Elgar SAS - Solar Array Simulator

900–1000 W

450 or 500 W/channel Solar Array Simulator

- Total control of I/V behavior
- Designed to operate at the knee
- Fast profiling current source
- Bus overvoltage protection
- Hardware shutdown system
- Multiple master SAS systems can be connected to create very large SAS systems
- Customer defined output connectors

≈	208	400

ETHERNET GPIB

Product Overview

A spacecraft solar array is subjected to large temperature excursions, varying insolation (the amount of sunlight falling on the array), mechanical changes and aging, which substantially effect both its short and long term performance. In order to test the spacecraft's power environment, a cost-effective solution for ground based testing is to utilize a solar array simulator.

The Elgar SAS system reproduces all possible solar array outputs, based on the wide variety of input conditions that an array faces, including orbital rotation, spin, axis alignment, eclipse events, beginning-of-life and end-of-life operation. The SAS also provides complete programmable control of all the parameters that shape the solar cell I/V output curve. By being able to accurately simulate solar panels under various space conditions with complete control, a system developer can comprehensively verify design margins and quickly test, in production, spacecraft power systems and their associated electronics.

Each Solar Array Simulator is a fully integrated, turn-key system complete with Windows graphical user interface and hardware control software. It can be remotely controlled and is addressable as a single device when integrated into a customer's test system. This control is accomplished via a standard ethernet or optional GPIB interface using standard SCPI format commands.

As a very important consideration in spacecraft testing, discrete hardware protection systems are a standard part of every SAS. These include subsystems that can remove power at the output of the SAS in under 35 microseconds. Each SAS string has an electronic circuit breaker and relay disconnect, so faults are localized and minimize disruption of the test process. SAS systems have been designed and delivered ranging from desktop, 2 channel, R&D units to systems capable of controlling 8,18 channel SAS systems simultaneously. AMETEK's Engineered Solutions Group can assist in defining special requirements and customize each system using a standard building block approach. This allows each customer to get exactly what is needed while minimizing costs.

Features And Benefits

Total Control Of I/V Behavior.

AMETEK's Fast Profiling Current Source (FPCS) provides the ability to simulate real world solar array power more accurately than other technologies by allowing programmable control of all four parameters necessary to independently control the characteristic I/V diode output curve, or profile, of each FPCS channel.

In addition, the user may choose the non-parametric mode of operation and program I/V curves unique to the application. The basic building block of an Elgar SAS is the FPCS. Each FPCS module simulates either one or two array strings, or can be connected in series or parallel with other FPCS modules to simulate larger array segments. The 900W and 1000W chassis consist of two (2) 450W or 500W power modules in parallel, housed in a single 5-1/4" chassis with one control assembly. Open circuit voltage and short circuit current are scaled to meet a customer's requirements.

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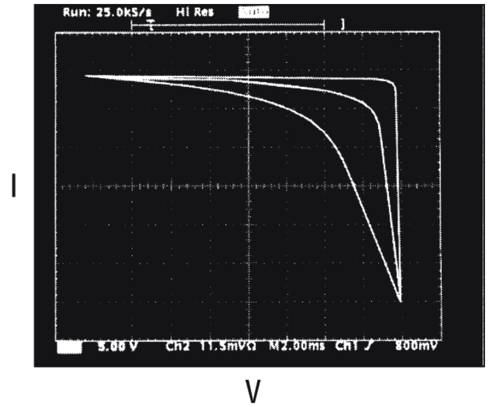
AMETEK PROGRAMMABLE POWER

SAS - Solar Array Simulator

Designed To Operate At The Knee.
The FPCS is designed to operate continuously at the peak power output, or the knee, of the solar array output. With a bandwidth of over 500 kHz, the FPCS is stable into capacitive, resistive and inductive loads up to at least 10μH (higher depending on curve parame at any point of the I/V curve. It can operate continuously at the peak power point of the output curve, into a sequential shunt unit (SSU), or into any other power system output topology.

