NHR 9400 Series
Regenerative Bi-Directional AC

USER'S MANUAL

Part No. 09-0329

REVISION B

March 28, 2016

Document History

Rev A	**ECO 17364**	**03/24/2016**	**EW**
Rev B	**ECO 17423**	**03/28/2016**	**EW**

Proprietary Rights Notice

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 7
1.1 MODELS 7
1.2 SYMBOLS USED 7
1.3 WARRANTY 8
1.4 INTENDED USAGE 8
1.5 SAFETY NOTICE – NO USER SERVICEABLE PARTS INSIDE 8
1.6 GENERAL SAFETY NOTICES 8

2. TECHNICAL OVERVIEW 9
2.1 SYSTEM DESCRIPTION 9
2.2 OUTPUT SPECIFICATIONS 10
2.3 MEASUREMENT SPECIFICATIONS 11
2.4 FACILITY & MECHANICAL SPECIFICATIONS 11
2.5 SYSTEM SIZE 13
2.5.1 MODULE FRONT VIEW 14
2.5.2 MODULE REAR VIEW 16
2.5.3 CABINET SYSTEMS 21

3. INSTALLATION 22
3.1 UNPACKING THE 9400 SERIES SYSTEM 22
3.2 LOCATION MOUNTING AND COOLING 22
3.3 CONNECTING AC FACILITY POWER 23
3.4 RECOMMENDED BREAKER & FACILITY WIRING 24
3.5 EMERGENCY-OFF CONNECTOR SETUP 25
3.6 INTERLOCK 25
3.7 UUT WIRING 25
3.7.1 EXTERNAL SENSE 25
3.7.2 400VAC OPTIONAL VOLTAGE SUPPORT 26
3.8 TURN ON CHECKLIST 27
3.8.1 PRIOR TO APPLYING EXTERNAL POWER TO THE UNIT 27
3.8.2 POWERING UP THE SYSTEM 27
3.9 CONFIGURING THE IP ADDRESS 27
3.9.1 CONNECT A COMPUTER WITH A WEB BROWSING APPLICATION 28
3.9.2 CONFIGURING THE MASTER MODULES IP ADDRESS 29
3.9.3 CONFIGURING THE TOUCH PANEL'S IP ADDRESS 30
3.9.4 CONNECTING WITH AN EXTERNAL APPLICATION 32
3.10 POWERING DOWN THE SYSTEM 32

4. TOUCH PANEL CONTROL 33
4.1 SETUP 33
4.2 MONITOR SCREEN 35
4.3 CONTROL SCREEN 35
4.4 OPTIONS SCREEN 35
4.5 SAFETY SCREEN 35
4.6 MACROS SCREEN 35

5. SOFTWARE (PC TOOLS) CONTROL 36
5.1 NHR 9400 PANEL 36

6. APENDIX - HARDWARE MODES 37
6.1 THREE CHANNEL POWER MODULE 37
6.1.1 MODE 0: ONE 3-PHASE AC 38
6.1.2 MODE 1: ONE AC 39
6.1.3 MODE 2: ONE DC 40

6.1.4 MODE 3: THREE AC 41
6.1.5 MODE 4: THREE DC 42
6.1.6 MODE 5: ONE 2-PHASE AC AND ONE AC 43
6.1.7 MODE 6: ONE 2-PHASE AC AND ONE DC 44
6.1.8 MODE 7: TWO AC 45
6.1.9 MODE 8: ONE AC AND ONE DC 46
6.1.10 MODE 9: TWO AC AND ONE DC 47
6.1.11 MODE 10: ONE AC AND TWO DC 48
6.1.12 MODE 11: ONE DC AND ONE AC 49
6.1.13 MODE 12: TWO DC 50
6.2 TWO CHANNEL POWER MODULE 51
6.2.1 MODE 0: ONE 2-PHASE AC 52
6.2.2 MODE 1: ONE AC 53
6.2.3 MODE 2: ONE DC 54
6.2.4 MODE 3: TWO AC 55
6.2.5 MODE 4: TWO DC 56
6.2.6 MODE 5: ONE AC AND ONE DC 57
6.3 ONE CHANNEL POWER MODULE 58
6.3.1 MODE 0: ONE AC 59
6.3.2 MODE 1: ONEDC 60

7. APENDIX – ADDITIONAL INFORMATION 61
7.1 OVERVIEW 61
7.1.1 AUX SYS ADDRESS SETUP 61
7.1.2 EMERGENCY-OFF CONNECTOR SETUP 61
7.1.3 OPTION DIPSWITCH SETUP 61
7.1.4 PARALLEL CONNECTORS 62
7.1.5 KEY FEATURES 62
7.1.5.1 OUTPUT ISOLATION AND FLEXIBLE MODE CONFIGURATION 62
7.1.5.2 POWER FLOW BI-DIRECTIONAL AND POWER REGENERATIVE 62
7.1.5.3 NEAR UNITY POWER FACTOR 63
7.1.5.4 HIGH EFFICIENCY AND HIGH POWER DENSITY 63
7.1.5.5 ALL DIGITAL CONTROL AND FIRMWARE UPGRADABLE 63
7.1.5.6 PROGRAMMABLE LIMITS 63
7.1.5.7 SAFETY FEATURES TO PROTECT THE OPERATOR 63
7.1.5.8 SAFETY FEATURES TO PROTECT THE UUT 63
7.2 CONFIGURATION 63
7.3 LED INDICATORS 64
7.4 IMPORTANT TERMINOLOGY 65
7.4.1 OUTPUT 65
7.4.2 POWER MODULE 65
7.4.3 CHANNEL 65
7.4.4 INSTRUMENT 65
7.4.5 UUT 65
7.4.6 UNITS 66

8. SERVICE 67
8.1 FIRMWARE UPDATES 67
8.2 PERIODIC MAINTENCE - CLEANING 70

1. GENERAL

1.1 Models

This manual applies to the following hardware modules provided by NH Research.

9410 Regenerative Grid Simulator			
Model	Maximum Power	Channel Count	Footprint
9410-04	4kW / 8 kVA	1 Channel	19" Rack-mountable Module
9410-08	8kW / 16 kVA	2 Channels	
9410-12	12kW / 24kVA	3 Channels	
9410-24	24kW / 48kVA	3 Channels	43" Tall Cabinet
9410-36	36kW / 72kVA		78" Tall Cabinet
9410-48	48kW / 96kVA		78" Tall Cabinet
9410-60	60kW / 120kVA	3 Channels	Dual Bay 78" Cabinet
9410-72	72kW / 144kVA		
9410-84	84kW / 168kVA		
9410-96	96kW / 192kVA		

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

Complete model lists and their associated specifications is available models is available from NH Research upon request.

1.2 Symbols Used

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

	**Potential life threatening danger** **Please use extreme caution**
	**General safety warnings** **Failure to take precautions may result in bodily harm or equipment damage**
	**General notes or keys for operation**

1.3 Warranty

NH Research provides a one (1) year standard warranty for hardware test equipment products.

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

1.4 Intended Usage

The 9400 Series provides AC or DC bi-directional power control and measurement. It is primarily used in the evaluation, performance, functional, & endurance testing for either AC or DC products.

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

1.5 Safety Notice – No User Serviceable Parts Inside

The 9400 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

Note To 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"

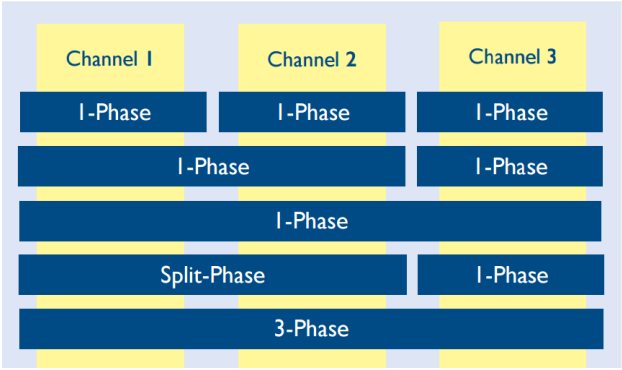
Additional Notes

- The test equipment should only be used by trained personnel or under the 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.

2. TECHNICAL OVERVIEW

2.1 System Description

This system description is provided clarify the technical specifications section which follows. The 9400 Series, depending on model selected, provides one (1), two (2), or three (3) power control channels which are configured through software in order to provide any combination of AC and DC test channels.



For example, the 9410-12 provides three (3) $310V_{ACRMS}$, 30A, 4kW/8kVA channels. These channels may be configured to operate as separate AC channels, combined in order to provide a higher single output channel (8kW or 12kW), or combined to provide multi-phase output (split -phase or 3-phase). Each channel supports AC & DC operation making the 9400 Series a very flexible, regenerative, bi-directional power test system.

Each power channel may be further expanded by adding an auxiliary module. This increases the power and current capability of each channel directly. For example a 9410-24 uses a master module and a slave auxiliary module. In this case, each of the three (3) channels is capable of $310V_{ACRMS}$, 60A, 8kW/16kVA.

Systems may be ordered with a reduced channel count providing only one (1) or two (2) channels. In this case, the power and current capability of each channel is still $310V_{ACRMS}$, 30A, 4kW/8kVA per channel.

These details will be helpful in understanding the following technical specification tables.

2.2 Output Specifications

9410 Series Regenerative Grid Simulator								
Model	**9410-4**	**9410-8**	**9410-12**	**9410-24**	**9410-36**	**9410-48**	**9410-72**	**9410-96**
AC Output Specifications								
Number of channels	1	2	3					
Phases / Output Channels	1	1 or 2	1, 2 or 3					
Max Power (Total) Current Ranges (max 1ϕ) Current Ranges (per ϕ)	4kW/8kVA 6A, 30A 6A, 30A/ϕ	8kW/16kVA 12A, 60A 6A, 30A/ϕ	12kW/24kVA 18A, 90A 6A, 30A/ϕ	24kW/48kVA 36A, 180A 12A, 60A/ϕ	36kW/72kVA 54A, 270A 18A, 90A/ϕ	48kW/96kVA 72A, 360A 24A, 120A/ϕ	72kW/144kVA 108A, 540A 36A, 180A/ϕ	96kW/192kVA 144A, 720A 48A, 200A/ϕ
Peak Current	3x Max RMS Current							
Voltage Ranges Accuracy Resolution	155, 310V_{rms} (400V_{rms} Option) 0.2% setting + 0.2% range 0.005% range							
Frequency	30 – 100Hz							
Distortion	< 1% @ 50/60Hz (full power into resistive load @ 480$V_{rms\ l\text{-}l}$							
Output Wave Shapes	Sine, n-Step Sine, Triangle, Clipped-Sine, Arbitrary (user-defined)							
Phase Angle Control	0 ^{o} to 359 ^{o} / 1 ^{o} resolution							
DC Output Specifications								
Max Power (Total) Current Ranges (max 1ch) Current Ranges (per ch)	4kW 6A, 30A 6A, 30A/ch	8kW 12A, 60A 6A, 30A/ch	12kW 18A, 90A 6A, 30A/ch	24kW 36A, 180A 12A, 60A/ch	36kW 54A, 270A 18A, 90A/ch	48kW 72A, 360A 24A, 120A/ch	72kW 108A, 540A 36A, 180A/ch	96kW 144A, 720A 48A, 200A/ch
Voltage Ranges Accuracy Ripple	200, 400V_{dc} 0.2% setting + 0.2% range < 800mV							

2.3 Measurement Specifications

9410 Series Regenerative Grid Simulator								
Model	**9410-4**	**9410-8**	**9410-12**	**9410-24**	**9410-36**	**9410-48**	**9410-72**	**9410-96**
AC & DC Measurements								
Peak Voltage	250V, 500V							
Accuracy (AC_{rms})	0.1% reading + 0.06% range							
Accuracy (DC)	0.1% reading + 0.10% range							
Accuracy (Peak)	0.5% reading + 0.20% range							
Resolution	0.005% range							
Peak Current (per ch)	20A / 100A	20A / 100A	20A / 100A	40A / 200A	60A / 300A	80A / 400A	120A / 600A	160A / 800A
Accuracy (AC_{rms})	0.2% reading + 0.06% range							
Accuracy (DC)	0.2% reading + 0.06% range							
Accuracy (Peak)	0.5% reading + 0.20% range							
Resolution	0.005% range							
Peak Power	V range * I range							
Accuracy (kW / kVA)	0.3% reading + 0.025% range							
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	125k Samples / Second							
Memory Depth	64k Samples							
Aperture Time	1 cycle to 64 seconds							
Accuracy	0.5% reading							
Resolution	0.05% range							

2.4 Facility & Mechanical Specifications

9410 Series Regenerative Grid Simulator								
Model	**9410-4**	**9410-8**	**9410-12**	**9410-24**	**9410-36**	**9410-48**	**9410-72**	**9410-96**
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”43”	23”x30”x78”		46”x30”x78”	
Weight	105 lbs	120 lbs	135 lbs	370 lbs	505 lbs	855 lbs	1340 lbs	1610 lbs
Operating Temp	0°C to 35°C							
Isolation	Facility to Chassis – 1000V, Output to Chassis – 500V, 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 0.95							
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 Power Utilization refers only to the amount of power drawn during operation. See the installation section for breaker and facility wiring recommendations

2.5 System Size

NH Research provides separate modules as well as pre-wired cabinets for larger system sizes. Both systems use the same modules making it possible to expand power in the field as needed.

