# Model 9430
# Regenerative 4-Quadrant AC Load

**NHR**
**NH Research**

*Linear & Non-Linear AC Loading in Several Emulation Modes*
*with User-Defined Waveforms, Power & Crest Factor Control*

## Key Features

- 8 Sizes – 4 to 96kW
- Single, Split or Three-Phase programmable
- 10 to 350VAC
- 30 to 880Hz
- DC operation to 10 to 400VDC
- Reactive power capability 2.6 x Real Power
- Sink power regenerated back to facility with >90% efficiency
- Power factor range: -1 to +1
- Crest factor range: 1.414 to 4.000
- High-resolution waveform digitizer
- 9" Touch-Panel user interface
- High power density/minimum rack space

## Applications

The 9430 is a current-regulated, 4-quadrant AC load with selectable phase inputs/outputs and a built-in waveform digitizing measurement system. In the sink mode, it sends power back to the facility mains rather than dissipated as heat. The 9430 has the capability of simulating almost any linear or non-linear load. Applications include testing of UPSs, AC sources, inverters, rectifiers, switches, circuit breakers and fuses.

## 4-Quadrant Operation

The most unique feature of the Model 9430 AC Load is its ability to operate in all 4-quadrants. This bi-directional capability significantly expands load simulation relative to 2-quadrant AC loads. More specifically, the 9430 allows creating the reverse current caused by inductive or capacitive loads (low power factors); namely sending power back to the UUT (source) during part of the AC cycle (Fig. 1). In this manner the 9430 accurately duplicates real-world reactive electrical power flows.



*Model 9430 36kW Regenerative AC Load*
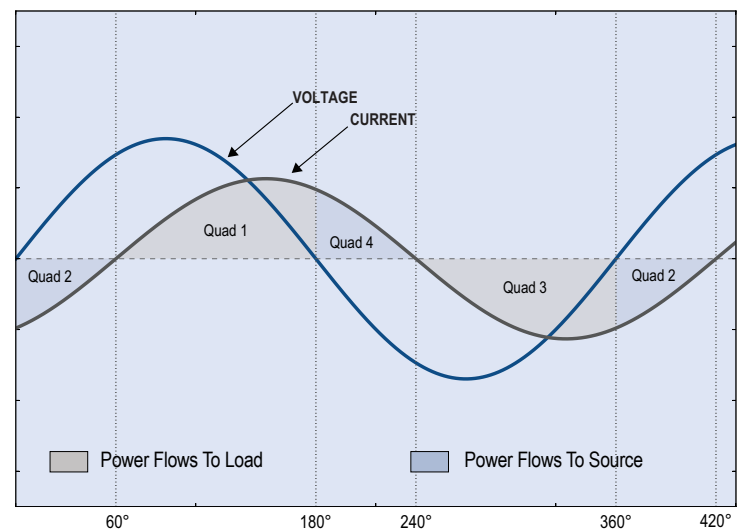


*Figure 1 - 0.5 PF Inductive Load waveform showing bi-directional power flows.*

## HIVAR® Design Provides Reactive Loading without Derating True Power

This advanced design feature provides for testing high reactive load input power without the customary reduction of true power (Watts) normally required with conventional loads. The HiVAR design provides testing sources with reactive power (VARs) as large as 2.6 x true power (Watts.) All 9430 Loads are rated both for true power and apparent power. For instance, a 12kW Load is also rated for 31.5kVA.
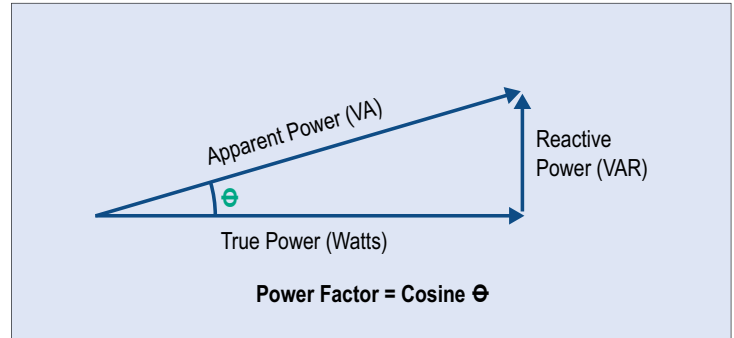


