NHR 9430 SERIES

USER'S MANUAL

Part No. 09-0344

REVISION L

December 14, 2021

Document History

Rev A	**ECO 17711**	**12/19/2017**	**MW**
Rev B	**ECO 17832**	**12/18/2018**	**MJ**
Rev C	**ECO 17849**	**02/07/2019**	**RW**
Rev D	**ECO 17862**	**03/19/2019**	**MJ/KM**
Rev E	**ECO 17901**	**05/29/2019**	**MJ/KM**
Rev F	**ECO 17910**	**06/20/2019**	**RW**
Rev G	**ECO 17915**	**07/10/2019**	**KM**
Rev H		**09/23/2019**	**RW**
Rev I		**07/27/2020**	**MW/GL/KM**
Rev J	**ECO 18044**	**06/30/2020**	**KM**
Rev K	**ECO 18118**	**10/14/2021**	**BH**
Rev L	**ECO 18144**	**12/16/2021**	**BH**

The material in this publication is current as of the release date on the cover page and is subject to change without notice. Any questions concerning the product or any questions or comments concerning this manual should be directed to the NH Research Field Service Department during normal business hours Monday through Friday at (949) 474-3900 or FAX (949) 474-7062 or www.nhresearch.com.

TABLE OF CONTENTS

1. GENERAL

1.1 Models

This manual applies to the following hardware modules provided by NH Research.
See the product comparison matrix in the following sections for more information about the different product series.

9430 – Regenerative AC Load

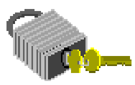
BOLD – Standard Models
Non-standard models available with longer lead times.

9430 Regenerative AC Load			
Model	Maximum Power	Channel Count	Footprint
9430-4	4kW / 10.6kVA	1 Channel	9U Module 19” Rack-mountable
9430-8	8kW / 21 kVA	2 Channels	
9430-12	**12kW / 31.5kVA**	3 Channels	
9430-24	**24kW / 63kVA**	3 Channels	43” Tall Cabinet
9430-36	**36kW / 94.5kVA**		78” Tall Cabinet
9430-48	**48kW / 126kVA**		78” Tall Cabinet
9430-60	60kW / 157.5kVA	3 Channels	Dual Bay 78” Cabinet
9430-72	**72kW / 189kVA**		
9430-84	84kW / 220.5kVA		
9430-96	**96kW / 252kVA**		

This manual will also apply to new product variations released by NH Research.

1.2 Symbols Used

Warnings, cautions, & notes will be highlighted within this document with the following symbols.

	**Failure to observe warning(s) may cause life threatening danger. Please use extreme caution.**
	**General safety warnings - Failure to observe warning(s) may cause bodily harm or equipment damage.**
	**General notes or keys for operation.**

1.3 Warranty

NH Research provides a standard one (1) year warranty standard.

Details, limitations, and other information are included within the general terms and conditions provided with the product quote.

1.4 Intended Usage

The 9430 Series provides AC or DC **current control** and measurement. It is primarily used in the evaluation, performance, functional, & endurance testing for either AC or DC products. Usage for other purposes outside of this manual's description which result in product failure may be considered as customer abuse and therefore may not be covered under warranty.

	**Operators of the equipment should be trained in safety procedures. Any damage caused by non-intended usage is not covered under warranty.**

The 9430 is an electronic load specially designed source allowing for true phase shifted currents including allowing true power to flow in the reverse direction. When used in AC, the output current tracks the external voltage and frequency at a relative phase angle which at 180 degrees results in a reverse true power flow. When operating in this way, the 9430 is still referred to as a load (rather than a source) as it maintains current control while drawing or even delivering power.

1.5 Safety Notice – No User Serviceable Parts Inside

The 9430 series contains no internally replaceable or serviceable parts.

	Internal adjustment or component replacement is only permitted by qualified NH Research personnel. No internal adjustments or system access should be attempted by non-NH Research personnel.
	Safety Notice For Qualified Technician: • Remove all external voltage sources • Disconnect power cord • Wait a minimum of 1 minute to discharge internal circuits • Verify circuits are fully discharged

1.6 General Safety Notices

The following are general notices which should be observed by the operator.

	Potential for Mortal Hazard: • Internal access should be avoided – No serviceable parts • All connections should be carried out under 0V conditions • All connections should be properly terminated leaving no exposed wires which could present an electrical shock hazard • Always assume the output has potential even when "OFF"
	Additional Notes • The test equipment should only be used by trained personnel or under the direct supervision of trained personnel. • Do not insert any object through the air intake • Avoid use of liquids near the test equipment when possible • Ensure proper polarity is observed when connecting the equipment to the unit under test. Reverse polarity can damage either the equipment or the UUT.

1.7 Important Terminology

1.7.1 General Terms

The following general terms are used throughout this document.

Unit-Under-Test (UUT)
The Unit-Under-Test (or UUT) is the device which is being tested.

Input
Input is a generic term applied to the connection from the facility to a 9430.
The use of the term Output does not imply the direction of power flow.

Output
Output is the generic term applied to the connection from the UUT to the 9430. The use of the term Output does not imply the direction of power flow.

Channel
A channel is comprised of a master output and the corresponding auxiliary output.
Each channel may be configured for AC or DC operation as well as be configured to operate together to produce a single larger channel.

Module or Power Module
A Module is the generic name for chassis within a 9430 system.
There are two primary module versions including a “Master” and an “Auxiliary”.

Auxiliary (Module) or Auxiliary (Power Module)
An auxiliary module contains the power electronics needed to supplement a master modules power. It does not contain the control and communications components needed to operate as a standalone system. These output channels are controlled by a master module and are to be wired in parallel with the output channels of the controlling master.

Master (Module) or Master (Power Module)
A master module contains the control and communications hardware along with one or more output channels. Master module current as well as power is expanded by connecting a compatible auxiliary module.

Instrument
The instrument is an abstraction term allowing one or more channels to be treated as a logical group. For example, when the 9430 is configured for single 1-phase or configured for 3-phase operation, all of the channels will be grouped together into a single instrument. By comparison, if three separate channels are configured the system will address this as three separate instruments.

1.7.2 Units

Unless otherwise stated, units are as follows:

Angles	degrees (°)
Apparent power	Volt-Amperes (VA)
Crest Factor	Unit-less and is always calculated as $Current_{(AC\text{-}PEAK)}$ / $Current_{(AC–RMS)}$
Current $_{(AC)}$	Amperes (A_{RMS}) - calculated as RMS across one cycle
Current $_{(AC - Peak)}$	Amperes (A_{PEAK}) - the maximum instantaneous current value
Current $_{(DC)}$	Amperes (A_{DC}) - calculated as the average current over 3.33ms
Energy	Ampere-Hours (Ah) Kilowatt-Hours (kWh), Kilovolt-Ampere-Hours (kVAh)
Frequency	Hertz (Hz)
Power Factor	Unit-less and always is True Power / Apparent Power
Resistance	Ohms (Ω)
Time	seconds (s)
True power	Watts (W)
Voltage $_{(AC)}$	Volts (V_{RMS}) - calculated as RMS across one cycle
Voltage $_{(AC - Peak)}$	Volts (V_{PEAK}) - the maximum instantaneous voltage value
Voltage $_{(DC)}$	Volts (V_{DC}) - calculated as the average voltage over 3.33ms

This page intentionally left blank.

2. 9430 SERIES OVERVIEW

2.1 Module Front View

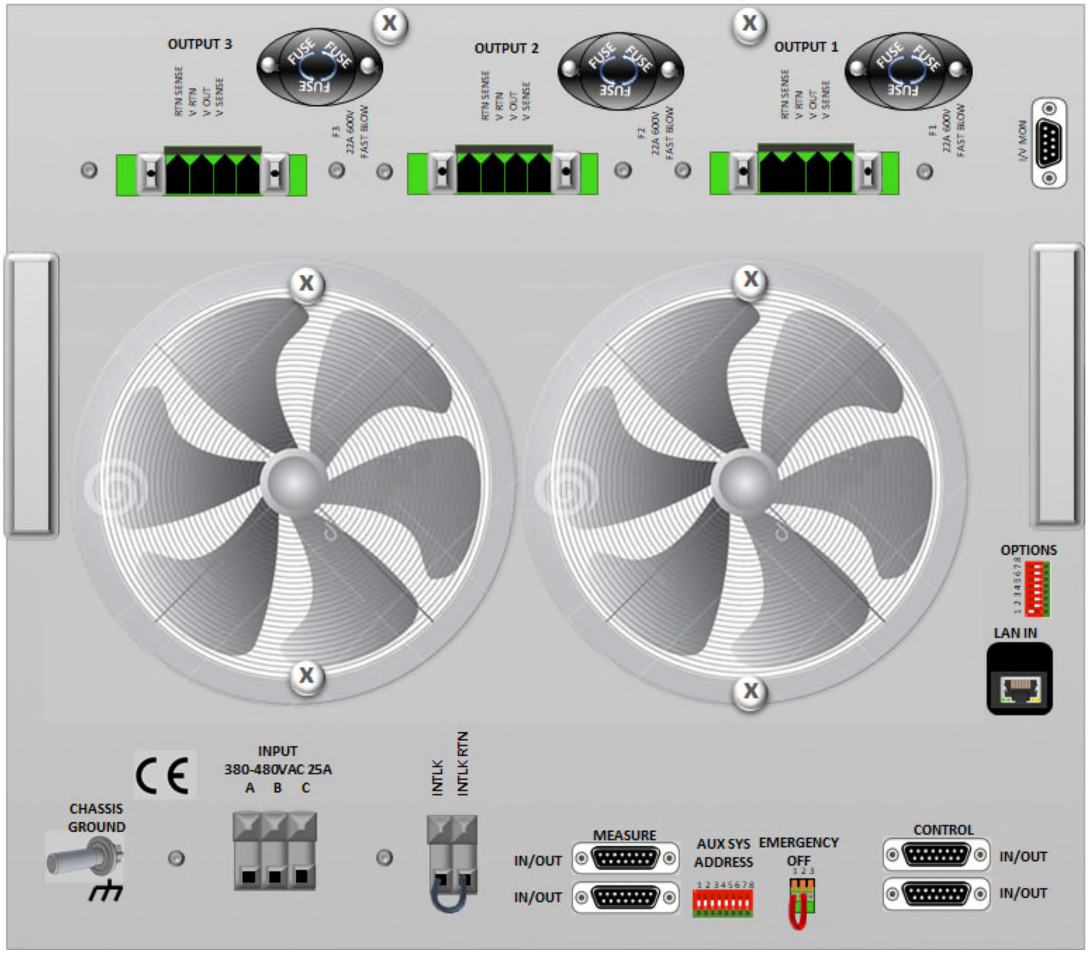
The Front of the system module includes the series name (9430 Regenerative AC Load), a touch panel interface, output & status indicators, Digital IO, Trigger ports, and a circuit breaker.

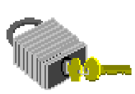
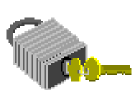
Air intake is from the front and exhausted to the rear.

9430 Regenerative AC Load Shown

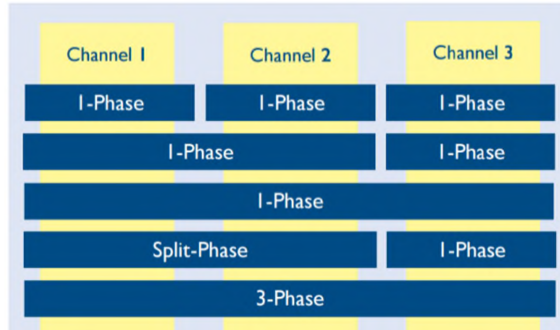
2.2 Module Rear View

The rear of the system includes connections for interlocks, power (facility & UUT), communication, and system expansion.



	**All power and communications connections are made at the rear of the system and are not typically changed after installation. Refer to the installation section for information about connections.**
	**See LEGACY UUT AND POWER INTERFACE CONNECTORS section at the end of this manual if the connectors on the back of the unit do not appear to match the image above**

2.3 System Description



This system description is provided clarify the technical specifications in the following sections. The number of channels supported by a given system depends on the model selected. For example, a 4-kW model provides one (1) channel, an 8-kW model provides two (2) channels, and models from 12-kW to 96-kW provide three (3) channels. These channels may be configured through software to provide any combination of AC and DC **current control** channels that phase lock and respond to an external voltage and frequency source.

2.4 9430 Product Features

The 9430 is regenerative and draws current following the UUT voltage and frequency. The current draw is full 4-quadrant allowing for emulation of current draws historically required use of discrete components such as capacitors and inductors. To protect the UUT, both systems include a programmable safety trip feature for voltage, current, and power (W/VA).

Feature	9430 Series Regenerative AC Load			
Control Mode	Current Control (Current depends on model and Output Configuration)			
Max Frequency	Up to 880Hz			DC
Loading Modes	Normal	Resistance	Series RL	DC
Loading Controls	CC, CP, CS	CR, CC, CP	CRL	CV, CC, CP, CR
Programmable PF	✓	Always Unity	Based on R&L	-
PF Sinking Current	0 to 1	Always 1	0 to 1	-
Bi Directional Mode (Enable in Software)	Any PF From -1 to 1	Unity -1 or 1	-	-
Crest Factor (CF)	Up to 4	-	-	-
Current Wave-shaping	✓	-	-	-
Safety (V, A, kW, & Peak)	✓	✓	✓	✓

Related Products

For 9410 Regenerative Grid Simulator Series or 9420 ATE AC Source Series:
Refer to the *9410 & 9420 User's Manual (NHR P/N: 09-0329)* or product brochure.

2.5 9430-Series Specifications

The following specifications are common to all 9430 series systems and list the maximum capabilities only. The 9430 is a load (i.e. controls current) and requires an external voltage source with appropriate frequency.

2.5.1 Electrical Output Specifications

9430 Regenerative AC Load Models								
Model	**9430-4**	**9430-8**	**9430-12**	**9430-24**	**9430-36**	**9430-48**	**9430-72**	**9430-96**
AC Output Specifications	`							
Number of channels	1	2	3					
Phases / Output Channels	1	1 or 2	1, 2 or 3					
Max True Power (Total)	4kW	8kW	12kW	24kW	36kW	48kW	72kW	96kW
Max Apparent Power	10.5kVA	21kVA	31.5kVA	63kVA	94.5kVA	126kVA	189kVA	252kVA
Current Ranges (max 1ϕ)	6A, 30A	12A, 60A	18A, 90A	36A, 180A	54A, 270A	72A, 360A	108A, 540A	144A, 720A
Current Ranges (per ch) [1]	6A, 30A	6A, 30A/ϕ	6A, 30A/ϕ	12A, 60A/ϕ	18A, 90A/ϕ	24A, 120A/ϕ	36A, 180A/ϕ	48A, 200A/ϕ
UUT Voltage Ranges	175, 35-350V_{rms} with positive zero crossing frequency from 30 – 880Hz							
Peak Current	3x Max RMS Current							
Output Current Shapes	Sine, n-Step Sine, Triangle, Clipped-Sine, Arbitrary (user-defined)							
Phase Angle Control	0° to 359° / 1° resolution (<100 Hz)							
DC Output Specifications	Current draw only from UUT into 9430							
Max Power (Total)	4kW	8kW	12kW	24kW	36kW	48kW	72kW	96kW
Current Ranges (max 1ch)	6A, 30A	12A, 60A	18A, 90A	36A, 180A	54A, 270A	72A, 360A	108A, 540A	144A, 720A
Current Ranges (per ch) [1]	6A, 30A	6A, 30A/ch	6A, 30A/ch	12A, 60A/ch	18A, 90A/ch	24A, 120A/ch	36A, 180A/ch	48A, 200A/ch
Voltage Ranges	200, 400V_{dc}							

[1] In DC & single phase modes, multiple channels may be used to increase current / power. These ranges therefore are multiplied by the number of parallel channels configured for use.

2.5.2 Measurement Specifications

9430 Regenerative AC Load Models								
Model	**9430-4**	**9430-8**	**9430-12**	**9430-24**	**9430-36**	**9430-48**	**9430-72**	**9430-96**
AC & DC Measurements								
Peak Voltage	260V, 520V							
Accuracy (AC_{rms})	0.1% reading + 0.06% range (< 100 Hz) 0.2% reading + 0.12% range (≥ 100 Hz)							
Accuracy (Peak)	0.5% reading + 0.20% range (< 100 Hz) 1.0% reading + 0.40% range (≥ 100 Hz)							
Accuracy (DC)	0.1% reading + 0.10% range							
Resolution	0.005% range							
Frequency / Accuracy	30 ~ 1000Hz / 0.1% for sinusoidal voltage							
Phase Angle (ϕX-ϕA)	0 ~ 359.9°							
Accuracy	2° (<100Hz) 6° (≥ 100 & < 400Hz) 15° (≥ 400Hz)							
Peak Current (per ch) [1]	20A / 100A	20A / 100A	20A / 100A	40A / 200A	60A / 300A	80A / 400A	120A / 600A	160A / 800A
Accuracy (AC_{rms})	0.1% reading + 0.1% range (< 100 Hz) 0.2% reading + 0.2% range (≥ 100 Hz)							
Accuracy (Peak)	0.5% reading + 0.20% range (< 100 Hz) 1.0% reading + 0.40% range (≥ 100 Hz)							
Accuracy (DC)	0.2% reading + 0.1% range (High Range) 0.2% reading + 0.3% range (Low Range)							
Resolution	0.005% range							
Peak Power	V range * I range							
Accuracy (kW / kVA)	0.3% reading + 0.025% range (< 100 Hz) 0.6% reading + 0.05% range (≥ 100 Hz)							
Resolution	0.005% range							
Additional Measurements	Energy (Ah, kWh, kVAh), AC Crest Factor, AC Power Factor, Waveform Capture							
Waveform Digitizer	Output Voltage & Current							
Sample Rate / Depth	125k Samples / Second up to 64kSamples per channel (AC or DC)							
Aperture Time	1 cycle to 64 seconds (For DC, Minimum aperture time is 3.334mS)							
Accuracy	0.5% reading							
Resolution	0.05% range							

[1] In DC & single phase modes, multiple channels may be used to increase current / power.
These ranges therefore are multiplied by the number of parallel channels configured for use.

2.5.3 Facility & Mechanical Specifications

9430 Regenerative AC Load Models								
Model	**9430-4**	**9430-8**	**9430-12**	**9430-24**	**9430-36**	**9430-48**	**9430-72**	**9430-96**
Physical Characteristics								
Output Connections	Terminal Block			Bus Bar				
Form Factor	Single Module			Single Cabinet			Double Cabinet	
Dimensions (WxDxH)	19" x 24" x 15¾" (9U)			23"x30"x49"	23"x30"x61"	23"x30"x78"	46"x30"x78"	
Weight	145 lbs.	150 lbs.	155 lbs.	480 lbs.	640 lbs.	780 lbs.	1280 lbs.	1560 lbs.
Operating Temp	0°C to 35°C							
Isolation	Facility to Chassis – 1000V, Output to Chassis – 1000V, Facility to Output Internal Isolation – 2000V							
Input Characteristics								
Voltage	Universal Input – 380V to 480V ± 10% (L-L, 3 Phase, 50/60Hz)							
Efficiency	Greater than 85% (typical)							
Facility Power Factor	Greater than 0.99							
Power Utilization	Energy (Ah, kWh, kVAh), AC Crest Factor, AC Power Factor, Waveform Capture							
Input per ϕ @ 380V	9A	17A	25A	49A	73A	97A	144A	192A
Input per ϕ @ 400V	9A	17A	24A	47A	69A	92A	137A	183A
Input per ϕ @ 480V	8A	14A	20A	39A	58A	77A	114A	152A

Input rating refers only to the amount of power returned during operation.
See the installation section for breaker and facility wiring recommendations.

2.5.4 9430 Normal & Constant-Resistance AC Loading Modes

9430 Regenerative AC Load Models						
Model	**9430-4/8/12**	**9430-24**	**9430-36**	**9430-48**	**9430-72**	**9430-96**
Normal Loading Mode	Constant Current (CC), Constant Power (CP), Constant VA (CS) with current modifier options (CF / PF / ARB)					
Constant Current (CC)	6A, 30A/ch	12A, 60A/ch	18A, 90A/ch	24A, 120A/ch	36A, 180A/ch	48A, 200A/ch
Accuracy	0.4% setting + 0.4% range (< 100 Hz)			0.8% reading + 0.8% range (≥ 100 Hz)		
Resolution (per ch)[1]	(I_{MAX} / 30) mA					
Constant Power (CP) per ϕ	4kW	8kW	12kW	16kW	24kW	32kW
Constant VA (CS)	V_{RANGE} * I_{RANGE}					
Accuracy	0.4% setting + 0.4% range (< 100 Hz)			0.8% reading + 0.8% range (≥ 100 Hz)		
Resolution (per ch)[1]	(I_{MAX} / 3) mW or mVA					
Current Modifiers	Including prioritization (CF, PF, Unity-Power Factor, or ARB Wave-shape)					
Crest Factor (CF)	1.414 to 4 (up to 3x MAX A_{RMS})					
CF Accuracy	1% + 1% kW rating (< 100 Hz & I_{LOAD} ≥ 3A_{RMS})			2% + 2% kW rating (≥ 100 Hz & I_{LOAD} ≥ 3A_{RMS}		
CF Resolution	0.001					
Power Factor (PF)	0 (lag) to 1 (unity) to 0 (lead)			-1 to 1 when Bi-Directional mode enabled		
PF Accuracy	0.01 (< 100 Hz)			0.02 (>= 100 Hz)		
PF Resolution	0.001					
User ARB Wave-shape	360 Points representing one point per degree					
Constant Resistance Mode	When operating in CR Loading Mode Only (Note, CC and CP from above also available in this mode)					
Standard (per ch)[1]	1.5 ~ 1000 Ω	0.75 ~ 500 Ω	0.5 ~ 333.3 Ω	0.375 ~250 Ω	0.25 ~ 166.6 Ω	0.188 ~ 125 Ω
BiDirectional (per ch)[1]	-10 ~ -1000 Ω	-5 ~ -500 Ω	-3.4 ~ -333.3 Ω	-2.5 ~ -250 Ω	-1.67 ~ -166.6Ω	-1.25 ~ -125 Ω
Resolution (per ch)[1]	(300 / I_{MAX}) mΩ					
Load Current (I_{LOAD})	$V_{MEASURED}$ / R_{SET}					
Accuracy of I_{LOAD}	0.4% (I_{LOAD}) + 0.4% (I_{MAX}) (< 100 Hz)			0.8% (I_{LOAD}) + 0.8% (I_{MAX}) (≥ 100 Hz)		

[1] In single phase mode, multiple channels may be used to increase current / power.
The CC, CP & CS ranges therefore are multiplied (CR divided) by the number of parallel channels configured for use.

2.5.5 9430 Series-RL AC Loading Mode

9430 Regenerative AC Load Models						
Model	**9430-4/8/12**	**9430-24**	**9430-36**	**9430-48**	**9430-72**	**9430-96**
Constant Series-RL Mode	When operating in CR Loading Mode Only (Note, CC and CP from above also available in this mode)					
Standard (per ch)[note 1]	1.5 ~ 1000 Ω	0.75 ~ 500 Ω	0.5 ~ 333.3 Ω	0.375 ~250 Ω	0.25 ~ 166.6 Ω	0.188 ~ 125 Ω
Inductance (per ch)[note 1]	0 ~ 1H	0 ~ 0.5H	0 ~ 0.33H	0 ~ 0.25H	0 ~ 0.166H	0 ~ 0.125H
Resolution (per ch)	300 / I_{MAX}) mΩ		(30 / I_{MAX}) µH			
Load Current (I_{LOAD})	$V_{MEASURED}$ / (2πfL_{SET} + R_{SET})					
Accuracy of I_{LOAD}	1% (I_{LOAD}) + 1% (I_{MAX}) (< 100 Hz)		2% (I_{LOAD}) + 2% (I_{MAX}) (≥ 100 Hz)			

Note 1: Series RL with channels paralleled for single phase operation or for larger systems:

Example: A 9430-12 is configured for single-phase (single-channel) and programmed with 2Ω &5.3mH to load 200V_{AC} at 60Hz:

$$I_{LOAD} = \frac{V_{MEASURED}}{2\pi f L_{SET} + R} = \frac{200}{2\pi f \cdot 5.3 + 2} = \frac{200}{4} = 50A_{RMS}$$

If the above example is changed where a 9430-12 is configured for single-phase (two-channels in parallel) and programmed with the same values, the 9430 internally doubles both the programmed resistance and inductance values resulting in the same effective load current draw.

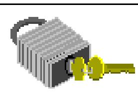
$$I_{LOAD} = \sum I_{LOAD(EACH)} \quad where \quad I_{LOAD\ (each)} = \frac{V_{MEASURED}}{2\pi f L_{SET} + R} = \frac{200}{2\pi f \cdot 10.6 + 4} = \frac{200}{8} = 25A_{RMS(each)}$$

$$I_{LOAD} = I_{LOAD(CH1)} + I_{LOAD(CH2)} = 25A_{RMS} + 25A_{RMS} = 50A_{RMS}$$

2.5.6 9430 DC Loading Mode

9430 Regenerative AC Load Models						
Model	**9430-4/8/12**	**9430-24**	**9430-36**	**9430-48**	**9430-72**	**9430-96**
Normal Loading Mode	Constant Voltage (CV), Constant Current (CC), Constant Power (CP), & Constant Resistance (CR) in any combination					
Constant Voltage (CV)	10 - 200 or 400V_{DC}					
Accuracy	0.2% setting + 0.2% range					
Resolution	10mV					
Voltage Noise	< 800mV RMS					
Constant Current (CC)	6A or 30A/ch	12A or 60A/ch	18A or 90A/ch	24A or 120A/ch	36A or 180A/ch	48A or 200A/ch
Accuracy	0.4% setting + 0.4% range (< 100 Hz)			0.8% reading + 0.8% range (≥ 100 Hz)		
Resolution (per ch)[1]	(I_{MAX} / 30) mA					
Current Noise (per ch)[1]	< 1% (I_{MAX})					
Constant Power (CP)	4kW	8kW	12kW	16kW	24kW	32kW
Accuracy	0.4% setting + 0.4% range (< 100 Hz)			0.8% reading + 0.8% range (≥ 100 Hz)		
Resolution (per ch)[1]	(I_{MAX} / 3) mW					
Constant Resistance (CR)	1.5 ~ 1000 Ω	0.75 ~ 500 Ω	0.5 ~ 333.3 Ω	0.375 ~250 Ω	0.25 ~ 166.6 Ω	0.188 ~ 125 Ω
Resolution (per ch)[1]	$V_{MEASURED}$ / R_{SET}					
Load Current (I_{LOAD})	0.2% (I_{LOAD}) + (1.5% * kW rating) mA (< 100 Hz)			0.4% (I_{LOAD}) + (3% * kW rating) mA (≥ 100 Hz)		
Accuracy of I_{LOAD}	0.2% (I_{LOAD}) + 0.2% (I_{MAX}) (< 100 Hz)					

[1] In DC loading mode, multiple channels may be used to increase current / power.
The CC, CP ranges therefore are multiplied (CR divided) by the number of parallel channels configured for use.



When more than one regulation mode is enabled, DC Loading will automatically select the regulation mode which results in the lowest current draw.

2.6 System Size (All Models)

Systems up to 12kW are provided as rack mountable modules. Systems between 12kW and 84kW may be expanded up to a maximum of 96kW by ordering and installing auxiliary modules.

Systems larger than 12kW are provided in a cabinet with all of the input and output connections pre-wired thereby providing a single connection point for each.

BOLD – Standard Models
Non-standard models are available with longer lead times.

19" Rack Mountable Module (19" x 24" x 15¾")			
Model	Maximum Power	Height	Channel Count
9430-04	4kW / 10.5kVA	15¾" (9U)	1 Channel
9430-08	8kW / 21 kVA	15¾" (9U)	2 Channels
9430-12	**12kW / 31.5kVA**	15¾" (9U)	3 Channels

Single Cabinet (28" x 30" x H)			
Model	Maximum Power	Height	Channel Count
9430-24	**24kW / 63kVA**	49" Cabinet	3 Channels
9430-36	**36kW / 94.5kVA**	61" Cabinet	
9430-48	**48kW / 126kVA**	78" Cabinet	

2-Bay Cabinet (46" x 30" x H)			
Model	Maximum Power	Height	Channel Count
9430-60	60kW / 157.5kVA	78" Cabinet	3 Channels
9430-72	**72kW / 189kVA**		
9430-84	84kW / 220.5kVA		
9430-96	**96kW / 252kVA**		

3. INSTALLATION

3.1 Unpacking the 9430 Series

Prior to shipment, the 9430 System was tested, calibrated, inspected and found to be free of mechanical or electrical defects. Upon unpacking, inspect visible damage or tripped shock watch sensors indicating the unit may have been damaged during transit.

If damage is detected, file a claim with the carrier immediately and notify NH Research Customer Support. Keep all packing materials in case the system needs to be returned.

Do not proceed with installation if damaged during shipping.

3.2 Location Mounting and Cooling

This unit is air-cooled and uses fans. The air intake is from the front of the module (or cabinet) and exhausts to the rear of the module (or cabinet).

For all systems, NH Research recommends 24 inches (60cm) of unrestricted air space in front of the unit and 30 inched (76cm) of unrestricted airspace to the rear of the unit.

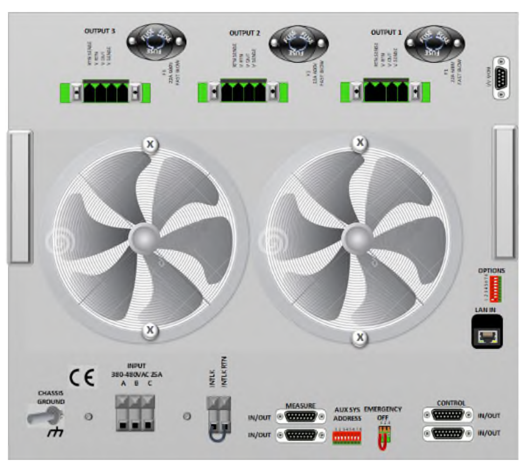
Input air filtration is recommended if the equipment is used harsh/dusty environments.

3.3 Rear of Module or Cabinet

Systems up to12kW,
Power and communications connections are made on the rear of the Module.

Systems larger than 12kW,
the master module and auxiliary modules have been pre-wired for a common facility input, UUT output, and eStop.

The interlock and sense connection are made on the rear of the master module located within the cabinet.



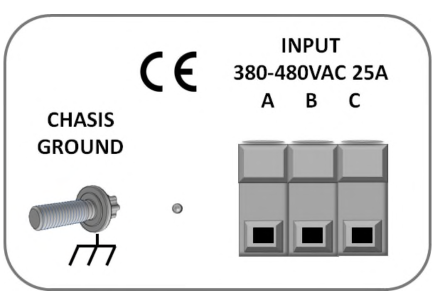
3.3.1 Connecting AC Facility Power

	Connecting the system to a three phase AC line should be made by an electrician or other qualified personnel.
	There is a potential for electrical shock if the system is not properly connected to a safety ground connection.
	NH Research is only able to provide general recommendations. It is the responsibility of the user to ensure that wiring, breaker sizing, and associated power connections meet local ordinances.
	WARNING: Connecting the AC Line to an AC Line that is unable to absorb energy quickly, (i.e., a "soft" source) may result in an increase in voltage on the line during regeneration. If the voltage rises to the maximum allowed, the NHR equipment will shut down. **OTHER EQUIPMENT ON THE SAME LINE MAY BE DAMAGED.**

The 9430 are powered by a universal input accepting 3-Phase voltages between 380$V_{l\text{-}l}$ and 480$V_{l\text{-}l}$. The connection is 4-wire (3-phase + safety ground) and has no phase rotation dependency. Each module contains a separate 30A breaker protecting itself from internal wiring failures.

For systems up to12kW,
three-phase AC power is connected to the terminal block on the rear of the module.

For systems larger than 12kW,
three-phase AC power is connected to a wiring block in the rear of the cabinet.



Module Facility Power Connection

Chassis Power Connection

Recommended Breaker & Facility Wiring

The recommended wiring is based on 30A facility power per module (counting all master and auxiliaries). The Facility breaker is intended to protect the wiring from the service panel to the unit only. Each module protects itself internally with a separate 30A breaker.

⚠	**NH Research can only make general recommendations. Please consult local electricians for local wiring ordinances.**
⚠	**Breakers and Facility Power should be at least 20% higher than the maximum power draw of the unit to prevent trips.**
⚠	**A) A switch or circuit-breaker must be included in the installation** **B) It must be suitably located and easily reached** **C) It must be marked as the disconnecting device for the equipment**

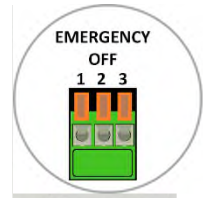
94xx System	Recommended Panel Breaker	Recommended Wire Gauge
9430-8/12	30A	AWG 10
9430-24	60A	AWG 6
9430-36	90A	AWG 4
9430-48	120A	AWG 2
9430-60	150A	AWG 1
9430-72	180A	1/0
9430-84	210A	2/0
9430-96	240A	3/0

Note: Additional product variations will be added as they are released to the above table.

Models 9430-4/8: Max branch circuit required for 4kW and 8kW devices is **20A**.

Cabinet Installation: Units not pre-installed into rack-mount cabinets shall be installed into a rack-mount enclosure during installation.

3.3.2 Emergency-OFF Connector Wiring



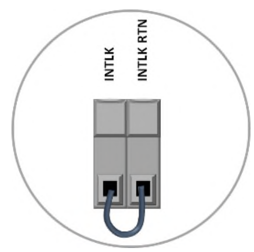
For 12kW and smaller systems, the user needs jumper pins 1 and 2 of the Emergency-Off connector with either wire or a eStop switch.

For systems larger than 12kW, NH Research provides a pre-wired eStop switch prominently mounted on the cabinet.

In either case, when pins 1 and 2 are disconnected (open), the 9430 responds by opening the input relays, the output relays, stops all power semi-conductor switching, generates an Emergency Off error, and remains in this state until the pins are reconnected and is followed by a power cycle or a hardware reset to clear the error.

3.3.3 Interlock & External Sense Wiring

Interlock



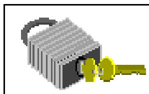
The interlock connection is located to the right of the input connector on the master module.
This connection must be shorted for normal operation.

When disconnected (open) during operation, the 9430 responds by opening the output relays, stops UUT output semi-conductor switching, and generates an Interlock error.

Unlike emergency off, the interlock connection will allow new operating commands to be accepted once the connection is reestablished.

External Sense

External sense is a required connection located at the output connector. This interface allows the 9430 to compensate for voltage drops caused by fixture wiring. The sense leads must be connected at either the UUT or module output connections for proper operation.



Connecting of sense leads is required
and ensures accurate measurements when connected at the UUT.

3.3.4 UUT Wiring

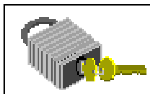
The UUT Wiring will depend on the operating mode. The outputs are per channel (OUTPUT 1, 2, 3 with associated returns V OUT & V RTN).

The outputs are isolated and generally need to the neutrals to be connected for proper referencing. See examples in appendix section for more information on wiring the output.

A customer supplied external transformer may be used for higher (or lower) Line-Neutral test capability. In this case, the sense leads as well as UUT power connections must be connected to the primary side of the transformer.

Output Connector for Channel 1

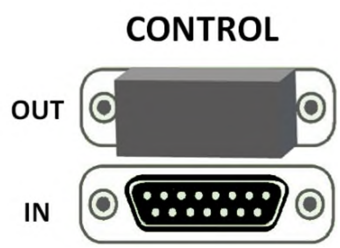
OUTPUT MATING CONNECTOR:	
NH Research	P/N: 6355968
Phoenix Contact	P/N: 1777859



Contact NH Research to discuss your application and for additional information before connecting an external transformer to the 9430.

3.3.5 Terminator Installation

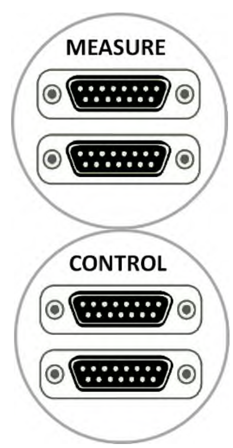
For 12kW and smaller systems,
The terminator from the accessory kit must be installed on the control output connection. Only one terminator is required for proper operation.
For systems larger than 12kW,
the terminator and paralleling cables are pre-installed.



Terminator installed correctly

In Field Expansion

The paralleling interface is used to add an auxiliary module to a system master in order to expand current capabilities.
Only NH Research supplied cables should be used.



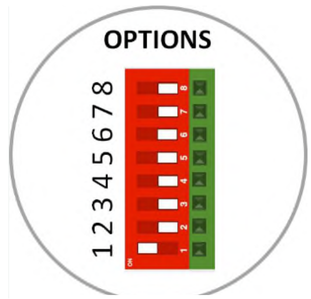
Mating Cable Type:		
Control Paralleling Cable	NHR	P/N: 12-0977-00
Measure Paralleling Cable	NHR	P/N: 12-0978-00
Terminator	NHR	P/N: 12-0976-00

Contact NH Res+earch for more information adding an auxiliary module.

3.3.6 Dip-Switches

Options Dip Switches

For all systems in normal operation, the options dip switches should always be in the OFF position (switched to the right). These switches should not be changed unless specifically instructed to do so by either NH Research customer support or by a programming update procedure (i.e. firmware update). The only exception to this statement is Switch #1 which may be used to force the IP address of the unit to 192.168.0.2 for configuration purposes.



Switch 1 shown as ON

See Configuring the IP Address section for more information about how to use Switch #1.

Aux Sys Address Dip-Switches

For 12kW and smaller systems,
the Aux Sys Address dip switches should always be in the OFF position (switched down) and should not be changed unless specifically instructed to do so by either NH Research customer support or by a programming update procedure.

For systems larger than 12kW,
the Aux Sys Address dip switches are used to properly address auxiliary modules and have been pre-set. These switches should not be changed unless specifically instructed to do so by NH Research customer support or by a programming update procedure.

Contact NH Research before beginning a field installation of an Auxiliary module.

3.3.7 Analog V/I Monitor

For all systems, the analog Voltage (V) and Current (I) monitor is located on the rear of the master module.

Pin #	Signal	Connector (DB-9)
1	GND	
2	V1(V1-V1RTN)	
3	V2(V2-V2RTN)	
4	V3(V3-V3RTN)	
5	N/C	I/V MON
6	I1	
7	I2	
8	I3	
9	GND	

This is an uncalibrated output which mirrors the internal Analog-to-digital (ADC) raw readings. The output may have considerable error (< 5%) and should be used for indication only.

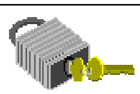
Current sign for V/I Monitor:
Current will be indicated as positive when the instantaneous direction is from the 9430 to the UUT. This differs from the internal measurement of current by 180^{o}.

Note: In all operating modes, these output mirrors per channel voltage and current internal readings. Therefore when channels are operated in parallel, the individual channel current readings must be externally summed.

Voltage	Scaling Factor
Low Range	0.047
High Range	0.0235

Current	Scaling Factor
Low Range	0.4945
High Range	0.0989

$$Actual\ Value = \frac{Monitor_{(VOLT)}}{Scale\ Factor}$$



The Analog V/I monitor is uncalibrated.
This interface should be used for indication only.

3.3.8 LAN Connection

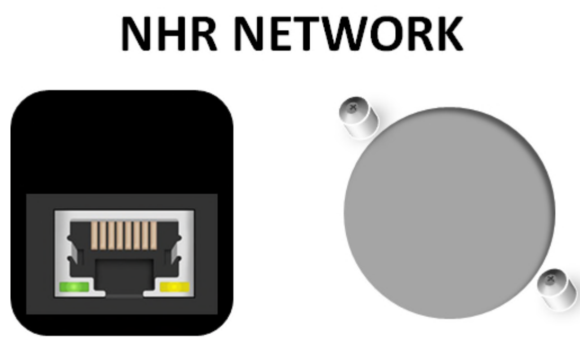
The 9430 uses LAN as the primary communication from either the touch controller or an external controller such as a PC, PLC, real-time system, etc. This connection supports auto-MDIX allowing either a straight or crossover cable to be used.

Changing the pre-configured IP address will require a PC or other web-browser capable computer. The system, internal touch controller, and any external controller must have a unique IP address in the same domain (192.168.0.xxx). The system is labeled with the IP addresses for the internal touch controller and the system.

For 12kW and smaller systems, the LAN connection is located at the rear of the module.

For systems larger than 12kW, the LAN connection is located at the rear of the cabinet.

Standalone Module LAN Connection

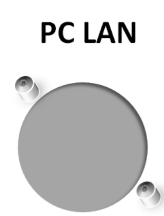


Chassis LAN Connection

One Connection if No PC Installed
Two Connections if a PC is Installed

A standard ethernet cable (Belkin A3L791-14 or equivilent) or a crossover ethernet cable may be used.

Systems larger than 12kW may optionally include a blade controller.
When present, a PC LAN connection is also provided which connects only to the blade controller and has no control to the system itself.



3.4 Turn On Checklist

3.4.1 Prior to Applying External Power to the Unit

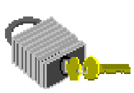
- Verify external door is closed (if equipped).
- Verify the front/rear have enough spacing for air cooling.
- Verify e-Stop is unlocked and in ready position (if equipped).
- Verify Interlock and sense leads are connected.
- Verify all system breakers are in the “Off” Position (switched to the right).
- Verify all power and communications cable connections are tight.
- Verify terminator is installed.

3.4.2 Powering Up the System

- Turn on facility 3-phase power.
- Switch all auxiliary breakers to the “On” position (switched to the left).
- Switch on the master breaker to the “On” position (module with the touch panel).
- The Touch Panel will automatically start into the monitoring application.
- Ensure Grid-On & LAN LEDs are lit before attempting PC communications.

3.4.3 Powering Down the System

- Turn off the outputs.
- Stop and close any external control software (if used).
- Turn off the master module’s circuit breaker.
- Turn off the remaining auxiliary module(s) circuit breaker(s).
- Turn off external power (optional).

	**Never assume that the output terminals are safe to touch even though the system breakers are off.** **Always verify that all potential sources of power are turned off and connections are carried out under 0V conditions.**
	**The modules use internal contactors to isolate themselves from Facility Power when a fault occurs or when the system is powered off.**

3.5 Configuring the IP Address

The 9430 Series uses standard 100BaseT Ethernet for external control.

There are a large number of potential networking configuration options which should be discussed with your local information technology (IT) department.

NH Research generally recommends either static IP addressing or DHCP where the MAC addresses are assigned to a fixed address to prevent IP addressing conflicts.

Each system is shipped with a label containing the MAC addresses and IP addresses contained in the system. These may be changed by the user.

Each 9430 system has an IP address for the master module as well as the touch panel (if equipped). Both of these addresses as well as any controlling PC will need to be in the same broadcast domain. All addresses must be unique.

> **If we assume the touch panel was configured with an IP address of 192.168.0.1 and the master module was configured with the IP address of 192.168.0.2. Any additional PC's or modules should have a unique address in the range of 192.168.0.3 to 192.168.0.254.**

> **NH Research labels the IP address for the touch controller and 9430 on the rear of the system.**

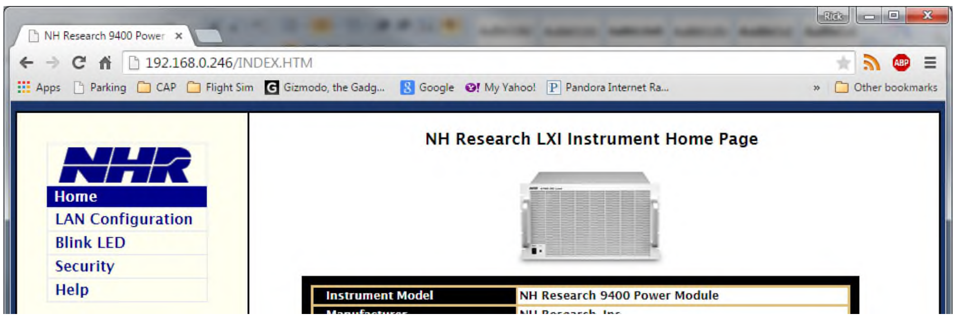
3.5.1 Configuring the Master Modules IP Address

If the Module IP address is unknown

Turn off the master module's breaker and switch the options switch (#1) to the ON position then turn the module's breaker back on. This will force the module to use a fixed IP address of 192.168.0.2. This is a temporary configuration intended to allow the system's IP address to be known for the purposes of configuration. Continue with the known IP addressing setup as follows.

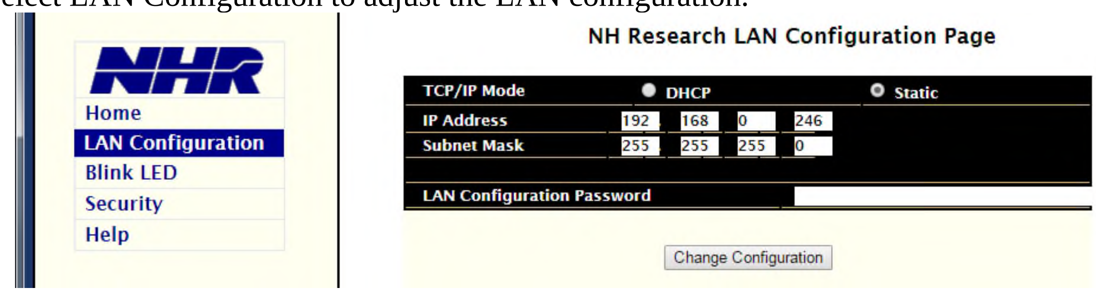
If the Module IP address is known

Open a web browser and browse to http://(IP_ADDRESS) where the IP address is the master modules address (for example http://192.168.0.246). This will open the configuration screen as shown.



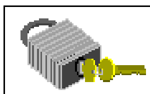
Selecting "Blink LED" in the left menu will cause the module to blink the LAN LED. This may be used to ensure the proper module has been selected before making a change.

Then select LAN Configuration to adjust the LAN configuration.



Here a static IP or DHCP configuration may be made. If DHCP is selected, NH Research recommends IT assign the modules MAC address to a static DHCP address for proper operation. Be sure to record the new IP address as it will be required by the touch panel.

The default security password is not set (blank).

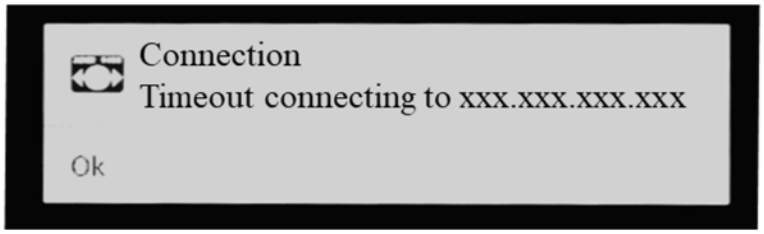


If you set the switch on the rear panel to force a 192.168.0.2 address be sure to return this switch to the OFF position before cycling power.

