AMETEK®

PROGRAMMABLE POWER

ELGAR

ETS1000X
Photovoltaic Simulator

Operation and Maintenance Manual

Programmable Power Solutions

About AMETEK

AMETEK Programmable Power, Inc., a Division of AMETEK, Inc., is a global leader in the design and manufacture of precision, programmable power supplies for R&D, test and measurement, process control, power bus simulation and power conditioning applications across diverse industrial segments. From bench top supplies to rack-mounted industrial power subsystems, AMETEK Programmable Power is the proud manufacturer of Elgar, Sorensen, California Instruments and Power Ten brand power supplies.

AMETEK, Inc. is a leading global manufacturer of electronic instruments and electromechanical devices with annualized sales of $2.5 billion. The Company has over 11,000 colleagues working at more than 80 manufacturing facilities and more than 80 sales and service centers in the United States and around the world.

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Exclusion for Documentation

Date and Revision

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Important Safety Instructions

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

⚠ **WARNING**	**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.**
⚠ **WARNING**	**The equipment used contains ESD sensitive ports. When installing equipment, follow ESD Safety Procedures. Electrostatic discharges might cause damage to the equipment.**

Only *qualified personnel* who deal with attendant hazards in power supplies, are allowed to perform installation and servicing.

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.

Always ensure that facility AC input power is de-energized prior to connecting or disconnecting any cable.

In normal operation, the operator does not have access to hazardous voltages within the chassis. However, depending on the user's application configuration, **HIGH VOLTAGES HAZARDOUS TO HUMAN SAFETY** may be normally generated on the output terminals. The customer/user must ensure that the output power lines are labeled properly as to the safety hazards and that any inadvertent contact with hazardous voltages is eliminated.

Guard against risks of electrical shock during open cover checks by not touching any portion of the electrical circuits. Even when power is off, capacitors may retain an electrical charge. Use safety glasses during open cover checks to avoid personal injury by any sudden component failure.

Neither AMETEK Programmable Power Inc., San Diego, California, USA, nor any of the subsidiary sales organizations can accept any responsibility for personnel, material or inconsequential injury, loss or damage that results from improper use of the equipment and accessories.

SAFETY SYMBOLS

Symbol	Meaning	Symbol	Meaning
⚠	WARNING Risk of Electrical Shock	⚠	CAUTION Refer to Accompanying Documents
◯	Off (Supply)	===	Direct Current (DC)
⏻	Standby (Supply)	∼	Alternating Current (AC)
		On (Supply)	3∼	Three–Phase Alternating Current
⏚	Protective Conductor Terminal	⏚	Earth (Ground) Terminal
Fuse	Fuse		Chassis Ground

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WARRANTY TERMS

AMETEK Programmable Power, Inc. ("AMETEK"), provides this written warranty covering the Product stated above, and if the Buyer discovers and notifies AMETEK in writing of any defect in material or workmanship within the applicable warranty period stated above, then AMETEK may, at its option: repair or replace the Product; or issue a credit note for the defective Product; or provide the Buyer with replacement parts for the Product.

The Buyer will, at its expense, return the defective Product or parts thereof to AMETEK in accordance with the return procedure specified below. AMETEK will, at its expense, deliver the repaired or replaced Product or parts to the Buyer. Any warranty of AMETEK will not apply if the Buyer is in default under the Purchase Order Agreement or where the Product or any part thereof:

- is damaged by misuse, accident, negligence or failure to maintain the same as specified or required by AMETEK;
- is damaged by modifications, alterations or attachments thereto which are not authorized by AMETEK;
- is installed or operated contrary to the instructions of AMETEK;
- is opened, modified or disassembled in any way without AMETEK's consent; or
- is used in combination with items, articles or materials not authorized by AMETEK.

The Buyer may not assert any claim that the Products are not in conformity with any warranty until the Buyer has made all payments to AMETEK provided for in the Purchase Order Agreement.

PRODUCT RETURN PROCEDURE

1. Request a Return Material Authorization (RMA) number from the repair facility (**must be done in the country in which it was purchased**):

   - **In the USA**, contact the AMETEK Repair Department prior to the return of the product to AMETEK for repair:

     Telephone: 800-733-5427, ext. 2295 or ext. 2463 (toll free North America)
     858-450-0085, ext. 2295 or ext. 2463 (direct)

   - **Outside the United States**, contact the nearest Authorized Service Center (ASC). A full listing can be found either through your local distributor or our website, www.programmablepower.com, by clicking Support and going to the Service Centers tab.

2. When requesting an RMA, have the following information ready:

   - Model number
   - Serial number
   - Description of the problem

NOTE: Unauthorized returns will not be accepted and will be returned at the shipper's expense.

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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PRODUCT OVERVIEW

1.1   INTRODUCTION

The Elgar PV Simulator is a programmable digital power source designed to simulate the electrical behavior of terrestrial photovoltaic arrays. The simulator provides a turn-key hardware and software solution 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 simulator to characterize the inverter's MPPT algorithm performance quickly and efficiently. It also allows to perform conversion efficiency, thermal analysis and dynamic performance tests by supplying a highly stable and repeatable stimulus to the inverter under test.

1.2   USER INTERFACE

The simulator front panel only features an on/off switch and a status indicator. The user interacts with the simulator through a remote Ethernet connection.

A single desktop or laptop computer running TerraSAS software can control up to 48 simulators. Due to the high transmission speed and data integrity provided by the Ethernet architecture, operating parameters are displayed in real time on the computer screen at refresh rates comparable to standard instrumentation.

The 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), βv (voltage temperature coefficient) and βp (power temperature coefficient).

In addition to static tests, the software allows to execute irradiance/temperature profiles that can closely duplicate real life conditions or predefined test sequences.

1.3   APPLICABLE ELGAR PART NUMBERS

ETS1000X10C-PVF   10kW, 208VAC
ETS1000X10D-PVF   10kW, 400VAC
ETS1000X10E-PVF   10kW, 480VAC
ETS1000X10C-PVF-TL   10kW, 208VAC, Inrush Limiter Option
ETS1000X10D-PVF-TL   10kW, 400VAC, Inrush Limiter Option
ETS1000X10E-PVF-TL   10kW, 480VAC, Inrush Limiter Option

1.4 PV SIMULATOR BLOCK DIAGRAM
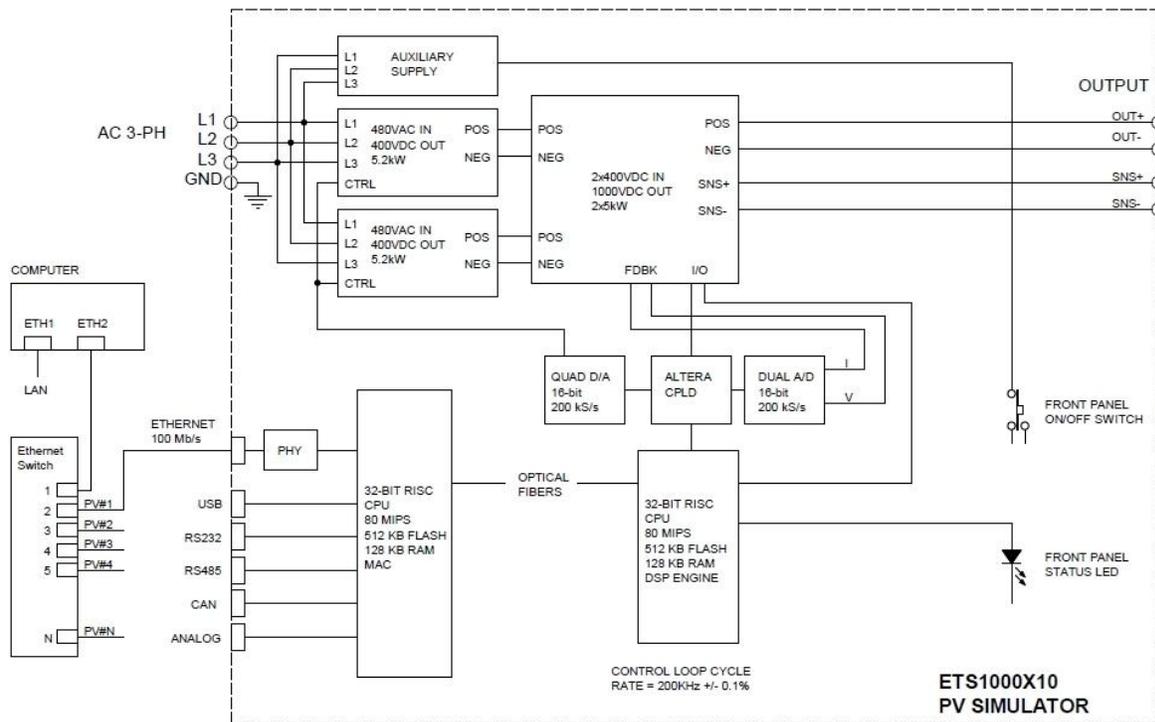
Figure 1-1 PV Simulator block diagram

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

One processor interfaces with a 16-bit measurement and control system that monitors the source output voltage and current at 5 µs intervals.

