California
Instruments™

SEQUOIA SERIES

Precision Programmable Regenerative Grid Simulators

THE MOST ADVANCED PLATFORM OF POWERFUL AC SOLUTIONS

The California Instruments Sequoia Series combines intelligence and flexibility with high power to create an advanced platform of AC solutions. Using a state-of-the-art SiC power switching architecture, this full four-quadrant product combines compactness, robustness, and functionality in a floor-standing chassis.

This easy-to-configure power product covers a wide spectrum of single and multi-phase AC or single channel and multi-channel DC power applications at an affordable cost. With the add-on electronic load option, the Sequoia Series can support additional advanced renewable energy simulation and test requirements.

LXI | CE

FEATURES AND CAPABILITIES

- Dual Voltage ranges that support over voltage testing on 480V based systems
- Instrument Setups for quickly re-establishing the known instrument state
- 500uS time resolution for Transients
- Virtual Panels control software included
- Non-Linear current waveform programming during Load mode
- Phase coordination among multiple units (LKM/LKS)

- Powerful set of analog controls for PHIL and Modulation tests
- Trigger In & Out to permit extensive coordination with external systems
- Extensive Onboard diagnostics
- Digital I/O, including RS232, USB, Ethernet (GPIB optional)
- Intuitive 5" color display for ease of navigation
- Auto-paralleling for maximum flexibility with multi-chassis configurations
- Separate terminal blocks for single phase and 3 phase outputs

Simple Operation

The Sequoia Series can be operated completely from its menu driven front panel controller. The full color-touch display shows menus, setup data, and read-back measurements. USB and LAN remote control interfaces and instrument drivers for popular ATE programming environments are available. This allows the Sequoia Series to be easily integrated into an automated test system. With the programmable arbitrary waveform generator, the user can generate application specific waveforms, obtain time and frequency domain measurements, and capture actual voltage and current waveforms.

Configurations

The Sequoia Series offers five single chassis configurations: 15kVA, 22.5kVA, 30kVA, 45kVA and 90kVA. For higher power requirements, multi-cabinet models are available. These systems offer Reflex capability, allowing flexible user reconfiguration as needed. This ability to reconfigure the system greatly expands your test coverage and is not commonly found in power systems.

Choice of Voltage Ranges

The Sequoia Series offers dual range 0 - 166V & 0 - 333V line to neutral direct coupled output. These models provide a maximum 3 phase output capability of 287 VAC & 576 VAC line to line respectively. For applications requiring more than 333 V L-N (or 576 V L-L), the optional -XVC400 output transformer provides an additional 0 - 442 V L-N and 0 - 766 V L-L output range for use in AC mode only. For custom applications, the user defined XVC option is available.

High Crest Factor

With support for high crest factor loads, the Sequoia can drive difficult nonlinear loads with ease. Since many modern products use switching power supplies, they tend to pull high repetitive peak currents. The SQ30 with a crest factor rating of 4.5, for example, can deliver up to 300 Amps of repetitive peak current (166 V AC range) per phase to handle three phase loads. Refer to the specifications for peak repetitive currents for each model.

Remote Control

Standard RS232C, USB, and LAN, along with optional IEEE-488 remote control interfaces, allow programming of all instrument functions from an external computer. The popular SCPI command protocol is used for programming.

Hardware In the Loop

The External Drive (-EXTD) feature allows external analog signal control of the source while in AC operation, turning the source into a high bandwidth amplifier. Most common applications include hardware in the loop (HIL) simulation of power plants, hybrid electric vehicles, and renewable energy generation and their effect on the utility grid. Combining an HIL simulator with the Sequoia grid simulator results in as little as 100uS delay, meaning the overall solution is real time.

TESTING APPLICATIONS

Power Conditioning Equipment Testing

With the ever-increasing demand for electrical power, power quality is becoming a global challenge and many power conversion solutions, whose functionalities are grid-interactive, should be thoroughly tested to ensure product performance and reliability. Thanks to the flexibility offered by Sequoia Series, it is now possible that a single solution can support a wide variety of roles within your test setup, including AC/DC Programmable Power source, AC/DC Grid Simulator, or AC/DC Resistive or Complex Electronic load. With the ability to change most parameters during the test and the ability to synchronize the waveform with internal and external, Sequoia provides multiple methods of validation for R&D Testing.

