs**
Voltage Programming & Readback			
Minimum voltage (Vout):	-0.025	_____	0.025
Voltage measured over interface:	Vout - 0.02	_____	Vout + 0.02
High voltage (Vout):	129.8775	_____	130.1225
Voltage measured over interface:	Vout - 0.124	_____	Vout + 0.124
CV Ripple and Noise			
peak-to-peak:	N/A	_____	0.5
rms:	N/A	_____	0.05
Current Programming & Readback			
Minimum current (Iout):	- 0.01	_____	0.01
Current measured over interface:	Iout - 0.025	_____	Iout + 0.025
High current (Iout):	7.974	_____	8.026
Current measured over interface:	Iout - 0.041	_____	Iout + 0.041
Current Sink Test			
Negative current rating:	- 511 mA	_____	- 489 mA

	MP4362A UUT Settings	Programmed Source Settings
Voltage Programming & Readback Min:	Voltage priority: 0 V, 1 A	not used
Voltage Programming & Readback High:	Voltage priority: 130 V, 1 A	not used
CV Ripple and Noise:	Voltage priority: 80 V, 8.2 A	not used
Current Programming & Readback Min:	Current priority: 130 V, 0 A	not used
Current Programming & Readback High:	Current priority: 130 V, 8 A	not used
Current Rating (Isink):	Current priority: 132 V, -0.5 A	Voltage priority: 130 V, 0.52 A

7
Service and Maintenance

Introduction

Self-Test Procedure

Firmware Update

Calibration Switches

Battery Replacemsnt

Cleaning

Disassembly

KEYSIGHT TECHNOLOGIES

Introduction

Repair Service Available

If your instrument fails during the warranty period, Keysight Technologies will repair or replace it under the terms of your warranty. After your warranty expires, Keysight offers repair services at competitive prices. Many Keysight products have optional service contracts that extend coverage after the standard warranty expires.

Obtaining Repair Service (Worldwide)

To obtain service for your instrument, contact your nearest Keysight Technologies Service Center. They will arrange to have your unit repaired or replaced, and can provide warranty or repair–cost information where applicable. Ask the Keysight Technologies Service Center for shipping instructions, including what components to ship. Keysight recommends that you retain the original shipping carton for return shipments.

Before Returning the Unit

Before returning the unit, make sure the failure is in the instrument rather than any external connections. Also make sure that the instrument was accurately calibrated within the last year (see Calibration Interval).

If the unit is inoperative, verify that:

- the ac power cord is securely connected to the instrument
- the ac power cord is plugged into a live outlet
- the front-panel Power On/Standby switch has been pushed

If self-test failed, Ensure that all connections (front and rear) are removed when self-test is performed. During self-test, errors may be induced by signals present on external wiring, such as long test leads that can act as antennae.

Repackaging for Shipment

Keysight suggests that you always insure shipments. To ship the unit to Keysight for service or repair:

- Attach a tag to the unit identifying the owner and indicating the required service or repair. Include the model number and full serial number.
- Place the unit in its original container with appropriate packaging material.
- Secure the container with strong tape or metal bands.

CAUTION Do not ship MPS mainframes with the power modules installed. Remove all power modules from the mainframe before returning the instrument.

Self-Test Procedure

Power-On Self-Test

Each time the instrument is powered on, a self-test is performed. This test assures you that the instrument is operational.

Self-test checks that the minimum set of logic and power mesh systems are functioning properly. Self-test does not enable the output or place any voltages on the output. It leaves the instrument in the reset state.

User-Initiated Self-Test

The user-initiated self-test is the same as the power-on self-test.

Front Panel Reference	SCPI Command
Cycle ac power.	*TST?
If self-test fails, the front panel ERR indicator comes on. Press the Error key to display the list of errors.	If 0, self-test passed. If 1, self-test failed. If self test-fails, use SYSTem:ERRor? to view the self-test error.