At each interval, the processor sends computed data to its 16-bit D/A control system that adjusts the current source setpoint to follow the programmed IV curve.

The other processor supports the Ethernet interface, analog and digital I/O.

While in static simulation mode, the simulator executes a single IV curve.

In the PV Simulator memory, 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.

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.

When irradiance / temperature profiles are executed, dynamically updated IV curves are downloaded at fixed 1-second intervals. The PV simulator linearly interpolates between consecutive curves 128 times per second (7.8 ms intervals), delivering smooth voltage and current waveforms to the unit under test.

1.5   ETS1000X10 SPECIFICATIONS

DC Output
    Open Circuit Voltage, Voc: 1 – 1000 VDC
    Short Circuit Current, Isc: 0 – 10A per chassis

    Maximum output power   8.5 kW
    at fill factor 0.85

Output isolation
    ±1400 Vpk, positive or negative output to chassis ground, continuous

Output leakage
    Output to chassis ground, DC :   < 0.1 mA @ 500Vdc
    Output to chassis ground, AC :   < 1 mA @ 200Vpp, 60Hz

Tracking speed
    Compatible with inverters sweeping the MPP at up to 200 Hz.

Accuracy
    Voltage programming and readback: ±0.2% of full scale voltage
    Current programming and readback: ±0.5% of full scale current

Sampling resolution
    Voltage and current are synchronously sampled by two independent 16-bit A/D converters at 200kS/s.

Curve Resolution
    1,024 points. Each point represents a single voltage / current point on the IV curve. The PV simulator interpolates the 1,024 points in its curve memory with 16-bit resolution, delivering an actual curve resolution of 65,536 points.

Profiles resolution
    There is no limit to the profile length. One-second profiles for a full day of simulation are typically 50k points. The simulator interpolates between points 128 times per second, delivering smooth voltage and current waveforms that closely resemble real solar arrays under cloudy conditions (requires TerraSAS software)

Curve equations
    Equations used to calculate and translate 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 and in the EN50530 standard.

PV Array
Parameters
    Irradiance level: 0 to 1999 W/m^2
    Temperature value: -100°C to +100°C
    Voltage level: 0 to 1000VDC
    Current level: 0 to 10A
    Voltage and power temperature coefficients: ±1.99%/°C

Expansion
    Unrestricted expandability, allowing total system power above 1MW

Available I/O	**Ethernet 10/100 Mb/s:** TerraSAS software proprietary high-speed link. **Analog Irradiance/Temperature inputs**: allow to adjust the IV curve in real time based on two external analog signals. **Trigger input:** allows to start executing an irradiance/temperature profile in sync with external equipment. Useful for accurate energy measurements using external power analyzers. **SCPI interface:** through TerraSAS software
Remote sense	Maximum line drop 10V per line
Input Nominal Voltage	3 phase, 3 wire + ground 208/220 VAC (operating range 187 - 242 VAC) 380/400 VAC (operating range 342 - 440 VAC) 440/480 VAC (operating range 396 - 528 VAC)
Input Frequency	47 – 63 Hz
Power Factor	>0.9 typical
Protection (typical)	½ cycle ride-though on all three phase 3 cycle ride through on single phase; missing phase shutdown
OVP Accuracy	0.2% of full scale voltage
OVP Resolution	0.002% of full scale voltage
Output noise	< 0.6 Vpp measured across a 1µF capacitor at the end of a 1.8m (6ft) line at full load.
Current noise	< 200 mAp-p at maximum output current, 650kHz bandwidth < 50 mArms at maximum output current, 650kHz bandwidth
Efficiency	85% typical at nominal line and max load
Stability	±0.05% of set point after 30 minute warm-up and over 8 hours at fixed line, load and temperature, typical
Temperature Coefficient	0.02%/ °C of maximum output voltage rating for voltage set point, typical 0.03%/ °C of maximum output current rating for current set point, typical
Operating Temperature	0 to 50º C
Storage Temperature	-25º C to 65º C
Humidity Range	Relative humidity up to 95% non-condensing, 0º C – 50º C

<u>Altitude</u>	Operating full power available up to 5,000 ft. (~1,500 m), derate 10% of full power for every 1,000 feet higher; non-operating to 40,000 ft. (~12,000 m)
<u>Cooling</u>	Front and side air inlet, rear exhaust. Temperature controlled variable speed fans. Units may be stacked without spacing.
<u>Regulatory</u>	Certified to UL/CSA 61010 and IEC/EN 61010-1 by a NRTL, CE Compliant, Semi-F47 Compliant. LVD Categories: Installation Category II: Pollution Degree 2; Class II Equipment: for Indoor Use Only.
<u>EMC Directive</u>	EN 61326:1998
<u>Accessories</u>	K550212-01: 3U Rack Slides 5550568-01: Front panel dust filter - field installation kit 5609609-01: Inrush Limiter Option – field installation kit
<u>Physical</u>	Width 19.00 in (48.3 cm) Depth 28.24 in (71.8 cm) (including output filter assembly) Height 5.25 in (13.3 cm) Weight 80 lbs (36 kg)

