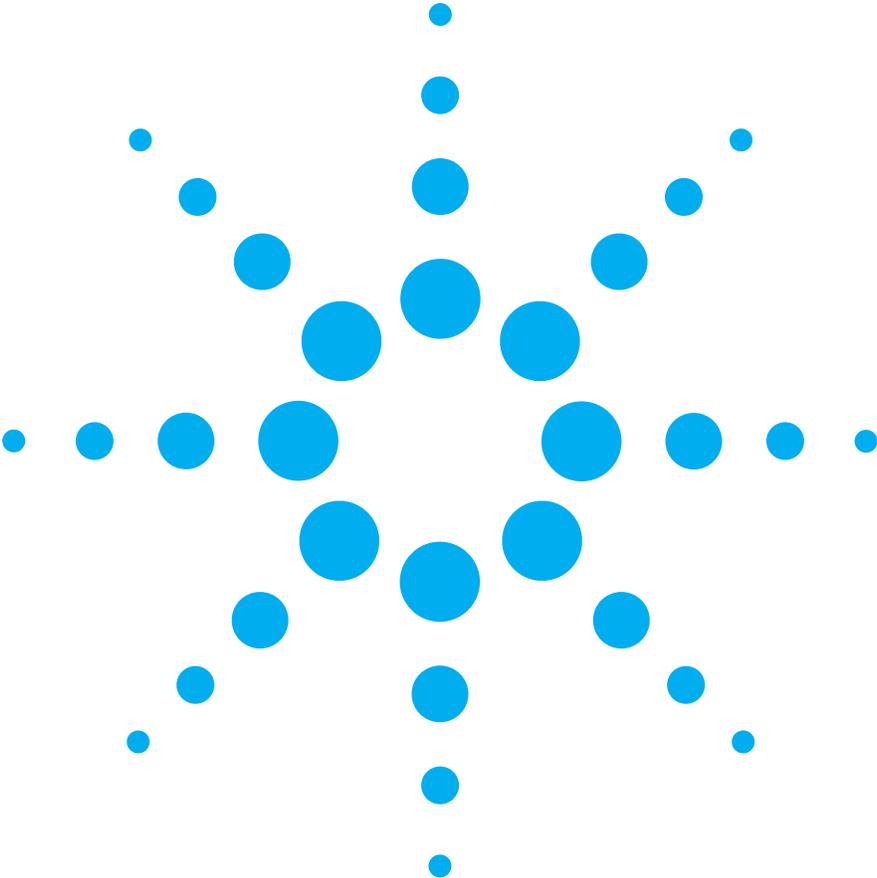


Side-by-Side Comparison

Agilent E435xB Solar Array Simulator and Agilent E436xA Modular Solar Array Simulator

Application Note



Introduction

The Agilent Technologies E4350B and E4351B solar array simulator (SAS) DC power sources have been providing excellent solar array simulation to the satellite industry for many years. Changes that have occurred during this time period in the industry, in power supply design, and in interface technology have prompted Agilent to create a new line of SAS power products: the Agilent E4360A, E4361A, and E4362A modular solar array simulator DC power

sources. These new SAS models provide many of the same functions and capabilities of the previous SAS models while adding more functionality and even more power in a smaller size package.

This application note provides a comparison between the older E435xB SAS and the new E436xA SAS models. Mechanical, electrical, and programming attributes are just some of the main topics

discussed in the comparison. Note that while this comparison provides a great deal of detail on the similarities and differences between these models, some operational details are beyond the scope of this note. The user's guide for each product should be consulted for further details.

