



***ELGAR***  
**TerraSAS**  
**Solar Array Simulator**  
**Operation and Maintenance Manual**  
*Programmable Power Solutions*



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# Important Safety Instructions

Before applying power to the system, verify that your product is configured properly for your particular application.

 <b>WARNING</b>	<b>Hazardous voltages may be present when covers are removed. Qualified personnel must use extreme caution when servicing this equipment. Circuit boards, test points, and output voltages also may be floating above (below) chassis ground.</b>
 <b>WARNING</b>	<b>The equipment used contains ESD sensitive ports. When installing equipment, follow ESD Safety Procedures. Electrostatic discharges might cause damage to the equipment.</b>

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Ensure that the AC power line ground is connected properly to the Power Rack input connector or chassis. Similarly, other power ground lines including those to application and maintenance equipment *must* be grounded properly for both personnel and equipment safety.

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**WARNING**  
Risk of Electrical Shock



**CAUTION**  
Refer to Accompanying Documents



Off (Supply)



Direct Current (DC)



Standby (Supply)



Alternating Current (AC)



On (Supply)



Three-Phase Alternating Current



Protective Conductor Terminal



Earth (Ground) Terminal



Fuse



Chassis Ground

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## Product Family: Terra-Sas Operation and Maintenance Manual

### Warranty Period: One Year

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Telephone: 800-733-5427, ext. 2295 or ext. 2463 (toll free North America)  
858-450-0085, ext. 2295 or ext. 2463 (direct)
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2. When requesting an RMA, have the following information ready:
  - Model number
  - Serial number
  - Description of the problem

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**NOTE:** A returned product found upon inspection by AMETEK, to be in specification is subject to an evaluation fee and applicable freight charges.

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# **SECTION 1**

## **TERRASAS THEORY OF OPERATION**

This section provides the theory of operation and specifications for the Elgar TerraSAS PV Solar Simulator.

### **1.1 INTRODUCTION**

TerraSAS is an easily programmable system designed to simulate the electrical behavior of a photovoltaic array. The system provides a turn-key hardware and software approach to deliver all the functionality required to test the maximum peak power tracking (MPPT) characteristics of solar inverters and charge controllers. The ability to simulate any fill factor and material technology allows the system to characterize the inverter MPPT algorithm performance quickly and efficiently. Test software including items based on the Sandia National Labs “Performance Test Protocol for Evaluating Inverters Used in Grid-Connected Photovoltaic System” is incorporated to allow easy programming of the various test requirements.

The TerraSAS software allows modeling a PV panel from data normally found in the manufacturer data sheet. These parameters are Voc (open circuit voltage), Isc (short circuit current), Vmp (voltage at the maximum power point), Imp (current at the maximum power point),  $\beta_v$  (voltage temperature coefficient) and  $\beta_p$  (power temperature coefficient).

