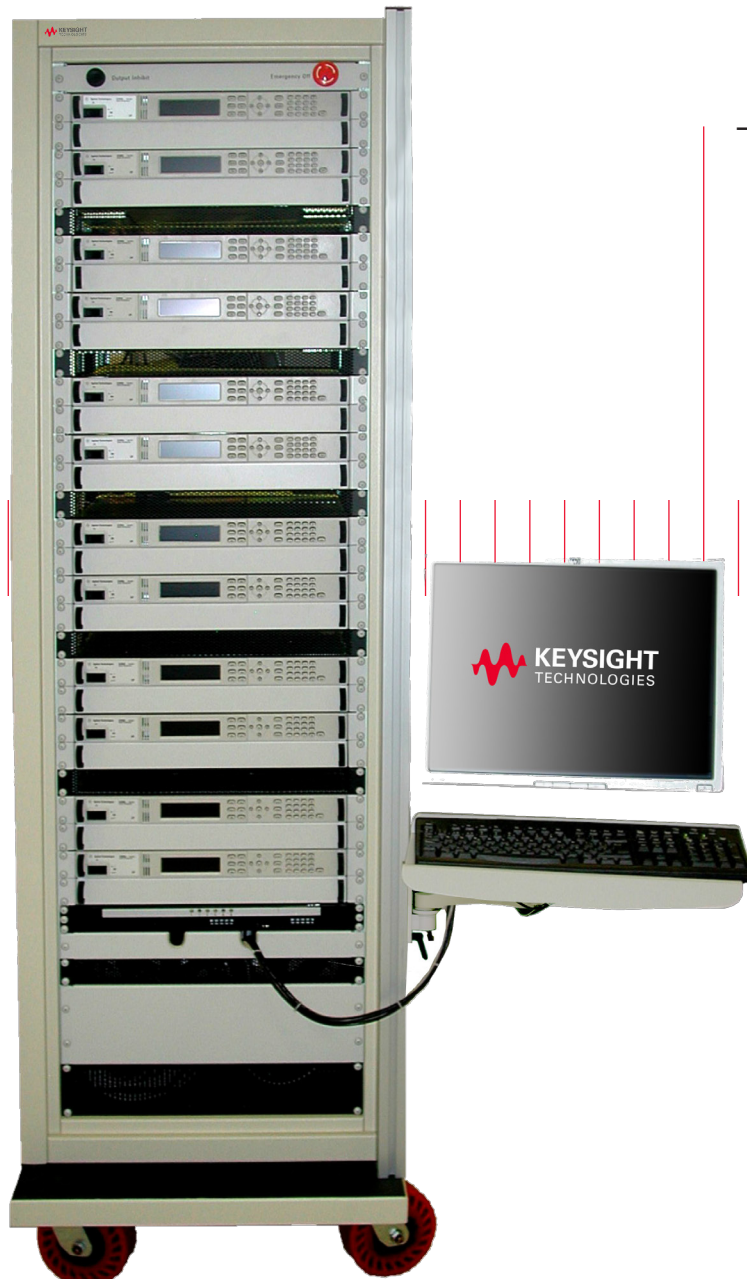
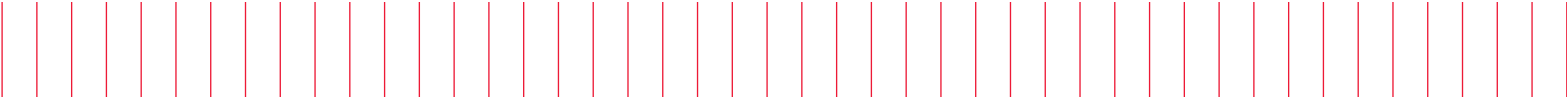


Keysight Technologies Solar Array Simulator System

Technical Overview





Introduction

The Keysight Technologies Solar Array Simulator (SAS) System provides precise, fast, and cost efficient simulation of multiple segment solar array output characteristics. The simulator is able to work with voltage regulation topologies including:

- MPPT – Maximum Peak Power Tracker
- Sequential Shunt Regulation
- Series Switch Regulation
- Direct Connection

A typical SAS system contains between 12 and 100 power output modules with each module capable of simulating a single string, segment or solar module. The power output modules can be grouped in collections consistent with the solar array architecture.

