Model 9410
Regenerative Grid Simulator

For The Testing of PV Inverters & Other AC Power/Frequency Conversion Products

NHR
NH Research, Inc.

Key Features

- 8 models - Power from 4kW/10$^{1/2}$ kVA to 96kW/2452kVA
- Reactive Power capability 2.6 x True Power
- Output AC Voltage Ranges - 175, 350VRMS (L-N)
- Output Frequency - DC, 30 to 100Hz
- Output DC Voltage Ranges - 200, 400VDC
- Programmable 1, 2 or 3-Phase modes
- Powerful line disturbance creation tools
- High-resolution waveform digitizer with scope display & charting
- Sink power returned back to facility mains
- 9" Touch-Panel user interface

Application

The 9410 is a four-quadrant (bi-directional) AC/DC source with selectable phase outputs, a built-in waveform-digitizing measurement system and robust line disturbance creation tools. When used in the regenerative (sink) mode, it sends returned power back to the facility mains rather than being dissipated as heat. The most frequent application of the 9410 is use as a grid simulator for testing PV inverters and other grid-tied products for compliance to industry standards.

Model 9410 36kw cabinet

Unique Configuration Flexibility

The Model 9410 is particularly flexible in both output form and power level. Output can be AC or DC and the AC can be single, split or 3-Phase (*Fig.1*). Frequency is programmable between 30 and 100 Hz. Power is scalable from 4 kW/1ø to 96kW/3ø. With this broad selection of power, phase configuration and frequency, the 9410 provides the flexibility to test the widest range grid-tied products.

Figure 1 - 3 channels with multiple configuration possibilities.

More Reactive Power Capability per kW

The 9410 is rated in both true power (kW) and apparent power (kVA) in order to optimally size the tester to meet the test requirements. Its HiVAR design provides a VA-rating 2.6-times the W-rating. The tester is able to maintain full true power across a wide operating voltage range as well as maintain this true power level even when additional reactive power (kVARS) or reactive current harmonics are present. Sizing a traditional kVA-only rated system for true power must account for the worst-case power factor and the effects due to current harmonics. For example, in some instances a 45kVA rated system is able to provide 45kW when the power factor is unity (PF=1) but only able to provide only 30kW when there is an equal amount of reactive power (PF=0.7). In order to provide 45kW at a 0.7 power factor, a 64 kVA system is required. Having this reactive power capability significant extends the range of products that any of the 9410 Series can test within any kW-rated unit.

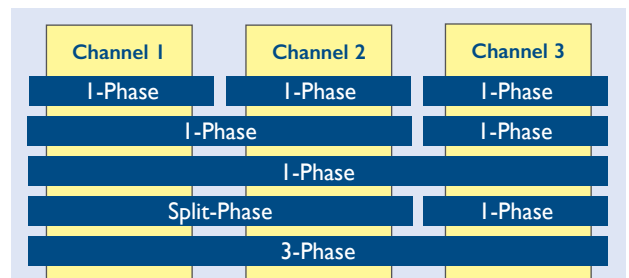## Area Electrical Power System Disturbance Simulation

The 9410 Grid Simulator is able to replicate power line disturbances through a combination of user-definable wave shapes and Macros. User-defined waveshapes permit generation of non-sinusoidal voltages including asymmetrical inflections, transient anomalies, voltage harmonics (*Fig.2*), or any other irregularity which can be drawn as a single-cycle. These waveshapes are created through a Graphical Waveshape Editor and downloaded the Grid Simulator where they are then scaled to the programmed voltage and frequency.

Macros are a pre-programmed sequence of settings where each new setting is present for a sub-cycle, any number of cycles or for a fixed amount of time. This sequence is entered using a menu-driven, programming free interface. The sequence is then downloaded to the Grid Simulator where it is executed to provide precise control of any phase.

The combination of user-definable waveshapes and Macros insures the 9410 can simulate sub-cycle transients (*Fig. 3*), phase jumps (*Fig. 4*) and multi-cycle line conditions (*Fig. 5*) as required by either current or emerging regulatory standards.