Grid Interactive Green Energy & Distributed Power Generation

Global initiatives for green electrical energy generation are accelerating, and the number of devices that can export power to the grid in a distributed manner are on the rise. The Sequoia Series can uniquely act as an ideal grid, regenerating current from PV Inverters, Wind Turbines etc., with nearly complete power recovery. With seamless switchover between source and sink mode or its ability to program parallel RLC, Sequoia can emulate the test conditions mandated by international standards like IEC 61727 and IEC 62116.

Avionics & Shipboard Electronics Testing

Optional test suites for avionics power quality standards like MIL-STD 704, RTCA DO-160, and MIL STD 1399 shipboard power bus emulation save time in creation of test cases and help to quickly pre-validate the product compliance. With fundamental frequency support up to 905Hz with the high frequency (HF) option, Sequoia can simulate a wide array of electrical power supplies in most aircrafts and shipboard electrical systems. With the ability to sink power from DC to 500Hz incoming frequency and programmability of load current waveform, the optional eLoad mode is your solution for validating onboard power conversion systems.
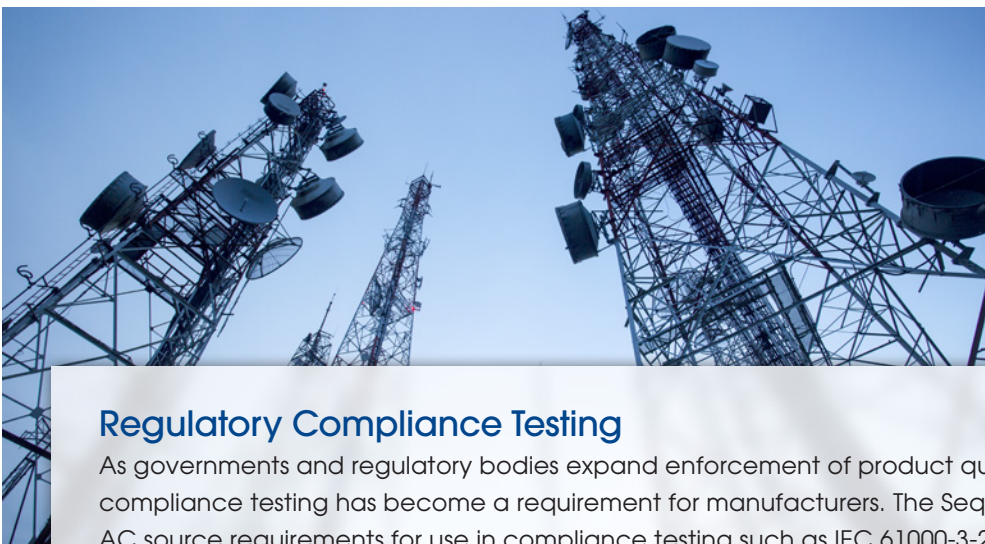
Regulatory Compliance Testing

As governments and regulatory bodies expand enforcement of product quality standards, regulatory compliance testing has become a requirement for manufacturers. The Sequoia Series is designed to meet AC source requirements for use in compliance testing such as IEC 61000-3-2, 3-3, 3-11, 3-12, to name a few. Tight integration with Virtual Panels software facilitates easy generation of test sequence for various safety, compliance and EMI tests, as per various UL, IEC, IEEE standards, and national electric grid code of conduct/compatibility.

TESTING APPLICATIONS

Electric Vehicle (EVSE, V2G) Testing

With the vast expansion of EV infrastructure, the inter-compatibility between various vendors' equipment is a key to success. This can be ensured only by testing the charging infrastructure compliance to standards. While the Sequoia Series grid simulator mode can help simulate various grid conditions from strong grid to weak grid, its electronic load mode can help emulate the car's On-Board battery charger load. With 85% of power recovery efficiency, the Sequoia Series not only helps by saving electricity, but also minimizing heat emissions inside the lab. What's more, the DC source mode and AC sink mode operations of the Sequoia Series make it ready for the bidirectional Vehicle- to-Grid testing.