For a list of errors, see SCPI Error Messages.

Firmware Update

NOTE

To determine the instrument's firmware version, click the front panel **Menu** key, then touch **Help**, followed by **About Instrument**.

The lockout bar must be installed in order to update the firmware.

Firmware Versions

Version 1.1.09

- Added Diode Mode SCPI commands and front panel configuration screen. This mode allows the user to optionally enable the Reverse-Current Blocking Diode on the +OUT terminal.
- Added "Less Than Vmp" (LT_Vmp) SAS compensation mode for regulation DUTs operating at voltages below Vmp.
- Various defect fixes.

Software Required

To update the firmware you need to download the following two items onto your computer from the firmware download page at MP4300 Series Firmware.

- The Firmware Update Utility
- The latest firmware version

Update Procedure

Directions on how to download and install the above items are located on the firmware download page.

Once you have completed the downloads, you must run the Firmware Update Utility.

The update utility will update the firmware and restart your instrument. The entire update process may take up to ten minutes for a fully loaded mainframe.

Calibration Switches

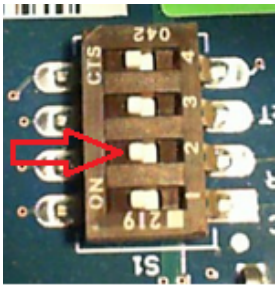
WARNING SHOCK HAZARD Only qualified, service-trained personnel who are aware of the hazards involved should remove instrument covers. Always disconnect the power cable and any external circuits before removing the instrument cover. Some circuits are active and have power for a short time even when the power switch is turned off.

Two switches control the access to calibration commands. The switches are on the interface board and are accessible by removing the top cover.

Accessing the Calibration Switch

1. Remove the instrument covers as described under Disassembly.
2. To change the calibration switch settings, use a small screwdriver to move the switches. As shipped, all switches are set toward the ON position (refer to the ON label on the switch).

The red arrow shows which way to slide switch 2 to turn it off.



CAUTION Do not use a pencil to move the switches. Any graphite dust that gets on the switches will conduct electricity.

3. Replace the top cover when finished.

Switch Functions

Switches 1 and 2 set the calibration configuration as follows. Switches 3 and 4 are not used.

	Switch 1	Switch 2	Description
Normal	ON	**ON**	This is the as-shipped switch setting. The calibration functions are accessible after entering a numeric password. The default password is 0 (zero).
Clear Password	OFF	ON	The calibration password is reset to 0 when the instrument is first powered on. Use this setting if you have forgotten the password.
Inhibit Calibration	ON	OFF	All calibration commands are disabled. This is useful where access is guarded by instrument seals.

Battery Replacement

WARNING SHOCK HAZARD Only qualified, service-trained personnel who are aware of the hazards involved should remove instrument covers. Always disconnect the power cable and any external circuits before removing the instrument cover. Some circuits are active and have power for a short time even when the power switch is turned off.

The internal battery powers the system clock. The primary function of the clock it to provide time stamp information for the BenchVue Power Control and Analysis Software. If the battery fails, the time will not be available for the software. No other instrument functions are affected.

Under normal use at room temperature, the lithium battery has a life expectancy between seven and ten years. Note that battery life will be reduced if the instrument is stored for a prolonged period at temperatures above 40 degrees C.

The part number of the battery is Panasonic CR 2032.

Replacing the Battery

1. Remove the instrument covers as described under Disassembly.
2. Use a flat-bladed screwdriver and carefully push on the tab to remove the pressure on the side of the battery. Use needle nose pliers to lift the battery out.

The red arrow shows on where to remove pressure from the battery.

The red circle shows the spring clips that hold the battery.