System Simulation for Space Based Solar Array Applications

The system structure offers the following:

- Outstanding modularity for dynamic reconfiguration as array architecture changes from program to program
- Accurate simulation of any type of solar array
 - Small size - 2 outputs in 2U of rack space
 - High output power – up to 600 W per output
 - Fast I-V curve change and fast recovery switching time
- Exceptional MTTR (Mean Time To Repair) including individual module service and calibration, ensuring maximum uptime availability

Multi Mode Simulation to Meet Test Requirements

Solar array simulation

Solar panels consisting of multiple solar arrays provide power to satellites. They have unique I-V characteristics. Since the output power of a solar array varies with environmental conditions (i.e. temperature, darkness, light intensity), a specialized power supply like a solar array simulator must be used for accurate simulation. As the trend moves toward higher power solar panels, there is a need for higher power solar array simulators or a larger number of solar array simulators to supply the additional power needed to simulate these higher power solar panels. Rack space is thus becoming a premium. Satellite designers and manufacturers want to quickly and accurately simulate real world conditions placed on a satellite's solar panel in orbit and they want to reduce the size of their test racks by using smaller, higher density solar array simulators.

In two rack units, an E4360A can provide 1200 W resulting in a single rack as shown on the cover page, providing 14.4 kW of power.

Multiple simulation modes

The E4360 SAS modules provide three operating modes, Simulator, Table and Fixed modes.

To accurately simulate the I-V curve of a solar array, use simulator or table mode. When a standard power supply is needed, use fixed mode.

1. Simulator mode:

The E4360 Series SAS internally generate a 4,096 I-V point table for each output channel. An internal algorithm is used 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:

- Voc – open circuit voltage
- Isc – short circuit current
- Imp – current at the peak power point on the curve
- Vmp – voltage at the peak power point on the curve

2. 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 4000 points. A point corresponds to a specific value of I and V. The SAS then automatically calculates an internal table from the user defined points. As many as 30 tables may be stored in each of the E4360A SAS built-in volatile and non-volatile memories. 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. Additionally, current and voltage offsets can be applied to the selected table to simulate a change in the operating conditions of the solar array.

3. Fixed mode:

This is the default mode when the unit is powered on. The unit has the rectangular I-V characteristics of a standard power supply and can automatically correct between constant voltage (CV) and constant current (CC) modes.

SAS Monitor and Control Software

Custom applications suite of software included with Z2094B

The monitor and software control application consists of three (3) major components:

- SAS Self Test
- SAS Monitor and Event Log
- System Level SCPI Remote Interface

SAS self test

System self test performs internal diagnostic tests for all mainframes, modules, and additional instruments. OVP, OCP, isolation relay, digital port connections, fault/inhibit response, and more are retested with self test loads installed. All results are reported and logged for archival reference.

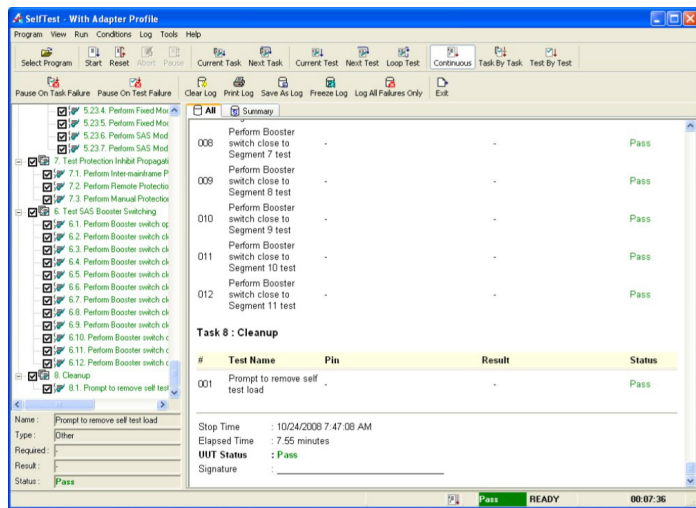


Figure 1. Self Test is an independent application that can run with the satellite connected or disconnected. Coverage is limited when connected to the satellite.