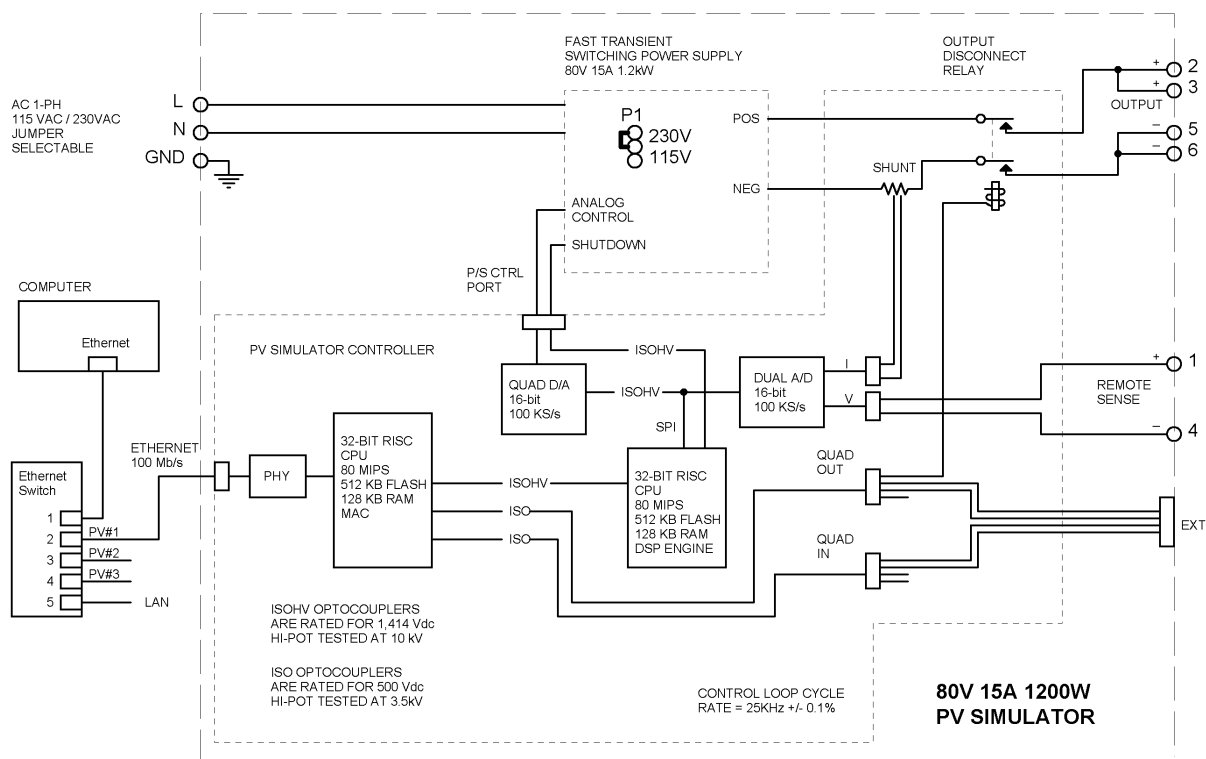
### **1.2 SYSTEM CONTROLLER**

The System Controller is a computer running Microsoft Windows 7. It is the primary interface for controlling the operation of the system and reading back measured data. The user interacts with the system through the controller’s LCD monitor and keyboard or remotely through the site network (LAN).

The System Controller communicates with one or more PV Simulators via its Ethernet port and Ethernet switch. On large multi-channel systems, the System Controller is equipped with an industrial grade Ethernet switch, which connects to the simulators. Up to 48 simulators can be connected to a single controller.

## 1.3 PV SIMULATOR ENGINE

The PV Simulator is the core of the TerraSAS simulator system. It receives IV curve data from the system controller and continually monitors and influences the output voltage and output current being delivered by its associated power source(s). See Fig. 1-1 below.



**Figure 1-1 TerraSAS 80V 15A 1200W PV Simulator block diagram**

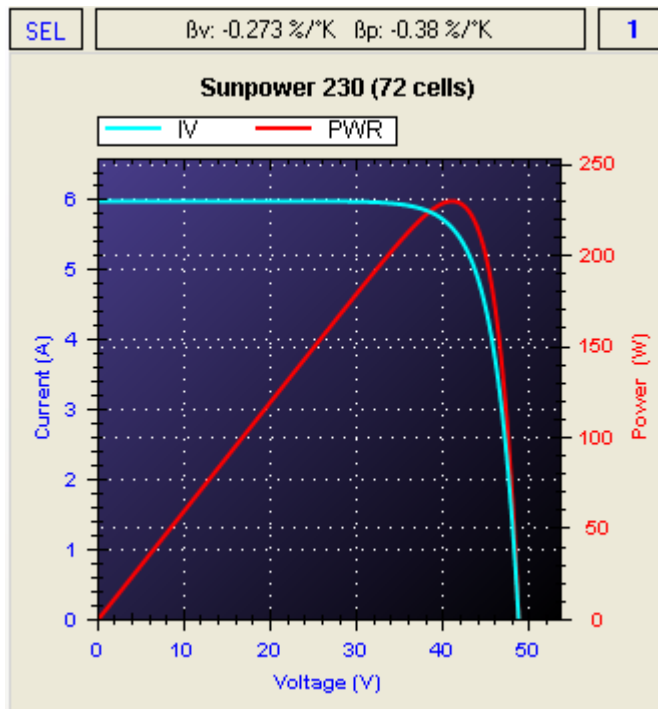
At the heart of the PV simulator are two 80 MIPS RISC microcontrollers.

One processor interfaces with a 16-bit measurement system that monitors the DC power supply's output voltage and current at 40  $\mu$ s intervals.

At each interval, the processor sends computed data to its 16-bit D/A control system that adjusts the power supply's analog input controls to precisely follow the IV curve loaded in curve memory.

The other processor is dedicated to the Ethernet interface and digital I/O.

While in Static Simulation mode, the PV Simulator executes a single IV curve. A typical PV panel IV curve is shown in Figure 1-2 below.



**Figure 1-2 Example IV Curve**

In the PV Simulator system, an IV curve is represented by 1,024 data pairs or points. Each pair of values represents a single voltage / current point on the IV curve.

For any given voltage on the curve there is a corresponding current value. The PV Simulator retains the active curve in memory and continuously programs the power supply to respond to changes measured in output voltage and current.

The PV simulator interpolates the 1,024 points in its curve memory with 16-bit accuracy, delivering an actual curve resolution of 65,536 points.