*Figure 2 - The Power Triangle.*

## Several Emulation Modes

To provide testing under the broadest range of loading conditions, the 9430 Load will operate in several Emulation Modes. Constant Current (CC) Mode provides current to be drawn constantly, making it suitable for linear, non-linear and regulation loading. Constant Resistance (CR) Mode allows the load to emulate a power resistor with a unity power factor. Constant Power (CP) Mode emulates a load such as a switching power supply. Constant Apparent Power (CS) Mode expressed as VA, is a vector quantity where there is both real power and reactive power (Fig. 2). Constant RL (CRL) Mode emulates a resistive load with an inductive component such as a motor.

## User-Defined Waveforms

In addition to programmable power and crest factors, one of the tools used by the 9430 AC Load for creating non-linear waveforms is a graphics editor. This editor allows starting with a straight line or modifying a generated waveform based on current, power and crest factor. The graphical editor includes an auto-check feature to ensure the settings are compatible with each other and within the capabilities of the 9430. It also supports waveform smoothing, symmetrical and asymmetrical waveform manipulation. With this graphics editor, waveforms can be quickly created to duplicate waveform distortions or transient events such as spikes, dropouts or any other anomaly that can be drawn as a single cycle (Fig. 3).
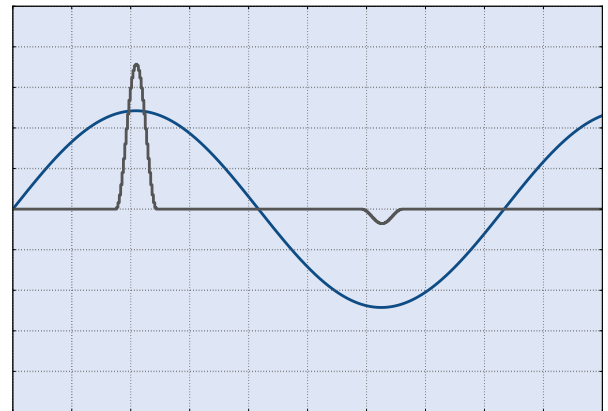


*Figure 3 - User-Defined Asymmetrical Current*

## Macros

A second powerful user-defined waveform tool are Macros. These are a pre-programmed sequence of settings where each new setting is effective 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 AC Load where it is executed at high speeds to provide precise control of any phase. Macros can be stored for use on other test programs (Fig. 4).
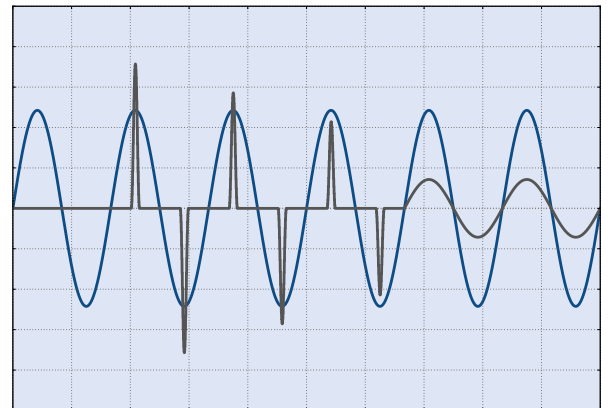


*Figure 4 - Start-Up Inrush Current Macro*

## Regenerative Return of Load Power to Facility Line

The 9430 Load returns greater than 90% of power to the facility thereby providing significant electrical savings. It certain continuous loading testing, it has been shown that the load will recover its purchase cost in 2 - 3 years. Even for intermittent load usage, the savings from regenerative return to the facility is substantial and worth evaluating. Additional benefits are a more comfortable work environment, less air conditioning required and an elimination of facility power upgrades.

## Built-In Digital Measurement

Model 9430 Loads 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 9430 eliminates the integration complexity, prolonged start-up time, extra cabinet space and cost for those additional measurement instruments often required. The user is ready to begin testing the day the 9430 is delivered.

