

# Keysight MP4300A Series

Modular Solar Array Simulator (MP4301-02A, MP4361-62A)

## Introduction

The Keysight Technologies MP4300A Series Modular Solar Array Simulator (SAS) gives you a new level of performance in a small footprint. The 2U mainframe can accommodate up to six SAS modules, providing a compact solution even when the emulation of many PV segments is required. The MP4300A series SAS will help you overcome your toughest solar array simulation test challenges by delivering industry-leading specifications and innovative features motivated by Keysight's decades of experience in SAS applications.



The MP4300 offers two classes of 1kW SAS modules, the highest performance MP4361A 160V/10A auto-ranging module and the MP4362A 130V/8A module.

- Up to 160 V, up to 10 A, up to 1000W per module
- High channel density, up to 6 modules per mainframe
- High output power system, 6 kW per mainframe
- Save valuable rack space with a compact 2U-high size
- Faithfully emulate multiple PV segments with high-performance hardware and advanced IV-curve generation and sequencing
- Accelerate test-system throughput with industry-leading speed
- Add flexibility to your test system via modularity
- Minimize installation and service time with rear-loading modules
- Achieve rapid deployment and debugging of new test systems with the help of an intuitive, 5" touch screen interface

## Solar Array Simulator Module Portfolio

Module Type	Max Power	Max Voltage	Max Current	Max Channels Per Mainframe
MP4361A Solar Array Simulator Auto Ranging 0-160V, 0-10A, 1kW	1000 W	160 V	10 A	6
MP4362A Solar Array Simulator Module 0-130V, 0-8A, 1kW	1000 W	130 V	8 A	6

## Solar Array Simulation

Satellite test applications - Solar panels, which consist of multiple solar cells, provide power to satellites. They have unique I-V characteristics. Since the output power varies with environmental conditions (temperature, irradiation) and operational conditions (eclipse, spin), you must use a specialized power supply such as the solar array simulator (SAS) for making accurate tests and verifying the satellite power system.

## Keysight Solar Array Simulator

The Keysight Technologies, Inc. MP4300A Modular Solar Array Simulator (SAS) is a six-output programmable dc power source that simulates the output characteristics of a solar array. The MP4360 SAS is primarily a current source with very low output capacitance and is capable of quickly simulating the I-V curve of different arrays under different conditions (e.g., temperature, age, etc.). It provides up to 6 outputs and 6000 W in a small 2U-high mainframe. Whether you build your test system requiring instrument only or if you want a full turn-key system with all the instruments and software integrated and installed – Keysight gives you the flexibility you need. The MP4360 SAS is readily available as an off-the-shelf instrument and also is available from Keysight integrated into a full turn-key solar array simulator system configured to your exact specification.

# Multiple Simulation Modes

The MP4360 SAS provides three operating modes, Simulator (SAS), Table, and Fixed modes. To accurately simulate the I-V curve of a solar array, use SAS or table modes. When a standard power supply is needed, use fixed mode. Fixed mode operation allows the user to use the power supply as a source or load.

## SAS mode

The MP4360 SAS internally generates a 1024 I-V point table evenly spaced between 0V and  $V_{oc}$ . It uses an internal algorithm to approximate an I-V curve. This can be done via the I/O interfaces or from the front panel where a PC is not needed. These four input parameters are needed to establish a curve in this mode:

- $V_{oc}$  - open circuit voltage
- $I_{sc}$  - short circuit current
- $I_{mp}$  - current at the peak power point on the curve
- $V_{mp}$  - voltage at the peak power point on the curve

## Table mode

The I-V curve is determined by a user-defined table of points. A table can have a minimum of 3 points, up to a maximum of 1024 points. A point corresponds to a specific value of I and V. You can store as many as 30 tables in each MP4360 SAS built-in volatile and non-volatile memory. The tables (I-V curve) stored in this non-volatile memory will be retained when the power is turned off, while those stored in volatile memory will be erased after power is removed.