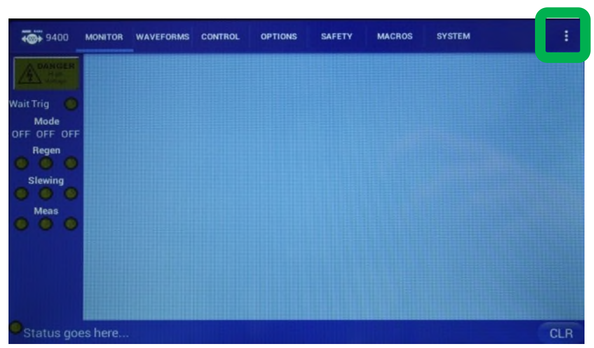
Power Cycle the module and continue with the touch panel configuration.

3.5.2 Configure the Touch Controller Software

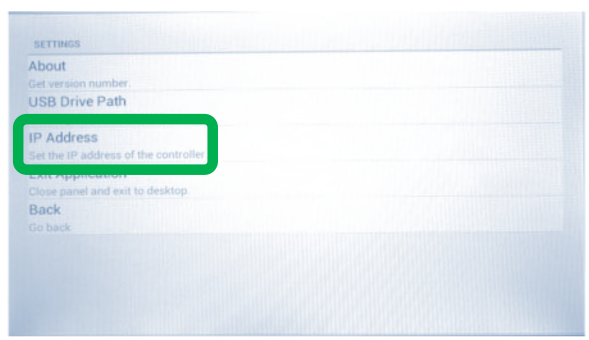
The following screen may appear after the module reboots.
Press OK and continue with the following steps to configure the Touch Controller.



First, click the "Menu" button located at the upper right left of the touch panel This will open the additional menu options.

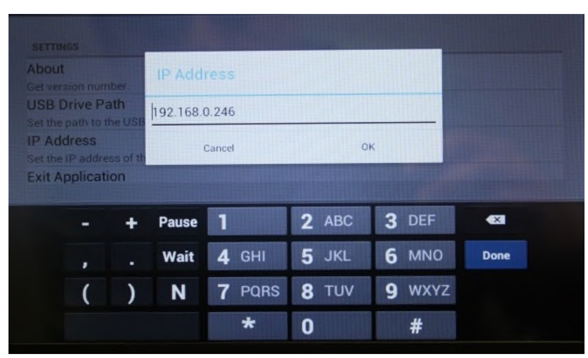


Select "IP Address"



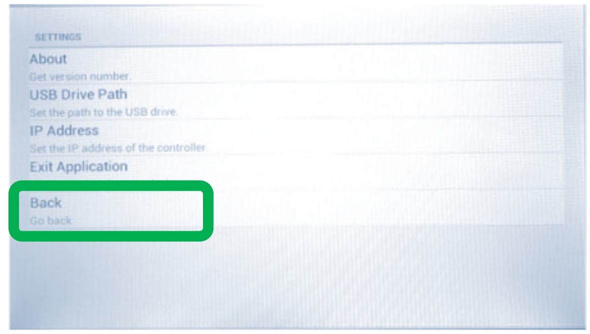
Provide the IP Address set in section 3.9.2
Then press OK.

Note: This is not the touch panel's address; it informs the touch screen where to look for the system on the network.



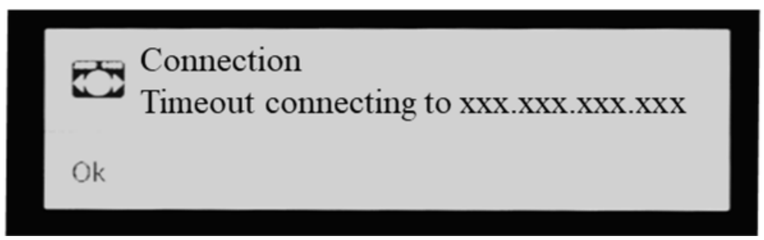
Configuring Touch Controller Software Continued

Select "BACK"



If the module has the same domain (first three numbers of the IP address),
The Touch Controller will now load and is ready for use. (No further steps required).

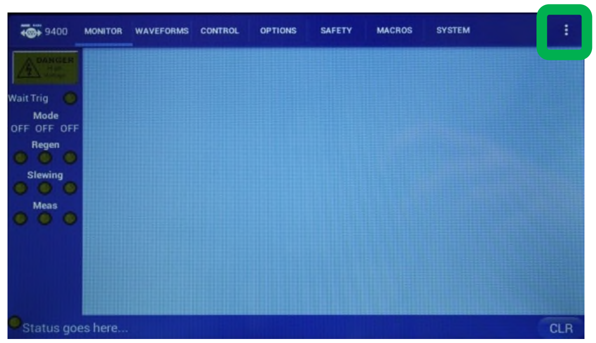
If the domain is different or an IP address conflict is detected, the touch controller will need to be assigned a unique IP in the same domain.
Press OK and follow the steps in the Section 3.5.3 below.



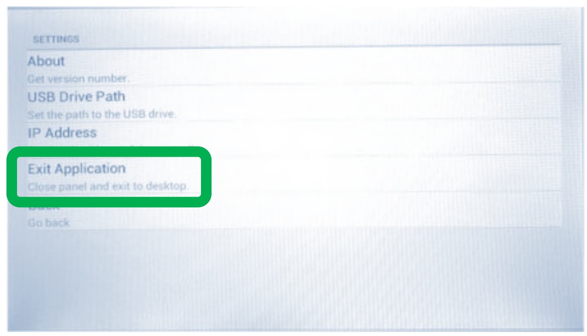
3.5.3 Configure the Touch Controller's IP Address

The following screen may appear after the module reboots.
Press OK and continue with the following steps to configure the Touch Controller.

Click the "Menu" button located at the upper right left of the touch panel
This will open the additional menu options.

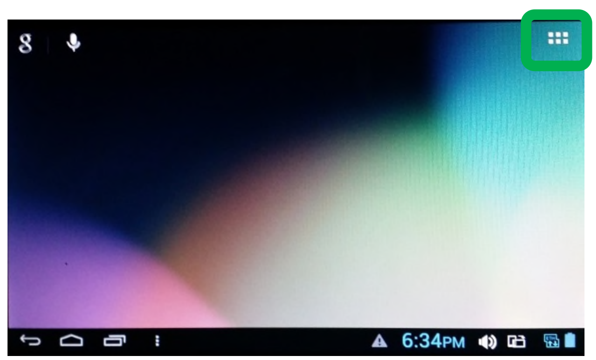


Select "Exit Application"

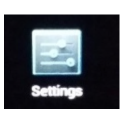


Then Select The Menu Button

This is found in the Upper Left.



Then Select Settings
from the list of options.

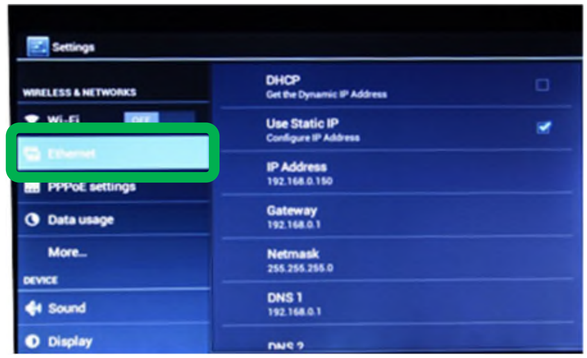


Configuring Touch Controller's IP Address Continued

The controller's ethernet IP address settings are located under Ethernet Tab.

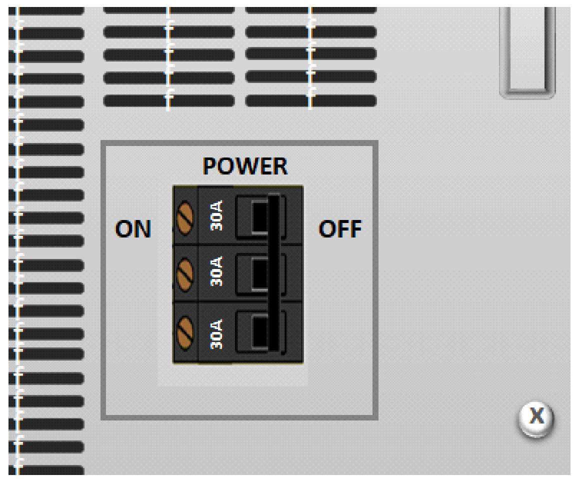
Be sure to assign a unique IP address that will be used by the touch panel.

Consult your IT administrator



Power Cycle the master module:
On the module with the touch controller, Turn off the breaker (switched to the right). Wait 10 seconds then turn on the same breaker (Switched to the left).

The System will reboot.



Never assume that the output terminals are safe to touch even though the system breakers are off.

Always verify that all potential sources of power are turned off and connections are carried out under 0V conditions.

3.5.4 Configuring an external application

External applications will use the Master's IP address and port number 5025.

The resource ID string used for LabVIEW, VISA, and NH Research tools is
TCPIP::IPADDRESS::5025::SOCKET

Where the IP address is the one configured in section 3.5.1.

This page intentionally left blank.

4. SYSTEM FEATURES

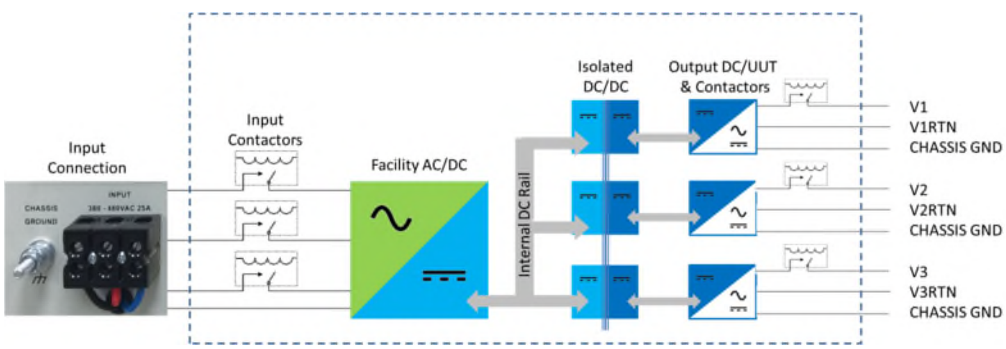
4.1 Theory of Operation

The 9430 internally utilizes multiple bi-directional power conversion stages to generate the AC or DC ***current output*** depending on the hardware operating mode.
The term <u>output</u> refers only the UUT connection and **not** power flow direction.

When sinking true power, the power from the UUT drawn from the ***current output*** is converted internally to DC. This internal rail is then converted to the internal bulk DC rail through a second isolated DC/DC converter. The internal bulk DC rail is then buffered, precisely matched to the facility, and returned to the facility with near-unity power factor for use within the facility.

When sourcing true power, the power for the voltage/frequency following ***current output*** is initially drawn from the facility power connection through a bi-directional PFC/Inverter to generate an internal DC rail. This internal rail is then converted to an isolated and calibrated DC voltage by a second DC/DC converter. Finally, this calibrated DC voltage is converted to either an AC ***current output*** following the UUT voltage and frequency. This operating mode applies to AC outputs configured as Bi-Directional.

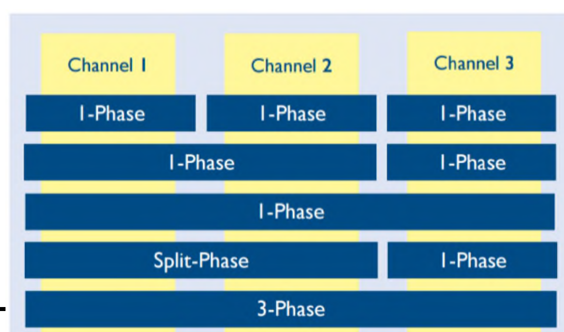
Reactive power (all AC modes) operates out of phase with respect to true power and is internally recirculated without requiring any additional facility power transfers.



9430 Simplified Internal Block Diagram

4.1.1 Multi-Channel Design

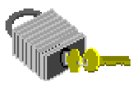
As described in the System Features section above, the 9430 Series provides up to three (3) ***current control*** channels which are configured through software in order to provide any combination of AC and DC test channels.



Refer to the following sections for information about configuration options.

4.1.2 Isolated Outputs

Each output channel of the 9430 is isolated from the input (facility power), chassis, communications interfaces, and the other output channels. This permits the system to be used with multiple separate ground references and maximizes the configuration flexibility for the system.

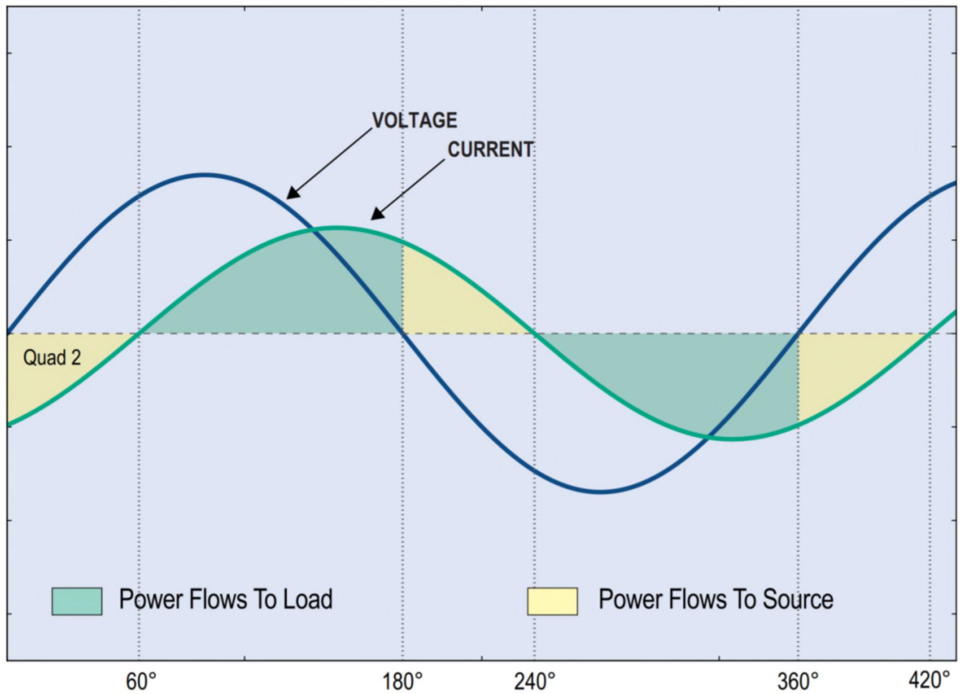


For Multi-Phase operation, the Neutral connection for each phase must be tied together and will require a current carrying return path from the load.

4.1.3 4-Quadrant AC Operation

When loading, the 9430 is able to maintain a current wave-shape at a specified AC_{RMS} value which follows the AC_{RMS} voltage and frequency. 4-Quadrant operation allows instantaneous power to flow in either direction and does NOT imply the direction of true power flows.

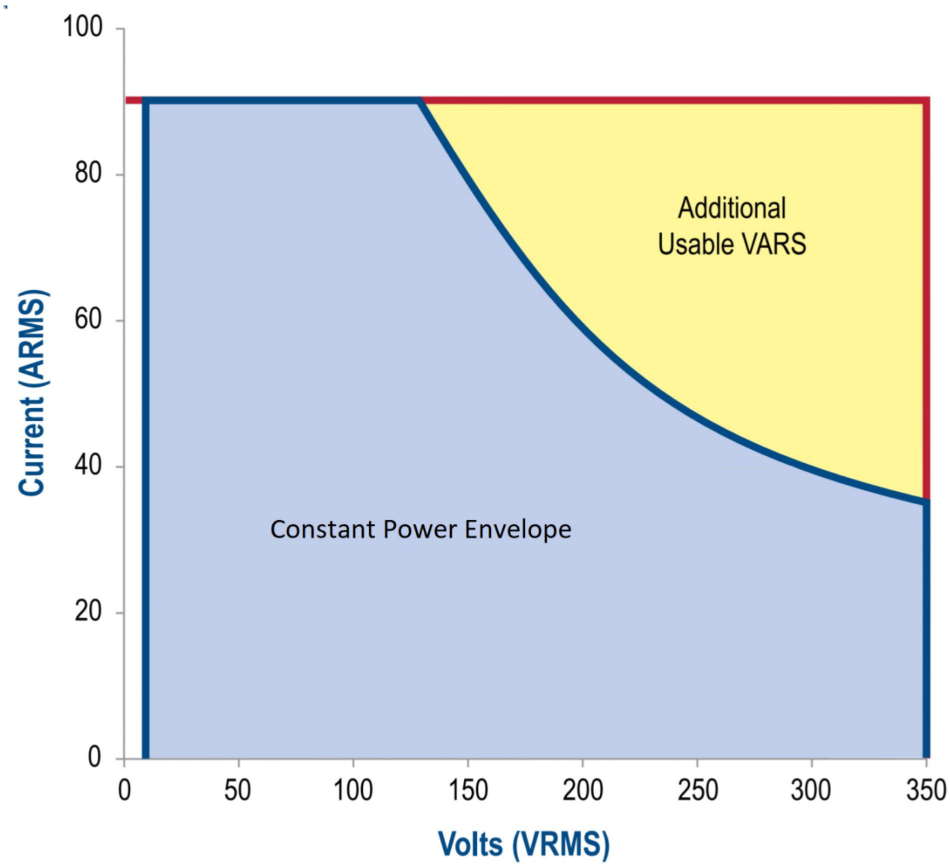
By default, True power flows from the UUT to the system when the phase angle between the RMS voltage and current is between -90^o and $+90^o$. The 9430 may optionally be enabled for bi-directional mode where the current may be simulated with any relative phase angle from -180^o to $+180^o$. When less than -90^o or greater than $+90^o$, the power factor is negative and true power if flowing from the system to the UUT simulating current flows from devices such as Vehicle-to-Grid (V2G) and grid tied solar inverters.



4.1.4 Constant Power Envelope with HiVAR

The 9430 supports full-time current control including at full Line-Neutral voltage up to the true power rating of the system. This full-time operating range allows at any combination of voltage and current without requiring range changes and provides a wider operating envelope especially when compared with traditional AC loads.

The 9430 is a switching load and generates VARs locally. This extends the operating with an additional usable VAR region allowing even higher current draws than fixed resistive loads can able achieve especially when loading high voltages with low power factors. By comparison, traditional AC loads are resistive, and are unable to provide a true power factor shift, and are able to only draw current up to the thermal power rating of the system.



Constant Power Envelope for 9430-12 operating as 1-ϕ Load

4.1.5 All Digital Control and Firmware Upgradable

The output control is performed by upgradable, onboard DSP devices for fast measurement and command response times. All the micro code for the DSPs and the communication microcontroller is stored in FLASH memory so that firmware upgrades can be performed in the field by downloading over the control interface.

4.1.6 Field Expandable Power

All 9430 Models may be expanded in the field by adding an auxiliary module. Up to seven (7) auxiliaries may be added to a single master module each of which increase the current and power of each channel by an additional 30A_{RMS} and 4kW / 10.5kW.
For example a 9430-12 may be expanded to a 9430-24 by adding a 9430-auxiliary module. In this case, the system would then provide three (3) channels each providing

$350V_{ACRMS\ L\text{-}N}$ up to 60A, 8kW/21kVA.

Contact your local NH Research sales representative for more information.

4.1.7 Reduced Channel Models

The 9430 Models may be ordered with a reduced channel count providing only one (1) or two (2) channels. For example, a 9430-4 includes one channel and a 9430-8 includes 2 channels. These product versions still provide the voltage control with the same power and current capability of $350V_{ACRMS\ L\text{-}N}$ up to 30A, 4kW/10.5kVA per channel. A single channel system may be used for one (1) AC or DC channel whereas a two channel system may be used as a single AC output, single DC output, two separate outputs each being either AC or DC, or in Split-Phase in which the two AC channels have a phase angle relationship.

NH Research offers Auxiliary modules for 12kW and higher systems.
Reduced channel count systems may not be field expanded.

4.1.8 Safety Features

Operator Protection Features

- **Interlock Connector:** Each 9430 Master Module provides an interlock input. If the interlock signal loop becomes open, the output relay will open immediately and the system will give the interlock error and perform the normal output off sequence.
- **Emergency Off Connector:** There is an Emergency Off connector on all 9430 modules. For systems up to 12kW, Pin 1 and 2 of the connector has to be shorted to turn on the unit. For larger systems (>12) NHR supplies a cabinet with an eStop button prominently mounted to the cabinet and the connections are prewired.

UUT Protection Features

There are 6 types of safety features available in each power module:

- Protection from an AC grid voltage or frequency excursion beyond preset limits.
- Programmable limits to the output current, voltage and power.
- Programmable safety trip to the output current, voltage and power.
- Protection from a PC or touch-panel failure.
- Ability to shut down based on an outside fault.

4.2 Flexible AC & DC Output Operating & Loading Modes

The 9430 provides flexible AC operating modes including multi-phase operation, multiple separate AC phases, separate DC phases or combining multiple channels for higher power AC or DC operation. See the appendix sections for "Hardware Modes" for configurations directly supported by a 9430 system.

The 9430 is regenerative and draws current following the UUT voltage and frequency. The current draw is full 4-quadrant allowing for emulation of current draws historically required use of discrete components such as capacitors and inductors. To protect the UUT, both systems include a programmable safety trip feature for voltage, current, and power (W/VA).

Feature	9430 Series Regenerative AC Load			
Max Frequency	Up to 880Hz			DC
Loading Modes	Normal	Resistance	Series RL	DC
Loading Controls	CC, CP, CS	CR, CC, CP	CRL	CV, CC, CP, CR
Programmable PF	✓	Always Unity	Based on R&L	-
PF Sinking Current	0 to 1	Always 1	0 to 1	-
Bi Directional Mode (Enable in Software)	Any PF From -1 to 1	Unity -1 or 1	-	-
Crest Factor (CF)	Up to 4	-	-	-
Current Wave-shaping	✓	-	-	-

4.2.1 Programmable Limits

The 9430 series Power Module has multiple loading modes allowing for easy programming of various current loading cases.

Normal Mode provides Constant Current (CC), Constant Power (CP), Constant Apparent Power (CS), Crest Factor Modifiers (CF), Power Factor Modifiers (PF), a unity power factor mode (UPF), and arbitrary current wave-shaping. Enabling Bi-Directional mode extends the power factor range from 0 – 1 to -1 – 1 which allows this mode to emulate a grid-tied inverter.

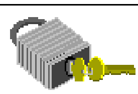
Another unique feature of the NHR 9430 series load is that it can simulate a real inverter if we select CC or CP mode and set PF equals -1. This feature will make NHR 9430 series load a great test equipment for grid emulators.

Resistance Mode provides Constant Resistance (CR) and Constant Current (CC) limits. Enabling Bi-Directional mode extends the allowed resistance values to use negative values allowing this mode to emulate a voltage-following grid-tied inverter.

RL Mode provides a simulated series Constant Resistance (CR) and Constant Inductance (CL). This simulates a voltage-following frequency-dependent current draw with a lagging power factor shift.

DC Mode provides a DC electronic load with Constant Voltage (CV), Constant Current (CC), Constant Power (CP), and constant resistance (CR). The load will automatically select the loading mode which results in the least current draw.

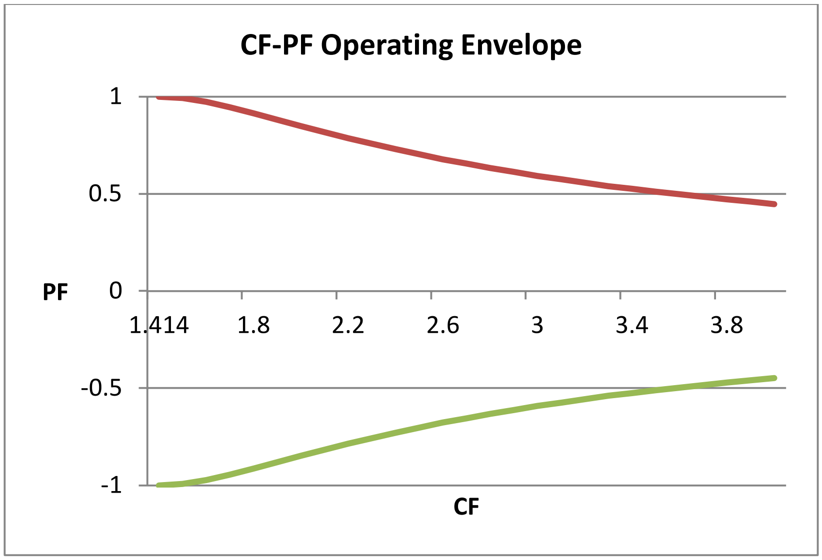
For example, When the load is in DC mode and set for CC = 10 & CR = 10. When a 50VDC signal is applied, the load would draw 5A (CR is least current). When a 200VDC signal is applied, the load would draw 10A (CC is least current).



Changing the loading mode will turn off the selected instrument and will return a number of Control & Options limits to default.

4.2.2 Crest Factor and Power Factor Relationship

For NHR 9430 series load, the operating envelope is much wider since we can really do 4-quadrant operation. The operating envelope for 9430 Loads is illustrated below.



Four Quadrant 9400 Operating envelope

User can define CF/PF to determine where the load will be in the envelope. A special case is that user define unity power factor (PF = ±1). In this case, the load will act like a variable resistor that will make sure the current waveform follows the voltage waveform, and at the same time, make sure the load has the right current and power). If user set the CF and PF number outside of the operating envelope, the pre-define priority (CF or PF) will determine the actual wave shape.

4.2.3 Bi-Directional AC Power

The 9430 is a may be enabled for AC bi-directional power flow. When enabled, the AC channels permit negative power factors (Normal Loading Mode) and negative resistance values (Constant resistance loading mode). In these cases, the 9430 will source current emulating the characteristics of a grid-tied inverter rather than an electronic load.

4.2.4 Single Phase & DC Outputs - Per Channel Relationships

The 9430 may have the outputs configured to operate as either single phase AC or DC. Additionally these modes support paralleling multiple channels to create a single larger AC or DC channels. For example, a 9430-12 operating as a 12kW load uses three (3) channels. These settings also apply to per-phase settings for multi-phase outputs in which case the channel count is always equal to 1.

Set & Measurements Relationships DC and AC (1-ϕ and per-ϕ)			
	Set Points		Measurements
	Set Value	Get value	Get Value
Voltage (V_{DC}) [1]	SET	$SET_{(CH1)}$	$MEAS_{(CH1)}$
Current (A_{DC} / $A_{RMS\ L\text{-}N}$) [2,3] Power (kW) [2,3]	$\frac{SET}{\#_{CH}}$	$\sum SET_{(CHn)}$	$\sum MEAS_{(CHn)}$
Apparent Power (kVA) [2]	$\frac{SET}{\#_{CH}}$	$\sum SET_{(CHn)}$	$V_{meas} \cdot I_{meas}$
DC Resistance(Ω) [1]	$\#_{CH} \cdot SET$	$\frac{SET_{(CH1)}}{\#_{CH}}$	$\frac{V_{meas(CH1)}}{\sum I_{meas(CHn)}}$
Resistance (Ω) [3, 4] Inductance (H) [4]	$\#_{CH} \cdot SET$	$\frac{SET_{(CH1)}}{\#_{CH}}$	N/A
I_{PEAK} (Crest Factor) [2]	$CF \cdot I_{SET/CH}$	Programmed Value	$\sum I_{Peak(CHn)}$
Power Factor [2]	SET	Programmed Value	$\frac{Power_{meas}}{Apparent\ Power_{meas}}$
Voltage-Peak [5] Current-Peak [5]	Same as VSET Same as ISET	Programmed Value	N/A

Slew Rates (DC or AC Single Phase Only)		
	Set_{ch} per channel	Get value
Current (A/s) [1, 2, 3] Power (W/s) [1,2,3] Power (VA/s) [2]	$\frac{1}{\#_{CH}} \cdot SLEW$	$\#_{CH} \cdot SLEW_{(CH1)}$
Resistance(Ω/s) [1, 3]	$\#_{CH} \cdot SLEW$	$\frac{1}{\#_{CH}} \cdot SLEW$
Power Factor Slew [2]	$SLEW$	$SLEW$

[1] Applies to DC mode or for a Safety limit as either DC or AC $RMS_{L\text{-}N}$ setting.
[2] Applies to AC-Normal Loading Mode.
[3] Applies to AC-Constant Resistance Mode.
[4] Applies to AC-Constant Resistance Mode.
[5] Instantaneous values used in safety settings as AC Line-Neutral value or DC.

Note: Slew rates are set on a per instrument level.
For multi-phase outputs, refer to the following section.

4.2.5 Multi-Phase AC Outputs - Per Channel Relationships

The 9430 may have the outputs configured to operate as either three-phase or split-phase output with an additional single phase AC or DC channel. This mode makes it possible to set or measure the output of the multiple phases in a single step.

Multi-Phase Set & Measurements Relationships			
	Set Points		Measurements
	Set Value (Per ϕ)	Get value	Get Value
Voltage 2-ϕ ($V_{RMS\ L\text{-}L}$) [1]	$\frac{1}{2} \cdot SLEW$	N/A	$\sum MEAS_{\varphi}$
Voltage 3-ϕ ($V_{RMS\ L\text{-}L}$) [1]	$\frac{1}{\sqrt{3}} \cdot SLEW$	N/A	$\sqrt{3} \cdot \frac{\sum MEAS_{(\varphi)}}{3}$
Current ($A_{RMS\ L\text{-}N}$) [2,3]	SET	$\frac{\sum SET_{(\varphi)}}{\#_{\varphi}}$	$\frac{\sum I_{meas(\varphi)}}{\#_{\varphi}}$
Power (kW) [2,3]	$\frac{1}{\#_{\varphi}} \cdot SET$	$\sum SET_{(\varphi)}$	$\sum P_{mease(\varphi)}$
Apparent Power (kVA) [2]	$\frac{SET}{\#_{CH}}$	$\sum SET_{(CHn)}$	$V_{meas} \cdot I_{meas}$
Resistance (Ω) [3,4] Inductance (H) [4]	SET	$\frac{\sum SET_{(\varphi)}}{\#_{\varphi}}$	N/A
I_{PEAK} (Crest Factor) [2]	$CF \cdot I_{SET(\varphi)}$	Programmed Value	$MAX\left(I_{PEAK(\varphi)}\right)$
Power Factor [2]	SET	Per Phase Only	$\frac{Power_{meas}}{Apparent\ Power_{meas}}$
Voltage-Peak 2-ϕ [5] Voltage-Peak 3-ϕ [5] Current-Peak [5]	Same as VSET/ISET	Programmed Value	N/A

Slew Rates (Multi-Phase)		
	Slew (Per ϕ)	Get value
Current (A/s) [1, 2, 3]	$SLEW$	$SLEW_{(\varphi A)}$
Power (W/s) [1,2,3] Power (VA/s) [2]	$\frac{1}{\#_{\varphi}} \cdot SLEW$	$\#_{\varphi} \cdot SLEW_{(\varphi A)}$
Resistance (Ω/s) [1, 3]	$SLEW$	$SLEW_{(\varphi A)}$
Power Factor Slew [2]	$SLEW$	$SLEW$

[1] Set Value applies to Safety limit as an AC $RMS_{L\text{-}L}$ setting otherwise use is only SLEW.

NHR

[2] Set Value applies to AC-Normal Loading Mode.
[3] Set Value applies to AC-Constant Resistance Mode.
[4] Set Value applies to AC-Constant Resistance Mode.
[5] Instantaneous set values used in safety settings as AC Line-Neutral value or DC.

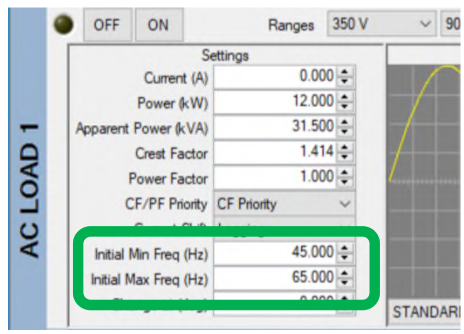
4.2.6 Switching Loading Considerations

Initial AC Frequency Detection & PLL Locking

This sub-section applies when the initial loading frequency is outside the 45-65Hz range.

For frequencies outside this range, an initial frequency detection window must be programmed and may be set through the touch panel, NHR 9400 panel, LabVIEW Vis, or through SCPI using **LOAD:FREQ <F$_{MIN}$>,< F$_{MAX}$>**. Any hardware reset including power on and output hardware mode changes will return these settings to the default value (45 and 65Hz respectively).

Touch Panel Setting (Under Control)



NHR 9400 Panel Settings

Theory of operation: AC loading channels use a 0° phase locking Phase Lock Loop (PLL) to determine the supplied AC voltage for operating frequency and phase angle. The PLL uses a detection window to qualify the initial frequency, locks the PLL, allow current draw, and will track frequency changes up to 500 Hz/s even when the frequency changes beyond the detection window limits.

Minimum (Low) Current Draw at Higher Frequencies

For low-frequencies (< 100Hz), the 9430 regulates within accuracy specifications (all loading modes) when the current is greater than 10% of the selected operating range.

For high frequencies (>100Hz), the minimum operating current (I_{MIN}) is given by:

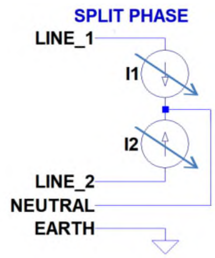
$$I_{MIN} = maximum\left(10\% \cdot I_{RANGE}\ or\ \left(1.5 \cdot \frac{V_S \cdot f_S}{350 \cdot 800} \cdot \frac{P_{INST}}{4kW\ \cdot \#_{PHASE}}\right)\right)$$

For example a 9430-12, Configured for 3 phase ($\#_{PHASE}$) 12kW (P_{INST}) AC load operating at 350V (V_S), at 800Hz (F_S), and in the 6A range:

$$I_{MIN} = maximum\left(10\% \cdot 6\ or\ \left(1.5 \cdot \frac{350 \cdot 800}{350 \cdot 800} \cdot \frac{12kW}{4kW \cdot 3}\right)\right)$$

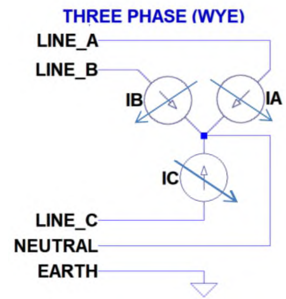
$$I_{MIN} = maximum\ (0.6\ or\ 1.5) = 1.5A$$

Neutral Current Requirement for Multi-Phase loading modes



The 9430 supports multi-phase AC loading output channels. When operating in multi-phase, the output may be considered as a number of current elements with each between Line and Neutral.

Using split-phase as an example, the split phase loading mode should only be used when there is a four (4) wire connection which includes a neutral connection. Consider using a single phase loading configuration (line-to-line) if the split phase connection has only 3 wires (Line, Line, Earth).



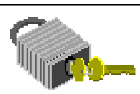
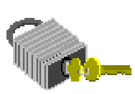
Soft Source Considerations

The 9430 load follows the voltage waveform and controls current flow.

$$Z_{LOAD} = \sqrt{((0.0028 \cdot f)^2 + 0.04)} \cdot \frac{4kW \cdot \#_{PHASE}}{P_{INST}}$$

All of the below examples assume a 9430-12 with various output configurations:

- Operating as a 1 phase 12kW (P_{INST}) load at 60Hz (f) has a ZLOAD ≈ 0.09 $\Omega_{L\text{-}n}$
- Operating as a 2 phase 8kW (P_{INST}) load at 60Hz (f) has a ZLOAD ≈ 0.26 $\Omega_{L\text{-}N}/\varphi$
- Operating in 3 phase 12kW (P_{INST}) load at 60Hz (f) has a ZLOAD ≈ 0.26 $\Omega_{L\text{-}N}/\varphi$
- Operating in 3 phase 12kW (P_{INST}) load at 800Hz (f) has a ZLOAD ≈ 2.25 $\Omega_{L\text{-}N}/\varphi$

	**When possible, NHR recommends using a source with less than 1/3 of the load impedance (Z_{LOAD}) as calculated above.**
	**When using a soft source is unavoidable - Operating may be further improved by reducing the slew rate of the controlling mode to limit the range of change to less than 10,000 A/s.**

Using 9410 or 9420 as Source for 9430

Some applications (i.e. Electric Vehicle Supply Equipment (EVSE) or micro-grids) use a 9410 grid simulator or a 9420 ATE AC Source as the primary power source. NH Research recommends increasing the minimum voltage to improve the stiffness of the source as these devices operate in a similar manor as the 9430.

For example, Use a minimum of 35V for frequencies below 200Hz,
50V for frequencies of 200-400Hz, and 80V for frequencies > 400Hz.

Using 9430 as a Delta Load

The Line-Neutral connections of a 9430 are designed to be connected as a wye with a current carrying neutral. As the outputs are isolated, they may be connected as a delta however the measurement and set points must be calculated by the user based on a wye-delta relationship.

For example, a balance Wye resistive Load with each element of "R" is equivalent to a delta based load where the resistance value is 3*R.

	The 9430 output is $350V_{ACRMS}$ from V1 to V1RTN and may be used as a Wye or a Delta Connection. Any voltage exceeding $350V_{ACRMS}$ will cause damage to the load.
	Measurements will reflect direct measured values. For Example: Voltage – Line to Line (vs Line-Neutral) Current – Phase Current (vs Line Current) True Power – Phase Power (Same value as true power) Apparent Power – Phase Power (Same value as apparent power) Etc.

Using 9430 to Load a PWM

Do not attempt to use the 9430 to directly load PWMs or AC outputs like those used for variable frequency motor drive (VFD) applications. Significant filtering is required to reduce the dV/dt and to remove the harmonic components allowing the 9430's PLL to lock and then draw current from the source.

VFD and un-filtered PWM AC Sources require significant filtering. Contact NH Research for more details before attempting to use a 9430 for a PWM loading application.

4.3 Front Panel Indicators and Controls

The following described controls are found on the 9430 Master Module only.

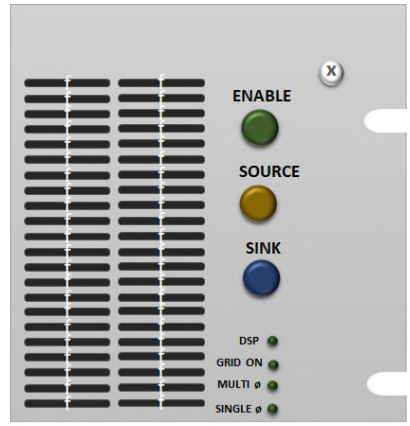
9430 Regenerative AC Load Shown

Touch Panel Interface

This interface provides direct manual control of the system without requiring an external PC or control device. In addition, it serves as a monitor for voltage, current, power, frequency, and other measurements while the system is under local control.

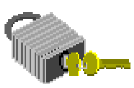
For additional details, refer to the using the touch panel control section.

Output Status Indication



The three indicators in the upper left provide a visual indication.

- Enable – Output Contactors are connected (closed)
  Enable does not imply that current is being drawn or indicate direction of power flow.
- Source – All channel powers are summed & Net Power is flowing from the 9430 to the UUT (Bi-Directional Mode).
- Sink – All channel powers are summed & Net Power is flowing from the UUT to the 9430.

	**Always assume electrical connections may have voltage until all external sources of power have been removed.**
	The Source & Sink lights may NOT illuminate when the arithmetic sum of all channel power is near zero. For example, if two channels are sourcing 2kW each and another is sinking 4kW the sum is near zero and neither light will be illuminated even though significant power is flowing on a per channel basis. Never use Source & Sink as a safety indication.

System Status Indicators

The six indicators in the upper left provide a visual indication.

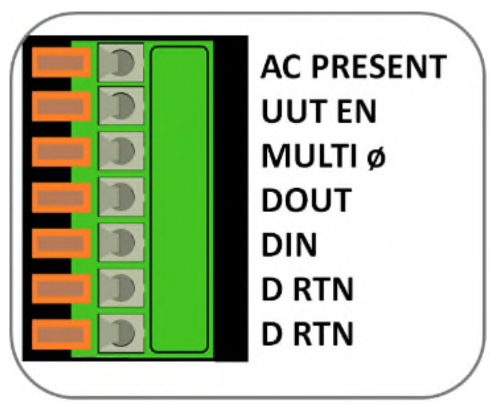
- DSP – Status indication for the internal processor.
- Grid On – Illuminates when internal power reaches normal operational levels.
- Multiϕ – Indicates multiple phases are active.
- Singleϕ – Indicates a single phase is active.
- Status – Status indication for the communications processor.
- LAN – Illuminated when good network connection is detected.

LED Pattern	DSP Meaning	Status Meaning
Blinking Green	Normal Operation	Normal Operation
Blinking Yellow	Non-fatal error occurred	System Error
Blinking Red	Not Configured, safety limit, or fatal error occurred	Hardware Error

Digital IO Interface

This interface uses a wire terminal block with release lever.

All signals are reference to "D RTN".
All output signals are open collector and provide an internal a 1K pull-up to $+5V_{dc}$.
All output signals may source up to 5mA and sink up 50mA.



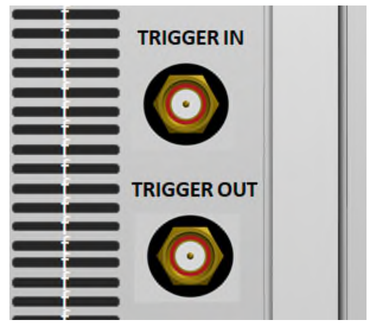
- AC PRESENT – Output indicating the presence of AC at the output terminals.
- UUT EN – Output indicating the output contactor state.
- Multiϕ – Output indicating the output is operating with multi-ϕs active.
- DOUT – Output available as a general purpose Digital Out.
- DIN – Input available as a general purpose digital input. The input voltage should not exceed 12V (5V is recommended).
  May be enabled through software as a rising/falling edge trigger source.

- D RTN – Return signal / reference for all digital IO interfaces. This return is isolated from chassis ground up to 100V.

Trigger In / Out

This interface uses a SMB connector and provides Trigger In and Trigger Out controls. These signals are references to D RTN in the Digital IO Interface section and include a 1k resistor to $+5V_{dc}$.

- Trigger In – Input enabled through software for rising or falling edge generates a trigger which is generally used to advance a Macro. The input voltage should not exceed 12V (5V is recommended).
- Trigger Out – Output enabled through software. Generates a positive pulse for each operating command processed. Generally used to trigger external devices such as an oscilloscope.



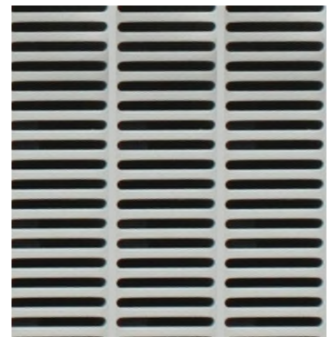
Mating Cable Type:		
Cable Assembly	NHR	P/N: 12-0879-00
Connector Coax Miniature	NHR	P/N: 6000262
Wire Coax RG174/U	NHR	P/N: 8010023

4.3.1 Front Panel Air-Intake and Breaker

The following applies to all 9430 modules (Both master and auxiliary).

Air Intake

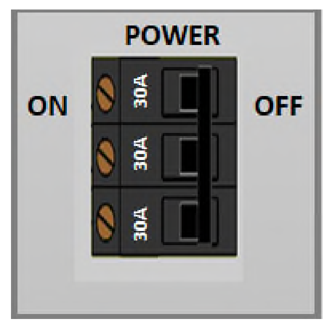
The system is cooled with ambient air. Cooling air is drawn from the front of the unit and exhausted out of the rear.



	Never insert tools, metal objects, or allow liquids to be drawn into the air intake slots.
	NH Research recommends 24 inches (60cm) of unrestricted air space.

Circuit Breaker

Each master and auxiliary module provides a 30A main circuit breaker which is used to protect the internal wiring and power stage against internal failures. See the installation section for recommendations about sizing a breaker to power a 9430 system.

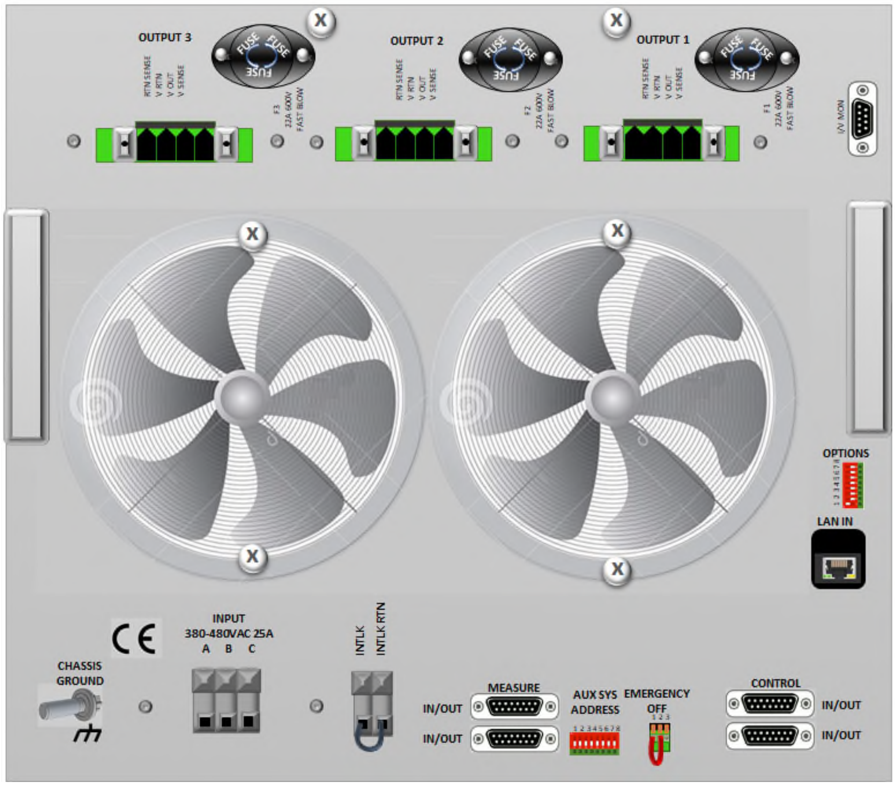


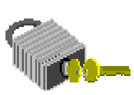
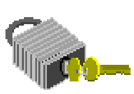
	See the installation section for breaker and facility wiring recommendations.

4.3.2 Module Rear View

The rear of all module types include: power connections (facility & UUT), an emergency off connection, paralleling address switches, and a paralleling interface connector.

The 9430 master module (with a touch screen) includes the remote sense connections (with interlock), communications (LAN), options dip switches, and a voltage/current monitor.



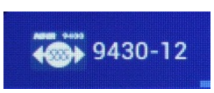
	**All power and communications connections are made at the rear of the system and are not typically changed after installation. Refer to the installation section for information about connections.**
	**See LEGACY UUT AND POWER INTERFACE CONNECTORS section at the end of this manual if the connectors on the back of the unit do not appear to match the image above**

5. TOUCH PANEL CONTROL

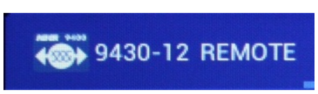
The 9430 system may be manually operated through the front touch controller.

5.1 System Identification

The upper left hand corner displays the system model number and size.
This indication is automatically updated based on the model detected as well as the number of detected auxiliary modules at power up.
See the troubleshooting section if the reported system size is not correct.