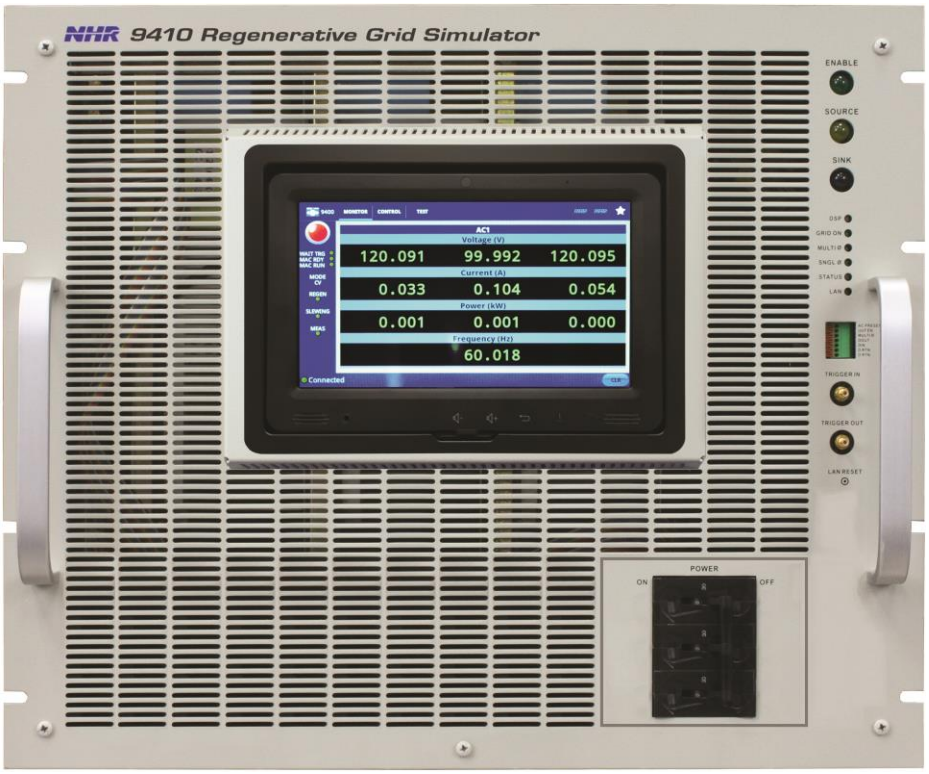
19" Rack Mountable Module (19" x 24" x 15¾")			
Model	Maximum Power	Channel Count	Height
9410-04	4kW / 8 kVA	1 Channel	15¾" (9U)
9410-08	8kW / 16 kVA	2 Channels	
9410-12	12kW / 24kVA	3 Channels	

Single Cabinet (28" x 30" x H)			
Model	Maximum Power	Channel Count	Height
9410-24	24kW / 48kVA	3 Channels	43" Tall Cabinet
9410-36	36kW / 72kVA	3 Channels	78" Tall Cabinet
9410-48	48kW / 96kVA		

2-Bay Cabinet (46" x 30" x H)			
Model	Maximum Power	Channel Count	Height
9410-60	60kW / 120kVA	3 Channels	78"
9410-72	72kW / 144kVA		
9410-84	84kW / 168kVA		
9410-96	96kW / 192kVA		

2.5.1 Module Front View

The Front of the system module includes a touch panel interface, output & status indicators, Digital IO, Trigger ports, and a circuit breaker. Air intake is from the front.



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

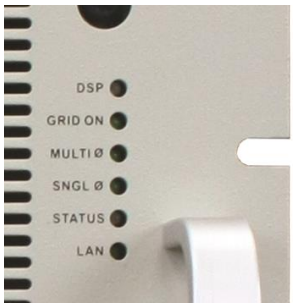
The three indicators in the upper left provide a visual indication

- Enable – Output Contactors are currently active
- Source – Net Power is flowing from the facility to UUT
- Sink – Net Power is flowing from the facility to the UUT

Note: Source and Sink refer to the net power of the entire system

System Status Indicators

The three indicators in the upper left provide a visual indication



- DSP – Turns Red when there is a processor error
- Grid On – Indicates current facility power status
- Multiϕ – Indicates multiple phases are active
- Singleϕ – Indicates a single phase is active
- Status – Turns Red when there is a system error
- LAN – Indicates LAN communications are active

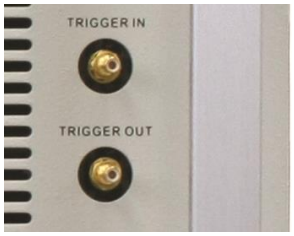
Digital IO Interface

This interface uses a wire terminal block with release level. This interface provides an open collector input/output with internal pull up indicating status and may be used for external device control.

- AC PRESENT –
  Indicates the presence of AC at the output terminals
- UUT EN –
  Indicates the output contactor state
- Multiϕ –
  Indicates the output is operating in multiϕ
- DOUT – General Purpose Digital Out
- DIN – General Purpose Digital input
- D RTN – Return signal / reference for digital IO interface.

Trigger In / Out

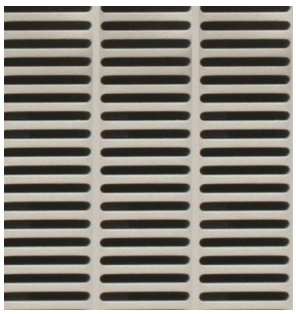
This interface uses a SMB connector and provides Trigger In and Trigger Out controls.



- Trigger In –
  Generally used to start or advance a macro sequence
- Trigger Out –
  Indicates each command as it is applied

Air Intake

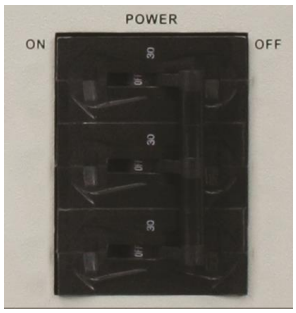
The system is cooled with ambient air. Cooling air is drawn from the front of the unit and exhausted out of the rear.



Never insert tools or metal objects into the air intake slots

Circuit Breaker

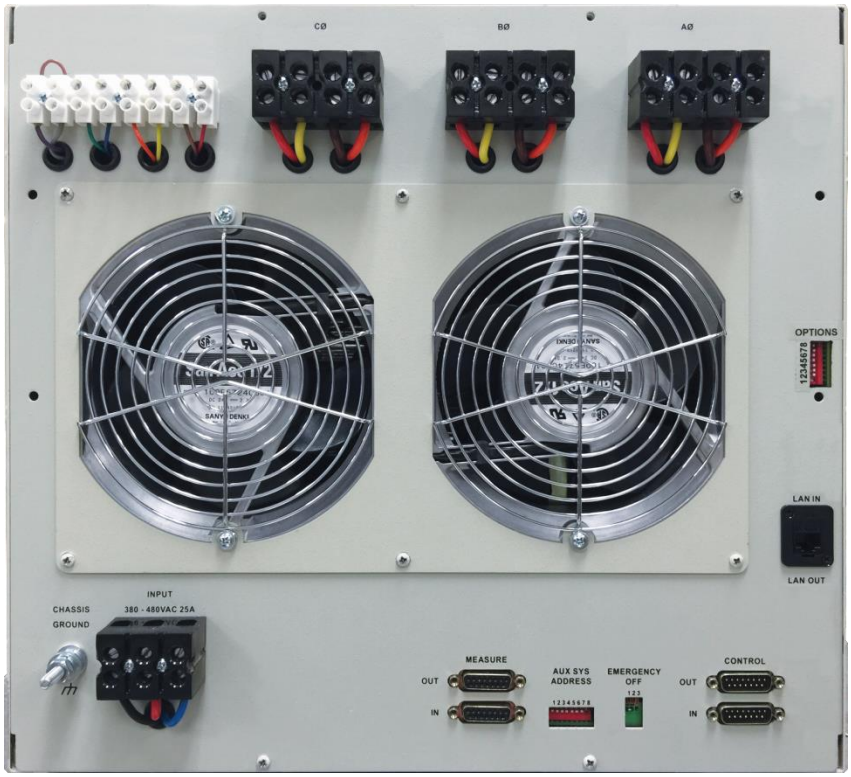
Each master & auxiliary module provides a 30A main circuit breaker. This is used to protect the internal wiring and power stage against internal failures. See the installation section for recommendations about sizing a breaker to power a 9410 system.



See the installation section for breaker and facility wiring recommendations

2.5.2 Module Rear View

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



Facility Power & Safety Ground

The power module uses a universal input accepting 3-Phase voltages between $380V_{l\text{-}l}$ and $480V_{l\text{-}l}$. The connection is 4-wire (3-phase + safety ground) and has no phase rotation dependency.

Each module provides a separate 30A breaker protecting itself from internal wiring failures. Refer to the installation section for more details and recommended wiring gauges.

	**Connection of the system to a three phase AC Line should be made by an electrician or other qualified personnel** **Never wire a system directly to a live power feed.** **All wiring should be conducted in a 0V / No Power state.**
	**There is a potential shock hazard if the system is not connected to safety ground via the provided terminal.** **Ensure all wires are properly terminated with tight connections.** **Improper termination may result in exposed conductors.**
	**See the installation section for breaker and facility wiring recommendations**

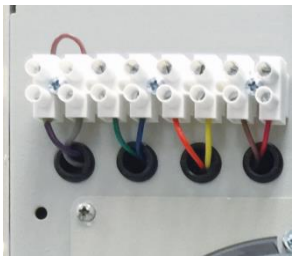
UUT Power Connections

UUT Power connections are made in the rear of the module. Each output is isolated and needs to be wired based on the desired operating mode.

See the Hardware Operating Modes in the appendix sections for recommendations in wiring these outputs.

	**Never wire a system when either the system or UUT is powered. Ensure all wires are properly terminated with tight connections.**
	**The three (3) output channels are isolated from each other and from chassis ground. Please refer to the recommended wiring diagrams in the Hardware Operating Modes section.**

Remote Sense & Interlock



Remote sense connections compensate for wire losses between the Power Module and the UUT. These connections are made only to the master module and must be connected for proper operation.

See the Hardware Operating Modes in the appendix sections for recommendations in wiring these connections.

The interlock connection is the left most terminal. These terminals must be shorted for proper operation and provide an external signal which can be used to disable the power module.

Emergency Off (E-Stop)

Emergency Off turns off the system and will require software reset command before the unit is able to return to an operating state.

Pins 1 & 2 must be connected for normal operation. When pin1 & 2 are disconnected, all input and output relays will open and the internal power electronics will stop switching.

	**See the Installation section for recommendations for wiring E-Stop.**

LAN Communications Port

The 9400 Series modules provide a standard Ethernet 100BaseT RJ-45 8 pin connector with auto-MDIX. This interface does not require a crossover cable to enable communications.

Mating Cable Type:		
Standard Ethernet Cable	Belkin	A3L791-14 (or equivalent)

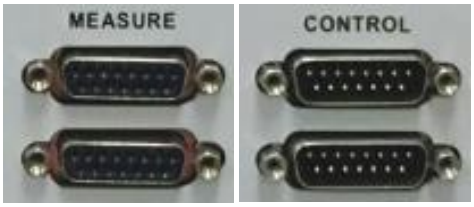
See the changing the IP address section for information about configuring the IP address.

Options Dip-Switches

Options dip switches should not be changed unless specifically instructed to by NH Research customer support or by a programming update procedure. 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.

See the changing the IP address section for more information about how to use Switch #1.

