AMETEK
PROGRAMMABLE POWER

ELGAR™
ETS TerraSAS

Standalone TerraSAS Photovoltaic Simulator

(850W–1.5MW, 60–1000V)

208 | 400 | 480 **115 | 230**

For microgrids, energy storage, and inverter test applications, the TerraSAS™ series photovoltaic (PV) simulators are specifically designed to emulate the dynamic electrical behavior of a terrestrial PV solar array. They offer low output capacitance and high closed loop bandwidth to keep up with the advanced Maximum Power Point Tracking (MPPT) algorithms used in today's grid-tied inverters.

The Embedded TerraSAS (ETS) is a high performance solution in a small form factor that combines an agile power supply with an innovative I-V curve generator in a single standalone unit.

- ETS 600/1000: For isolated and non-isolated string inverters up to 1000Vdc Voc.
- ETS 60/80/150: For use with micro-inverters or DC optimizers up to 150Vdc Voc

Advantages:

- **Low output capacitance**
- **High bandwidth up to 30kHz**
- **High resolution I-V curve simulates static and dynamic conditions**
- **Designed for high speed Maximum Power Point Tracking (MPPT)**
- **Can be integrated into a multi-channel system for higher power testing**
- **Low voltage, high bandwidth version for DC Power Optimizers**
- **EN50530 support**

Application

Many solar inverters generate AC ripple on their DC input, which is connected to the photovoltaic array. For single phase inverters, the frequency of this ripple is twice the line frequency (120 Hz for US models). The simulator's power supplies must not suppress this ripple as a function of their regulation loop. An increasing number of inverters (and virtually all micro-inverters) accurately measure amplitude and phase of the ripple voltage and current to quickly track the MPP of the array. This approach allows tracking the MPP at a much higher speed when compared to conventional dithering techniques (also called perturbate-and-observe). Faster tracking of the MPP results in a much higher overall efficiency in cloudy conditions, where the irradiance is constantly changing. It is likely that all solar inverters will use this approach in the near future, since end users are very sensitive to the overall efficiency of their solar energy installations. To satisfy this requirement, the PV simulator must be capable of reproducing the voltage / current behavior of a solar array at the ripple frequency. Most standard switching power supplies employ very large output capacitors and inductors in their output circuits and are unable to deliver the required performance—regardless of the response speed of the I-V curve controller. The Elgar TerraSAS line of PV simulators are based on high speed versions of our standard products, where output capacitors and other speed-limiting components have been adjusted. This results in a speed improvement of 10 times or better.

Proprietary features built into the PV controller hardware and firmware, combined with our high speed power supplies, deliver the required performance. This technology was extensively tested on micro-inverters and is ready to test the next generation of inverters. The required performance is delivered by high speed switching power supplies and advanced Digital Signal Processing techniques. In some conditions traditional DC power sources using IGBT technology do not meet MPPT response speed requirements, depending on the MPPT principles. Our power supplies use Power MOSFETs, which typically switch ten times as fast as the most recent IGBTs. Higher switching frequency translates to smaller output capacitors and inductors—which is the key to a successful high speed power supply design.

Product Overview

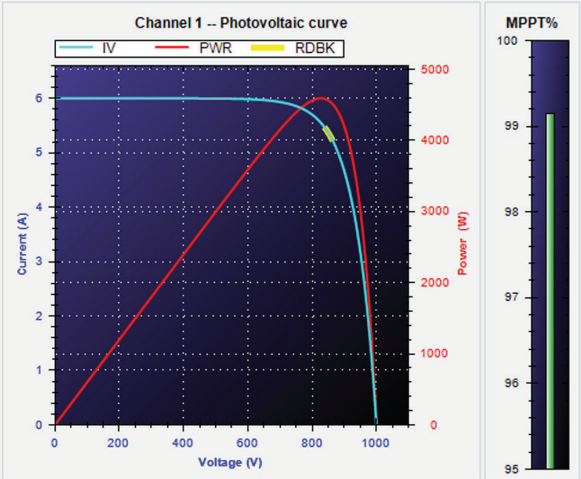
The ETS series standalone TerraSAS consists of a high performance, programmable DC power supply with control software and GUI interface, output isolation, and a unique PV simulation engine that provides the I-V curve. This combination of hardware, software, and firmware allows the TerraSAS to simulate test protocols or combinations of events that a real-world solar installation will be subjected to.