12kW 9430 Detected



External Controller Connected

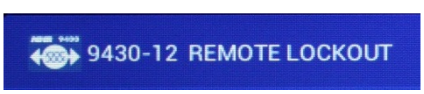


Figure Panel Locked

This field also indicates if the system has detected an open remote communication port or has been remotely locked out by a remote application (i.e. PC Tools: NHR 9400 Panel).

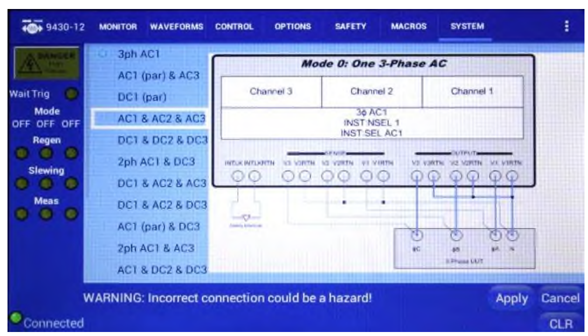
5.2 Setting the Output Operating Mode

The 9430 series contains a number of hardware operating modes.
The System tab on the main screen is used to review and select a hardware operating mode.

Changing the operating mode will likely require a change in fixture wiring. Please review this selection process carefully.

Then Select the System tab.

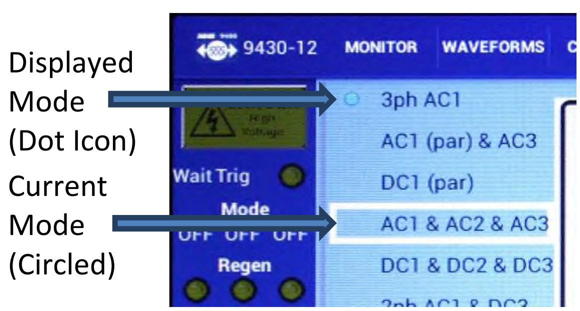
In this screen, any operating mode and recommended fixture wiring may be viewed. The new mode will not take effect until the Apply button is pressed.



The active hardware mode is circled.

Any selected hardware operating mode as well as the wiring associated with this mode is indicated with a dot icon .

Pressing apply will send the configuration commands to the hardware.

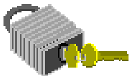


Changes to the operating mode may require output wiring changes.

Changes to operating mode will disable previous safety limit settings.

5.3 Setting the Output Loading Mode

The 9430 series contains a number of loading modes in addition to hardware operating modes. The loading mode and bi-directional option is found under the options tab.



Changing the loading mode will turn off the selected instrument and will return a number of Control & Options limits to default.

Then Select the Options tab.

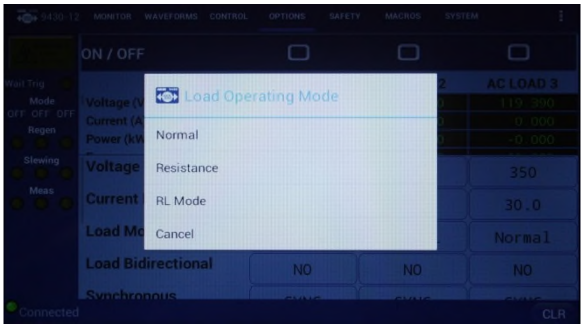
Select Load Mode for the instrument that is to be use an alternate loading mode.

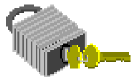
Note: Only AC outputs can have the a loading profile mode selected.

From the pop-up select :

Normal: CC / CS / CP / CS with CF & PF
Resistance: CR / CC / CP (Unity PF)
RL Mode: Series CR & CL

More on each mode in the next sections.





Refer to section 4 for more information about Loading Mode Features.

5.4 Touch Screen Overview

The touch screen includes a number of tabs and indicators. The touch panel may be locked out preventing manual changes when the system is being operated remotely such as with the NHR 9400 panel. The monitor tab and the error clear buttons are the only active fields when the panel has been locked by a remote application.

Panel is Primary Controller

Panel is Locked Out (remote controller)

5.5 Indicators

The touch screen (if equipped) supplies a number of indicators which are displayed to the left regardless of the tab selected.

The number of indicators shown will depend on the number of logical instrument as configured by the hardware operating mode. For example a 3-ϕ AC output is a single logical instrument whereas three separate 1-ϕ AC outputs would be three channels.

These are ordered left to right.

Examples
1x 1-ϕ AC or DC
3-ϕ AC

Examples
2-ϕ + AC or DC
2x AC or DC

Examples
3x 1-ϕ AC
3x DC

Indicators below are described from top to bottom

When lit, the output of one or more channels is active.
This button may be pressed to turn all channels off.
This feature is locked out in remote lockout mode.

Always assume voltage may be present at the output.

Indicates one or more instruments are waiting for a trigger before performing the next action such as taking a measurement or macro step.

Indicates logical instrument is on/off or the current regulation mode.

Indicates the logical instrument indicated is converting UUT power to into internal DC power.

Indicates a slew to a new set value is occurring on the logical instrument indicated.

Indicates a measurement is in progress on the logical instrument indicated.

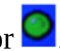
Indicates the macro is executing (i.e. local high-speed control is active).

Only displayed when a macro has been downloaded to the system.

A macro run button may also appear when the system is under touch panel control.

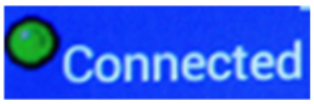
More information about building and using macros can be found in later sections.

5.6 System Status

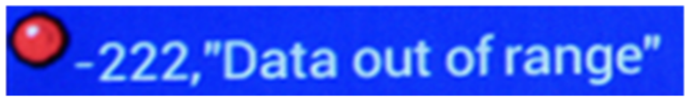
The lower portion of the screen includes a status bar including an indicator .
The indicator shows a communications status (heart beat) as well as error status.

- Blinking Yellow – Normal status & communicating with system
- Blinking Red – An Error has been detected
- Solid (any color: on or off) – Communication with the system has failed
  (A reset or power cycle may be required)

Immediately to the right of this indicator is a status message.
This message shows either "Connected" or an error message (if present).



No Error and Communicating



Error Detected

The displayed error (if present) may be cleared by pressing 

found to the right.

5.7 Screen Selection Tabs

The multiple control screens are selected using the tabs at the top of the touch panel. The current selected tab is indicated by a blue underline as shown below.

All control screens are available when the system is under touch panel control.

The monitor tab is the only screen available when the touch screen is locked out. The other tabs (circled below) are removed thereby preventing local changes which may affect the testing results.

Control tabs are described from left to right

MONITOR	The monitor tab provides digital measurements for each instrument. For multi-phase instruments, tap any measurement to switch between per phase (l-n) and multi-phase (l-l) views
WAVEFORMS	Provides a waveform view of the current output (voltage & current).
CONTROL	Provides set control for single values (voltage, current, frequency, etc.) Like the monitor tab, tap the measurements to switch between per phase (l-n) and multi-phase (l-l) control views.
OPTIONS	Provides access to additional set controls (ranges, wave-shapes, etc.)
SAFETY	Provides access to the safety limit settings.
MACROS	Provides access to the internal local high-speed control system.
SYSTEM	Used to set up the operating mode of the device. Note: This will likely require a wiring change. For more information see “Setting the operating mode” section.
⋮	Used to access setup menus for installation. For more information see the “installation section.”

5.7.1 Monitor Screen

The Monitor screen provides measurements for each configured instrument.
For 1-ϕ and DC these measurements are always referenced to neutral (l-n).
For multi-ϕ modes, the measurements are available as line-line or per-phase (l-n).

This monitor screen is available at all times even when the system is being controlled externally with another application (such as the NHR 9400 Panel software).

Monitor Screen showing a 9430 in split phase (2-ϕ) + 1 AC (1-ϕ) Configuration

5.7.1.1 Instrument Labels

The monitor screen provides the instrument names based on the hardware configuration.

These are placed atop of the measurements as shown.

The background of the instrument label changes to YELLOW when the output is active. This indication is in addition to the left indicators which are displayed across all screens.

Channel is Active (ON)

Channel is Inactive (OFF)


DANGER
High
Voltage
Mode
CC OFF
9430-12
MONITOR
WAVEFORMS
CONTROL
OPTIONS
SAFETY
MACROS
SYSTEM
Wait Trig
Regen
Slewing
Meas
AC LOAD 1
Voltage (V)
238.230
Current (A)
2.000
Power (kW)
0.477
Frequency (Hz)
60.017
AC LOAD 3
Voltage (V)
119.550
Current (A)
0.000
Power (kW)
-0.000
Frequency (Hz)
60.014
Connected
CLR

5.7.1.2 Switching between Line-Line and Line-Neutral Views

For multi-phase outputs, tap any measurement toggles between multi- & per-phase views

9430 Line-Line view for AC Load 1 Shown

9430 Per Phase (L-N) view for AC Load 1 Shown

Multi-Phase view takes into account the operating mode to correctly display an equivalent multi-phase voltage, current, and power. The following table provides some additional details on the calculations used to display Multi-Phase monitored values.

Hardware Mode	Per Phase View (only)
DC Output	Voltage Shown as L-N
Single Phase (1-ϕ)	Actual line currents
	Power (kW)
	Energy (Ah)
	Energy (kWh)
	Apparent Power (VA)

Hardware Mode	Multi-Phase View	Per Phase View
Three Phase (3-ϕ)	Voltage shown as $V_{A\phi\ l\text{-}n} \cdot \sqrt{3}$	Voltage Shown as L-N per ϕ
	Average of line currents A_{RMS}	Actual line currents per ϕ
Split Phase (2-ϕ)	Voltage shown as $V_{A\phi\ l\text{-}n} + V_{B\phi\ l\text{-}n}$	Voltage Shown as L-N per ϕ
	Average of line currents A_{RMS}	Actual line currents per ϕ
Common Multi-ϕ	Total Power (kW)	Power (kW) per ϕ
	Total Energy (Ah)	Energy (Ah) per ϕ
	Total Energy (kWh)	Energy (kWh) per ϕ
	Total Apparent Power (VA)	Apparent Power (VA) per ϕ

+Peak and –Peak voltage, current, & power are always displayed per ϕ.

Frequency is indicated for instruments configured for AC outputs.

5.7.1.3 Scrolling for Additional Measurements

The system reports more measurements than can be shown on the screen at one time. The touch screen takes advantage of Androids swipe capability allowing the entire list of measurements to be viewed. To see the additional measurements, keep touching the screen and scroll up & down to see the additional available measurements.

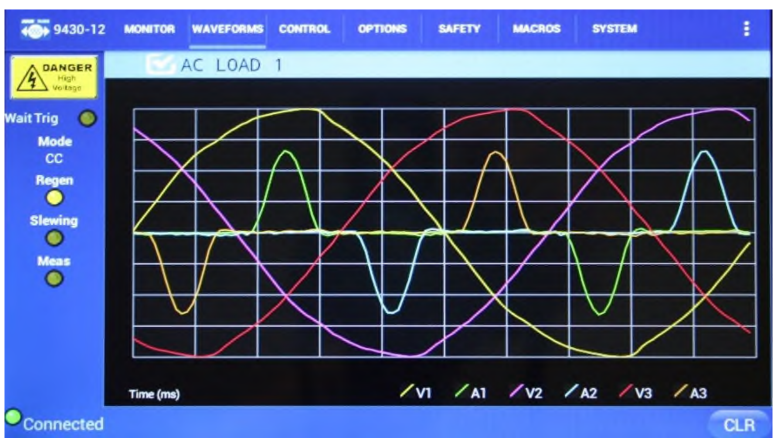
Scrolling for more measurements on AC Load 3

Scrolling for more measurements on AC Load 3

5.7.2 Waveform Screen

The waveform screen provides a graphical representation of the voltage & current for any or all of the configured instruments. The displayed waveform synchronizes to the 0^{o} start angle of the output and displays one cycle (AC) or 10mS (DC).

To access this feature, select the waveforms tab then check the desired instruments.



9430 Loading NHRs Facility Voltage (3-ϕ) with 3.5 Crest Factor

5.7.3 Control Screen

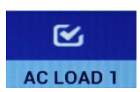
The control screen allows single value updates to any instrument. In single phase, this may be voltage, frequency, or any other single parameter. In multi-phase, the adjustment can be to all phases (such as returning to a balanced voltage) or on a per-phases basis.

Macros (described later) are available to adjust multiple phases simultaneously as well as provide timed or cycle count based changes to settings.

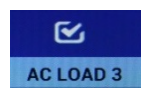
9430 Control Screen for a split phase (2-ϕ) + 1 AC (1-ϕ) Configuration

5.7.3.1 Turning the Output On/Off

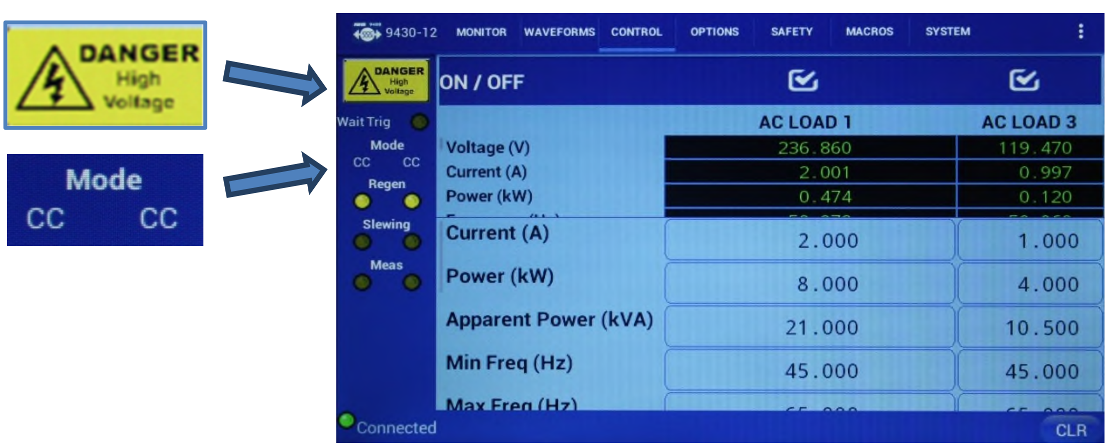
An output is turned on/off by taping the check box directly above the instrument label. This check-box is in addition to the left indicators which are displayed across all screens as well as the active measurements directly below.



Channel is Active (ON)



Channel is Active (ON)



5.7.3.2 Measurements & Settings Panels

Directly below the On/Off checkbox control is a measurements panel. This provides similar functionality as the monitor screen including taping for multi- versus per-phase views as well as scrolling the measurements to see other values which do not fit on the screen. The only significant difference is both instruments will scroll together rather than separately as is available in the monitor screen.

The settings panel is used to select which setting will be adjusted.

5.7.3.3 Switching Control from Line-Line to Line-Neutral

Similar to the monitor panel, a single tap in the **measurements panel** switches between multi- & per-phase views. The control options in the **settings panel** also switch between multi- or per-phase setting controls as shown below.

9430 Line-Line control for 2-ϕ instrument

9430 Per Phase (L-N) control for 2-ϕ instrument

Multi-Phase programming uses a fixed line-neutral relationship for all phases whereas per-phase and single channels permit individual line-neutral programming values.

In multi-phase mode, the current as well as modifiers (lead-lag/ power factor / crest factor) are applied equally to all channels. Similarly, programming a power limit (for example 2kW) programs an equal amount of power per phase (kW / # of φ). In per-phase as well as the single channel (AC GRID 3) is programmed with separate Line-Neutral values. For more information about the 9400 multi-phase calculations used, see the multi-phase calculation section.

5.7.3.4 Scrolling for Additional Settings

Similar to the monitor panel, the number of possible settings is greater than the number that can be shown on the screen at one time. The touch screen takes advantage of Androids swipe capability allowing the entire list of settings to be viewed or selected. To see the additional settings, keep touching settings area and scroll up & down to see the additional available set options.

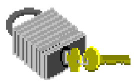
Scrolling up for more 9430 settings (2-ϕ shown)

Scrolling up for more 9430 settings (2-ϕ shown)

5.7.3.5 Adjusting Output Settings

Tapping on a setting opens a control allowing the setting to be changed.

The setting may be adjusted by direct value entry or using a live-update feature.



Only the available settings appropriate for the hardware operating and loading modes.

For example: AC Load 1 is in Normal loading mode whereas AC Load 3 is in CR loading mode.

Adjusting through direct value entry

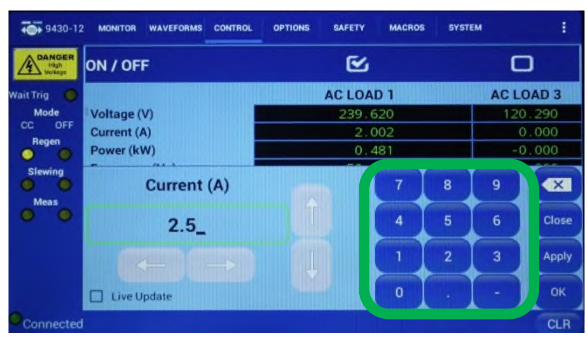
Taping the value field opens a control panel allowing for direct numerical entry.

Tap on the measurement value
That is to be adjusted.

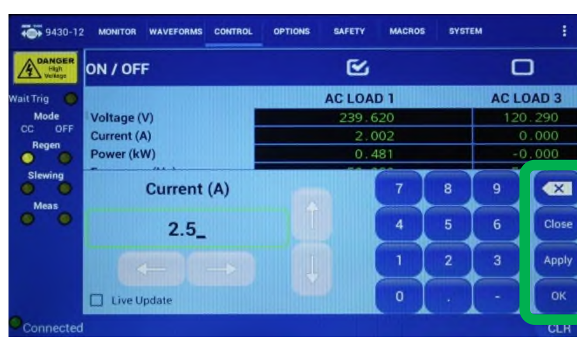
Click on 2A.

Note: for multi-ϕ, this is the current for all phases line-neutral
for single-ϕ & per-ϕ, this is line-neutral.

Enter the new setting
using the numeric keypad.

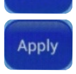


Then select close, apply, or Ok.



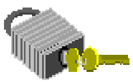
 Deletes last digit entered.

Close (No Setting Change).

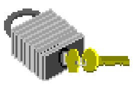


Apply Setting (Keep control open).

Apply Setting and close control.



Switching between Multi-Phase and Per phase views occurs before selecting the setting to be adjusted. For more information, see the previous "Switching control from line-line to line-neutral" section.



Single phase and per phase view settings are always entered as line-neutral.

Multi-phase settings (such as power) are entered as a total power.

See the multi-phase calculations section for more information.

Adjusting using a Live-Update (Up/Down value) modification

The NHR 9400 Panel allows a value to be adjusted using an up/down button approach.

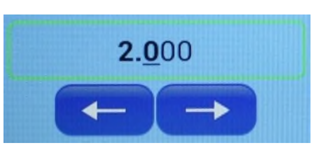
Tap on the measurement value
that is to be adjusted.

Click on 2A.

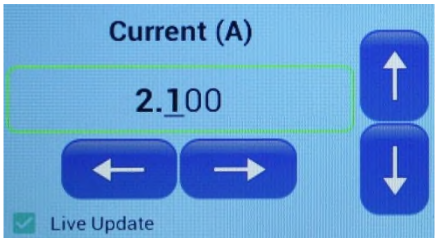
Note: for multi-ϕ, this is the current for all phases line-neutral
for single-ϕ & per-ϕ, this is line-neutral

Check the Live Update Checkbox.

Use the left & right arrows to
select which digit will be adjusted.



Use the up & down arrows to
increase or decrease the selected digit.



Note: Settings are sent to the hardware with each increase or decrease in value.

5.7.4 Options Screen

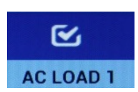
The options screen provides settings which accept one or more fixed values rather than user-specified values like the control screen. This screen operates in a similar way as the control screen except that a selected value provides a menu choice rather than a value entry screen.

All of these settings may also be adjusted using macros similar to the control screen.

Options Screen for 9430 in split phase (2-ϕ) + 1 AC (1-ϕ) Configuration

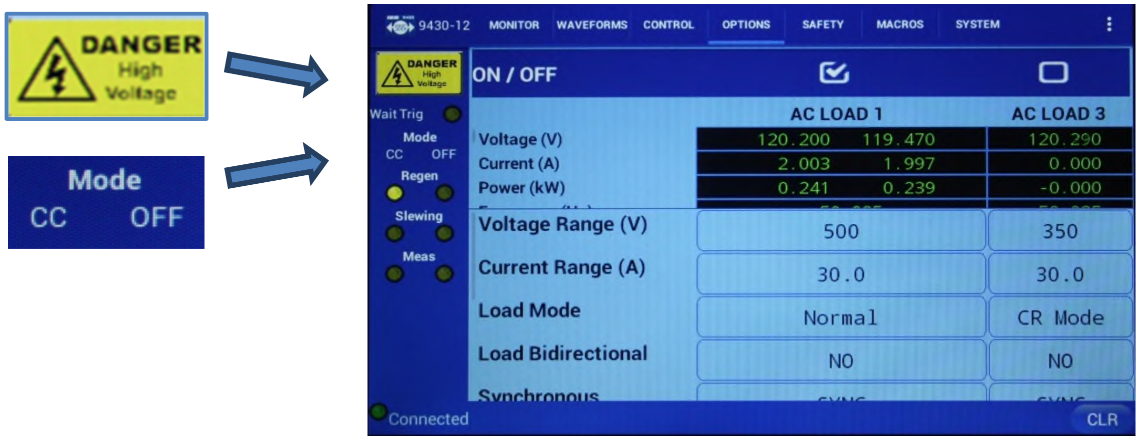
5.7.4.1 Turning the Output On/Off

Similar to the control screen, an output is turned on/off by taping the check box directly above the instrument label. This check-box is in addition to the left indicators which are displayed across all screens as well as the active measurements directly below.



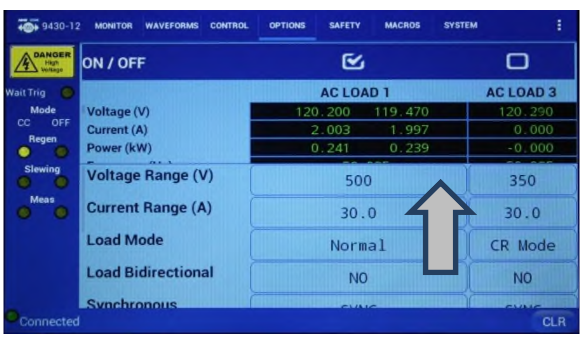
Channel is Active (ON)

Channel is Active (OFF)



5.7.4.2 Scrolling for Additional Settings

Similar to the control panel, the number of possible settings is greater than the number that can be shown on the screen at one time. The touch screen takes advantage of Androids swipe capability allowing the entire list of settings to be viewed or selected. To see the additional settings, keep touching settings area and scroll up & down to see the additional available set options.



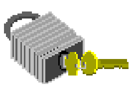
Scrolling up for more settings (2-ϕ + AC shown)

Scrolling up for more settings (2-ϕ + AC shown)

5.7.4.3 Adjusting Output Options

Similar to the control screen, Tapping on a setting opens a control allowing the setting to be changed. When selected, a menu option will pop up providing a selection option.

Tap a setting to change the value

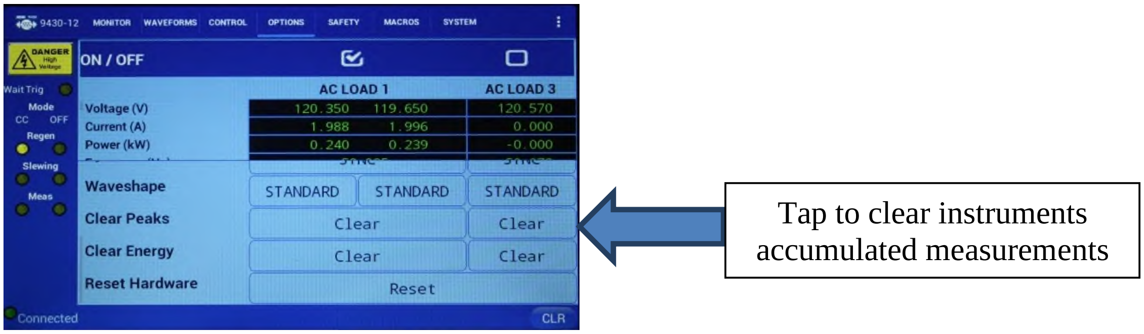


Note: Changing the Loading Mode will also change the initial settings and may clear previously established safety limit settings.

Please refer to the section 4 for more information about loading modes.

5.7.4.4 Clearing Accumulated Measurements

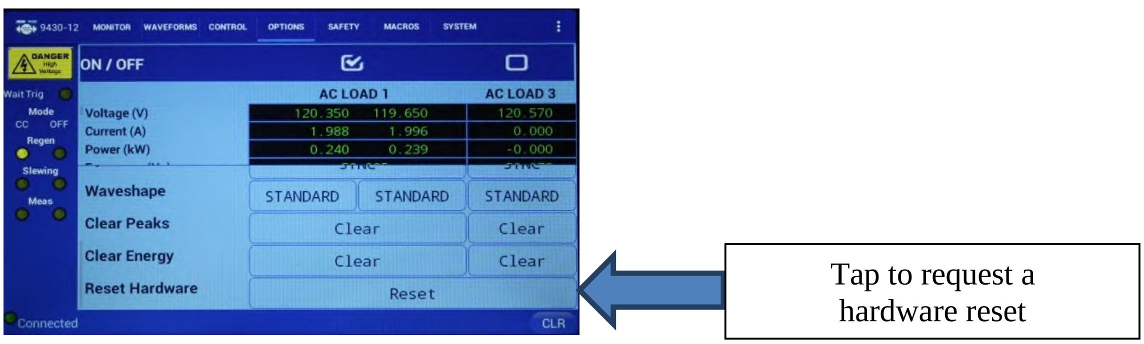
Options to clear accumulated measurements such as peak voltage, current, power as well as energy is found at the bottom of the options screen.



When pressed, the touch panel requests confirmation before clearing the measurements .

5.7.4.5 Performing a Hardware Reset

A hardware reset may be requested from the options screen.



When pressed, the touch panel requests conformation before applying a hardware reset.

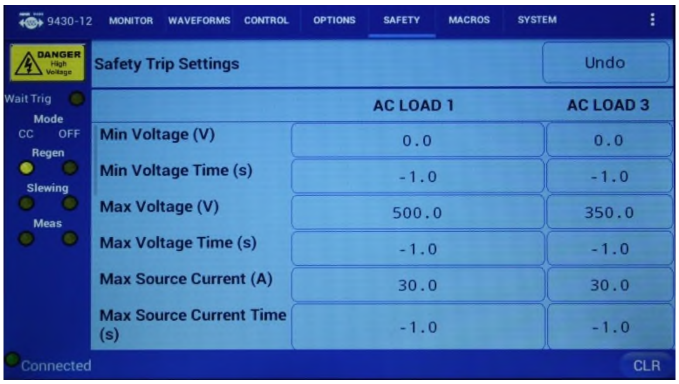
Hardware resets will turn off all outputs and return the system to a power up state. This sets all wave shapes back to the pre-programmed wave shapes, ranges to default, and settings to default.

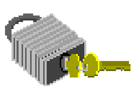
Safety limits are preserved through reset. It is generally advised to ensure the system is fully prepared including ranges, safety limits, and operating modes before turning on the output again.

⚠	**Always assume the voltage is present at the output even after performing a hardware reset.**

5.7.5 Safety Screen

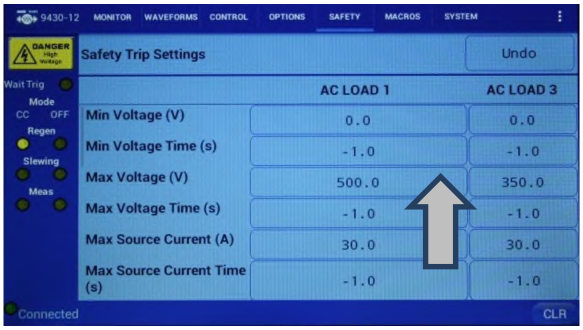
The safety screen provides programmable safety limits intended to limit UUT damage due to operator errors. Safety limits act like a programmable fuse and will disable and disconnect the system from the UUT when the programmed level is exceeded for the time specified. Like a fuse or circuit breaker, the setting value should be greater than the nominal expected and will trip faster when the actual value exceeds the threshold by a larger value.



	**Safety limits are sent to the hardware when another screen is selected.** **Provide the desired changes and then select another screen.**
	**Changing hardware operating modes disables all safety limits values.** **Ensure safety limits are implemented before turning on the output.**

5.7.5.1 Scrolling for Additional Settings

Similar to other screens, the number of possible settings is greater than the number that can be shown on the screen at one time. The touch screen takes advantage of Androids swipe capability allowing the entire list of settings to be viewed or selected. To see the additional settings, keep touching settings area and scroll up & down to see the additional available set options.

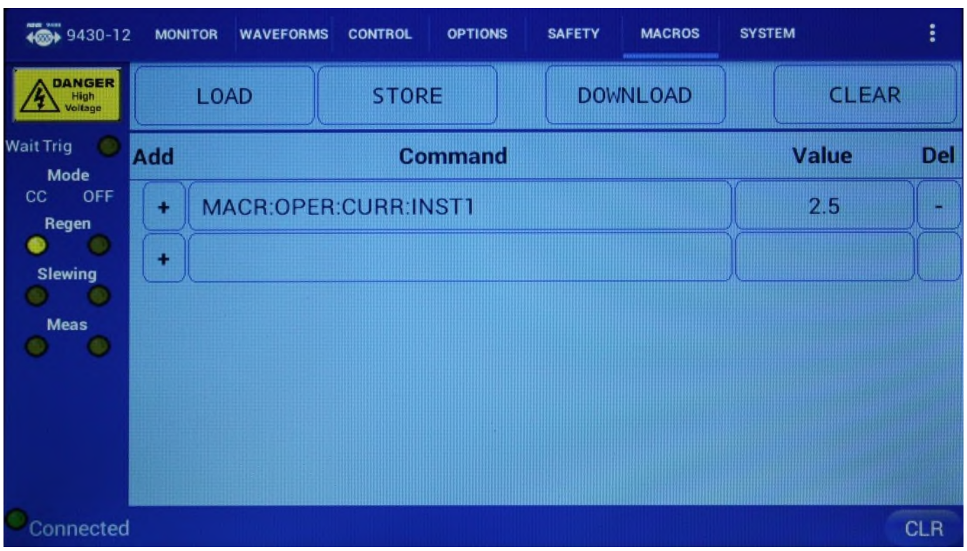


Scrolling for more settings (9430 Split-ϕ + 1AC)

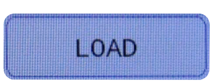
Scrolling for more settings (9430 Split-ϕ + 1AC)

5.7.6 Macro Editor Screen

A Macro is short pre-programmed pattern that is downloaded and executed locally on the hardware in order to provide direct cycle and sub-cycle control. Macros provide deterministic cycle-based and time-based changes to settings across all instrument channels, to any phase, to wave-shape selection, and any other programmable setting.

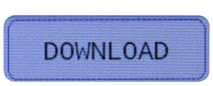


Button Options below are described from left to right

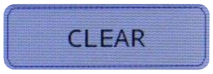


Retrieves a previously generated and stored macro file.

Saves the current macro file for later use.



Downloads the current macro file to the hardware.



Clears the macro editor screen (and macro loaded in hardware).

Inserts a new macro step above the current step.

Selectable entry field.

Deletes the selected macro step.

More information and usage examples can be found in the
“MARCOS & USAGE EXAMPLES” section below.

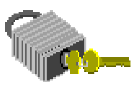
6. SOFTWARE (PC TOOLS) CONTROL

NH Research provides a number of PC-Based tools along with each 9430 System. One of these is the NHR 9400 Panel which permits manual control of the hardware. Alternatively, the Power Module can be controlled through communications terminals (like HyperTerminal) using SCPI commands, or through any software package which is able to issue SCPI commands, VXI-11, or LabVIEW Vis..

On Windows 7, the provided utilities and documentation is found under
Start → All Programs → NH Research → 9400 Series

On Windows 10, the provided utilities and documentation is found under
Start → All Programs → NH Research

Or on the local hard drive under
"C:\Program Files (x86)\NH Research\NHR 9400 Utilities\"

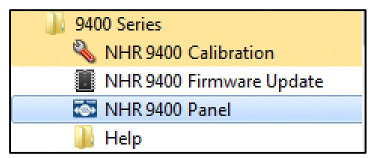


The LabVIEW VIs and SCPI language are supported for non-windows control including PLCs and real-time systems.

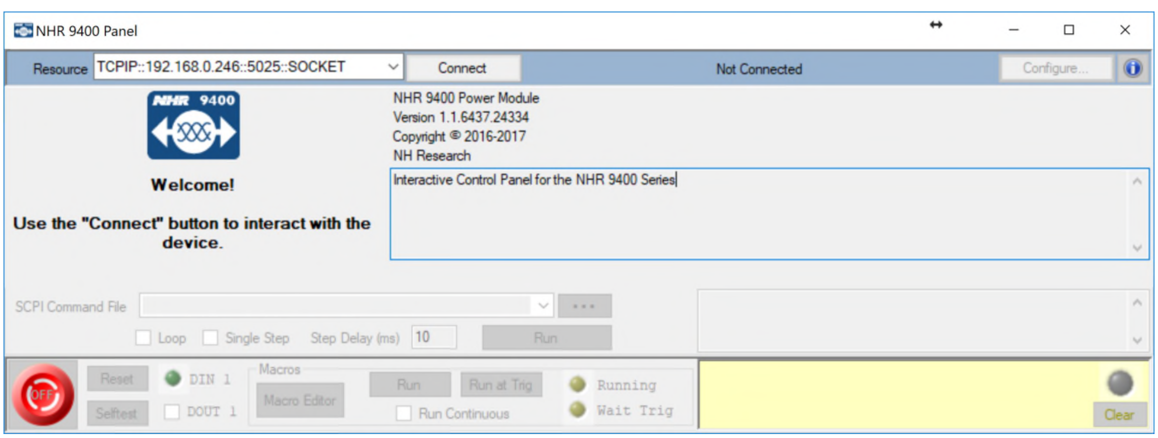
6.1 Launching the NHR 9400 Panel

On Windows 7, The 9400 Panel software is found under
Start → All Programs → NH Research → 9400 Series

On Windows 10, The 9400 Panel software is found under
Start → All Programs → NH Research

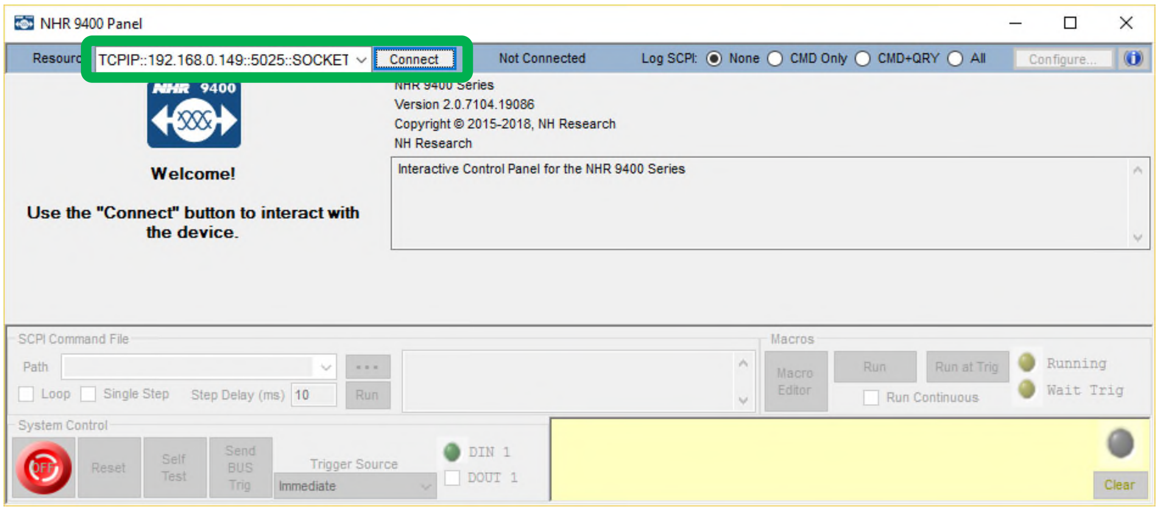


After selecting the NHR 9400 Panel, the program will open with the following screen.



6.2 Connecting the NHR 9400 Panel to System

The panel software will require the IP address for the system.
This IP address is provided on a label on the rear of the system and may be changed as needed following the “Configuring the Master Module” section in the installation section.

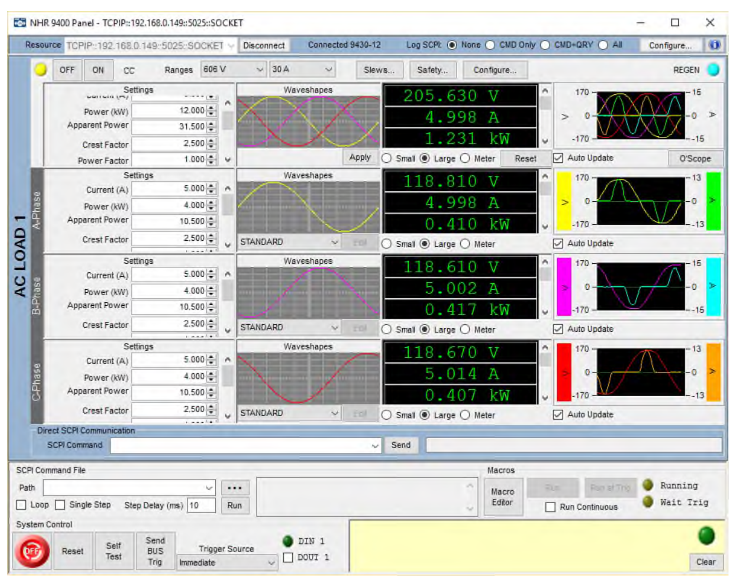


Supply the IP address using the form of “TCPIP::(IP_ADDRESS)::5025::SOCKET”

Press the connect button.

The application connects to the system and displays the active hardware operating mode as well as the active settings.

Connection of the application does NOT reset the hardware.



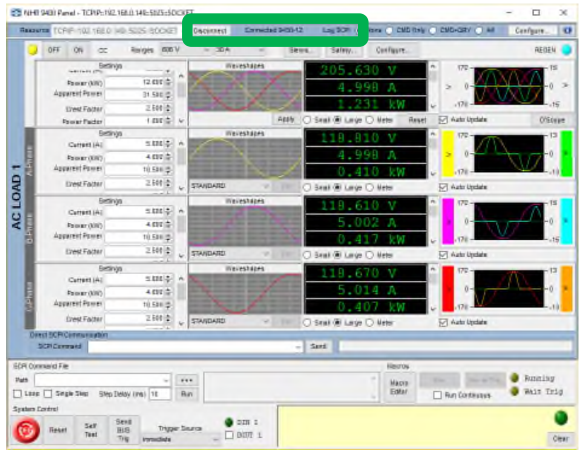
NHR 9400 Connected to 9430-12 in 3-ϕ Mode

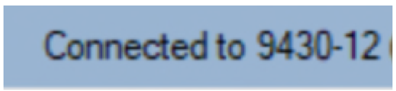
> **Be sure to observe the operating stat**

6.3 NHR 9400 Panel - Overview

6.3.1 System Identification

The system connected to is displayed in the upper portion of the NHR 9400 Panel.



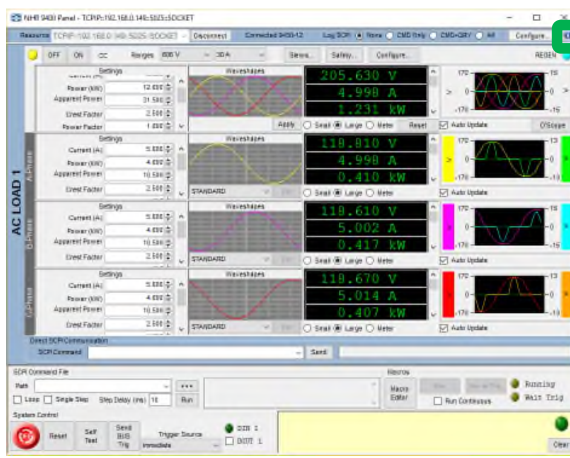


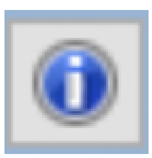
This displays:
- Model number (9430 shown)
- Maximum power level (-12 for 12kW)

See the troubleshooting section if the reported system size is not correct.

6.3.2 System Information

System information can be displayed by pressing the information button located in the upper right.

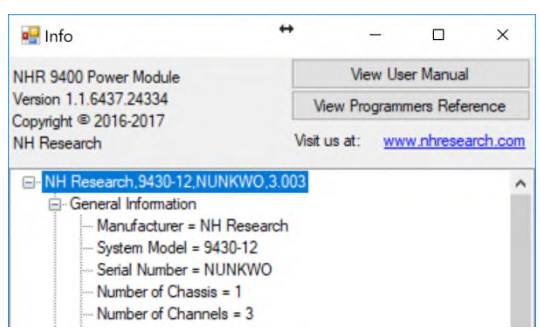




An information screen will display:

<u>System Information</u>
- Manufacturer Name
- System Model
- Serial Number
- Firmware versions

<u>Instrument Specific Information</u>
- Instrument Type
- Device Capabilities



6.3.3 Changing the Hardware Operating Mode

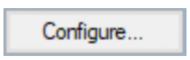
Changing the output hardware operating mode will affect the entire system.

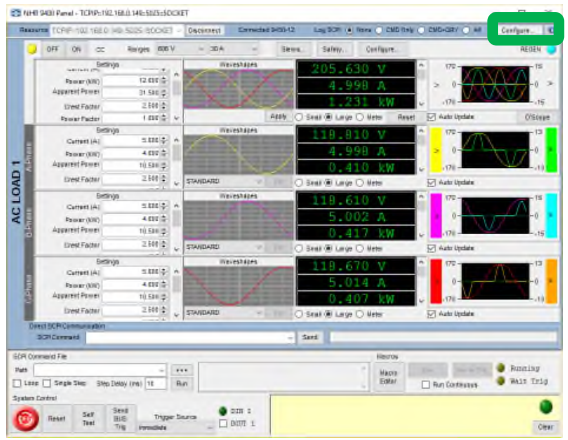
Changing the operating mode will typically require changes in the output connections to the UUT.
Please read this section completely before proceeding.

The 9430 provides a number of operating modes which are intended to simplify programming and overall user experience.

The Appendix provides a complete list of hardware operating modes as well as recommended UUT wiring for each output hardware operating mode.

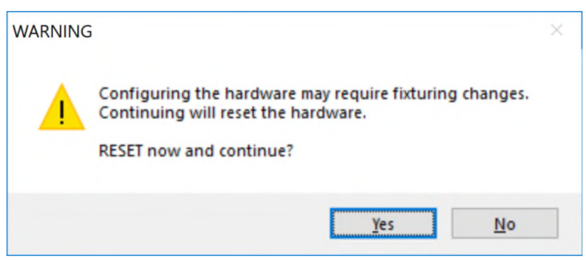
Press the Configure button.





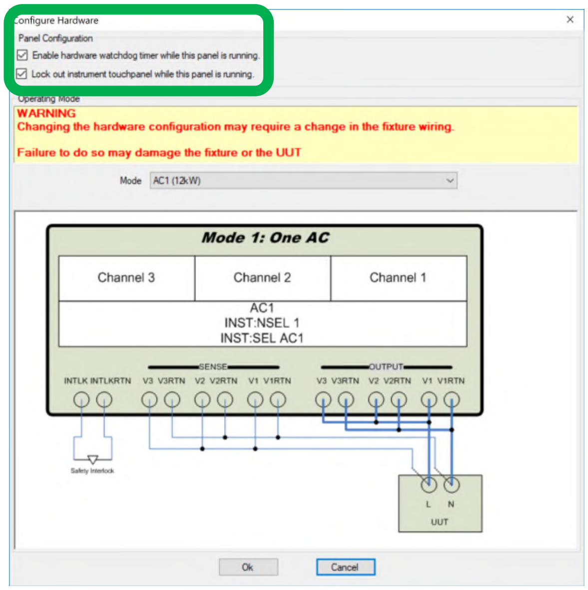
Changes the the output configuration requires a hardware reset.

Review this section completely along with wiring changes before procceding.

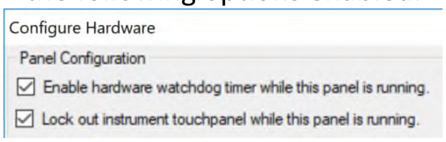


Wiring and Configuration should always be done in an OFF state with no external UUT power applied.

Changing the Hardware Operating Modes (Cont'd)

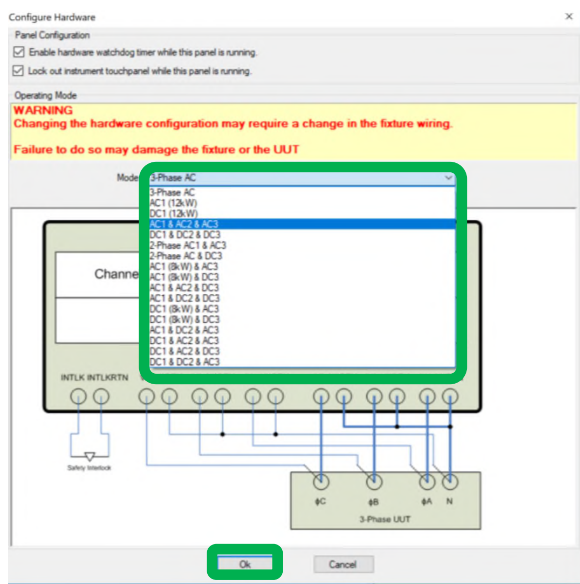


NH Research recommends keeping the following options enabled:

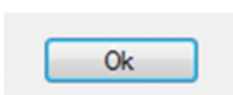


Option: Enable hardware watchdog
- Reset if communication is interrupted

Option: Lock out instrument touchpanel
- On system touchscreen is locked out



Use the drop down list to select the desired mode then press "OK".