Paralleling Interface



A standalone master should have a terminator installed on the control IN connector. This terminator is either pre-installed or can be found in the supplied accessory kit shipped with the unit.

This 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 to make this connection.

Mating Cable Type:		
Control Paralleling Cable	NHR	P/N: By Request
Terminator	NHR	P/N: By Request

Contact NH Research for more information adding an auxiliary module

Aux Sys Address Dip-Switches

Aux Sys Address dip switches should not be changed unless specifically instructed to by NH Research customer support. These switches are used to identify the address of an auxiliary which is connected to a master.

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

2.5.3 Cabinet Systems

Photos and connector descriptions will be added as soon as available

3. INSTALLATION

3.1 Unpacking the 9400 Series System

Prior to shipment, The 9400 System was inspected and found to be free of mechanical or electrical defects. Upon unpacking, inspect for any damage or shock watch sensors which may indicate that the unit was potentially 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 will be returned to NH Research.

Do not proceed with installation if damaged during shipping.

3.2 Location Mounting and Cooling

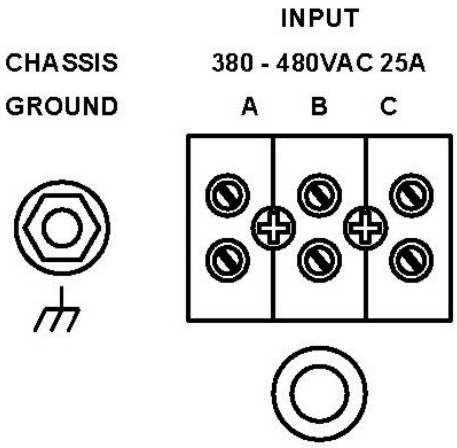
This unit is air-cooled and uses fans. The air intake is from the front of the module (or cabinet) and exhausts to the rear of the module (or cabinet).

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.

3.3 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.**

For individual modules, the three phase AC Line connects to the system via a terminal block located at the rear of the unit as per the attached drawing. For larger systems, the three phase AC line connects the system via a terminal block located in the rear of the cabinet as shown below.



Module Facility Power Connection

Photo provided when available

Chassis Power Connection

3.4 Recommended Breaker & Facility Wiring

The recommended wiring is based on 30A facility power per module (master or auxiliary). 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.**

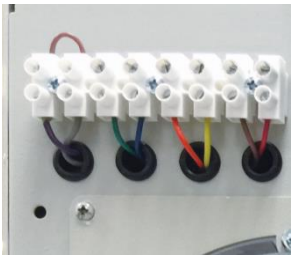
9410 System	Recommended Panel Breaker	Wire Gauge
9410-4 9410-8 9410-12	30A	AWG 10
9410-24	60A	AWG 6
9410-36	90A	AWG 4
9410-48	120A	TBD
9410-60	150A	TBD
9410-72	180A	TBD
9410-84	210A	TBD
9410-96	240A	TBD

Note other product variations will be added as released to the above table

3.5 Emergency-OFF Connector Setup

User need to jumper pin1 and pin2 of the Emergency-Off connector to turn on the system. This connector provides a way to quickly turn off the system with an outside switch at emergency. When pin1 and pin2 are disconnected, all the input relay and output relay will open, and all the semi-conductors will stop switching. System will generate an Emergency Off error and be latched off even if the jumper is back. Recycle power or a reset command can clear the error.

3.6 Interlock



User need to jumper the interlock pins found at the far left of the external sense connector block. When these pins are disconnected, the output relay will open, and all the semi-conductors will stop switching. System will generate an error if an set operation command (i.e. OUTP:ON) is sent and these pins are not connected. A power cycle or reset is NOT required to clear this error.

3.7 UUT Wiring

The UUT Wiring will depend on the operating mode. Additionally, NH Research offers an Auto Transformer option for 400V Line-Neutral test capability. This should be installed and wired in a zero-volt state before activating the module.

Refer to the output operating mode section in the appendix for UUT wiring recommendations.

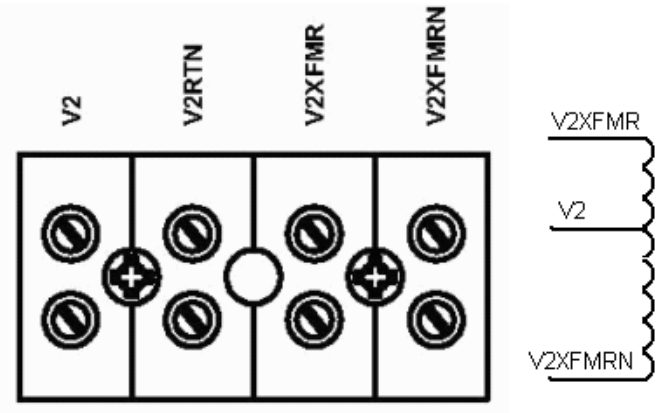
3.7.1 External Sense

External sense is a required connection. The sense leads must be connected at either the UUT or module output connections for proper operation.

3.7.2 400VAC Optional Voltage Support

While a single system provides a maximum output voltage of 310VACrms$_{(l\text{-}n)}$, NH Research offers a modular option to boost the output voltage to 400VACrms$_{(l\text{-}n)}$. The system is designed to measure the output voltage as well as the current and properly scale the measurements and settings using NH Research supplied options.

The voltage boost circuit is based on an auto transformer.
The following figure shows how to connect this option to the rear of the system.



When 400VAC option is used, the output and output_return must be connected to VnXFMR and VnRTN.

THE 400VAC OPTION HAS TO BE SPECIALY DESIGNED TO AVOID SATURATION AND IS ONLY USED FOR AC OUTPUT MODES.
THE 400VAC OPTION SHOULD NOT BE USED FOR DC OPERATION AS IT WILL RESULT IN THE OUTPUTS BEING SHORT CIRCUITED

3.8 Turn On Checklist

3.8.1 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 is connected
- Verify all system breakers are in the "Off" Position (switched to the right)
- Verify all Options dipswitches (section 2.5.2) are in "off" position
- Verify all power and communications cable connections are tight
- Verify terminator is installed

3.8.2 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.

3.9 Configuring the IP Address

The 9400 Series uses standard 100BaseT Ethernet for external control.

There are a large number of potential configurations 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 confusion in later use.

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

Each 9400 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 & 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.

3.9.1 Connect a computer with a web browsing application

Changing the IP address will require a PC or other web-browser capable computer. This external PC must have a similar but different IP address as the manual. (for example, if the system if 192.168.0.2 then the system the PC would need to have an ip address between 192.168.0.1 and 192.168.0.254 with the exception of module.)

Standalone Module LAN Connection

Photo provided when available

Chassis LAN Connection

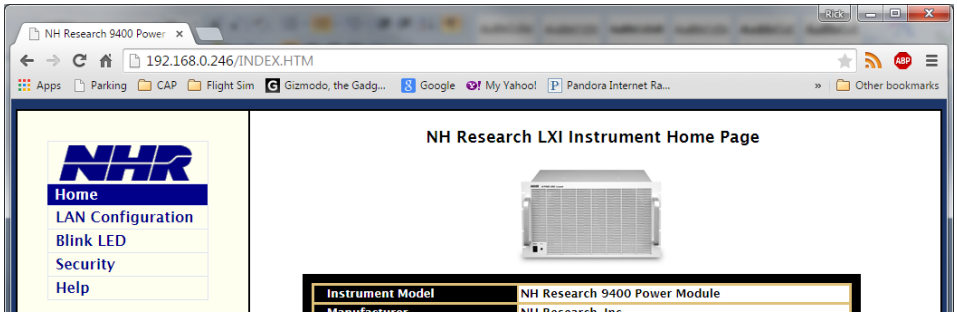
3.9.2 Configuring the master modules IP address

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.

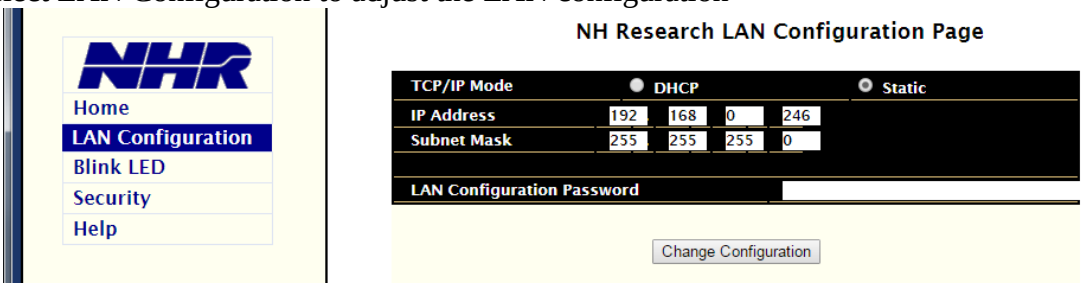
If the Module IP address is known

Open a web browser and browse to http://(IP_ADDRESS) where the IP address is the master modules address (for example http://192.168.0.2). 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 assigning 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 password

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.

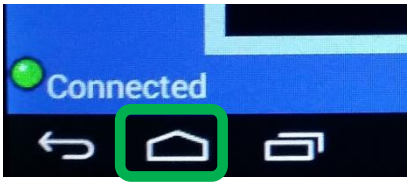
Restart the module and continue with the touch panel configuration.

3.9.3 Configuring the Touch Panel's IP address

The touch panel has two separate IP configurations required:

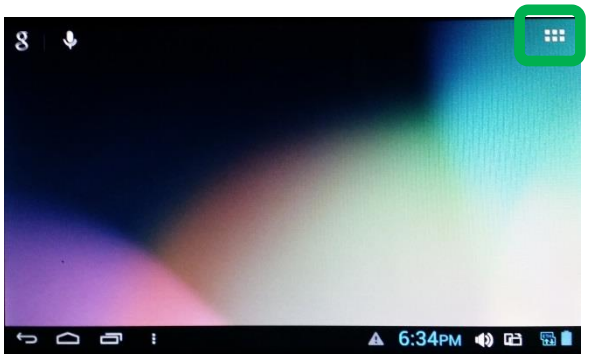
Configuring the Panel's IP Address

To configure the panel's IP address,
First, click the "Home" button
Located at the lower left of the panel
This will return you to the Android Screen

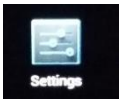


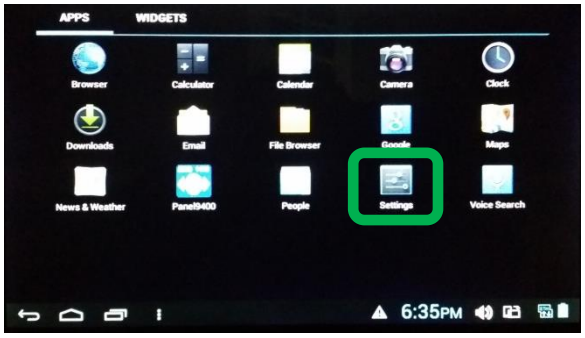
Then Select The Menu Button

This is found in the Upper Left



Then Select Settings
from the list of options

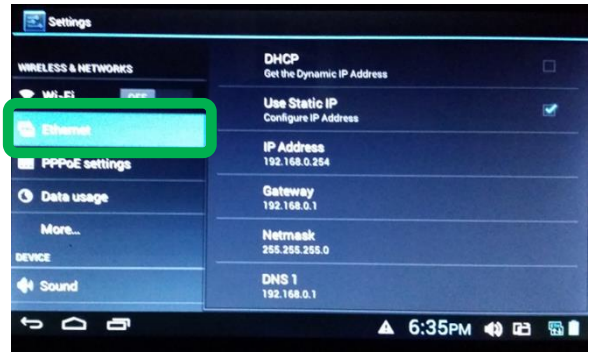




The panel's ethernet IP address settings are located under the Ethernet Tab.

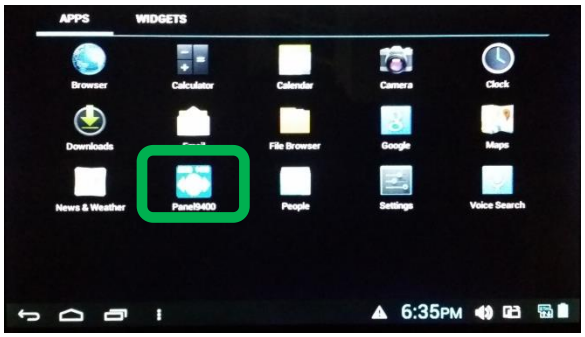
Be sure to assign a unique IP address that will be used by the touch panel.