Older E435xB series



1 output/3U height
480 W/output
(480 W total)

Newer E436xA series



2 outputs/2U height
Up to 600 W/output
(1200 W total)

Figure 1. The new E436xA mainframe/module SAS has 3 times the output density and 3.75 times the power density of its predecessor, the E435xB SAS

Table 1. A comparison of some of the key general attributes of the two SAS model series

	Previous models (individual stand alone products)		New models (modules to be installed in a mainframe)	
	E4350B	E4351B	E4361A	E4362A
Mainframe height	3U	3U	2U	2U
Outputs/mainframe	1	1	2	2
Outputs/1U of rack height	0.33333	0.33333	1	1
Maximum power	480 W	480 W	510 W	600 W
Power density	160 W per 1U	160 W per 1U	510 W per 1U	600 W per 1U
Maximum open circuit voltage	65 V	130 V	65 V	130 V
Maximum short circuit current	8 A	4 A	8.5 A	5 A
Interface(s)	GPIB	GPIB	LAN, USB, GPIB	LAN, USB, GPIB

Key General Attributes

One of the most notable differences between these two series of SAS products is the number of outputs per unit of height, and consequently, the amount of available power per unit of height. The older E435xB models have a single output in a 3U (~5.25 inches) high package at 480 W of power while the new E436xA models consist of a more compact

mainframe/module system. The new E4360A mainframe is only 2U (~3.5 inches) high and can contain 2 power modules, each of which is of even higher power than its predecessor with up to 600 W per output. Therefore, the output density of the new E436xA SAS is three times that of the older E435xB models since 6 power supply outputs

can fit in the same space previously occupied by only 2 outputs. See Figure 1. Additionally, the power density of the E436xA is up to 3.75 times that of its predecessor with up to 600 W per 1U of rack space as compared to 160 W per 1U. Refer to Table 1.

Comparing Electrical Performance

While much of the electrical performance of the newer E436xA series is similar to that of the older E435xB series, there are some significant differences. As noted in Table 1, the maximum open circuit voltage for the models in each series is the same, but the maximum short circuit current of the newer models is higher. Consequently, the maximum power of the newer models is also higher. Some of the other similarities and key differences are noted in the following paragraphs.

AC input voltage

Both series of SAS products can be operated from any single phase AC power line (for example, 100 VAC, 120 VAC, 230 VAC, etc.). However, the older E435xB series required the user to remove the cover and move jumpers in order to change the AC input line voltage. The new E4360A mainframe has a universal AC input with power factor correction, enabling it to operate from any standard AC line voltage without the need to change anything on the product. However, when operating at the lower AC input line voltages (100 VAC or 120 VAC nominal)

with 2 modules installed, the E4360A mainframe limits the output current of the modules to one-half of their ratings in order to avoid exceeding the current rating of a standard AC mains outlet. If just one module is installed in the mainframe, full output power and current are available from that module at any AC input voltage.

AC input power and efficiency

In many SAS applications, many power supply outputs are required; for example, sometimes 98 outputs. Consequently, AC input power and efficiency considerations are important. As mentioned earlier, the newer models have a much higher power density than the older models: up to 3.75 times the output power in the same rack space. Additionally, the newer models have greater efficiency than the older models and therefore consume less power from the AC mains. At full power out, the older E435xB series was rated at 1380 VA input power per output while the newer E4360A mainframe will draw up to 2000 VA total for 2 outputs resulting in only 1000 VA of input power per single output. Note that the newer models have *lower input power* requirements per output despite their *higher output power* capabilities. Additionally, the inrush current of the newer models is significantly lower.

Parallel operation

When higher output current or output power than is available from a single output is required, outputs can be placed in parallel. Up to 3 identical models of the older E435xB series could be placed in parallel, while up to 4 identical modules of the new E436xA can be placed in parallel.

Series operation

When higher output voltage or output power than is available from a single output is required, outputs of the older E435xB series can be placed in series. No output terminal may be more than ± 240 V from chassis ground. Putting outputs of the newer E436xA in series should be avoided.

Chassis grounding the output terminals

Both series of SAS products have floating output terminals. The outputs can float ± 240 V from chassis ground. Either the plus or minus output terminal of the E435xB series may be connected to chassis ground. On the E436xA series, either output terminal may be connected to chassis ground; however, the plus output terminal should not be connected to chassis ground if the output voltage is repeatedly changing as is the case in a shunt regulator application. The minus output terminal may be connected to chassis ground in these types of applications.