1.6 MECHANICAL DRAWINGS
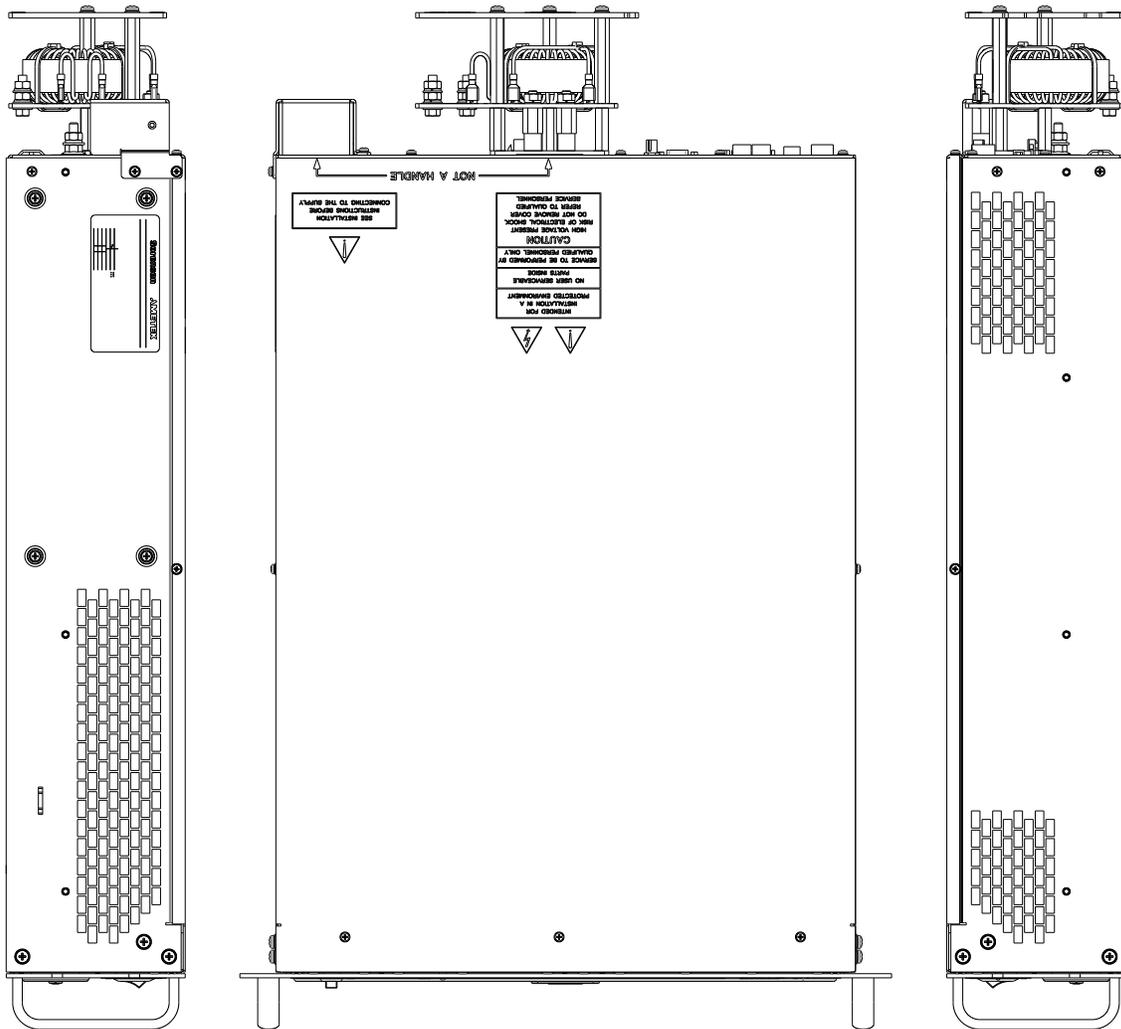
Figure 1-2 Top and side views
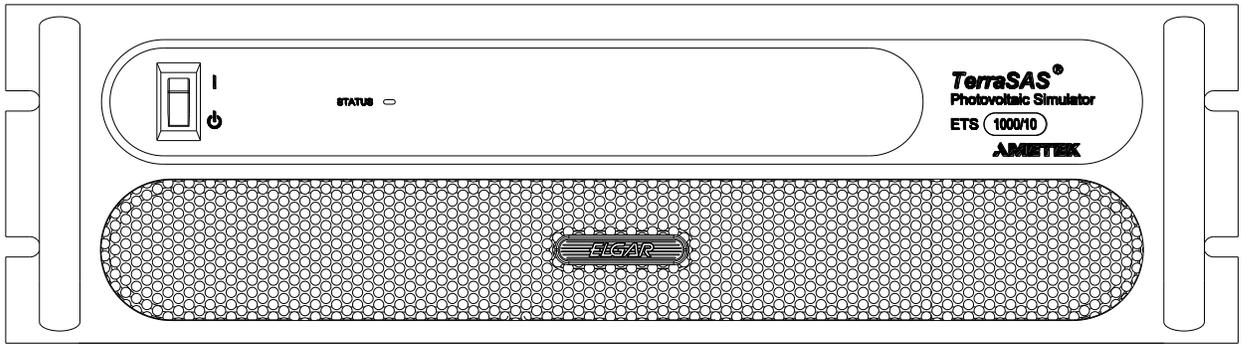
Figure 1-3 Front panel
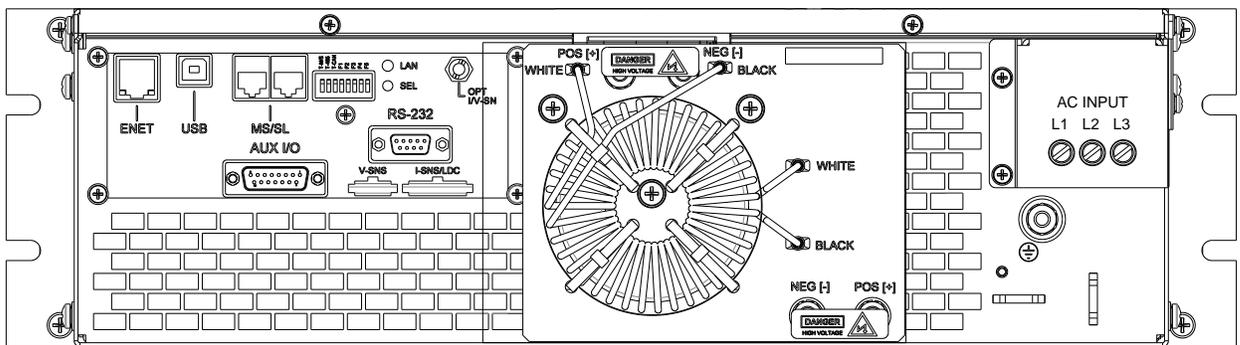
Figure 1-4 Rear view
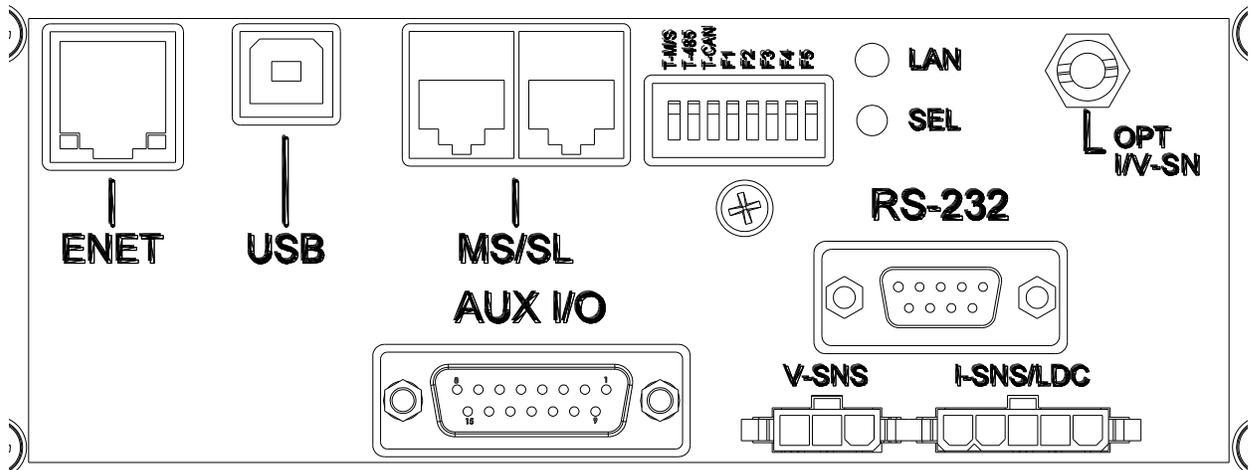
Figure 1-5 Rear I/O panel

INSTALLATION

2.1 UNPACKING AND INSPECTION

After unpacking the unit, 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.

The following items should be included:

```
ELGAR P/N    DESCRIPTION                              QTY

856-390-03   REMOTE SENSE MATING CONNECTOR, 3 POLES    1
856-390-00   CRIMP CONTACTS FOR ABOVE                  4
856-DA1-5P   AUX I/O MATING CONNECTOR, 15 PINS         1
856-247-15   BACKSHELL (HOOD) FOR ABOVE                1
110-032-01   SCREW,10-32 X .500,BLACK 27038            4
107-240-17   LUG,#5/16,12-10AWG,RING,NYL               3
M551066-02   PRINTED COPY OF THIS USER MANUAL          1
9609637-01   COVER,ACRYLIC,RELAY DRV                   1
275001       Label\High Voltage\Danger                 2
5609155-XX   TERRASAS SOFTWARE INSTALLATION DISK       1
```

THIS PRODUCT IS INTENDED FOR INTEGRATION INTO AN ELECTRICAL CABINET OR ENCLOSURE.