Consult your IT administrator



Configuring The Module's Location

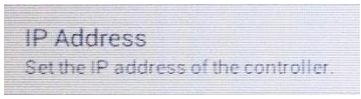
Restart the Panel
The application will be on the home screen or under the "Apps" menu

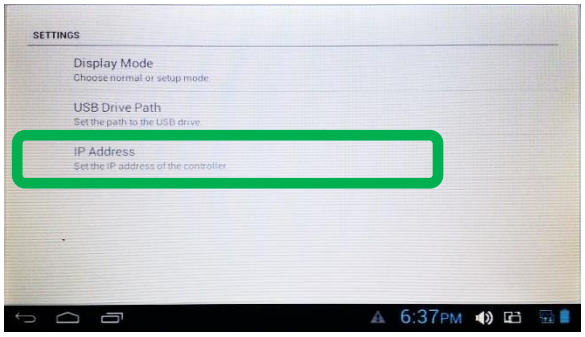


Then Select The Menu Button

This is found in the Upper Left

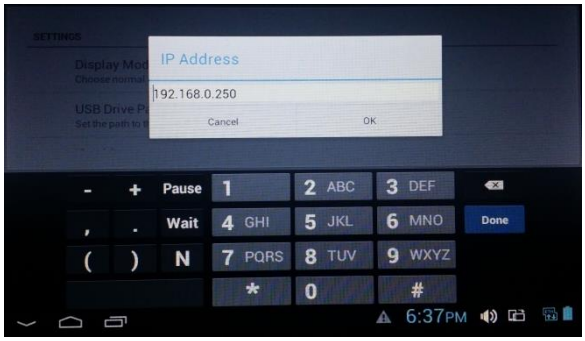
Then Select IP Address Option





Provide the Controller's IP Address
This is the address set in section 3.9.1

Note: This is not the panel's address but the address assigned to the 9400 Master Module.



3.9.4 Connecting with an external application

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

For VISA Devices the resource ID string is typically:
TCPIP::IPADDRESS::5025::SOCKET

For NH Research PC tools the resource ID string is typically:
TCPIP::IPADDRESS

3.10 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)

The modules use internal contactors to isolate themselves from Facility Power when a fault occurs or when the system is powered off.

- Turn off external power (optional)

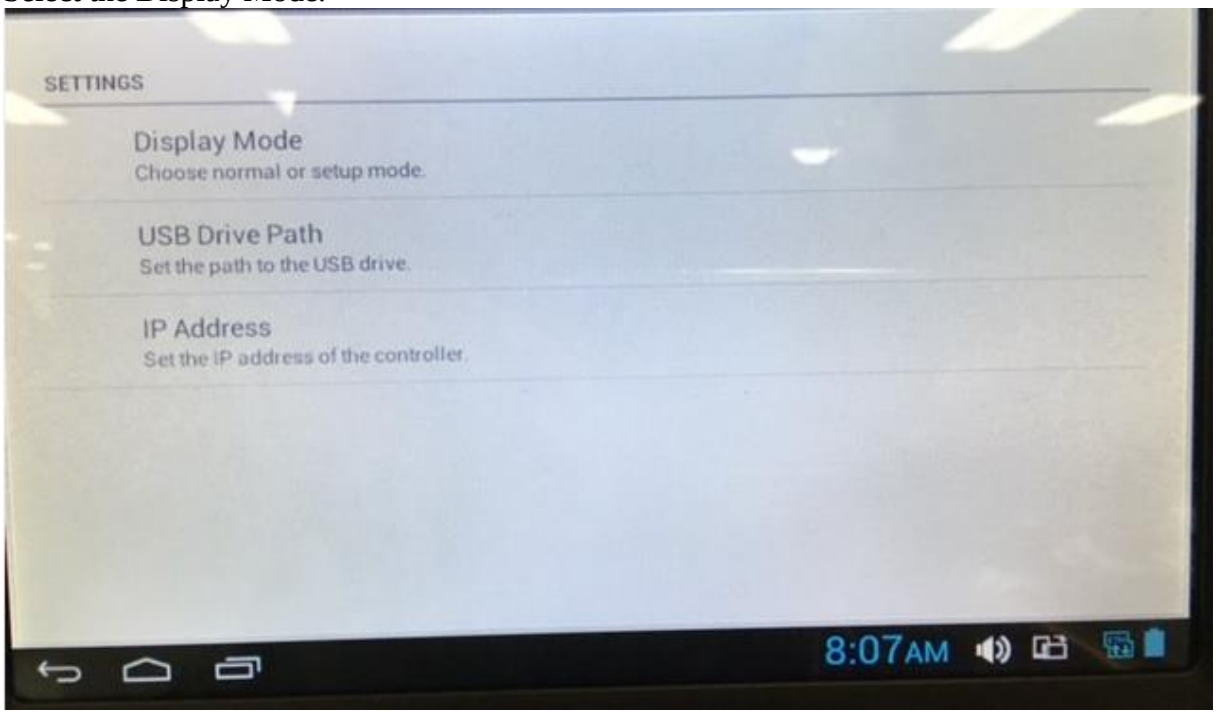
4. TOUCH PANEL CONTROL

The Power Module can be controlled through the supplied front panel touch control.

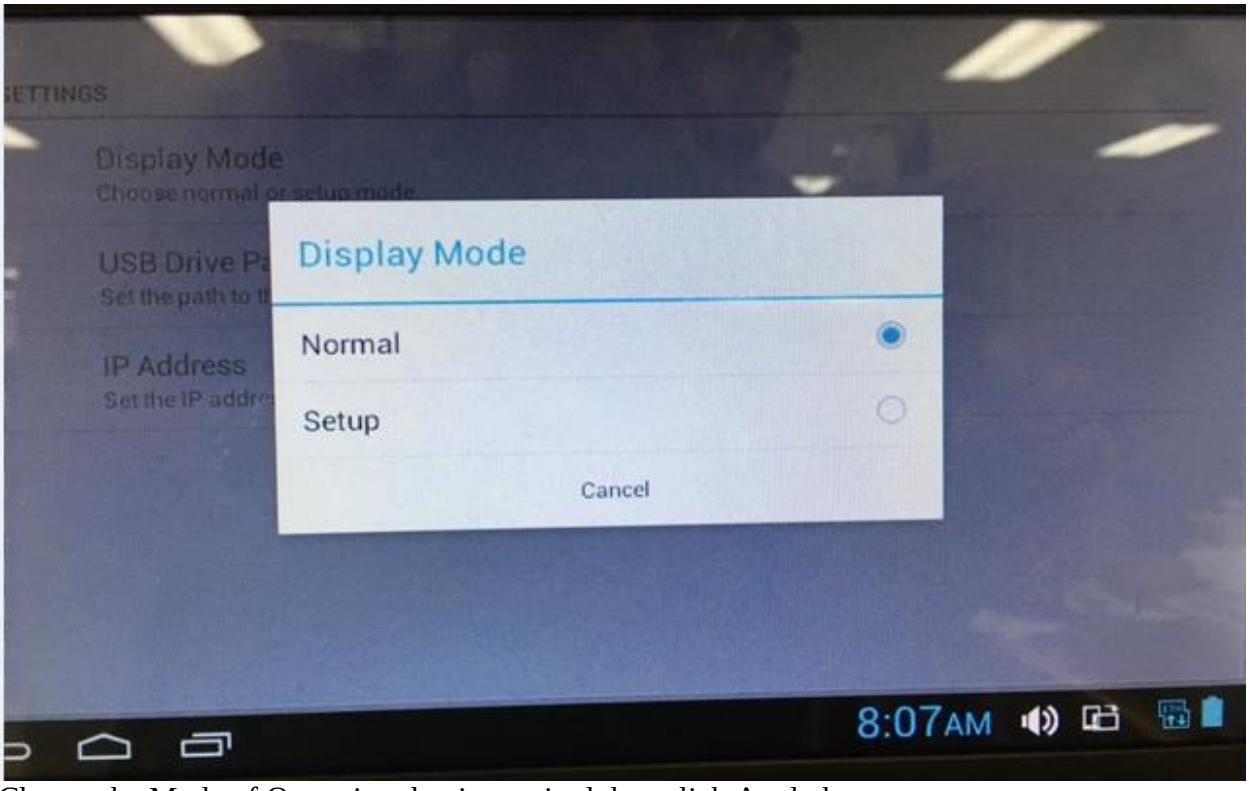
4.1 Setup

To change or select a new Mode of Operation, click the Menu icon on the top right of the screen.

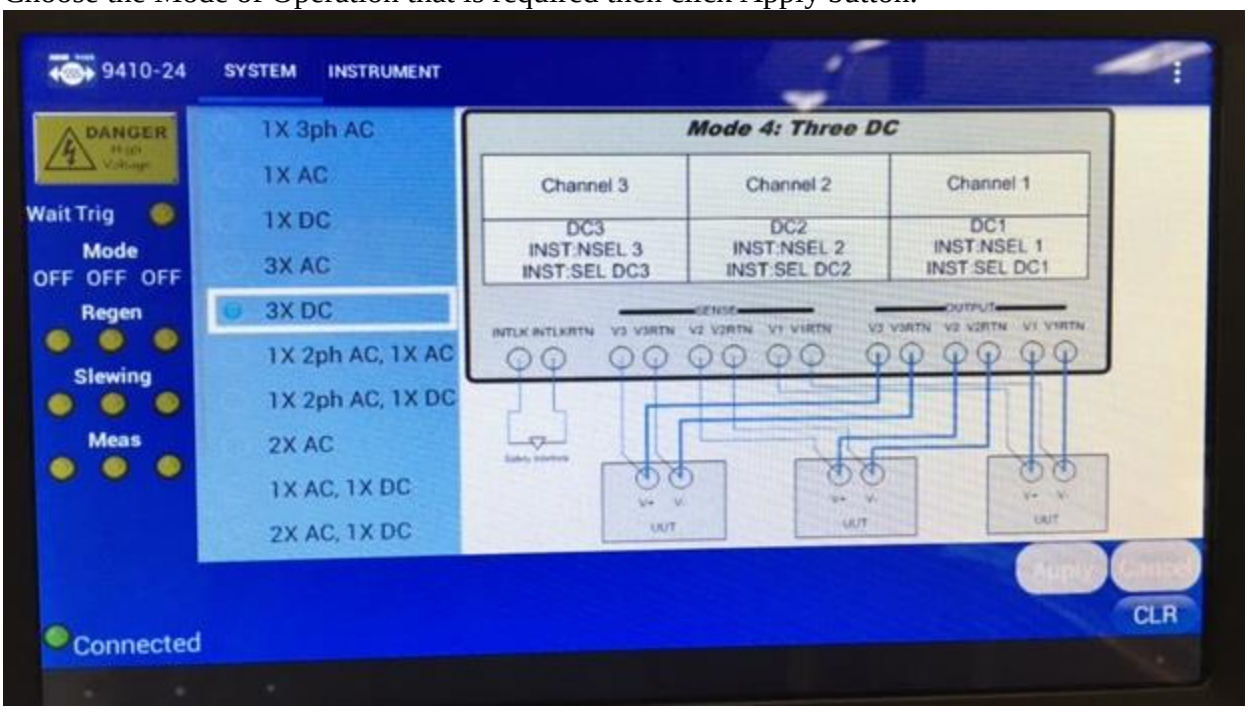
Select the Display Mode.



Select Setup then click the Return icon on the bottom left of the screen to return to setup menu.



Choose the Mode of Operation that is required then click Apply button.



To return to monitor screen click the Menu icon then click Display Mode and then select Normal. Click the Return icon to return to the monitor screen.

4.2 Monitor Screen

Monitor Screen is the default view which displays all available measurements; the measurements can be changed between Line-to-Line and Line-to-Neutral.

4.3 Control Screen

Control screen is used for programming proposes.

4.4 Options Screen

Options provide non-typically adjusted controls or multi-step programming such as Voltage/Current Ranges, Synchronous Angles, and Trigger Angles etc.

4.5 Safety Screen

The safety screen provides programmable safety limits intended to limit UUT damage due to operator setting errors. These limits are preserved in the Power Module and apply from application to application.