Output capacitance

Since most SAS configurations require the power supply outputs to operate in constant current mode, it is important for the output capacitance inside the power supply outputs to be low. Both the old and new SAS series have low output capacitances: <100 nF for the 65 V models and <50 nF for the 130 V models. If needed, up to 2000 μ F can be added externally to the output of either series.

Output protection

In SAS applications, protecting the device under test is imperative. Therefore, extensive output protection is implemented on the SAS power supply outputs. Over-voltage, over-current, and over-temperature protection is implemented on both series of SAS products. When the over-voltage trips on either series, an SCR (crowbar) across the output turns on to bring the output voltage down as quickly as possible (in less than 100 μ s).

Over current protection considerations

On the older E435xB products, there are two types of protection used for over current: over-current protection (OCP) and over current (OC). OCP works only in Fixed mode (it is disabled in Simulator

and Table modes) and behaves similarly to the standard OCP available on many Agilent power supplies. When OCP is enabled (with Current:Protection:State command), it turns the output off when the output transitions into CC (constant current) mode using the current limit setting. Momentary transitions into CC mode as a result of programming an output change (not due to a load change), such as changing the output voltage from a lower value to a higher value, can be ignored thereby preventing nuisance tripping of the OCP by using a delay setting (set with Output:Protect:Delay command). Alternatively, OC works in all modes on these older E435xB products. When activated, it turns the output off and fires the SCR (crowbar) that is across the output. It is set to a level (with Current:Protection:Level command) that is independent of the current limit setting.

On the newer E436xA products, there is only one type of protection used for over current. While it is called OCP, it behaves exactly the same way as the OC behaves on the older E435xB products. That is, it works in all modes and is always enabled. When activated, it turns the output off and fires the SCR (crowbar) that is across the output. The OCP level is set on the

E436xA products using the same command used to set the OC level on the E435xB products (Current:Protection:Level command). The Current:Protection:State and Output:Protection:Delay commands do not exist on the newer E436xA products.

Maximum load lead drop

Remote sensing is an important feature to use when trying to regulate or measure the voltage with a load located at a distance from the power supply output since it compensates for the voltage drop in the load leads. The maximum voltage drop allowed in the load leads for either series is dependent upon the operating mode and settings: it is 2 V total in Fixed mode and $2\text{ V} + (V_{OC} - V_{mp})$ in SAS (Simulator) and Table modes where V_{OC} is the open circuit voltage setting and V_{mp} is the maximum power voltage setting.

Current sinking capability

When a power supply has the ability to sink current, it can more quickly reduce its output voltage when the setting changes from a higher value to a lower value or during a current load transient that causes the output to rise temporarily. Both the older E435xB and new E436xA power supplies can sink current: about 420 mA in Fixed mode and about 350 mA in SAS (Simulator) and Table modes.

Output current derating at higher operating temperatures

The operating temperature range of both series of products is 0 to 55°C with the output current derated when operating between 40 and 55°C. Above 40°C, the E4350B output current is derated 0.1 A/°C and the E4351B output current is derated 0.05 A/°C. On the newer series, above 40°C, the E4361A output current is derated 0.11 A/°C, while that of the E4362A is derated 0.063 A/°C.

Evaluating the Interface and Programming Capabilities

As was true for the electrical performance, there are similarities and differences in the interface and programming capabilities of the older E435xB series and newer E436xA series. Table 2 compares some of these capabilities while others are discussed in the text of this section.

SCPI and channel lists

Both series use SCPI programming, however, one of the main differences is a result of the newer series being comprised of multiple modules (outputs) loaded in a mainframe while the older series had one output per box. Due to the multiple modules used in the E436xA, a channel list is used when a channel specific command is sent to the mainframe to identify to which channels the command is intended.