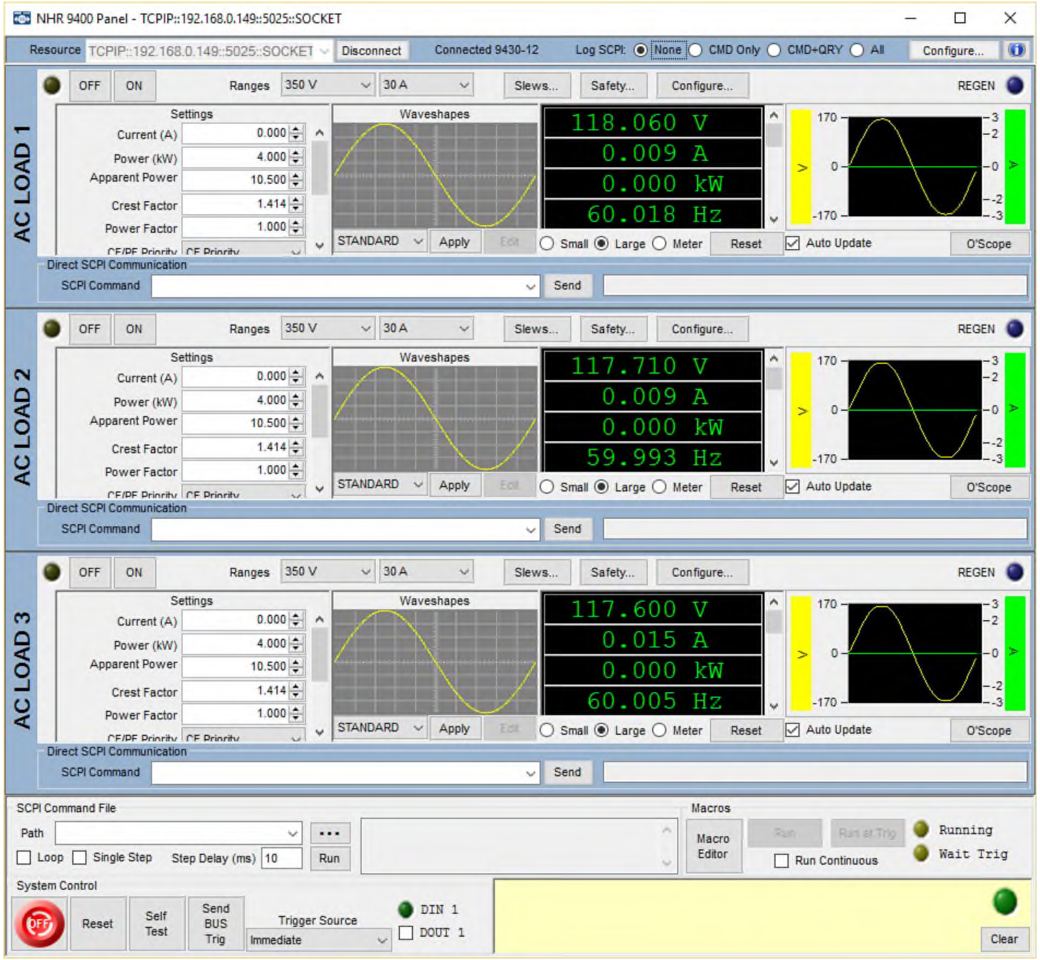


Changes to the operating mode may require output wiring changes.

Changes to the operating mode will disable any previously established settings including safety limits.

Changing the Hardware Operating Modes (Cont'd)

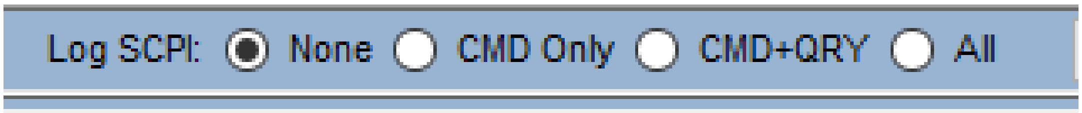
Pressing OK will select the new operating mode and apply the changes to hardware. The NHR 9400 Panel will automatically adjust their views to the new operating mode.



The on-system touch screen will automatically adjust to the new operating mode as well.

> **Changing the operating mode will typically require changes in the output connections to the UUT. Previously established safety limits are also cleared.**

6.3.4 Logging SCPI Communication



Any interaction between the panel and the instrument can be recorded. When a Log SCPI mode other than “None” is selected. You will be prompted for a file name used to record the information.

After returning to “None”, the file can be opened in any text editor or played back as a SCPI command file.

CMD Only: Records all SCPI commands sent but does NOT record queries or the responses to queries. This is the most compact form and is most useful for generating command scripts.

CMD+QRY: Records all SCPI commands and queries but does NOT record the responses to queries. This can be usefull if you want to see the results of queries when the file is played back.

All: Records all SCPI commands and queries along with the responses to queries.

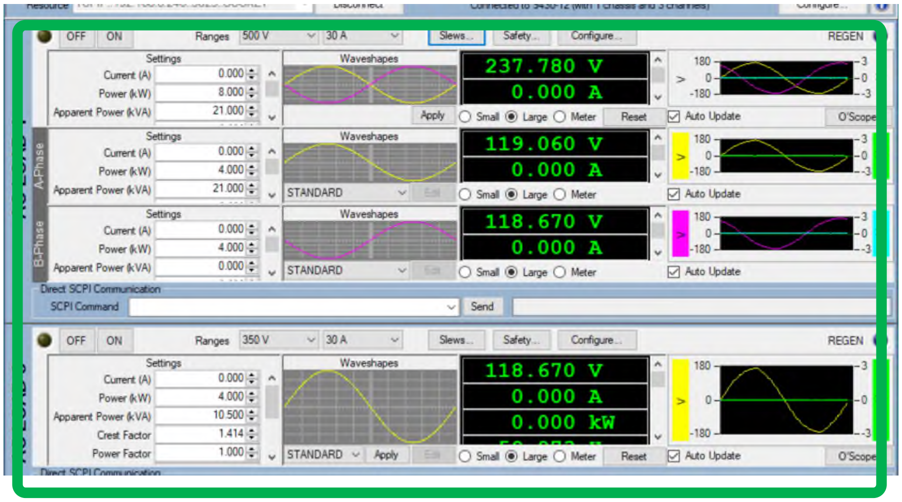
This feature is most often used to:

- Create a script to preset the instrument as desired. For example, select “CMD Only” or “CMD+QRY” and then interact with the unit using the panel. Everything you do will be recorded. When complete, select “None”. Then, in the SCPI Command File section, load the file and run it and it will play back what you recorded.
- Create a log that can be viewed to help diagnose an issue. In this case, select “All” to record the commands and queries with the responses. When complete, select “None” and view the file with a text editor to review. Note, this file format can also be played back as a SCPI command file.

6.3.5 Instrument Controls & Measurements

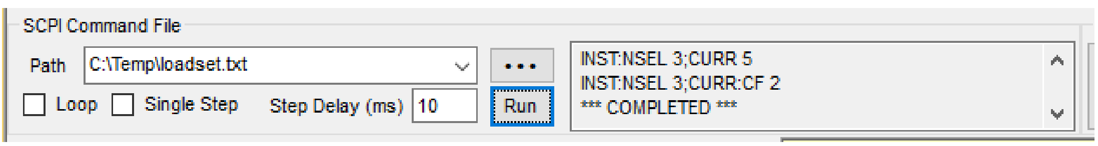
The instrument controls comprise the majority of the NHR 9400 Panel.

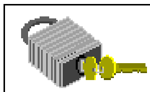
These controls will be discussed in further detail in the instrument control section below.



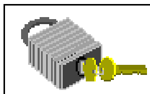
6.3.6 External SCPI Command File

The NHR 9400 panel allows a plain text (.txt) file containing SCPI commands to be read and executed. The executed commands and query responses are printed in the status window to the right.



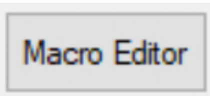


The plain text file should be explicit in addressing the instruments.



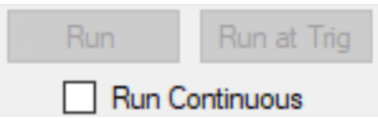
Refer to NHR 9400 Programmers Reference (NHR P/N: 09-0335 for a list of commands appropriate for the 9410 and 9420.

6.3.6.1 Macro Support

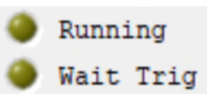


Macros are predefined sequences which are loaded to the hardware and executed locally. This ensures rapid fire timing and accurate cycle counting when needed.

More about macros can be found in the programming with macro's section below.



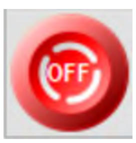
The "Run" and similar buttons shown are used with macros.



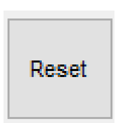
These status indications are associated with Macro's operating state.

6.3.6.2 Other Controls

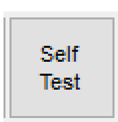
Controls from left to right



The OFF button provides a quick turn off feature for all output channels. This is different from an e-Stop output as any channel may be turned on again without requiring a reset command to be issued.

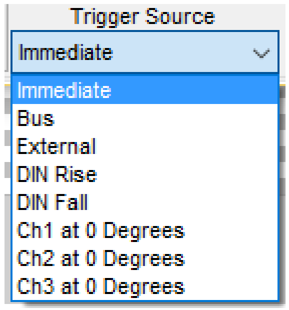


The Reset button sends a hardware reset to the system. All channels will return to default settings.



The Self-test button instructs the system to perform a hardware self-diagnostic. Feature is used for troubleshooting issues by NHR Customer support.

Sends the command *TRG to the system. That will cause the hardware to trigger if it is waiting for a BUS Trigger.

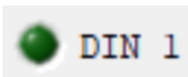


Sets the trigger source used when starting a macro triggered and when capturing a waveform triggered.

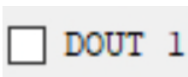
Immediate does NOT wait

BUS – Triggers on receipt of *TRG command

Others as named.



Digital Input Indicator.

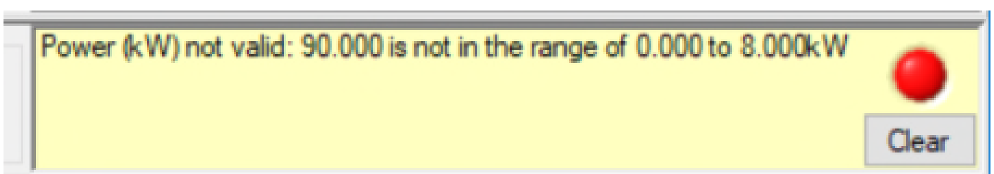


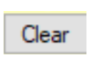
Digital Output Control.

6.3.7 Error Message Queue

The lower right corner provides an Error Message Queue. This area under normal operation should be blank. When an error is observed, the associated error message (along with additional instructions as needed) are added to this display window.

When there is an Error, the indicator above the “Clear” button will flash red.



Pressing Clear 

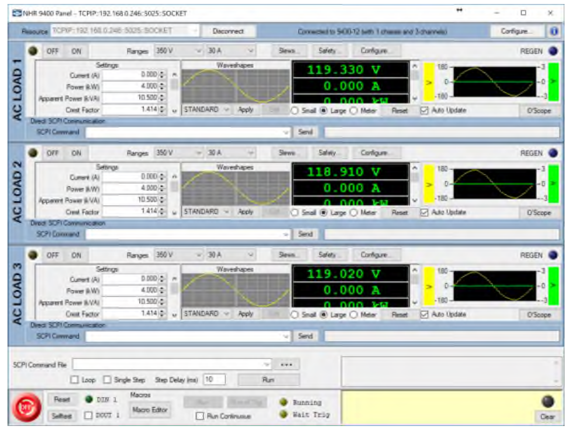
will clear most error messages.

Safety trips as well as internal fault detections require additional user intervention such as providing a reset after the issue has been resolved.

6.4 NHR 9400 Panel – Instrument Level Controls

The output channels may be configured into groups resulting in one or more virtual instruments. For example, a 9430-12 includes three channels which may be configured as a single 3-phase, three separate 1-phases, or a split-phase + an additional AC channel.

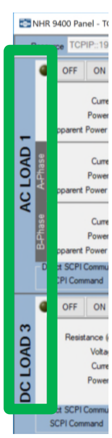
9430-12 Three Phase View (with per phase)



9430-12 Three 1 Phase Channels

9430-12 One Split Phase Channel + One AC Channel

6.4.1 Instrument Labels



The 9430 labels instrumnets with outputs configured for

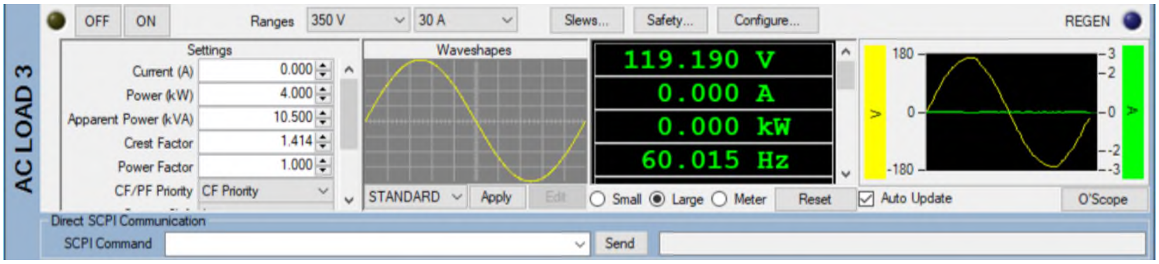
AC as AC LOAD 1 DC as DC LOAD 3

In Multi-Phase operating modes, the individual phases are labeled

A-Phase and B-Phase as shown

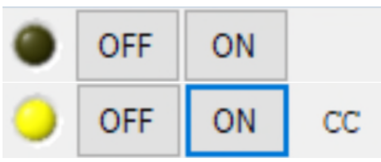
6.4.2 Instrument Output Controls

Each instrument provides multiple control features including safety, turn on/off, command phase angle triggers, slew rates, ranges, etc.



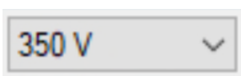
9430 Single Phase channel shown

Controls from left to right



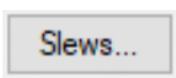
On and Off will activate or deactivate the output.

The output state is shown with both in indicator form and current output regulation mode (i.e. CV or OFF).

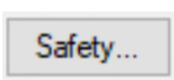


Voltage ranges are automatically scaled for Line-Line or Line-Neutral depending on the selected hardware mode.

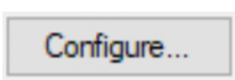
Current ranges are automatically scaled based on system size and the selected hardware mode.



The Slews button provides access to the programmable slew rates. More details in the following sections.

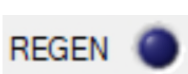


The Safety button provides access to the programmable safety limits. More details in the following sections.



The Configure button provides access to additional options like phase angle trigger behavior & load mode selections.

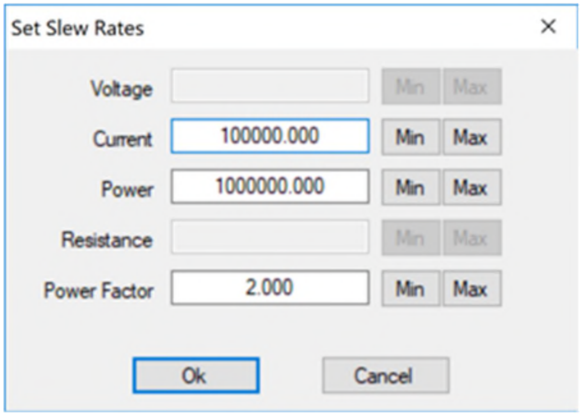
Busy Icon when present indicates an operation is pending.



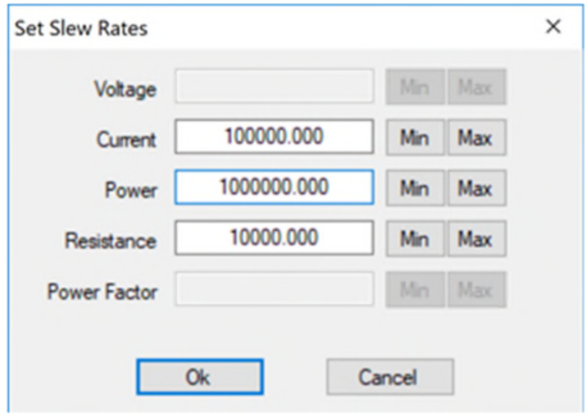
The REGEN indication shows power is being absorbed by the UUT and transferred back to the facility.

6.4.3 Adjusting Slew Rates

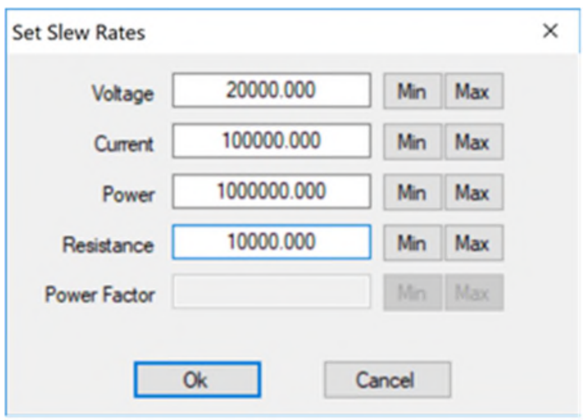
Pressing the “Slews” button  displays the slew rate control panel.



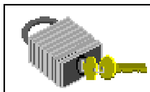
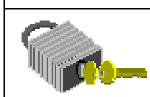
Slew Rate Options – Normal AC Loading



Slew Rate Options - Constant Resistance Loading



Slew Rate Options - DC Loading

	**Only slew rates which apply to the active loading mode are enabled.**
	**Refer to section 4 for more information about Multi-phase & parallel channel slew rate definitions and relationships.**

Slew rates provide a ramped linear control between two setting values.

Slew Rate Example

A 9430-12 AC Load is operating as a one-phase mode in normal mode loading at 30A from a $120VAC_{rms}$/60Hz voltage source.

The slew rate is set for current to 900 A_{rms} /sec.
The next setting is to apply at 0^o phase angle.

> If the module is then told to regulate to $15A_{rms}$, this represents a 15A change which would take $1/60^{th}$ of a second (1 cycle @ 60Hz)

Result: a 1 cycle linear slew from $30A_{rms}$ to $15A_{rms}$.

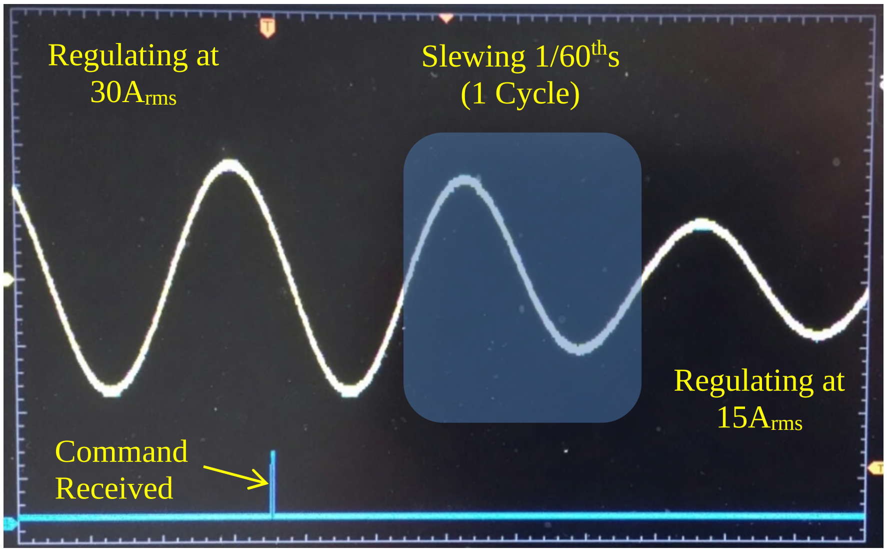
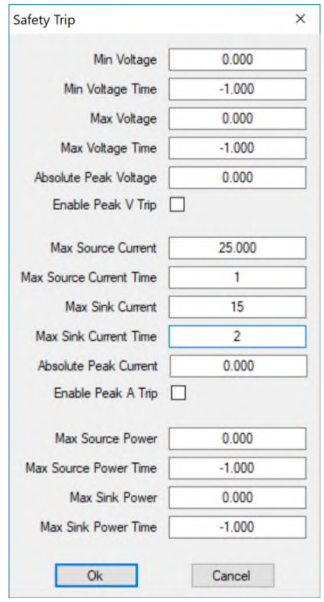


Figure 1 - Scope Capture of 9430 Output showing linear slew

6.4.4 Adjusting Safety

Pressing the "Safety" button 

displays the safety trip settings panel.

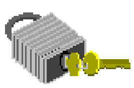


Safety limits can be thought of as a programmable breaker which is aware of the power flow direction. When any of the limits are exceeded the system stops flowing power and opens the UUT side contactor isolating the system from the UUT.

Each limit includes a value and a time field. For example, the maximum source current (from 9430 to the UUT) has been shown programmed to 25Arms with a time constant of 1s. Like a circuit breaker or fuse, if the current far exceeds 25Arms the time constant is shortened automatically based on the energy being transferred.

There is also a maximum sink current (from UUT to the 9430) allowing a separate limit to be set based on the direction of power flow. In this case, this has been shown programmed for 15Arms and a time constant of 2s.

There are additional limits based on voltage, power, and peak values for either voltage or current.

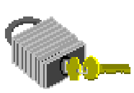


Setting a time allowed to -1 disables the safety setting.

Setting a time allowed to 0 may result in noise causing a safety trip. General recommendations are 0.1 for a fast acting fuse and 0.5 for a slow-blow fuse equivalent.

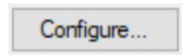
Safety limits should be set outside of normal operating parameters and are intended to limit UUT damage due to operator error or UUT failure.

They should be used in the same way that a fuse or circuit breaker would be used in a similar application.

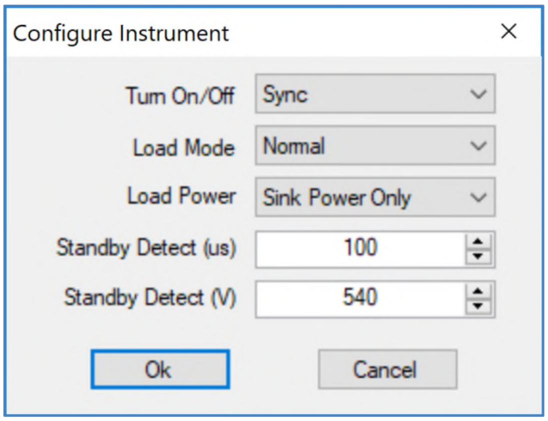


Safety limits do not affect programming capability. It is therefore possible to inject a noise pulse which exceeds the limits as long as it returns to nominal before safety detection time has elapsed.

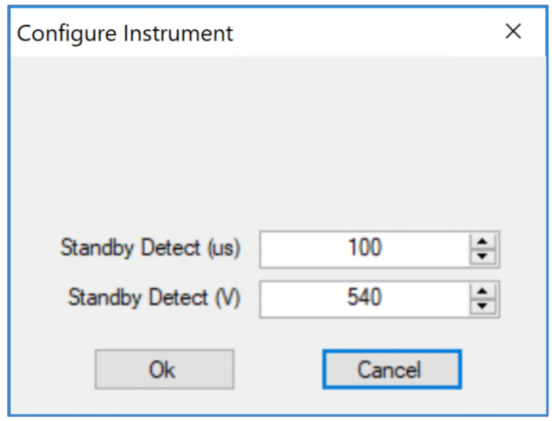
6.4.5 Instrument Configuration Options

Immediately to the right of the "Safety Button", the configure button 

opens the instrument configuration panel.



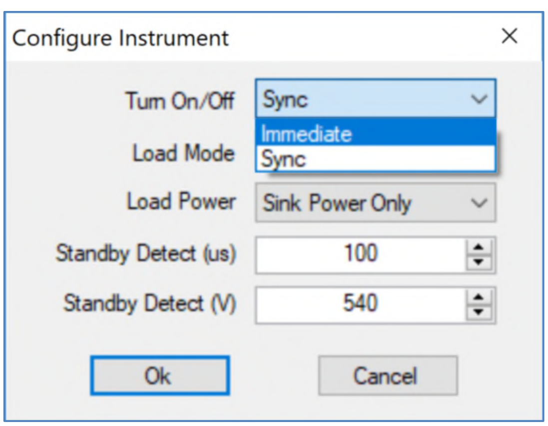
9430 AC Output Configuration Panel



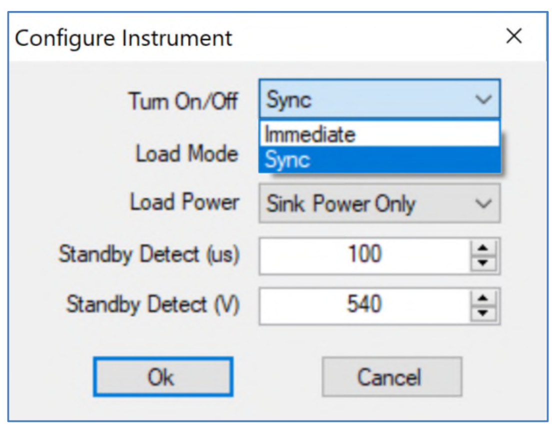
9430 DC Output Configuration Panel

Setting Asynchronous & Synchronous AC settings changes:

Turn On/Off determines if commanded settings changes are executed immediate or phase angle triggered based on the change at (deg.) angle specified in output controls.



Settings are applied immediately

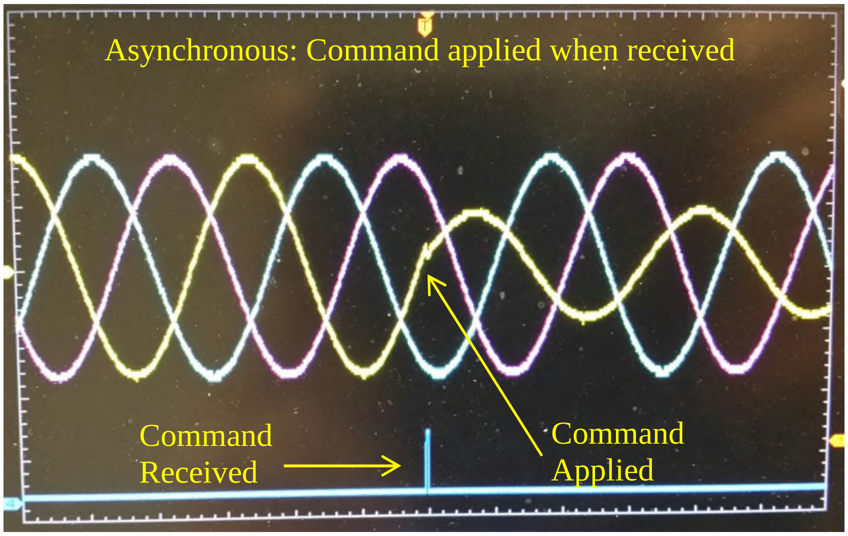


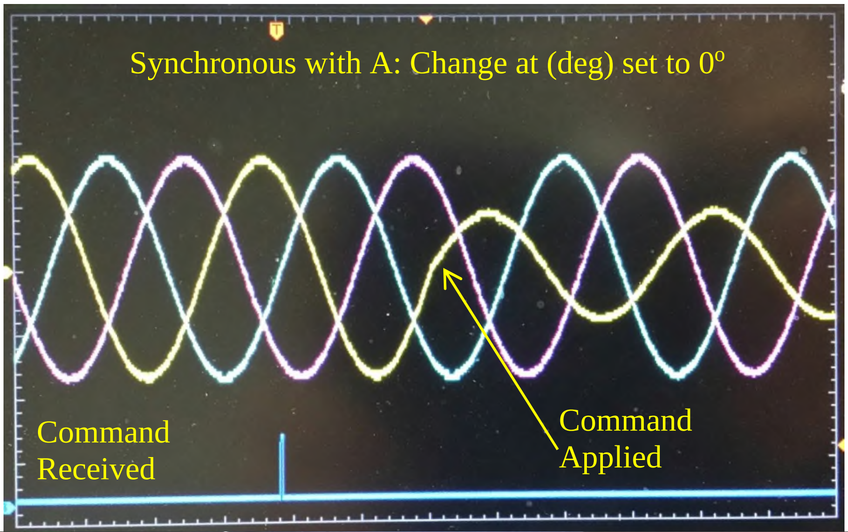
Settings are applied at phase angle

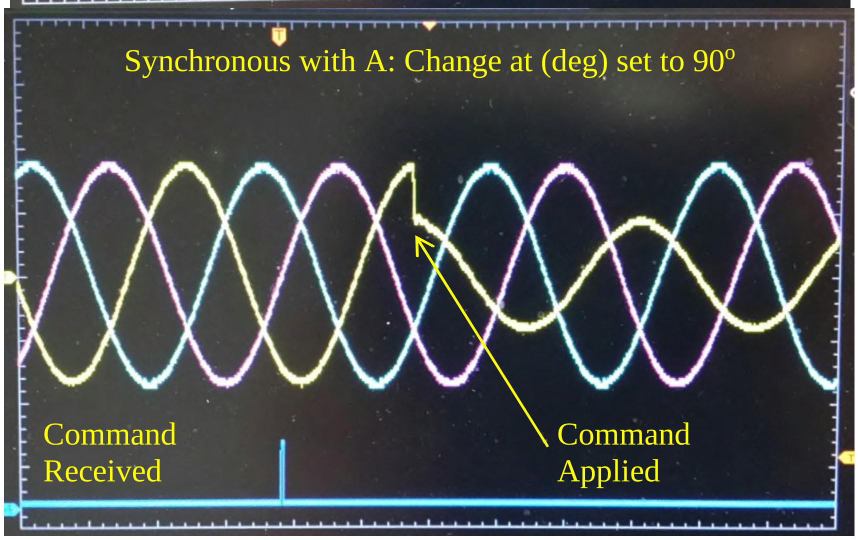
The examples on the following page will demonstrate the differences which can be observed between Asynchronous and Synchronous mode.

Asynchronous & Synchronous Examples:

All examples show a transition from $30A_{rms}$ to $15A_{rms}$.



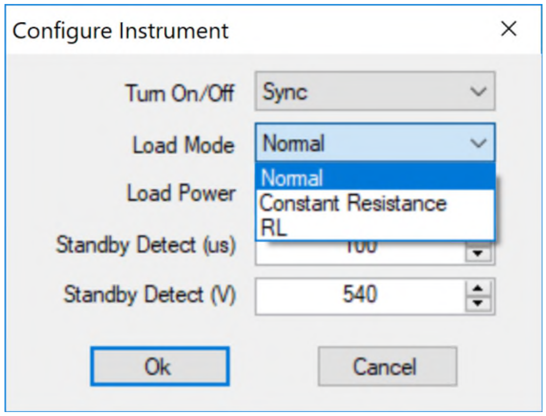




Setting AC Loading Mode:

Load mode sets the instrument for Normal, Constant Resistance, or Constant-RL loading.

Note: Changing the loading mode also resets regulation values in the instrument control.



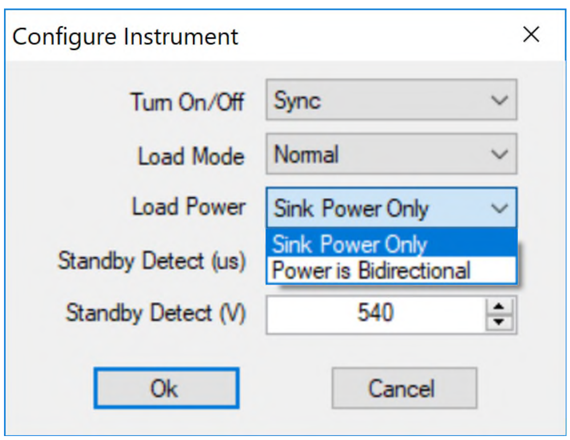
Selecting between loading modes

Setting AC Bi-Directional Power:

The 9430 is able to emulate a voltage/frequency following current source (a grid-tied inverter) when operating in either **Normal** or **Constant-Resistance** loading modes.

This mode is enabled by selecting Load Power – Power is Bidirectional.

This setting is returned to default with any reset or output operating mode change.



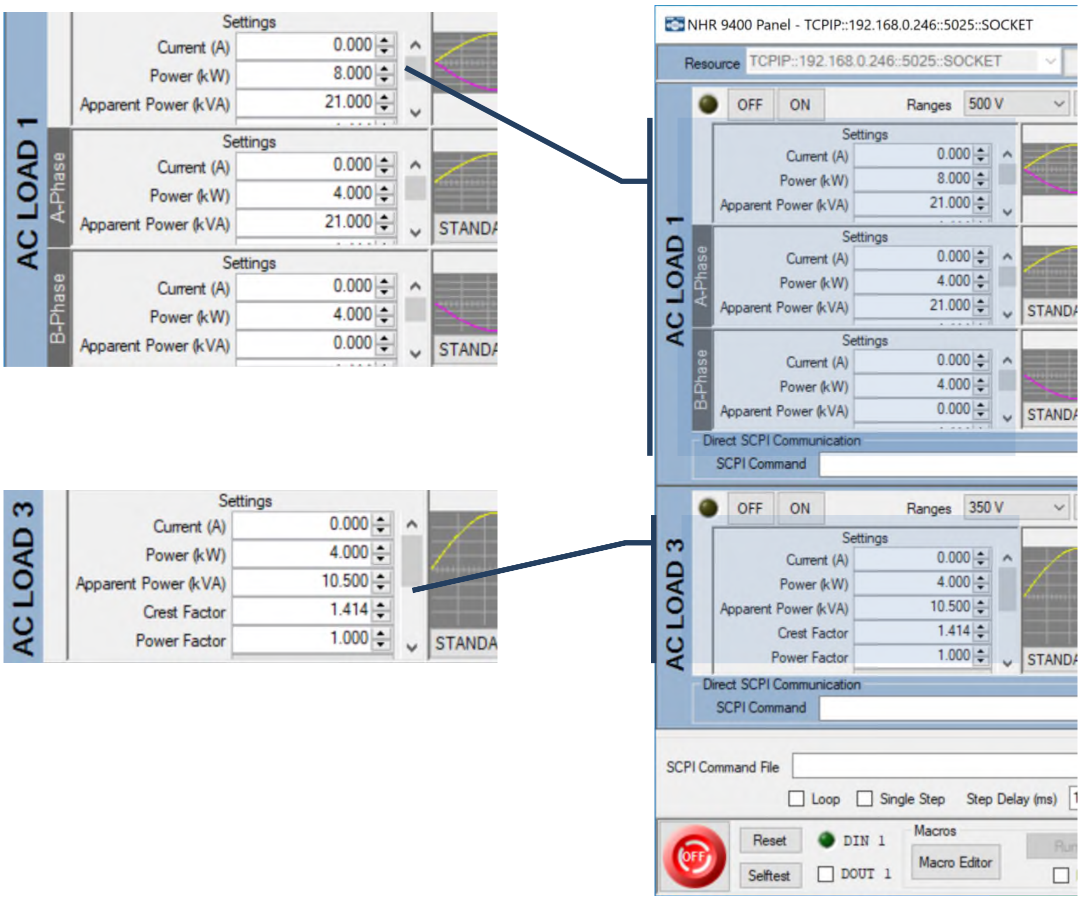
Standby Detect (uS and V):

The 9430 is a switching a 4-quadrant load which may rail when an AC voltage reference is removed. These settings determine a peak voltage value and detect time the load should use to disable the output switching, enter standby, and wait for an AC voltage to be qualified again before drawing current.

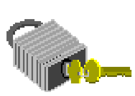
6.4.6 Establishing Per Phase & Multi-Phase Regulation Limits

When an instrument is multi-phase (either split-ϕ or 3-ϕ), the outputs may be simultaneously programmed using line-line values. Line-neutral values are used when an instrument is single phase, DC, or an individual phase is being programmed.

Note in the example below that a 9430 configured for split-ϕ loading (AC LOAD 1) which assumes a 180° offset between Phase A and Phase B The same system may additionally be configured to load a separate AC or DC source (AC LOAD 3 as shown).



The panel automatically provides the programmable featured based on the supplied model and hardware operating and loading modes selected.

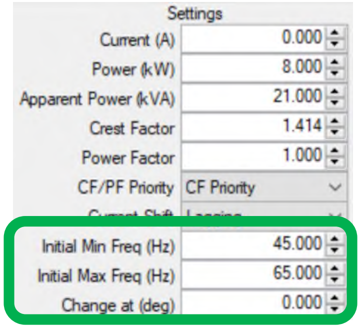


For AC outputs, the Change at (deg) is trigger angle when operating in Synchronous Mode. See Instrument Configuration Options for more information about Synchronous / Immediate settings.

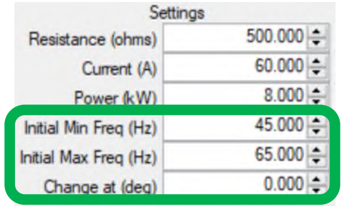
Common 9430 AC Setting Limits

Common AC Loading Modes – Settings

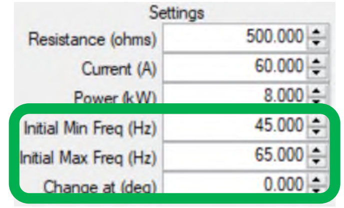
AC Normal Loading



Constant Resistance Loading



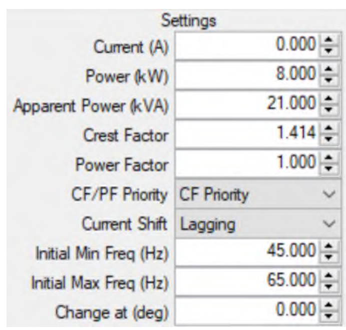
Constant RL Loading



The PLL initially searches for an AC voltage positive zero crossings which occur with a frequency between the "Initial Min Frequency" and "Initial Max Frequency". Then PLL locks to this phase angle relationship and frequency allowing the load to draw current based on the regulation Settings. After locking, the PLL will track frequency changes up to 500Hz/s even when outside the initial locking frequency band. The reset default values for these settings are 45 & 65Hz respectively and would only need to be adjusted with the initial frequency is outside of this region.

Change at (deg) determines the phase angle trigger when in Synchronous mode.

Programming 9430 Limits – Normal AC Loading



Normal AC loading permits Constant Current (CC), constant power (CP) and Constant Apparent Power (CS) along with a number of waveform modifiers.

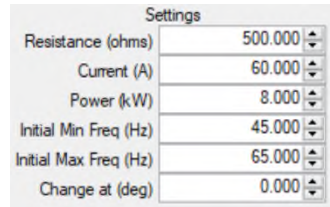
Crest factor adjusts the peak current value as a ratio of the RMS current being drawn. This modifier is disabled when using a user defined current wave-shape.

Power factor adjusts the relative phase angle of the current draw along with the current shift of leading or lagging setting. This modifier is also available when using a user wave-shape allows relative angle shifts for the current wave-shape calculated as if the wave-shape were sinusoidal.

CF/PF Priority determines if the Crest Factor, Power Factor or unity power factor modes should take priority. Unity power factor acts similar to a last-cycle dependent resistor which is calculated based on the CC, CP, CS setting and the previous cycles voltage.

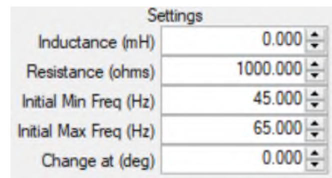
Programming 9430 Limits - Constant-Resistance Loading

Constant Resistance loading tracks the instantaneous voltage changes similar to a programmable power resistor. Additional settings include a constant current (CC) and constant power (CP) limit.



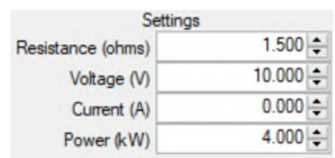
Programming 9430 Limits – Constant-RL Loading

Constant RL loading tracks the instantaneous voltage changes emulating a series Resistor/Inductor. The frequency for the inductance impedance is based on the measured last cycle frequency.



Programming 9430 Limits – DC Loading

DC Loading permits constant voltage (CV), constant current (CC), constant power (CP) and constant resistance (CP) loading. This loading mode automatically selects the regulation mode which results in the lowest current draw.



For example, If the load was set to a CC of 5A and a CP of 1kW and presented with 300VDC, the load will draw 3.33A as the CP limit (300V * 3.33A = 1kW). If the CP limit was then increased to 2kW, the load will draw 5A as the CC limit now requests the lowest amount of current.

Multi-Phase single setting control is also supported.
See section 4 for more about multi-phase programming relationships.

6.4.7 Selecting Output Wave shapes

The 9430 provides a standard (sine) and three (3) user programmable current wave shapes per channel. These are typically used for harmonics and non-pure sinusoidal output controls. The wave shapes are scaled and slewed using the current regulation limits provided in the earlier section. For multi-phase operation, the relative phase angle is also taken into account when using user defined wave shapes.

A thumbnail representation of the wave shape is shown allowing the user to confirm the selection before pressing “Apply”.

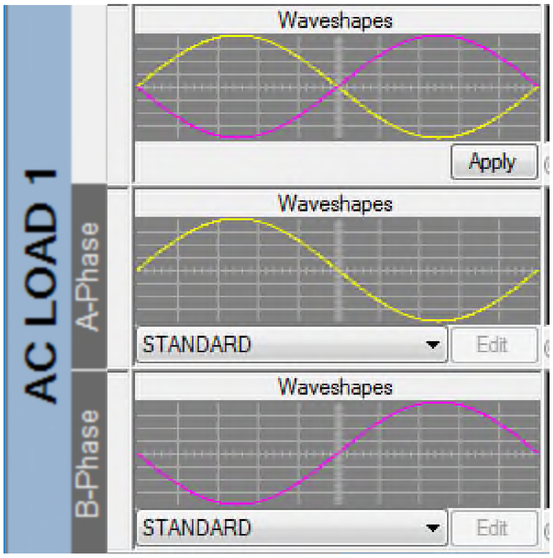


Figure 2 – Wave shape Controls

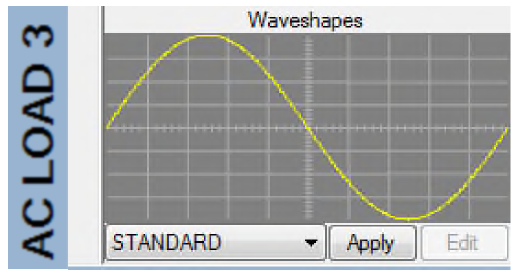
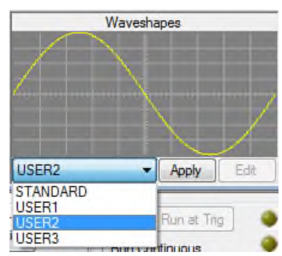
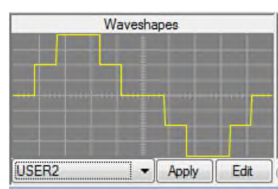


Figure 3 - Single Phase Wave Shape Controls



Selecting a wave shape

To select an alternative output wave shape click on the selection tab below the desired phase and select Standard (sine) or one of the three (3) user definable wave shapes.

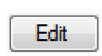


At power-up, the following wave-shapes are pre-loaded for use:

- User 1: Triangle
- User 2: n-Step Sine
- User 3: Clipped Sine

Pressing the apply button 

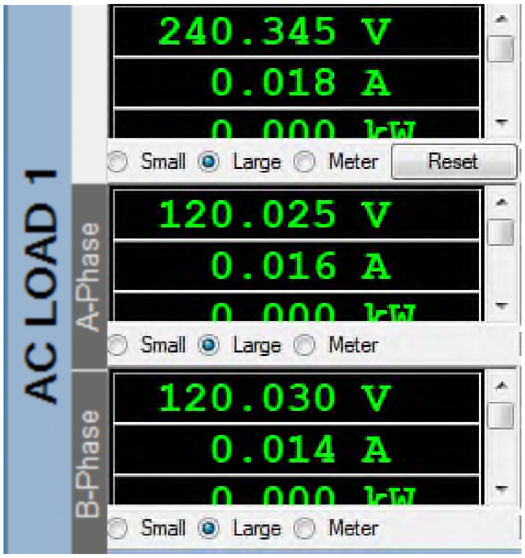
will change the wave shape of the output to the selected wave shape immediately.

The user wave shapes may be edited by pressing the edit button. 

More information about the wave shape editor can be found in the advanced control options sections.

6.4.8 Measurements

The 9400 provides a number of last cycle measurements. All of the measurements for any given phase are synchronously captured including voltage, current, power, etc.

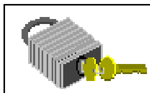


AC Load 1 - Split Phase (L-L) with per phase (L-N)

The font size is adjustable and will display as many measurements as the screen size will allow.

Separate font size and meter views are possible on a per phase as well as a multi-phase basis.

AC Load 3 - Single Phase (L-N) Shown



See section 4 for more about multi-phase measurement relationships.

6.4.9 Output Thumbnail Waveform Capture

The NHR 9400 Panel accesses the internal digitizer feature to synchronously capture and display 1-cycle for all voltage & current waveforms per instrument. This provides a real-time view of both the voltage and current behaviors of the UUT.

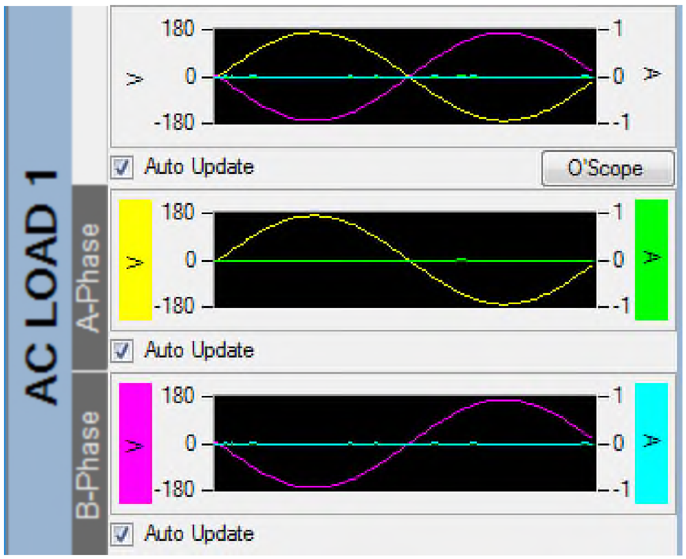


Figure 4 - Split Phase (L-L) with per phase (L-N)

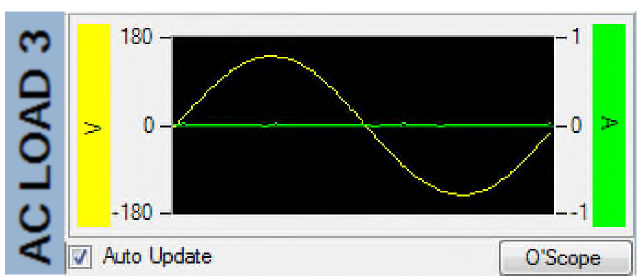
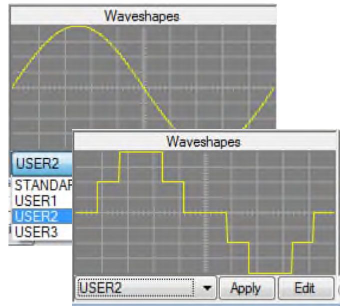


Figure 5 - Single Phase (L-N)

Higher resolution views are possible using the O'Scope panel which is accessed using the O'Scope button. More information about the built in digitizer and O'Scope panel can be found in the following Additional Controls section.

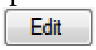
6.5 Advanced Control Features

6.5.1 Editing an Output Wave Shape

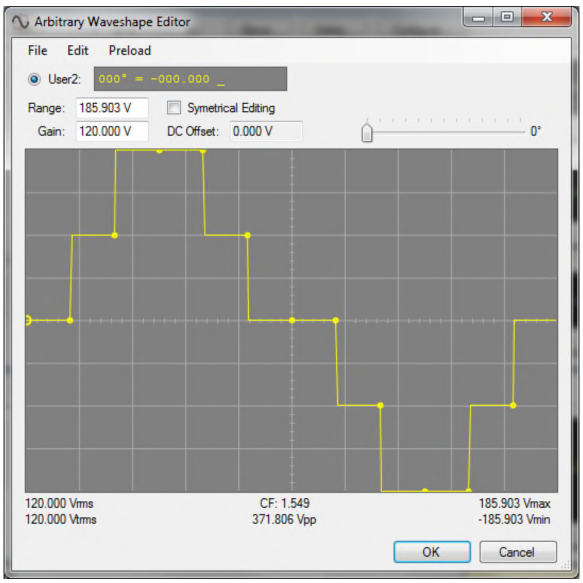


The NHR 9430 Series provides three (3) user definable current wave shapes in addition to the standard (sine) output wave shape.