Manufacturing Line Testers

The Sequoia Series are a good fit for end of production line functional testers, as they offer many benefits for test developers, operators, and quality team. The automatic paralleling option helps to scale-up / scale-down the power capacities, dynamically, to safeguard the investment on infrastructure. Full support for SCPI commands, availability of NI LabVIEW drivers, and IVI Drivers, helps test automation developers to choose their comfortable development environment. Load dependent variable fans help reduce the acoustic noise and improve occupational health.

OPTIONAL CONFIGURATIONS

Regenerative AC/DC eLoad

Among the optional configurations is the programmable, regenerative electronic load mode. Designed to provide precisely controlled non-linear loads for testing AC power generation equipment, the Sequoia Series load mode can accurately simulate real world load conditions, including high crest factor and variable power factor loads.

Traditional loads use resistive load banks. This approach does not simulate real world conditions such as switching DC/AC converters found in many AC powered products, nor does it fully exercise the equipment under test (EUT) under worst case operating conditions. High peak currents and low power factor loads can significantly impact the operating characteristics of a UPS or AC power product.

Sequoia's optional eLoad mode can simulate real world load conditions that can significantly increase product reliability while minimizing energy costs by regenerating the load current back to the utility mains.

Mode		Description
Constant Power	CP	This mode effectively emulates constant power loads such as switching power supplies
Constant Impedance	CZ	Provides independent programming of resistance, capacitance, and inductance
Constant Current	CC	Provides constant current load. This mode may be used to simulate both linear and non-linear (active) loads for voltage regulation testing.

Virtual Panels (Graphical User Interface)

Virtual Panels allow remote control of the Sequoia Series grid simulator as well as programming communication and monitoring without front panel display.

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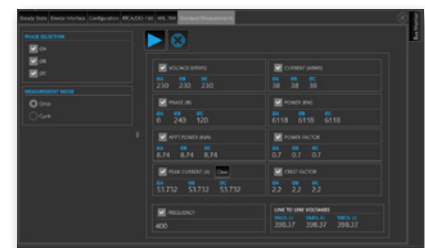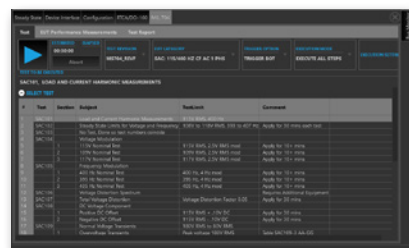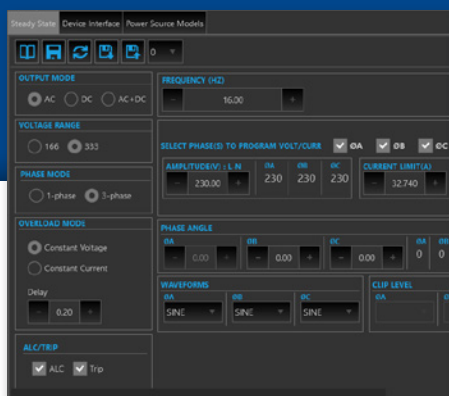
SEQUOIA SERIES
PRECISION PROGRAMMABLE REGENERATIVE GRID SIMULATORS