The Proven Source.
The FPCS has been proven to supply peak power tracking, sequential shunt and series regulator power topologies. It has even been used to test Xenon Ion propulsion devices. The following is a short list of the many companies now using the Elgar Solar Array Simulators:

Ball Aerospace
Boeing Research
Boeing Space Systems
Boeing Rocketdyne
Jet Propulsion Lab
Lockheed-Martin
Northrop Grumman (TRW Space)
Northrop Grumman
Space Systems Loral
Thales Alemia Space ETCA
Thales Rome
Thales Camus
Thales Torino
Thales L'Aquita
Thales ETCA
Thales Milano
Goodrich
Astrium (Matra Marconi, DASA)
Bristol Aerospace
Clemessy
ISS Reshetnev VNIIEM
European Space Agency – ESTEC
Israeli Aircraft Industries, MBT
Korea Aerospace Research Institute
Korea Aerospace Industries
Mitsubishi Electric Corporation
Mitsubishi Heavy Industries
NEC Toshiba Space Systems, Ltd.
Patria OHB
Surrey Satellite
Siemens
Swedish Space Corporation
Terma Aerospace



I/V Diode Output Curve Control Parameters.
- Voc Maximum programmed open circuit voltage at no load
- Isc Maximum programmed short circuit current operating into short
- Rs Maximum programmed effective series resistance (voltage mode slope adjustment)
- N Curve factor (current mode steepness adjustment)

Quick Curve Recalculation
Since the FPCS is capable of a smooth transition from one calculated curve to another without any output disturbances, varying insolation patterns can easily be simulated. With a maximum curve update rate of 8 times/second, entire orbits can easily be simulated with fine time resolution.

Embedded Computer In Each Module.
An embedded Motorola microprocessor in each FPCS module provides the computational power necessary to calculate the output transfer function, to communicate via a fiber optic data link to the system computer and to continuously monitor the state of the power sections.

Fastest Switching Recovery Time.
Elgar systems feature switching recovery time of 2 microseconds or less. 450 And 900 Watt Modules and 500 and 1000 Watt Modules Systems can be as small as one 450 watt channel or they can also be paralled to achieve much higher channel counts and power levels.

Simulates Both Silicon And Gallium Arsenide Arrays
Silicon, gallium arsenide, and other types of solar array panels can be simulated realistically. The FPCS technology was specifically designed to operate into sequential shunt unit (SSU) as well as peak power tracking and linear regulation systems.

Galvanic Isolation Of Outputs.
Each FPCS chassis is controlled via a fiber optic link to eliminate nuisance ground loops associated with other hardwired control systems, such as RS-232 or GPIB

SYSTEM SPECIFICATIONS			
Specification	**Value**	**Test Conditions**	**Notes / Definitions**
Max Number of Channels	Unlimited		
Parametric IV Curve	4096 points		Voc, Isc, Rs, N
Custom IV Curve	2 to 4096 points		
System Shutdown Timing	Programmable from 25µs (default) to 99.9ms		FPCS response time is 10µs. Total minimum time is 35µs.
Operating Modes	Normal parametric IV curve simulation Switcher (12 pre-stored curves, parametric or custom). Spin (custom waveshapes, 1Hz maximum frequency). Eclipse (up to 16 curves, 32 segments)		The FPCS power sources have been tested in both series, shunt (S3R, S4R), Hybrid Series/Shunt, and MPPT modes of operation
Eclipse Mode dwell time	0.25sec – 16800sec		
Remote Control	Ethernet Standard GPIB Optional		
OVP chassis input impedance	20Megohms		Optional Chassis
OVP chassis response time	20µs		Optional Chassis
OVP Chassis filter	3dB roll off at 85KHz		Optional Chassis
Ambient Operating Temperature	0 – 38 °C		
Operating Humidity	20% to 80% non-condensing		
Operating Altitude	Up to 6,000 feet above sea level		
Non-operating Environment	Temp: -25 – 65 °C Altitude: 50000 ft Humidity: 95% non-condensing		
AC Input	208VAC L-L ±10% , 3PH 5 wire Wye, 50/60Hz or 380–400VAC L-L ±10%, 3PH 5 wire Wye, 50/60Hz		

