Model 9510
Regenerative Grid Simulator 50kW - 1.2MW

Test solution for engineering development, compliance verification and manufacturing for all utility grid-tied products. Immediate applications for Distributed Energy Resources, Energy Storage Systems, Solar PV, and Vehicle to Grid test, evaluation, and certification.

Key Features & Capabilities

- Regenerative AC/DC Grid Simulator and Power Amplifier
- Optimized for PHIL applications
- 50kW, 75kW, 100kW Power Modules
- Modular & Scalable AC Power from 100kW to 1.2MW
  - Same unit can act as master or parallel auxiliary unit
  - Field expandable for future increased power demands
- AC Load option: Modules can be configured as Regenerative AC/DC Grid Simulator or 4-Q AC Load
- Fully isolated design:
  - Facility to output and channel to channel
  - High voltage remote sense up to 1286VL-L
- Widest True-Power Operating Envelope
  - Wide range of power factors
  - Wide range of voltage (150V to 350V with full power)
- Provides extra current for different voltage grid tied products
- High power density with small footprint
- Multiple phase and DC capability covers all utility source and load requirements
  - Programmable three-phase, split-phase, or single phase
- Independent voltage and current measurement range for enhancing measurement accuracy
- Powerful waveform synthesizer combined with high-resolution digitizer covers extensive test and evaluation requirements.
- Ideal for regulation testing standards: UL 1741SA, IEEE 1547, IEC 62116, IEC 61000-4-11(pre-compliance), 4-13, 4-14, 4-28, etc.

Applications

E-mobility
Smart Grid
Utility Grid
Energy Storage
Photovoltaic
Research
Power HIL
IEC Testing

Model 9510

Introduction

The 9510 Regenerative Grid Simulator is the industry leading solution for testing and verification of high power grid-tied applications in compliance with regulatory testing standards, worldwide. The 9510 has a built-in power amplifier mode for Power Hardware in the Loop (PHIL) applications providing further testing and simulation capability ideal for research labs. Select power levels ranging from 50kW, 75kW or 100kW modules. Modular and scalable power is available in 100kW modules up to 1.2MW. Programmable frequency is between 30Hz and 120Hz. The output can be AC, DC or AC+DC and the AC can be single, split or 3-Phase. With this wide range of power, frequency, and phase configuration options, the 9510 provides the ultimate flexibility to test the broadest selection of grid-tied products.

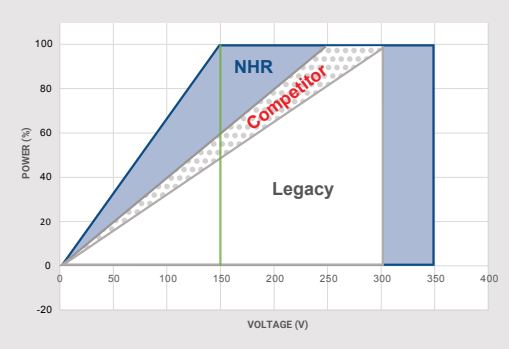
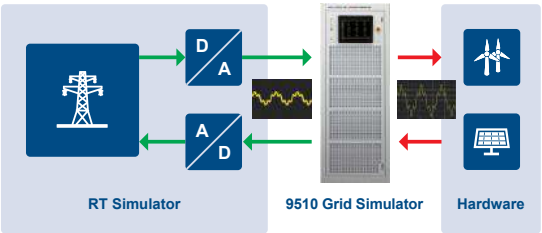


Figure 1 *- Max Power Delivered at 150VAC L-N*

Amplifier Mode for Power Hardware in the Loop (PHIL) with Low Latency

The 9510 is externally controllable via a low latency, per-phase analog input. This feature amplifies control signals from real-time simulation systems for power hardware in the loop testing. The dual range output ensures the maximum flexibility and accuracy in PHIL simulations.