OUTPUT SPECIFICATIONS

PARAMETER	SQ0015	SQ0022	SQ0030	SQ0045	SQ0090
Power	15kVA / 15kW 1 Φ	22.5kVA / 22.5kW 1 1 or 3 Φ	30kVA / 30kW 1 or 3 Φ	45kVA / 45kW 1 or 3 Φ	90kVA / 90kW 3 Φ
Modes	AC, DC, AC+DC (Source mode only)				
Voltage Range (AC)	Low Range: 0-166 Vrms L-N High Range: 0-333Vrms L-N				
Voltage Range (DC)	Low Range: 0-220VDC High Range: 0-440VDC				
Output Coupling	Standard configurations: DC coupled. Optional 3rd AC coupled range: 0- 440, 550, 660, or 715Vrms L-N				
Voltage Accuracy	AC Mode: ±0.3%≤100Hz, ±0.6% >100Hz DC Mode: ±1V				
Voltage Resolution	0.1V, AC, DC, AC + DC modes				
Voltage Distortion	<66Hz: 0.5%, 66-500Hz: 1%, >500Hz: 1.5%				
Current per Φ (max)	125/62.5 Arms 85/42.5 Adc	62.5/31.2 Arms 42/21 Adc	83/41 Arms 57/28 Adc	125/62.5 Arms 85/42.5 Adc	250/125 Arms 170/85 Adc
Load Regulation (Source Mode)	DC, ≤100Hz: 0.25% FS >100Hz: 0.5%				
Line Regulation	0.1% for a 10% line change				
Phase Programming Accuracy	≤100Hz: ±1.5°, 100-500Hz: ±2°, >500Hz: ±4°				
Phase Programming Resolution	0.1°				
Frequency Range	DC, 16-550Hz, DC, 16-905Hz with HF Option (source mode only)				
Frequency Accuracy	±0.01% + (resolution/2)				
Frequency Resolution	≤81.91Hz: 0.01Hz, 82.0 to 819.1Hz: 0.1Hz, >819.1Hz: 1Hz (With LKM/LKS option, 1Hz from 16 Hz to 905 Hz)				
Voltage Stability	0.25% over 8 hours at constant line, load, & temperature, with external sense leads connected				

ELOAD OPTION SPECIFICATIONS

PARAMETER	SQ0015	SQ0022	SQ0030	SQ0045	SQ0090
Modes	Current, Power, RLC				
Current Range	125/62.5 Arms 85/42.5 Adc	62.5/31.2 Arms 42/21 Adc	83/41 Arms 57/28 Adc	125/62.5 Arms 85/42.5 Adc	250/125 Arms 170/85 Adc
Current Accuracy	0.2% FS				
Current Resolution	0.1% FS				
Power Range	15kVA / 15kW	22.5kVA / 22.5kW	30kVA / 30kW	45kVA / 45kW	90kVA / 90kW
Power Accuracy	±0.4% FS				
Power Resolution	10VA / 10W				
RLC - Resistance Range	Min(mΩ): 461/1850 Max(Ω): 230/925	Min(mΩ): 923/3700 Max(Ω): 461/1388	Min(mΩ): 692/2775 Max(Ω): 345/1388	Min(mΩ): 461/1850 Max(Ω): 230/925	Min(mΩ): 231/924 Max(Ω): 115/462
RLC - Resistance Resolution	<1Ω: 0.001Ω, 1Ω-9.99Ω: 0.01Ω, 10Ω-999.9: 0.1Ω, >1000Ω: 1Ω				
RLC - Inductance Range	Min(uH): 147/590 Max(mH): 732/2946	Min(uH): 294/1179 Max(mH): 1468/5892	Min(uH): 221/884 Max(mH): 1099/4419	Min(uH): 147/590 Max(mH): 732/2946	Min(uH): 74/295 Max(mH): 366/1471
RLC - Inductance Resolution	<1mH: 0.001mH, 1-9.99mH: 0.01mH, 10-999.9mH: 0.1mH, >1000mH: 1mH				
RLC - Capacitance Range	Min(uF): 2/1 Max(uF): 6908/1721	Min(uF): 1/1 Max(uF): 3450/861	Min(uF): 1/1 Max(uF): 4602/1148	Min(uF): 2/1 Max(uF): 6908/1721	Min(uF): 3/1 Max(uF): 13787/3447
RLC - Capacitance Resolution	1-999uF: 1uF, ≥1000uF: 10uF				