## 1.4 DC POWER SOURCES

The DC Power source(s) used in the TerraSAS system are enhanced versions of Sorensen DCS80-15 and SGA600-XX power supplies. Modifications were made to improve the response time by a factor of 10, compared to standard catalog models. The new ETS1000 series, based on the SGA architecture, extends the maximum channel voltage to 1000V .

On DCS power supplies, mainly used on micro-inverter test systems, the PV controller is embedded into the power supply, providing a complete solution in a 1U chassis.

## 1.5 SYSTEM SPECIFICATIONS

*Performance specifications not explicitly listed in this document are not guaranteed.*

**Number of PV Simulator Channels:** 1

**Remote Control:** Ethernet

**Operating System:** Microsoft Windows 7

**Elgar Part Number:** 5609187-03 (System), 5609105-01 (PV Simulator)

**Control Computer:** DELL Latitude E5520, Elgar p/n 881-686-26

### AC Input

**Line voltage :** 200-240 V 50/60 Hz as shipped from the factory  
Jumper selectable to 100-120 V

### DC Output

**Open Circuit Voltage, Voc:** 0 - 80 VDC

**Short Circuit Current, Isc:** 0 – 15A (per channel)

**Maximum output power at MPP:** 1020 W at fill factor 0.85 (per channel)

### Accuracy

**Voltage:** 1% error of calculated curve formula at  $E > 250 \text{ W/m}^2$

**Current:** 2% error of calculated curve formula at  $E > 250 \text{ W/m}^2$

**Voltage Readback:** 0.2% of max voltage

**Current Readback:** 0.5% of max current

### Curve equations

Equations used to calculate the IV curves are found in Appendix A1 and A2 of the publication "Performance Test Protocol for Evaluating Inverters Used in Grid-Connected Photovoltaic System", October 2004, Sandia National Labs.

### PV Array Parameters

**Irradiance level:** 0 to 1999  $\text{W/m}^2$

**Temperature value:**  $-100^\circ\text{C}$  to  $+100^\circ\text{C}$

**Voltage level:** 0 to 80 VDC

**Current level:** 0 to 15A

**Voltage and power temperature coefficients:**  $-1.99\%/^\circ\text{C}$  to  $+1.99\%/^\circ\text{C}$

## **SECTION 2**

# **SYSTEM INSTALLATION**

This section provides specific information on system connections and installation requirements.

### **2.1 UNPACKING AND INSPECTION**

The shipping package should contain the following items:

- QTY 1 PV Simulator p/n 5609105-01
- QTY 2 Output mating connectors with 12 crimp type pins
- QTY 1 DELL Latitude E5520 complete with power adapter and power cord
- QTY 1 CISCO SD2005 5-port Ethernet switch with power adapter
- QTY 3 CAT-6 Ethernet cables, 7 ft (2.1 m) long
- QTY 1 TerraSAS Software install disk p/n 5609155-XX

After unpacking the TerraSAS package, inspect the contents for any obvious physical damage. If damage has occurred, contact the shipper of the hardware. If replacement parts are required, contact Ametek Customer Service at 1-800-733-5427, ext. 2295 or 858-450-0085, ext. 2295.

### **2.2 ENVIRONMENTAL REQUIREMENTS**

#### **2.2.1 Airflow**

Position the PV Simulators to allow unrestricted airflow. Air intake is located on the right side of the chassis. Exhaust is through the left and back sides of the chassis. Air intake of the computer is located on the bottom side, exhaust is through the back.