3. Install the new battery. Make sure that the positive side (+) is facing up. Place the battery *under* the small spring clips indicated by the circle, then push down on the opposite end of the battery indicated by the red arrow. The top of the small spring clips should be visible after the battery is seated (see red circle)
4. Replace the top cover when finished.
5. Reset the date and time (see Clock Setup)

Cleaning

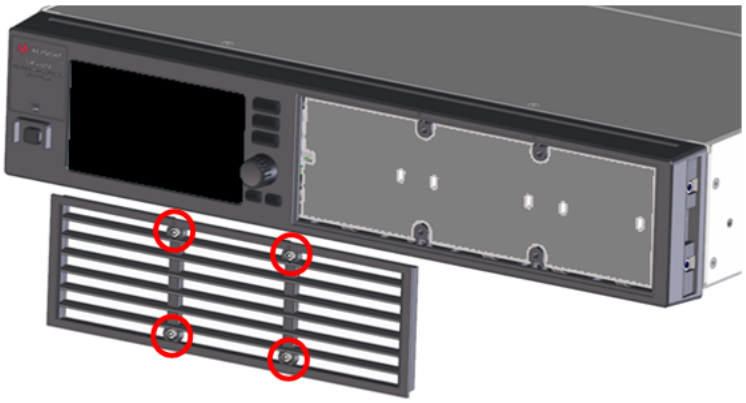
WARNING SHOCK HAZARD To prevent electric shock, disconnect the ac mains before attempting the following cleaning procedures.

Cleaning the Outside

Clean the outside of the instrument with a soft, lint-free, slightly damp cloth. Do not use detergent. Disassembly is not required or recommended for cleaning the outside. Ensure that the instrument is completely dry before turning it on.

Cleaning the Filter

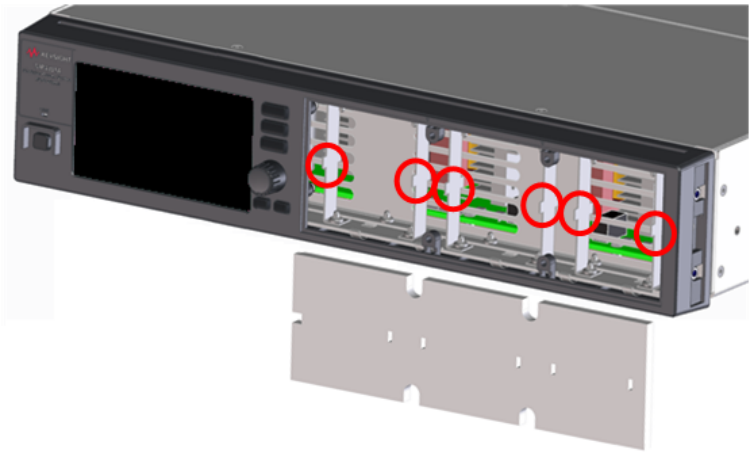
1. Remove the filter housing by removing the four T10 screws that secure the housing.



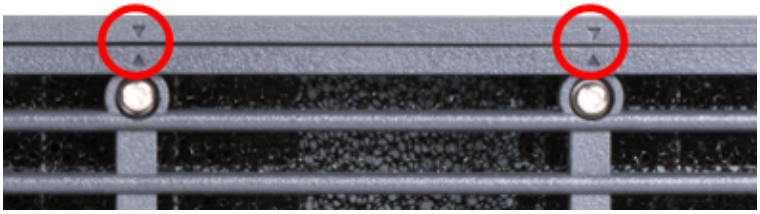
2. Remove the filter from the front panel.

3. Shake the filter to remove the dust and particles that are attached to the filter. If the filter is extremely dirty, clean the filter using water-diluted neutral detergent. Be careful not to damage the filter material. Ensure that the filter is completely dry before installing it.

4. Install the filter in the front panel. Firmly attach the filter so the metal tabs protrude into the slits in the filter. Note that the filter is asymmetrical and can only be correctly installed one way.



