PRELIMINARY

Model 9410
Regenerative Grid Simulator

For The Testing of Grid-Tied Inverters, V2G & Other AC Power Products

NH Research, Inc.

Key Features

- 8 Models - Power from 4kW/8kVA to 96kW/192kVA
- Output Voltage - 0 to 310, 400 VRMS L-N
- Output Frequency - DC, 30 to 880 Hz
- Programmable 1, 2 or 3-Phase modes
- Full 4-quadrant operation
- 1 MS/sec waveform digitization on all V & I channels
- Minimal heat – Unit Under Test (UUT) power regenerated back to facility
- 7" Touch-Panel user interface
- SCIPI programming and NI-certified LabVIEW drivers

Model 9410 *single module front panel view*

Unique Power Modules Provide Exceptional Configuration Flexibility

The Regenerative Grid Simulator testers, Model 9410, are typically composed of a number of independent 12 kW Power Modules, each of which contains three channels, one for each phase. The Power Modules are paralleled in software to meet higher power requirements and appear to the user a single source. All channels of all 12 kW Modules are programmable to provide single, split or 3-Phase operation (Fig. 1). With this control over both parallelability and phase selection, the Regenerative Grid Simulator, Model 9410, sets a new configuration flexibility standard.

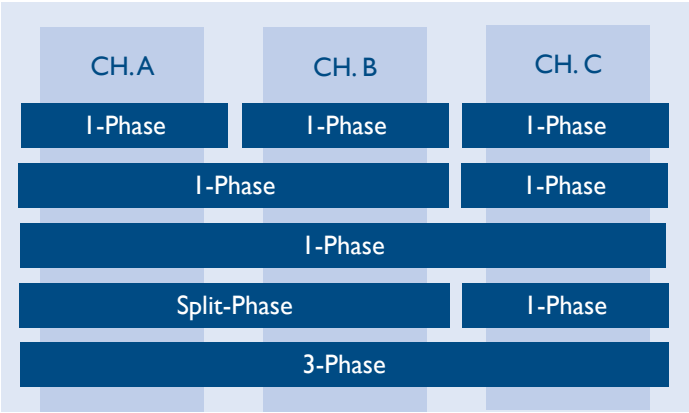


Figure 1 - 3 channels with multiple configuration possibilities.

More Reactive Power Capability per kW

The Regenerative Grid Simulator, 9410 Model, is rated in both true power (kW) and apparent power (kVA) in order to ideally size the test system to the test requirements. The system 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 *(Fig. 2)*. 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, a 45kVA-only rated system is able to provide 45kW when the power factor is unity (pf=1) and is able to provide only 30kW when there is an equal amount of reactive power (pf=0.7). In order to maintain 45kW at a 0.7 power factor requires a system which is 64kVA

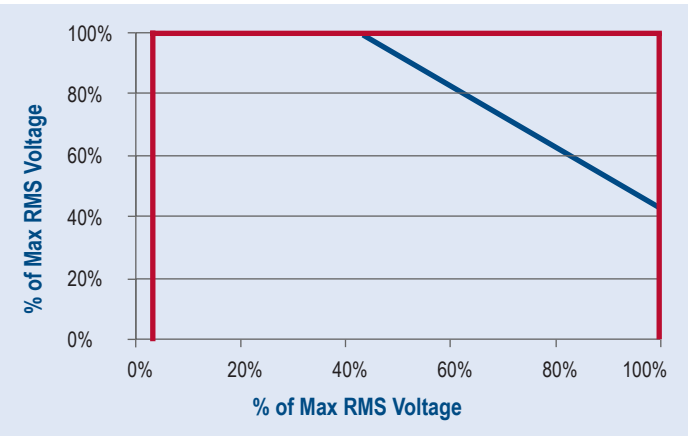


Figure 2 - Operating Envelope, "Full Operation" (— NHR 9400) & "True Power" (— True Power).

or larger. This sizing can be even more complicated when reactive current harmonics are considered. The Regenerative Grid Simulator, Model 9410, simplifies this selection process by allowing the system to be specified in true power while still providing a higher VA rating to support reactive power needs. For example, A 9410-48 system is rated to provide up to 48kW of power and is able to maintain an apparent power of up to 96kVA, thereby meeting the needs for both true power and reactive power transfer requirements.