MEASUREMENT SPECIFICATIONS

PARAMETER	RANGE	ACCURACY (±) [1]	RESOLUTION
Frequency	16.00 - 820.0 Hz	0.01% + 0.01 Hz	0.01 to 81.91 Hz, 0.1 to 500 Hz
RMS Voltage	0 - 400 Volts	0.05V + 0.02%, <100 Hz, 0.1V + 0.02%, 100-820 Hz	0.01 Volt
DC Voltage	0 - 500 Volts	0.5 V	0.1 V
RMS Current	0 - 150 Amps	0.15A + 0.02%, <100 Hz, 0.3A + 0.02%, 100-820 Hz	0.01 Amp
DC Current	0 - 400 Amps	0.5 Amps	0.01 Amp
Peak Current	0 - 400 Amps	0.15A + 0.02%, <100 Hz, 0.3A + 0.02%, 100-820 Hz	0.01 Amp
DC Current	0 - 400 Amps	0.5 Amps	0.01 Amp
VA Power	0 - 15 kVA	30 VA + 0.1%, <100 Hz, 60 VA + 0.1%, 100-820 Hz	10 VA
Real Power	0 - 15 kW	30 W + 0.1%, <100 Hz, 60 W + 0.1%, 100-820 Hz	10 W
DC Power	0 - 15 kW	1% FS	10 W
Power Factor (>0.2kVA)[2]	0.00 - 1.00	0.01, <100 Hz, 0.02, 100-820 Hz	0.01

1. Accuracy specifications are valid above 100 counts. For current and power measurements, specifications apply from 2% to 100% of measurement range. Current and Power range and accuracy specifications are times three for SQ22.5, SQ30, SQ45 operated in single phase mode. For the multi chassis models the current and power range accuracy specifications are to be multiplied by No of chassis.

2. Power factor accuracy applies for PF > 0.5 and VA > 50 % of max.

HARMONIC MEASUREMENTS

PARAMETER	RANGE[2]	ACCURACY (±)[1]	RESOLUTION
Frequency Fundamental	16.00 - 820 Hz	0.03% + 0.03 Hz	0.01 Hz
Frequency Harmonics	32.00 Hz – 16 KHz	0.03% + 0.03 Hz	0.01 Hz
Phase	0.0 - 360.0°	2° typ.	0.5°
Voltage — Fundamental	Fundamental	0.75V	0.01V
Voltage — Harmonic 2 - 50	Harmonic 2 - 50	0.75V + 0.3% + 0.3%/kHz	0.01V
Current — Fundamental	Fundamental	0.5A	0.1A
Current — Harmonic 2 - 50	Harmonic 2 - 50	0.15A + 0.3% + 0.3%/kHz	0.1A

1. Accuracy specifications are valid above 100 counts. For current and power measurements, specifications apply from 2% to 100% of measurement range. Current and Power range and accuracy specifications are times three for SQ22.5, SQ30, SQ45 operated in single phase mode.

2. For the multi chassis models the current and power range accuracy specifications are to be multiplied by No of chassis.

INPUT SPECIFICATIONS

PARAMETER		SQ0015	SQ0022	SQ0030	SQ0045	SQ0090
Line Voltage (3-phase, 3-wire + ground (PE))		208 V_{LL} ±10%, 230 V_{LL} ±10%, 380 V_{LL} ±10%, 400 V_{LL} ±10%, 480 V_{LL} ±10%, 600V L-L ±10%				
Frequency		47 - 63Hz				
Line VA		18kVA	26kVA	37kVA	53kVA	106kVA
Line Current (Arms)	187V L-L	58	89	116	175	350
	207V L-L	52	79	105	157	314
	342V L-L	Not available	49	64	95	190
	360V L-L	30	46	60	90	180
	432V L-L	25	38	50	75	150
Efficiency		85% (typical) depending on line and load				
Power Factor		0.95 (typical) / 0.99 at full power				
Inrush Current (Apk)	208V L-L	77	153	230	230	460
	230V L-L	73	146	220	220	440
	342V L-L	Not available	94	140	140	280
	400V L-L	44	87	132	132	264
	480V L-L	37	73	110	110	220
Hold-up Time		>10mSec				
Isolation Voltage		2200VAC Input-to-Output, 1350VAC Input-to-Chassis				