The types of measurements are broad and include almost any type of voltage, current, power and timing. In a 3-phase 9430, all six channels of voltage and current measurements are digitized simultaneously at 125kSamples/sec to be displayed, recorded or further processed to yield a custom measurement. Specialized measurements such as abnormal grid detection thresholds, disconnection timing, power ramp-up timing, and generated harmonic current limits are possible.

## Physical Connections & Controls



Model 9430 - 12
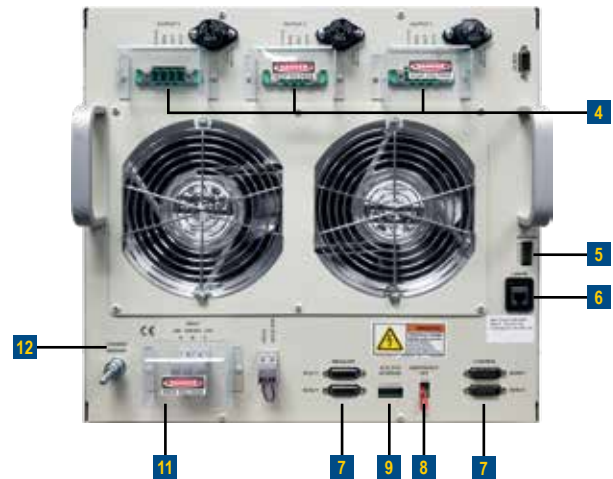
| | | | | | |
|---|---|---|---|---|---|
| **1** | Touch Panel Based Control & Display | **5** | Options Switch | **9** | Auxiliary Configuration |
| **2** | Status Lights & Trigger | **6** | LAN (Ethernet) Port | **10** | Safety Interlock |
| **3** | Circuit Breakers | **7** | Parallel Connections | **11** | Input AC Power Terminal |
| **4** | Output Power Connectors & External Sense | **8** | Remote Emergency Off | **12** | Chassis Ground |

# Model 9430 AC Load Specifications

| MODEL NUMBER | 9430-4 | 9430-8 | 9430-12 | 9430-24 | 9430-36 | 9430-48 | 9430-72 | 9430-96 |
|---|---|---|---|---|---|---|---|---|
| **AC Loading Programmability** | | | | | | | | |
| Phases/Output Channels | Single | Single, Split-Phase | Single, Split or 3-Phase | | | | | |
| Input Voltage (LR,HR) | 10 - 175, 350VRMS L-N (30Hz - 880Hz) | | | | | | | |
| Current Limit Set Ranges[1] (per Φ) | 6, 30A (1Φ) | 6, 30A (2Φ) | 6, 30A (3Φ) | 12, 60A (3Φ) | 18, 90A (3Φ) | 24, 120A (3Φ) | 36, 180A (3Φ) | 48, 240A (3Φ) |
| Current Limit Set Max[1] (per Load) | 6, 30A (1Φ) | 12, 60A (1Φ) | 18, 90A (1Φ) | 36, 180A (1Φ) | 54, 270A (1Φ) | 72, 360A (1Φ) | 108, 540A (1Φ) | 144, 720A (1Φ) |
| Power Limit Set Max[2] (1, Split, 3Φ) | 4kW | 8, 8kW | 12, 8, 12kW | 24, 16, 24kW | 36, 24, 36kW | 48, 36, 48kW | 72, 48, 72kW | 96, 64, 96kW |
| Maximum Apparent Power[2] | 10.5kVA | 21kVA | 31.5kVA | 63kVA | 94.5kVA | 126kVA | 189kVA | 252kVA |
| Normal Mode (CC/CP/CS) | | | Resistance Mode (CR/CC/CP) | | | RL Mode (Series CR & CL) | | |
| Crest Factor | 1.414 - 4.0 (up to 3x MAX ARMS) | | Constant Resistance | -4Ω to -1000Ω / 1.5Ω to 1000Ω | | Constant Series-RL | 1.5Ω to 1000Ω / 0H to 1H | |
| Power Factor | -1.0 - +1.0 | | Resolution | 10mΩ | | Resolution | 10mΩ / 1µH | |
| Slew Rate | 10%-90% Range in < 500µs | | Resultant Current1 | Vin / Rset | | Resultant Current | $Vin / \sqrt{R2 + (2\pi fL)2}$ | |
| **DC Loading Programmability** | | | | | | | | |
| Input Voltage | 10 - 200, 400VDC | | | | | | | |
| DC Loading Modes | Constant Voltage (CV), Constant Current (CC), Constant Power (CP), Constant Resistance (CR) in any combination | | | | | | | |
| Current Limit Set Ranges[1] | 0 - 6, 30A | 0 - 12, 60A | 0 - 18, 90A | 0 - 36, 180A | 0 - 54, 270A | 0 - 72, 360A | 0 - 108, 540A | 0 - 144, 720A |
| Power Limit Set Max[2] | 0 - 4kW | 0 - 8kW | 0 - 12kW | 0 - 24kW | 0 - 36kW | 0 - 48kW | 0 - 72kW | 0 - 96kW |