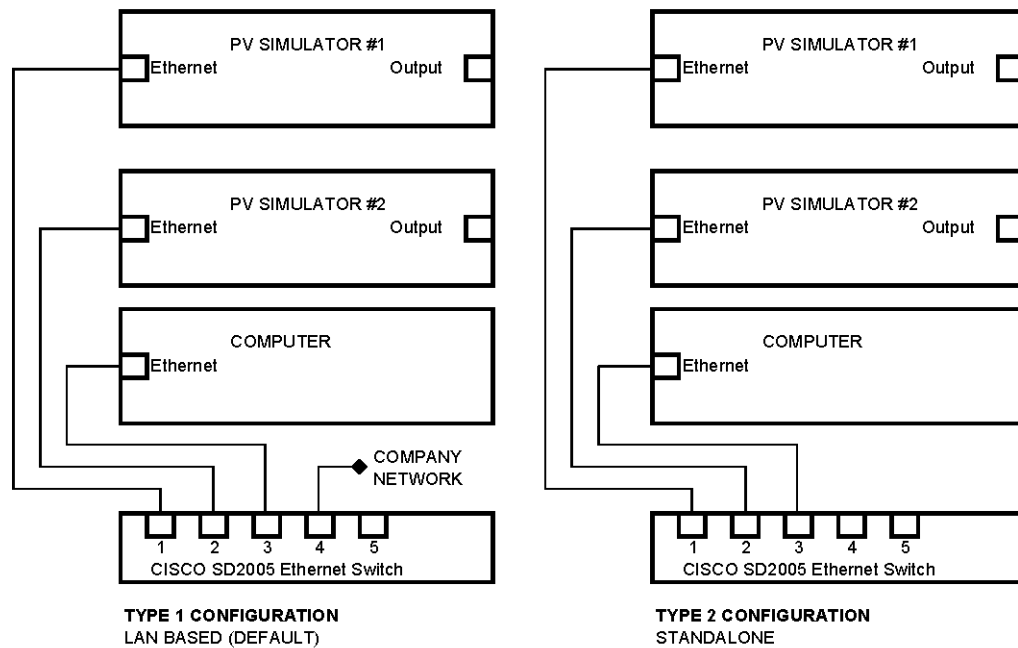
#### **2.2.2 Temperatures**

The maximum ambient temperature for the TerraSAS to meet full power specifications is 40°C. The ambient temperature range for normal operation is 0–40°C. The storage temperature range is –40°C to 70°C.

#### **2.2.3 Humidity**

The non-condensing humidity range is 0 to 85% at 25°C, de-rated to 50% at 40°C.

## 2.3 ETHERNET NETWORK SETUP

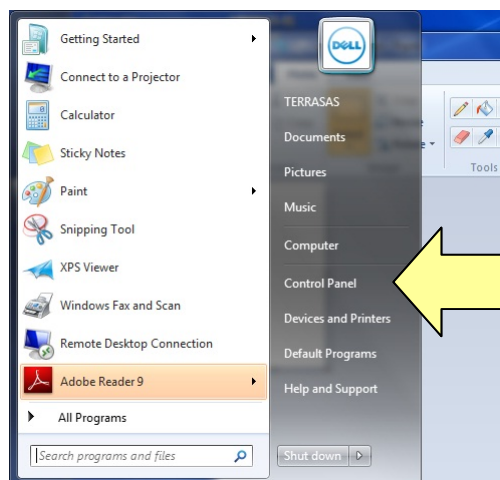


**Figure 2-1 Network connections**

The system is factory configured and ready to operate for a **TYPE 1** configuration. In this connection, the company network (LAN) provides the DHCP service that is required to assign Ethernet IP addresses to the computer and all PV Simulators.

If a local area network (LAN) is not available, it does not support DHCP or it is not desirable to connect the TerraSAS system to the network, perform the setup described below. This enables the TerraSAS internal DHCP server, which assigns IP addresses to the PV Simulators.

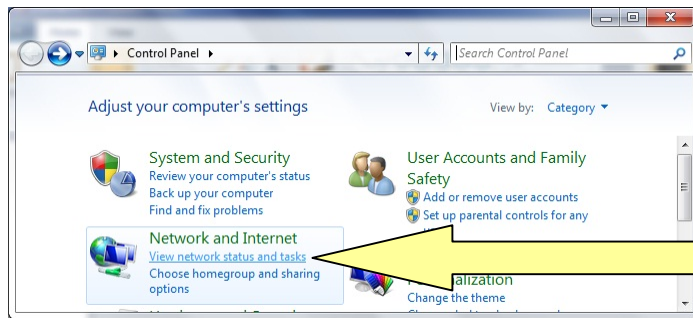
After connecting the components as indicated (right side in Fig. 2-1), turn off the simulators. Turn on the computer and perform the following:



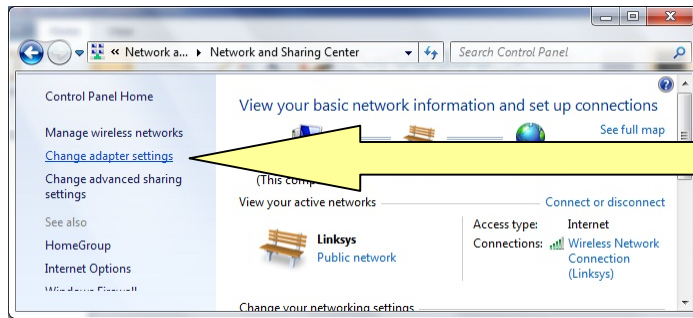
Click the Windows logo on the taskbar or press the key with the same logo on the keyboard (between the keys **Fn** and **Alt**, bottom left) to open the main Windows menu.

Click on the Control Panel tab to open the Control Panel.