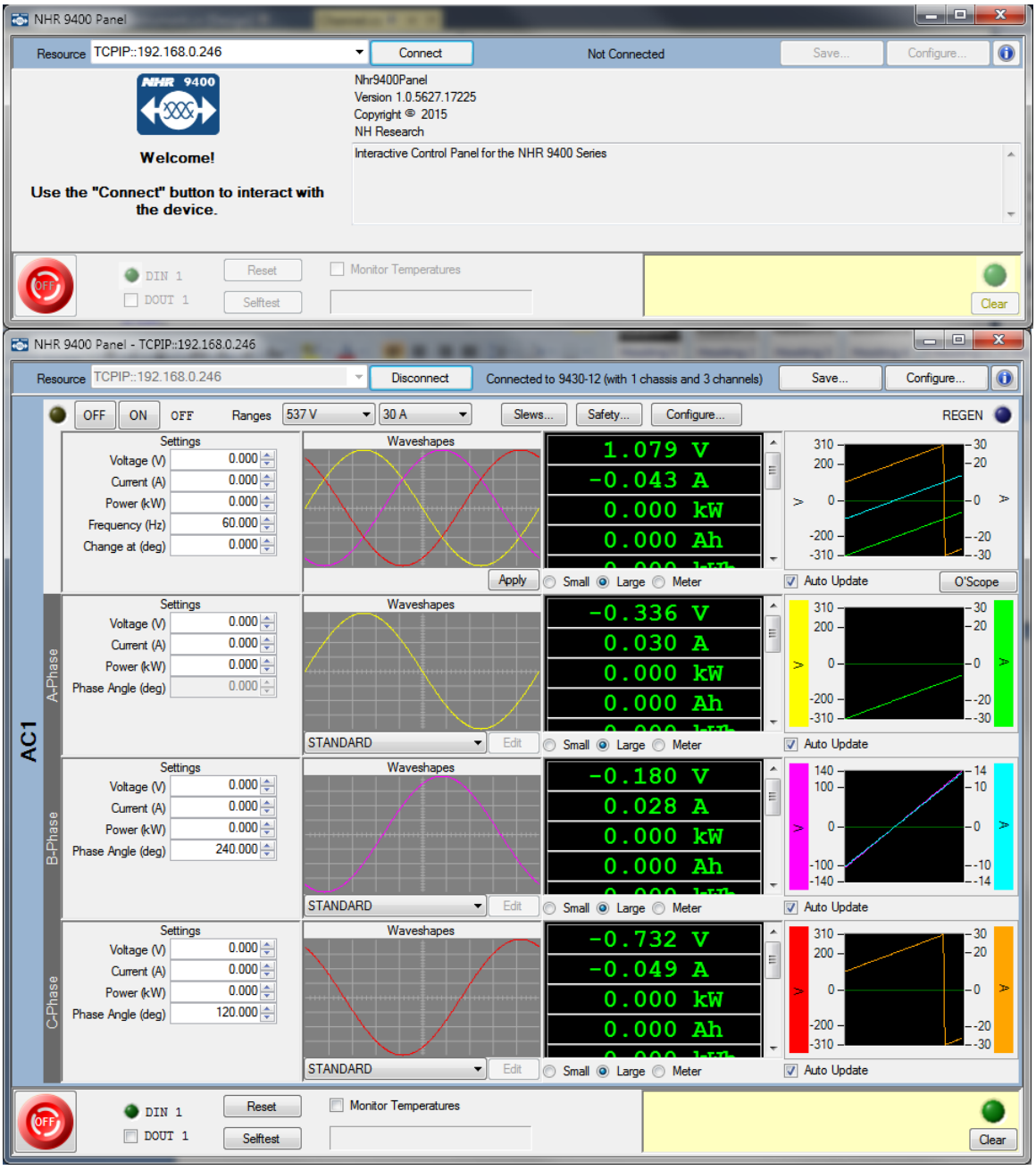
4.6 Macros Screen

Macros are pre-programed sequences, used to generate Pulses, Cycle Changes, Brown-Outs, and Wave Shape changes.

5. SOFTWARE (PC TOOLS) CONTROL

The Power Module can be controlled through the supplied "NHR 9400 Panel" (a Windows-PC application), through a communications terminal (like HyperTerminal) using SCPI commands, or through a custom program via SCPI, IVI-COM, IVI-C, or LabVIEW (see the *Programmer's Reference Manual* for more details).

5.1 NHR 9400 Panel



6. APENDIX - 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 9400 power module, six for a two channel 9400, and two for a one channel 9400. Once set, the mode can be saved as the default so it needn't be set again.

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

!!! WARNING !!!
The fixture wiring MUST match the selected configuration mode. If it does not, DAMAGE may occur to the fixture or UUT!

6.1 Three Channel Power Module

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)	AC1 (Phase B 240°)	AC1 (Phase C 120°)
1	One AC	AC1		
2	One DC	DC1		
3	Three AC	AC1	AC2	AC3
4	Three DC	DC1	DC2	DC3
5	One 2-Phase AC and One AC	AC1 (Phase A)	AC1 (Phase B 180°)	AC3
6	One 2-Phase AC and One DC	AC1 (Phase A)	AC1 (Phase B 180°)	DC3
7	Two AC	AC1		AC3
8	One AC and One DC	AC1		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		AC3
12	Two DC	DC1		DC3

The following figures show the basic wiring for each mode.

6.1.1 Mode 0: One 3-Phase AC

Logical Instrument Configuration and UUT Wiring

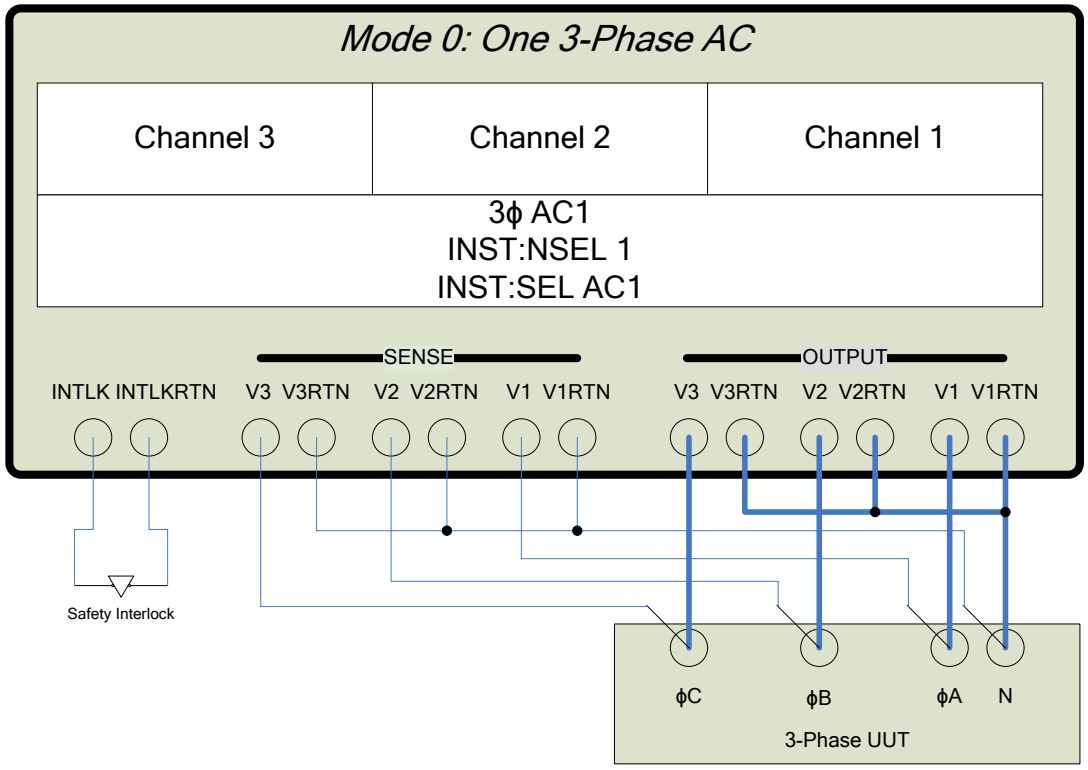


Figure 1 - Mode 0: One 3-Phase AC

Key Maximums for Each Logical Instrument

	Model							
AC1 (3-Phase)	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
Max Power	12 kW	24 kW	36 kW	48 kW	60 kW	72 kW	84 kW	96 kW
Max Voltage	310 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							

6.1.2 Mode 1: One AC

Logical Instrument Configuration and UUT Wiring

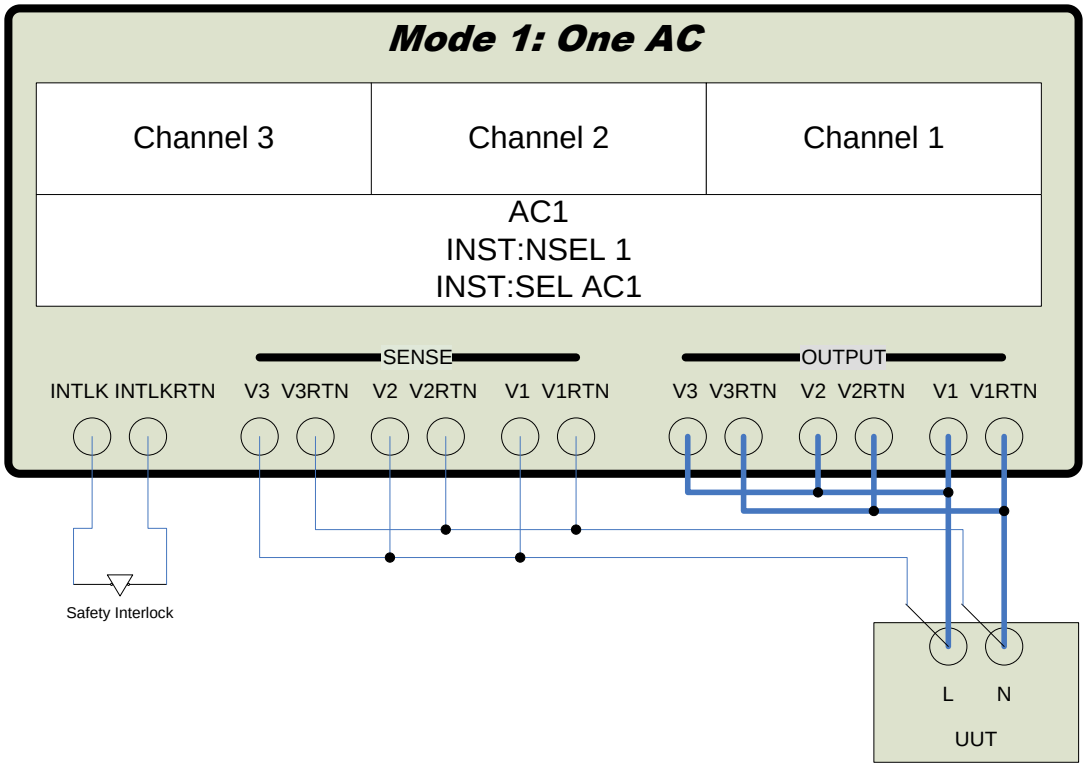


Figure 2 - Mode 1: One AC

Key Maximums for Each Logical Instrument

	Model							
AC1	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
Max Power	12 kW	24 kW	36 kW	48 kW	60 kW	72 kW	84 kW	96 kW
Max Voltage	310 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							