Low Voltage Ride-Through (LVRT) & Area Electrical Power System (EPS) Disturbance Simulation

The 9510 Grid Simulator is able to directly simulate common power line disturbances, such as LVRT test patterns ***(Fig. 2 and 3)***, through a combination of macros and user-definable wave shapes. Macros are pre-programmed sequences of settings which are entered through a user-friendly menu, downloaded to the grid simulator, and are executed to provide precise control of the output(s). This method is used to generate LVRT test patterns, sub-cycle, and multi-cycle changes to the output covering nearly every need.

User-definable wave shapes extend this capability by permitting the generation of outputs including transient anomalies, voltage harmonics, or any other irregularity which can be drawn as a single cycle ***(Fig. 4 - 6)***. These wave shapes can be played continuously or switched in through the macro programming interface.

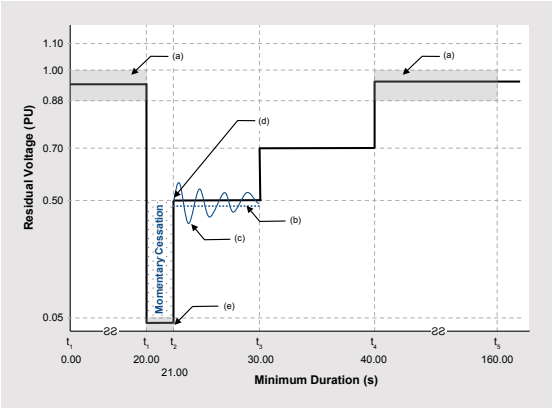


Figure 2 *- LVRT as per 1547.1:2020 Section 5.4.4*

Waveforms

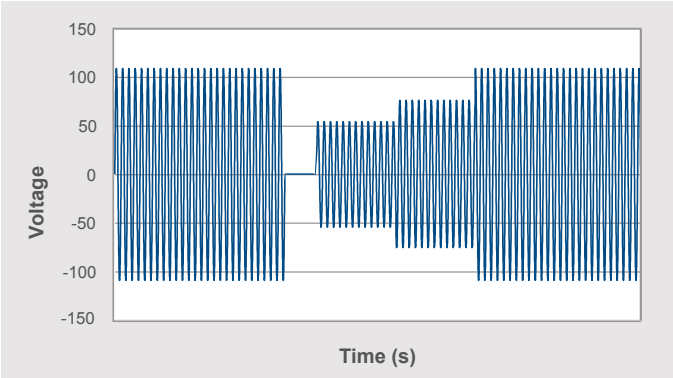


Figure 3 *- LVRT Profile*

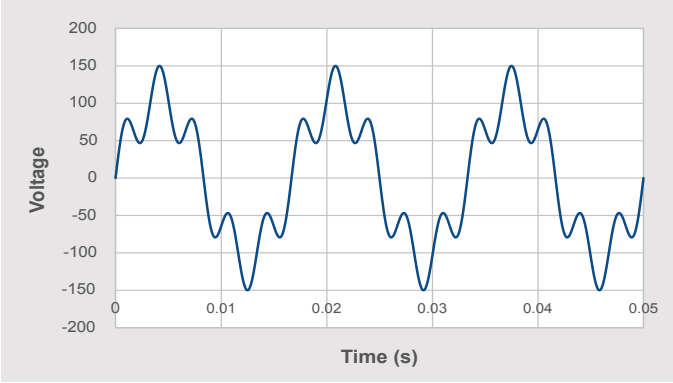


Figure 4 *- Distorted Waveform with Harmonics*

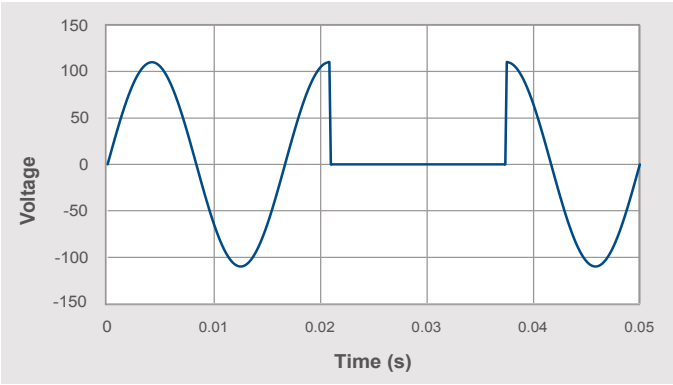


Figure 5 *- Sub-cycle Transient*

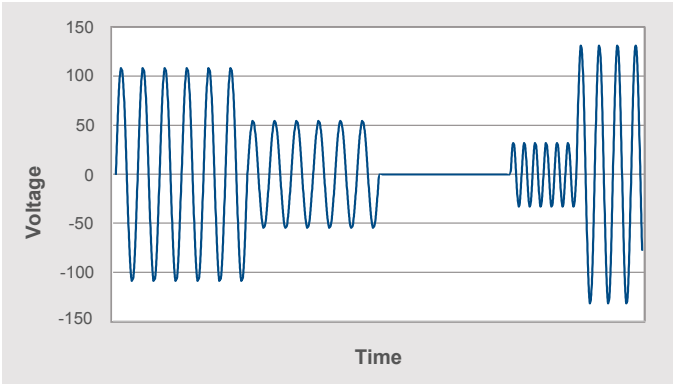


