

# Solar Array Simulation System Integration

## Technical Overview

When laying out the design of an E4360A solar array simulator (SAS) system, steps can be taken up front to ensure proper and reliable system operation. Pay special attention to the following four areas of the design:

1. Racking the E4360A (SAS) main-frames
2. Heat considerations inside the rack
3. AC power requirements for the system
4. Other considerations



## Racking the E4360A SAS mainframe

When assembling the system with E4360A SAS mainframes, be careful not to block the air flow. The mainframe is 2U high; if you are using standard rails, they will cover a portion of the perforated vents on the side of the instrument and impede the air flow, causing the instrument to overheat. The manual gives specific instructions about how to rack mount the E4360A using rack kits sold with the instrument.

The E4360A has 2 different air flows:

- In the front of the E4360A, where the AC/DC inverters are, the air flow is from side to side. Therefore, when connecting two racks next to each other, be sure to leave a minimum of 3" spacing between two adjacent E4360A mainframes.
- The main cooling is from the sides to the rear. Therefore, it is important not to block the perforations on the sides and the rear exit. Using standard rack mount rails is not acceptable.

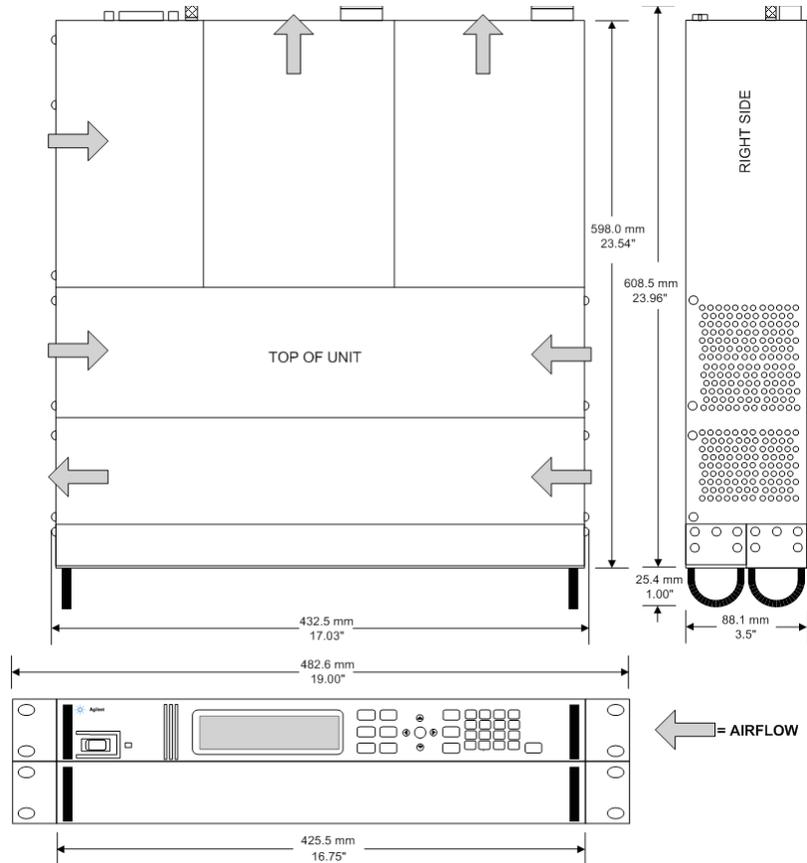


Figure 1. Airflow in a E4360A mainframe

This diagram shows how the rail kits are connected to the SAS mainframe and to the rack. See the user guide for more information.

<http://cp.literature.agilent.com/litweb/pdf/E4360-90001.pdf>

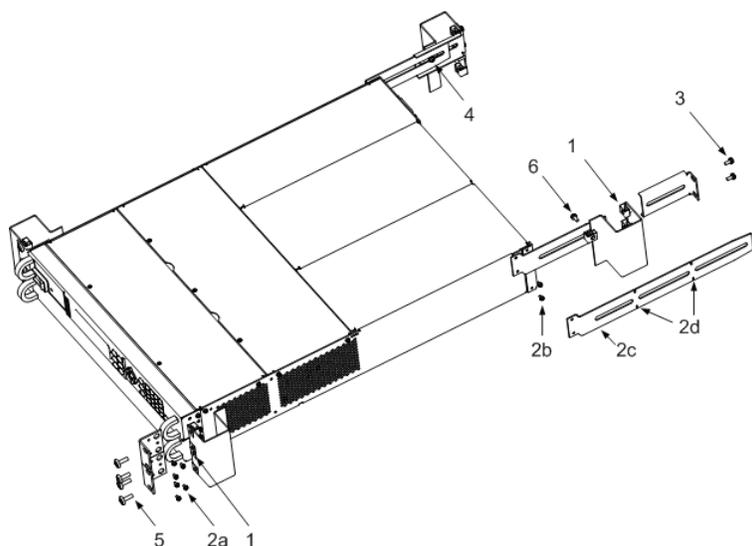


Figure 2.