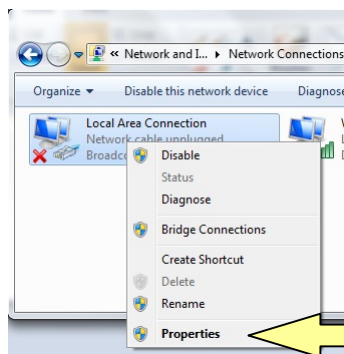




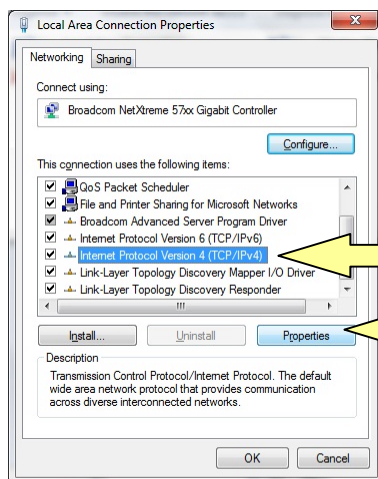
Locate "Network and Internet" and click on "View network status and tasks"



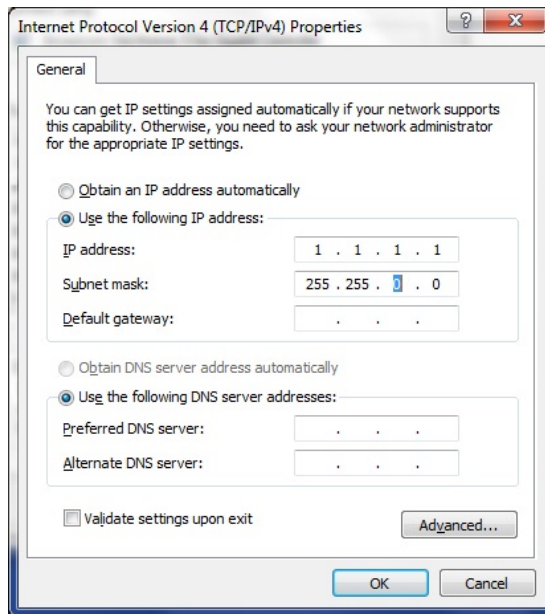
Click on "Change adapter settings"



Right-click "Local Area Connection" and select Properties.



Select "Internet Protocol Version 4 (TCP/IPv4)" and click on the Properties button.



Select as shown:

Static IP address

IP address: 1.1.1.1

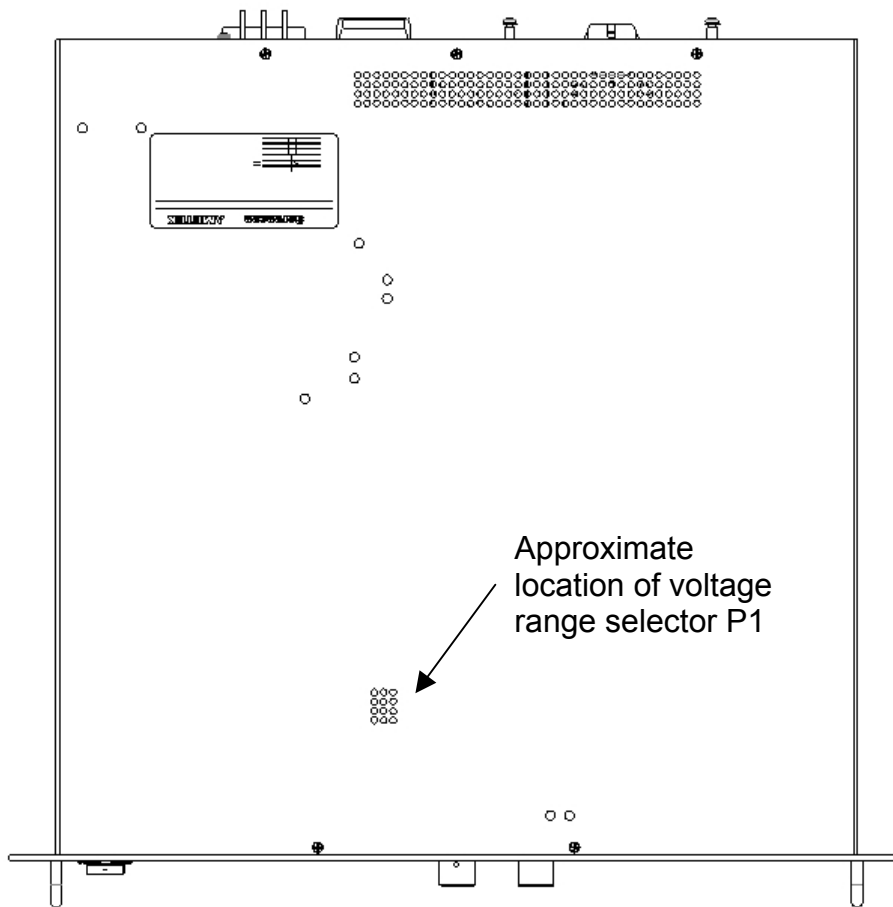
Subnet mask: 255.255.0.0

Click OK twice to complete the setup. Turn on the PV simulators and confirm that the LAN LED in the back (next to the Ethernet connector, see fig 2-3) fast blinks after a few seconds. This confirms an IP address was successfully assigned.