Hundreds of Precision Measurements

The Regenerative Grid Simulator, Model 9410, includes a built-in measurement system which provides the power analysis tools typically found in digital multi-meters, oscilloscopes, and power analyzers. Having such a comprehensive measurement system eliminates the integration complexity, start-up time, extra cabinet space and cost for the additional measurement instruments normally required. The user is ready to begin testing the day the Regenerative Grid Simulator tester is delivered.

The types of measurements are practically limitless. In a 3-Phase Power Module, all six channels of V & I 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 possible. The number of such specialized measurements is limited only by the users' capability to create additional measurement algorithms.

User Defined Waveforms

In addition to several standard waveforms, the Regenerative Grid Simulator, Model 9410, has the ability to control voltage through user-defined waveforms, which can be then saved within the tester for later use. These waveforms can be created in two different ways. First would be through downloading a table of numbers that correspond to the desired value of each point over the entire cycle. A second method of creating special waveforms is through a NH Research, Inc. (NHR)-designed graphical waveform editor. This provides actual manipulation of the waveform and allows adding asymmetrical inflections, transient anomalies, harmonics and any wave shape that can be drawn as a single-cycle.

The output voltage amplitude and frequency are independently programmable so that the basic wave shape can be used with other voltages and frequencies. Additionally, each test channel/phase can use its own separate wave shape allowing the most versatility in creating a simulated grid condition.

More Ranges for Improved Voltage & Current Accuracy

The Regenerative Grid Simulator, Model 9410, provides selectable high/low range for both voltage and current. This separate range control significantly improves set-point and measurement accuracy especially when compared to single-range or dual-range, voltage-only control. A 9410 test channel can be set to operate and measure in the optimum range for both voltage and current. Through this capability, the tester can be programmed in any combination of these ranges thereby providing four effective ranges including low-voltage/low-current, low-voltage/high-current, high-voltage/low-current and high-voltage/high-current.

Higher Power is a Field Upgrade

In addition to each Power Module being phase configurable, any tester can be reconfigured with additional 12 kW Modules to provide more power. In this manner, a user can obtain just what is necessary for the current project knowing that if more power is needed in the future, it is a straightforward field upgrade.

Grid-Tied DG Regulations Testing

The Regenerative Grid Simulator, Model 9410, System provides the programmable power and measurement features required by IEEE 1547, UL 1741, VDE-4015, and other grid-tied equipment test standards.

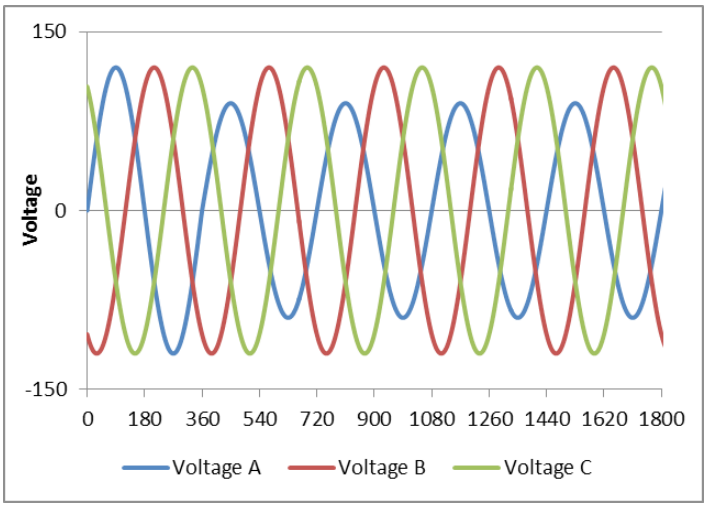


Figure 3 - DG testing waveforms

- Abnormal frequency conditions
- Imbalance/abnormal voltage conditions
- Measuring inverter generated current harmonics
- Low voltage & frequency ride-through
- AC power immunity testing

Low Voltage Ride-Through (LVRT) Tests

Grid-tied standards are very specific in describing how a device is to operate and for how long during either low voltage or abnormal frequency conditions. For example, the BDEW standard requires an inverter to remain connected and maintain its output for at least 150mS when the utility voltage drops to 15% of nominal. The Regenerative Grid Simulator , Model 9410, provides the capability needed to simulate this low voltage condition and measure the disconnection time to ensure the inverter meets the ride-through certification requirements.