SEQUOIA SERIES
PRECISION PROGRAMMABLE REGENERATIVE GRID SIMULATORS

OPERATIONAL CHARACTERISTICS

Operational characteristics common for all three operation modes (Source mode, SINK-Grid Simulator mode and SINK-Electronic Load mode)

PARAMETER	CHARACTERISTIC
Parallel Operation	Multi-chassis configurations are automatically accomplished when the chassis are interconnected with the interface cables, and require no user setup, except to wire the inputs and outputs. Maximum power is limited to 270 kVA with the SQ45 and 1.08MVA with the SQ90.
Output Relays	Isolation and range relays are provided internally to automatically configure the outputs, turn the output on/off, and disconnect the load from the output amplifier when in the off state.
1-Phase and 3-Phase mode selection	Switches between 1 and 3 phase outputs. This mode is available SQ22.5, SQ30 and SQ45 models only.
Non-Volatile Memory	16 complete instrument setups and transient lists, 100 events per list.
Waveform Management	Sequoia Series employs independent arbitrary waveform generator for each phase, this allows the user to create custom waveforms. In addition, three standard waveforms sine, square and clipped are always available.
Fault Identification	On-board diagnostics identify when an assembly has experienced a fault.
Emergency Stop	This mushroom style switch is installed on the front panel of each chassis. When pushed in, the amplifiers will be disabled, the voltage will be programmed to 0V and the output relay(s) will open. Note that the controller (and front panel display) will still be powered up, but no power is available to the amplifiers and there will be no output power.
Calibration	Calibration interval is 1 year; calibration is firmware-based through the digital interface or Virtual Panels.

OPERATIONAL CHARACTERISTICS SPECIFIC TO SOURCE MODE

Current Limit Modes	Two selectable modes of operation: Constant Voltage (CV) & Constant Current (CC). In CC mode, the voltage folds back with automatic recovery during an over-current event. In CV mode, the output is programmed to 0V and the output relays open with an over current event.
Automatic Level Control (ALC)	User-selectable ALC operation enables a digitally implemented feedback control loop to precisely regulate the RMS value of the output voltage. Note: ALC operation is not applicable in the Electronic Load Mode
Transient Generator	Output could be controlled to produce list transient events with 500 µs programming resolution. Voltage: drop, step, sag, surge, sweep; Frequency: step, sag, surge, sweep; Voltage and Frequency: step, sweep.

OPERATIONAL CHARACTERISTICS SPECIFIC TO REGEN-GRID SIMULATOR MODE

Protection Characteristics	When the absolute value of the current exceeds the regenerative programmable current limit set point, the output voltage of the Grid Simulator will be increased gradually to reduce the amount of current being returned.

OPERATIONAL CHARACTERISTICS SPECIFIC TO ELECTRONIC LOAD MODE

Over-Voltage Protection	Output protected for voltage transients above user setpoint.
Transient Generator	Output could be controlled to produce transient events with 500 µs programming resolution: Current: drop, step, sag, surge, sweep.
RLC Programming	User can program Resistance, Inductance and Capacitance as load as per the range specified for each output model. In this mode SQ programs the RMS current with appropriate phase angle to the output as per the programmed RLC values.
Non-Linear Current Programming	Using current waveform programming feature, a nonlinear current (example, six pulse rectified current waveform) can be programmed to the SQ output. The highest peak current programmed is as defined by output repetitive peak current rating.

ENVIRONMENTAL SPECIFICATIONS

PARAMETER	SPECIFICATIONS
Operating Temperature	0° to +40° C. (Except in Constant Power mode). +32° to +104° F.
Storage Temperature	-40° to +85 °C. -40° to +185° F.
Altitude	< 2000 meters
Relative Humidity	0-95 % RAH, non-condensing maximum for temperatures up to 31°C decreasing linearly to 50% at 40°C.
Vibration	Designed to meet ISTA 1A transportation levels.
Shock	Designed to meet ISTA 1A transportation levels.
Transportation integrity	ISTA Test Procedure 1A