FPCS SPECIFICATIONS			
Specification	**Value**	**Test Conditions**	**Notes / Definitions**
Output Power	450W or 500W per channel with 2 channels per chassis 900W or 1000W per channel with one channel per chassis		5-¼” 3U chassis
IV Formula	$V = \dfrac{\left(\dfrac{V_{oc}\ln\left(2-\left(\dfrac{I}{I_{sc}}\right)^{N}\right)}{\ln(2)}\right) - R_s(I - I_{sc})}{1+\left(\dfrac{R_s I_{sc}}{V_{oc}}\right)}$		Voc = Open Circuit Voltage Isc = Short Circuit Current Rs = Series Resistance N = Current Mode Behavior
Open Circuit Voltage range (Voc)	40 – 200 V		
Short Circuit Current (Isc)	Maximum 15A		
Output Voltage Accuracy	± 0.06% + 0.06% Vocmax	RL> 1MΩ, Tamb = 25 ± 5 °C	
Programmable Voc Resolution	0.025% of Vocmax	Tamb = 25 ± 5 °C	
Voltage Readback Accuracy	± 0.1% + 0.1% Vocmax	Tamb = 25 ± 5 °C	
Voltage Readback Resolution	0.025% of Vocmax	Tamb = 25 ± 5 °C	
Output Current Accuracy	± 0.1% + 0.1% Iscmax	Vout < 1V, Rs=0, N=100, Tamb=25 ± 5 °C	
Programmable Isc Resolution	0.025% of Iscmax	Tamb = 25 ± 5 °C	
Current Readback Accuracy	± 0.2% + 0.2% Iscmax	Tamb = 25 ± 5 °C	
Current Readback Resolution	0.025% of Iscmax	Tamb = 25 ± 5 °C	
Programmed Change Response Time	Voltage: 1VDC/ms		
	Current: 0.01ADC/ms	Settle to within 0.1% of programmed value	
Output Voltage Ripple	≤ 0.025% of Vocmax rms	20 Hz – 300 kHz	Apply 0.1 µF ceramic cap in parallel with meter
Output Voltage Noise (PARD)	≤ 0.25% of Vocmax	20 Hz – 20 MHz	Apply 0.1 µF ceramic cap in parallel with probe
Output Current Ripple	≤ 0.05% of Iscmax rms	20 Hz – 5 MHz, RL=3Ω, Rs=0.5, N=44, Voc=Vocmax, Isc=Iscmax	Use non inductive load resistor
Output Current Noise (PARD)	≤ 0.5% of Iscmax	20 Hz – 5 MHz, RL=3Ω, Rs=0.5, N=44, Voc=Vocmax, Isc=Iscmax	Use non inductive load resistor
Over Voltage Accuracy	± 0.5% Vocmax	Tamb = 25 ± 5 °C	
Over Voltage Resolution	± 0.03% Vocmax	Tamb = 25 ± 5 °C	
Over Voltage Range	11.5V – 110% Vocmax		
Standard Over Voltage Protection Circuitry Timing	$t = 420\mu s * \ln\left(\dfrac{V_P - V_O}{V_P - V_{LIM}}\right)$	VP-VO is the magnitude of the voltage step. VP-VLIM is the amount by which the output voltage step exceeds the limit voltage.	VLIM = voltage limit VO = initial voltage VP = final voltage

