

# Model 9410 Regenerative Grid Simulator

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



## Key Features

- 8 models - Power from 4kW/10<sup>1</sup>/<sub>2</sub> kVA to 96kW/252kVA
- Reactive Power capability 2.6 x True Power
- Output AC Voltage Ranges - 175, 350VRMS (L-N)
- Output Frequency - DC, 30 to 100Hz (option up to 880Hz)
- 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.

## 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/1 $\emptyset$  to 96kW/3 $\emptyset$ . With this broad selection of power, phase configuration and frequency, the 9410 provides the flexibility to test the widest range grid-tied products.

## 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.



Model 9410 36kw cabinet

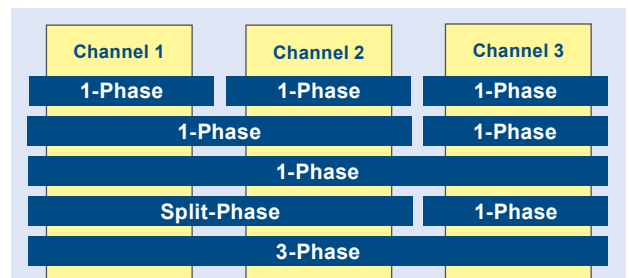


Figure 1 - 3 channels with multiple configuration possibilities.

## 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 to 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 1MS/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

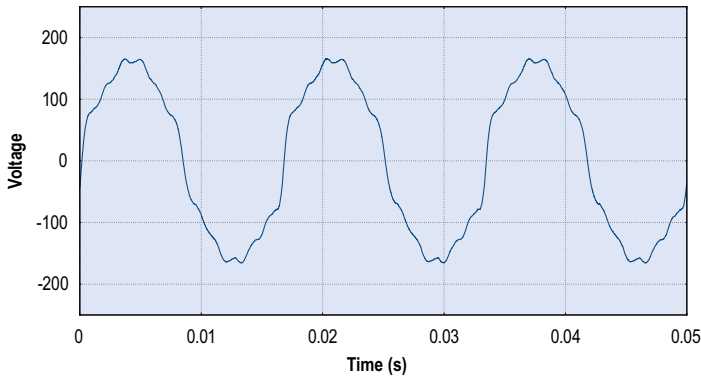


Figure 2 - Simulating Area EPS Voltage Harmonics

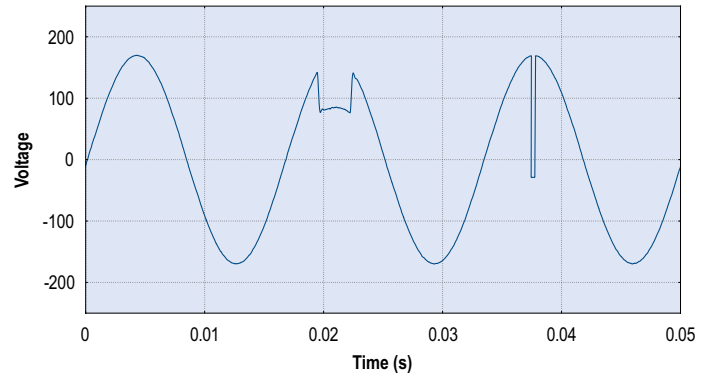


Figure 3 - Simulating Sub-cycle Transients

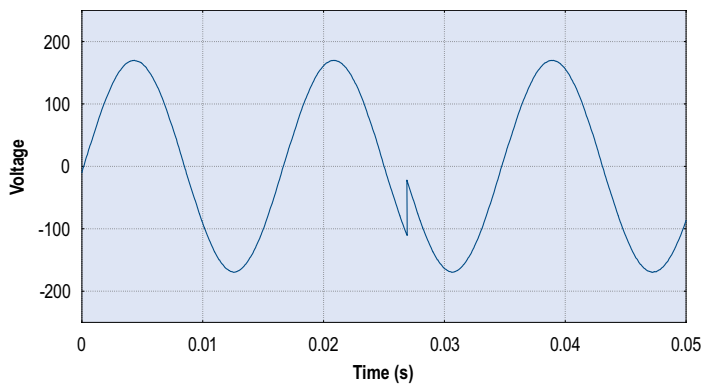


Figure 4 - Simulating Phase Jump

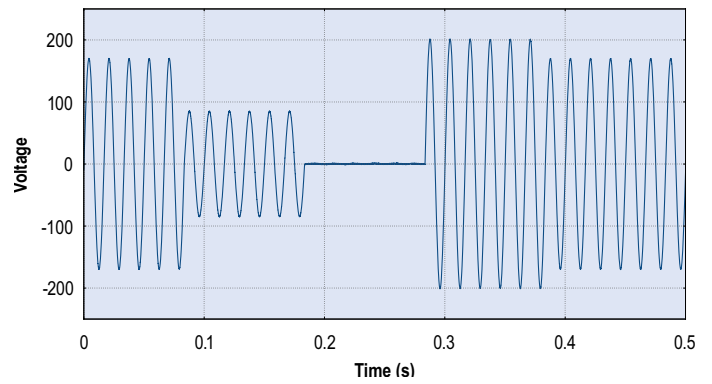
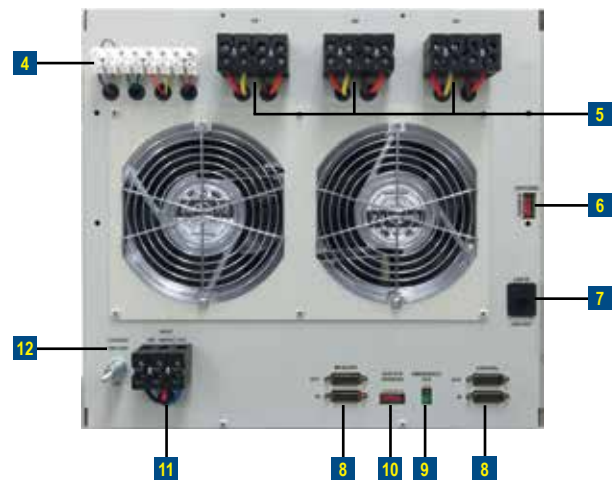