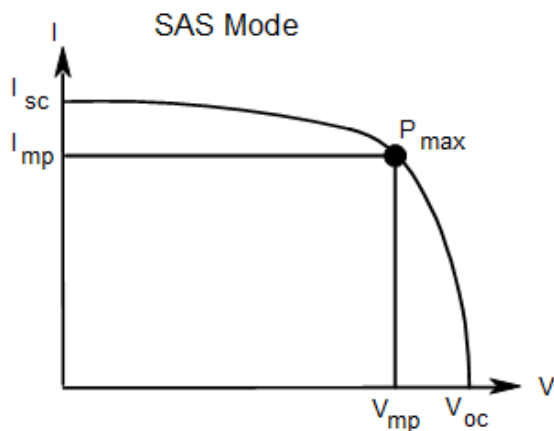
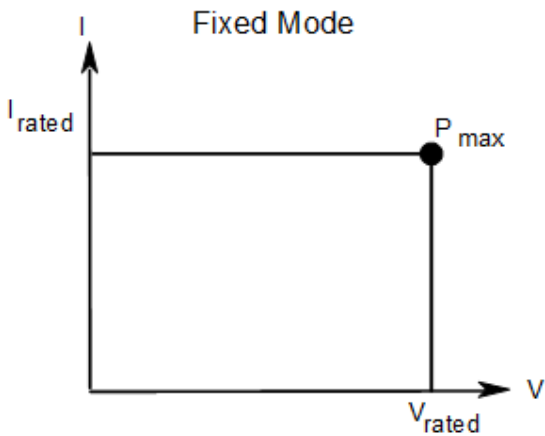


Figure 1. Output characteristic in SAS mode

## Fixed mode

This is the default mode when the unit is powered on. The MP4362A has the rectangular I-V characteristics of a standard power supply, and the MP4361A output characteristic is autoranging. In this operation power supply can be configured to source or sink current.



**Figure 2.** MP4362A output characteristic in Fixed mode

## Fast I-V Curve Changes

The MP4360 offers fast curve changes to enable better simulation of solar arrays under various environmental conditions, like eclipse and spin. Simulation (SAS) and table mode use a 1024-point table per output to generate a smoother I-V curve within 8ms from receipt of a command.

## Small Size

The Keysight MP4300 provides up to 6000 W and 6 outputs in a small 2U high, 19-inch wide package.



Figure 3. Mainframe rear view with 6 modules installed

## Built-in Measurement of Voltage and Current

The MP4300 modules come standard with built-in measurement of voltage and current.

## Protection Features

The MP4300 module has over-voltage, over-current, and over-temperature protection to safeguard your device from damage. You can configure the MP4300 such that a fault condition in one module can be detected within 10 microseconds by other modules so that they can be quickly shut down to avoid hazardous conditions on your DUT.

## Connectivity

The MP4300 Modular Solar Array Simulator comes standard with LAN, USB-C interfaces, and optional GPIB. It allows you to use your interface of choice today and in the future. The MP4300 is fully compliant with the LXI Class C specification.

## AC Power Requirement

The MP4300 series mainframes consist of two models with a 3-phase AC input requirement. MP4301A 200/208 VAC inputs and MP4302A 380/400/480 VAC inputs. This gives you the ability to use the MP4300 anywhere in the world. When available, choose 200/208 VAC for regions such as the Americas and Japan, or choose 380/400/480 VAC for regions such as Europe and Asia. The MP4300 uses 3-phase AC input connections: L1, L2, L3, and PE.

## Front Panel

In addition to full control over its three interfaces, the MP4300 has a high-resolution touch display making accessing the full features easy and quick. You can have confidence that the MP4300 is working properly because you can view the settings and actual output values on all outputs simultaneously. Further, all SAS modes can be programmed and controlled from the front panel.



Figure 4. Intuitive touch display, setting SAS curve

## Quick Disconnects

Each MP4360 SAS module has quick disconnects for easy system setup and maintenance. Each module simply slides into the mainframe for ease of installation.

## Rack Mount Kit

The MP4300 is easily rack-mounted using available accessories 1CP104A and RP7908A. This provides all the necessary hardware to rack mount one MP4300A mainframe in 2U of rack space. These accessories include front rack handles and rails to support the instrument.

# Custom Turn-key System

Keysight offers an affordable complete turn-key solar array simulator system with all the instruments and software integrated and installed. Save valuable system development time by letting Keysight handle all the system design elements. This SAS system is built on the MP4300 Modular Solar Array Simulator platform, making this system the smallest available on the market. The MP4300 modular architecture makes it easy to configure, re-configure, and support this system since modules can be easily installed. Whether you need spares, want to configure the system yourself, or want Keysight to build your system, the MP4300 allows you to choose the configuration that best meets your test strategy.