STANDALONE OPERATION IS NOT SAFE SINCE THE USER IS NOT PROTECTED FROM HIGH VOLTAGE HAZARDS.

2.2 ELECTRICAL CONNECTIONS

2.2.1 AC Input

See figure 1-4 to locate the AC input terminal block and ground stud. The wire gauge should be sized according to the table below.

Table 1 - Maximum input current per phase (Amps)

	10 kW
208 VAC	40.4
400 VAC	22.1
480 VAC	19.1

2.2.2 DC Output

See figure 1-4 to locate the output studs. Use the 5/16" ring lugs and hardware provided with the unit to make a reliable connection. The wire gauge should be sized according to the table below.

Table 2 - Maximum output current (Amps)

10 kW
10.0

2.2.3 Ethernet

Use standard CAT5e or CAT6 Ethernet patch cords.

2.2.4 HV-SNS Remote Sense

Remote sense lines should be connected as close as possible to the input terminals of the inverter under test, to maximize measurement accuracy. Use the mating connector and contacts provided with the unit. Connections are as follows:
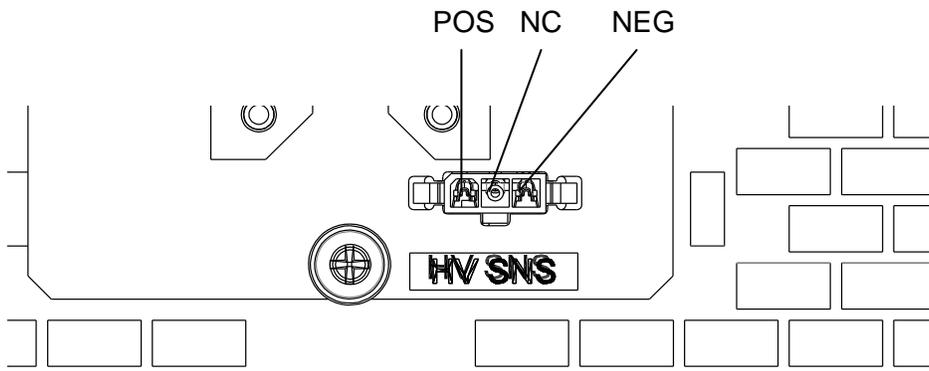
2.2.5 USB, MS/SL, RS-232, I-SNS/LDC, OPT I/V-SN

These high speed digital, analog and optical interfaces are not supported in the current firmware release and are intended for future use.

2.2.6 AUX I/O

This is a standard 15-pin female D-SUB connector. The mating connector is provided with the unit. Electrical signals are listed below:

PIN #	DESCRIPTION	VOLTAGE	CURRENT	COMMENTS
	AUX I/O CONNECTIONS			
	MATING CONNECTOR TYPE: D-SUB 15 PIN MALE			
1	CAN BUS H	CAN standard		Not supported by current firmware revision.
2	CAN BUS L			
3	RS-485 D+	RS-485 standard		Not supported by current firmware revision.
4	RS-485 D-			
5	IRRADIANCE INPUT	0 to 2.5V	<10 µA	0 to 1999 W/m^2 (1)
6	TEMPERATURE INPUT	0 to 2.5V	<10 µA	-100°C to 100°C (1)
7	INTERLOCK +	24V ±20%	<3 mA	Output turns off if interlock signal is not present, unless interlock override is active (DIP switch F3). (2)
8	INTERLOCK -			
9	FAULT OUTPUT +	30V max	1A max	Not supported by current firmware revision.
10	FAULT OUTPUT -			
11	CAL RELAY +	30V max	1A max	Used by calibration fixture and software.
12	CAL RELAY -			
13	TRIGGER INPUT	0 to 5V	< 2mA	Active low. (3)
14	REFERENCE VOLTAGE	2.5V	5 mA max	Precision voltage reference
15	SIGNALS GROUND			Analog and digital return
BODY	CHASSIS GROUND			Connect to cable shield

NOTES:

1) See software user manual for details about monitoring these signals or allowing them to control an IV curve in real time.

2) The interlock input is isolated from ground and can tolerate up to ±100V from each input to chassis ground. This input is handled by the microcontrollers and is therefore not intended for safety-critical applications. Electromechanical relays or circuit breakers that remove the AC input to the simulator are required to meet safety regulations when failure to operate could harm human operators or otherwise represent a safety hazard.

3) This input accepts standard TTL/CMOS logic levels. It also accepts an isolated relay contact due to the internal pull-up resistor to +5V. When active, this signal starts executing a profile. See software user manual for details about loading and executing irradiance/temperature profiles.

2.3   REAR PANEL SWITCHES AND INDICATORS

8-POSITION SWITCH (see figure 1-5)		
SWITCH	**DEFAULT POSITION**	**FUNCTION**
T-M/S	OFF	Master / Slave line termination (120 Ω)
T-485	OFF	RS-485 line termination (120 Ω)
T-CAN	OFF	CAN line termination (120 Ω)
F1	OFF	Not used
F2	OFF	Set max output voltage to 600V (*)
F3	OFF	Interlock input override (desktop mode)
F4	OFF	Not used
F5	OFF	Firmware update mode

(*) Restart software after toggling to update output rating. Unit will behave like an ETS600X unit rated 600V 10A.

LAN FEATURES (see figure 1-5)		
ITEM	**TYPE**	**FUNCTION**
LAN	INDICATOR	LAN status
SEL	PUSHBUTTON	Select (used during system configuration)

2.4   FRONT PANEL STATUS INDICATOR

The front panel STATUS indicator (blue LED) visually reports one of five possible operating conditions. Blinking patterns are repeated every 2 seconds.

FRONT PANEL STATUS INDICATOR		
LIGHT PATTERN	**STATUS**	**DESCRIPTION**
Steady OFF	OFF	The simulator is turned off (front panel power switch off or no power)
Long pulse	IDLE	The simulator is turned on but not communicating with the system controller (PC). Output power is automatically turned off.
Steady ON	ON	The simulator is turned on and communicating with the system controller (PC).
One short pulse	OVP	Overvoltage protection tripped. Reduce the output voltage; turn the output off, then on to clear (see TerraSAS software manual)
Two short pulses	FAULT	Power module overheat or fault. Turn the front panel power switch off, then on to clear. Contact the factory if this condition becomes permanent and cannot be cleared.

2.5   SYSTEM ASSEMBLY RECOMMENDATIONS

❖ Elgar PV simulators are heavy. When assembling multi-channel systems into standard 19" racks, select rugged steel cabinets intended for industrial applications. Aluminum cabinets designed for light instrumentation will not likely meet the requirement.

❖ Use rack slides (Elgar p/n K550212-01) or heavy-gauge steel brackets to properly support the weight of the simulators.

❖ On rack systems, ensure adequate ventilation is provided to avoid excessive temperatures. Elevated temperatures reduce the life of the unit and can cause over-temperature protections to trip.

❖ High power inverters produce strong EMI fields, both radiated and conducted. Do not use computer keyboards with touch-pads as this technology is very sensitive to RF fields and will likely malfunction. Optical trackballs or mice provide the best results. Optical isolation on USB keyboards is recommended to avoid frequent lock-ups and erratic operation. Suitable USB isolators can be purchased from Ametek (isolator p/n 881-004-06 and short A-B cable p/n 890-504-03). USB isolators need to support the USB 1.1 low speed protocol (1.5 Mbits/s) in order to work properly with most keyboards.

❖ Keep data and control lines wiring as far as possible from AC and DC power and sense lines.

❖ Use wire, terminal blocks and connectors rated for 1000V operation on all output and sense wiring.

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OPERATION

3.1 CONNECTING TO A COMPUTER

The TerraSAS software can control one or more PV simulators over a single Ethernet link. The CD that comes with the unit contains the installation files and the software user manual in Adobe PDF format. Detailed installation instructions are included in the manual. After installing the software, follow the instructions below to establish communication with one or more PV simulators.