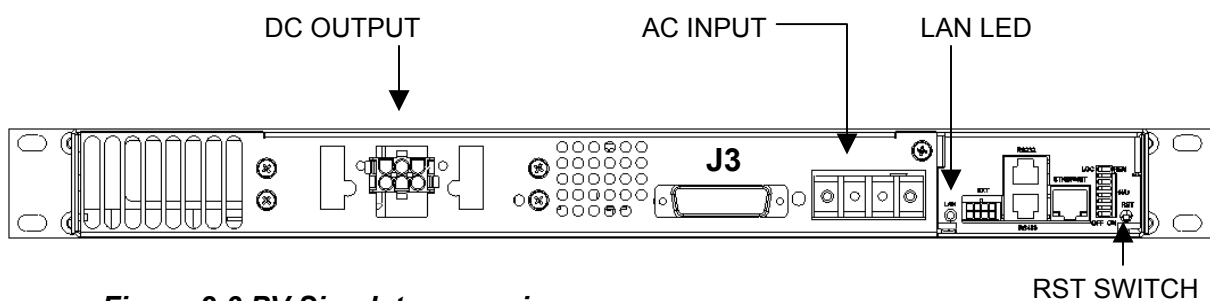


When the system is configured as TYPE 2, do not connect it to the LAN. The internal DHCP server can interfere with the normal operation of the company network and may cause serious service disruptions.

## 2.4 PV SIMULATOR ELECTRICAL CONNECTIONS



**Figure 2-2 PV Simulator top view**



**Figure 2-3 PV Simulator rear view**

### 2.4.1 AC terminal block

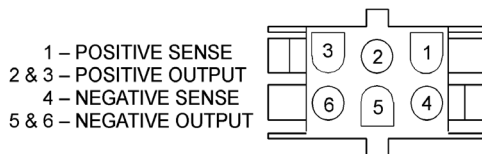
The AC line connects to the rear terminal block and ground stud (see fig. 2-3). The unit is factory configured for 200-240 V operation. It is possible to reconfigure the unit for 100-120V by removing the top cover and changing the voltage range selector. The voltage selector is located on the main board and is marked **P1** (see Fig 2-2). Simply unplug the 240V jumper and plug in the 120V jumper. Replace the cover when done.



The unit will be permanently damaged if connected to a 240V circuit while configured for 120V operation.

### 2.4.2 DC Output connector

The output of the PV simulator is available from the six-terminal connector located in the back (see Fig. 2-3). Figure 2-4 below shows the connector as seen when watching from the back side.



**Figure 2-4 PV Simulator Output**

Mating connector information (qty 4 included with shipment):

Housing - Elgar p/n : 1063643-2      AMP Tyco p/n : 1-480704-0  
Contacts - Elgar p/n : 856-033-04      AMP Tyco p/n : 350550-1  
Crimp tool: AMP Tyco p/n 90300-2

### 2.4.3 Unused rear panel items

Connectors marked EXT, J3, RS232 and RS485 are not used in this system. They are intended for multi-channel rack systems and factory automated test support. The 8-position switch is not used and all switches should be in the OFF position. The RST switch is only used during system configuration, which is described in the software user manual (p/n M609155-01). The user only needs to perform the configuration procedure in case PV simulators are added or replaced.

## SECTION 3

# GETTING STARTED

This section describes the basic operation of the TerraSAS Simulator.

### 3.1 STARTING THE SYSTEM

#### 3.1.1 Powering Up the TerraSAS system

To power up the system, first verify that the front panel power switches on all PV simulators are in the OFF position.

Confirm all electrical and network connections described in section 2 have been completed. Make sure the Cisco switch power adapter is plugged into a wall outlet with a voltage in the range 100-240V 50/60 Hz.

The computer can run on batteries, however it is recommended to plug in its power adapter into a wall outlet for extended test sessions. The power adapter works with any voltage in the range 100-240V 50/60Hz.

Turn on the computer and wait until Windows 7 boots and the login screen is displayed.

#### 3.1.2 Logging In

At the prompt, type in your user password. When shipped, the system is configured as follows:

User Name: **TERRASAS**

Password: **override**

**NOTE:** the password is in all lower-case letters. Passwords in Windows 7 are *case-sensitive*.

Your System Administrator may elect to change the user name or password for security reasons, so be aware that the defaults specified above may be valid only when the system is first received from the factory.

After successfully logging in, turn on the PV simulators.