The included software allows modeling of a PV panel without an extensive knowledge of solar array parameters. The only parameters required for a simulation are the open circuit voltage (Voc), short circuit current (Isc), and the peak power parameters Vmp and Imp. Changes to these parameters allow the shape of the I-V curve to be adapted to any fill factor between 0.5 and 0.95.

Once an I-V curve has been generated, changes to the irradiation level or temperature can be modified on the fly to test the behavior of a grid tied inverter under realistic conditions for cloud shadowing and panel temperature rise. Long term weather simulations can be loaded and run to determine the amount of energy harvest delivered in a given situation. Inverter designers use these accuracy and efficiency tests to optimize real MPP search modes.

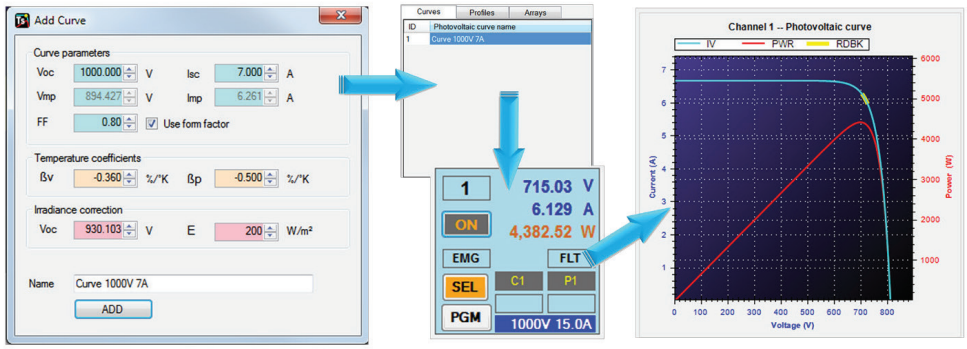
Scalability

Power supplies are available in 850W, 5kW, 10kW, and 15KW increments. The 80V units are available in two power levels: 1200W for microinverters and 850W for the latest generation microinverters and DC power optimizers. The bandwidth on the 850W version has been improved to 30kHz by adding a linear regulation output stage. 600V and 1000V units are available in 5kW, 10kW, and 15kW versions depending on Isc requirements. All versions are easily connected in parallel to scale output power up to handle microinverters, string inverters, and even utility scale inverters. Many models can also be connected in series to handle higher voltage tests. Please refer to the connection diagrams located in the User Manual and follow appropriate wiring codes before connecting ETS PV simulators in series or parallel.



Real time I-V Curve Display

The Elgar Real time I-V curve display is updated 20 times per second to illustrate dynamic inverter behavior (operating point and sweep amplitude). Compared to other commercially available solar array simulators with an update rate of only 1Hz, this allows more accurate analysis of the inverter's actual MPP tracking ability.

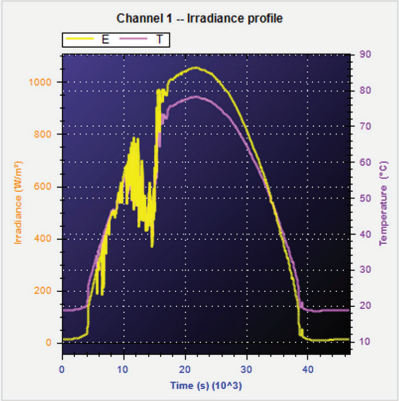


Basic I-V Curve Simulation

The Elgar TerraSAS user interface is intuitive, graphically colorful and simple to learn. I-V curves are created by entering simple parametric data or by importing data from the NREL SAM database. It is not necessary to use Java Script or any other Script hosting to create an IV curve and execute it.