3.1.1 Network configuration

The easiest way to connect to a single PV simulator is outlined below:

IP address 10.0.0.1
Subnet Mask 255.255.0.0

PV Simulator

IP address 10.0.0.2
Subnet Mask 255.255.0.0

Internet Protocol Version 4 (TCP/IPv4) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
● Use the following IP address:

IP address: 10 . 0 . 0 . 2
Subnet mask: 255 . 255 . 0 . 0
Default gateway: . . .

○ Obtain DNS server address automatically
● Use the following DNS server addresses:

Preferred DNS server: . . .
Alternate DNS server: . . .

☐ Validate settings upon exit

Advanced...

OK   Cancel

Simply access the Ethernet adapter Properties page and set as indicated.

With this topology, a static IP address is manually assigned to the computer.

When the PV simulator is turned on, it defaults to IP address 10.0.0.1 and communication is immediately established.

This method cannot be used to control two or more simulators.

When controlling more than one PV simulator, an Ethernet switch is required:
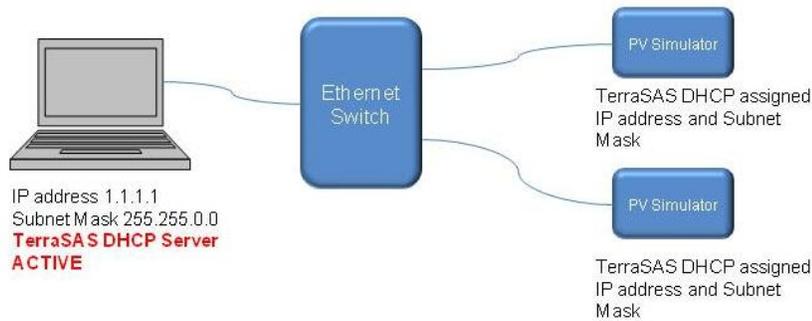
When setting the computer's IP address to 1.1.1.1, the TerraSAS DHCP server is automatically enabled. In this topology, always make sure that the computer is turned on and a user is logged in before turning on the PV simulators. Within a few seconds, all PV simulators are assigned an IP address. When this happens, the LAN LED on the rear panel (see figure 1-5) starts blinking faster. This confirms that the Ethernet network is active and working properly.

If not, the computer has a **firewall** installed. Refer to the firewall documentation to unblock the program dhcpsrv.exe, located in C:\TerraSas Configuration.

If desired, the Ethernet switch can be connected to the Local Area Network:
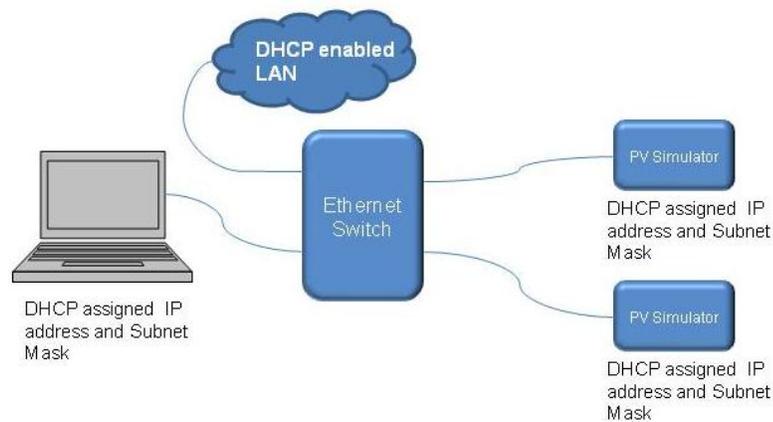
In this topology, the Ethernet adapter must be configured for DHCP ("Obtain an IP address automatically" and "Obtain DNS server address automatically", see screenshot on previous page.)

The advantage of this method is that PV simulators and computers can be located anywhere on the LAN, as long as they share the same subnet.

The disadvantage is that PV simulators are accessible to any computer on the LAN, which could lead to unauthorized access and safety hazards.

Never set the computer IP address to 1.1.1.1 in this topology, as the TerraSAS DHCP server will interfere with the LAN's DHCP server and cause serious service disruptions.

When it is desirable to control the TerraSAS computer from a remote location, a computer featuring two Ethernet adapters is recommended:
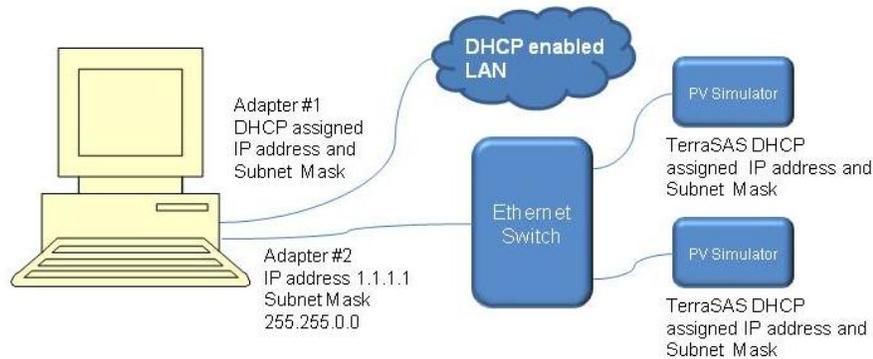
See the software user manual for software configuration details and one-time DHCP server startup procedures.

3.1.2 System configuration

Once the desired network has been wired and configured, launch TerraSAS. The software will inform that a system configuration table needs to be created and automatically opens the appropriate form. The purpose of the configuration table is to establish which PV simulators are to be controlled and what channel number should be assigned to each one. Once the system configuration table has been created and stored, TerraSAS will only communicate with the specified simulators, in the order that has been selected. Up to four configuration tables can be stored and retrieved, allowing additional flexibility. Detailed system configuration instructions are described in the software user manual and are also shown on the configuration form that opens in the software.

3.2 INVERTER TESTING

Carefully read the installation manual of the solar inverter or battery charger before connecting it to the PV simulator.

In particular, make sure the maximum Voc is never exceeded to avoid damaging the device under test.

It is strongly recommended to set the overvoltage protection at or below the maximum operating voltage to protect the inverter.

The ETS1000X simulator has isolated DC outputs and supports negative and positive PV array grounding schemes. Its low output leakage allows testing non-isolated (transformer-less) type inverters.

Always connect the sense lines as close as possible to the inverter under test to maximize measurement accuracy.

3.2.1 Parallel connections

The outputs of two or more ETS1000X simulators can be paralleled to increase the available output current. All sense lines must be connected and terminated as close as possible to the inverter under test to achieve the best possible measurement accuracy.
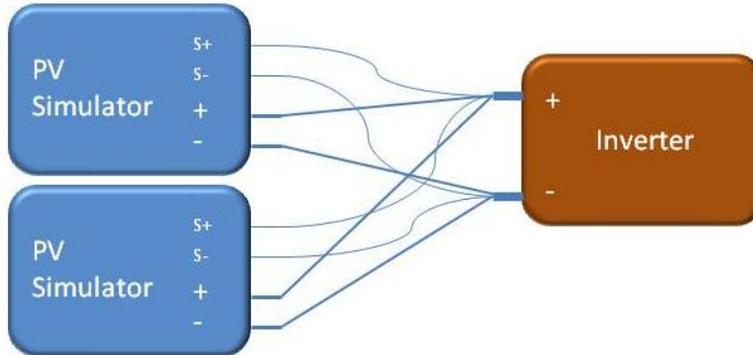
3.2.2 Series connections

Two ETS1000X simulators can be connected in series to achieve 2,000V operation. See electrical connections below.
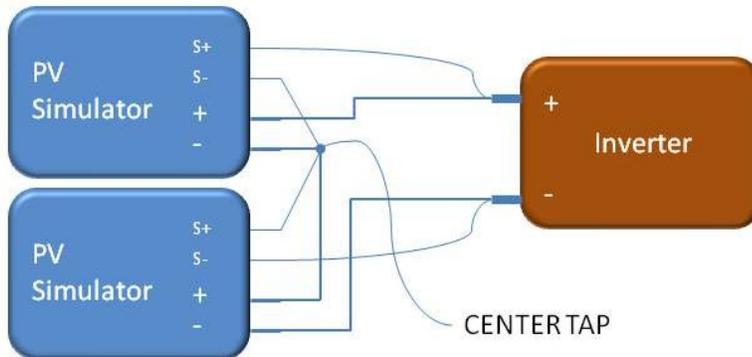
Since the maximum voltage-to-ground on any sense or output terminal is ±1,400V, connect the center tap as follows:

- ❖ For isolated inverters, connect the center tap to ground.