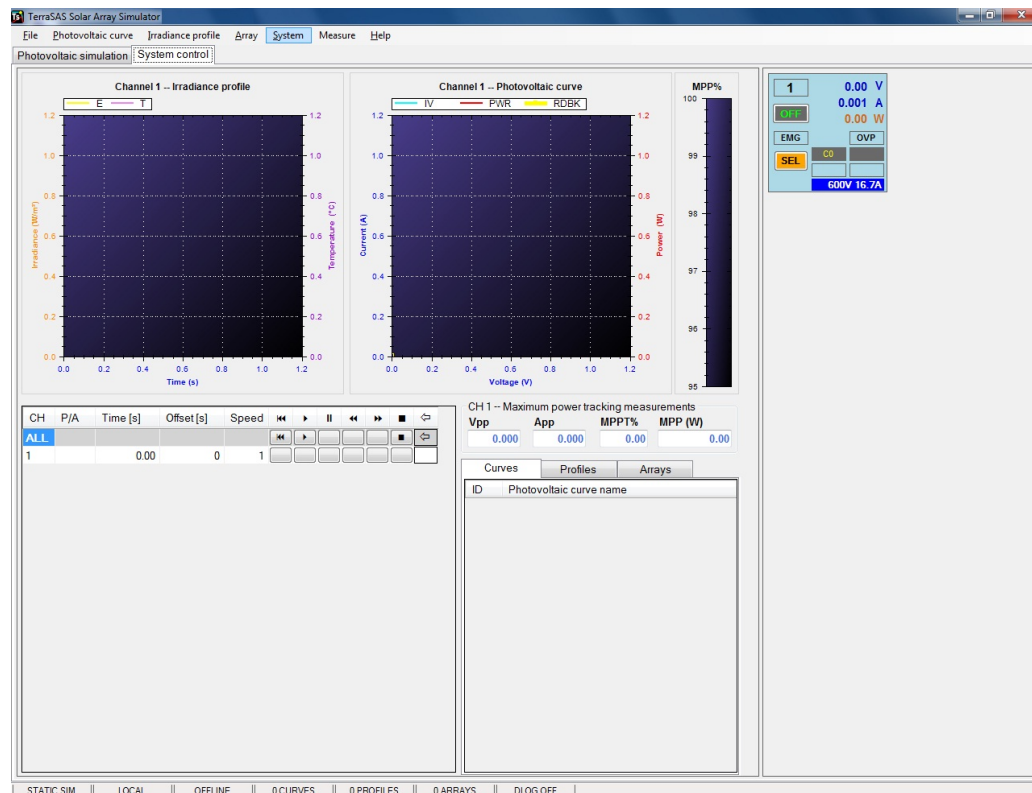
Wait about 10 seconds to allow the PV simulators to establish a connection to the computer.

### 3.1.3 Starting the TerraSAS program

Double click on the TerraSAS icon on your desktop:



Select the System control tab. The following screen should appear:




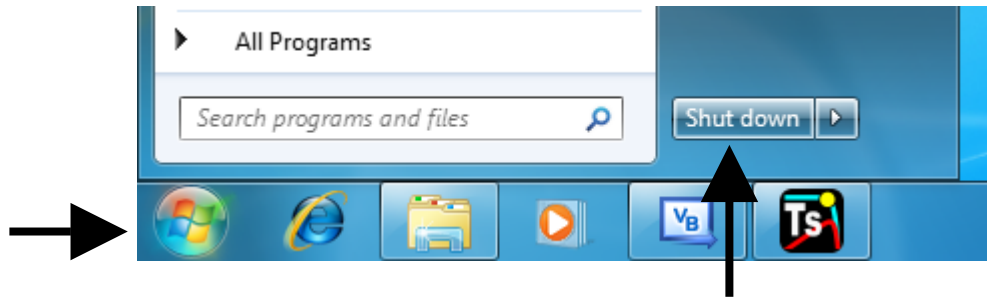
Confirm one light-blue colored tile is present for each channel in the system.

If one or more tiles are gray, PV simulators were probably not allowed enough time to connect to the computer. In this case, turn off all PV simulators. Watch the rear side and wait until all LAN LEDs turn off (see fig 2-3 for their location). Turn all PV simulators back on and confirm all LAN LEDs slow-blink and then fast-blink after a few seconds. If one or more LAN LEDs are not fast blinking, check network wiring and configuration. Please refer to section 2.3 for details. Swapping Ethernet cables and switch ports can help locate a defective connection, which can cause this communication fault.

If one or more tiles are still gray, please contact the factory for assistance.

## 3.2 SHUTTING DOWN THE SYSTEM

- Select **System / Reset** to terminate any simulation that might be running
- Click on the upper right corner [X]  to close TerraSAS
- Click on the Windows 7 logo, bottom left corner of the screen



- Click on **Shut down**
- Wait until the computer turns off
- Turn OFF all PV simulators

## 3.3 SOFTWARE OPERATION

The user needs to be familiar with the TerraSAS software to properly operate the system.