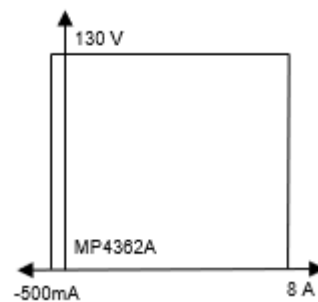
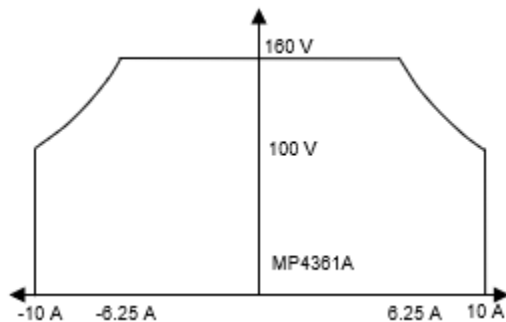


**Figure 5.** MP4300 series custom turn-key system

# Modification Service

While the MP4300 Modular Solar Array Simulator Series will meet most of your needs, Keysight recognizes that they may not match all needs. To better solve your specific problem, Keysight offers a special modification service. This service entails designing and manufacturing a modified version of standard MP4300 models.

**Output characteristics for solar array simulator system modules in the following diagrams**



# MP4361A and MP4362A SAS Modules

## Performance specifications

Unless otherwise noted, specifications are warranted over the ambient temperature range of 0 to 40 °C and are applicable for Fixed, Simulator, and Table modes.

	MP4361A	MP4362A
<b>Output Ratings (Simulator and Table Mode)</b>		
Maximum Power	1000 W	1000 W
Maximum open circuit voltage (Voc)	160 V	130 V
Maximum voltage point (Vmp)	160V	130V
Maximum short circuit current (Isc)	10 A	8 A
Maximum current point (Imp) <sup>1</sup>	10 A	8 A
Minimum impedance ( $\Delta V/\Delta I$ ) <sup>1</sup>	0.25 $\Omega$	0.25 $\Omega$
<b>Output Ratings (Fixed Mode)</b>		
Maximum Power	1000 W	1000 W
Maximum Voltage	160 V	130 V
Maximum Current	10A	8A
<b>Output Voltage Ripple &amp; Noise (Fixed Mode + DCDC20uF SAS)</b>		
Voltage noise Peak-Peak <sup>2</sup>	500 mV	500 mV
Voltage noise RMS <sup>3</sup>	50 mV	50 mV
<b>Programming and Measurement Accuracy</b>		
Voltage programming accuracy (@23 $\pm$ 5 °C)	0.05 % + 25 mV	0.075 % + 25 mV
Current programming accuracy (@23 $\pm$ 5 °C)	0.1% + 7mA	0.2 % + 10 mA
Voltage measurement accuracy (@23 $\pm$ 5 °C)	0.05 % + 25 mV	0.08 % + 20 mV
Current measurement accuracy (@23 $\pm$ 5 °C)	0.1% + 7mA	0.2 % + 25 mA

**Notes:**

1. There is no maximum impedance restriction. The programmed value for Imp can be less than or equal to Isc.
2. From 20 Hz to 20 MHz with 10 ohms in parallel with  $\geq 100\text{nF}$ , terminals ungrounded, or either terminal grounded.
3. From 20 Hz to 10 MHz with 10 ohms in parallel with  $\geq 100\text{nF}$ , terminals ungrounded, or either terminal grounded.



# Supplemental characteristics

Supplemental characteristics are not warranted but are descriptions of typical performance determined by design or type testing.