| **Measurements** *(Accuracies apply when the settings and/or measurements are greater than 10% of Range and input voltage is above 50VRMS.)* | | | | | |
|---|---|---|---|---|---|
| | Range | | | Accuracy | Resolution |
| Voltage (LR, HR) | 260, 520V Pk | | | | |
| AC RMS | 260, 520V Pk | | | ±(0.1% Rdg + 0.06% Rng) @<100Hz, ±(0.2% Rdg + 0.12% Rng) @>100Hz | 0.005% Rng |
| DC | 260, 520V Pk | | | ±(0.1% Rdg + 0.1% Rng) | 0.005% Rng |
| Peak Voltage | 260, 520V Pk | | | ±(0.5% Rdg + 0.2% Rng) @<100Hz, ±(1.0% Rdg + 0.4% Rng) @>100Hz | 0.005% Rng |
| Frequency | 30-1000Hz | | | 0.1% (Sinusoidal Voltage) | 0.01Hz |
| Current per Phase (LR, HR) | 0 - 20, 100A Pk | 20, 100A Pk | 20, 100A Pk / 40, 200A Pk | 60, 300A Pk / 80, 400A Pk | 120, 600A Pk / 160, 800A Pk | |
| AC Current | Model Number Dependent | | | ±(0.1% Rdg + 0.1% Rng) @<100Hz, ±(0.2% Rdg + 0.2% Rng) @>100Hz | 0.005% Rng |
| DC Current | Model Number Dependent | | | ±(0.2% Rdg + 0.1% Rng) | 0.005% Rng |
| Peak Current | Model Number Dependent | | | ±(0.5% Rdg + 0.2% Rng) @<100Hz, ±(1.0% Rdg + 0.4% Rng) @>100Hz | 0.005% Rng |
| Power (kW, kVA) | Voltage Range X Current Range | | | ±(0.2% Rdg + 0.1% Rng) @<100Hz, ±(0.2% Rdg + 0.2% Rng) @>100Hz | 0.005% Rng |
| Energy (AH, kWH, kVAH) | Time dependent | | | 0.3% Reading + 0.3% Rng | 0.005% Rng |
| Power Factor | -1.0 to +1.0 | | | ±(0.25% Rdg + 0.25% Rng) | 0.005% Rng |
| Crest Factor | | | | ±(0.6% Rdg + 0.6% Reading Pk) | 0.005% Rng |
| Phase Angle (ΦX-ΦA) | 0 to 360° | | | +-2 deg @ < 100Hz, 6 deg @ < 400Hz, 15 deg @ < 880Hz | 1 deg |

| **Waveform Capture** | | | | |
|---|---|---|---|---|
| Data Channels | 6 channels (3 phases of voltage and current) | | Accuracy/Resolution | 0.5% Range/0.005% Range |
| Bandwidth | DC to 50kHz | | | 35 total including AC/DC Voltage, Current, True Pwr, Apparent Pwr, Freq., Pwr Factor, Crest Factor, Energy, Phase Angle, Pk V, Pk I, Pk Pwr |
| Sample Rate | to 125 kSample/sec | | Background Measurements | |
| Memory | 64k samples for each of 6 channels | | | |
| Aperture | 1 cycle to 64 sec | | Aperture Measurements | 13 total including AC/DC Voltage, Current, True Pwr |