SAS monitor and event log

The SAS Monitor Application is a software suite that provides a complete configure, control, observe, and troubleshoot software package for use with the SAS system. The Monitor itself provides a graphical user interface that allows for easily observing the status of each of the Keysight E4360A mainframes in a system. It displays important details about each of the SAS modules, including its output state, output voltage, and current mode of operation.

Monitor status display

The screenshot shows the 'SAS Monitor' application window. It has a menu bar (File, Tools, Help) and a toolbar (Value, Stop, Options). The main area is a table with columns: Module Name, Module ID, State, Mode, Voltage, Current, Status, Condition, OVP, OCP, Max Voltage, Max Current, and Details. The table lists various modules and segments, including Module01, Module02, Segment02, Module03, Module04, Segment03, Module05, Module06, Segment04, Module07, Module08, Segment05, Module09, Module10, Segment06, Module11, Module12, Segment07, and Module13. The status for most modules is 'Disabled' or 'Fixed', while some are 'Enabled'. The bottom status bar shows 'localhost: 500' and 'Wait for Clear: 00'.

Figure 2. The Status Display is provided as part of the system. Custom displays can also be created using the SCPI library.

System level SCPI remote interface (Standard commands for programmable instruments)

The system level SCPI allows all of the SAS modules and subsystems to be programmed and controlled as a single system interface using a LAN connection. In addition, it provides a remote web interface to the system identical to the monitor and event logging application. The SCPI command set is in conformance with the SCPI Consortium 1999 standard. Details of this command interface can be found in the "Keysight Z2094B-103 Solar Array Simulator System Programmer's Reference." It utilizes TCP-IP and static addressing for remote communication.

The system supports the interface from NI-VISA, Keysight VISA, LabVIEW, C++ and C# programming.

Application specific simulations can be created using the tool available with the SAS SCPI interface. The interface allows multiple channels to be configured as groups and controlled by SAS lists. A series of list elements can emulate an eclipse, satellite rotation, partial occlusion by an approaching space craft, string failures, and other operational events.

Details of software applications are available in the following documents: SAS Monitor User's Guide Generic; Self Test User's Guide; and Keysight SAS Programmer's Reference.

SAS System Characteristics

System controller

The core system includes a ruggedized industrial PC (IPC), rack mounted in the SAS system controller. The customer may request custom configurations. Basic features include:

- Windows® operating system
- Multicore processor, DVD RW multi drive, and 500G hard drive
- 2 LAN ports, one for instruments, one for enterprise connection
- Monitor, mouse, and keyboard mounted on swing arm
- Drawer style KBD and integrated display

System software

The controller hosts the Solar Array Simulator System Control tools (14360A).

The Solar Array Simulator System Control tools (14360A) are a powerful addition that greatly simplify the programming and control of multiple E4360A instruments. It consists of three components: the Software Driver, the Configuration Wizard, and the Server Control with Web GUI. For more information refer to the URL: [Keysight 14360A Solar Array Simulator System Control Tools User Guide](#)

Output modules

Currently, Keysight offers any combination of the following output modules for configuration in the system as shown in the table below.

Cooling

The SAS system has been designed to maximize the cooling efficiency of the rack. Input air is routed from the front of the rack to the top and rear to maximize cooling and minimize acoustic noise.

Interconnect panel

The rack rear view below shows the Power Distribution Unit, LAN I/O, and the main system switching chassis with output interface.

Input power

Keysight offers complete systems including custom designed power distribution units (PDU) for your fully configured system. These systems typically require three phase power due to the high power demands of a large SAS system.