Figure 6 *- Voltage/Frequency Variation*

Advanced Digital Measurement System Option

Some of the UL1741 or IEEE1547.1 compliance tests, such as “enter service”, are very difficult to measure using oscilloscopes or simple engineering tools as they require long term measurement. Accomplishing these tests typically requires data acquisition and custom software to measure the clearing time and ramping period. The 9510 provides a unique measurement feature to measure key time points to dramatically simplify test. By specifying an event list, the 9510 reports on what cycle number each event is observed. These lists of cycles then can be used to determine key measurement features and show compliance with the standards.

The ***Figure 7*** shows an example of setting up six events in a list for IEEE1547.1 Inverter disconnect test and enter service test. When the area-eps voltage drops to an abnormal level, the 9510 detects this and starts the event measurement process. The device under test (DUT) will eventually stop delivering current and the event system measures the number of cycles until this is observed (point 2).

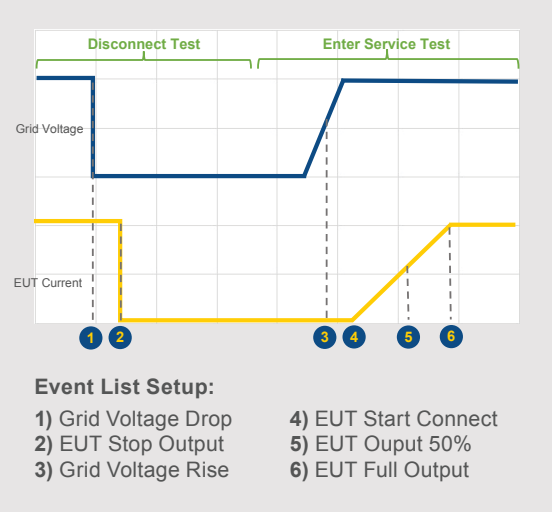


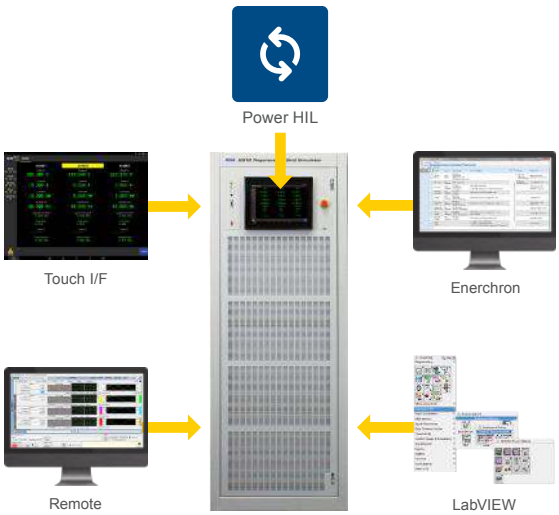
Figure 7 *- Events List for Inverter Disconnect Test and Enter Service Test*