## Heat considerations

The main heat source inside the rack is the heat generated from the E4360A SAS. This power supply has a DC/DC converter front end with a linear regulation output that allows it to generate the fast response time required. There are two outputs (modules) in each E4360A mainframe. Each output is capable of generating 600W to the load for a total of 1200W in 2U of rack space. Since the internal regulator is a DC/DC converter with a linear post regulator, heat dissipation inside a module is dependent on the load.

### Power dissipation inside the rack

*The power dissipation inside a module can be calculated as follows:*

$$P_{\max} = [ \{ (V_{oc} + 10 \text{ V}) - V_{out} \} \times I_{load} ] / 0.82 \text{ (0.82=DC/DC converter efficiency)}$$

As an example, let's assume we use an E4362A module at the following conditions:

$$\text{Max } V_{oc} = 130 \text{ V}, V_{out} = 90 \text{ V}, I_{out} = 5 \text{ A}$$

Then

$$P = [(130+10) - 90] \times 5 / 0.82 = 304.8 \text{ W}$$

This is the power dissipated inside the module. In addition to the power dissipated in each module, the mainframe also dissipates about 170 W from the inverters, bias supply and fans.

The power dissipation of two modules and the mainframe is:

$$P = (2 \times 304.8) + 170 = 779.6 \text{ W}$$

If there are 10 E4360A mainframes, the total power dissipated inside the rack is:

$$P_{total} = 779.6 \times 10 = 7796 \text{ W}$$

### Sequential shunt regulation

*The power dissipation inside a module can be calculated as follows:*

Assume the output voltage changes from  $V_{mp}$  to  $V=0$  at  $I_{sc}$ .

For example  $V_{mp} = 100 \text{ V}$ ,  $\text{Max } V_{oc} = 130 \text{ V}$ ,  $I_{sc} = 5 \text{ A}$  and the switching frequency is 10 kHz at a 50% duty cycle, the power dissipation in a module is then:

$$P_{short} = [ \{ (130+10) - 0 \} \times 5 ] / 0.82 \times (1-0.5) = 427 \text{ W}$$

$$P_{vmp} = [ \{ (130+10) - 100 \} \times 5 ] / 0.82 \times 0.5 = 122 \text{ W}$$

$$P_{total} = 427 \text{ W} + 122 \text{ W} = 549 \text{ W}$$

The overall power dissipation for two modules and a mainframe in the above example will be:

$$P_{mainframe} = 2 \times 549 + 170 = 1,268 \text{ W}$$

If there are 10 E4360A mainframes in the rack, the total power dissipation in the rack is:

$$P_{total} = 1268 \times 10 = 12,680 \text{ W}$$

### Power dissipation in maximum peak power tracking (MPPT)

*In MPPT, the power dissipation per module is as follows (same conditions as in above example):*

$$V_{mp} = 100 \text{ V}, I_{mp} = 5 \text{ A}, \text{Max } V_{oc} = 130 \text{ V}$$

$$P = [ (130+10) - 100 ] \times 5 / 0.82 = 244 \text{ W}$$

For a mainframe with two modules, the overall power dissipation is (same conditions as in above):

$$P_{mainframe} = 2 \times 244 + 170 = 658 \text{ W}$$

If there are 10 mainframes in the rack, then the total power dissipation in the rack is:

$$P_{total} = 658 \times 10 = 6,580 \text{ W}$$

## Extracting the heat out of the rack

When you integrate a system with multiple mainframes, Agilent strongly recommends leaving 1U of rack space between mainframes to draw in outside air.

Once the system is configured, the number of mainframes is known, the type of modules and type of regulation are decided upon, then you should calculate the total power dissipated inside the rack. You can then decide the type and number of fans required to keep the temperature inside the rack within the operating temperature of the modules (40 °C without current derating). If you assume the ambient temperature outside the rack is 25 °C, the delta temperature inside the rack should not be greater than 15 °C. To calculate the fan cubic feet per minute (CFM), use the following formula:

$$\Delta T = [1,76] \times \frac{\text{watts dissipated}}{\text{CFM}}$$

Where watts dissipated is the total power dissipated in the rack. For many systems with multiple SAS mainframes, it is required to have multiple fans to keep the maximum temperature rise inside the rack to less than 15 °C.