- ❖ For non-isolated inverters (also called transformer-less) leave the center tap floating (not connected).

If the maximum voltage-to-ground is exceeded the internal protection trips, the output is turned off and a module fault is asserted.

Sense lines carry little current and AWG20 wires rated for 1000V operation are recommended.

Once the electrical connections are made, select **System > Channels grouping setup** to configure the software for the desired wiring. See the software user manual for additional details.

3.3   INRUSH LIMITER MODULE

The Inrush Limiter relay module is basically a 100 ohms, 90W resistor with a   DC-rated high voltage, high current relay in parallel. This is placed in series with the PV simulator output to limit the peak current when recently designed transformerless (TL) solar inverters short their PV input to quickly sample the array performance.

Unlike standard resistors, those employed in the TL module are rated for pulse operation and can reliably absorb a 9kW pulse lasting up to 100ms. This equates to an energy rating of 900 Joules.

Control and protection circuitry

100Ω 90W 900J Resistor bank

500A 1800V DC relay
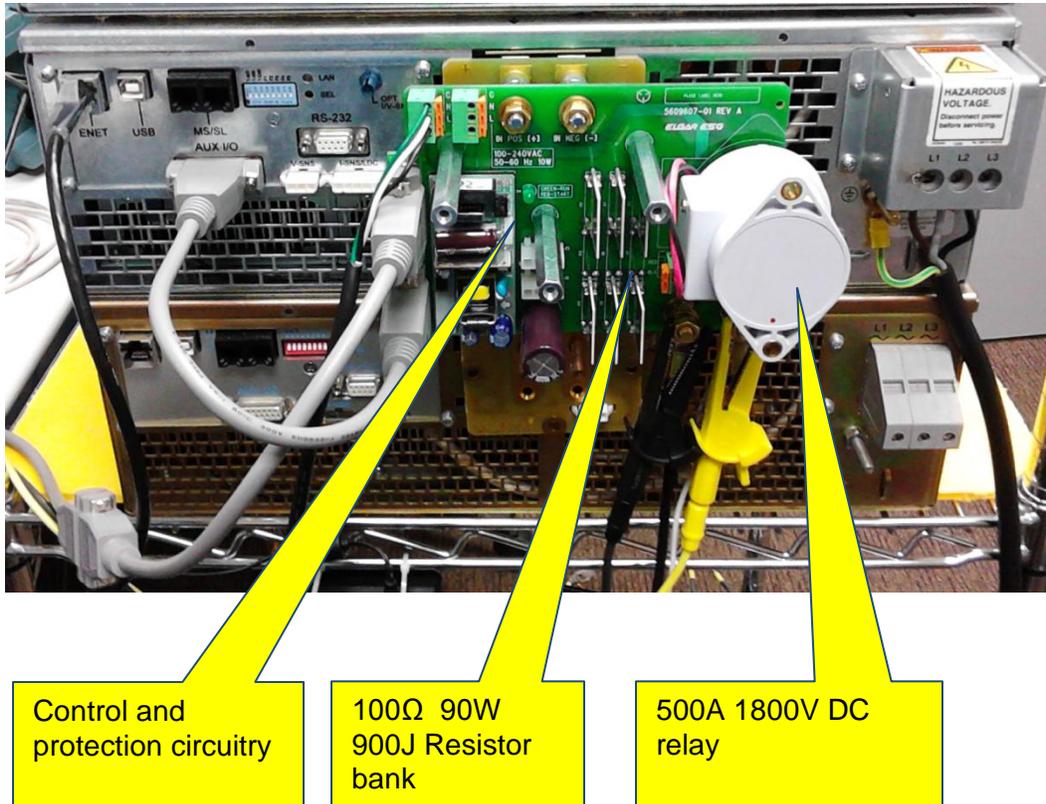
The Inrush Limiter module (Elgar p/n 5609609-01) can be easily installed on the back of the ETS1000. The above part number includes mounting hardware and detailed installation instructions.

Since the relay needs to be closed after the last array verification event but before the inverter starts, the module can be programmed to work with different inverters. The waveforms and calculations below are provided as a guideline.

Scope waveforms captured while waking up a recently introduced inverter

CH1: inverter input voltage   CH2: inverter input current   CH4: relay drive signal

Fast Isc
measurement

Fast IV
curve trace

Negligible current
glitch when the relay
is activated

Inverter starts
normally about 10s
later
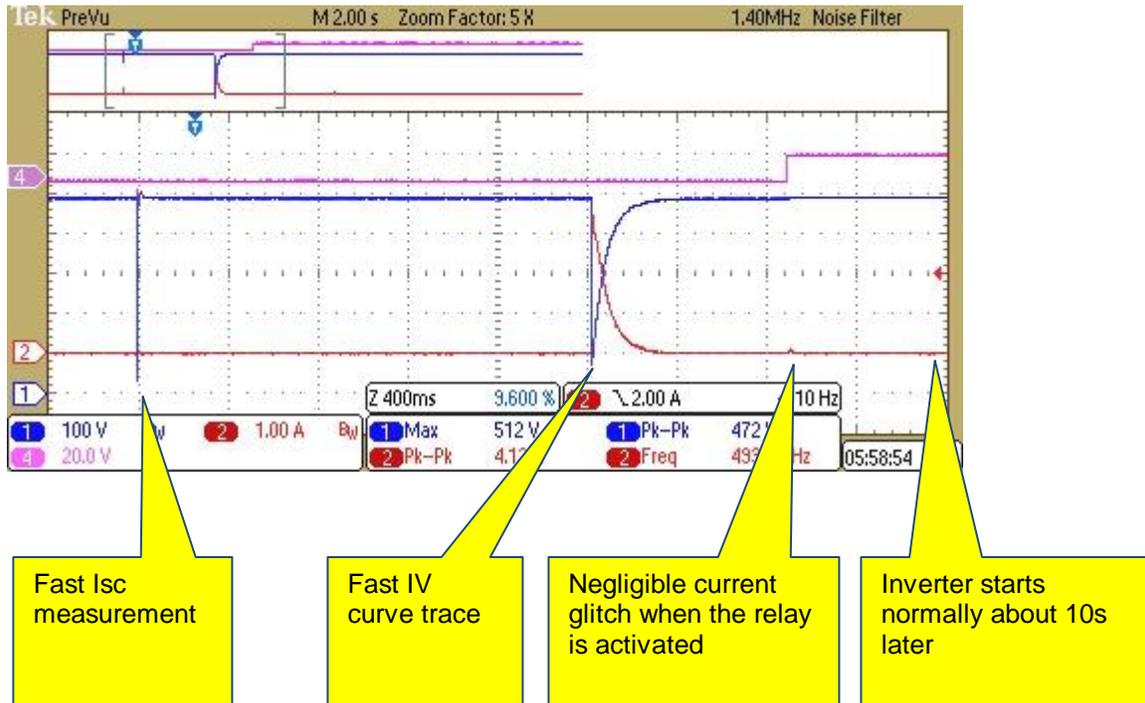
Fast Isc measurement detail