Dynamic Irradiance Profile Display

The Elgar TerraSAS profile display of Irradiance and temperature is unique and innovative. It enables inverter designers to easily load and implement standards based cloudy condition scenarios, such as the weighted efficiency measurements called out in EN50530 or California Energy Commission. The ability to model dynamic performance profiles allows complex test validation in any situation in a repeatible, reliable manner. These standard profiles are impossible to simulate with a real array. It can also be controlled to a very fine degree and real profiles can be entered and run from actual speed to 100 times actual speed for accelerated lifecycle tests.



TerraSAS Dynamic Irradiance Profile Display

CH	P/A	Time [s]	Offset [s]	Speed
ALL				
1	P1	10,220.95	10,213	1
2		0.00	0	1
3		0.00	0	1
4		0.00	0	1
5		0.00	0	1
6		0.00	0	1
7		0.00	0	1
8		0.00	0	1

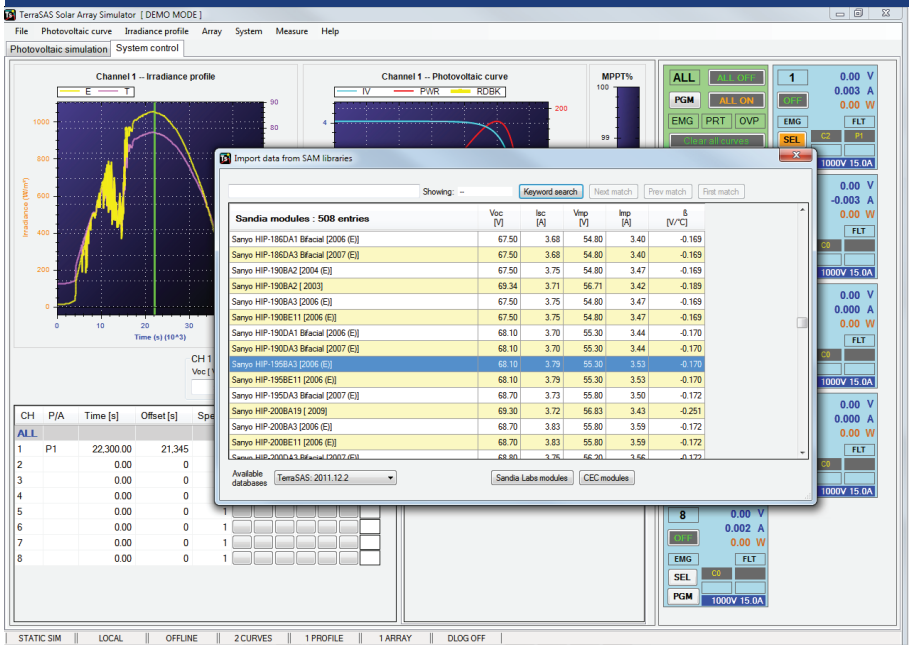
Curves | Profiles | Arrays

ID	Irradiance profile name
1	Cloudy day

Photovoltaic Array Modeling

This feature allows the user to quickly define an array of PV panels connected in series or parallel. Using this array modeling capability, the user can simulate such real world conditions as mismatched panels, which result in multiple hump I-V curves. It is important to verify that the MPPT algorithm finds and settles on the universal MPP, not a local maximum.

Photovoltaic Array Modeling



Import module data from embedded Sandia database and create I-V Curve.

Build the array model by binding to the desired curve and specifying the array size.

The effects of shadowing, aging and faulty modules can be previewed in real time. the resulting I-V curve can be dragged and dropped to any output for inverter testing.