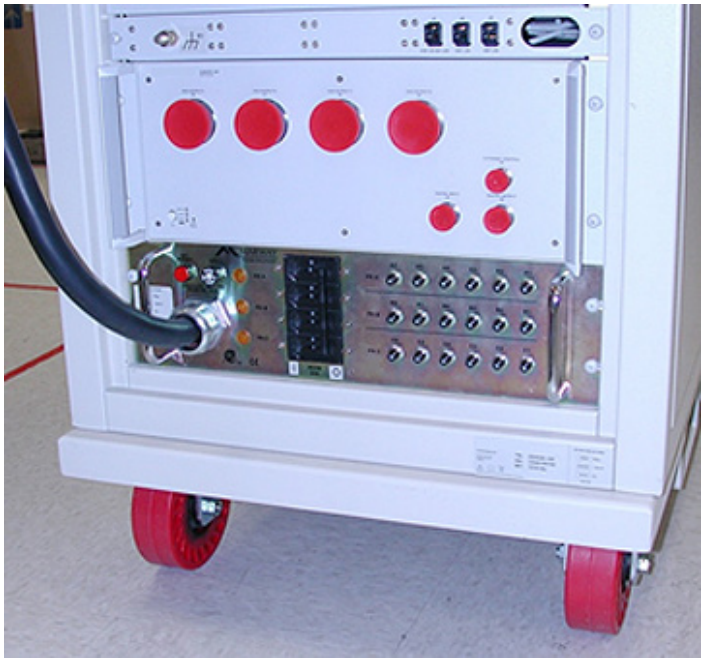


Figure 3. Input AC power and output SAS power connectors. PDU configured as three phase 208v at 60 Amps per phase or 360v at 60 Amps per phase.

Maximums For:	E4361A	E4361A- J01	E4361A- J02	E4361A- J03	E4362A	E4362A- J01	E4362A- J02	E4362A- J03	E4362A- J04	E4362A- J05	E4362A- J06	E4362A- J18
Power (Watts)	510	497.6	553.6	549.2	600	594	594	600	596.6	552.5	564.9	560
Open Circuit Voltage (Voc) Volts	65	58	75	85	130	117	120	108	170	95	180	150
Voltage Point Voltage (Vmp) Volts	60	53.5	69.2	78.5	120	108	110	100	157	87.7	166.2	140
Short Circuit Current (Isc) Amps	8.5	9.3	8	7	5	5.5	5.4	6	3.8	6.3	3.4	4
Circuit Point Current (Imp) Amps	8.5	9.3	8	7	5	5.5	5.4	6	3.8	6.3	3.4	4

See E4360A data sheet for more details: [Keysight E4360 Modular Solar Array Simulators Data Sheet](#).

SAS System Chassis – Z2091B-197

The Z2091B-197 SAS Chassis provides output disconnect relays and digital signal routing, conditioning and expansion for systems using Keysight's E4360A Solar Array Simulator (SAS) Mainframes and E4360 series Power Supply Modules. The chassis implements a parallel signal propagation scheme that is well suited to a system employing many E4360A mainframes.

In a multiple-rack system, the Z2091B-197 chassis are daisy-chained (see figure below). The triggers from the master mainframe in the primary rack are transmitted to the chassis in the secondary rack, then the tertiary rack, then back to the primary rack. Inter-rack propagation delays are on the order of nanoseconds. Within each rack, triggers are propagated in parallel to the mainframes in that rack.

Key features

- Fault Output signals from the SAS mainframe's frame will assert its digital port fault output signal which can be configured to shut down the entire system.
- Output Inhibit manual push-button on the rack
- "Expansion system" signals to coordinate multiple racks as a single system up to 100 strings (50 mainframes) are supported
- External switch can be used to inhibit the SAS outputs
- Programmatic inhibit signal - system software can inhibit the SAS outputs
- Optically isolated TTL level signal - the SAS outputs can be inhibited by a TTL input signal, which can be made active high or active low, level sensitive