The area-eps voltage is raised again and the measurement as to which cycle is reported. Eventually after the ES delay time and depending on the test case from IEEE1547.1 (table 11), the inverter is supposed to start ramping current. Having a cycle number for 10%, 50%, and 90% output currents makes it easy to calculate the amount of time the inverter was off and the ramp rate ensuring full compliance with IEEE1547.1 The 9510 additionally works like a Power Analyzer providing measurement features including true power (W), reactive power (VARS), apparent power (VA), crest factor (CF), power factor (PF), and many other measurements. When even deeper analysis is required, an internal 125kSample/second digitizer may be used to capture the voltage and current waveforms.

The Power of Choice: Flexible Control Options

There are multiple ways to control the 9510 High Voltage Grid Simulator.

- Fully programmable using NI standard tools such as LabVIEW and VeriStand. These include SCPI, OS-independent LabVIEW VIs for Windows applications.
- An integrated Touch-Panel provides a simple manual control interface and allows basic tests to be run within minutes of powering up the tester.
- For more complex test programs, a remote soft-panel interface on the user’s PC or laptop provides additional control features such as wave-shape editors, waveform captures and test program step controls using Macros.
- Analog interface for Power Hardware in the Loop (PHIL)
- Enerchron® Test Management Software for energy testing



Flexible Control Options

Protection and Safety

The 9510 has built-in safety features to prevent serious failures and protect the operator, UUT, and the facility. Internal hardware contactors isolate the power module from the device under test and the facility power. Protection features cover grid-side (line in), internal (9510), output (UUT) failures, and detection of unintentional Islanding conditions. Interlock and eStop are provided for rapid shutdown.