Approximately 6.4 Joules,
4A, 4ms pulse
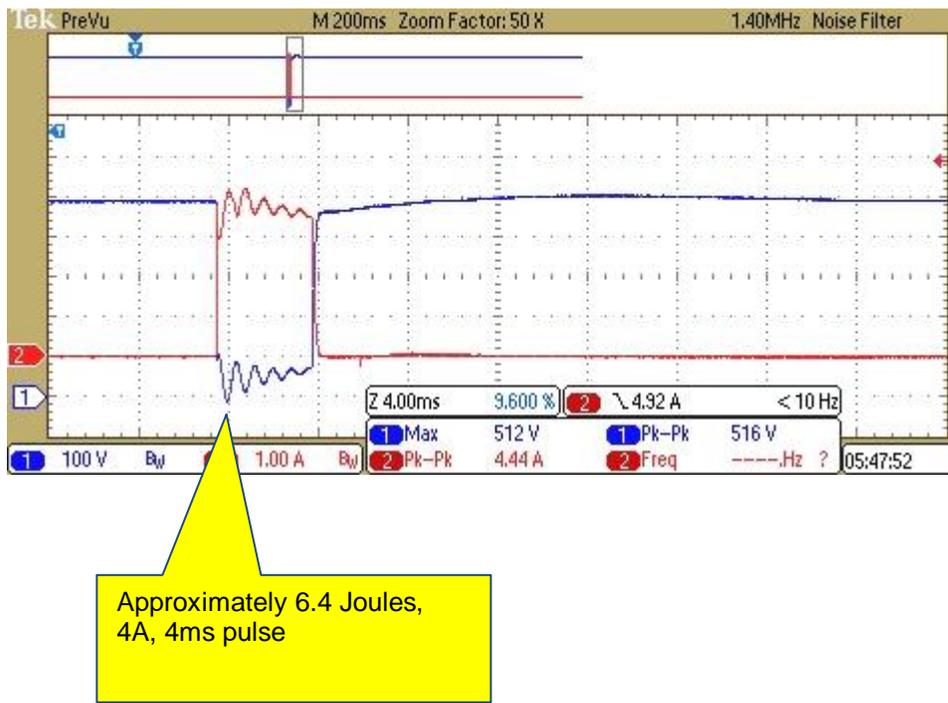
Energy (Joules) = $(4)^2 * 100 * 0.04 = 6.4$ J

Fast IV curve trace detail

Approximately 50 Joules
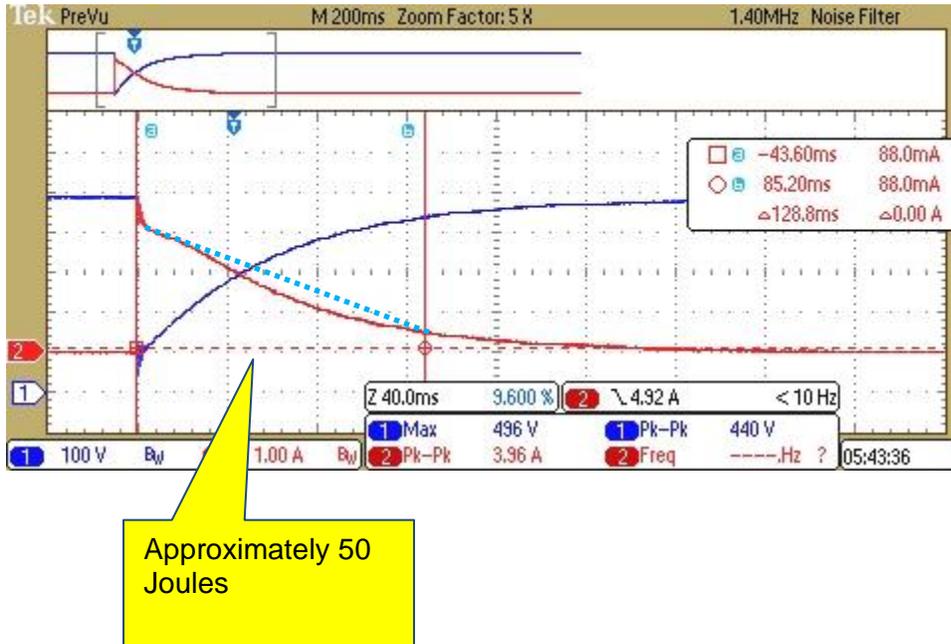
Energy estimate based on trapezoidal shape (actual pulse energy is lower, see dotted line)

Energy (Joules) $= 1/2 * ((3)^2 - (0.5)^2)* 100 * 0.129 + (0.5)^2 *100 * 0.129 = 59.7$ J

Programming

The TerraSAS software (see user manual for additional details) provides the following programming and readback parameters:

- Checkbox to enable or disable the TL module. When disabled, the relay is always closed
- Trigger energy threshold (Joules) -- 0.0 to 200.0
- High-speed energy integration meter readout (Joules) -- 0.0 to 3000.0

In order to work effectively, the trigger threshold must be programmed to a value that is below the total energy of the two (or more) fast transients. For this particular inverter, any value between 20 J and 40 J works fine.

The PV simulator firmware samples the energy profile at 25 kS/s and maintains a very accurate pulse energy integration register, with direct readout in Joules. When the programmed energy threshold is reached, the firmware looks for the current to decay below 5% of rated maximum (in this case 0.5A). The relay is activated approximately 0.5s after the current decay trigger is asserted.

The F3 switch on the rear panel must be OFF when this optional module is installed. Therefore a 24 V interlock voltage is required to turn on the output of the simulator. See section 2.2.6 and table 2.3 for wiring and setup details.

Severe damage to the module can occur if the F3 switch is left in the ON position. This would allow the ETS1000 to source power if the control power to the module is not present.

SECTION 4
COMPUTER MANAGEMENT

4.1 PERFORMING TERRASAS SOFTWARE UPDATES

4.1.1 Step 1: Uninstall TerraSAS

Click on the Windows 7 logo and select Control Panel:

Click on **Uninstall a program**

Right click on TerraSAS and click Uninstall/Change
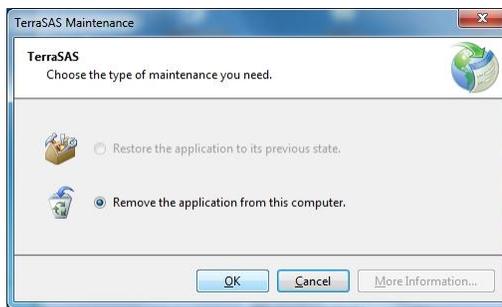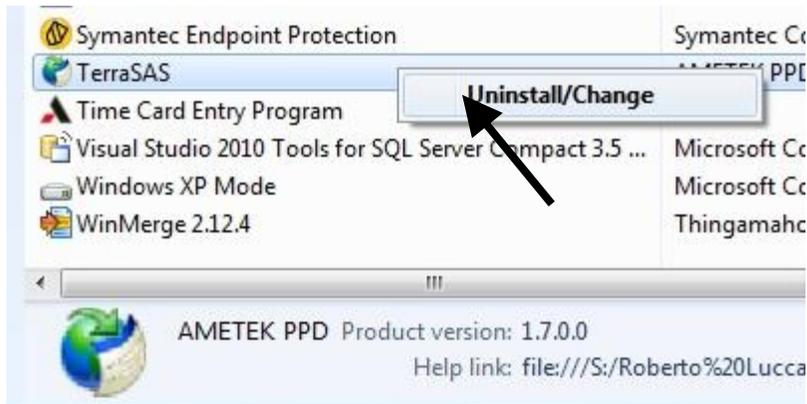
Click OK to remove TerraSAS. This only removes the software. System configuration, curves, profiles, data log and any other user files are not affected.

4.1.2 Step 2: Install a new TerraSAS software release
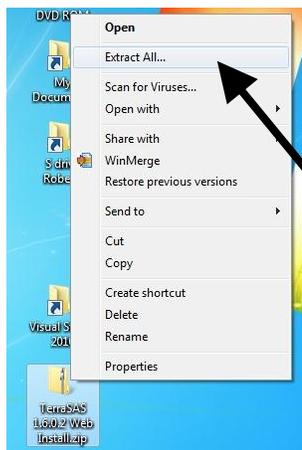
A new TerraSAS install set is usually e-mailed as a download link through Ametek's file transfer service Amefex. The file size is less than 10 Mbytes.