	MP4361A	MP4362A
<b>Output Current Ripple &amp; Noise</b>		
Current noise Peak-Peak <sup>1</sup>	48 mA	48 mA
Current noise RMS <sup>2</sup>	6 mA	6 mA
<b>Load Regulation – (Fixed Mode)</b>		
Constant voltage	4 mV	4 mV
Constant current	1 mA	1 mA
<b>Output Programming Range (Maximum Programmable Values)</b>		
Simulator/table mode – voltage	160 V	130 V
Fixed mode – voltage	163.2 V	132.6 V
Current	10.2 A	8.16 A
Overvoltage protection	0 – 172.5 V	0 – 142.5 V
Overcurrent protection	0 – 12.5A	0 – 10A
<b>Programming Resolution</b>		
Voltage and Overvoltage protection	1.8 mV	1.8 mV
Current and Overcurrent protection	120 $\mu$ A	120 $\mu$ A
<b>Programming Accuracy</b>		
Overvoltage protection	0.05% + 25 mV	0.075% + 25 mV
Overcurrent protection	0.1% + 7 mA	0.2% + 10 mA
<b>Temperature Coefficients (Output Change Per °C)</b>		
Voltage	0.01% + 1.5 mV	0.01% + 1.5 mV
Current	0.01% + 500 $\mu$ A	0.01% + 500 $\mu$ A
Output capacitance	80 nF	80 nF
<b>Output Current Settling Time</b>		
(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)	< 12.5 $\mu$ s	< 12.5 $\mu$ s
<b>Maximum Capacitive Load</b>		
(For stable operation. In simulator table and fixed mode)	2000 $\mu$ F	2000 $\mu$ F
<b>Load Lead drop With Remote Sensing</b>		
Simulator/table mode	Up to 2V + (Voc - Vmp)	Up to 2V + (Voc - Vmp)
Fixed mode	Up to 2V total	Up to 2V total
Current sinking capability (Fixed mode)	10 A	500 mA
<b>Voltage Programming Rise/Fall Time</b>		
(time for output to change from 90% to 10% or 10% to 90% of its total excursion)	< 30 ms	< 30 ms
Voltage programming settling time (time for output to change to settle within 0.1% of the rating of the unit)	100 ms	100 ms
Auto-parallel configuration	Up to 6 outputs	Up to 6 outputs
Shunt switching frequency <sup>2</sup> (switching frequency is controlled by a customer-supplied external shunt FET connected to the output)	20 kHz maximum	20 kHz maximum
Output terminal isolation (maximum, from chassis ground)	$\pm$ 240 Vdc	$\pm$ 240 Vdc
Recommended calibration interval	1 year	1 year

Notes:

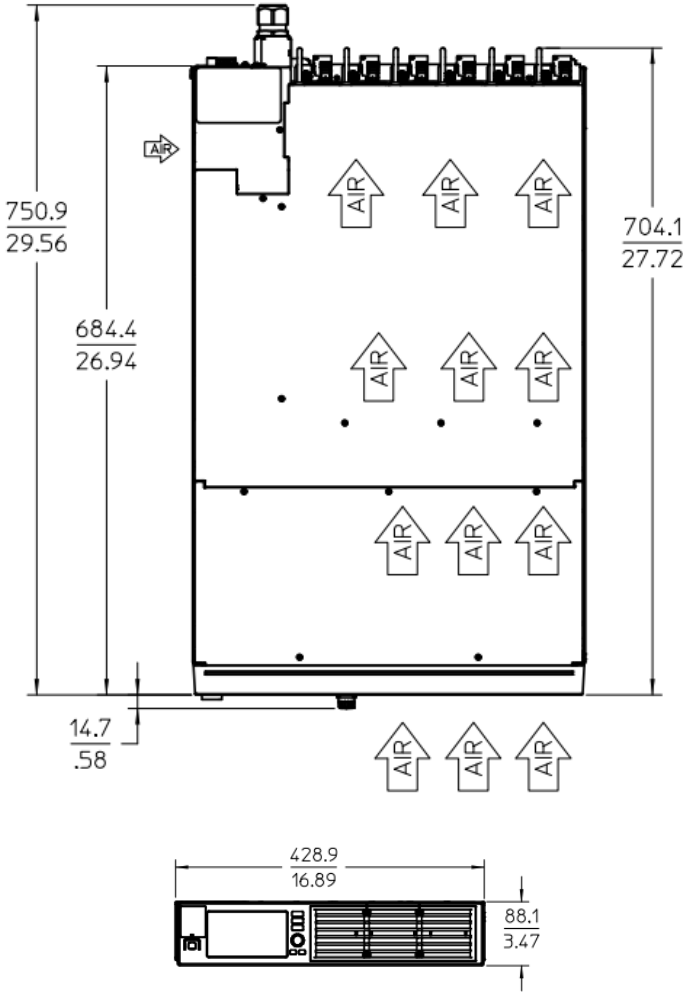
1. From 20 Hz to 10 MHz with resistive load, terminals ungrounded, or either terminal grounded
2. Higher switching frequencies may be possible given the right load conditions consisting of but not necessarily limited to the inductance of the load cable to the shunt switch and the on/off edge rate of the shunt switch.