5. Replace the filter housing on the front panel. Note that the triangle symbols must align.



6. Hand tighten the housing screws.

Replacement filters and parts can be ordered from Keysight Technologies using the following part numbers:

Part Number	Qty	Description
0515-0430	4	Screw M3 X 0.5 6mm Lg
5040-1765	1	Filter, Foam
5040-1766	1	Filter, Housing

Disassembly

WARNING SHOCK HAZARD Only qualified, service-trained personnel who are aware of the hazards involved should remove instrument covers. Always disconnect the power cable and any external circuits before removing the instrument cover. Some circuits are active and have power for a short time even when the power switch is turned off.

Electrostatic Discharge (ESD) Precautions

Almost all electrical components can be damaged by electrostatic discharge (ESD) during handling. Component damage can occur at electrostatic discharge voltages as low as 50 V.

The following guidelines will help prevent ESD damage during service operations:

- Disassemble instruments only in a static-free work area.
- Use a conductive work area to reduce static charges.
- Use a conductive wrist strap to reduce static charge accumulation.
- Minimize handling.
- Keep replacement parts in original static-free packaging.
- Remove all plastic, foam, vinyl, paper, and other static-generating materials from the immediate work area.

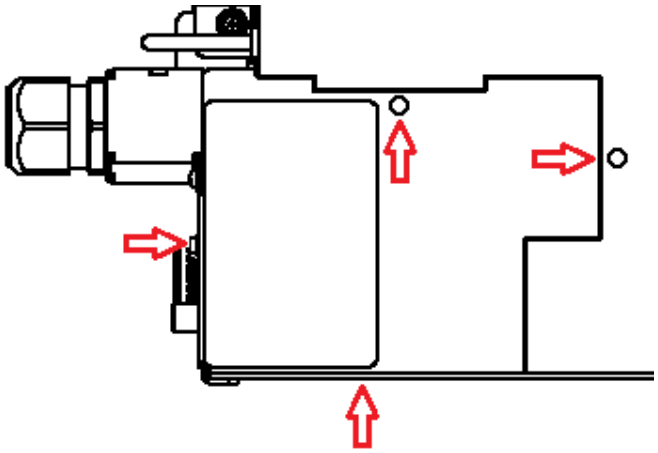
Tools Required

- T10 Torx driver for cover removal
- Small flat bladed screwdriver for battery removal
- Needle nose pliers for battery removal

Remove Maintenance Cover

1. Turn off the power. Remove all cables from the instrument.
2. Remove the four screws indicated in the following figure. Place the screws in a container so that you do not lose them.

Remove the four screws indicated by the arrows.



3. Remove the maintenance cover.
4. When reassembling, torque all screws to 9 in-lbs.

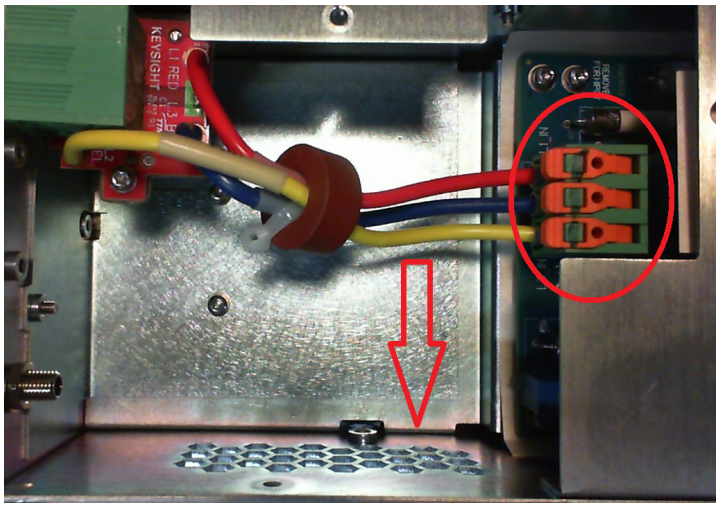
Access the Calibration Switches and the Battery

The Control board is located on the outside of the Constellation board. It must be removed to provide access to the battery and the P600 board, which are both locate on the Constellation board.