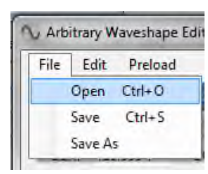
Select the user wave shape to be edited and press the edit button.



This will cause the wave shape editing tool to be displayed.

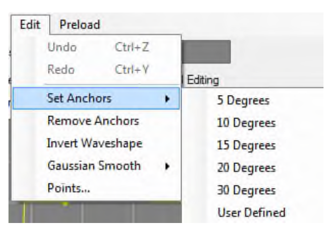


Menu Options

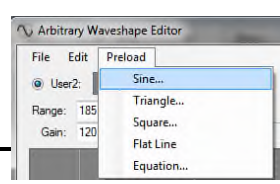


The File Menu – Allows a wave shape to be saved or recalled.

This allows the user to save their wave shapes and recall them or to copy the wave shape to other phases.



The Edit Menu – allows the wave shape to be edited on a point by point basis using anchors for a graphical approach or by points for direct value settings.

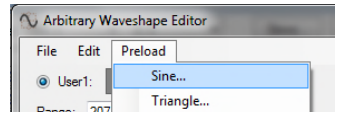


The Preload Menu – Preloads a pre-defined wave shape, use an equation, or generate a wave shape with harmonics.

6.5.1.1 Wave Shape Example – Using Anchors:

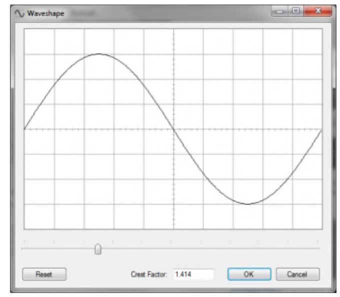
Anchors allow a manual manipulation of the AC output current wave-shape.

This type of wave shape is able to be generated using the NHR 9400 Panel.



Select User 1 and click "Edit" to edit the user wave-shape. Then load a sine shape to be modified by selecting

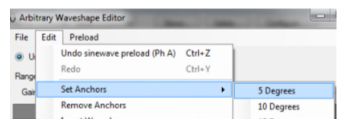
Preload → Sine…



A dialog will appear with a sine wave shape. The dialog allows other modifiers to be applied such as adjusting the crest factor for the wave shape.

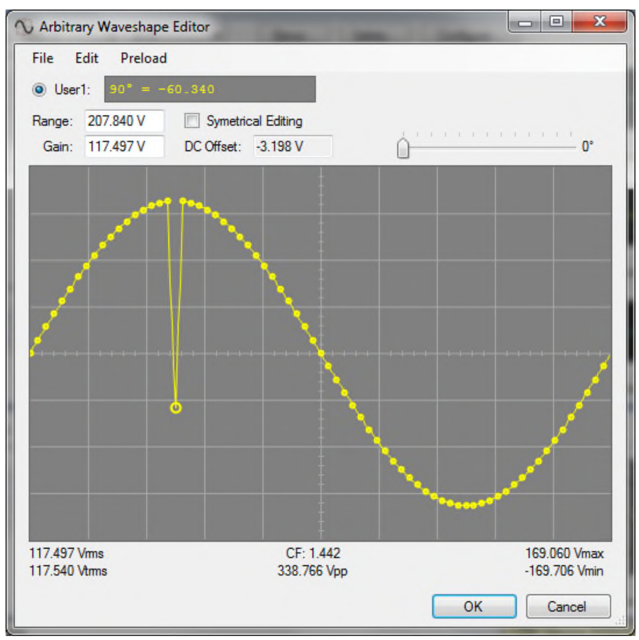
This example uses a standard sine as the starting point.

Click OK to close this dialog.



From the Edit Menu, click set anchors then select 5 degrees. This will place anchors on the wave shape allowing them to be graphically adjusted.

Grab the 90° anchor and drag it down to the desired level.

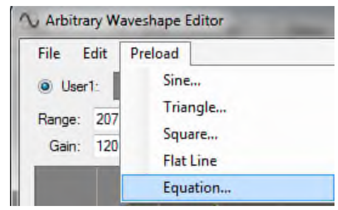


Note: The angle and amplitude are shown in text as well as graphically.

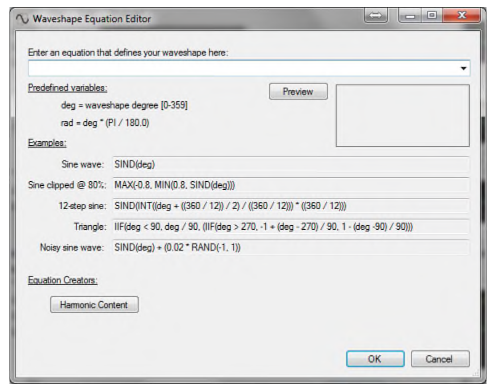
Press OK to load the wave shape into User 1.

6.5.1.2 Wave Shape Example – Formula Based:

The NHR 9400 panel permits direct manipulation of a wave-shape formula. This permits the user to specify the exact parameters mathematically. The next section provides a simple harmonic table approach which will automatically generate the mathematical formula needed.

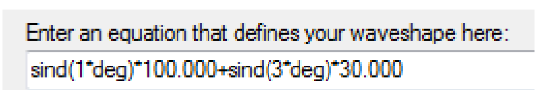


Select User 1 and click “Edit” to edit the user wave-shape. Then load a sine shape to be modified by selecting:
Preload → Equation…

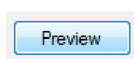


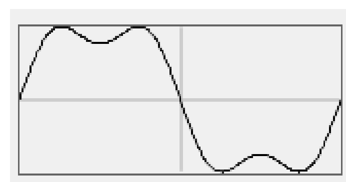
A dialog box will be presented allowing the user to specify a wave-shape formula along with a number of example formulas.

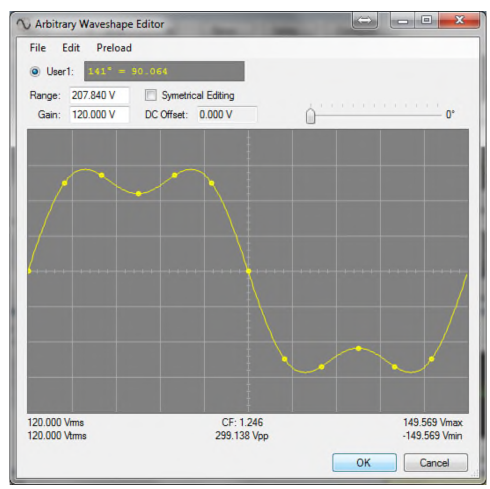
Enter the formula:



The above formula is equivalent to $A \cdot \sin(\omega) + 0.3 \cdot A \cdot \sin\,(3w)$

Click the “Preview” button  to see a graphical representation of the newly generated wave-shape.

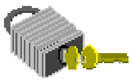




Press “OK” to close the formula editor, the pre-loaded wave-shape is displayed on the wave shape editor allowing further modification such as was described using anchors example.

If no further modification is desired,

- Save the wave-shape for later use (File → Save)
- Click “OK” to load this wave-shape to User 1



Wave-shapes are supported in NORMAL loading mode and are automatically scaled based on the current setting controls.

Wave shape example – Formula Based (Cont'd)

The NHR 9400 Panel supports a wide range of mathematical operations which may be used to generate a formula-based wave shape. All operators and functions are case insensitive.

Simple operations

Symbol	Description	Example	Result
`+`	Add	`1 + 1`	`2`
`-`	Subtract	`9 – 5`	`4`
`-`	Unary negation	`-(5 + 4)`	`-9`
`*`	Multiply	`3 * 6`	`18`
`/`	Divide	`9 / 2`	`4.5`
`\`	Integer divide	`9 \ 2`	`4`
`Sqr`	Square root	`sqr(64)`	`8`
`Mod`	Modulo (remainder)	`7 mod 4`	`3`
`^`	Raise to power of	`4 ^ 5`	`1024`
`!`	Factorial	`5!`	`120`
`Sin`	Sine (angle in radians)	`sin(pi/2)`	`1`
`Sind`	Sine (angle in degrees)	`sind(90)`	`1`
`Cos`	Cosine (angle in radians)	`cos(pi)`	`-1`
`Cosd`	Cosine (angle in degrees)	`cosd(180)`	`-1`
`Tan`	Tangent (angle in radians)	`tan(pi/4)`	`1`
`Tand`	Tangent (angle in degrees)	`tand(45)`	`1`
`Atan`	Arc tangent (result in radians)	`atan(1)`	`0.7853…`
`Atand`	Arc tangent (result in degrees)	`atand(1)`	`45`
`Abs`	Absolute value	`abs(-8)`	`8`
`Exp`	e to the power of	`exp(3)`	`20.08…`
`Log`	Common log (base-10)	`log(100)`	`2`
`Ln`	Natural log	`ln(100)`	`4.6051…`
`Ceil`	Round up	`ceil(6.2)`	`7`
`Int`	Truncate to integer	`int(6.8)`	`6`
`Frac`	Fractional part	`frac(3.125)`	`0.125`
`Sgn`	Sign (returns -1, 0 or 1)	`sgn(-9)`	`-1`
`Min`	Minimum value	`min(10, 3)`	`3`
`Max`	Maximum value	`max(1, 9, 2)`	`9`
`And`	Bitwise AND	`13 and 6`	`4`
`Or`	Bitwise OR	`13 or 6`	`15`
`Pi`	The ratio of the circumference of	`Pi`	`3.14159…`

	a circle to its diameter		

Wave shape example – Formula Based (Cont'd)

The NHR 9400 Panel supports comparisons as well as random number generation.

Comparisons

Symbol	Description	Example	Result
`>`	Greater than	`9 > 2`	`-1`
`<`	Less than	`7 < 4`	`0`
`==`	Equal	`(5 * 4) == (4 * 5)`	`-1`
`>=`	Greater than or equal	`3 >= 3`	`-1`
`<=`	Less than or equal	`10 <= 9`	`0`
`<>`	Not equal	`(9 / 2) <> (9 \ 2)`	`-1`

Additional Functions

operand1 **AndAlso** *operand2*

Returns true (-1) if *operand1* is non-zero and so is *operand2*. This is important in situations where *operand2* might evaluate something like a division by zero.

Inline If

Syntax: IIF(expr, truepart, falsepart)

- *expr* is the expression that is to be evaluated
- *truepart* is returned if the expr evaluates as true
- *falsepart* is returned if the expr evaluates as false

Example: `iif(1 + 1 == 2, 4, 5)` returns `4`

operand1 **OrElse** *operand2*

Returns true (-1) if either *operand1* or *operand2* is non-zero. **OrElse** uses short-circuit evaluation, which means that if *operand1* is a non-zero value, then OrElse will return a result without proceeding to evaluate *operand2*.

Rand([*x*]**)**

Rand(*a*, *b***)**

Example:

`rand()` No parameters

Returns a floating point random number between 0 and 1.

`rand(x)` where x > 0

Returns a floating point random number between 0 and 1, using x as seed. The number chosen is the next in a random sequence.

`rand(x)` where x < 0

Returns the same random number each time, using the parameter as seed.

`rand(0)`

*Returns the same random number as the one previously generated.

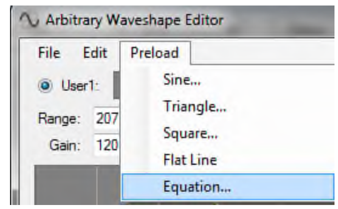
`rand(a, b)`

Returns an integer random number between values *a* and *b*.

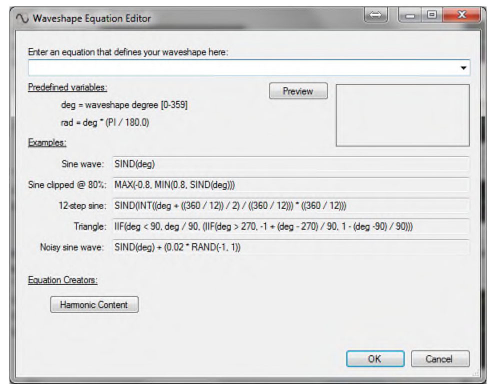
6.5.1.3 Wave Shape Example – Harmonics Entry:

The NHR 9400 panel permits direct entry of the value as well as phase angle for individual harmonics. The result is a pre-built wave-shape formula which may be further edited as described in the previous two sections.

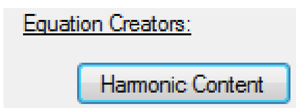
Select User 1 and click "Edit" to edit the user wave-shape. Then load a sine shape to be modified by selecting
Preload → Equation…



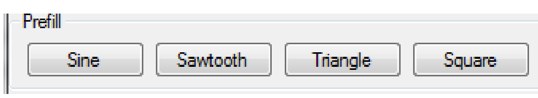
A dialog box will be presented allowing the user to specify a wave-shape formula along with a number of example formulas.

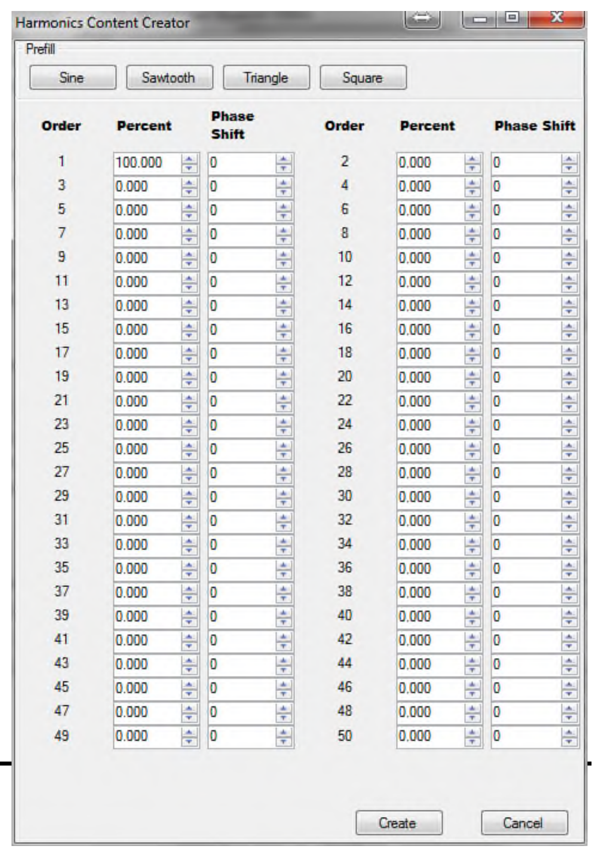


Select the harmonic content button

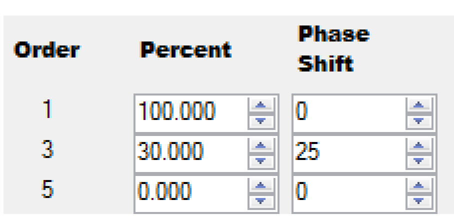


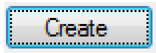
The Harmonics table may be pre-filled using standard shapes or individual harmonics may be provided.





For this example set the 1st order harmonic to 100 with a 0^{o} phase angle and the 3rd harmonic to 30 with a 25^{o} phase angle by entering these values in the appropriate fields.



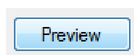
Finally click Create. 

Wave shape example – Harmonics Entry (Cont'd)

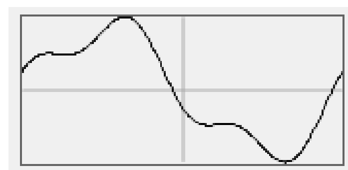
Note: The input field "Percent" may use percent or actual values from a power meter. The wave-shape is normalized allowing the 9400 to automatically scale the output based on the wave-shape equivalent RMS and the programmed RMS level.

The harmonics equation is displayed in the equation field allowing it to be further edited.

The above formula is equivalent to $A \cdot \sin(\omega) + 0.3 \cdot A \cdot \sin\,(3w + 25^0)$

Click the "Preview" button 

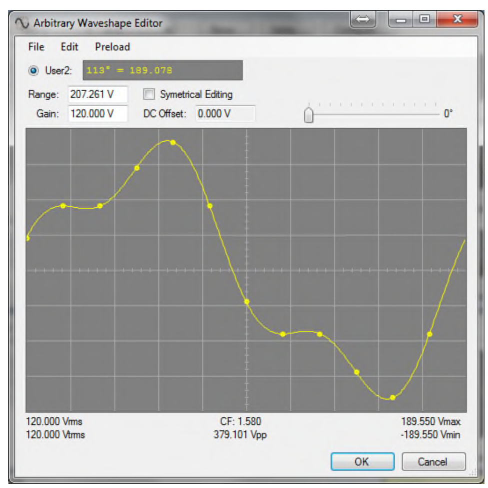
to see a graphical representation of the newly generated wave-shape.



Press "OK" to close the formula editor,
the pre-loaded wave-shape is displayed on the wave shape editor allowing further modification such as was described in the line-slap example.

If no further modification is desired,

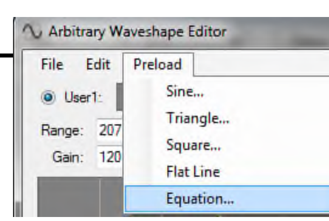
- Save the wave-shape for later use (File → Save)
- Click "OK" to load this wave-shape to User 1



6.5.1.4 Wave Shape Example – Simulating Phase Jump:

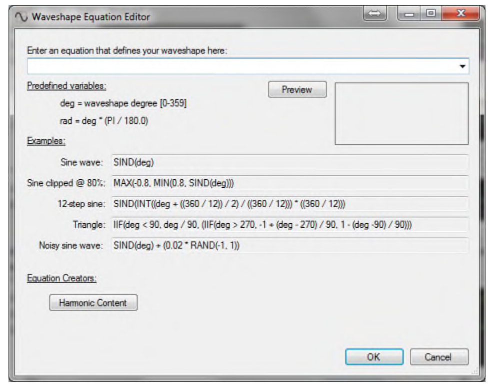
The NHR 9400 is able to support a programmed phase-jump allowing for simulations where the frequency is matched but the relative amplitude or phase angles jump.

This is programmed in a similar manor as the harmonics section above where the fundamental has been shifted by a specified phase angle.

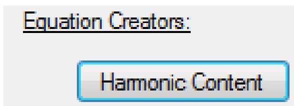


Select User 1 and click “Edit” to edit the user wave-shape.
Then load a sine shape to be modified by selecting
Preload → Equation…

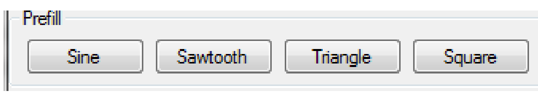
A dialog box will be presented allowing the user to specify a wave-shape formula along with a number of example formulas.

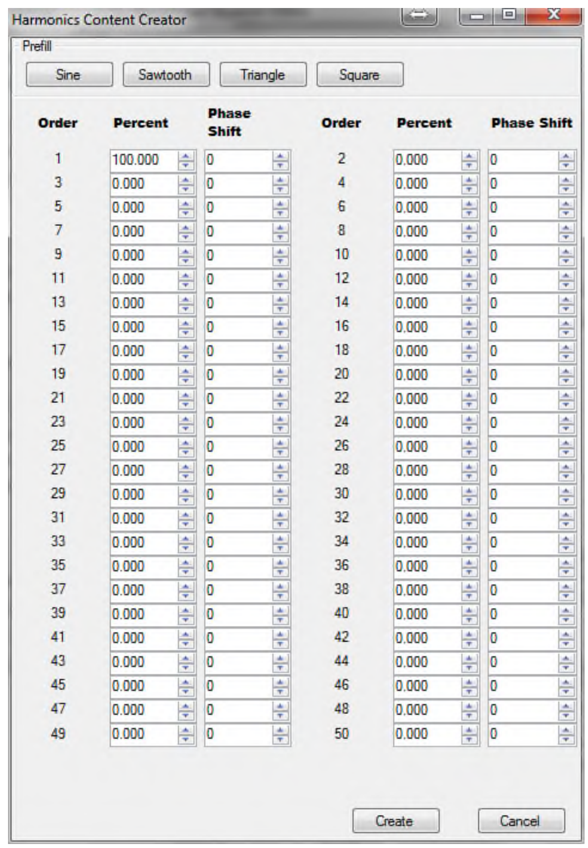


Select the harmonic content button

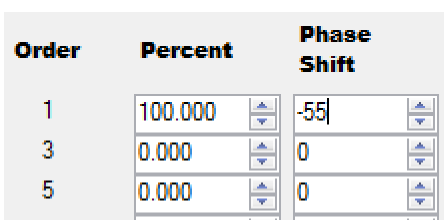


The Harmonics table may be pre-filled using standard shapes or individual harmonics may be provided.





For this example set the 1st order harmonic to 100 with a -55^{o} phase angle all other harmonics set to 0.



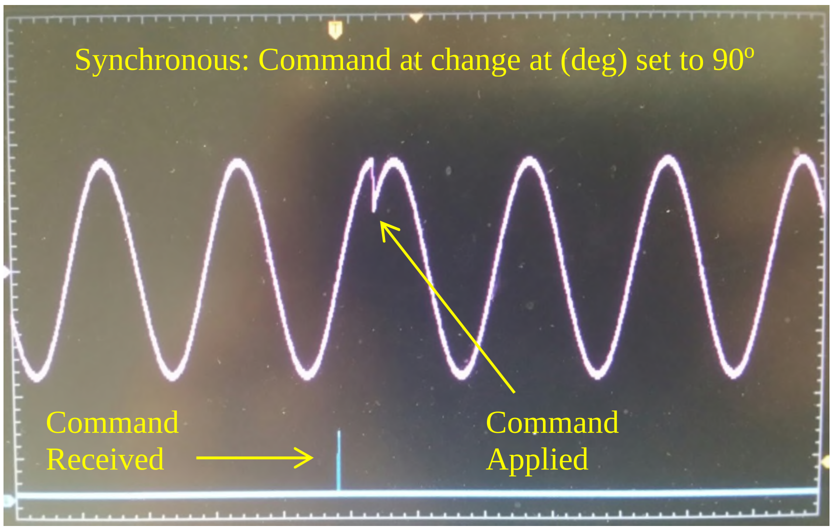
This will generate a phase shifted waveshape in User 1.

Wave shape example – Simulating Phase Jump (Cont'd)

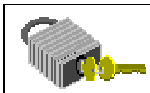
The User 1 now contains a sinusoidal wave-shape which is 55º offset from the standard wave-shape. The main panel may now be used to determine the frequency, amplitude, and the Change at (deg) angle the wave-shape will use.

Note: When the system is in synchronous mode, the new wave shape will be applied at the Change at (deg) angle. When the system is operating in immediate mode the wave shape will change based on when the command was received.

Refer to the Adjusting phase angle trigger section above for more information.



Any arbitrary wave shape can be created, downloaded to, & selected for any output.

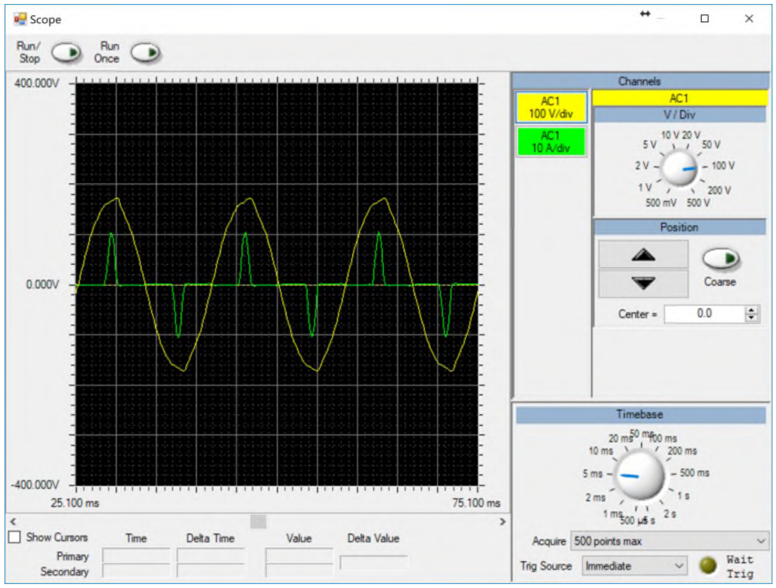


Macros may be used to simultaneously switch amplitude, phase angle triggers, wave-shape, and other multi-phase output settings.

6.5.2 Accessing Oscilloscope View

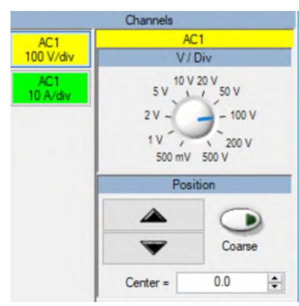
Pressing the "O'Scope" button  opens an oscilloscope panel.

This utility accesses the internal hardware digitizer and provides many similar functions to an oscilloscope including measurement cursors, horizontal control (time) and vertical control (V/Div & A/Div) as well as cursor measurements.



All captures start at the 0º reference phase angle for self-phase (in single phase operation) or the 0º reference phase angle for A-Phase (in multi-phase operation).

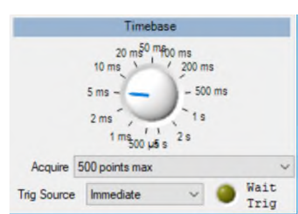
6.5.2.1 Adjusting Vertical Scale and Position



The Oscilloscope allows separate scales per measurement channel as well as vertical positioning of each channel.

These are adjusted by first selecting the channel and then adjusting the knob and position as shown to the left.

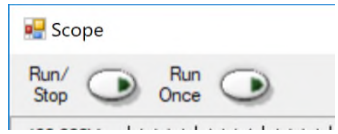
6.5.2.2 Adjusting the Time-Base & Number of Samples



The Oscilloscope function captures between 500uS and 5s per division (1mS up to 50s). It is also possible to specify the maximum number of points between 500 & 50k points which are uniformly distributed across the entire capture time.

Adjusting the time base after a capture provides a waveform

“Zoom” feature along with a scroll bar below the displayed waveform to adjust the horizontal view.



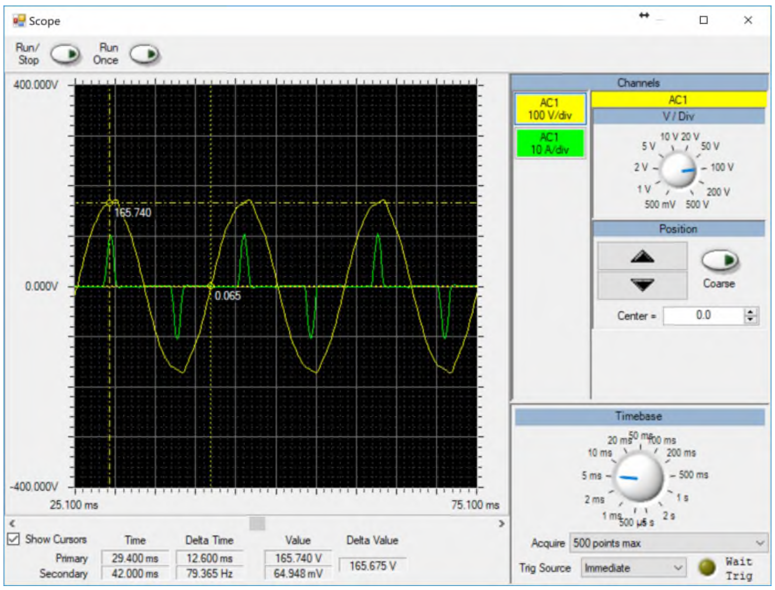
6.5.2.3 Capturing the Output

The Run/Stop works similar to an oscilloscope’s “normal mode” which arms, triggers at the 0º reference, downloads the waveform data, and re-arms to capture the output again.

Run once works similar to an oscilloscope’s “single sequence mode” which arms, triggers at the 0º reference, and downloads the waveform data one time only.

6.5.2.4 Cursors

Cursors are activated by checking on the “Show Cursors” check box in the lower left.



The primary cursor is placed using a left click.
The secondary cursor is placed using a right click.

The time & value of each cursor as well as the delta (in time, frequency, and value) is shown in text in the lower panel. The value of each cursor is also placed near the cursor measurement location on the waveform.

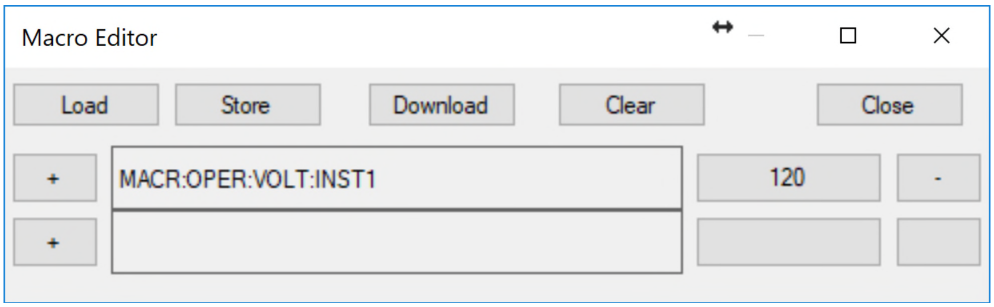
6.5.2.5 Closing the Oscilloscope View

The oscilloscope view is closed by pressing the close window button.

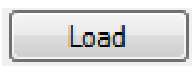
This page intentionally left blank.

7. MACROS & USAGE EXAMPLES

A Macro is pre-programmed pattern that is downloaded and executed locally on the hardware in order to provide direct cycle and sub-cycle control. Macros provide deterministic cycle-based and time-based changes to settings across all instrument channels, to any phase, to wave-shape selection, and any other programmable setting.

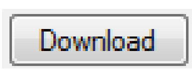


Button Options below are described from left to right

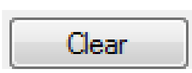


Retrieves a previously generated and stored macro file.

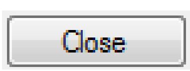
Saves the current macro file for later use.



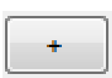
Downloads the current macro file to the hardware.



Clears the macro editor screen (and macro loaded in hardware).

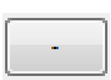


Closes the editor macro editor window.

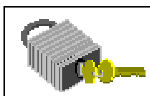


Inserts a new macro step before current selected step.

Editable value entry field.



Deletes the selected macro step.



Macros are entered in a similar manor on the touch panel.
Please ensure you read the following sections about instrument level

control options before attempting to program a macro.

7.1 Macro Organization

Macros are organized in an identical fashion when implemented on the touch panel, NHR 9400 Panel software, and have a nearly identical structure when programmed using SCPI or LavVIEW VIs. Refer to NHR 9400 Series Programmer's Reference Manual (09-0335) for the appropriate syntax and detailed descriptions of each command.

7.2 Macro Timing Control

7.2.1 AC Synchronization Angle

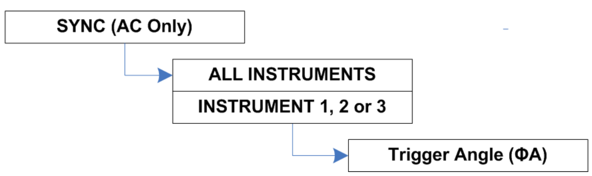
The macro permits changing the trigger angle used by the system.

When the channel is configured for immediate execution,

the cycle counter uses this trigger angle and is commonly used to provide a synchronization angle before applying a new time-based regulation limit.

When the channel is configured for synchronous execution,

the cycle counter and regulation limits use the trigger angle.



See the Waits section for more information about cycle counting and the output characteristics based on Synchronous / Immediate modes.

7.2.2 Waits

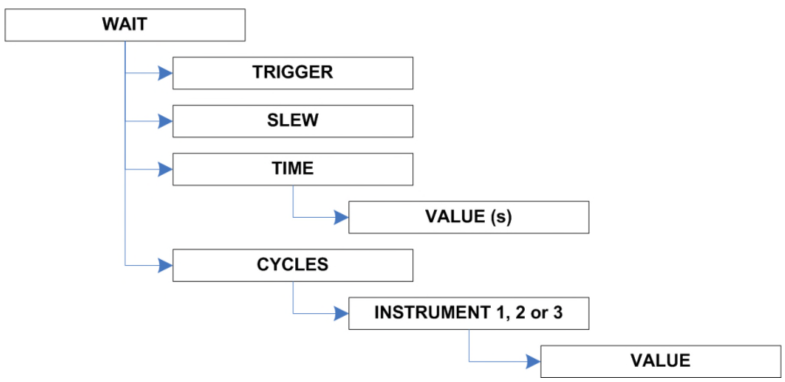
Macros may be set to wait for a trigger, until the slew is complete, for a specified period of time, or until number of cycles have completed.

Wait Trigger: Set externally to the Macro and causes pause until the trigger is received.

Wait Slew: Macro pauses until ALL outputs have finished any slew-rate based changes.

Wait Time: Macro pauses for a specified amount of time in seconds.

Wait Cycles: Macro pauses until the specified number of crossings of the trigger angle.



Example: A 9430-12 is configured for single-phase AC Normal loading, operating at 50Hz, with a 6A current limit, and the following sequence is executed:

Sequence Steps	Immediate Execution	Synchronous Execution
WAIT → CYCLE → INSTRUMENT1 1	Waits for Next Angle For example, assume elapsed time after angle is 0mS	
OPERATION → CURRENT → INSTRUMENT1 3	Executes Command (Elapsed 0mS)	Executes at Next Angle (Elapsed 20mS)
WAIT → CYCLE → INSTRUMENT1 1	Waits for next Angle (Elapsed 20mS)	Waits for next angle (Elapsed 40mS)
OPERATION → CURRENT → INSTRUMENT1 6	Executes Command (Elapsed 20mS)	Executes at Next Angle (Elapsed 60mS)

7.3 Macro Programming –Output Control

Sequentially issued Macro **Operations** are merged automatically. This merging occurs until the same output is adjusted a second time or any other Macro command is issued.

Example using the 9430-12 operating as a three phase load with Normal loading:

Sequentially Issued Commands	Command Description	Merged
OPERATION→CURRENT→CHANNEL1 12 OPERATION→CURRENT→CHANNEL2 6	Sets A Phase to $12A_{RMS}$ Sets B Phase to $6A_{RMS}$	Yes
OPERATION→CURRENT→ALL 12	Sets A/B/C to $12A_{RMS}$	No
OPERATION→CURRENT→CHANNEL1 6 OPERATION→CURRENT→CHANNEL2 12	Sets A Phase to $6A_{RMS}$ Sets B Phase to $12A_{RMS}$	Yes
OPERATION→CURRENT→CHANNEL1 12 ????	Sets A Phase to $12A_{RMS}$????	Depends on next command

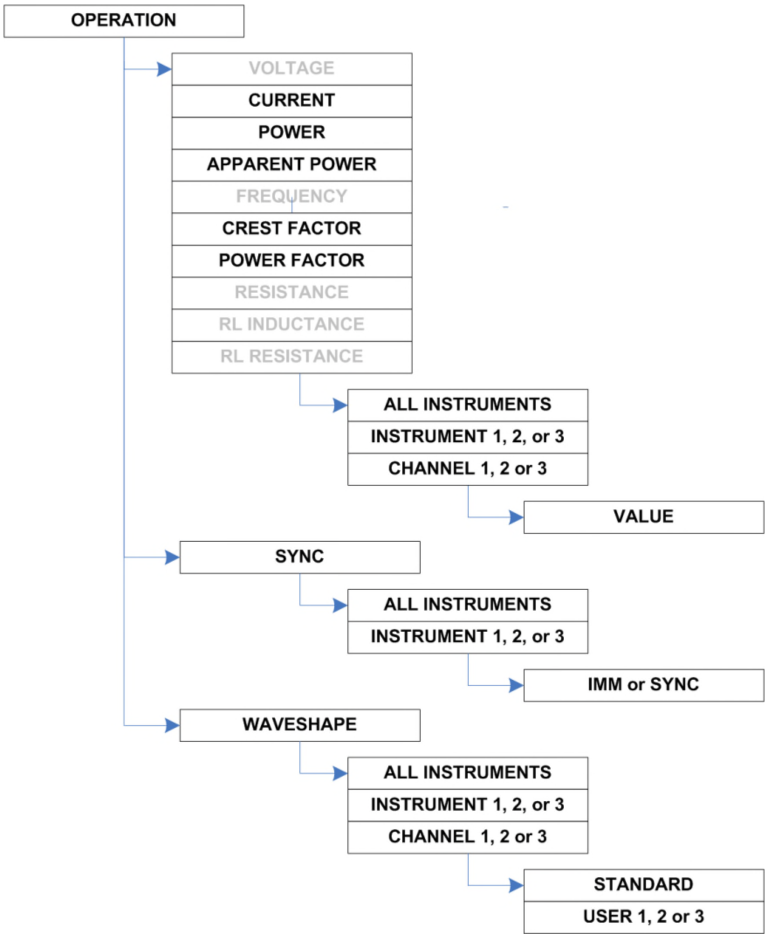
7.4 OPERATION

The operation section allows setting operational settings. It is important to understand that the macro language is independent of the hardware connected so it will present options which are not appropriate for all models (like INST3 on a single phase system) or setting frequency in DC.

Normally, operation settings in a macro are applied in the order received. To force the system to apply multiple settings at the same time, the OPERATION / APPLY MODE can be set to WAIT. This will stop ALL operation settings until an OPERATION / APPLY command is received. Once in OPERATION / APPLY MODE = WAIT, you MUST include the OPERATION / APPLY command after any new setting (or group of settings) or NOTHING will be set.

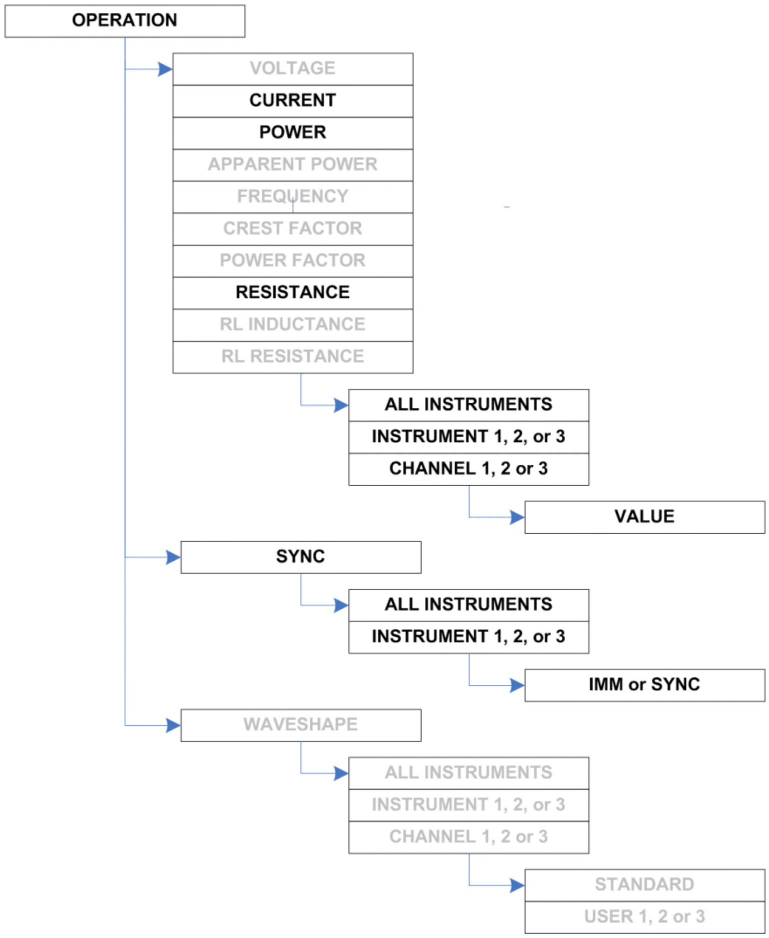
Set OPERATION / APPLY MODE = IMM to automatically apply OPERATION settings.

7.4.1 OPERATION - AC Normal Loading

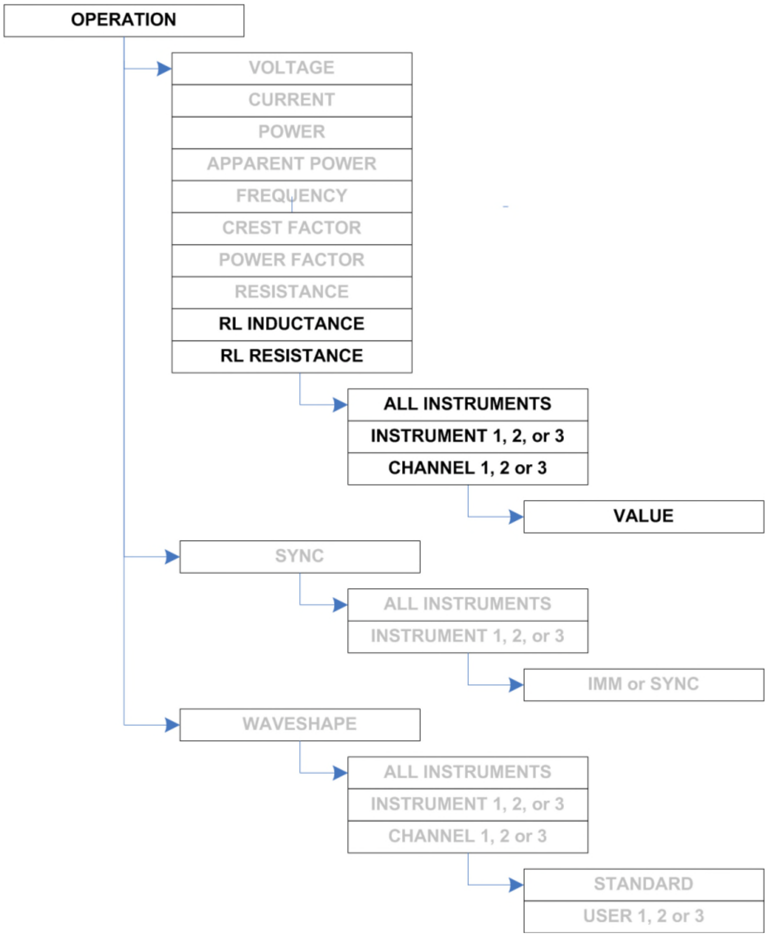


.

7.4.2 OPERATION - AC Constant Resistance Loading

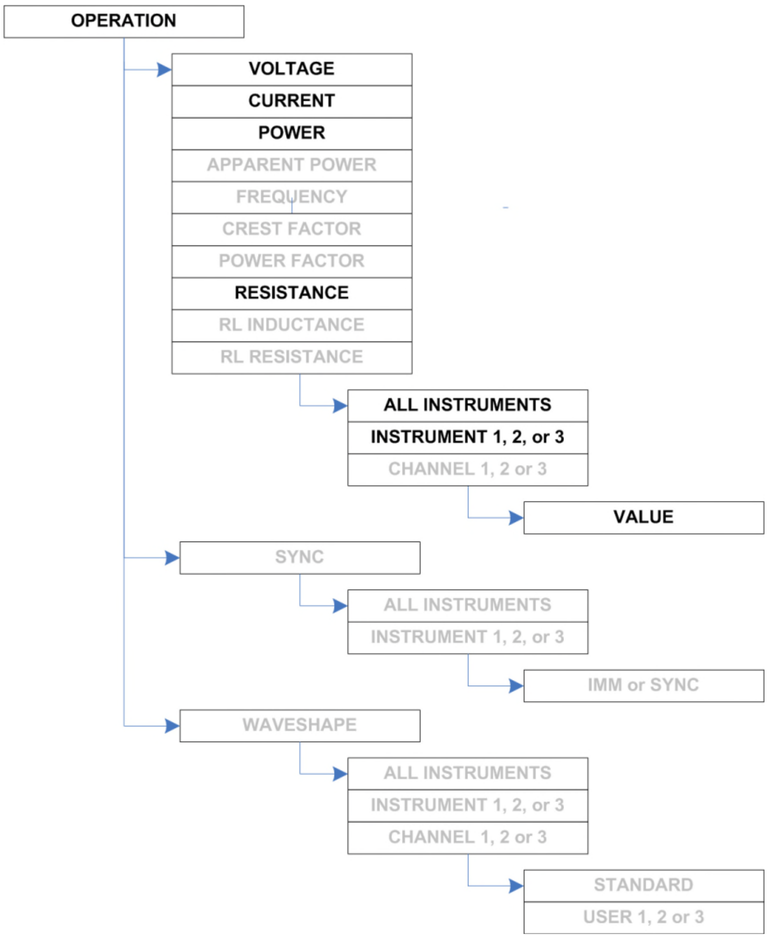


7.4.3 OPERATION - AC Constant RL Loading



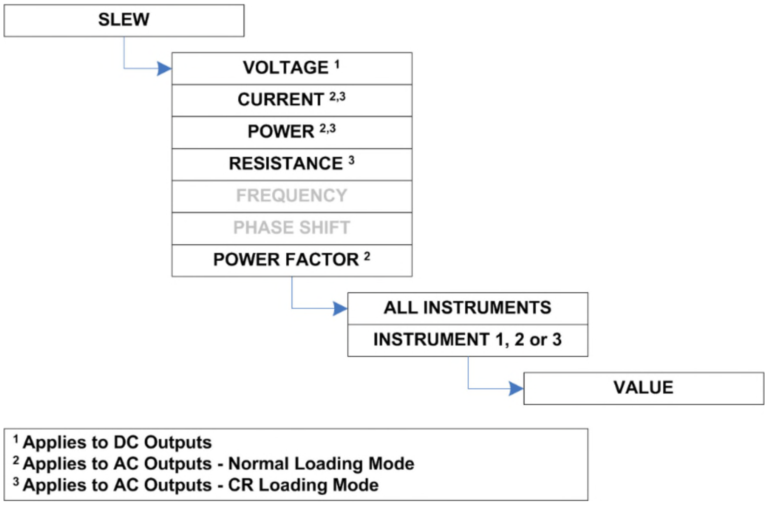
7.4.4 OPERATION - DC Loading

DC Outputs are programmable with Voltage, Current, Power, and Resistance limits.



7.4.5 Slew Rate Controls

Slew rates may be adjusted and take effect immediately upon execution.

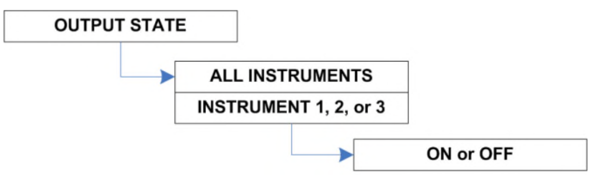


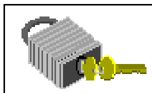
7.5 Macro Programming – Infrequency Used Commands

The commands in this section are supported even though they are not generally implemented within Macros.

7.5.1 Changing the Output (ON/OFF) State

The output of the system may be turned on or off on a per channel basis.