# MP4301/02A Modular SAS Mainframe

## Mainframe characteristics

AC Input	
Connections	L1, L2, L3, and PE; do not require a neutral connection
Phase and range	3 phase: 200 VAC $\pm$ 10% and 208 VAC $\pm$ 10%; 47-63 Hz (MP4301A)
	3 phase: 380 VAC $\pm$ 10%, 400VAC $\pm$ 10% and 480 VAC $\pm$ 10% ; 47-63 Hz (MP4302A)
Input VA	7.2 kVA
Input Current Per Phase	
MP4301A 200 VAC input	23.1 A
MP4302A 400 VAC input	12.2 A
Efficiency At Full Power	
MP4301A	85 %
MP4302A	85 %
Power Factor	
	0.99 at nominal input and rated power
Command Processing Time	
	$\leq$ 1 ms from receipt of command to start of output change
Protection Response Characteristics	
INH input	5 $\mu$ s from receipt of inhibit to start of shutdown
Fault on coupled outputs	< 10 $\mu$ s from receipt of fault to start of shutdown
Computer Interfaces	
LXI	1.5 LXI Device Specification 2016
LAN	10 Mb, 100 Mb, 1 Gb LAN
USB	USB C with one mating screw
GPIB (Option-GPB)	SCPI - 1993, IEEE 488.2 compliant interface
Environmental Conditions	
Operating environment	Indoor use, installation category III (for AC input), pollution degree 2
Temperature range	0 to 55 °C (current is derated 1% per °C above 40°C ambient temperature)
Relative humidity	Up to 95%
Altitude	Up to 2000 meters
Storage temperature	-30 to 70 °C
LED statement	Any LEDs used in this product are Class 1 LEDs as per IEC 825-1
Dimensions	
Height	88.1 mm (3.5 in.)
Width	428.9 mm (16.89 in.)
Depth	765.6 mm (30.14 in.)
Typical Weight	
MP4301/02A	42.4 lbs. (19.3 kg)
MP436xA	3.8 lbs. (1.7 kg)

# Outline diagram – MP430xA



# Ordering Information

Model	Descriptions	Remarks
<b>Mainframe</b>		
MP4301A	Modular Power System 6kW Mainframe - 200/208Vac	Holds up to 6 modules
MP4302A	Modular Power System 6kW Mainframe – 380/400/480Vac	Holds up to 6 modules
<b>Line Cord And Terminations (Plugs)</b>		

If the AC input voltage where the SAS system will be used is:

- 180 to 229, 3-phase, please choose a 200/208 VAC model (MP4301A)
- 342 to 528, 3-phase, please choose a 380/400/480 VAC model (MP4302A)

Due to the number of different line cords and terminations worldwide, the MP43xx does not come with line cords or terminations. Users will need to supply their own depending on the local laws and codes of the country/region where the power supply will be used.

<b>Modules</b>		
MP4361A	MP4361A Solar Array Simulator Auto Ranging 0-160V, 0-10A, 1kW	Mainframe holds up to 6 modules
MP4362A	MP4362A Solar Array Simulator Module 0-130V, 0-8A, 1kW	Mainframe holds up to 6 modules
<b>Options</b>		
Option UK6	Commercial calibration with test results data	
Option GPB	GPIB option for MP4301A or M4302A	
Option FL5	Filler Panel for MP4300 Series Mainframes - 5 panels. For proper operation, you must fill any empty slots with filler panels. When configuring mainframes with less than 6 modules, you must order option FL5 or MP4309A kit.	
<b>Accessories <sup>1</sup></b>		
1CP104A <sup>2</sup>	Rack Mount Flange and handle kit 88.1mm (2U) Phantom Gray	
RP7908A	Rail Kit for System II Keysight Instrument Racks	

Notes:

1. Optional Rack Mount Kit - No spacer is required between mainframes
2. Requires RP7908A rail kit

Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at [www.keysight.com](http://www.keysight.com).



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