1. As shown in the figure, disconnect the ac input wires from the ac connector. Move them to the side so they will not interfere with accessing the switch or battery. If your unit has the optional GPIB board, you can access the battery and calibration switches directly as shown in the last figure. Note that only the MP4302A units have a ferrite core installed on the wiring.

Lift the orange locking tabs all the way and remove the ac wires.

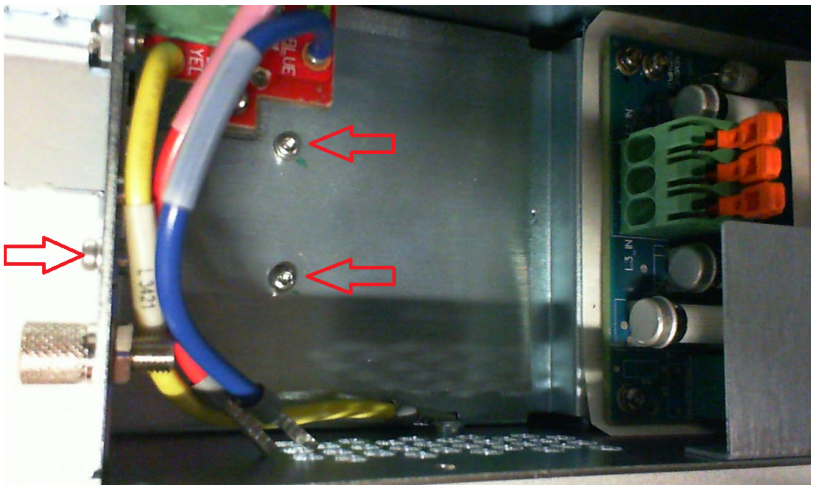
Move the wires to the side as indicated by the arrow.



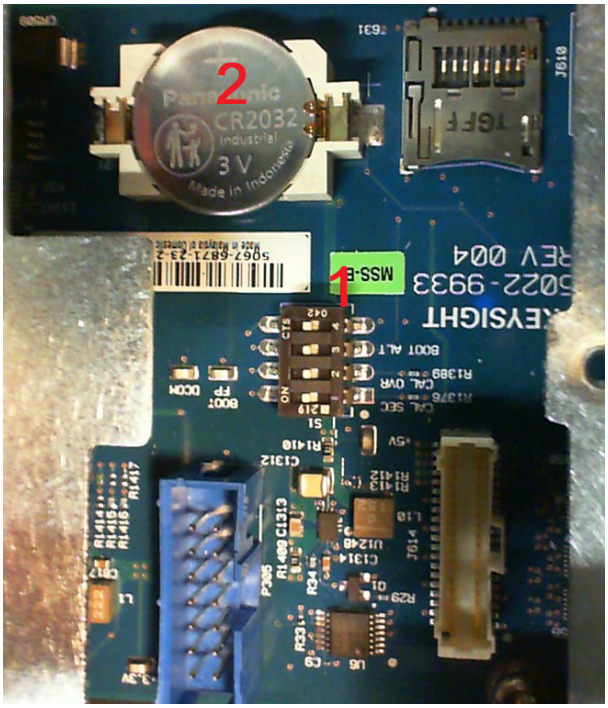
2. If your unit does not have GPIB board, you must also remove the shield located underneath the ac wires.

Remove the three screws indicated by the arrows.

Lift the right side of the shield up and out to remove.



3. You can now access both the calibration switches (1) and the battery (2).



4. When calibration switch settings or battery replacement is complete, reinstall the shield if you do not have a GPIB card.
   Reinsert the ac wires into the ac connector block and push down the orange locking tabs.
5. Reinstall the maintenance cover. When reassembling, torque all screws to 9 in-lbs.

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