Please refer to the TerraSAS Software User Manual, Elgar p/n M609155-01 for a complete description of the TerraSAS software and associated SCPI Language Commands Reference, which allows to remotely control the system.

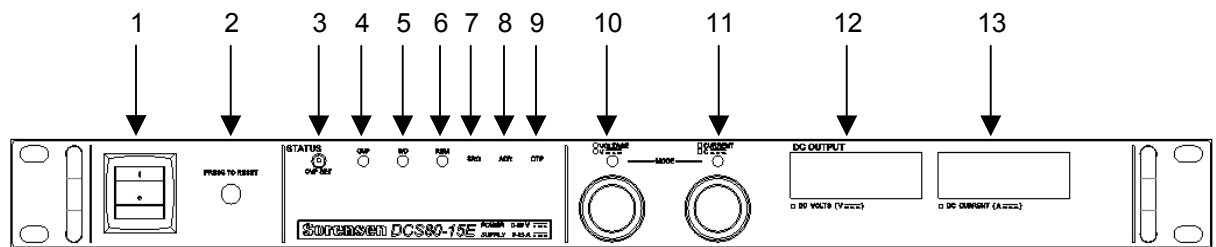
## 3.4 INVERTER TESTING

Always refer to the installation manual of the inverter or battery charger before connecting it to the simulator.

In particular, make sure the maximum  $V_{oc}$  is not exceeded to avoid damaging the device under test. It is highly recommended to set the overvoltage protection slightly above the maximum operating voltage to protect the device under test.

### 3.5 PV SIMULATOR FRONT PANEL DESCRIPTION

Fig 3-1 below shows the controls and indicators present on the PV simulator front panel. See table 1 for their description.



**Figure 3-1 PV Simulator front panel**

#	DESCRIPTION
1	ON/OFF switch
2	Circuit breaker protection. Push to reset.
3	Manual overvoltage setting. Not used, remotely controlled.
4	Overvoltage protection indicator. ON when protection tripped.
5	Shutdown indicator. ON when the output is turned off remotely.
6	Remote indicator. ON when the TerraSAS system controller is connected and communication is active.
7	SRQ indicator. Not used.
8	ADR indicator. Blinks when a new IV curve is transferred to the simulator.
9	OTP indicator. ON when the unit overheats and the output is turned off to protect the power conversion circuits.
10	Voltage mode indicator and voltage control knob. The voltage control knob is inactive, as the voltage setting is remotely controlled.
11	Current mode indicator and current control knob. The current control knob is inactive, as the current setting is remotely controlled.
12	Output voltage display.
13	Output current display.

**Table 1 Front panel controls and indicators**



## **SECTION 4**

# **COMPUTER MANAGEMENT**

### **4.1 COMPUTER SETUP**

The TerraSAS control computer has been factory configured for best performance. The user can of course customize operating system settings and desktop appearance to satisfy his or her preferences.

However, the following settings are critical to maintain good system performance:

- The screen saver feature has been disabled. The TerraSAS software communicates with each PV simulator 20 times per second and real time charts are updated at each communication cycle. The screen saver can cause unstable system behavior when resuming operation.
- The power scheme has been set to "Always ON", which means the computer will not hibernate or sleep when idle. Hibernation and sleep modes interrupt all control activities, which are suddenly resumed when pressing any key or touching the touchpad. This can interfere with inverter test sessions and cause unexpected system behavior.
- Third party software can be installed and used. However, as TerraSAS is CPU and graphics intensive, it is advisable to avoid running other applications when TerraSAS is running, especially during the execution of irradiance profiles.

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## **SECTION 5**

# **CALIBRATION**

This section describes the TerraSAS Calibration support.

### **5.1 REQUIRED EQUIPMENT**

The TerraSAS system supports fully automated calibration, which requires the following equipment, software and associated documentation:

- Agilent model 34401A or Keithley 2000 Digital Multimeter
- RS-232 Cable (Agilent requires a crossover type, Keithley requires a straight through type)
- Banana to banana test cables, 1000V, 24 inch long, quantity 4 each
- TerraSAS Calibration Box, Ametek p/n 5609175-50 (50 A) or 5609175-200 (200A)
- TerraSAS Calibration software, Ametek p/n 5609174-01
- TerraSAS Calibration User Manual, Ametek p/n M609174-01

### **5.2 OPERATION**

The calibration box has an internal, calibrated precision shunt. It connects to the TerraSAS DC output, the digital multimeter and the system interlock connector.

After loading the software, the user is guided through a simple procedure, which takes about five minutes to complete for each output channel.

### **5.3 CALIBRATION INTERVAL**

The recommended calibration interval for all TerraSAS models is one year.