Model 9510 Regenerative Grid Simulator Specifications

MODEL NUMBER	9510-50	9510-75	9510-100	9510-200	9510-300	9510-400	9510-500	9510-1000	9510-1200
Description	50kW	75kW	100kW	(Only 100kW cabinet can support parallel expansion up to 1.2 MW[3])					
AC Output Ratings									
Operating Modes	4-Quadrant with Programmable Voltage (CV), Power Amplifier (PHIL), Optional AC Load								
Output Configurations	3 independent set per channel 3 x 1Φ (AC or DC), 2Φ + 1Φ (AC or DC), or 3Φ AC outputs								
Power, Max (1Φ or 3Φ)	50kW/ 118kVA	75kW/ 177kVA	100kW/ 236kVA	200kW/ 472kVA	300kW/ 708kVA	400kW/ 945kVA	500kW/ 1181kVA	1000kW/ 2362kVA	1200kW/ 2835kVA
Current Ranges (RMS per Φ)	25, 112.5 A	50, 168 A	50, 225 A	100, 450 A	150, 675 A	200, 900 A	250, 1125 A	500, 2250 A	600, 2700 A
Current Ranges (RMS 1Φ Mode)	75, 337.5 A	150, 506 A	150, 675 A	300, 1350 A	450, 2025 A	600, 2700 A	750, 3375 A	1500, 6750 A	1800, 8100 A
Frequency	30 – 120Hz (10 mHz resolution)								
Voltage Ranges	10 - 175, 10 - 350VRMS L-N (Split Phase 10-125, 20-250V Max)								
Voltage Accuracy	± 0.1% F.S.								
Programming Resolution	0.01V								
Load Regulation	± 0.02%								
Distortion (THD)[1]	0.45% (Typical) 0.65% (Max) <70Hz no load to full load ; 0.6% (Typical) 0.85% (Max) >70Hz no load to full load								
Slew Rate	1V/µS (10% to 90% measured at 90 degree turn-on into resistive load)								
Waveforms	Sine, n-Step Sine, Triangle, Clipped-Sine, Arbitrary (user defined)								
Phase Angle Control	0 to 359 degrees / 0.1 degree resolution								
DC Output Ratings									
Operating Modes	DC Constant Voltage (CV), Constant Current (CC), Constant Power (CP), Power Amplifier (PHIL), Optional DC Load								
Power Max (1ch or 3ch)	50 kW	75 kW	100 kW	200 kW	300 kW	400 kW	500 kW	1000 kW	1200 kW
Current Ranges (Per Ch.)	25, 100 A	50, 150 A	50, 200 A	100, 400 A	150, 600 A	200, 800 A	250, 1000 A	500, 2000 A	600, 2400 A
Current Ranges (1 Ch.)	75, 300 A	150, 450 A	150, 600 A	300, 1200 A	450, 2400 A	600, 2400 A	750, 3000 A	1500, 6000 A	1800, 7200 A
Voltage Ranges	10 - 200, 10 - 400 VDC								
Ripple	< 400mV RMS (into resistive load)								
Power Amplifier Mode									
Control Method[2]	Analog Input ±10V PK-PK amplified to ±247.5V PK-PK (low range) and ±495V PK-PK (high range)								
Latency (input-output)	50 uS typical								
AC & DC Measurements									
Peak Voltage	406V / 724V RMS								
Accuracy	0.1% Reading + 0.1% F.S. (AC RMS or DC)								
Resolution	0.005% F.S.								
Peak Current (per Ch.)	167, 500A per channel								
Accuracy	0.1% Reading + 0.1% F.S. (AC RMS or DC)								
Resolution	0.005% F.S.								
Peak Power	V Range x I Range								
Accuracy (kW or kVA)	0.1% Reading + 0.1% F.S.								
Resolution	0.005% F.S.								
Additional Measurements	Energy (Ah, kWh, kVAh), AC Crest Factor, AC Power Factor, True Power (P), Reactive Power (Q), Waveform Capture								
Waveform Digitizer									
Data Acquisition	Output Voltage AND Current					Aperture Time		1 cycle to 64s	
Sample Rate	125 k Samples / sec					Accuracy		0.5% Range	
Memory Depth	64k Samples (V & I per Φ)								
Control									
Local User Interface	Built-in Touch-Panel and PC-Based software tools including graphical user interface								
External System Comm	LAN (Ethernet) supporting SCPI								
Drivers	NI-Compliant LabVIEW Drivers								
Analog Current Monitor	[-10V, +10V] corresponds to ±Full Measurement Scale								
Analog Voltage Monitor	[-10V, +10V] corresponds to ±Full Measurement Scale								
Safety									
Isolation	Facility to Chassis – 1000V, Output to Chassis – 1000V, Output to Output Internal Isolation – 2000V								
Module Protection	Self-protecting for over-voltage, over-current, over-power, and over-temperature								
Physical	Emergency Stop and external Inter-Lock								
Programmable Safety Limits	Min/Max Voltage, Current (per direction), and Power (per direction) with separate limits and time delay values								
Watchdog Timer	Continuously monitors control communications								
Physical									
Connectors	2 x ½ inch stud terminals per channel (Total of six) + Ground								
Cabinet Dimensions (HxWxD)	78" x 28" x 39" / 1980mm x 712mm x 990mm								
Cabinet Weight	1000lbs/454kg for 50kW cabinet; 1200lbs/545kg (for 75kW and 100kW cabinet)								
Operating Temperature	5 - 35°C (up to 95% RH non-condensing)								
Input Power (Single 100kW Cabinet)									
Voltage	Universal Input – 380V to 480V ± 10% (L-L, 3 Phase, 50/60Hz). Output Power reduced to 90kW below 360VAC input.								
Efficiency/Power Factor	Efficiency: > 90% typical (>92% at full power), Power Factor: > 0.95 typical (> 0.99 at full power)								
Current per Φ	168A@380V, 144A@400V, 134A@480V								

[1] Refer to the gain / frequency graph , [2] THD is tested based on output 480VL-L (277 VL-N) with resistive load, [3] Only 100kW cabinet can support parallel expansion; 50kW for standalone operation only.

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