Table 2. A comparison of some of the key interface and programming capabilities of the two SAS model series

	E435xB series (older models)	E436xA series (newer models)
SCPI	✓	✓
GPIB interface	✓	✓
Serial link	✓	
LAN and USB interfaces		✓
Built-in Web server		✓ (via LAN only)
Fixed, SAS (Simulator) and Table modes	✓	✓
VXI plug&play driver	✓	
IVI-COM driver		✓
Save/recall non-volatile states	5 (Fixed mode only)	2 total for the mainframe
Turn-on conditions upon AC powerup	User selectable between reset values or user defined values	User selectable between reset values or user defined values
Average command processing time	20 ms	<2 ms

For example, to set the voltage of channel 2 of an E4360A to 5 V, the command “VOLT 5, (@2)” would be used where the “,@2)” specifies channel 2. Note that a list of channels can be used here, such as “VOLT 5, (@1:2)” to set the voltage to 5 V for channels 1 and 2. For the E4360A, if the channel list is omitted in a channel specific command (for example, “VOLT 5”), the channel will be assumed channel 1 and no error will be generated. This channel list was not used with the older E435xB products.

Serial link

The older E435xB products have a serial link capability that allows individual control of up to 16 power supplies through one primary GPIB address (1 power supply as the direct unit and 15 linked supplies using secondary addressing). This capability does not exist with the newer E436xA products.

SAS, Simulator, and Table modes

The older E435xB series refers to the I-V curve simulation method using an exponential model to set V_{OC} , I_{SC} , V_{MP} and I_{MP} as “Simulator” mode. This is called “SAS” mode in the newer E436xA series. In the older series, the parameters for Simulator mode could be accessed only over the bus. In the newer series, these parameters are available from the front panel as well as over the bus. The same is true for Table mode. In Table mode, both series can have a total of 60 tables: 30 volatile and 30 non-volatile. Refer to Table 3 for a summary of SAS Table mode characteristics.

Response to *IDN? and *RDT?

The response to the *IDN? command is used to identify the product to which it is sent. The response consists of 4 comma separated fields: the company name, the model number, the serial number, and the firmware revision. For example, the E4360A response would be similar to this:

```
Agilent Technologies,E4360A,  
US43600010,A.00.01
```

Obviously, the model number, serial number, and firmware revisions can vary depending upon the product used.

Table 3. A comparison of the SAS Table mode characteristics

	E435xB series (older models)	E436xA series (newer models)
Total number of tables	60	60
Number of volatile tables	30 (4000 points max per table; 30,000 points total)	30 (4000 points max per table; no total point limit)
Number of non-volatile tables	30 (3500 points total)	30 (4000 points max per table)
Total I-V storage points	33,500 (point distribution subject to the numbers above)	No limit other than that which results from the numbers above

Since the new E4360A is a mainframe with multiple outputs installed as modules (channels), the modules themselves can be identified with the *RDT? command. For example, the E4360A response would be similar to this depending upon the modules installed:

```
chan 1:E4361A;chan 2:E4361A
```

External voltage programming of current (Fixed mode only)

Sometimes it is necessary to control the output current of a power supply using an externally generated signal. On both series of these SAS power supplies, there is an analog connector on the back that has +Ip and -Ip pins on it. 0 to -4 V applied from +Ip to -Ip on the analog connector corresponds to 0 to full rated output current enabling the user to set or offset the programmed current value through pins on this analog connector.

Appraising Mechanical Characteristics

The largest difference in these two series of SAS products is the mechanical packaging. As was mentioned earlier, the older E435xB series contains a single output in a 3U high package. The newer E436xA series consists of a mainframe/module system: the E4360A mainframe is a 2U high package and can accommodate 2 E436xA modules. Each module is a single output power supply yielding a total of two outputs per mainframe. The new series provides more outputs, each with more power in less space.

Front panel

The front panels of both series have the AC power switch, a display, and a keypad for control and numeric entry. The older E435xB series has voltage and

current setting knobs not present on the newer E436xA. The older E435xB display is a simple LCD without a backlight. The newer model display is a backlit graphics LCD with much more visibility and functionality. Both can show setting, measurement, and status data, however, only the newer E436xA display can show multiple channels at once and displays the menu driven user interface.