Advanced Digital Measurement System

The Model 9410 instruments include a digital measurement system that features a high-resolution waveform digitizer. This provides the power analysis tools typically found in test systems that include digital multi-meters, oscilloscopes, and power analyzers. Having such a comprehensive measurement system built into the 9410 eliminates the integration complexity, prolonged start-up time, extra cabinet space and cost for those additional measurement instruments normally required. The user is ready to begin testing the day the 9410 is delivered.

The types of measurements are broad and include almost any type of voltage, current, power and timing. In a 3-phase 9410, all six channels of voltage and current measurements are digitized simultaneously at 125kSamples/sec to be displayed, recorded or further analyzed. Specialized measurements such as abnormal grid detection thresholds, disconnection timing, power ramp-up timing, and generated harmonic current limits are also possible.

Control Choices

There are 3 methods of controlling the 9410 instruments.

- An integrated Touch- Panel provides a simple manual control interface that requires no configuration steps and allows basic tests to be run within minutes of powering up the tester.
- For more complex test programs, a soft-panel interface on the user's PC or laptop may be used. This application provides additional control features such as wave-shape editors, waveform captures and test program step controls using Macros.
- Custom programming with the user's own programming language is straight forward with NHR's fully documented drivers. These include SCPI/VX-11, OS-independent LabVIEW VIs and IVI drivers for Windows applications.

Protection and Safety

The 9410 has multiple layers of protection and safety. There are over 25 checks and mechanisms to prevent serious failures. These checks and safety devices are designed to protect the operator, the unit being tested, the facility as well as the 9410. Some checks are programmable; others are hardware implementations for the fastest possible speed of execution. Protection features cover grid-side (line in), internal (9410) and output (UUT) failures. Most importantly, the protection/safety features will actually physically disconnect and isolate the 9410 from the UUT, grid or both. And finally, an eStop is also provided for local or remote manual shutdown.
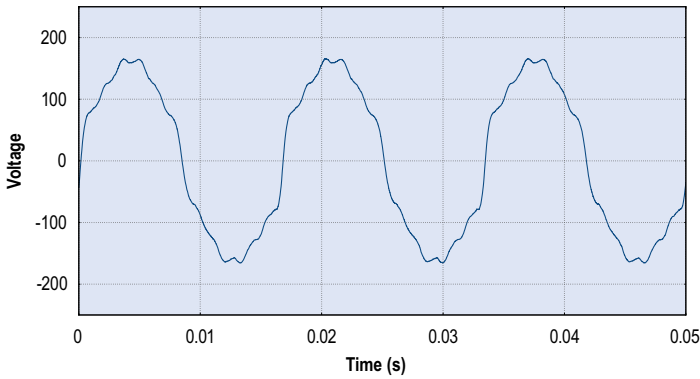
Waveforms

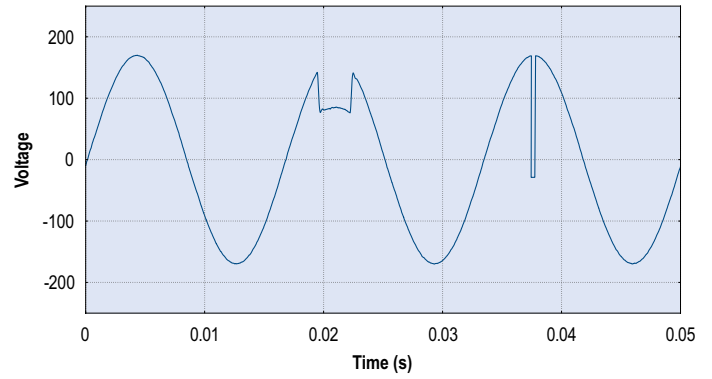Figure 2 - Simulating Area EPS Voltage Harmonics
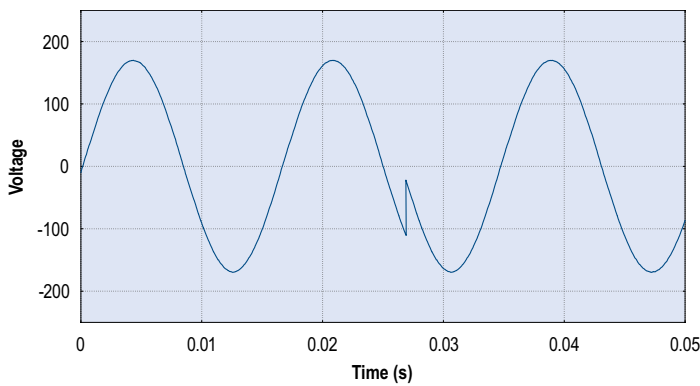