Specification	Value	Test Conditions	Notes / Definitions
Over Current Accuracy	± 100mA	Tamb = 25 ± 5 °C	
Over Current Resolution	± 0.03% Iscmax	Tamb = 25 ± 5 °C	
Over Current Range	0.57A – 105% Iscmax		
Standard Over Current Protection Circuitry Timing	$t = 420\mu s * \ln\left(\frac{I_P - I_O}{I_P - I_{LIM}}\right)$	IP-IO is the magnitude of the current step. IP-ILIM is the amount by which the output current step exceeds the limit current.	ILIM = current limit IO = initial current IP = final current
Redundant Over Voltage and Over Current modes	Time delay Integrator		
Redundant Over Voltage and Over Current trip delay Time Delay Mode	60µs to 249.9ms		
Redundant Over Voltage Accuracy (optional)	± 1.0% Vocmax	Tamb = 25 ± 5 °C	
Redundant Over Voltage Protection Circuitry Timing Integrator Mode	$t = 480\mu s * \left(\frac{V_{LIM} - V_O}{V_P - V_O}\right)$	VLIM-VO is the amount by which the output voltage step exceeds the limit voltage. VP-VO is the magnitude of the voltage step.	VLIM = voltage limit VO = initial voltage VP = final voltage
Redundant Over Current Accuracy (optional)	± 2.0% Iscmax	Tamb = 25 ± 5 °C	
Redundant Over Current Protection Circuitry Timing Integrator Mode	$t = 480\mu s * \left(\frac{I_{LIM} - I_O}{I_P - I_O}\right)$	ILIM-IO is the amount by which the output current step exceeds the limit current. IP-IO is the magnitude of the current step.	ILIM = current limit IO = initial current IP = final current
FPCS Output Fuse	125% of Iscmax typical		¼"X1¼" User accessible on rear panel of FPCS
Inductive Load Stability	0 – 10µH	0 ≤ Rs ≤ 10, 1 ≤ N ≤ 100	Equivalent to 40ft of AWG16 twisted pair cable
Inductive Load Stability	0 – 50µH	0 ≤ Rs ≤ 10, 20 ≤ N ≤ 100	Equivalent to 200ft of AWG16 twisted pair cable
Load Shunt Switching Recovery Time	≤ 2 µs 450W/500W ≤ 2.5 µs 900W/1000W	Vout= 0.5 to 32V, f=20 KHz, Voc=50V, Isc=70% of Iscmax, Rs=0.5, N=44, tr, tf=1µs	Recover to within ± 10% Isc Measured at the FPCS output connector.
Load Series Switching Recovery Time	≤ 100 µs	Vout=50 to 32V, f=1 KHz, Voc=50V, Isc=2A, Rs=0.5, N=44, tr, tf=1µs	10V or 10% voltage over shoot whichever is greater.
MPPT Voltage Tracking Error	≤ 2.0 %	f=200 Hz, Sweep amplitude 60mA p-p (3% Isc), triangular wave, Voc=50V, Isc=2A, Rs=0.5, N=44, Vout(avg)=42.5V	
MPPT Current Tracking Error	≤ 1.0 %	f=200 Hz, Sweep amplitude 60mA p-p (3% Isc), triangular wave, Voc=50V, Isc=2A, Rs=0.5, N=44, Iout(avg)=1.88A	
MPPT Voltage Tracking Error	≤ 3.5 %	f=200 Hz, Sweep amplitude 120mA p-p (6% Isc), triangular wave, Voc=50V, Isc=2A, Rs=0.5, N=44, Vout(avg)=42.5V	
MPPT Current Tracking Error	≤ 1.5%	f=200 Hz, Sweep amplitude 120mA p-p (6% Isc), triangular wave, Voc=50V, Isc=2A, Rs=0.5, N=44, Iout(avg)=1.88A	
Output Capacitance	Approximately 70nF		Modifiable by attaching capacitance to optional impedance adapter
Output Resistance	Infinite		Based on IV formula above.
Voltage Test Point Accuracy	≤ ± 1%	Tamb = 25 ± 5 °C, volt meter Zin > 10 MΩ	Located on FPCS front panel. Protected by 10Kohm resistors on + and -.
Current Test Point Accuracy	≤ ± 2.5 %	Tamb = 25 ± 5 °C, volt meter Zin > 10 MΩ	Located on FPCS front panel. Protected by 10Kohm resistors on + and -.
Minimum Voc	0.05V		
Minimum Isc	0.10A		
Output Isolation	≥ 8Megohms between channels. Outputs are completely floating and can be series or parallel connected. Either polarity may be grounded.		Series connection limited to 200V from any terminal to chassis ground. No limit for paralleled units.
Line Regulation	±0.01% of Vocmax ±0.1mA ± 0.005% Iscmax		
Recommended Calibration Interval	1 Year		
See "Telemetry Options for Solar Array and Battery Simulators" document.			