6.1.3 Mode 2: One DC

Logical Instrument Configuration and UUT Wiring

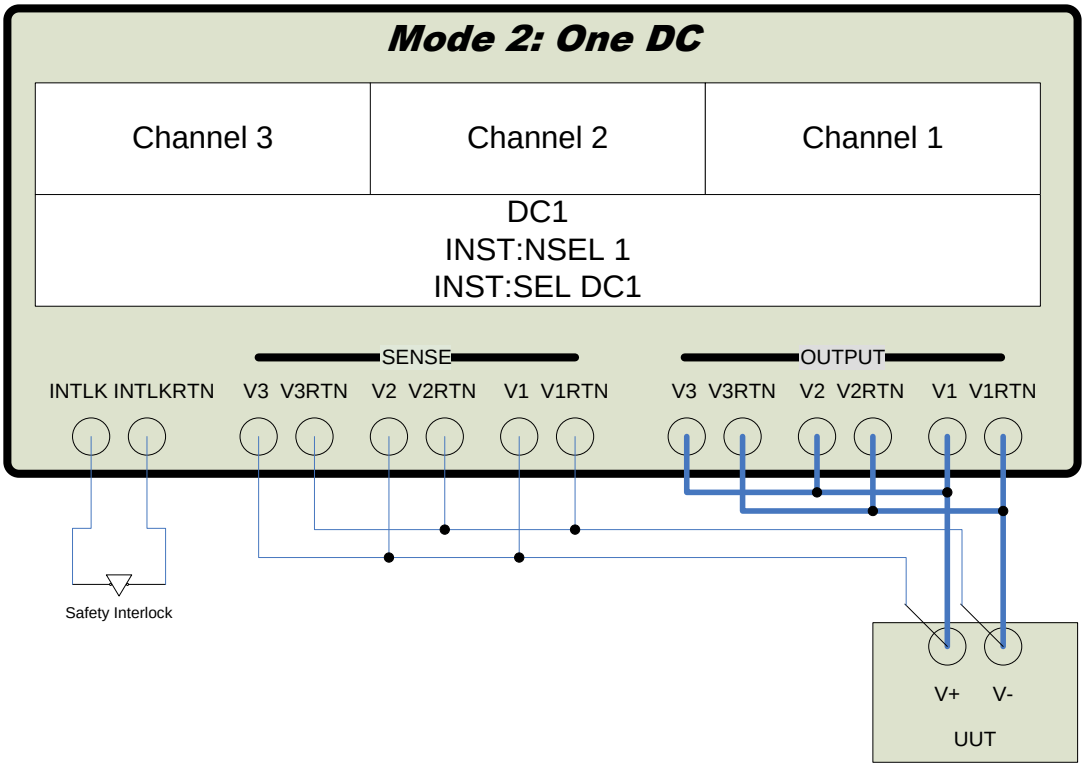


Figure 3 - Mode 2: One DC

Key Maximums for Each Logical Instrument

DC1	Model							
	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
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

6.1.4 Mode 3: Three AC

Logical Instrument Configuration and UUT Wiring

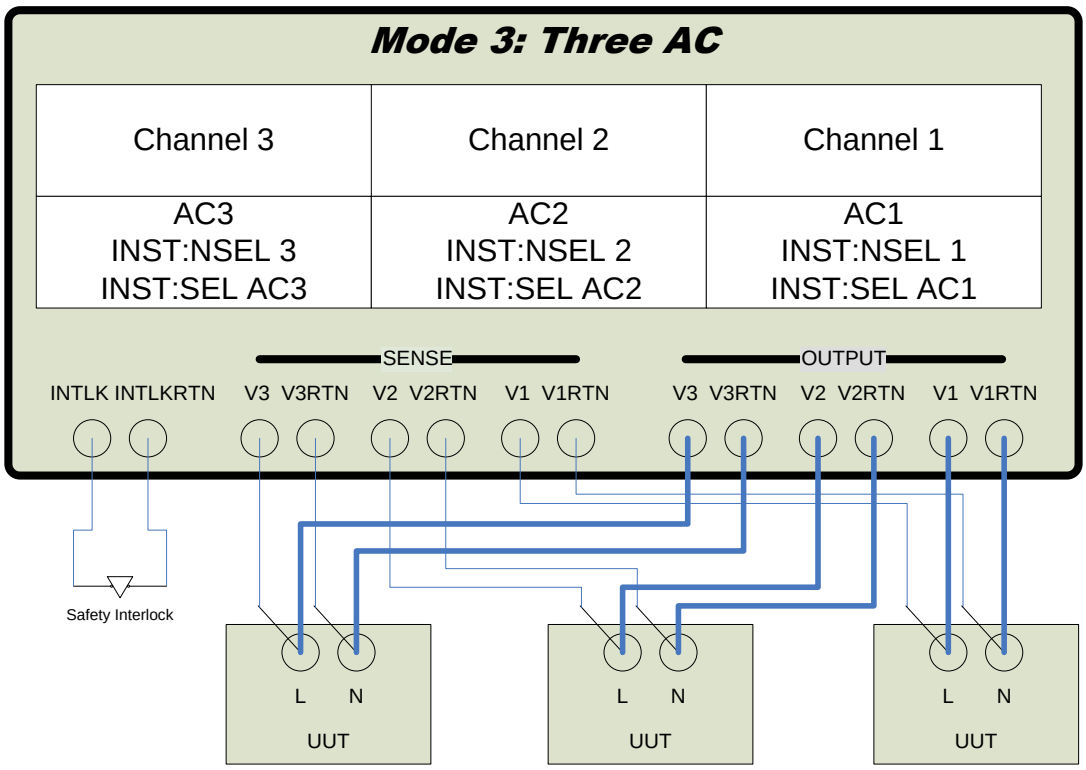


Figure 4 - Mode 3: Three AC

Key Maximums for Each Logical Instrument

	Model							
AC1	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	310 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	310 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	310 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							

6.1.5 Mode 4: Three DC

Logical Instrument Configuration and UUT Wiring

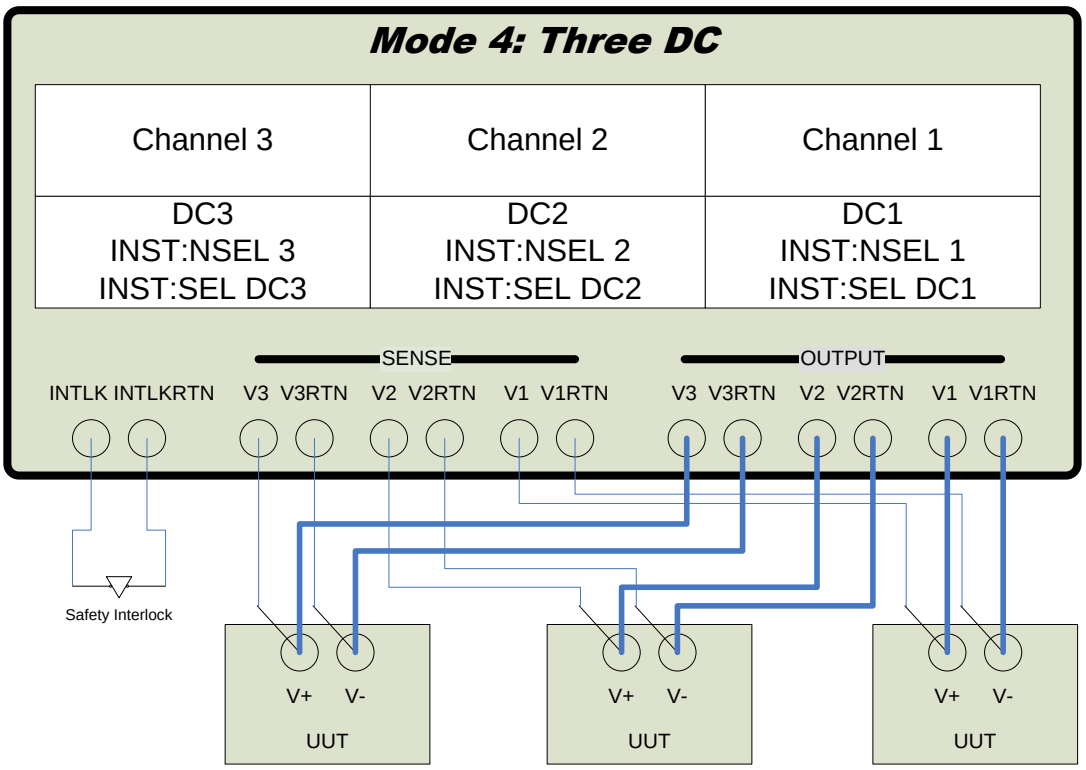


Figure 5 - Mode 4: Three DC

Key Maximums for Each Logical Instrument

	Model							
DC1	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
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

6.1.6 Mode 5: One 2-Phase AC and One AC

Logical Instrument Configuration and UUT Wiring

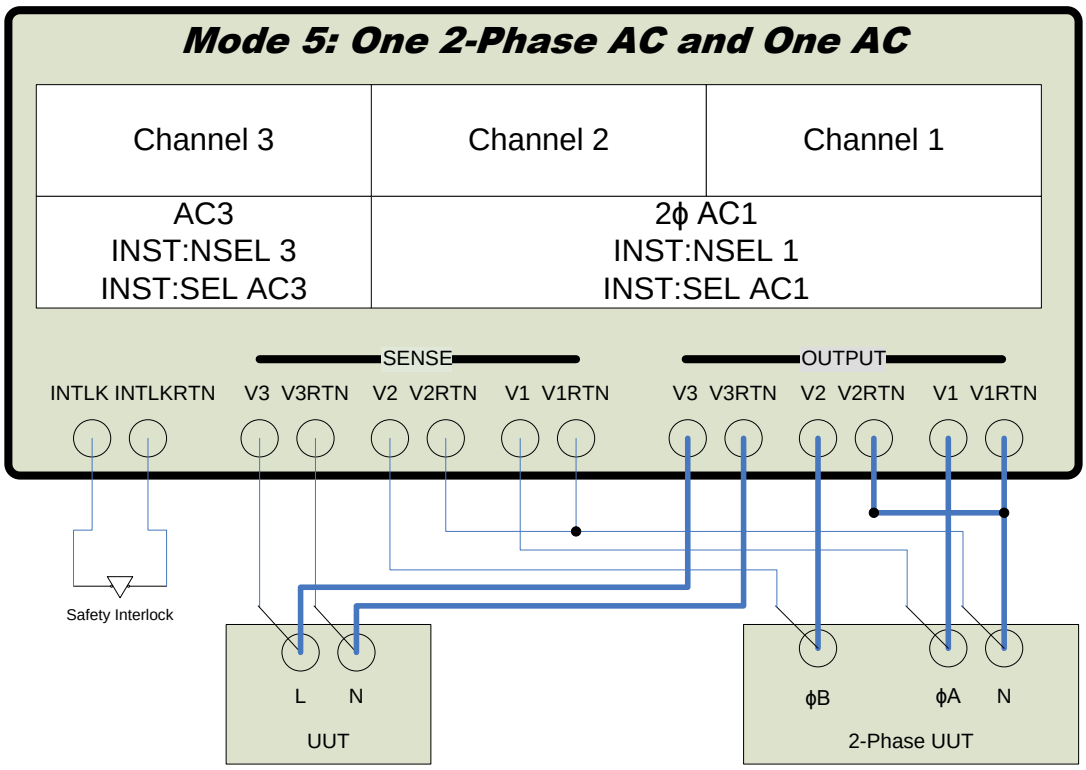


Figure 6 - Mode 5: One 2-Phase AC and One AC

Key Maximums for Each Logical Instrument

	Model							
AC1 (2-Phase)	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	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	310 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							

6.1.7 Mode 6: One 2-Phase AC and One DC

Logical Instrument Configuration and UUT Wiring

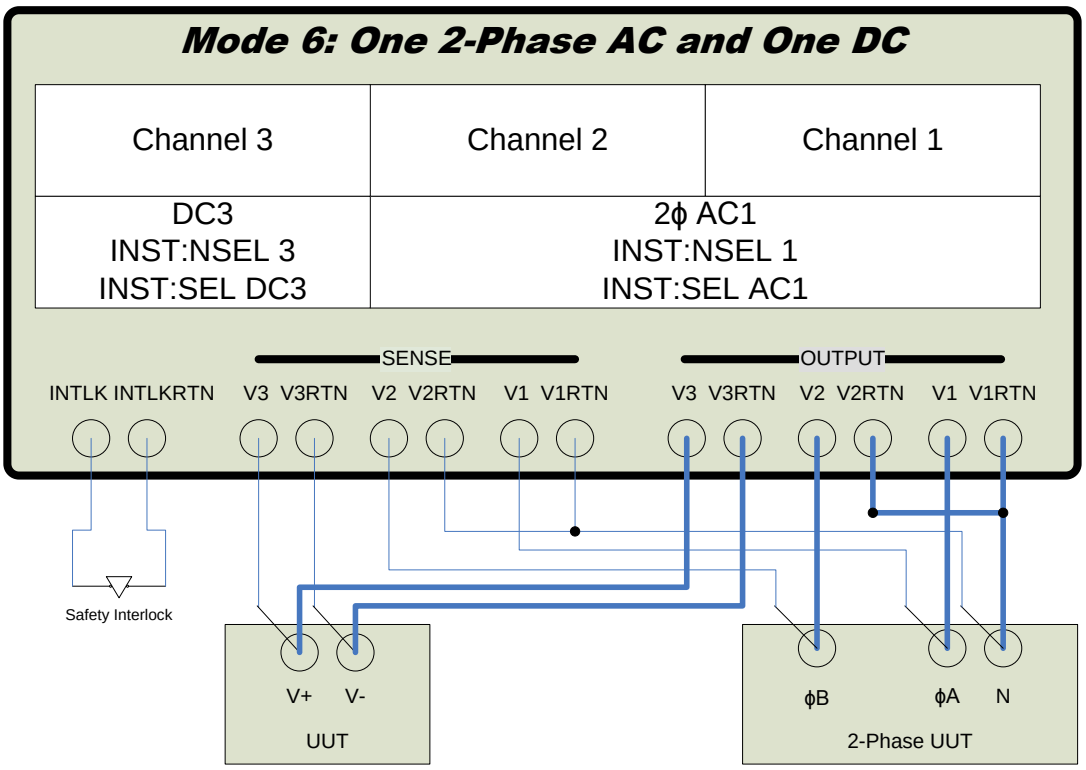


Figure 7 - Mode 6: One 2-Phase AC and One DC

Key Maximums for Each Logical Instrument

	Model							
AC1 (2-Phase)	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	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