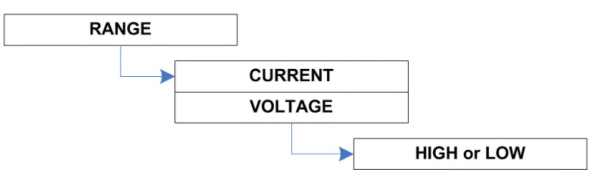




Output state also controls the UUT side contactors.

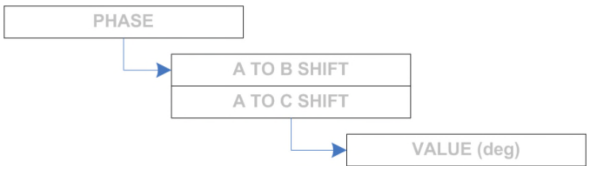
7.5.2 Changing Set & Measurement Ranges

Set & measurement ranges may be adjusted within a macro.



7.5.3 Multi-Phase Relative Voltage Angle

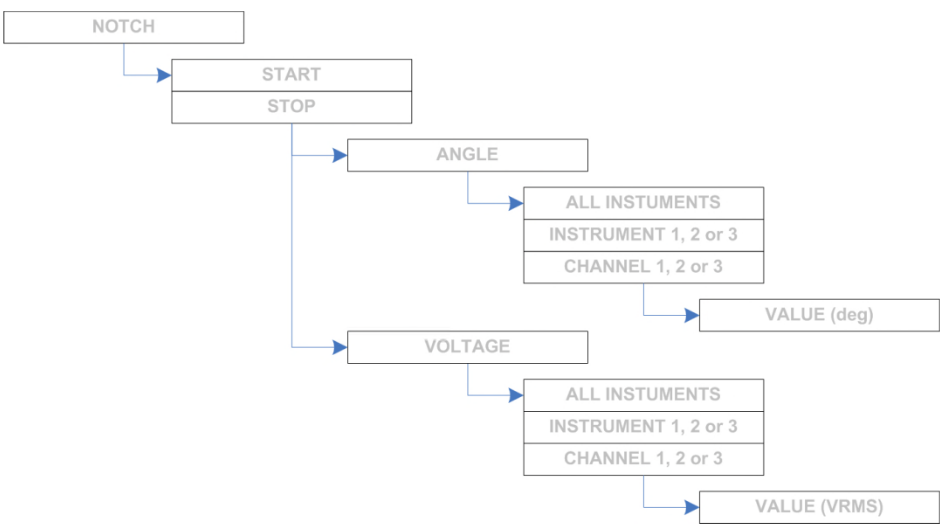
The relative voltage angle is determined by the UUT and not by the load.
As such, these commands should not be used with a 9430.



The NHR 9400 Panel provides control for the 9430 in addition to NHR's 9410 (Grid Simulator) and 9420 (AC Source) Products .

7.5.4 Sub-Cycle Voltage Notches

The AC Voltage characteristics including Notched, Harmonics and other disturbances are determined by the UUT and not the load. As such, these commands should not be used with the 9430.



The NHR 9400 Panel provides control for the 9430 in addition to NHR's 9410 (Grid Simulator) and 9420 (AC Source) Products

7.5.5 Accessing the Measurement System

A Macro may:

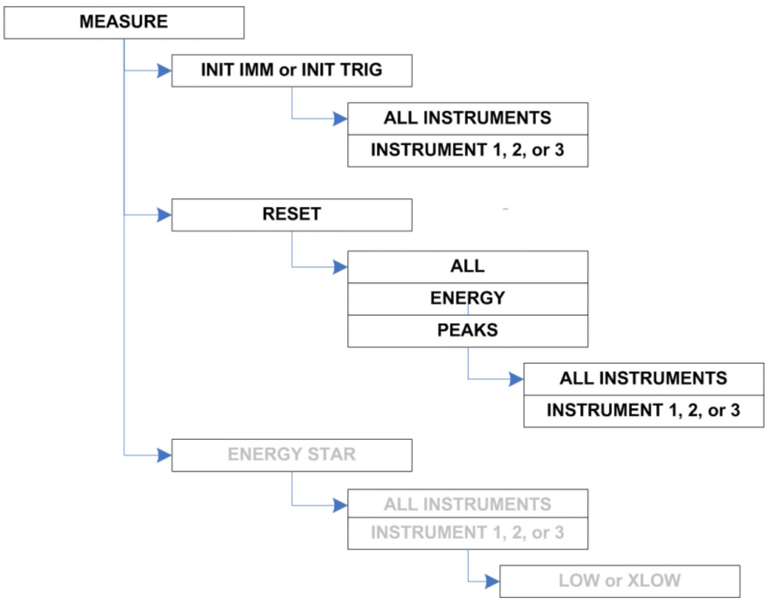
Trigger a measurement by the internal measurement system:

INIT IMM (Initiate Immediate)
INIT TRIG (Initiate Trigger)

The system takes an internal measurement when instructed (using previously set aperture settings) allowing the results and digitized waveforms to be downloaded by a customer's application.

Reset accumulated measurement values.

Other measurements (such as Energy Star) are supported on other products and should not be used with the 9430 system.

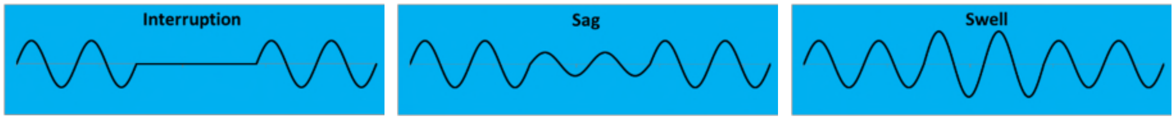


The NHR 9400 Panel provides control for the 9430 in addition to NHR's 9410 (Grid Simulator) and 9420 (AC Source) Products .

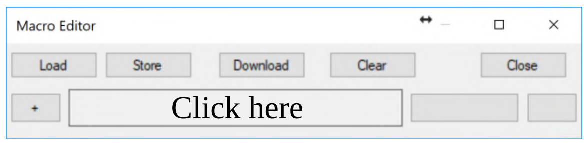
7.6 Macro Usage Examples

7.6.1 Simulating Voltage Interruptions, Sags, & Swells

While the causes of interruptions, sags, swells, and even brown-outs may be different, all of the conditions are similar in so far as they represent a change in voltage levels for a period of time.

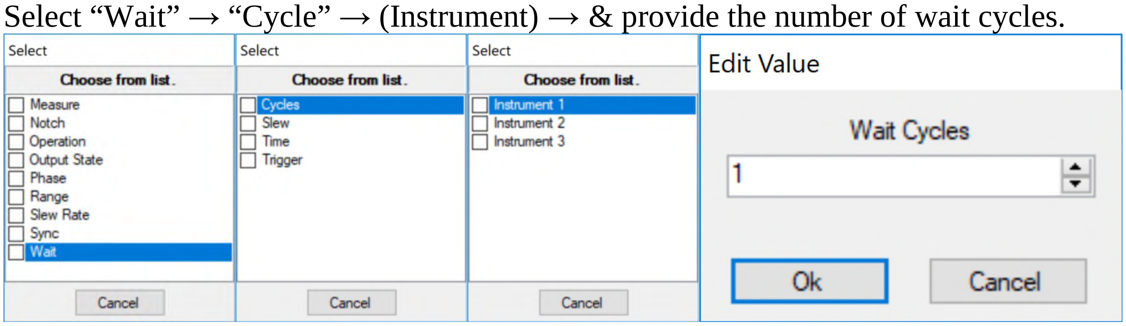


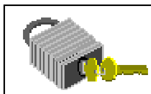
To simulate an interruption, sag, or swell for either an amount of time or cycle(s), open the Macro editor and click on the first empty cell to insert the first step.



The first step commonly selects if the macro will execute commands immediately or synchronously with the A Phase (or self-phase for 1 phase outputs). This setting applies only the following macro commands and does not affect manual operation.

Step 1: Determine the number of cycles that should occur before the disturbance:
Select "Wait" → "Cycle" → (Instrument) → & provide the number of wait cycles.

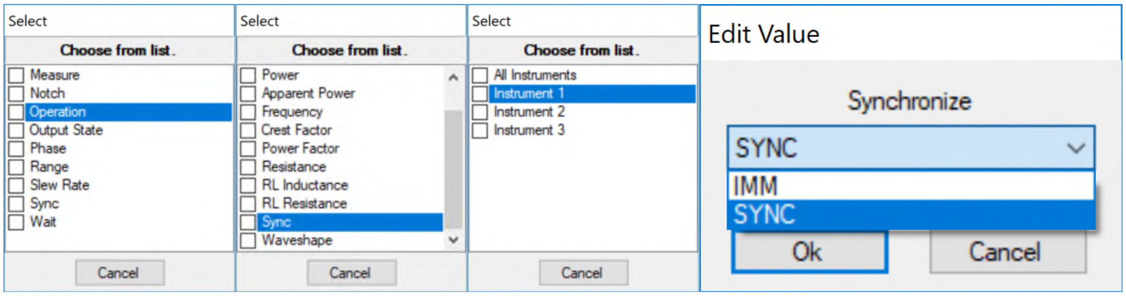


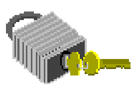


Wait cycles always counts the number of transitions at the angle specified by Change at (deg).

The above step serves two functions. First it will ensure that some number of cycles occur before making the change. Second, it will align the following changes based on the change at (deg) angle specified. This angle may also be adjusted in the macro before waiting for the pre-disturbance cycles to complete.

Step 2: Determine if the changes occur immediately or synchronously at the set angle. Select “Operation” → “Sync” → (Instrument) → & Select IMM or SYNC.

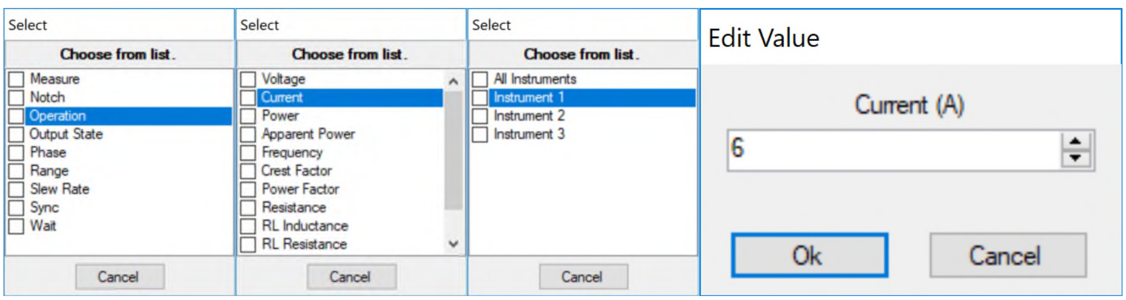




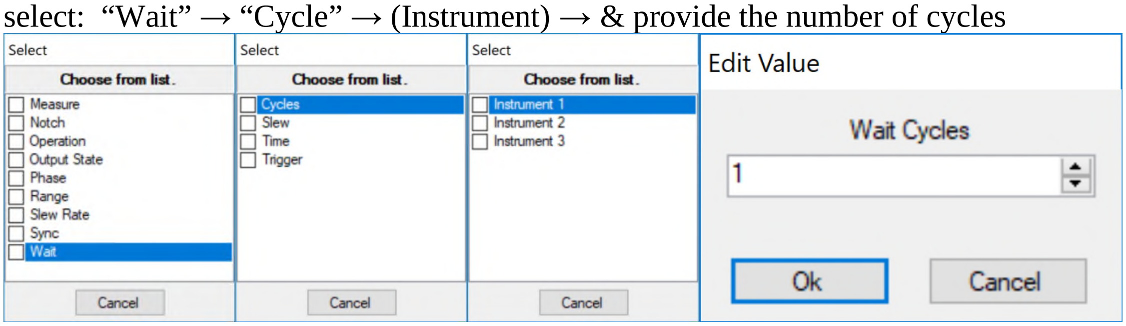
Selecting Immediate (IMM) all the following operation commands are applied immediately after any wait (time or cycles) expires.

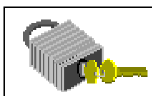
Selecting Synchronous (SYNC): The following operation commands are applied at the next changed at (deg) phase after the wait expires. In general, the command is applied on the next cycle.

Step 3: To set the disturbance voltage, click on the next open cell and select: “Operation” → “Current” → (Instrument or φ) → & supply the value desired.



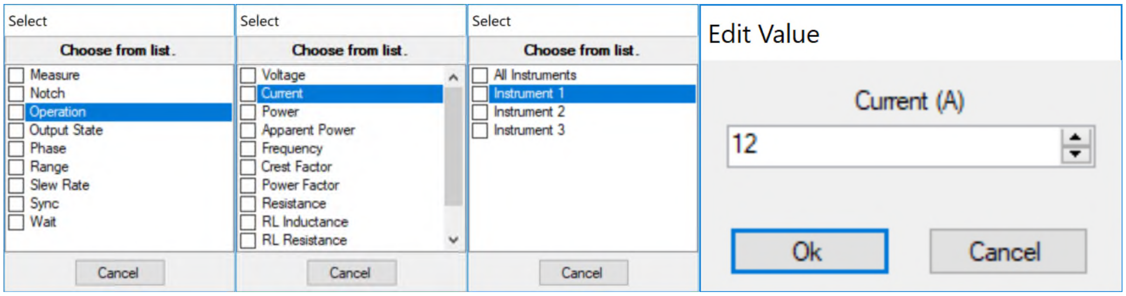
Step 4: Specify the time or cycle(s) the disturbance is to occur, Click the next open cell & select: “Wait” → “Cycle” → (Instrument) → & provide the number of cycles





In IMM Mode: Wait time will use actual time.
In SYNC Mode: Wait Time will be rounded up to the next complete cycle.

Step 5: Return the output to nominal, select the next open cell then select:
"Operation" → "Voltage" → (Instrument or φ) → & supply the value desired.



The macro is now complete.

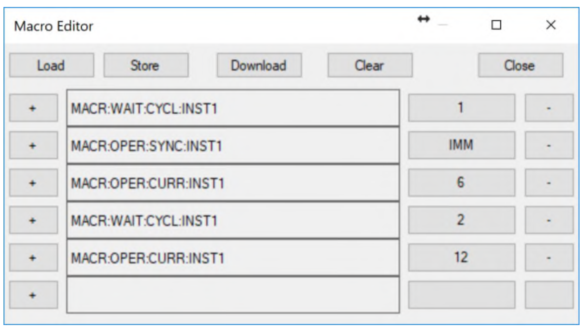


Figure 6 - Immediate Mode

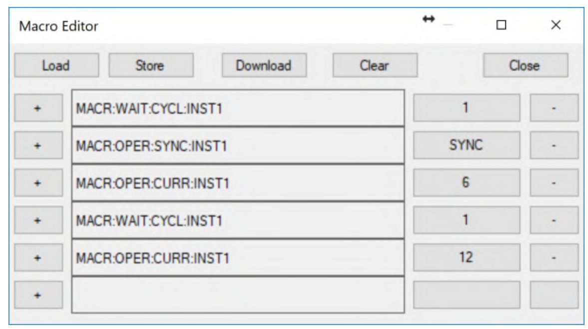
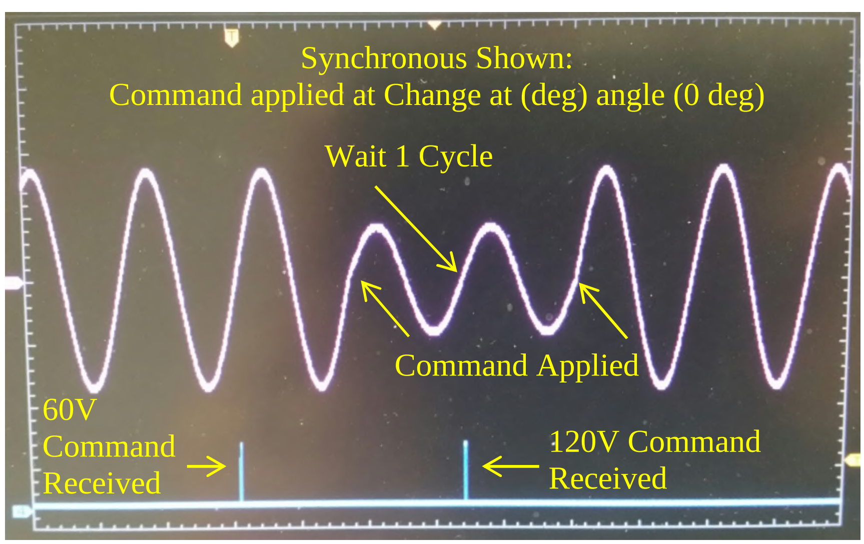
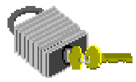


Figure 7 - Synchronous Mode

Running the above macro results in the following output:

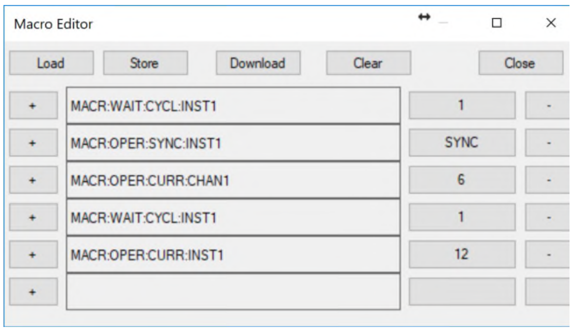


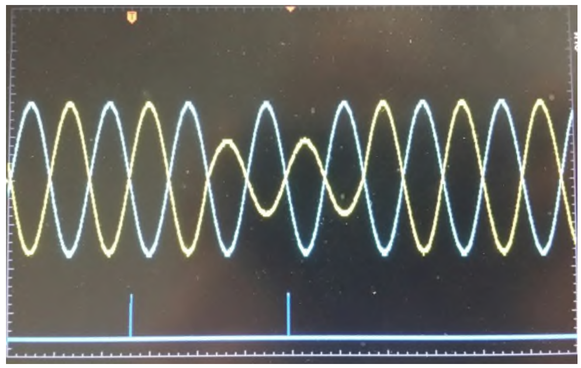


Example shows Sync Mode where the command is applied, Waits for 1 full cycle then releases the next command (120V) which is applied at the next change at (deg) angle.

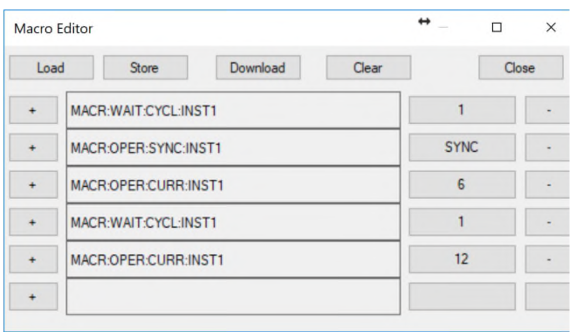
Multi-Phase output interruptions, sags, & swells

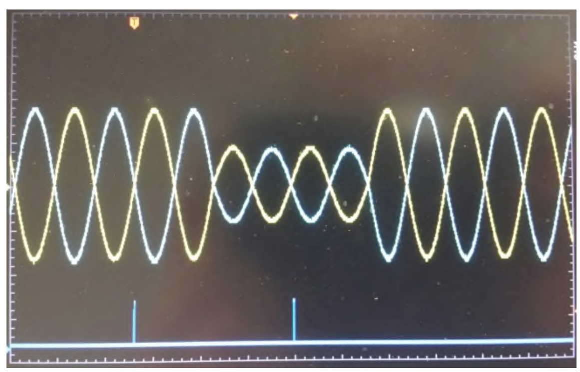
The same process is used to adjust individual phases or all phases of a multi-phase output. Below shows the macro's used to produce a 2-cycle sag on an individual phase, on both phases simultaneously, and on both phases with the sag starting at 90º.



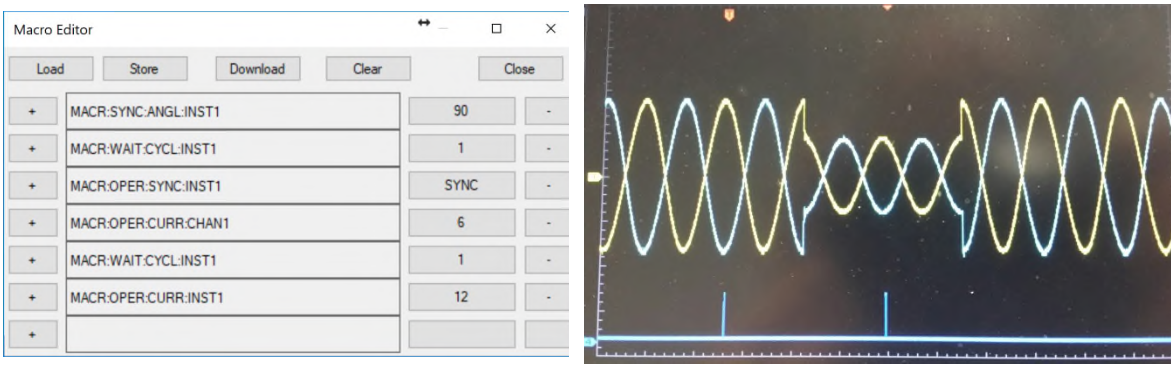


Affecting only one phase (Split Phase Shown)





Affecting both phases (Split Phase Shown)



Affecting both phases with 90° change angle

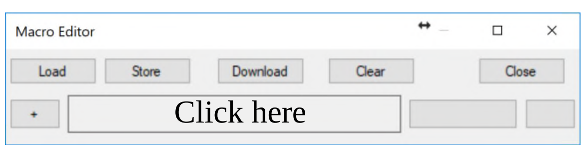
7.6.2 Switching Waves shapes

This section will describe how to use a macro to switch wave shaped either based on cycles or time. Switching wave shapes is commonly used for a line-slap simulation and may also be used to switch in a noisy sin, a harmonics distorted wave shape, or any other wave shape which has been loaded into the module.

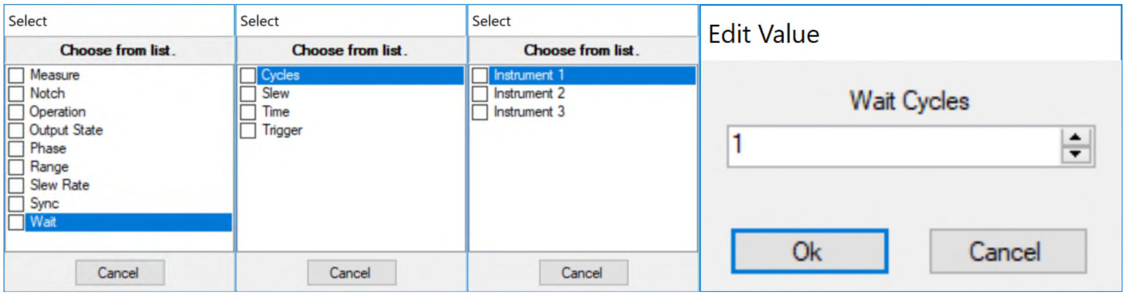
Step 1: Ensure the custom current wave shape is loaded into USER 1.
See the "Editing an output wave shape" for information in creating output wave shapes.

	User current wave-shapes are supported in AC Normal Loading Only.
	This macro will switch between the standard (sin) and a pre-loaded user voltage wave shapes. This technique will allow any of the of the pre-loaded wave shapes to be applied in a similar manor.

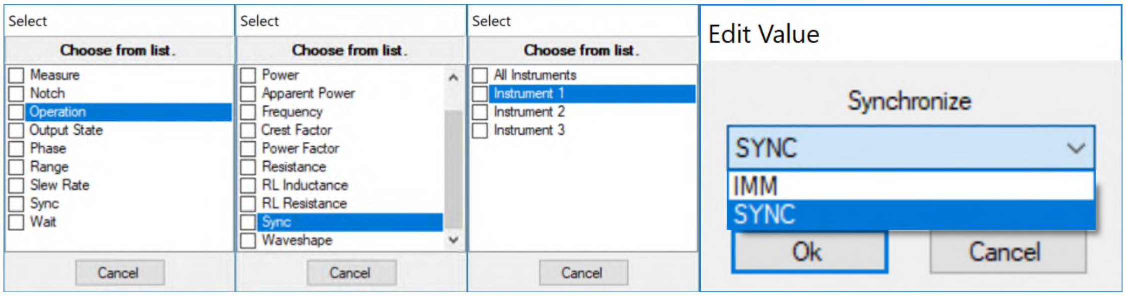
To switch between wave-shapes, open the Macro editor and click on the first empty cell.

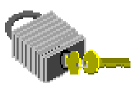


Step 2: Determine the number of cycles that should occur before the disturbance:
Select "Wait" → "Cycle" → (Instrument) → & provide the number of wait cycles.


Select
Choose from list.
Measure
Notch
Operation
Output State
Phase
Range
Slew Rate
Sync
Wait
Cancel
Select
Choose from list.
Cycles
Slew
Time
Trigger
Cancel
Select
Choose from list.
Instrument 1
Instrument 2
Instrument 3
Cancel
Edit Value
Wait Cycles
1
Ok
Cancel

Step 3: Determine if the changes occur immediately or synchronously at the set angle. Select "Operation" → "Sync" → (Instrument) → & Select IMM or SYNC.

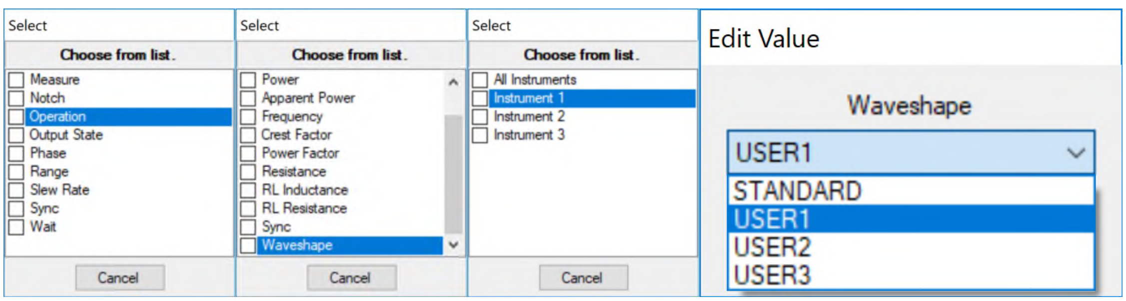




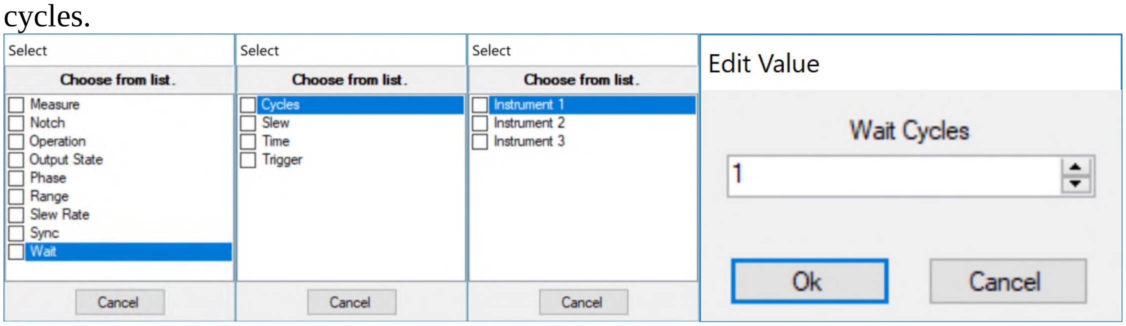
Selecting Immediate (IMM) all the following operation commands are applied immediately after any wait (time or cycles) expires.

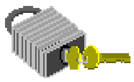
Selecting Synchronous (SYNC): The following operation commands are applied at the next changed at (deg) phase after the wait expires. In general, the command is applied on the next cycle.

Step 4: Determine the new output wave shape to be used wave shape. Select "Operation" → "Waveshape" → (Instrument or φ) → select the output shape.



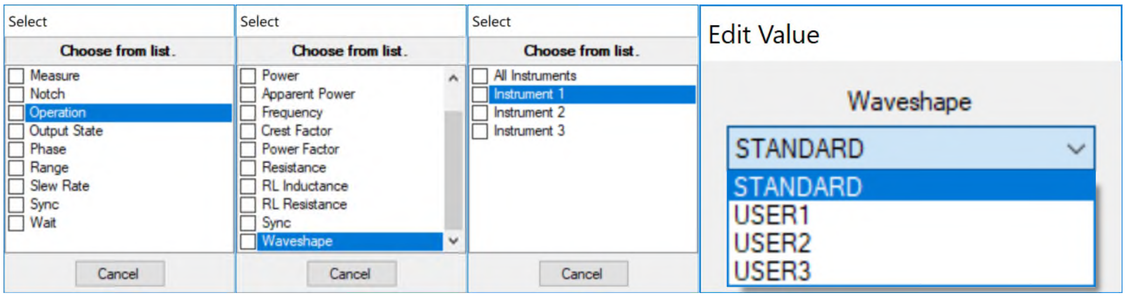
Step 5 (Optional): Specify the time or cycle(s) the disturbance is to occur. Click the next open cell & select: "Wait" → "Cycle" → (Instrument) → & provide the number of cycles.



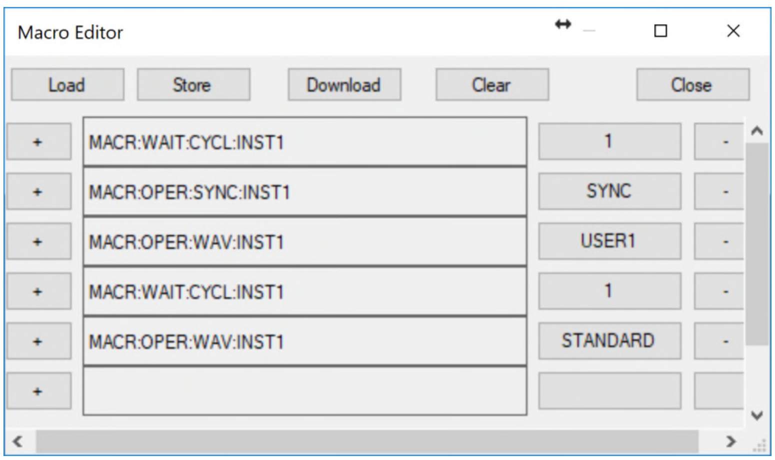


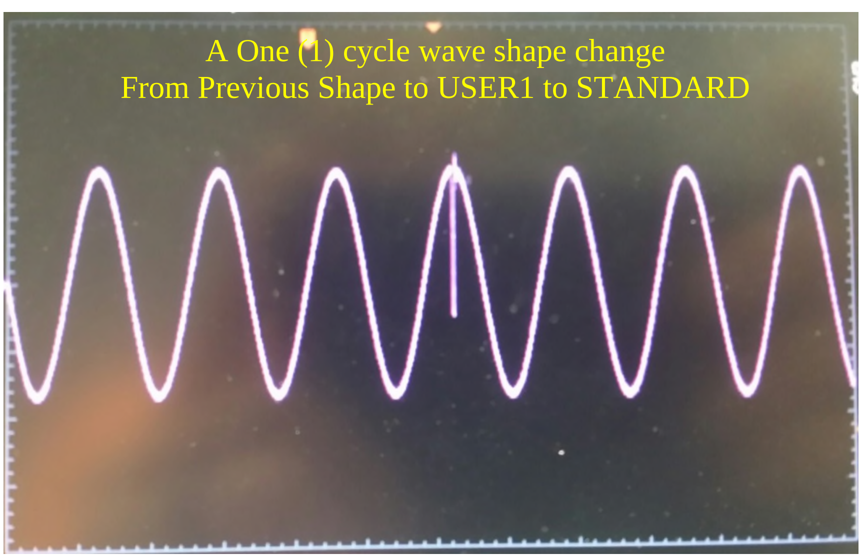
In Synchronous (SYNC) operation: Wave shapes requested for the same phase are applied on sequential cycles and do not need a cycle counter.

Step 6: Determine the next output wave shape to be used wave shape.
Select "Operation" → "Waveshape" → (Instrument or φ) → select the output shape.



The macro is now complete and provides the output as shown below.

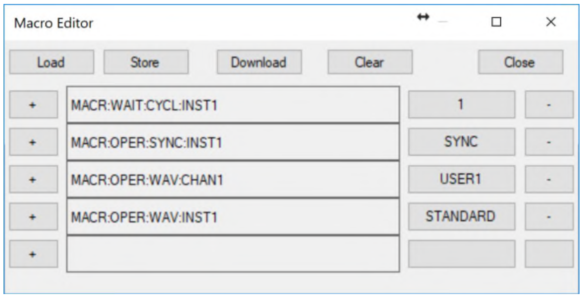


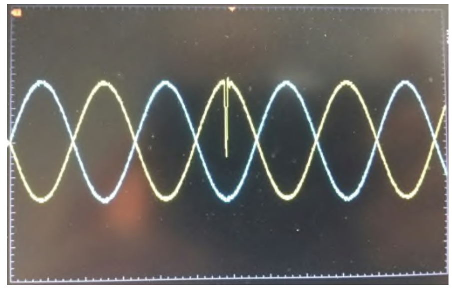


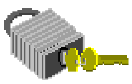
NHR

Multi-Phase– Changing a Single Phase

The same approach may be used on any phase of a multi-phase output as shown.







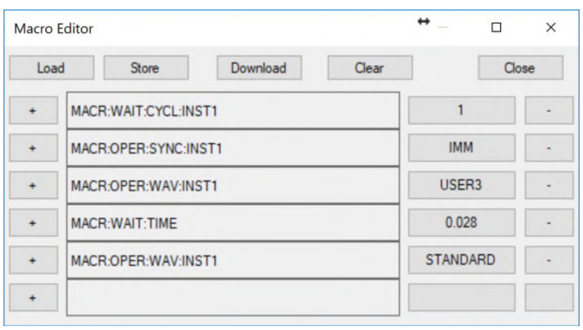
In Synchronous (SYNC) operation: Wave shapes requested for the same phase are applied on sequential cycles and do not need a cycle counter.

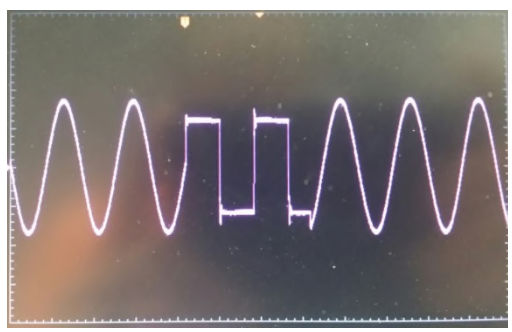
Using Time Based Changes

Waiting for a specific time generally require Immediate (IMM) to be selected in step 3 resulting in an immediate change after the timer expires. By comparison, synchronous (SYNC) operation allows the timer to expire and will apply the next operation command at the next Change at (deg).

Change step 3 from the above to IMM Mode and change step 5 to WAIT-TIME as shown.

Note: For clarity, example uses “USER 3” which has been pre-loaded with a square wave.





This page intentionally left blank.

8. APPENDIX – 9430 HARDWARE MODES

The organization of the channels is done by setting a “mode” with the “NHR 9400 Panel” PC tool (see section “Software” below) or through any programming interface (see *Programmer’s Reference Manual* 09-0335). Setting the mode will allow you to determine if it is a three output AC source, or a single output DC source, or anything in-between. There are a total of 13 hardware modes available for a three channel 9430 power module and six hardware modes for a two channel 9430. Once configured, the hardware operating mode persists even through all resets and power cycles.

Available hardware modes are dependent on the number of channels installed. Please refer to the appropriate section for details.

The fixture wiring must match the selected hardware operating mode. Failure to ensure may result in damage to the 9400, fixture-wiring, or the UUT.

8.1 9430 (3 Channel Version) –Programmable Modes

The three channel power module has 13 unique configurations.

Mode	***Available Instruments***	***Channel 1***	***Channel 2***	***Channel 3***
0	One 3-Phase AC	AC1 (Phase A) (Phase Ref)	AC1 (Phase B) (240° from A)	AC1 (Phase C) (120° from A)
1	One AC	AC1 (3x per channel power)		
2	One DC	DC1 (3x per channel power)		
3	Three AC	AC1	AC2	AC3
4	Three DC	DC1	DC2	DC3
5	One 2-Phase AC and One AC	AC1 (Phase A) (Phase Ref)	AC1 (Phase B) (180° from A)	AC3
6	One 2-Phase AC and One DC	AC1 (Phase A) (Phase Ref)	AC1 (Phase B (180° from A)	DC3
7	Two AC	AC1 (2x per channel power)		AC3
8	One AC and One DC	AC1 (2x per channel power)		DC3
9	Two AC and One DC	AC1	AC2	DC3
10	One AC and Two DC	AC1	DC2	DC3
11	One DC and One AC	DC1 (2x per channel power)		AC3
12	Two DC	DC1 (2x per channel power)		DC3

The following sections show NH Researches recommended wiring for each mode.

8.1.1 9430 (3 Channel Version) - Mode 0: One 3-Phase AC

Logical Instrument Configuration and UUT Wiring

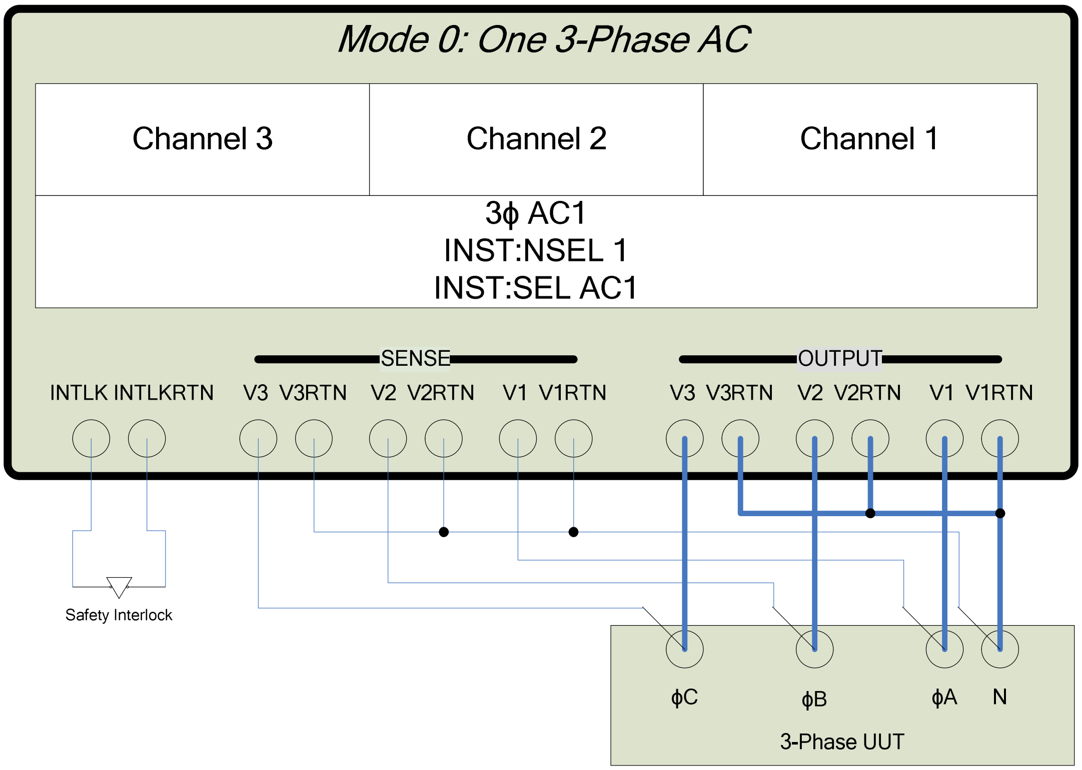


Figure 8 - Mode 0: One 3-Phase AC

Key Maximums for Each Logical Instrument

AC1 (3-Phase)	**Model**							
	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	12 kW	24 kW	36 kW	48 kW	60 kW	72 kW	84 kW	96 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current / Phase	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current / Phase	3 X Maximum RMS Current							

8.1.2 9430 (3 Channel Version) - Mode 1: One AC

Logical Instrument Configuration and UUT Wiring

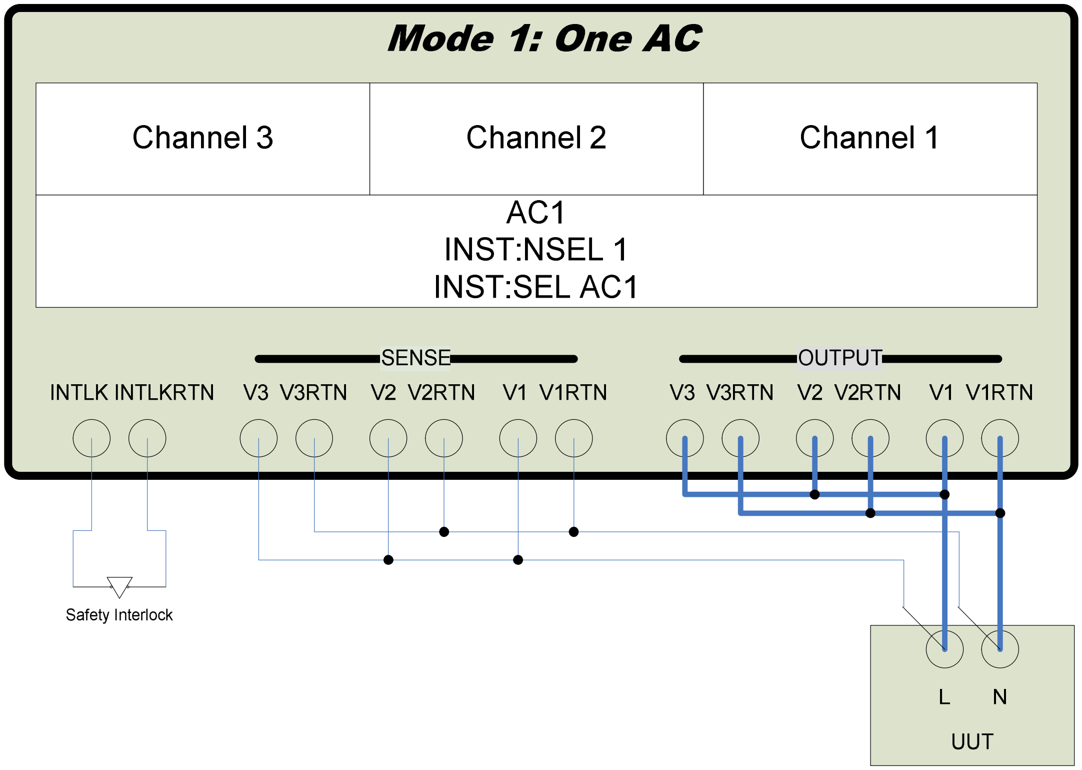


Figure 9 - Mode 1: One AC

Key Maximums for Each Logical Instrument

AC1	Model							
	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	12 kW	24 kW	36 kW	48 kW	60 kW	72 kW	84 kW	96 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	90 Arms	180 Arms	270 Arms	360 Arms	450 Arms	540 Arms	630 Arms	720 Arms
Peak Current	3 X Maximum RMS Current							

8.1.3 9430 (3 Channel Version) - Mode 2: One DC

Logical Instrument Configuration and UUT Wiring

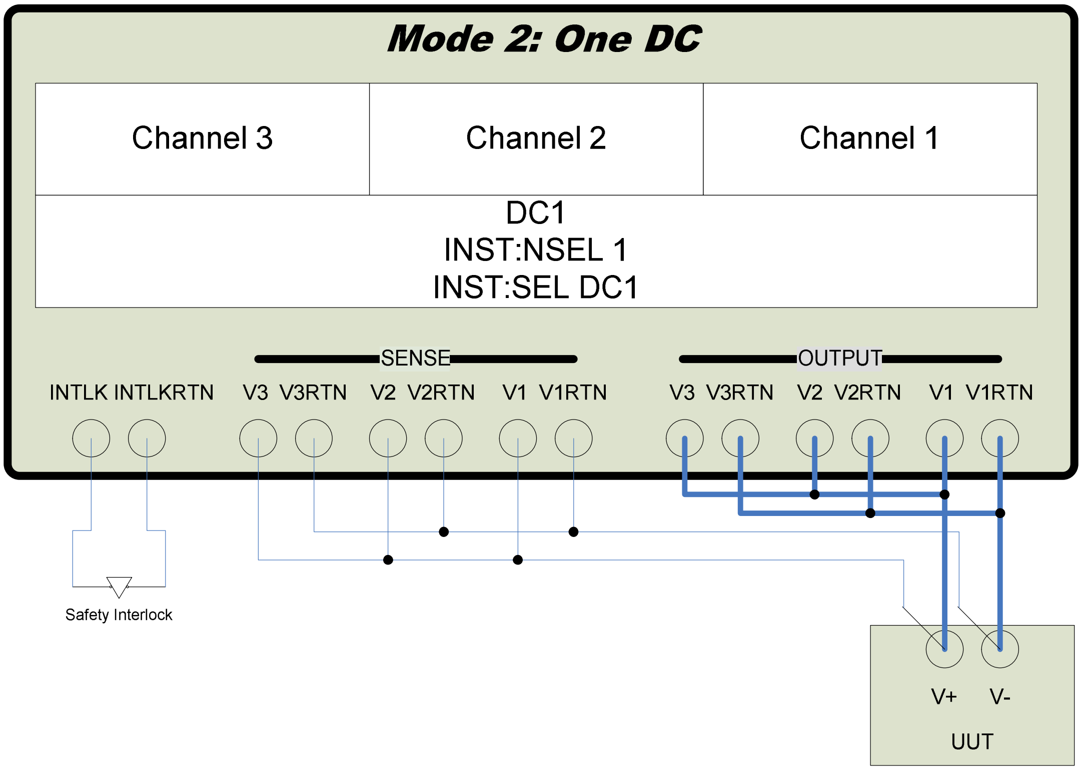


Figure 10 - Mode 2: One DC

Key Maximums for Each Logical Instrument

DC1	Model							
	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	12 kW	24 kW	36 kW	48 kW	60 kW	72 kW	84 kW	96 kW
Max Voltage	400 VDC							
Max Current	90 A	180 A	270 A	360 A	450 A	540 A	630 A	720 A