Specifications					
Model Number[1]	**ETS60X14C**	**ETS80X10.5C**	**ETS150X5.6C**	**ETS600X _ _**	**ETS1000Y_ _**
Output voltage, Voc (V)	60	80	150	600	1000
Maximum output voltage (V)	66	88	165	660	1100
Output current, Isc (A)	14	10.5	5.6	8.3, 16.7, 25	5, 10, 15
Output power @ 0.85FF (W)	714	714	714	4250, 8500, 1270	4250, 8500, 12750
MPP tracking speed (Hz)[2]	250	250	250	200	200
I-V curve resolution (# of pts)	1024	1024	1024	1024	1024
Output capacitance	<10nF	<10nF	<10nF	<70uF	<40uF
Output isolation (Vpk)	±1000	±1000	±1000	±600	±1400
Available I/O	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet
Remote sense	2V	2V	2V	10V	10V
AC Input Voltage, V (max operational range)	85-264VAC	85-264VAC	85-264VAC	C: 187-242VAC D: 342-440 VAC E: 396-528 VAC	C: 187-242VAC D: 342-440 VAC E: 396-528 VAC
Input frequency, Hz	47-63	47-63	47-63	47-63	47-63
Power factor	>0.99 typical	>0.99 typical	>0.99 typical	>0.9 typical	>0.9 typical
Output voltage noise Measured across a 1µF capacitor at the end of a 1.8m(6ft) line at full load, 20MHz	<0.35 Vpp	<0.35 Vpp	<0.6 Vpp	<0.6 Vpp	<0.6 Vpp
Output current noise Measured with hall effect sensor, BW = 650kHz	<60 mApp	<60 mApp	<60 mApp	< 200 mApp	< 200 mApp
Operating temperature	0-40˚C	0-40˚C	0-40˚C	0-50˚C	0-50˚C
Physical dimensions	22.6 x 1.7 x 19.0 in 574 x 43.6 x 483 mm 21 lbs (9.5 kg)	22.6 x 1.7 x 19.0 in 574 x 43.6 x 483 mm 21 lbs (9.5 kg)	22.6 x 1.7 x 19.0 in 574 x 43.6 x 483 mm 21 lbs (9.5 kg)	25.5 x 5.3 x 19.0 in 64.7 x 13.3 x 48.3 cm 5kW 40 lbs (18 kg) 10kW 60lbs (27kg) 15kw 80lbs (36kg)	28.3 x 5.3 x 19.0 in 71.8 x 13.3 x 48.3 cm 5kW 40 lbs (18 kg) 10kW 60lbs (27kg) 15kw 80lbs (36kg)
Regulatory	Certified to UL/CSA 61010 and IEC/EN 61010-1				

Notes: 1. See next page for full listing of model numbers and configurations
2. Maximum MPPT rate of the inverter under test. Closed loop analog output bandwidth is much greater

CE RoHS

EST Model Numbers							
Model Number	**Outout Isolation (V)**	**Output Leakage Capacitance (nF)**	**Voc (V)**	**Isc (A)**	**Power Rating**	**Input Voltage (AC)**	**MPP Update Rate**
ETS60X14C-PVF	±1000	45	60	14	840W	100-240VAC	250Hz (*)
ETS80X10.5C-PVF	±1000	45	80	10.5	840W	100-240VAC	250Hz (*)
ETS150X5.6C-PVF	±1000	45	150	5.6	840W	100-240VAC	250Hz (*)
ETS600X8 C D E-PVF	±600	200	600	8.3	5kW	208VAC 400VAC 480VAC	200Hz
ETS600X17 C D E-PVF	±600	320	600	16.7	10kW	208VAC 400VAC 480VAC	200Hz
ETS600X25 C D E-PVF	±600	440	600	25	15kW	208VAC 400VAC 480VAC	200Hz
ETS1000Y5 C D E-PVF	±1400	25	1000	5	5kW	208VAC 400VAC 480VAC	200Hz
ETS1000Y10 C D E-PVF	±1400	35	1000	10	10kW	208VAC 400VAC 480VAC	200Hz
ETS1000Y15 C D E-PVF	±1400	45	1000	15	15kW	208VAC 400VAC 480VAC	200Hz

(*) these models also support power optimizers. Not intended for spacecraft or high frequency shunt switching regulators. Consult factory for this or any other special application.

Listed part numbers refer to the end user package that contains the PV Simulator, a full set of accessories, cables and user manual in print form.
Please contact the factory to order PV simulators with a customized accessory kit.