6.1.8 Mode 7: Two AC

Logical Instrument Configuration and UUT Wiring

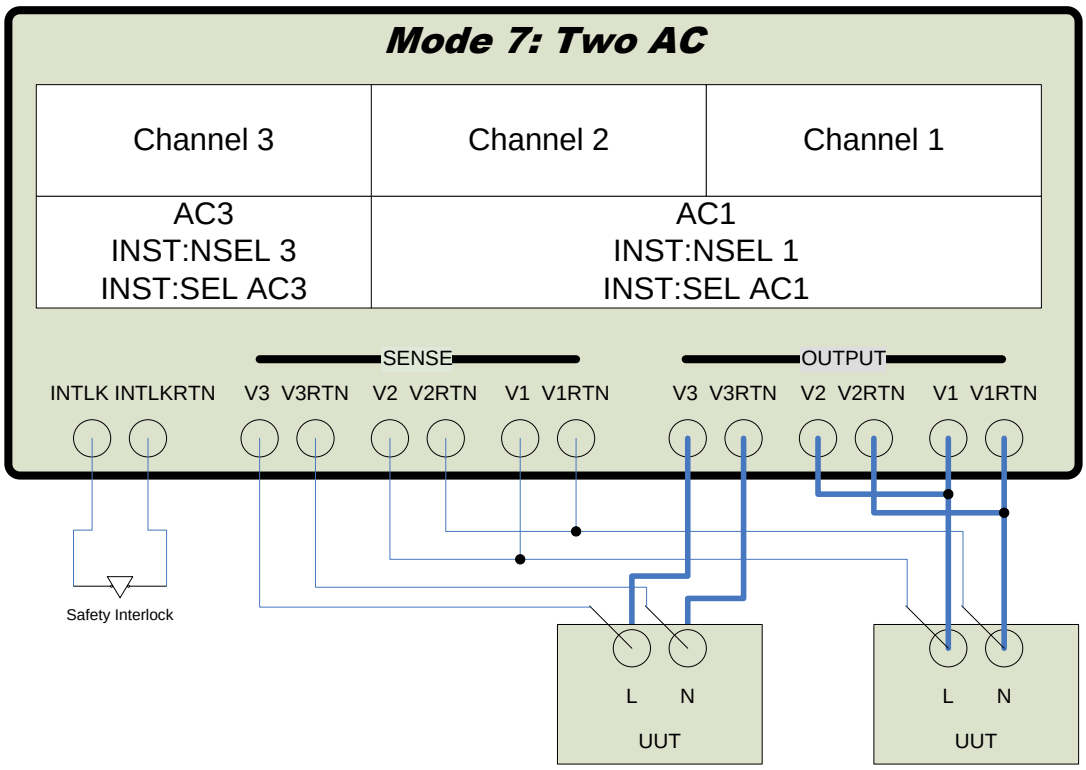


Figure 8 - Mode 7: Two AC

Key Maximums for Each Logical Instrument

	Model							
AC1	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	310 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	310 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							

6.1.9 Mode 8: One AC and One DC

Logical Instrument Configuration and UUT Wiring

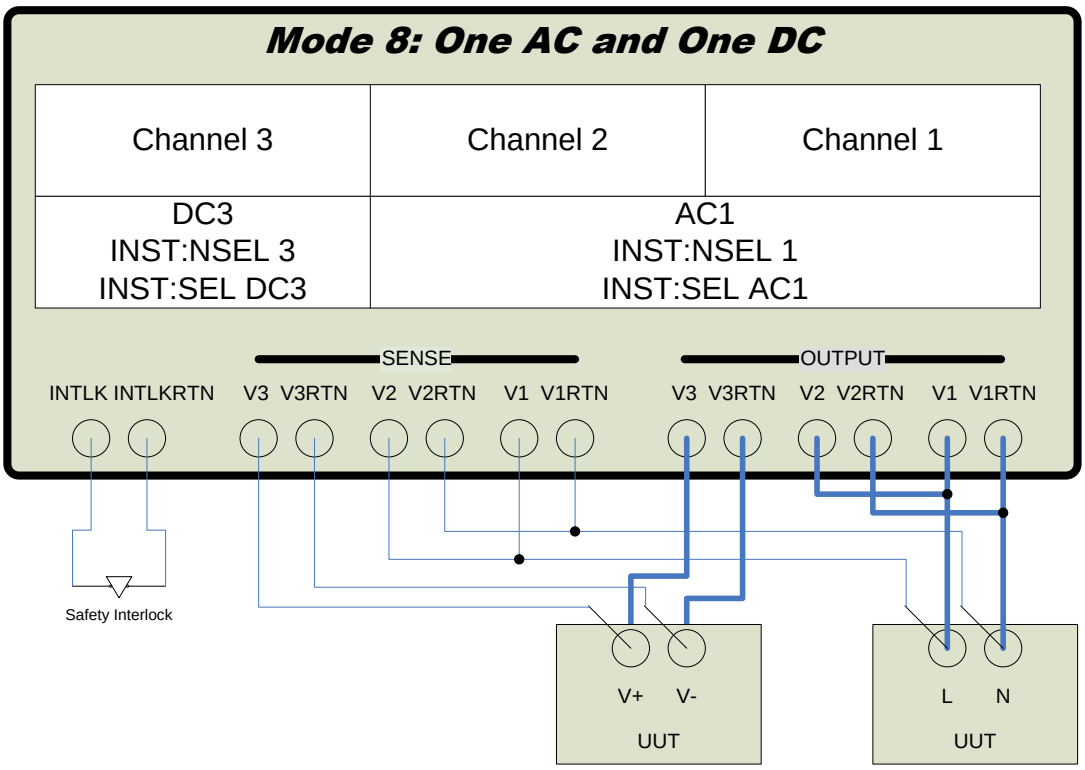


Figure 9 - Mode 8: One AC and One DC

Key Maximums for Each Logical Instrument

	Model							
AC1	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	310 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

6.1.10 Mode 9: Two AC and One DC

Logical Instrument Configuration and UUT Wiring

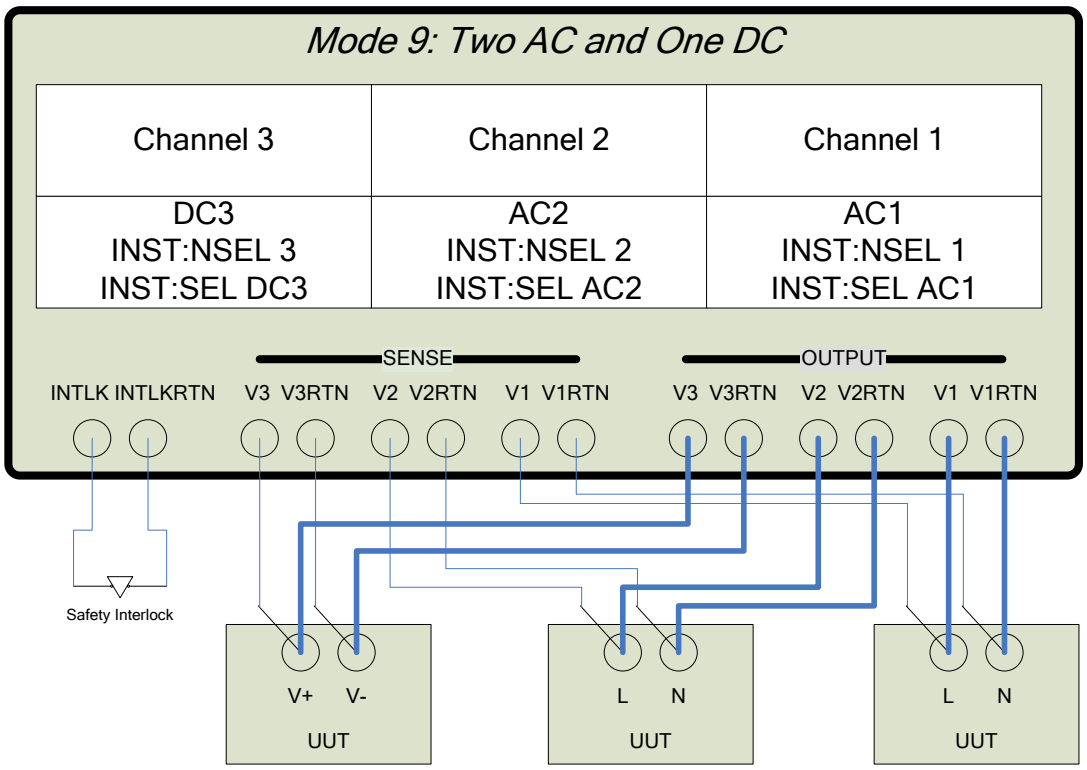


Figure 10 - Mode 9: Two AC and One DC

Key Maximums for Each Logical Instrument

	Model							
AC1	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	310 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	310 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

6.1.11 Mode 10: One AC and Two DC

Logical Instrument Configuration and UUT Wiring

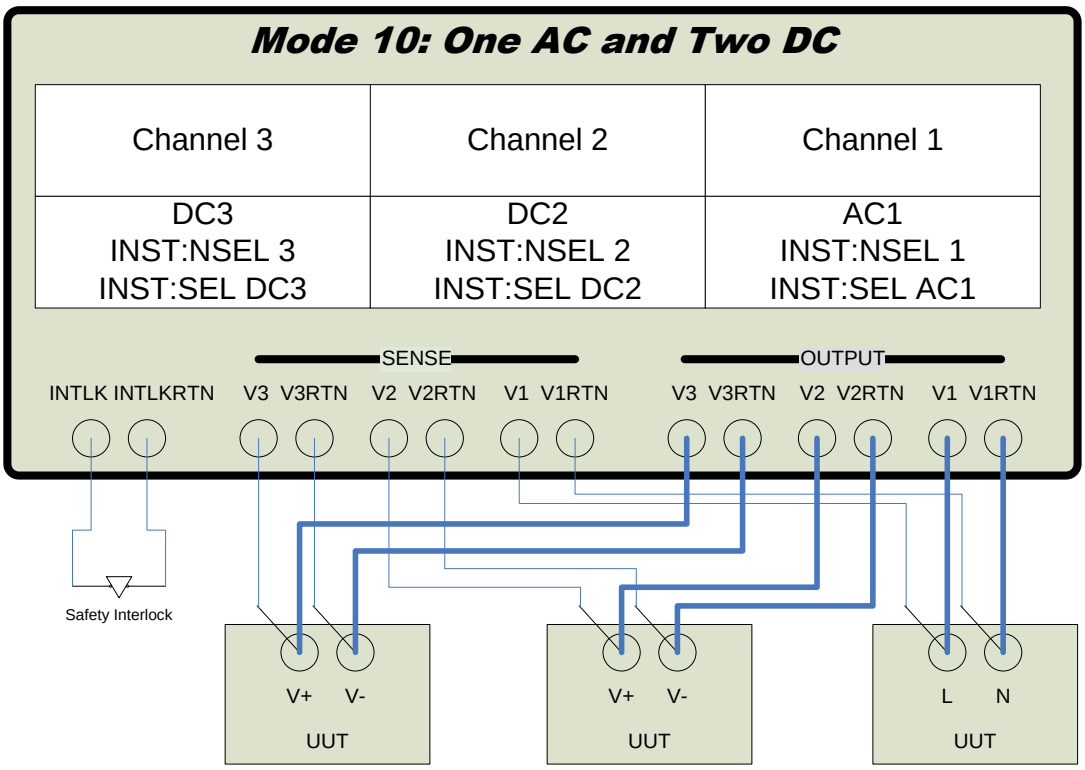


Figure 11 - Mode 10: One AC and Two DC

Key Maximums for Each Logical Instrument

	Model							
AC1	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	310 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