| **Custom Current Waveforms** | | | |
|---|---|---|---|
| Standard | Sine, n-step Sine, Triangle, Clipped Sine, Notched Sine, Arbitrary (User Def.) | User Defined | Graphical wave shape editor or downloaded Excel table |

| **Control** | | | |
|---|---|---|---|
| User Interface | Built-In Touch Panel &/or external PC w/ Windows software tools including GUI | External System Communication | LAN (Ethernet) supporting SCPI or VXI-II |
| | | Drivers | Ni-Compliant LabVIEW Drivers, Enerchron (opt.) |

| **Safety** | | | |
|---|---|---|---|
| UUT Programmable Limits | V Min/Max, I Max, W Max, each with time delay values | Watchdog | A continuous communication verification program controlled by a test executive |
| Physical | User Interlock, Emergency Stop & Remote e-Stop connection | | |
| Internal Protection | Over-Voltage, Over-Current, Over-Power, Over-Temperature | Self Test | An automatic hardware check upon power-up |
| Isolation | Facility to Chassis - 1kV, Facility to Output - 2kV, Output to Chassis - 1kV | EMC | CE Mark |

| **Physical** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Connectors | Terminal blocks | | | Terminal blocks and bus bars | | | | |
| Form | Chassis | Chassis | Chassis | Single Cabinet | Single Cabinet | Single Cabinet | Double Cabinet | Double Cabinet |
| Dimensions (HxWxD) | 15¾x19x24"/ 400x483x610mm | 15¾x19x24"/ 400x483x610mm | 15¾x19x24"/ 400x483x610mm | 49x23x30"/ 1245x584x762mm | 61x23x30"/ 1549x584x762mm | 78x23x30"/ 1981x584x762mm | 78x46x30"/ 1981x1168x762mm | 78x46x30"/ 1981x1168x762mm |
| Weight | 145lbs/66kg | 150lbs/68kg | 155lbs/70kg | 480lbs/218kg | 640lbs/290kg | 780lbs/354kg | 1280lbs/581kg | 1560lbs/708kg |
| Operating Temp. | 0° - 35°C, Non-Condensing | | | | | | | |

| **Input Power** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Voltage / Frequency | Universal Input - 380 to 480VAC ±10% (L-L, 3-Phase, 50/60Hz) / 49 - 51Hz or 59.3 - 60.5Hz | | | | | | | |
| Current/phase @ 380, 400, 480V | 15, 15, 12A | | 22, 20, 17A | 44, 40, 34A | 66, 60, 51A | 88, 80, 68A | 132, 120, 102A | 176, 160, 136A |
| Efficiency | 92% @ 480V Facility Input measured at full power when loading 480VRMS (L-L) / 60Hz | | | | | | | |
| Power Factor | Unity PF > 99% measured at full power when loading 480VRMS (L-L) / 60Hz | | | | | | | |
| Cooling | Air Cooled 35°C Max Ambient, reduced power from 35 to 50°C | | | | | | | |

| **Calibration** | |
|---|---|
| Method | Closed-cover with standard lab equipment capable of measuring to 0.25 % of device specifications |

[1] Programming Accuracies for Current are ±(0.2% Set+0.2% Range) @ < 100Hz & ±(0.4% Set+0.4% Range) @ > 100Hz.
[2] Programming Accuracies for Power are ±(0.4% Set+0.4% Range) @ < 100Hz and ±(0.8% Set+0.8% Range) @ > 100Hz.
[3] Programming Accuracies for RL Mode are +-(1% * ILoad +300mA) @ < 100Hz & +-(1% * ILoad +600mA) @ > 100Hz.

## ORDERING INFORMATION

| AC Load P/N | 9430 | kW Rating | -12 |
|---|---|---|---|

**NHR** NH Research