Rack mounting

Both series have been designed to be mounted in a rack. The E435xB series rack mount kits can be ordered (Agilent part number 5062-3977 or 5062-3983, with handles). The E4360A mainframe rack mount kit part number is E4360-60009 (option 908). Standard support rails are required for the E435xB series (part number E3663A), while the above mentioned rack mount kit for the E4360A includes all of the necessary hardware for rack mounting. Note that standard support rails for the E4360A should not be used since they block airflow.

Rear panel connectors

Table 4 compares the rear panel connectors of the two series of SAS products while Figure 2 shows the rear panels in photos. The primary differences are: the output connectors, the absence of serial link and the sense switch on the E4360A, and the addition of LAN and USB to the E4360A.

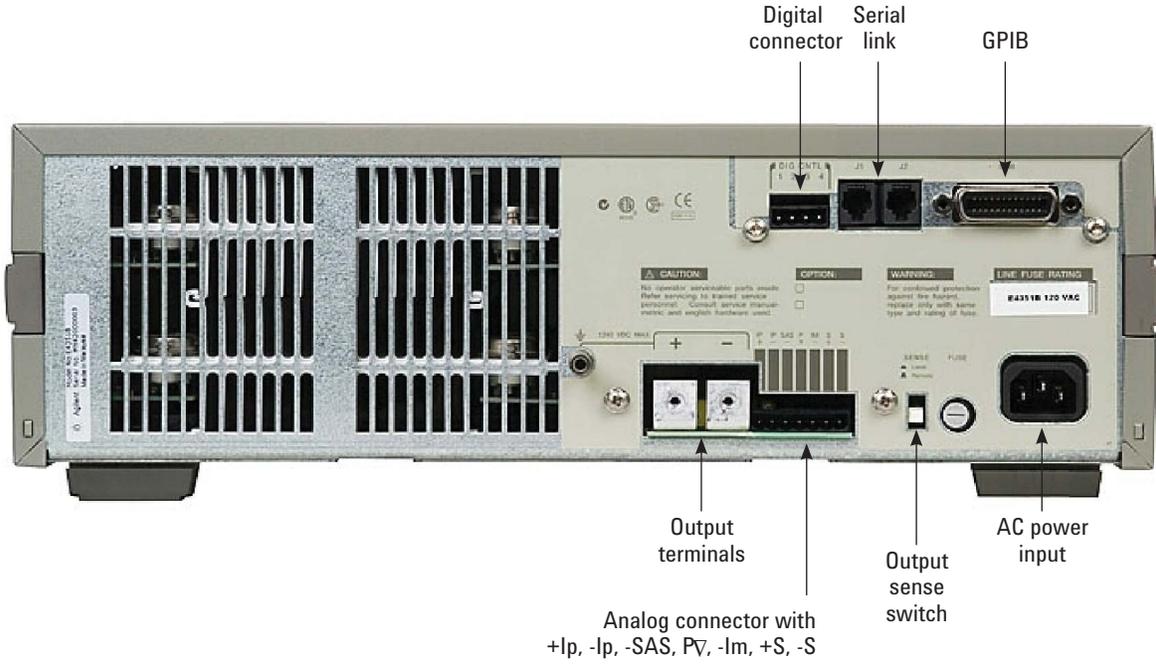
Table 4. A comparison of the rear panel connectors on the two SAS model series

	E435xB series (older models)	E436xA series (newer models)
AC power input	✓	✓ (on mainframe)
+Output, -Output connections	Busbar terminals	Part of a 5 pin connector including +S, -S, and +D (see diode terminal text below) (on modules)
Analog connector	✓ (includes +S, -S)	✓ (on modules)
Digital connector	✓	✓ (on mainframe)
Serial link	✓	
Output remote/local sense switch	✓	
Interface(s)	GPIB connector	LAN, USB, GPIB connectors (on mainframe)

Table 5. A comparison of some of the key mechanical features of the two SAS model series