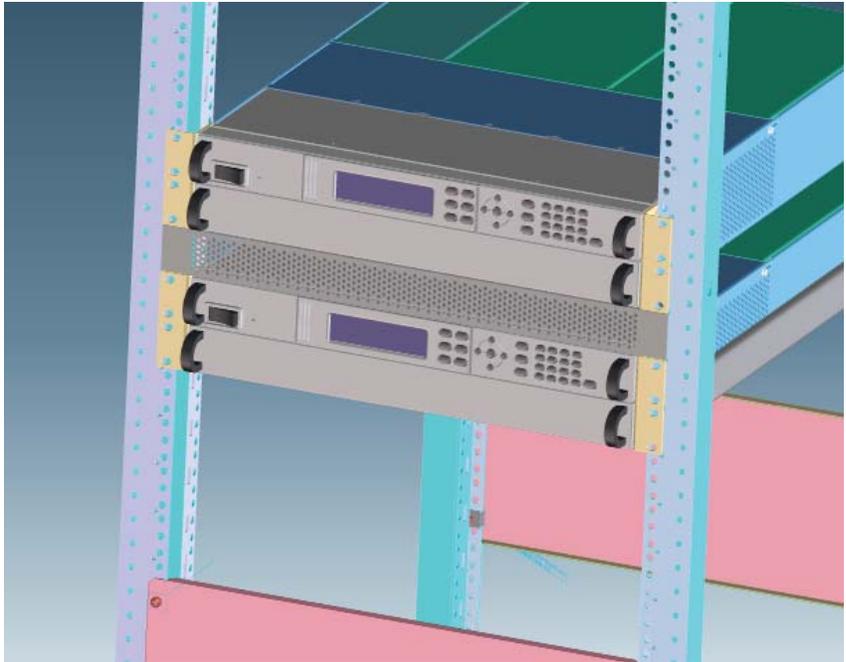


Figure 3. This drawing shows a rack with 1U of rack space between mainframes to draw in outside air.

## AC power requirements

To get maximum power from the SAS modules, the AC input voltage should be  $>180 V_{AC}$  (see specifications). When a 2m rack is fully populated with SAS mainframes (12 mainframes), it is important to size the AC input appropriately for voltage and current. Most designs will require  $208V_{AC}$  (or  $220 V_{AC}$ ), 3-phase. Depending on the number of SAS mainframes, one AC line drop of 30A/phase may be enough. Under other circumstances, two AC line drops may be required. You will need a power distribution unit (PDU) that will power the SAS (single phase) and will balance the load on the phases. It is important that:

- The AC line is rated appropriately to handle the current required by the system.
- The AC line drop is 3-phase with properly rated current
- You use a PDU to distribute the AC to individual mainframes and balance the load on each phase to meet your local code requirements.
- As always, make sure to follow the regulatory requirements in your region.

## Other considerations

1. If the rack is to be moved, it is important that it is stable and will not flip over when going up a small ramp (15 degrees). To prevent toppling, add a ballast at the bottom of the rack to provide stabilization.
2. In general, when the air flow is from bottom to top and different instruments are mounted in the rack, it is important to place the deepest instrument at the bottom of the rack. Otherwise, the deeper instruments will interfere with hot air rising, which can lead to hot spots.

In the SAS system, the air flow is from front to rear taking advantage of the 1U spacing between the mainframes.

3. It is important to have enough perforation on the rear door of the rack for the hot air to exit. Sometimes, it is necessary to have perforations on the side of the rack to bring in cool air.
4. Cabling inside the rack should be dressed in such a way to be out of the air flow path. Otherwise overheating may occur.
5. Safety is another important factor in designing a system. You may want to have a red emergency button, mounted in an easily accessible area on the front of the rack that when pressed, will shut off the power to the whole rack. In addition some local codes may require disconnecting the AC power to the instruments when the rear door is open.

## Agilent System Integration Services

Agilent provides SAS custom integrated systems complete with software and secondary level protection, such as output isolation relays. If you are interested and would like a system quote contact Agilent at:

[www.agilent.com/find/contactus](http://www.agilent.com/find/contactus)

## Summary

This technical brief introduces you to important considerations when designing a SAS system. It is important to understand the heat sources inside the rack and how they can affect the operation and the reliability of the system. Be careful to keep the temperature inside the rack, under worst case conditions, to within the operating temperature of the instruments



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