OPTIONS	DESCRIPTION
HF	Increases the maximum output frequency range to 905Hz
HF-FC	This option adds the HF option and changes the frequency accuracy to ±0.25% of program frequency
LKM	Clock and Lock, Master
LKS	Clock and Lock, Auxilliary
AVSTD	Includes RTCA/DO160 E/F/G, MIL-STD 704 A/B/C/D/E/F, Airbus ADB100.1.8 D/E, Airbus ADB100.1.8.1 B/C
AVALL	Includes RTCA/DO160 E/F/G, MIL-STD 704 A/B/C/D/E/F, Airbus ADB100.1.8 D/E, Airbus ADB100.1.8.1 B/C Includes RTCA/DO160 E/F/G, MIL-STD 704 A/B/C/D/E/F, Airbus ADB100.1.8 D/E, Airbus ADB100.1.8.1 B/C, B787B3-0147, AMD24C
MIL1399	MIL-STD 1399-300B Shipboard Power Test
EXTD	External Drive (0-7.00Vrms aux input)
LNS	Synchronizes the output frequency to the input line frequency
GPIB	GPIB Interface
XVC	Optional AC coupled voltage range (specifications below)

XVC400 SPECIFICATIONS

PARAMETER	SR0015	SR0022	SR0030	SR0045	SR0090
Voltage Range	0-440 Vrms L-N				
Voltag Resolution	0.1 V				
Voltage Accuracy	±1 Vrms				
Power	15kVA	22.5kVA	30kVA	45kVA	90kVA
Current per Φ (max)	42 Arms	21 Arms	28 Arms	42 Arms	85 Arms

REGULATORY AGENCY COMPLIANCE

PARAMETER	SPECIFICATIONS
EMC	CE marked for EMC Directive 2014/30/EU per EN 61326-1:2013 Class A for Emissions and Industrial Immunity levels as required.
Safety	CSA NRTL certified for US and Canada to CAN/CSA-C22.2 No. 61010-1-12, UL 61010-1 Third Edition. CE marked for LVD compliance 2014/35/EU to EN 61010-1 Third Edition as required for the EU CE mark.
CE Mark LVD Categories	Installation Overvoltage Category: II; Pollution Degree: 2; indoor use only.
RoHS	CE marked for compliance with RoHS3 EU Directive 2015/863/EU for Restriction of Hazardous Substances in Electrical and Electronic Equipment.

ORDERING INFORMATION

CONFIGURATION
G - GRID SIMULATOR
L - ELOAD
C - GRID SIMULATOR + ELOAD

INPUT
C - 208V L-L
D - 400V L-L
E - 480V L-L
F - 230V L-L
G - 380V L-L [2]
H - 600V L-L [1]

INTERFACE OPTIONS
0 - STANDARD
1 - GPIB
2 - GPIB-MC

CLOCK/LOCK OPTIONS
0 - NONE
A - LKM, CLOCK/LOCK LEADER
B - LKS, CLOCK/LOCK FOLLOWER

SERIES
SEQUOIA

SQ XXXX X X X X – X X X X X 000

POWER
0015 - 15KVA
0022 - 22.5KVA
0030 - 30KVA
0045 - 45KVA
0090 - 90KVA
0135 - 135KVA

NUMBER OF CHASSIS

OPTIONAL OUTPUT AC VRANGE
1 - NONE
2 - XVC440
3 - XVC550 [1]
4 - XVC660 [1]
5 - XVC715 [1]

FREQUENCY OPTIONS
0 - STANDARD
1 - HF
2 - HF-FC

REGULATORY TEST OPTIONS
0 - NONE
A - IEC
B - IEC-MC
C - LNS, LINE SYNC
D - LNS-MC
E - IEC+LNS
F - IEC+LNS-MC

POWER QUALITY TEST OPTIONS
0 - NONE
A - AVSTD
B - AVSTD-MC
C - AVALL
D - AVALL-MC
E - MIL1399
F - MIL1399-MC
G - MIL1399+AVSTD
H - MIL1399+AVSTD-MC
J - MIL1399+AVALL
K - MIL1399+AVALL-MC

NOTES: [1] Available only on Sequoia 90 Configurations [2] Not available on Sequoia 15 Configurations