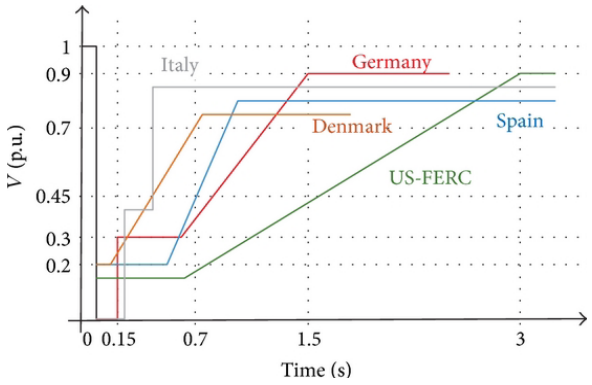


Figure 4 - Low-voltage ride through

Soft Panels

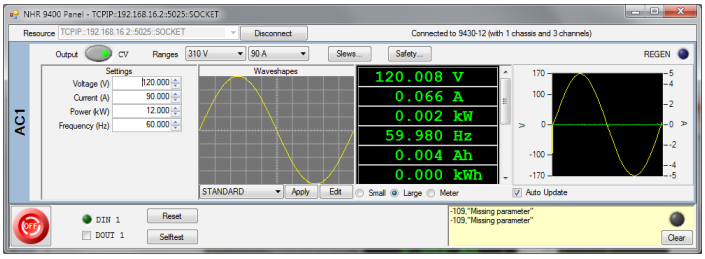


Figure 5 - Single phase, 6 measurements

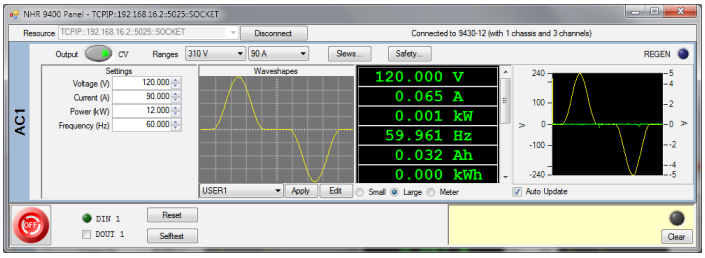


Figure 6 - Single phase waveform, distorted voltage wave shape

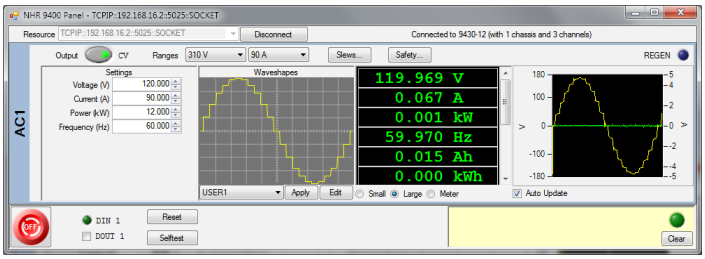
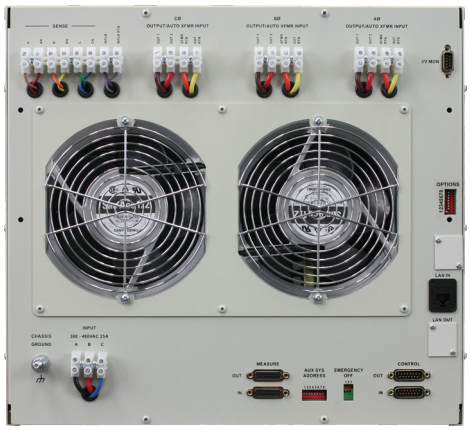