Figure 3 - Simulating Sub-cycle Transients

Figure 4 - Simulating Phase Jump
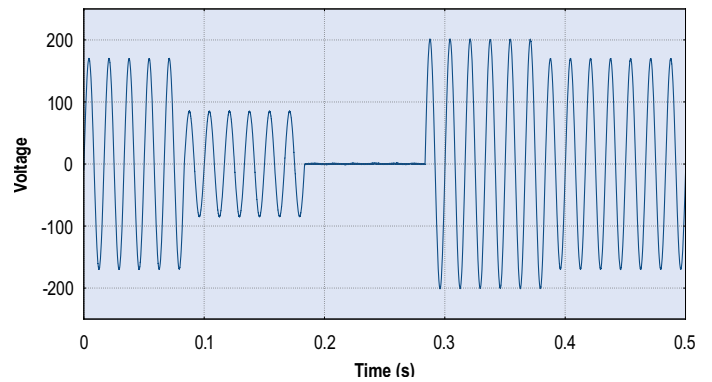
Figure 5 - Simulating abnormal voltages
(sags, swells, & drop outs)

Physical Connections & Controls
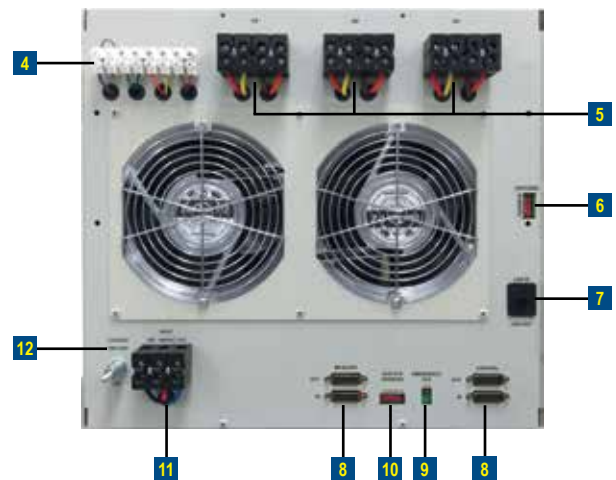
1 Touch Panel Based Control & Display	**5** Output Power Control & Measurement	**9** Remote Emergency Off
2 Status Lights & Trigger	**6** Options Switch	**10** Auxiliary Configuration
3 Circuit Breakers	**7** LAN (Ethernet) Port	**11** Input AC Power Terminal
4 External Sense	**8** Parallel Connections	**12** Chassis Ground