	E435xB series (older models)	E436xA series (newer models)
Support rails required	✓	(part of rack mount kit)
Fan speed control	✓	✓
Airflow	In sides, out rear	In sides, out rear (with some air exiting the left side toward the front)
Operating temperature range	0 to 55°C (derate current between 40 and 55°C)	0 to 55°C (derate current between 40 and 55°C)
Height	132.6 mm (5.22 in.)	88.1 mm (3.5 in.)
Width	425.5 mm (16.75 in.)	432.5 mm (17.03 in.)
Depth	497.8 mm (19.6 in.) (with safety cover)	633.9 mm (24.96 in.) (including handles)
Weight (net)	25 kg (54 lbs.)	17.6 kg (38.4 lbs.) (E4360A with 2 modules installed)

Rear view E435xB



Rear view of E4360A mainframe with 2 modules installed

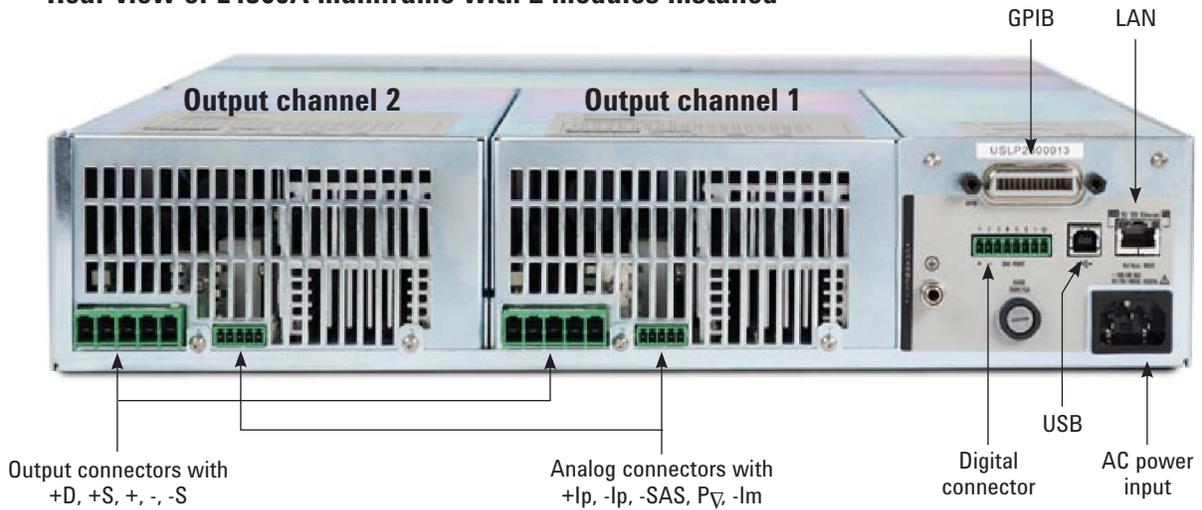


Figure 2. Rear views of the E435xB series and E436xA series

New for the E436xA SAS

Some new features and capabilities have been added to enhance the performance of these new E436xA solar array simulator products. These additions include:

Diode terminal added – optional use of an internal diode in series with + output

A built-in diode is included with its cathode connected to the +D terminal and its anode connected to the + output terminal. When the +D terminal is used instead of the + output terminal, this diode protects the output of the power supply module from reverse currents that can flow if a paralleled output or battery is connected to the output and the over-voltage protection trips on the module using the +D terminal.

Curve resolution setting– optimize for either higher resolution or faster update speed

The user can select from two choices for the internal table resolution to be used in SAS and Table modes. Choosing high resolution provides a smoother I/V curve (about 4000 points)

but takes longer to update (~350 ms). Choosing low resolution provides a less smooth I-V curve (about 240 points) and a much faster update rate (~35 ms). (Note that the E435xB resolution was fixed at about 4000 points and could take up to ~800 ms to update.) A faster update rate helps when simulating satellite spin.

Curve lists – List mode enables the generation of a succession of predefined I-V curves (SAS mode only) paced by user entered dwell times, bus triggers, or an externally generated trigger signal.