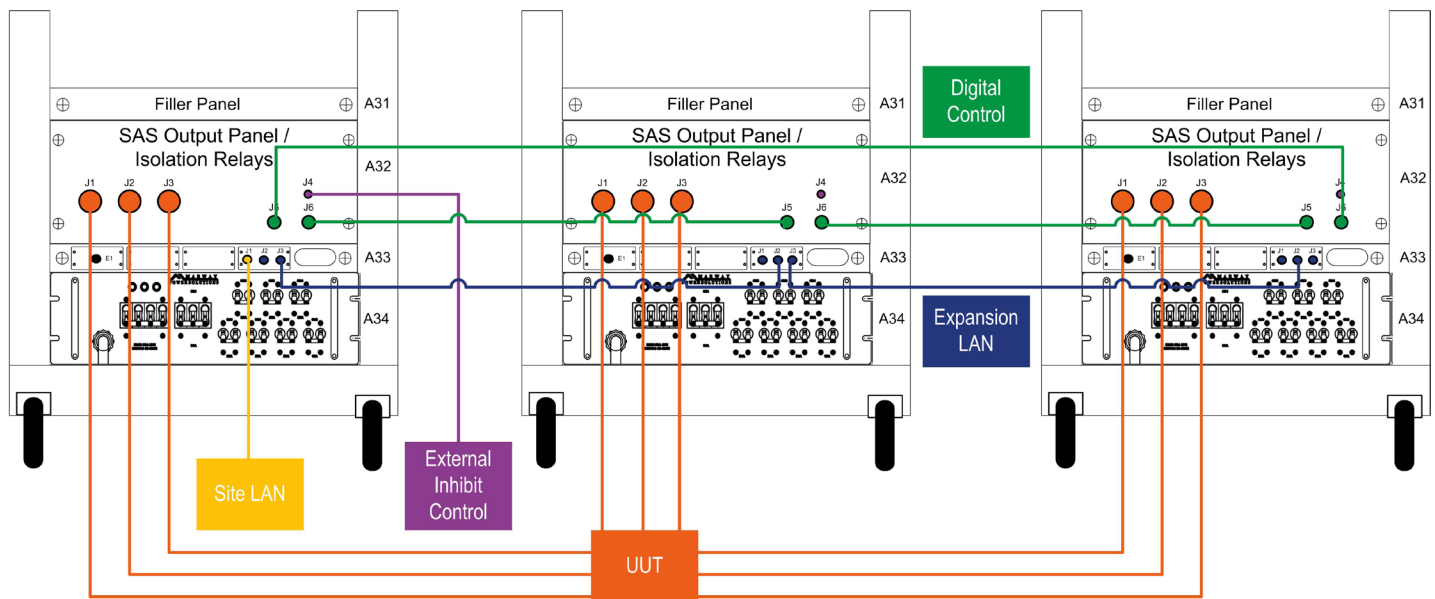


Figure 4. The block diagram above shows the interconnects between the UUT (Satellite), three SAS racks and the external LAN site and external inhibit control.

SAS System Ordering Information

Core solar array simulator system Z2094B-103

- Single 80" primary rack with PC controller and Z2091B-197 Switch Chassis
- Wiring infrastructure including power, networking, cooling, and output panel
- Supports up to 12 E4360A mainframes with up to 24 output modules at up to 600W each
- Suite of custom software applications (see below)
- Self Test adapters
- AC mains options
 - 120V/208V 60A 3-Phase
 - 230V/400V 60A 3-Phase

Expansion System Z2094B-104

- Single 80" secondary rack with Z2091B-197 Switch Chassis (requires primary rack with PC controller)
- Wiring infrastructure including power, networking, cooling, and interface panel
- Supports up to 12 E4360A mainframes with up to 24 output modules at up to 600W each
- Self Test adapters
- AC mains options
 - 120V/208V 60A 3-Phase
 - 230V/400V 60A 3-Phase

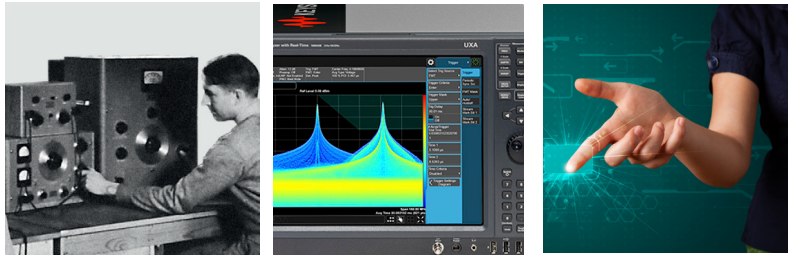
SAS monitor and control software included with primary rack

- Custom software applications for E4360A series equipment and Z2091B-197 Switch Chassis
- Rigorous Self Test – requires test adapters included with primary and secondary racks
- Remote interface – controls the SAS system from a secondary LAN with a PC anywhere in the world
- Status and parameter monitoring
- Easy development of custom sequences using intuitive script files
- Compatible with Windows 7™ 64-bit, 32-bit

The Z2094B SAS System is designed for easy customization and expansion for specific environments.

Evolving

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