8.1.4 9430 (3 Channel Version) - Mode 3: Three AC

Logical Instrument Configuration and UUT Wiring

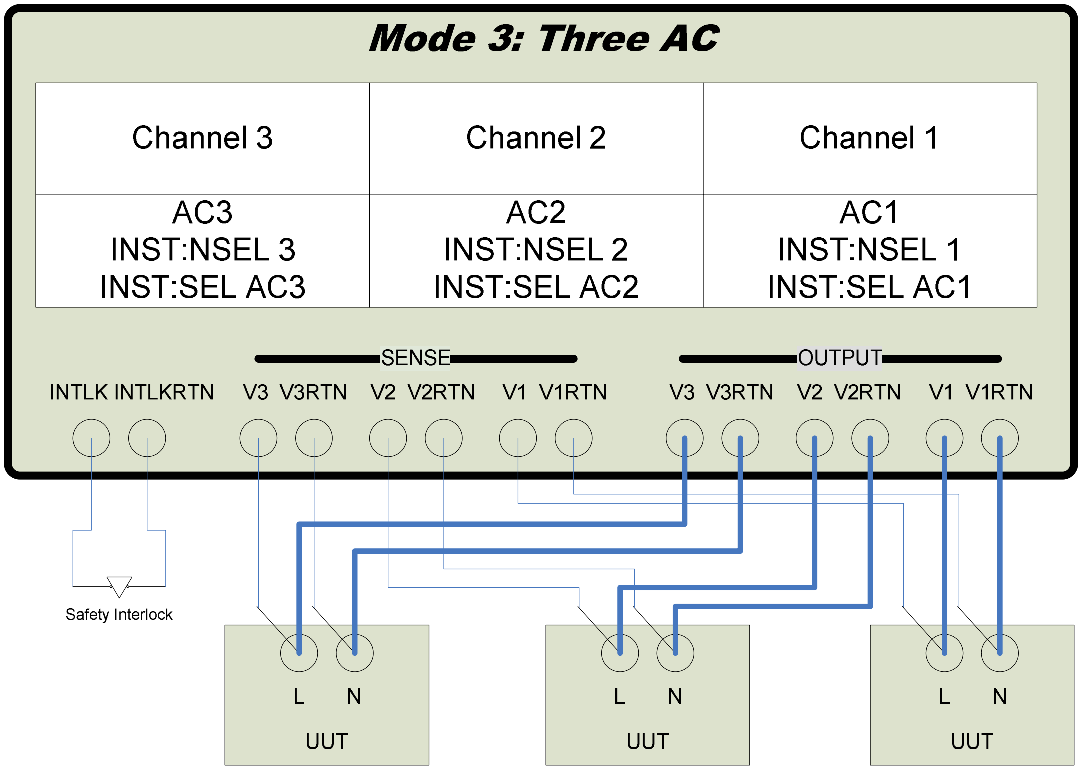


Figure 11 - Mode 3: Three AC

Key Maximums for Each Logical Instrument

	Model							
AC1	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current	3 X Maximum RMS Current							
AC2								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current	3 X Maximum RMS Current							
AC3								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current	3 X Maximum RMS Current							

8.1.5 9430 (3 Channel Version) - Mode 4: Three DC

Logical Instrument Configuration and UUT Wiring

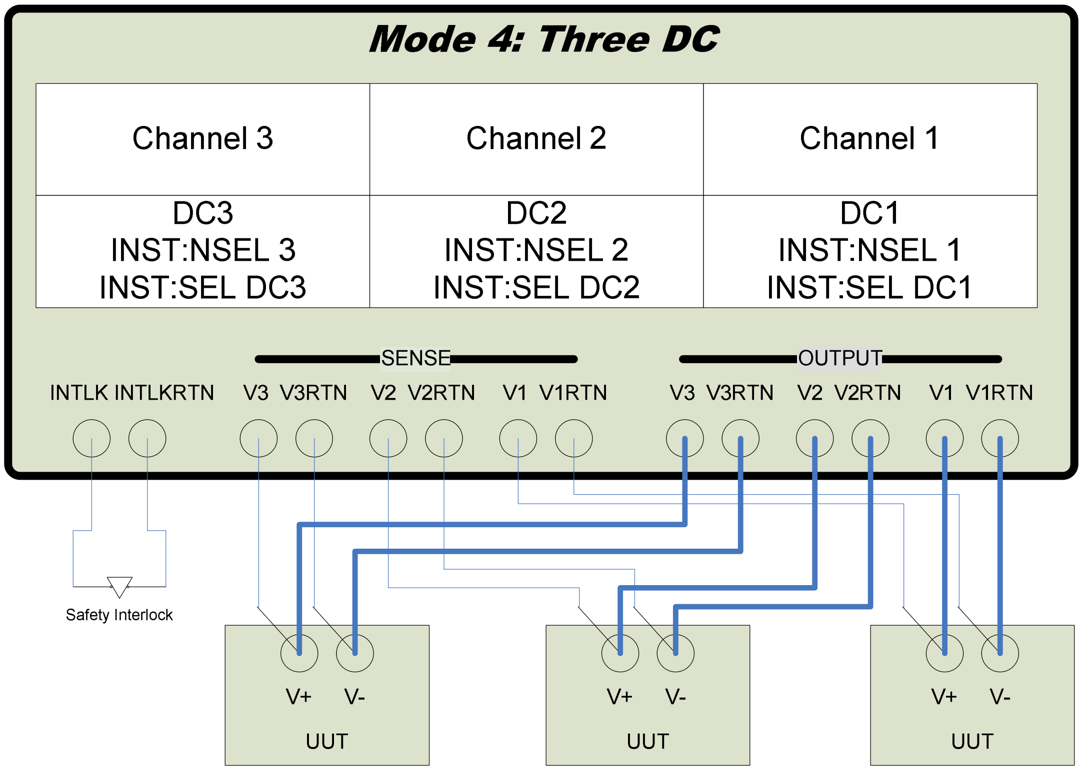


Figure 12 - Mode 4: Three DC

Key Maximums for Each Logical Instrument

	Model							
DC1	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	400 VDC							
Max Current	30 A	60 A	90 A	120 A	150 A	180 A	210 A	240 A
DC2								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	400 VDC							
Max Current	30 A	60 A	90 A	120 A	150 A	180 A	210 A	240 A
DC3								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	400 VDC							
Max Current	30 A	60 A	90 A	120 A	150 A	180 A	210 A	240 A

8.1.6 9430 (3 Channel Version) - Mode 5: One 2-Phase AC and One AC

Logical Instrument Configuration and UUT Wiring

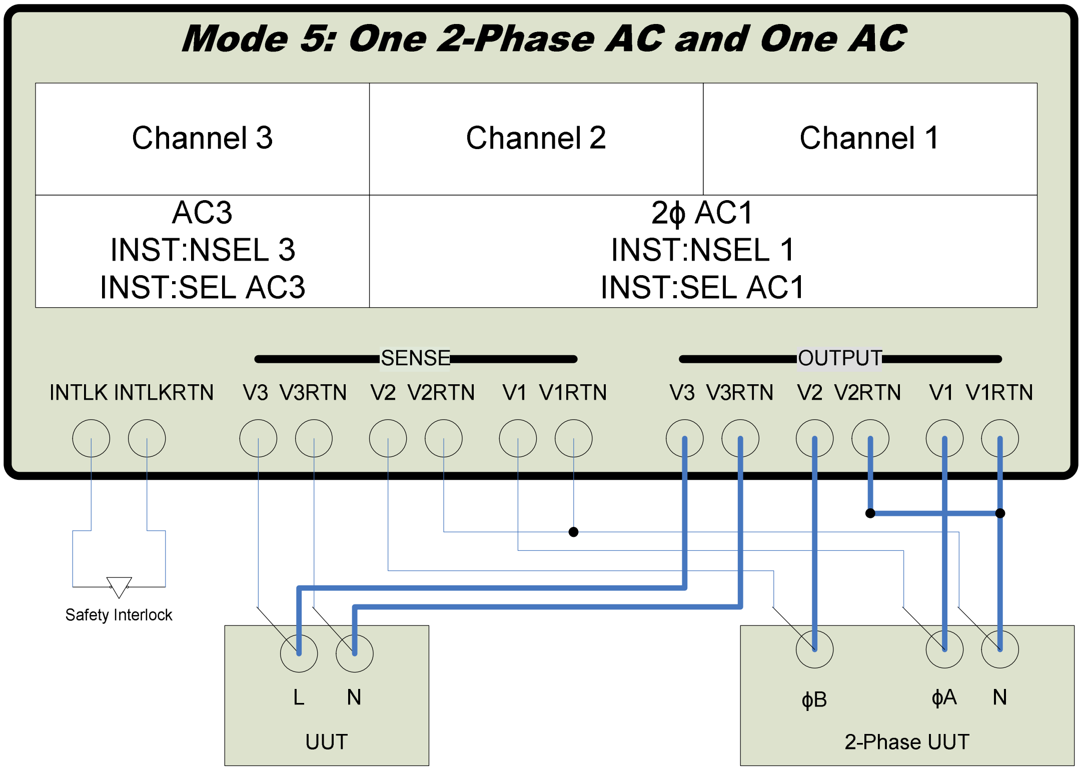


Figure 13 - Mode 5: One 2-Phase AC and One AC

Key Maximums for Each Logical Instrument

	Model							
AC1 (2-Phase)	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	250 Vrms Line-Neutral / 500 Vrms Line-Line							
Max Current / Phase	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current / Phase	3 X Maximum RMS Current							

AC3								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current	3 X Maximum RMS Current							

8.1.7 9430 (3 Channel Version) - Mode 6: One 2-Phase AC and One DC

Logical Instrument Configuration and UUT Wiring

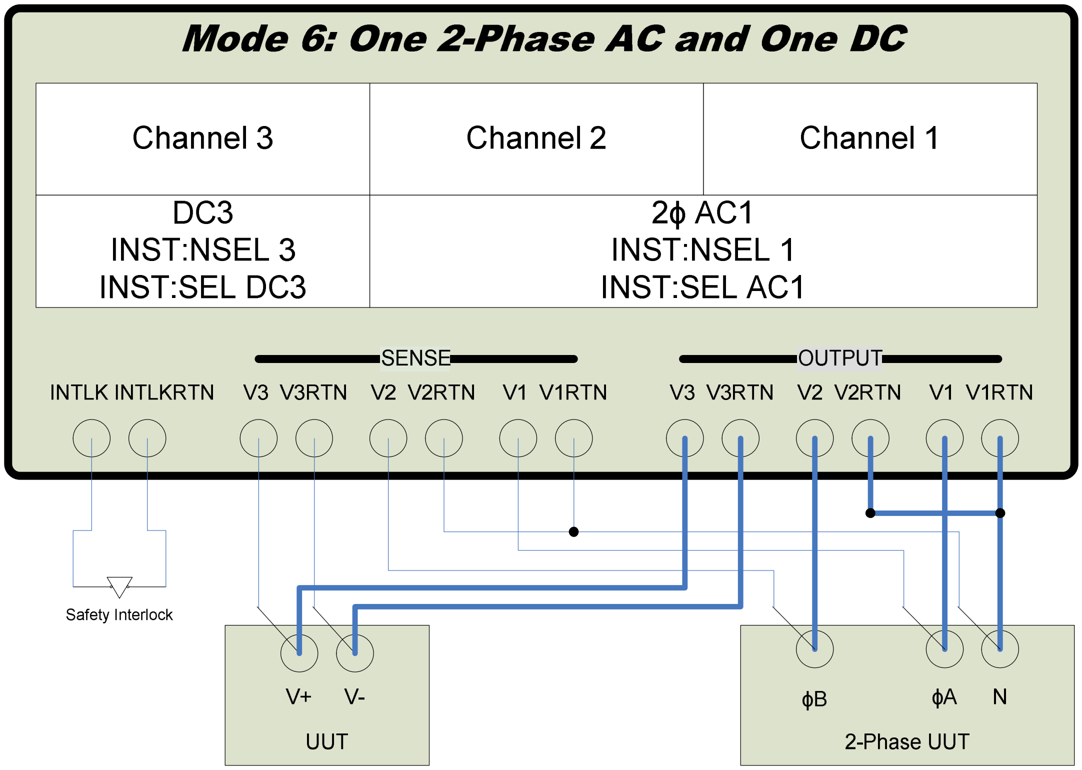


Figure 14 - Mode 6: One 2-Phase AC and One DC

Key Maximums for Each Logical Instrument

	Model							
AC1 (2-Phase)	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	250 Vrms Line-Neutral / 500 Vrms Line-Line							
Max Current / Phase	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current / Phase	3 X Maximum RMS Current							
DC3								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	400 VDC							
Max Current	30 A	60 A	90 A	120 A	150 A	180 A	210 A	240 A

8.1.8 9430 (3 Channel Version) - Mode 7: Two AC

Logical Instrument Configuration and UUT Wiring

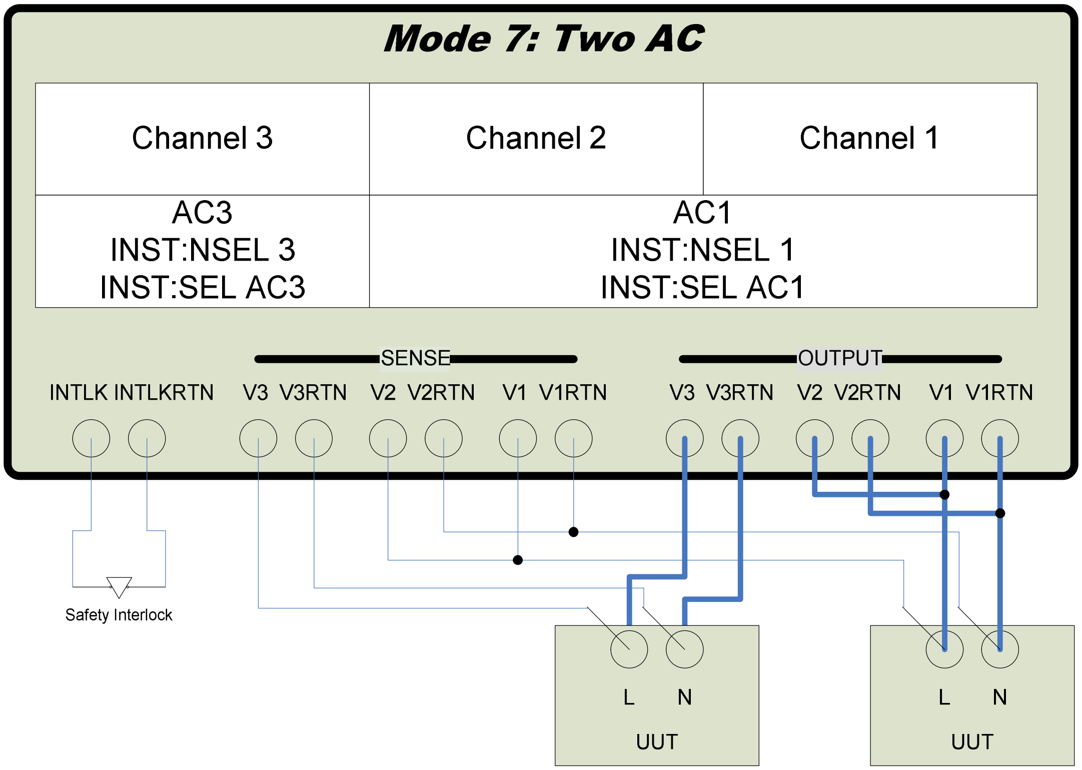


Figure 15 - Mode 7: Two AC

Key Maximums for Each Logical Instrument

	Model							
AC1	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	60 Arms	120 Arms	180 Arms	240 Arms	300 Arms	360 Arms	420 Arms	480 Arms
Peak Current	3 X Maximum RMS Current							

AC3								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current	3 X Maximum RMS Current							

8.1.9 9430 (3 Channel Version) - Mode 8: One AC and One DC

Logical Instrument Configuration and UUT Wiring

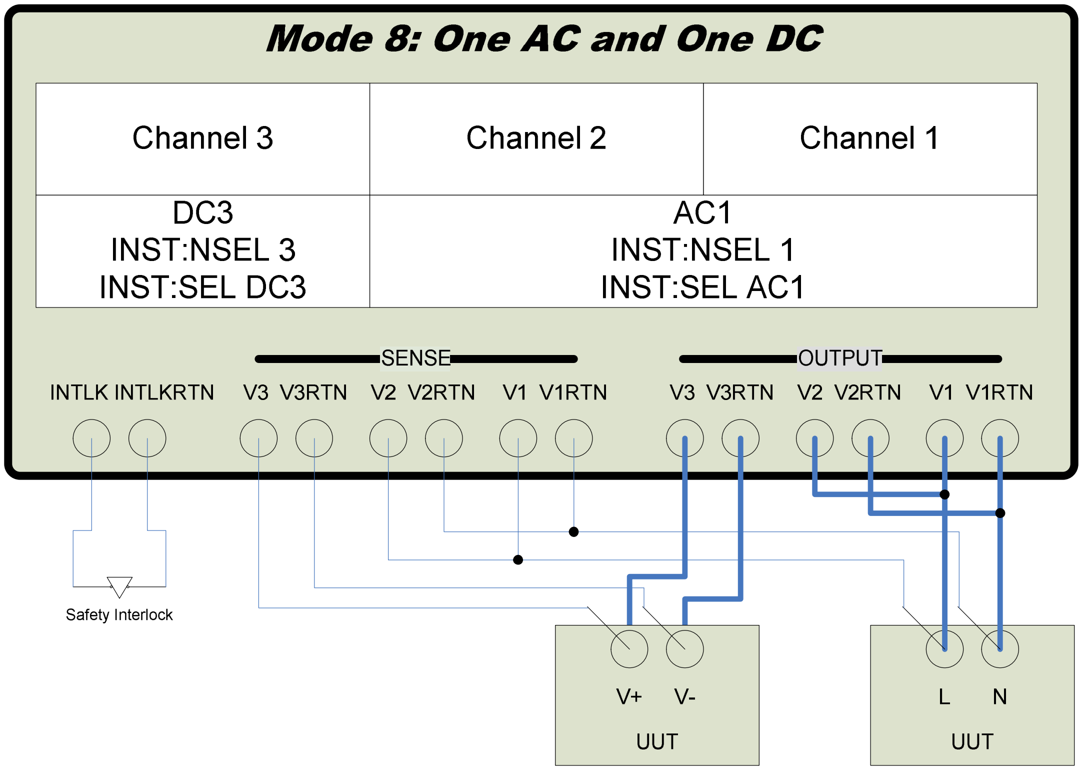


Figure 16 - Mode 8: One AC and One DC

Key Maximums for Each Logical Instrument

	Model							
AC1	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	60 Arms	120 Arms	180 Arms	240 Arms	300 Arms	360 Arms	420 Arms	480 Arms
Peak Current	3 X Maximum RMS Current							
DC3								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	400 VDC							
Max Current	30 A	60 A	90 A	120 A	150 A	180 A	210 A	240 A

8.1.10 9430 (3 Channel Version) - Mode 9: Two AC and One DC

Logical Instrument Configuration and UUT Wiring

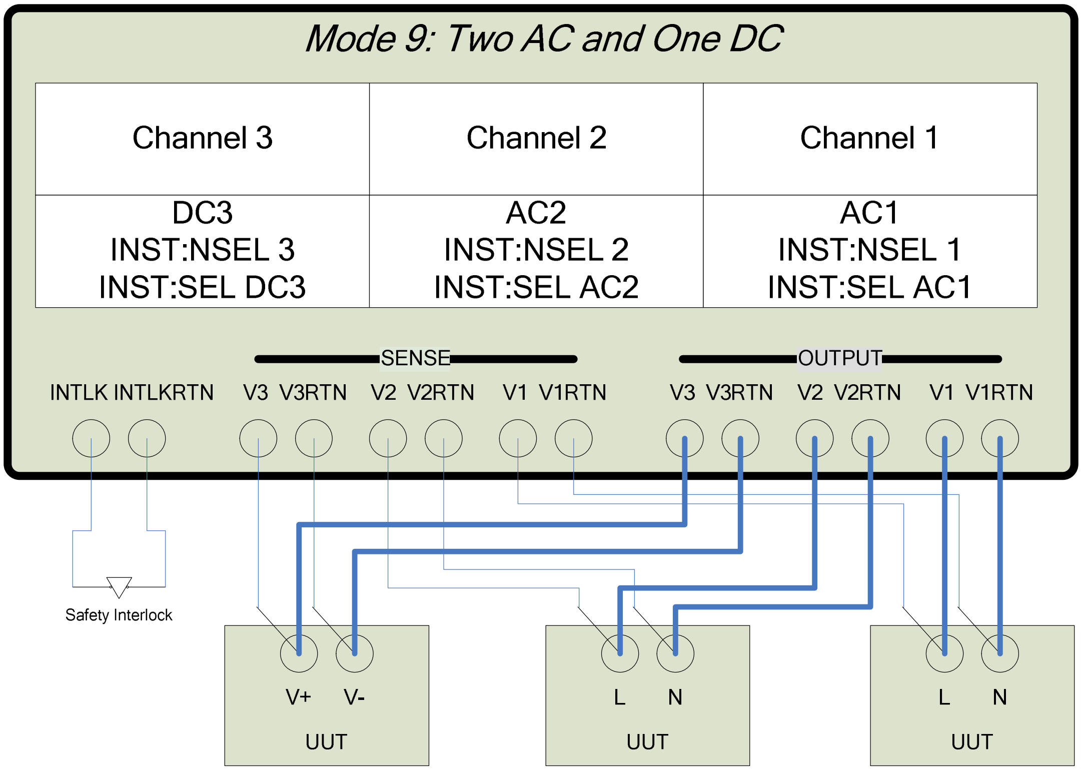


Figure 17 - Mode 9: Two AC and One DC

Key Maximums for Each Logical Instrument

	Model							
AC1	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current	3 X Maximum RMS Current							
AC2								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current	3 X Maximum RMS Current							
DC3								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	400 VDC							
Max Current	30 A	60 A	90 A	120 A	150 A	180 A	210 A	240 A

8.1.11 9430 (3 Channel Version) - Mode 10: One AC and Two DC

Logical Instrument Configuration and UUT Wiring

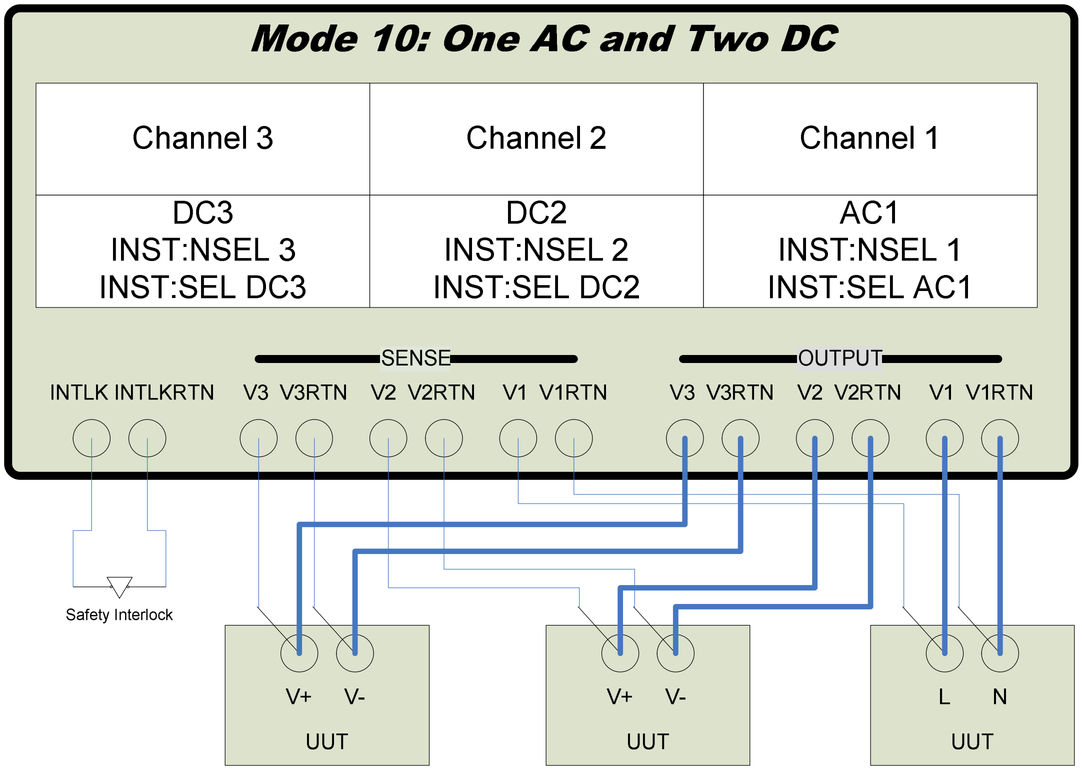


Figure 18 - Mode 10: One AC and Two DC

Key Maximums for Each Logical Instrument

	Model							
AC1	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current	3 X Maximum RMS Current							
DC2								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	400 VDC							
Max Current	30 A	60 A	90 A	120 A	150 A	180 A	210 A	240 A
DC3								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	400 VDC							
Max Current	30 A	60 A	90 A	120 A	150 A	180 A	210 A	240 A

8.1.12 9430 (3 Channel Version) - Mode 11: One DC and One AC

Logical Instrument Configuration and UUT Wiring

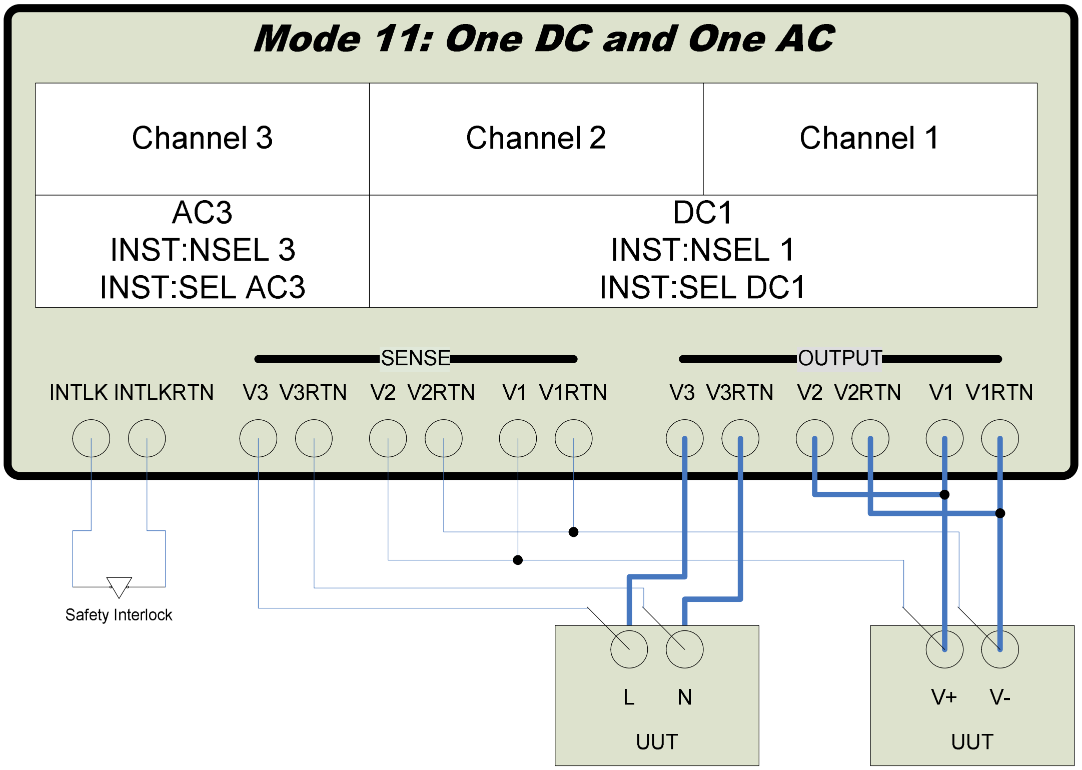


Figure 19 - Mode 11: One DC and One AC

Key Maximums for Each Logical Instrument

	Model							
DC1	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	400 VDC							
Max Current	60 A	120 A	180 A	240 A	300 A	360 A	420 A	480 A
AC3								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	350 Vrms Line-Neutral							
Max Current	30 Arms	60 Arms	90 Arms	120 Arms	150 Arms	180 Arms	210 Arms	240 Arms
Peak Current	3 X Maximum RMS Current							

8.1.13 9430 (3 Channel Version) - Mode 12: Two DC

Logical Instrument Configuration and UUT Wiring

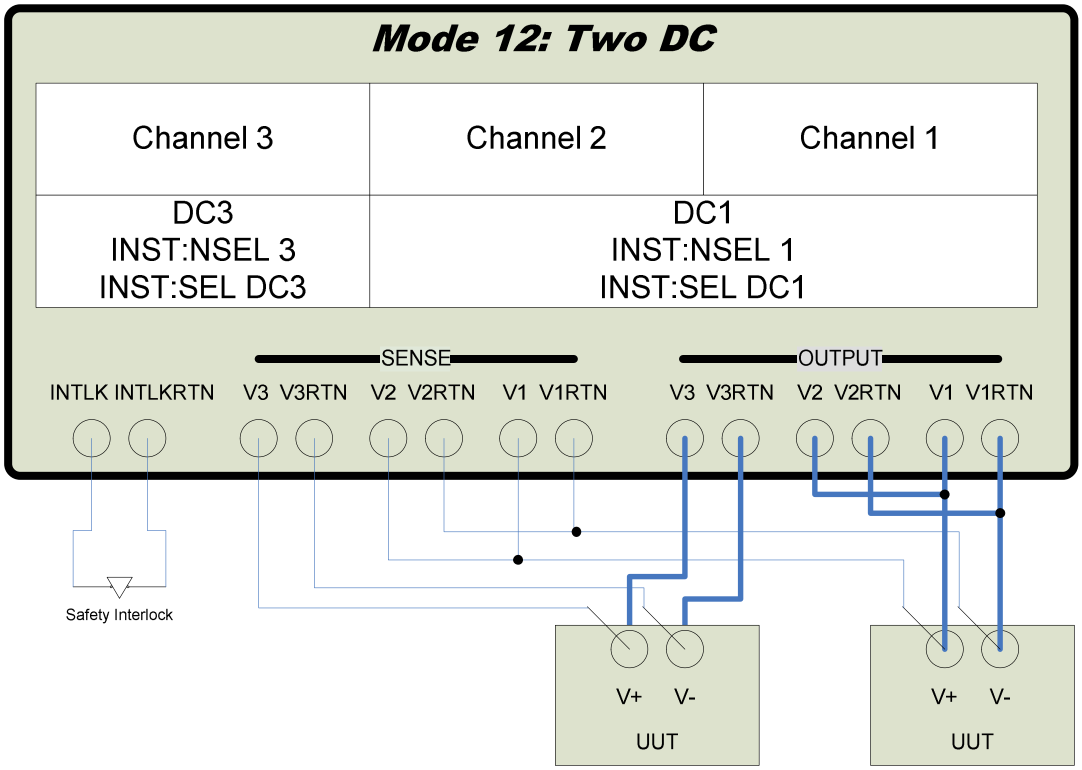


Figure 20 - Mode 12: Two DC

Key Maximums for Each Logical Instrument

	Model							
DC1	9430-12	9430-24	9430-36	9430-48	9430-60	9430-72	9430-84	9430-96
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	400 VDC							
Max Current	60 A	120 A	180 A	240 A	300 A	360 A	420 A	480 A
DC3								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	400 VDC							
Max Current	30 A	60 A	90 A	120 A	150 A	180 A	210 A	240 A

8.2 9430 Reduced Channel Models

NH Research manufactures two a reduced channel versions of the 9430 load.

The 9430-8 is a 8kW AC load which has 6 unique configurations.

Mode	*Available Instruments*	*Channel 1*	*Channel 2*
0	One 2-Phase AC	AC1 (Phase A)	AC1 (Assumes ϕA+ 180°)
1	One AC	AC1 (2x per channel power)	
2	One DC	DC1 (2x per channel power)	
3	Two AC	AC1	AC2
4	Two DC	DC1	DC2
5	One AC and One DC	AC1	DC2

The 9430-4 is a 4kW Regenerative single channel AC Load with 2 unique configurations.

Mode	*Available Instruments*	*Channel 1*
0	One AC	AC1
1	One DC	DC1

The following figures show the basic wiring for each mode.

8.2.1 9430-8 (2 Channel Version) - Mode 0: One 2-Phase AC

Logical Instrument Configuration and UUT Wiring

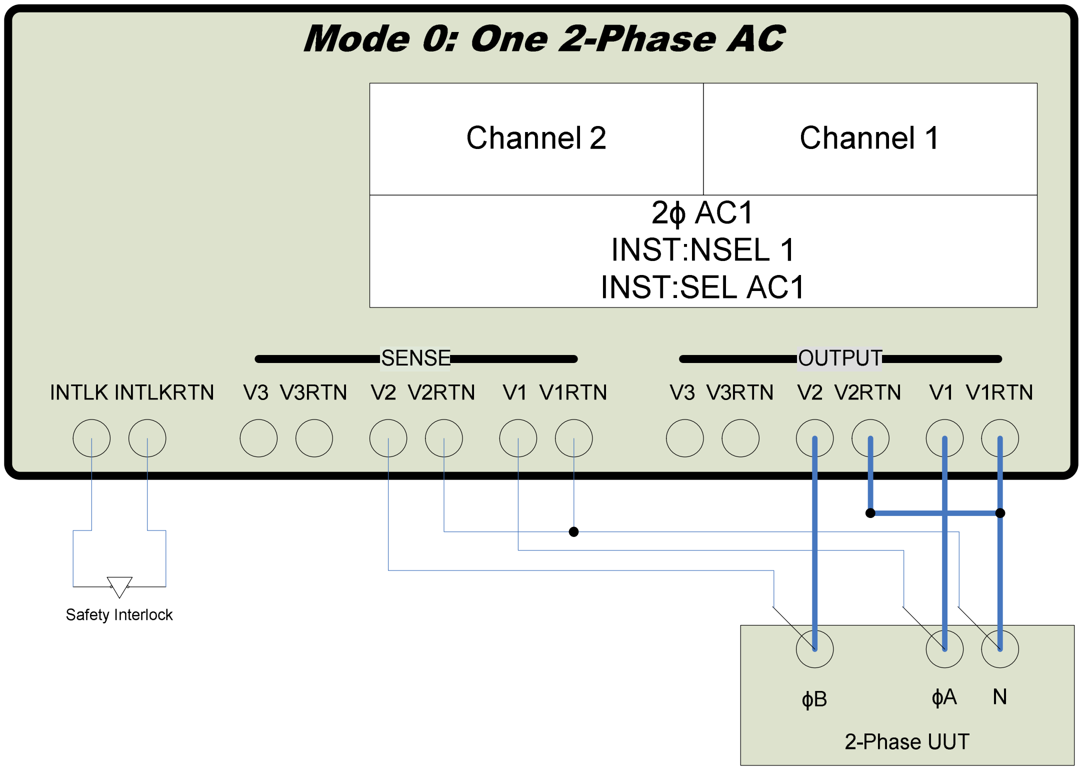


Figure 21 - Mode 0: One 2-Phase AC

Key Maximums for Each Logical Instrument

	Model 9430-8
AC1 (2-Phase)	
Max Power	8 kW
Max Voltage	250 Vrms Line-Neutral / 500 Vrms Line-Line
Max Current / Phase	30 Arms
Peak Current / Phase	3 X Maximum RMS Current

8.2.2 9430-8 (2 Channel Version) - Mode 1: One AC

Logical Instrument Configuration and UUT Wiring

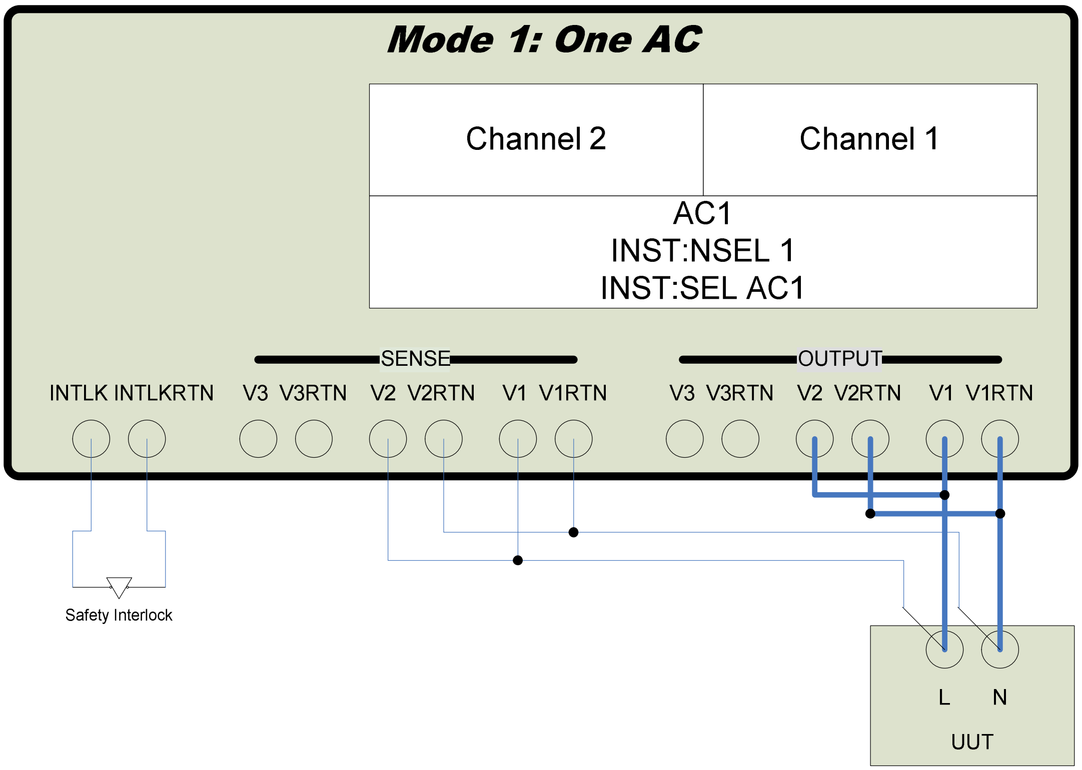


Figure 22 - Mode 1: One AC

Key Maximums for Each Logical Instrument

	Model 9430-8
AC1	
Max Power	8 kW
Max Voltage	350 Vrms Line-Neutral
Max Current	60 Arms
Peak Current	3 X Maximum RMS Current

8.2.3 9430-8 (2 Channel Version) - Mode 2: One DC

Logical Instrument Configuration and UUT Wiring

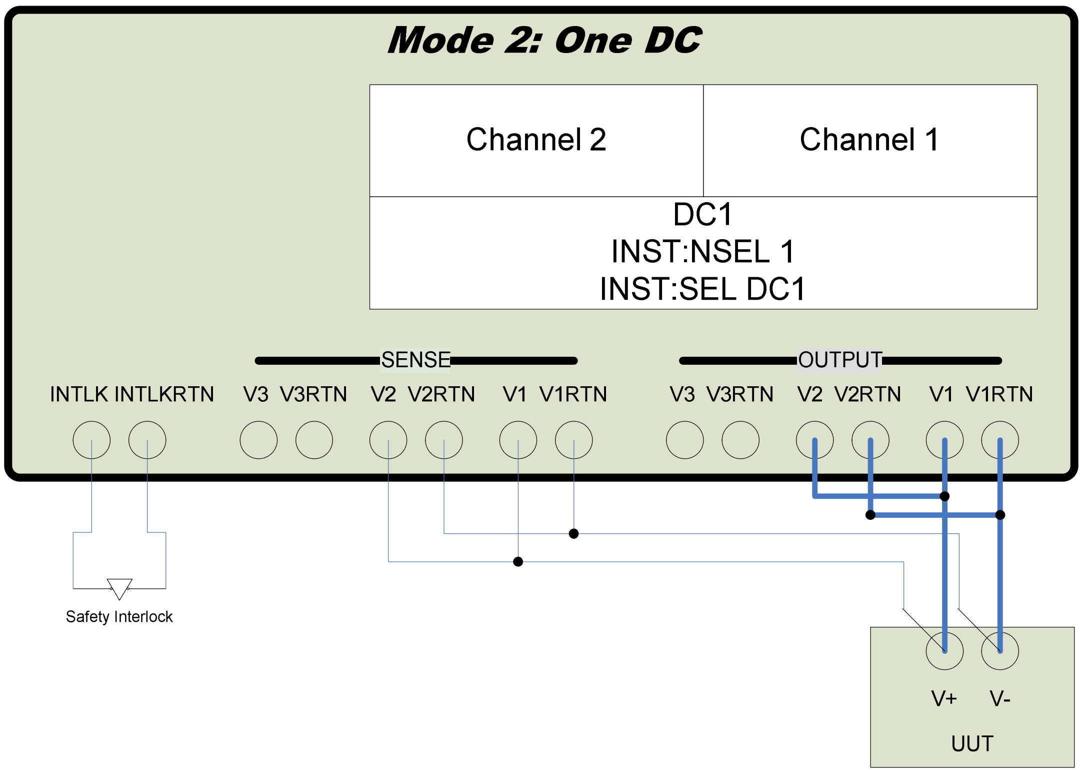


Figure 23 - Mode 2: One DC

Key Maximums for Each Logical Instrument

	Model 9430-8
DC1	
Max Power	8 kW
Max Voltage	400 VDC
Max Current	60 A

8.2.4 9430-8 (2 Channel Version) - Mode 3: Two AC

Logical Instrument Configuration and UUT Wiring

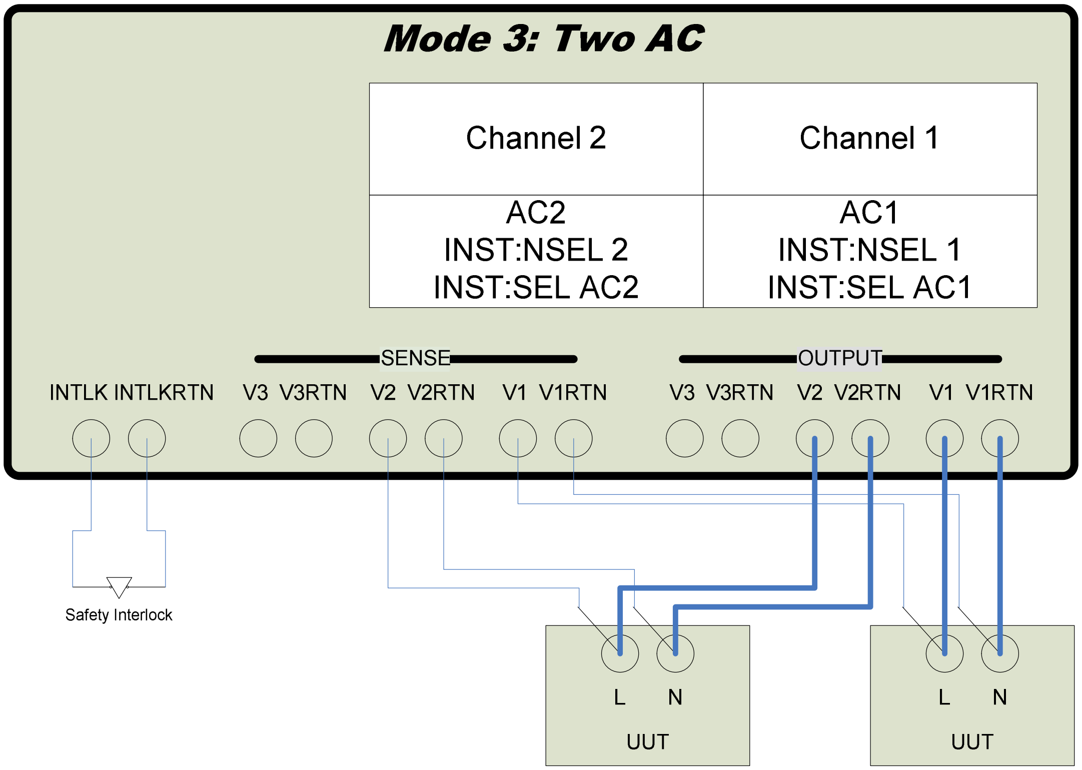


Figure 24 - Mode 3: Two AC

Key Maximums for Each Logical Instrument

	Model 9430-8
AC1	
Max Power	4 kW
Max Voltage	350 Vrms Line-Neutral
Max Current	30 Arms
Peak Current	3 X Maximum RMS Current
AC2	
Max Power	4 kW
Max Voltage	350 Vrms Line-Neutral
Max Current	30 Arms
Peak Current	3 X Maximum RMS Current

8.2.5 9430-8 (2 Channel Version) - Mode 4: Two DC

Logical Instrument Configuration and UUT Wiring

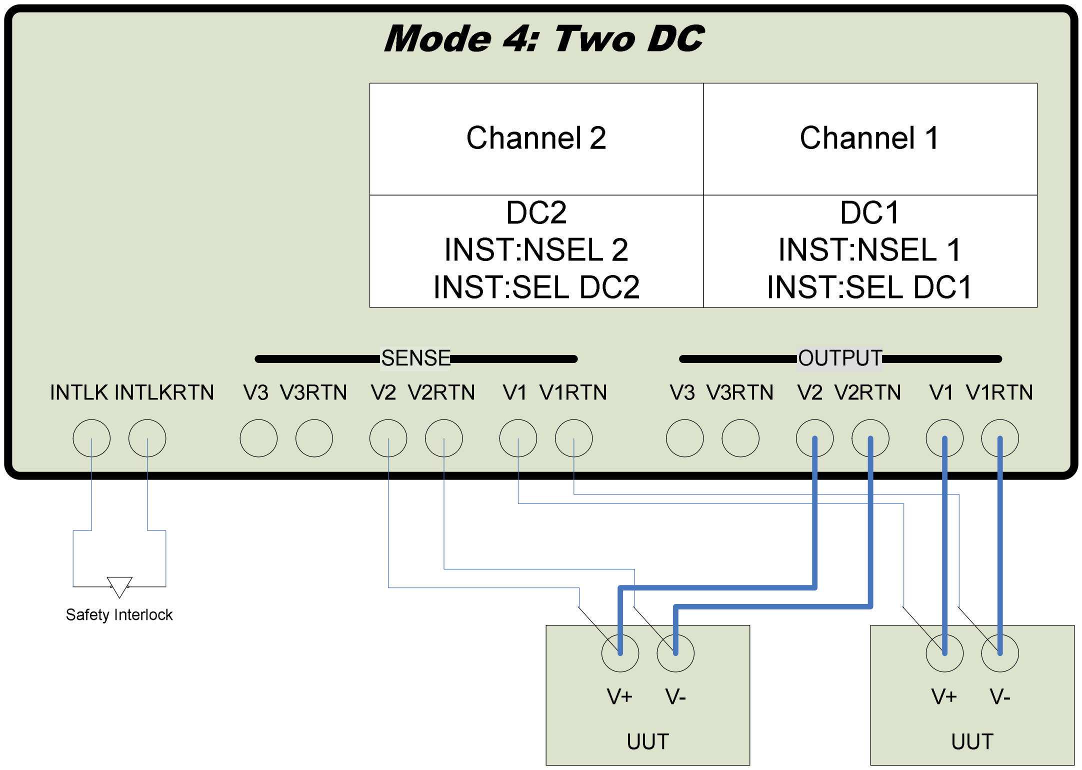


Figure 25 - Mode 4: Two DC

Key Maximums for Each Logical Instrument

	Model 9430-8
DC1	
Max Power	4 kW
Max Voltage	400 VDC
Max Current	30 A

DC2	
Max Power	4 kW
Max Voltage	400 VDC
Max Current	30 A

8.2.6 9430-8 (2 Channel Version) - Mode 5: One AC and One DC

Logical Instrument Configuration and UUT Wiring

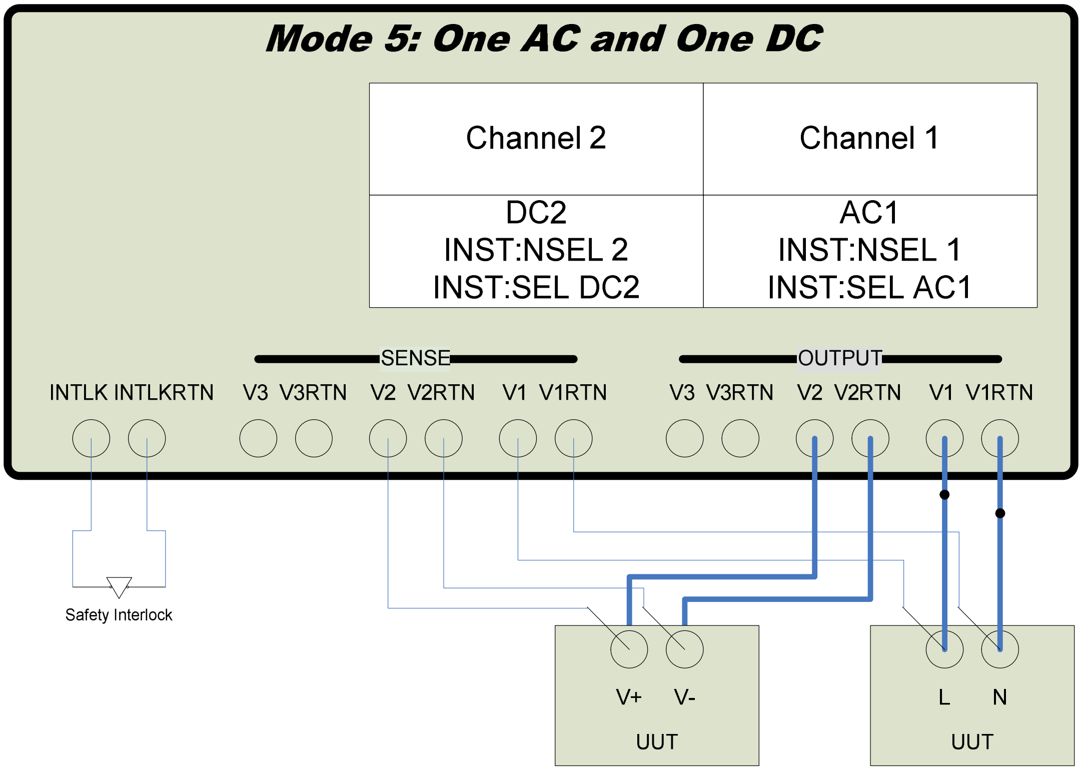


Figure 26 - Mode 5: One AC and One DC

Key Maximums for Each Logical Instrument

	Model 9430-8
AC1	
Max Power	4 kW
Max Voltage	350 Vrms Line-Neutral
Max Current	30 Arms
Peak Current	3 X Maximum RMS Current
DC2	
Max Power	4 kW
Max Voltage	400 VDC
Max Current	30 A