Figure 5 - Simulating abnormal voltages (sags, swells, & drop outs)

## Physical Connections & Controls



- 1 Touch Panel Based Control & Display
- 2 Status Lights & Trigger
- 3 Circuit Breakers
- 4 External Sense

- 5 Output Power Control & Measurement
- 6 Options Switch
- 7 LAN (Ethernet) Port
- 8 Parallel Connections

- 9 Remote Emergency Off
- 10 Auxiliary Configuration
- 11 Input AC Power Terminal
- 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       |
|---------------------------------|--|-------------|--------------|-----------------------------|-----------------------------|-----------------------------|--------------------------------------|---------------|
| <b>AC Output Ratings</b>        |  |             |              |                             |                             |                             |                                      |               |
| 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 (option up to 880Hz)  |             |              |                             |                             |                             |                                      |               |
| Voltage Ranges, L-N             | 10 - 175, 350VRMS L-N (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   |             |              |                             |                             |                             |                                      |               |
| <b>DC Output Ratings</b>        |  |             |              |                             |                             |                             |                                      |               |
| 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                  | 10 - 200, 400VDC   |             |              |                             |                             |                             |                                      |               |
| Accuracy                        | 0.2% Set + 0.2% Rng  |             |              |                             |                             |                             |                                      |               |
| Ripple                          | < 800mV RMS  |             |              |                             |                             |                             |                                      |               |
| <b>AC &amp; DC Measurements</b> |  |             |              |                             |                             |                             |                                      |               |
| Peak Voltage                    | 260, 520V  |             |              |                             |                             |                             |                                      |               |
| 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)               | 0.1% Rdg + 0.1% Rng  |             |              |                             |                             |                             |                                      |               |
| Accuracy (DC)                   | 0.2% Rdg + 0.1% Rng  |             |              |                             |                             |                             |                                      |               |
| Accuracy (Peak)                 | 0.5% Rdg + 0.2% Rng  |             |              |                             |                             |                             |                                      |               |
| Resolution                      | 0.005% Rng   |             |              |                             |                             |                             |                                      |               |
| Peak Power                      | V Range x I Range 0.2%   |             |              |                             |                             |                             |                                      |               |
| Accuracy (kW or kVA)            | Rdg + 0.1% Rng   |             |              |                             |                             |                             |                                      |               |
| Resolution                      | 0.005% Rng   |             |              |                             |                             |                             |                                      |               |
| Additional Measurements         | Energy (Ah, kWh, kVAh), AC Crest Factor, AC Power Factor, Waveform Capture                                     |             |              |                             |                             |                             |                                      |               |
| <b>Waveform Digitizer</b>       |  |             |              |                             |                             |                             |                                      |               |
| Data Acquisition                | Output Voltage and Current   |             |              | Aperture Time               |                             | 1 cycle to 64s              |                                      |               |
| Sample Rate                     | 125kSamples / sec  |             |              | Accuracy/Resolution         |                             | 0.5% Rng / 0.05%            |                                      |               |
| Memory Depth                    | 64kSamples   |             |              |                             |                             |                             |                                      |               |
| <b>Control</b>                  |  |             |              |                             |                             |                             |                                      |               |
| 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   |             |              |                             |                             |                             |                                      |               |
| <b>Safety</b>                   |  |             |              |                             |                             |                             |                                      |               |
| 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   |             |              |                             |                             |                             |                                      |               |
| <b>Physical</b>                 |  |             |              |                             |                             |                             |                                      |               |
| Connectors                      | Terminal Block   |             |              | Bus Bars                    |                             |                             |                                      |               |
| Form                            | Chassis  |             |              | Single Cabinet              |                             |                             | Double Cabinet                       |               |
| Dimensions (HxWxD)              | 15¼ x 19 x 24"<br>400 x 483 x 610mm  |             |              | 49x23x30"<br>1244x584x762mm | 61x23x30"<br>1549x584x762mm | 78x23x30"<br>1981x584x762mm | 78 x 46 x 30"<br>1981 x 1168 x 762mm |               |
| Weight                          | 105lbs/48kg  | 120lbs/54kg | 135lbs/61kg  | 370lbs/168kg                | 505lbs/229kg                | 855lbs/388kg                | 1340lbs/608kg                        | 1610lbs/730kg |
| Operating Temp                  | 35°C   |             |              |                             |                             |                             |                                      |               |
| Isolation                       | Facility to Chassis – 1,000V, Output to Chassis – 500 V, Facility to Output Internal Isolation – 2,000 V       |             |              |                             |                             |                             |                                      |               |
| <b>Input Power</b>              |  |             |              |                             |                             |                             |                                      |               |
| 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          |
| <b>Ordering Information</b>     |  |             |              |                             |                             |                             |                                      |               |
| Model                           | 9410   |             |              | kW Rating                   |                             |                             |                                      |               |
| Grid Emulator P/N               |  |             |              | -12                         |                             |                             |                                      |               |



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