Model 9410 Regenerative Grid Simulator Specifications

Model Number	9410-4	9410-8	9410-12	9410-24	9410-36	9410-48	9410-72	9410-96
AC Output Ratings								
Phases/Output Channels	1	1 or 2	1, 2, or 3					
Power, Max (1φ or 3φ)	4kW/10.5kVA	8kW/21kVA	12kW/31.5kVA	24kW/63kVA	36kW/94.5kVA	48kW/126kVA	72kW/189kVA	96kW/252kVA
Current Ranges (RMS per φ)	6, 30A/φ	6, 30A/φ	6, 30A/φ	12, 60A/φ	18, 90A/φ	24, 120A/φ	36,180A/φ	48, 240A/φ
Current Ranges (RMS 1φ)	6, 30A	12, 60A	18, 90A	36, 180A	54, 270A	72, 360A	108, 540A	144, 720A
Peak Current	3 X Max RMS							
Frequency	30 – 100Hz							
Voltage Ranges, L-N	175, 350V (Split Phase 250V Max)							
Accuracy	0.2% Set + 0.2% Rng							
Resolution	0.005% Rng							
Distortion (THD)	<1% @ 50/60Hz (Full power into resistive load at 480VRMS (L-L))							
Response Rate	1V/µS (10% to 90% measured at 90 degree turn-on into resistive load)							
Custom Waveforms	Sine, n-Step Sine, Triangle, Clipped-Sine, Arbitrary (user defined)							
Phase Angle Control	0 to 359 degrees / 1 degree resolution							
DC Output Ratings								
Power Max (1ch or 3ch)	4kW	8kW	12kW	24kW	36kW	48kW	72kW	96kW
Current Ranges (Per Ch.)	6, 30A/CH	6, 30A/CH	6, 30A/CH	12, 60A/CH	18, 90A/CH	24, 120A/CH	36, 180A/CH	48, 240A/CH
Current Ranges (Per System)	6, 30A	12, 60A	18, 90A	36, 180A	54, 270A	72, 360A	108, 540A	144, 720A
Voltage Ranges	200, 400VDC							
Accuracy	0.2% Set + 0.2% Rng							
Ripple	< 800mV RMS							
AC & DC Measurements								
Peak Voltage	250, 500V							
Accuracy (AC RMS)	0.1% Rdg + 0.06% Rng							
Accuracy (DC)	0.1% Rdg + 0.1% Rng							
Accuracy (Peak)	0.5% Rdg + 0.2% Rng							
Resolution	0.005% Rng							
Peak Current (per Ch.)	20, 100A	20, 100A	20, 100A	40, 200A	60, 300A	80, 400A	120, 600A	180, 800A
Accuracy (AC RMS)	0.2% Rdg + 0.06% Rng							
Accuracy (DC)	0.2% Rdg + 0.06% Rng							
Accuracy (Peak)	0.5% Rdg + 0.2% Rng							
Resolution	0.005% Rng							
Peak Power	V Range x I Range							
Accuracy (kW or kVA)	0.3% Rdg + 0.025% Rng							
Resolution	0.005% Rng							
Additional Measurements	Energy (Ah, kWh, kVAh), AC Crest Factor, AC Power Factor, Waveform Capture							
Waveform Digitizer								
Data Acquisition	Output Voltage and Current							
Sample Rate	125kSamples / sec							
Memory Depth	64kSamples							
Aperture Time	1 cycle to 64s							
Accuracy/Resolution	0.5% Rng / 0.05%							
Control								
Local User Interface	Built-in Touch-Panel and PC-Based software tools including graphical user interface							
External System Comm	LAN (Ethernet) supporting SCPI or VXI-11							
Drivers	NI-Compliant LabVIEW Drivers, IVI-C, IVI-COM							
Safety								
Module Protection	Self-protecting for over-voltage, over-current, over-power, and over-temperature							
Physical	Emergency Stop and remote E-Stop connection							
Programmable Limits	Min/Max Voltage, Current (per direction), and Power (per direction) with separate limits and time delay values							
Software Watchdog	Programmable							
Physical								
Connectors	Terminal Block			Bus Bars				
Form	Chassis			Single Cabinet			Double Cabinet	
Dimensions (WxDxH)	19"x24"x15¾"			23"x30"x49"	23"x30"x61"	23"x30"x78"	46"x30"x78"	
Weight	105 lbs	120 lbs	135 lbs	370 lbs	505 lbs	855 lbs	1340 lbs	1610 lbs
Operating Temp	35°C							
Isolation	Facility to Chassis – 1,000V, Output to Chassis – 500 V, Facility to Output Internal Isolation – 2,000 V							
Input Power								
Voltage	Universal Input – 380V to 480V ± 10% (L-L, 3 Phase, 50/60Hz)							
Efficiency/Power Factor	> 85% / > 0.95							
Current per φ @ 380 V	9A	17A	25A	49A	73A	97A	144A	192A
Current per φ @ 400 V	9A	17A	24A	47A	69A	92A	137A	183A
Current per φ @ 480 V	8A	14A	20A	39A	58A	77A	114A	152A

Ordering Information	Model	kW Rating
Grid Emulator P/N	9410	-12