Download the file to your desktop, then right click on it and select **Extract All**.
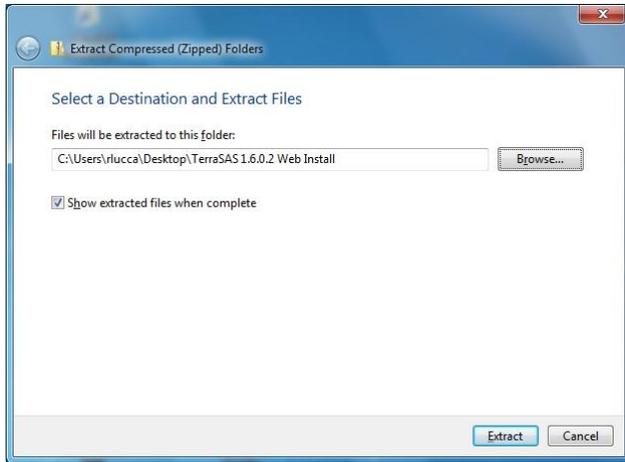
Click **Browse**…
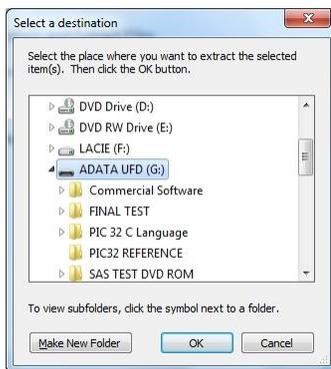
Insert a USB drive and navigate to it. Click OK
and then click **Extract** on the previous dialog to store
the install set on the USB drive.
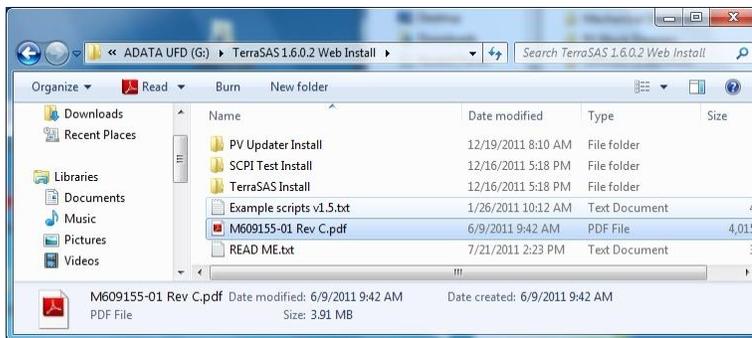
Insert the USB drive into
any available USB port
on the computer running
TerraSAS.

Navigate to the TerraSAS x.x.x.x Web Install folder. Open the READ ME file and, if
instructed to do so, execute section 4.3 to update the PV simulator firmware.
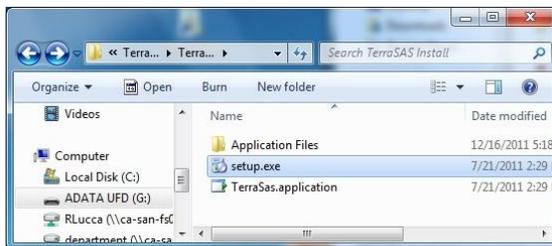
Open the folder named **TerraSAS
Install** and double click on the
setup.exe file.

Follow the instructions and then accept the security warning by clicking on the **Install** button.

The updated TerraSAS software will launch as soon as the above dialog will complete.

To complete the process, copy the updated software user manual (M609155-01 Rev X.pdf) and Example scripts vX.X to your **My Documents** folder.

4.2   PERFORMING FIRMWARE UPDATES

This procedure updates the computer code running on the two embedded processors within the PV simulator:

- Refer to the screenshots in section 4.1.2 to download and install the **PV Updater** software on the TerraSAS control computer. If a previous version of the PV Updater is present, refer to the screenshots in section 4.1.1 to remove it. **All PV simulators connected to the computer will be updated.**

- Turn off all PV simulators. Locate the 8-position switch on the rear side of the PV simulators (see figure 1-5)

- On all PV simulators, slide the F5 switch to the ON position

- Turn on all PV simulators. Note that the front panel **STATUS** LED does not blink as usual, as PV simulators entered firmware update mode. Wait 10 seconds to allow all simulators to acquire an IP address.
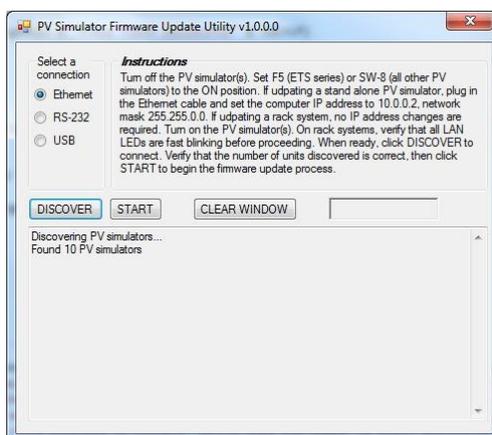
Double click on the PV updater icon to start the firmware update utility.

Click on the **DISCOVER** button to connect.

Verify that all PV simulators are detected

Click on the **START** button to begin.
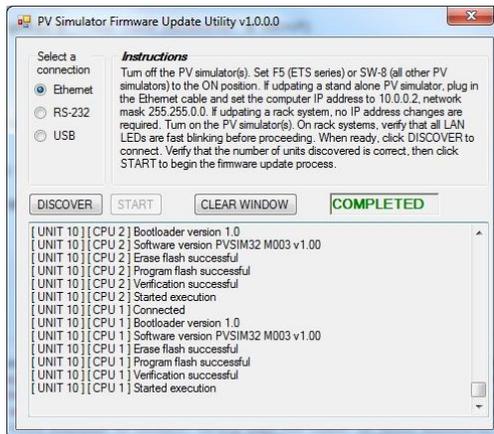
The process takes about one minute for each simulator, during which activity details are displayed. When all PV simulators are successfully updated, a green **COMPLETED** sign is shown.

If any step fails on one or more units, a red **FAILED** sign is displayed. In this case, scroll the activity window to locate which unit failed to update and then contact the factory for assistance.

- Turn off all PV simulators.

- On all PV simulators, slide the F5 switch back to the OFF position

- Turn on all PV simulators.

- Confirm the STATUS LED blinks as usual on all PV simulator front panels.

- Continue to section 4.1.2 to update the TerraSAS software and complete the process.

Note: the firmware update process can be repeated as many times as desired in the unlikely case that something goes wrong. However, after one or two failed attempts, it is strongly suggested to contact the factory for assistance.

IMPORTANT: avoid shutting down power, turning off the computer or the PV simulators while a firmware update is in progress. While these events have been extensively tested and caused no harm during software verification, it is advisable to refrain from intentionally causing them.

4.3 COMPUTER CONFIGURATION

The computer controlling one or more PV simulators should be configured with an "Always ON" power scheme. Features designed to conserve power should be disabled, in particular the computer should never hibernate, turn off the screen, reduce CPU speed or turn off the hard drive. All Elgar PV simulators turn off their outputs when the PC stops communicating for more than 50 ms. This is a safety feature designed to avoid loss of control.

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SECTION 5
CALIBRATION

5.1   REQUIRED EQUIPMENT

The Elgar PV simulator supports fully automated calibration, which requires the following equipment, software and associated documentation:

- Agilent model 34401A or Keithley 2000 Digital Multimeter

- TerraSAS Calibration Suitcase, Elgar p/n 5609175-25

- TerraSAS Calibration software v2.0.0.2 or above, Elgar p/n 5609174-XX

- TerraSAS Calibration User Manual, Elgar p/n M609174-01

5.2   OPERATION

The calibration suitcase has an internal, calibrated precision shunt. It connects to the simulator output, the digital multimeter and the AUX I/O connector on the rear panel.

All cables and accessories are included in the suitcase.

After installing and running the software, the user is guided through a simple procedure, which takes about five minutes to complete.

5.3   CALIBRATION INTERVAL

The recommended calibration interval for all Elgar PV Simulators is one year.