8.2.7 9430-4 (1 Channel Version) -Mode 0: One AC

Logical Instrument Configuration and UUT Wiring

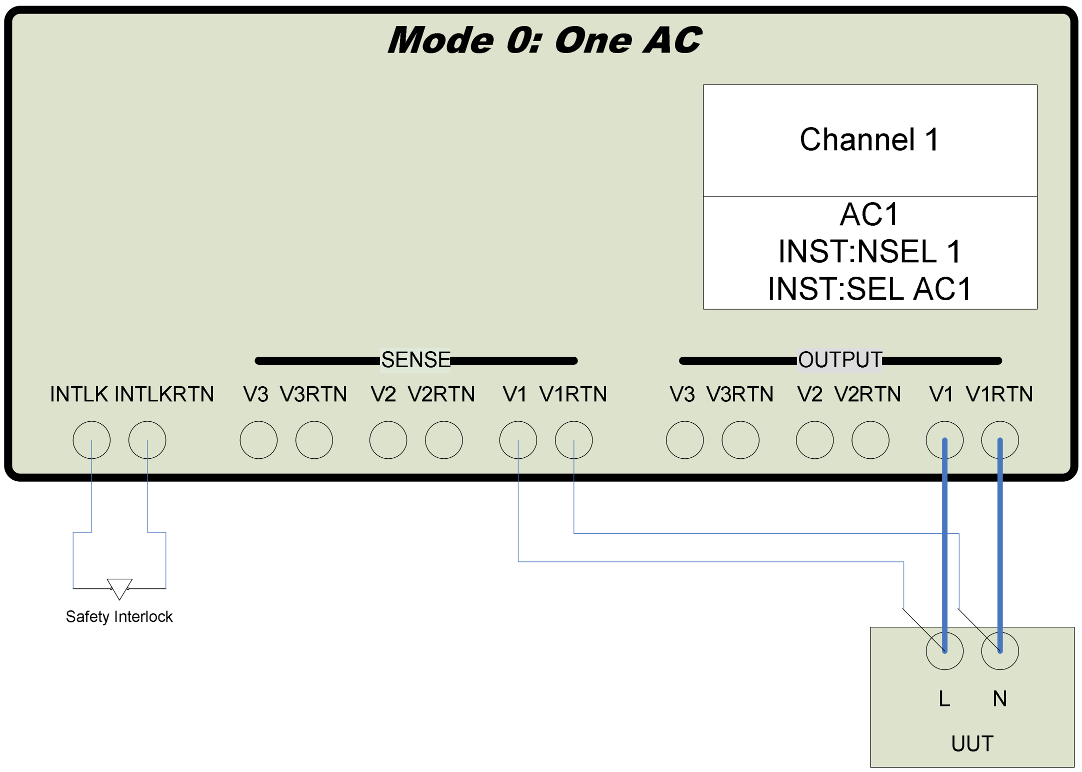


Figure 27 - Mode 0: One AC

Key Maximums for Each Logical Instrument

	Model 9430-4
AC1	
Max Power	4 kW
Max Voltage	350 Vrms Line-Neutral
Max Current	30 Arms
Peak Current	3 X Maximum RMS Current

8.2.8 9430-4 (1 Channel Version) -Mode 1: One DC

Logical Instrument Configuration and UUT Wiring

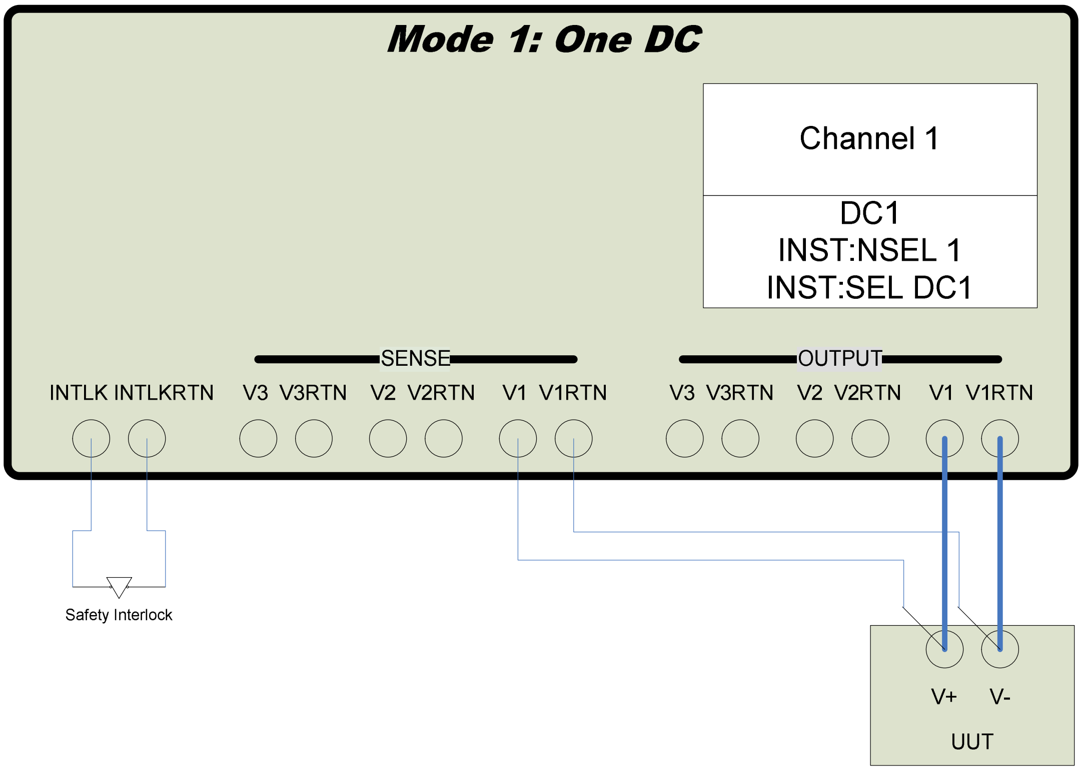


Figure 28 - Mode 1: One DC

Key Maximums for Each Logical Instrument

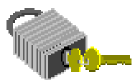
	Model 9430-4
DC1	
Max Power	4 kW
Max Voltage	400 VDC
Max Current	30 A

This page intentionally left blank.

9. SERVICE

9.1 Firmware Updates

There are three (3) separate processors and firmware levels which may periodically require NH Research to issue a firmware update. As such, it is important to understand what firmware is currently loaded on the system and which utility is needed to update the firmware. The following section is only a high level guide intended for NH Research support personnel or customers which have already performed a firmware update.



Discuss the firmware update process with NH Research customer support before attempting to perform an update.

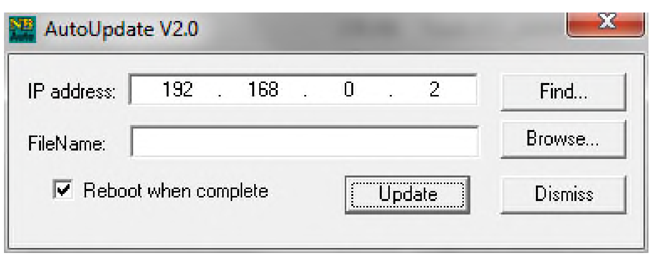
9.1.1 Updating the network processor

The network processor (also known as a netburner) provides the communication between the LAN interface and the internal processors. This processor is responsible for decoding the SCPI commands and converting them to the command interface used within the 9400.

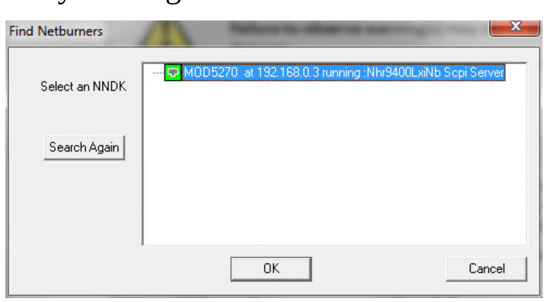
This processor is updated using AutoUpdate.exe which is generally found on the local PC which the 9400 Tools were installed.

Contact NH Research customer support if needed.

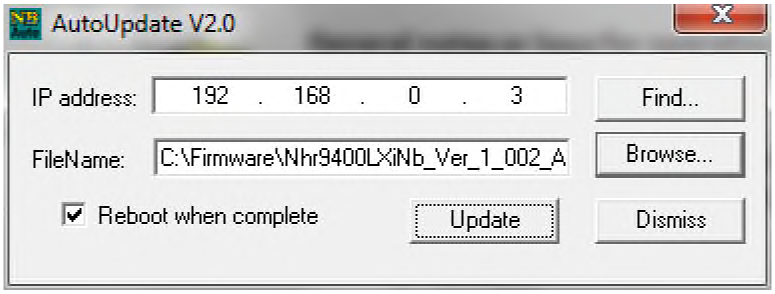
Step 1: Close all external applications and launch AutoUpdate.exe. When launched, AutoUpdate.exe will provide the following window.



Either provide the correct IP address or select “Find” to locate net-burner processors. The 9400 will show it is currently running Nhr9400LxiNb SCPI Server.

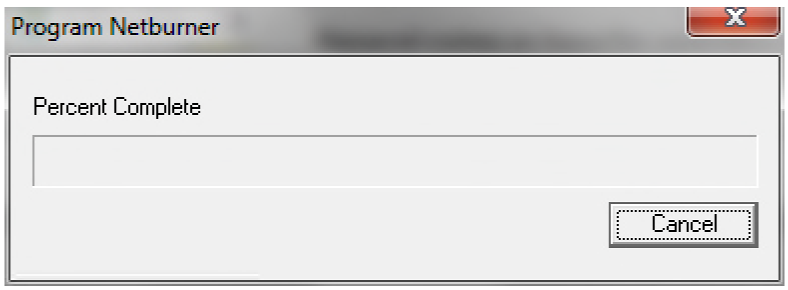


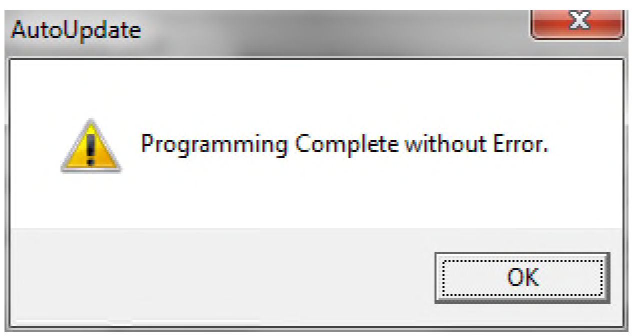
Step 2: Click Browse and locate the firmware file provided by customer support.



Step 3: Press Update

The utility will now show a progress bar and a programming complete message.





Step 4: Close the update utility and cycle power on the 9400.

9.1.2 Updating the Internal Processors

The following section is only a high level guide intended for NH Research support personnel or customers which have already performed a firmware update.

Before updating the firmware make sure:

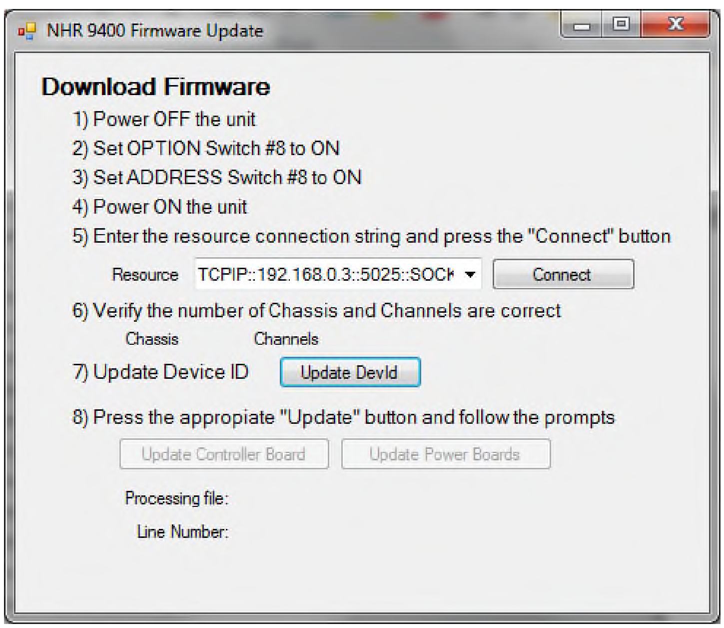
All external control programs are closed (including NHR 9400 Panel).
The system is powered off.

The firmware update utility can be found under:
Start → All Programs → NH Research → 9400 Series → NHR 9400 Firmware Update

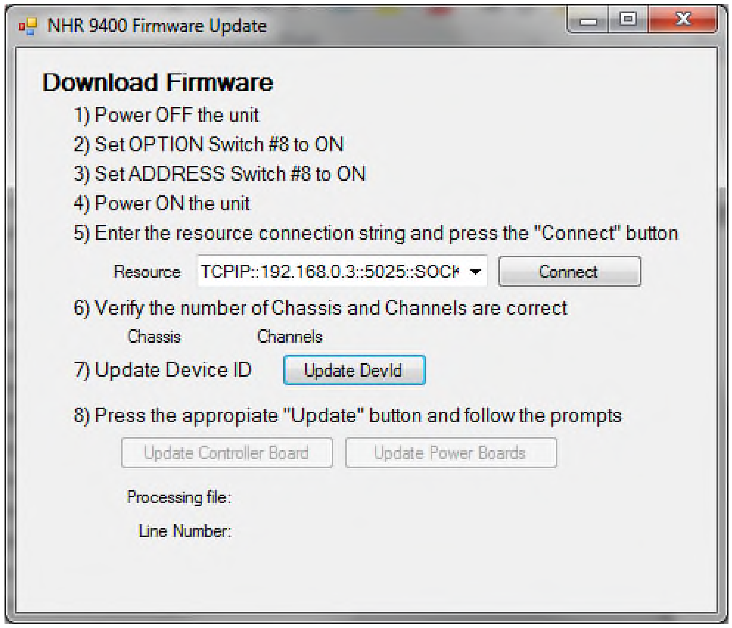
Or on the local hard drive under:
"C:\Program Files (x86)\NH Research\NHR 9400\Utilities\Nhr9400FwUpdate.exe"

When opened the program will instruct the user to take the following actions:

1. Power off the unit.
2. On the master set OPTIONS switch 8 to ON.
3. On the master and all auxiliaries set ADDRESS switch 8 to ON.
   (Do not change any of the other switches on the auxiliary modules).
4. Make sure the LAN cable is connected.
5. Power on the unit and start the firmware update utility.



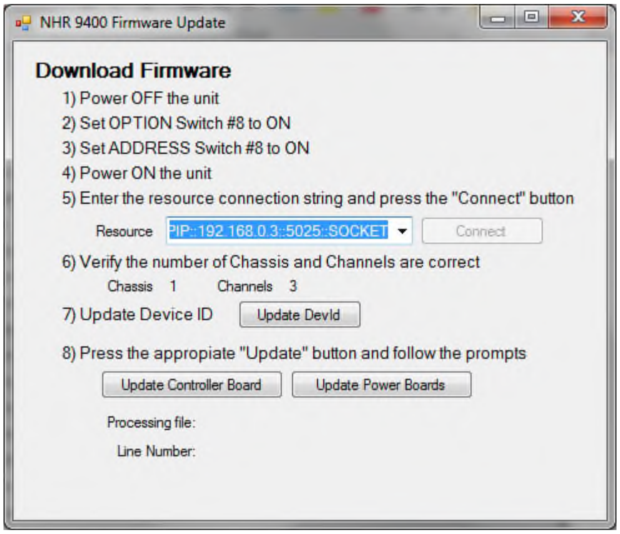
Next, enter the resource connection string in the form of "TCPIP::(ipaddress)::SOCKET" as shown below. The TCPIP address is of the master module which is specified on the back label or was changed using the "Configuring the master modules IP address" section as above.



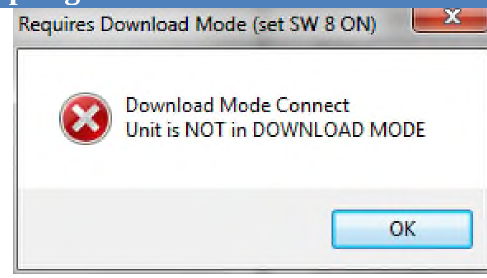
IP ADDRESS 192.168.0.3 used in example.
Be sure to use double colons in the resource ID string as shown.

Next, Press the connect button. The system will connect or display an error message: If error occurs, close the firmware update utility, correct the error and try again.

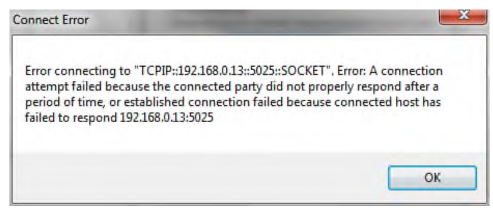
Possible outcomes when attempting to "Connect"



Ready to update firmware



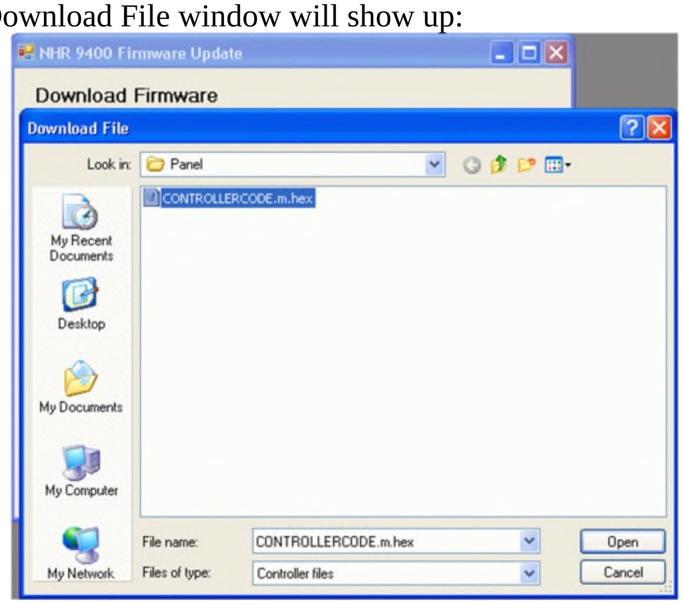
Error: Switches were not set properly



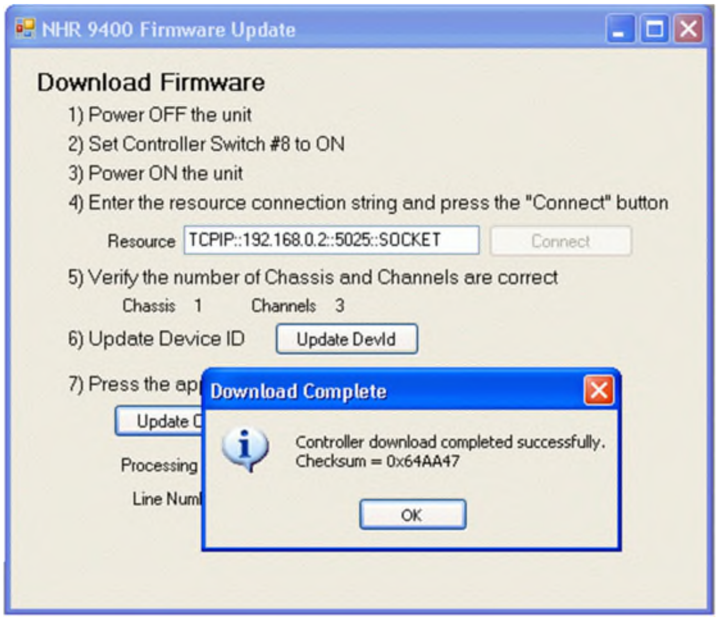
Error: Wrong IP address provided

The Device ID should not be modified. This is used for Factory identification only.

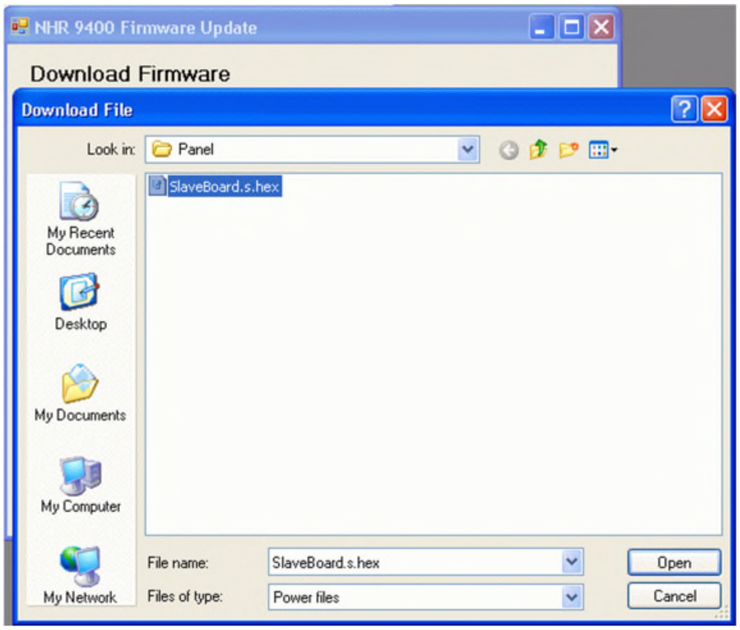
To update the controller board firmware, click the "Update Controller Board" button, the following Download File window will show up:



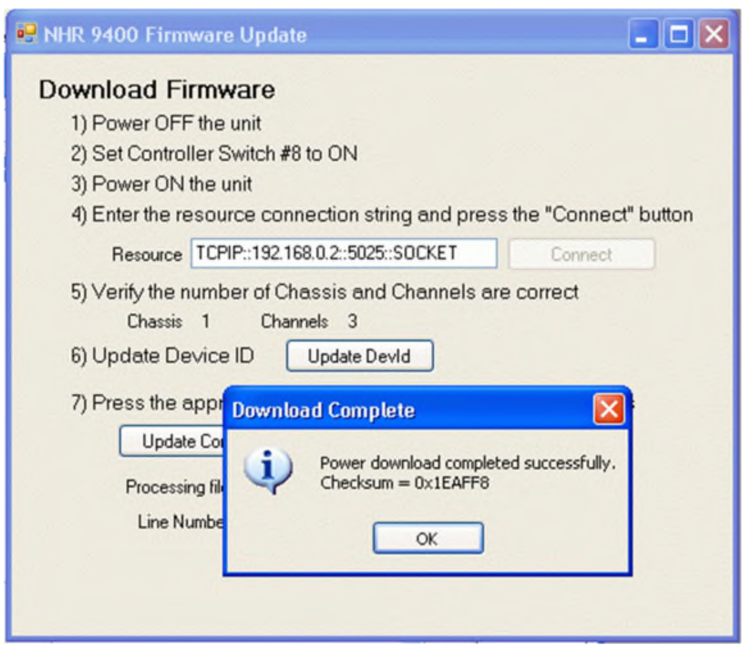
Browse to locate the firmware file provided by NH Research customer support (filename.m.hex) then select "Open". The entire process generally takes 1-2 minutes to download the controller board firmware. When complete, and if it is successful, a pop up window will say "Controller download completed successfully" as shown:


NHR 9400 Firmware Update
Download Firmware
1) Power OFF the unit
2) Set Controller Switch #8 to ON
3) Power ON the unit
4) Enter the resource connection string and press the "Connect" button
Resource
TCPIP::192.168.0.2::5025::SOCKET
Connect
5) Verify the number of Chassis and Channels are correct
Chassis 1
Channels 3
6) Update Device ID
Update DevId
Download Complete
Controller download completed successfully.
Checksum = 0x64AA47
OK

To update the controller board firmware, click the “Update Power Board” button, the following Download File window will show up:



Browse to locate the power board firmware file provided by NH Research customer support (filename.m.hex) then select “Open”. The entire process generally takes 1-2 minutes to download the controller board firmware. When complete, and if it is successful, a pop up window will say “Power download completed successfully” as shown:



Close the update utility, return all OPTION and ADDRESS switches #8 back to the OFF state and cycle power on the 9430 system. Do not change any other switches.

9.2 Periodic Maintenance

The following periodic maintenance schedule is recommended by NH Research and may need to be modified based on the environment or specific customer needs.

Cleaning: Semi-Annual (every 6 Months)

Calibration: Annually

9.2.1 Periodic Cleaning

Always turn off facility power to the 9430 before attempting to inspect or clean the system.

Failure to do so may result in a hazardous condition.

The 9430 should be inspected (externally) for dust buildup in the air intakes (front) and the exhaust fans (rear). Cleaning of the system should only be performed with facility power turned off. The exterior of the system may be cleaned with a cloth dampened with a mild detergent. Ensure the cloth is wrung out to prevent excess moisture from being left inside the unit.

Ensure any residual moisture is completely dry before reconnecting facility power or attempting to use the system.

Compressed air may be used to remove dust from the front and rear of the unit.
Do not allow the rear fans to spin at high speed when using compressed air.

The touch panel should only be cleaned with laptop or LCD cleaning wipes. Do not attempt to use detergent on the screen as it will damage the touch interface.

Do not open the system to clean internal components.

9.2.1 Periodic Calibration

NH Research recommends an annual calibration cycle. A utility is provided allowing a customer or external calibration laboratory to perform the calibration. Otherwise, contact NH Research customer support to discuss options for NHR personnel to perform the calibration on-site.

The calibration utility can be found under:
Start → All Programs → NH Research → 9400 Series → NHR 9400 Calibration.

Or on the local hard drive under:
"C:\Program Files (x86)\NH Research\NHR 9400\Utilities\Nhr9400Cal.exe".

Refer to NHR 9400 Calibration Manual (NHR P/N: 09-0347) for more information.

9.2.2 SCPI Programmers Reference

Refer to NHR 9400 Programmers Reference (NHR P/N: 09-0335) for more information.

10. ERROR CODES

10.1 Command Errors (-100 to -199)

Index #	Error Phrases	Description, Possible Reasons
-100	Command error	This indicates a syntax error, or a semantic error, or a GET command was entered, see IEEE 488.2, 11.5.1.1.4.
-102	Syntax error	Indicates that an unrecognized command or data type was encountered. For example, a string was received when the device does not accept strings.
-108	Parameter not allowed	Indicates that more parameters were received than expected for the header. For example, *ESE common command only accepts one parameter, so *ESE 0, 1 is not allowed.
-109	Missing parameters	Indicates that less than required parameters were received for the header. For example, *ESE requires one parameter, *ESE is not allowed.
-114	Header suffix out of range	Indicates the value of a header suffix attached to a program mnemonic makes the header invalid.
-151	Invalid string data	Indicates that a string data element was expected, but was invalid, see IEEE 488.2, 7.7.5.2. For example, an END message was received before the terminal quote character.
-171	Invalid expression	Indicates the expression data element was invalid, see IEEE 488.2, 7.7.7.2. For example, unmatched parentheses or an illegal character.
-180	Macro error	This error, as well as error -181 through -189, is generated when defining a macro or execution of a macro. This particular error message is used if the device cannot detect a more specific error.
-181	Invalid outside macro	Indicates that a macro parameter place holder was encountered outside of a macro definition.

10.2 NHR Common Device Errors (-1200 to -1299)

Index #	Error Phrases	Description, Possible Reasons and fixes
-1291	Grid over temperature	The Grid Board is over temperature. This is very rare unless the cooling fan stops working.
-1292	Hardware reset error	There is an unexpected restart of the DSP controller. This is very rare, normally caused by internal housekeeping problem or AC line fluctuation.
-1293	Macro Queue Full	Macro command buffer is full when there are more macro commands waiting to be learned. User needs to limit the total number of macro commands to less than 79 commands.
-1294	Range error	A command is received with its parameter out of the setting [min, max] range.
-1295	Mode error	A command is received without its prerequisite (Mode) set. For example, A Macro command is received without setting the Macro Mode to *Macro Learn*; A write calibration to flash command is received without setting the Write Cal Mode to *Write Cal Start.*
-1296	Command Error	The command is not recognized.
-1297	Interlock	The interlock connector (supposed to be shorted) is open when the user tries to turn on any channels. User should double check the wiring on the interlock connector.
-1298	Calibration Checksum Error	The calibration data saved in Flash has been corrupted. The system will not use the stored data, and instead, will use the default data. This will not affect the function of the system. However, this will affect the accuracy of the measurement.

Note: This group of errors does not require a *RESET command to clear error, a *CLS command (clear error command) will clear the error.

10.3 NHR Channel Device Errors (-1300 to -1399)

Index #	Error Phrases	Description, Possible Reasons and fixes
-1385	Energy star range error	This error will only apply to 9420. When the user tries to make an energy star measurement, if the actual current is higher than the energy star measurement circuit capacity, this error will flag. For example, if there is a 3A output current, the user didn’t realize and wants to use the 0.1A range energy star measurement circuitry to measure the current, in order to protect the circuit, the system will disallow the command and will raise an Energy star range error.
-1386	DC bus out of spec	This error will only apply to 9410DC and 9420DC configuration. If the 9410DC/9420DC system is connected to high-voltage equipment (Source, battery, capacitor or etc.) and its voltage is 10% over the current voltage range setting, this error will flag. In some cases this error indicates that the selected mode does not match the wiring, refer to section “94xx Hardware Modes” in the user’s manual and verify the selected mode and wiring.
-1387	Sink over power trip	When the Safety trip – OP Sinking is set and enabled (trip time >= 0), and when the output power is greater than the setting for a certain time, this error will flag. Or, if the output RMS is greater than the absolute hardware limit for a short amount of time, this error will flag. Here, Sinking means power flow direction
-1388	Sink over current trip	When the Safety trip – OC RMS Sinking is set and enabled (trip time >= 0), and when the output current RMS is greater than the setting for a certain time, this error will flag. Or, if the output RMS is greater than the absolute hardware limit

		for a short amount of time, this error will flag. Here, Sinking means power flow direction.

-1389	Under voltage trip	When the Safety trip - Under Voltage (RMS) is set and enabled (trip time >= 0), the output voltage RMS is monitored, when the channel is on and output voltage is less than the setting for a certain time, this error will flag.
-1390	Sense error	This error is normally caused by mis-wiring of the sense lead. The user could forget to connect the sense wire or reversed the sense leads.
-1391	Load High-Z error	This error only applies to 9430 Load. If the 9430 load is connected to a soft source, the control loop conflict could cause the source to oscillate. This is undesirable and could cause further damage to the system or UUT. The High-Z means the source has high impedance (or too soft). This error shows up more often in controller board firmware version 6.370 and previous. After version 6.372, it allows more ringing on the source. Recommend to upgrade firmware to 6.372 or later if user sees this problem.
-1392	Source over Power trip	When the Safety trip – OP Sourcing is set and enabled (trip time >= 0), and when the output power is greater than setting for a certain time, this error will flag. Or, if the output RMS is greater than the absolute hardware limit for a short amount of time, this error will flag. Here, Sourcing means power flow direction.
-1393	Source over current trip	When the Safety trip – OC RMS Sourcing is set and enabled (trip time >= 0), and when the output current RMS is greater than setting for a certain time, this error will flag. Or, if the output RMS is greater than the absolute hardware limit for a short amount of time, this error will flag. Here, Sourcing means power flow direction.

-1394	Over Voltage Trip	When the Safety trip - Over Voltage (RMS) is set and enabled (trip time >= 0), the output voltage RMS is monitored, when over the setting for a certain time, this error will flag.
-1395	Internal Over temperature error	System internal over temperature error is very rare unless the cooling fan stops working or the ambient temperature is too high.
-1396	Out of regulation	N/A in 9400 series.
-1397	Range error	A command for a channel is received with its parameter out of the setting [min, max] range.
-1398	Mode pre-requisite not set	A command for a channel is received without its prerequisite (Mode) set. For example, try to select a user waveform when the channel is configured to be DC output; Try to re-configure the channel when it is still on.

Note: This group of errors does not require a *RESET command to clear error, a *CLS command (clear error command) will clear the error.

This page intentionally left blank.

11. DEVICE ERRORS REQUIRE RESET TO CLEAR (100 TO 199)

Index #	Error Phrases	Description, Possible Reasons and fixes
101	Watch dog error	This error is normally caused by several reasons: 1 - Drop of the Ethernet cable. Check the Ethernet cable to the front monitor or from back of the Ethernet plug to computer or other systems. 2 - The internal DSPs or Micro controllers hang for some reason. Recycle power to clear error.
102	Emergency Off	Each 9400 Chassis, either the master or aux, has an E_OFF terminal block at the back panel under the fan. Pin1-2 of the terminal block needs to be shorted. Otherwise, system will not turn on and will show an "Emergency off error". In 9400-12, check the jumper wire at E-OFF terminal to see if it is loose. In 9400-24 and up, check if the E-OFF button has been pushed, or if the wire in the E-OFF terminal block is loose.
103	Can bus error	The 9400 system uses CAN BUS internally for inter-boards communication. This error shows the DSP controller has a problem talking to one or more of the power boards due to bus congestion or noise. This is very rare and normally only happens at 9400 Calibration stage.
104	Input AC OV	This error implies that the 9400 system sees a high input grid AC voltage. To protect itself, it will turn off the system and wait for a RESET command. This is normally cause by grid voltage fluctuation.

105	Input AC DUV	This error implies that the 9400 system sees the input grid AC voltage drop below its required minimum. To protect itself, it will turn off the system and wait for a RESET command. This is normally cause by two reasons: 1 - Other error in this table happened first that causes the system to turn off and open grid relays, the AC voltage sense will lose its input and raise an error. In this case, this error is just a by-product of other errors. 2 - Grid voltage fluctuation.
106	Grid turn on error	This error normally is caused by the user turning on-off the system too often, thus the soft start resistors (with is PTC resistor) is too hot and needs to wait 5-10 minutes until the resistors cool down. If the user did not recycle power too often and still sees this error, there might be not enough grid voltage (need at least 360VL-L to turn it on).
107	Grid over voltage	The 9400 system has an 800V DC bus internal, the DC Bus has capacitor bank store energy to handle power transient. This error typically shows that there is a high power transient than the capacitor bank can handle, so the voltage on the cap bank rise above a certain safety threshold. For example, a user connects 9410-12kW to an inverter and a load. Initially the load draws 12kW power from the 9410, and instantly, the load stops drawing power and the inverter starts to source 12kW power back to the 9410. This will cause a

		24kW instant power change. Before the control loop can react to it, the cap bank has to absorb the energy. If it can't, the voltage on the cap bank will rise and trip the error.
108	Grid voltage drop out	The 9400 system has an 800V DC bus internal, the DC Bus has capacitor bank store energy to handle power transient. This error shows that the 800Vdc has dropped below 700V. This could be caused by a couple reasons: 1 - Other error in this table happened first that causes the system to turn off, the 800VDC will slowly drop under 700V and raise an error. In this case, this error is just a by-product of other errors. 2 - There might be a high power transient similar to error code 107, that the cap bank can't handle and internal voltage dropped.
109	Grid over current	This error implies that the 9400 input AC side sees an over current. This error is very rare, and may be caused by several reasons: 1 - A noise caused the measurement circuitry to have a false trip. 2 - A line voltage fluctuation. 3 - If the error consistently shows up even at system power up, shows there might be a hardware issue with the grid board current sense circuitry. For example, a capacitor is shorted. The board needs to be sent back for repair or field service.
110	Grid frequency error	The 9400 series system monitors the input grid frequency and makes sure it follows

		the IEEE 1547 standard. If it sees the frequency outside the standard, it will raise this error and wait for a RESET. This error is rare and is normally caused by an unstable or fluctuation of grid.
111	Configuration Error	This error normally shows up in multi-chassis system when the Address DIP-Switch did not set right. At each 9400 chassis (either master or aux), there is an Address DIP Switch at the back panel under the fan. Each chassis needs to set to the right address. Master address is 0; Aux address starts from 1 then 2…. For example, if a customer has a 9410-96kW. The Master address should be 0; Aux Address should be 1-7. However, if a customer took out Aux5 and sent it back for repair without adjusting the Address DIP Switch, the controller will see Aux6 and Aux7, but it will not see Aux5 thus it will report a configuration error. In this case, adjust the Address DIP Switch Aux7 to Aux5 so the controller will see Aux1-6. System will be reconfigured as 9400-84kW.
112	Grid hardware inhibit	This error could be a by-product of Emergency-OFF error. If there is no E-OFF error, it could imply the 9400 grid board has a housekeeping voltage drop out issue. This is rare, probably caused by noise. If this keeps happening and RESET doesn’t fix the issue, it needs to be sent back for repair.
113	Internal voltage drop out	Each channel of the 9400 system has 540V DC bus internal, the DC Bus has capacitor bank to store energy to handle power transient. This error shows the internal voltage has dropped under 450V. Possible reasons are:

		1 - Other error in this table happened first that causes the system to turn off. The 540VDC will slowly drop under 450V and raise an error. In this case, this error is a by-product of other errors. 2 - There might be a high power transient in this channel that the cap bank can’t handle and dropped internal voltage.
114	Internal voltage over voltage	Each channel of the 9400 system has 540V DC bus internal, the DC Bus has capacitor bank store energy to handle power transient. This error shows this internal voltage has risen over 600V. This error typically shows that there is a higher power transient than the capacitor bank can handle, so the voltage on the cap bank will rise above a certain safety threshold. For example, a user connects 9410-12kW to an inverter and a load. Initially the load draws 12kW power from the 9410, and instantly, the load stops drawing power and the inverter starts to source 12kW power back to the 9410. This will cause a 24kW instant power change. Before the control loop can react to it, the cap bank has to absorb the energy. If it can’t, the voltage on the cap bank will rise and trip the error.
115	Internal DC-DC error	This error shows one of the UUT board cannot be properly turned on. If there are no other errors, this normally shows the board has a problem and it needs to be sent back and repaired.
116	Peak over voltage trip	This error implies that one of the channels sees a Peak over Voltage (540V). There might be several reasons: 1 - If the UUT has fair amount of

		inductance and a sudden open of UUT relay might cause a back-kick of the voltage. The 9400 systems see the voltage and will open relay to protect itself. 2 - There might be a control loop conflict between 9400 systems and the UUT, which may cause the output voltage to oscillate (ring). When this happens, the peak voltage might trigger this protection.

117	Peak over current trip	This error implies that one of the channels sees a Peak over current. The over current can be set at safety trip or if not, is 100A per channel per chassis by default. For example, a 9410-24 is configured 3-phase AC. It has a default PK current trip of 200A per phase by default. If it is configured single phase, it has a 600A PK current trip by default. This is probably one of the most frequently shown errors. Reasons for this error includes: 1 - The UUT has a high inrush current that triggered the protection. The high inrush current is normally caused by some internal caps that have to be charged up. Possible solution: an external soft start circuit (normally involves resistor and relay) is required. 2 - There might be a short circuit somewhere the user isn’t aware in the UUT or somewhere along the cable. Or the UUT is actually trying to draw a high current under certain conditions. 9400 system is trying to protect itself in this case. 3 - There might be a false trip due to

		the protection circuit false alarm caused by noise or failure of circuitry. If it keeps happening and *RESET command cannot clear the issue, it needs to send back for repair.

118	Internal PK over current trip	This error shows that the 9400 system internal DC/DC circuitry current protection tripped. This error is rare and there are several reasons: 1 - Sometimes a noise could cause trigger a false error; the *RESET command should clear it. 2 - Sometimes a high power transient could cause the internal voltage to fluctuate very fast, and the fluctuation could cause the internal current to trip. This is the circuitry trying to protect itself. 3 - There might be some hardware failure in the circuitry.
119	Hardware Inhibit error	This error could be a by-product of Emergency-OFF error; Or, if there isn’t an E-OFF error, it could imply the 9400 UUT boards have a housekeeping voltage drop out issue. This is rare, probably caused by noise. If it keeps happening and the RESET doesn’t fix the issue, it needs to be sent back for repair.

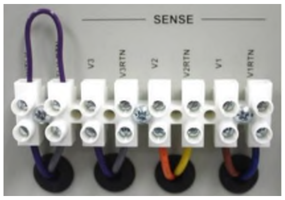
Note: All errors in this group need a *RESET command to clear.

This page intentionally left blank.

12. FATAL ERRORS THAT REQUIRE SERVICE (200 TO 299)

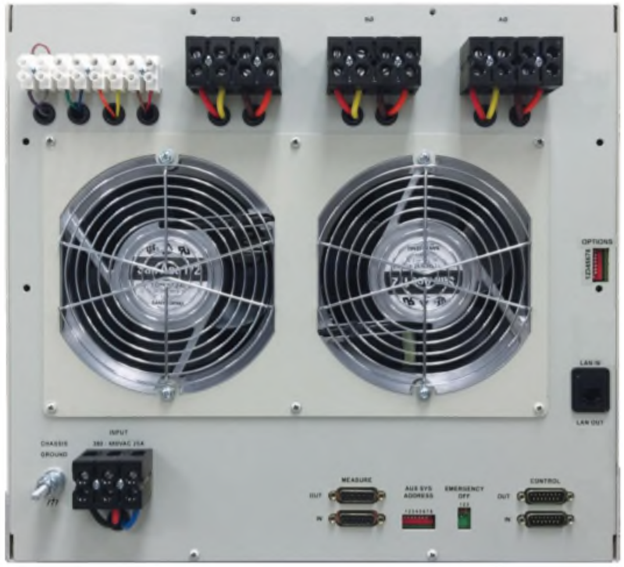
Index #	Error Phrases	Description, Possible Reasons and fixes
201	Firmware error	These error shows the firmware stored in flash is either corrupt or does not match the firmware version for each other. Need to re-download the firmware.
203	Slave firmware do not match	
204	Slave firmware error	
207	Controller Device number error	
208	Power board (slave) device number error	
209	No chassis error	One or more boards are not detected or the address of the chassis is set wrong. Need to use the statusmonitor.exe for further details.
210	No channel error	
211	Bad configuration error	

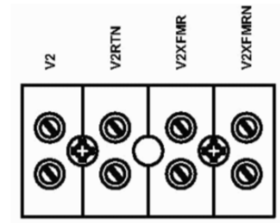
13. LEGACY UUT AND POWER INTERFACE CONNECTORS



The interlock and sense connection are made on the rear of the master module located within the cabinet.

Small Flat Head Screw



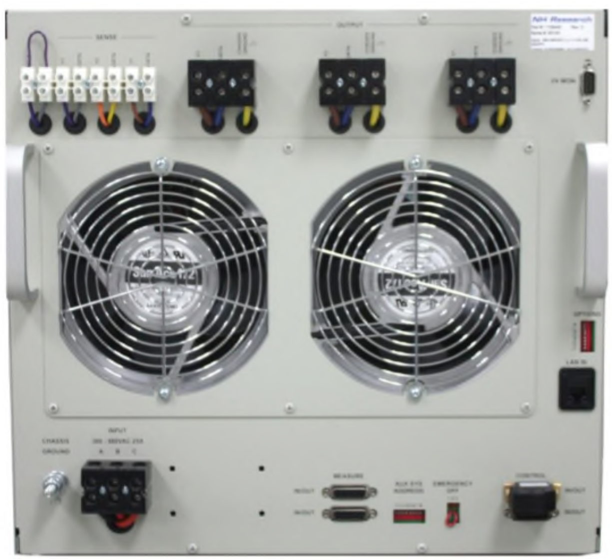


Use only the left most pins (i.e. V2 and V2RTN) On this style of connector

Flat Head Screw

Power input connection may be a solid terminal block with 3 screw terminals.

Flat Head Screw



3rd pin may or may not be labeled chassis ground.

For safety, electrically check all chassis ground conductivity before use.

Flat Head Screw

External Sense
All external sense connections for all phases are found on this connector on the master module. These are required connections for proper operation.

Interlock
The interlock connection is located to the right of the external sense connection on the master module.

UUT Wiring
UUT connections per phase may have a solid terminal block with three (3) or four (4) terminal locations. These are labeled with the output (V1, V2, & V3 with associated returns VxRTN). Additional locations should not be used especially on units labeled with VxXFMR / VxFMRN (if present).

14. DELARATION OF CONFORMITY

Declaration of Conformity

Application of Council Directives:

2014/30/EU (EMC)
2014/35/EU (LVD)

Standards To Which Conformity Is Declared:	EN61010-1: 2010 (LVD) EN61326-1: 2013 (EMC) EN55011 Class A Group 1 EN61000-4-2 EN61000-4-3 EN61000-4-4 EN61000-4-5 EN61000-4-6 EN61000-4-8
Manufacturer's Name:	NH Research, Inc.
Manufacturer's Address:	16601 Hale Avenue Irvine, CA 92606 949-474-3900
Equipment Description:	AC/DC Source, AC Load
Equipment Class:	- Laboratory, Measurement, & Process Control Equipment: Industrial Environment (EMC) - Class I (LVD)
Model Number:	9400

I the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s).

Company: NH RESEARCH

Signature: Thomas C. Fairburn

Full Name: Thomas C. Fairburn

Position: Sustaining Engr. Manger