Figure 7 - Single phase waveform, stepped sine

Figure 8 - Single phase waveform with harmonics

Physical Connections & Controls



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, 2	1, 2 or 3					
Power, Max (1 or 3ø)	4 kW/8 kVA	8 kW/16 kVA	12 kW/24 kVA	24 kW/48kVA	36 kW/72 kVA	48 kW/96 kVA	72 kW/144 kVA	96 kW/192 kVA
Current Ranges (per Phase)	6, 30 A/ø	6, 30 A/ø	6, 30 A/ø	12, 60 A/ø	18, 90 A/ø	24, 120 A/ø	36/180 A/ø	48/ 240 A/ø
Current Ranges (Max 1ø)	6, 30 A	12, 60 A	18, 90 A	36, 180 A	54, 270 A	72, 360 A	108, 540 A	144, 720 A
Peak Current	3 X Max RMS							
Frequency	30 -880 Hz							
Voltage Ranges, L-N	155, 310 V, 400 V Option							
Accuracy	0.2% Set + 0.2% Rng @ 50/60 Hz							
Resolution	0.005% Rng							
Distortion	<1% @ 50/60 Hz (Full power into resistive load at 480 VRMS (L-L))							
Slew Rate	0.01 V/sec - 1000 V/msec							
Isolation	Facility to Chassis - 1,000 V, Facility to Output - 2,121 V, Output to Chassis - 500V							
Custom Waveforms								
Types	Sine, n-Step Sine, Triangle, Clipped Sine, Notched Sine, Arbitrary (user-defined)							
DC Output Ratings								
Power	4 kW	8 kW	12 kW	24 kW	36 kW	48 kW	72 kW	96 kW
Current Ranges (Max)	6, 30 A	12, 60 A	18, 90 A	36, 180 A	54, 270 A	72, 360 A	108, 540 A	144, 720 A
Current Ranges (Per Channel)	6, 30 A	6, 30 A	6, 30 A	12, 60 A	18, 90 A	24, 120 A	36, 180 A	48, 240 A
Voltage Ranges	219, 438 VDC							
Accuracy	0.3% Set + 0.3% Rng							
Ripple	< 800 mV RMS							
Measurements								
	Accuracy		Resolution					
RMS & DC Voltage & Current	0.1% Rdg + 0.1% Rng		0.005% Rng					
Peak Voltage & Current	0.5% Rdg + 0.2% Rng		0.005% Rng					
Power (kW, kVA)	0.3% Rdg + 0.3% Rng		0.005% Rng					
Energy (Ah, kWh, kVAh)	0.3% Rdg + 0.3% Rng		0.005% Rng					
Frequency	0.2% Rdg + 0.2% Rng		0.005% Rng					
Power Factor (-1.0 to +1.0)	0.5% Rdg + 0.5% Rng		0.05% Rng					
Crest Factor (1 to 3)	0.6% Rdg + 0.6% Rng		0.005% Rng					
Phase (degrees from øA)	1°		0.1°					
Waveform Fetch per Phase								
Data Acqusition	Output Voltage and Current							
Bandwidth	DC to 100 kHz							
Sample Rate	to 1 Msample/sec							
Aperture	0 to 64 sec							
Memory	64 k Samples							
Accuracy/Resolution	0.5% of Rng/0.005% Rng							
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 NHR Embedded Protocol							
Drivers	NI-Certified LabVIEW Drivers, IVI-C, IVI-COM							
Safety								
Module Protection	OVP, OCP, OPP							
Physical	Emergency Stop Button with remote connector							
Programmable Limits	V Min & Max, A Source/Sink Max, W Source/Sink Max & Min, each with programmable time constant							
Watchdog Timer	Programmable							
Physical								
Connectors	Terminal block			Terminal block and bus bars				
Form	Chassis	Chassis	Chassis	Single Cabinet	Single Cabinet	Single Cabinet	Double Cabinet	Double Cabinet
Dimensions (WxDxH)	19"x15¾"x24"	19"x15¾"x24"	19"x15¾"x24"	23"x30"x40"	23"x30"x72"	23"x30"x72"	46"x30"x72"	46"x30"x72"
Weight	125 lbs	130 lbs	135 lbs	370 lbs	505 lbs	855 lbs	1340 lbs	1610 lbs
Operating Temp	35°C							
Input Power								
Voltage	Universal Input - 380 to 480 VAC ±10% (L-L, 3 Phase, 50/60 Hz)							
Current per phase @ 380 V	9 A	17 A	25 A	49 A	73 A	97 A	144 A	192 A
Current per phase @ 400 V	9 A	17 A	24 A	47 A	69 A	92 A	137 A	183 A
Current per phase @ 480 V	8 A	14 A	20 A	39 A	58 A	77 A	114 A	152 A
Efficiency	> 85% at full power into resistive load at 480 VRMS (L-L)/60 Hz							
Power Factor	Unity PF > 95% at full power into a resistive load at 480 VRMS (L-L)/60 Hz							
Calibration								
Method	Closed cover with standard lab equipment capable of measuring to ¼ of device specifications							

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

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