The user can create a list of up to 512 sets of points, where each set results in a different I-V curve for each output. A “set” of points consists of the four values needed to define an output curve in SAS mode, namely: V_{OC} , I_{SC} , V_{MP} , and I_{MP} . The curves are then paced by dwell times or trigger signals, again, selected by the user. Dwell times can be set up to 33554 seconds (with early firmware revisions, this was 65 seconds) with a best resolution of 1 ms. Programming using List mode enables the users to change curves more easily to better simulate an eclipse or satellite spin.

Channel grouping – two outputs connected in parallel can be configured (“grouped”) to behave as one output

For increased current and power capability, sometimes it is necessary to connect two outputs in parallel with each other. For convenience in controlling this parallel combination of outputs, the paralleled outputs within the E4360A mainframe can be grouped such that they are programmed as a single output. This capability is most useful if outputs are paralleled without using the System Control Tools. The user is still required to physically wire the outputs in parallel, but programming is greatly simplified.

More extensive digital I/O capability – external trigger and output coupling features are added along with active signal polarity control

The older E435xB series has a 4-pin digital connector providing either Fault/Inhibit or Digital I/O functions. To change the function of the pins on the connector, an internal jumper must be moved requiring the user to remove the instrument’s cover.

The newer E4360A has an 8-pin digital connector providing access to various functions. In addition to the Fault/Inhibit and Digital I/O functions available on the older models, the newer model includes external trigger in/out and output coupling state. Trigger in/out allows the user to configure the instrument to respond to a trigger input signal (for example, to initiate a measurement) or to generate a trigger output signal based upon a variety of events such as a measurement, data log timer, or dwell timer. The output coupling state allows the user to connect multiple mainframes together and have the output on/off state coupled across mainframes.

E4360A pins are configurable via commands (no jumpers or cover removal required) and the active signal polarity can be set by the user. One other difference between the old and new series is the way in which the Inhibit input works: on the older series, when the Inhibit input goes true, the output shuts down and latches off. On the newer series, the user can set this behavior to either latching off (like on the older series) or Off (the Inhibit input is ignored).

Built-in web server – LXI
Class C compliance includes a web server accessible via LAN.

Since the E4360A is an LXI Class C compliant instrument, it has a built-in web server. This built-in web server can be accessed from any standard PC web browser via a LAN connection between the PC and instrument. The E4360A web server enables the user to control and monitor the instrument directly from a PC. Note that the controlling/monitoring PC can be located anywhere that has LAN access to the E4360A instrument since only the IP address (or host name) of the E4360A is required.

System control tools – the
Agilent 14360A System Control Tools software is used to simplify the control of a large number of solar array simulator outputs in a system of E4360A SAS's and is included with all E4360A SAS instruments

The 14360A System Control Tools include a configuration wizard, a system driver, server

control, and an example application. The configuration wizard is used to create a configuration file that defines the details of the physical connections and intended use of the SAS outputs in the system. These details might include which outputs are connected in parallel as well as which outputs are "grouped" to be controlled together with a single command, greatly simplifying programming. The configuration file is used by the system driver commands to control the individual SAS outputs. The system driver can also be used on an "application PC" to control a "controller PC" (via server control) which, in turn, is sending commands directly to the individual SAS outputs.

Hardware trigger – enables the ability to effect an output change or take measurements synchronously across any number of preconfigured outputs

Using the hardware trigger, multiple outputs can be configured to do a variety of things. Some examples include: stepping through a curve list, taking a synchronized measurement on all outputs, or triggering a data-log on all connected mainframes. The trigger can also be used to synchronize list changes across multiple mainframes.

Summary

While the older E435xB series of SAS power supplies has served the satellite industry well for many years, the new E436xA series of SAS products goes even further in providing solutions. There are many similarities between these two series of products, but numerous improvements have been made in the creation of the latest family. The newer E436xA series of

products is the next generation of solar array simulators from Agilent Technologies. This new series offers 3 times the output density and 3.75 times the power density of its predecessor, the E435xB. In addition to these improvements in density, the additions of a LAN interface, hardware triggering, and the system control tools software will surely enable this new SAS product to meet the needs of the most stringent solar array simulation application.



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