6.1.12 Mode 11: One DC and One AC

Logical Instrument Configuration and UUT Wiring

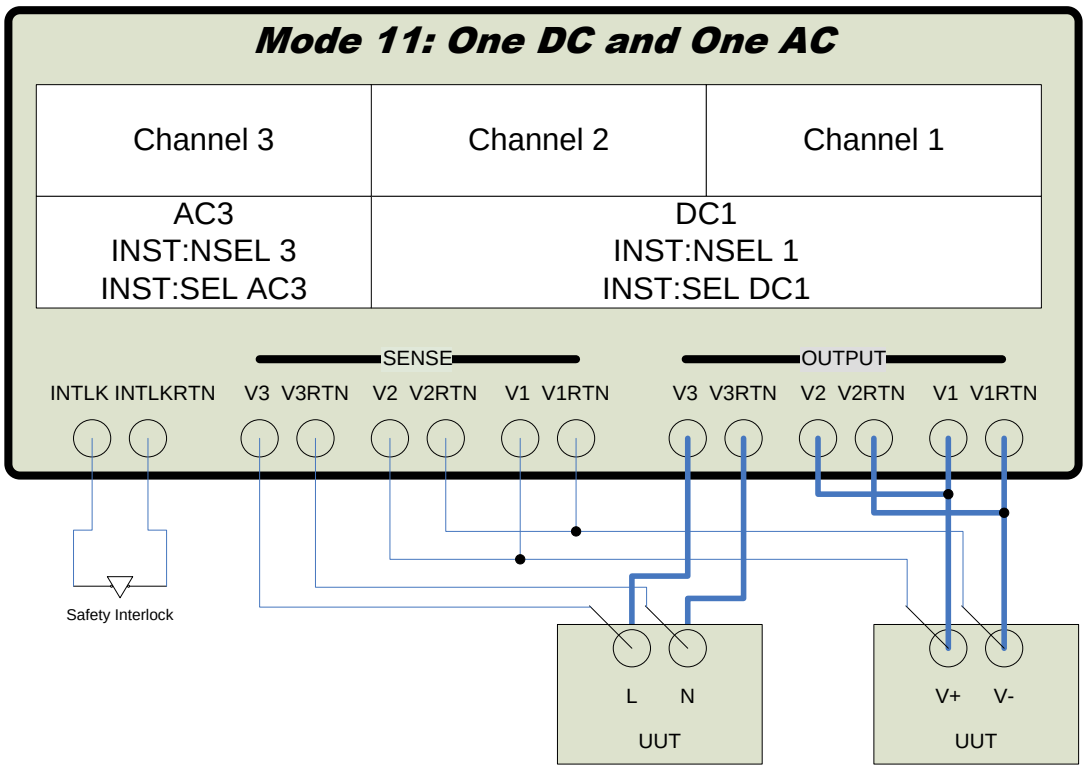


Figure 12 - Mode 11: One DC and One AC

Key Maximums for Each Logical Instrument

	Model							
DC1	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
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	310 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							

6.1.13 Mode 12: Two DC

Logical Instrument Configuration and UUT Wiring

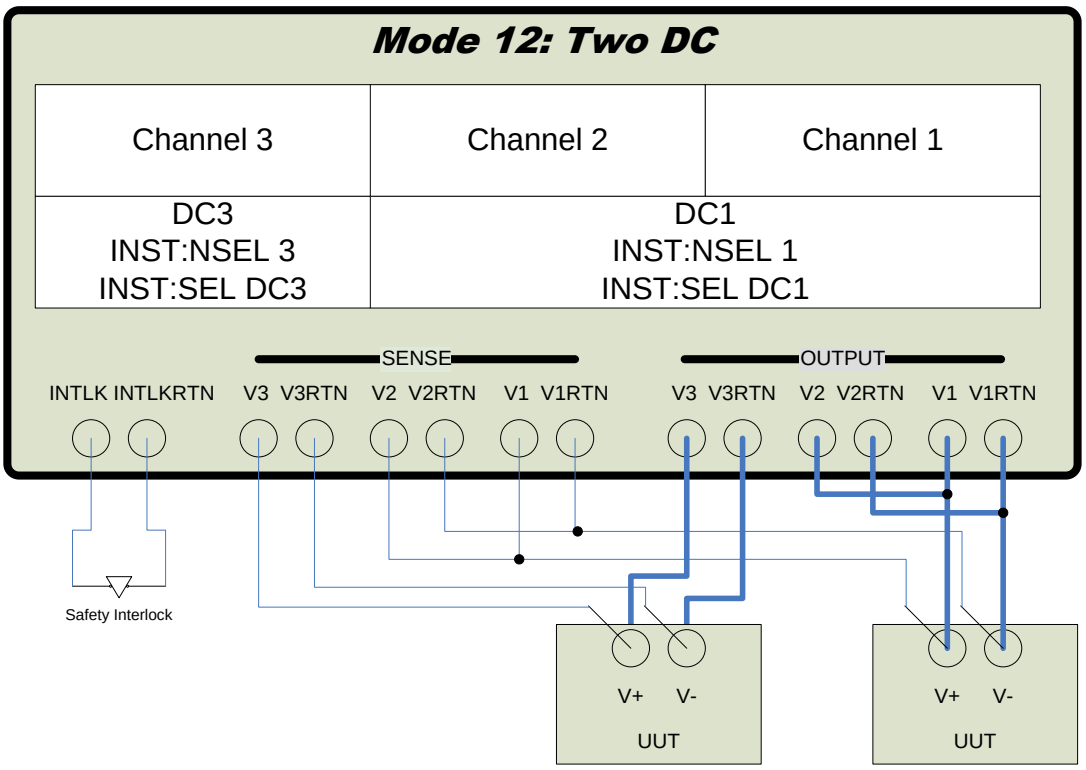


Figure 13 - Mode 12: Two DC

Key Maximums for Each Logical Instrument

	Model							
DC1	9410-12	9410-24	9410-36	9410-48	9410-60	9410-72	9410-84	9410-96
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

6.2 Two Channel Power Module

The two channel power module has 6 unique configurations.

Mode	*Available Instruments*	*Channel 1*	*Channel 2*
0	One 2-Phase AC	AC1 (Phase A)	AC1 (Phase B 180°)
1	One AC	AC1	
2	One DC	DC1	
3	Two AC	AC1	AC2
4	Two DC	DC1	DC2
5	One AC and One DC	AC1	DC2

The following figures show the basic wiring for each mode.

6.2.1 Mode 0: One 2-Phase AC

Logical Instrument Configuration and UUT Wiring

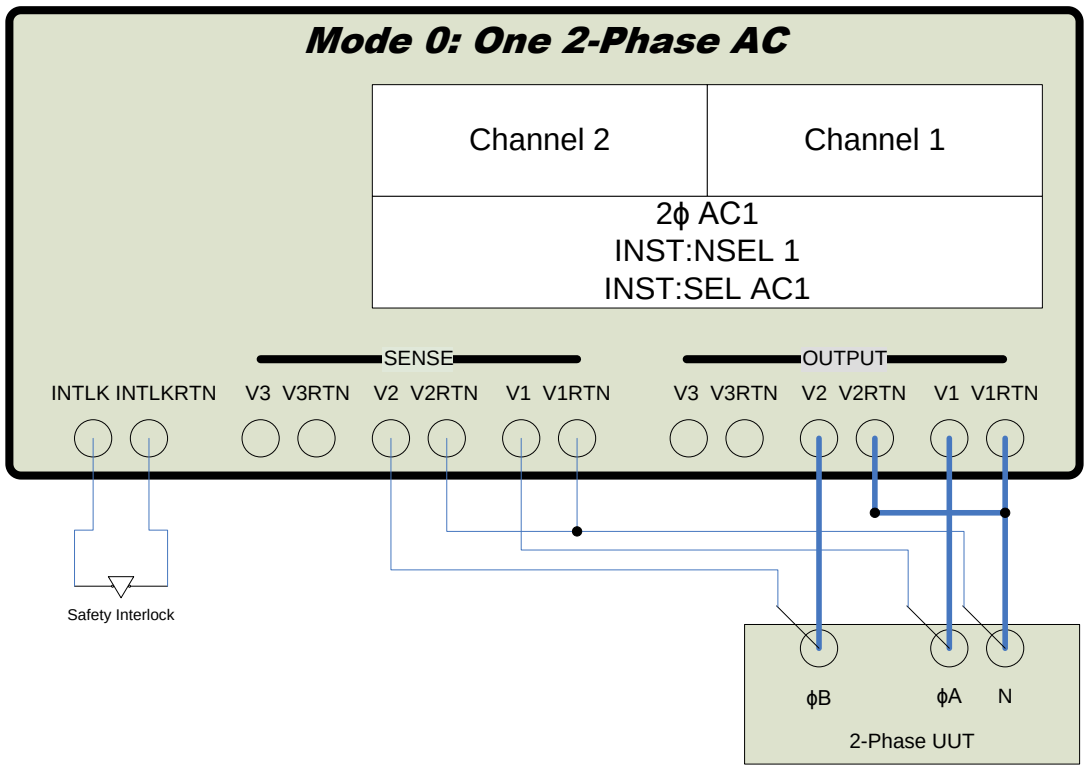


Figure 14 - Mode 0: One 2-Phase AC

Key Maximums for Each Logical Instrument

	Model							
AC1 (2-Phase)								
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	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							

6.2.2 Mode 1: One AC

Logical Instrument Configuration and UUT Wiring

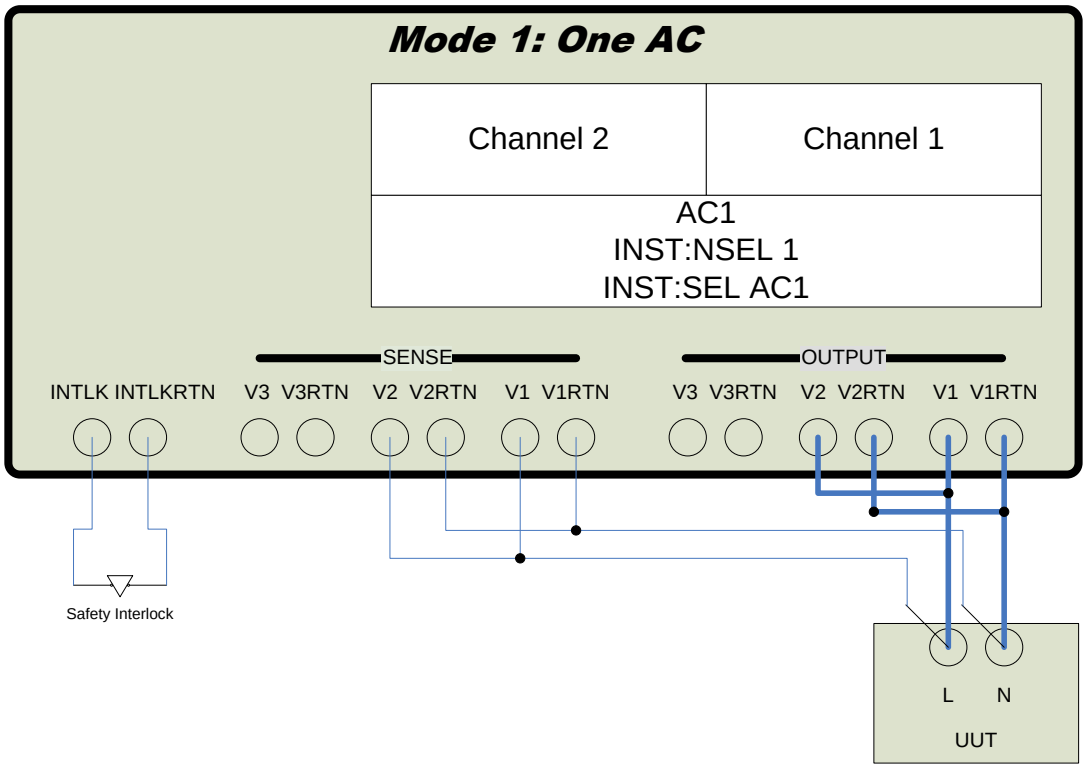


Figure 15 - Mode 1: One AC

Key Maximums for Each Logical Instrument

	Model							
AC1								
Max Power	8 kW	16 kW	24 kW	32 kW	40 kW	48 kW	56 kW	64 kW
Max Voltage	310 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							

6.2.3 Mode 2: One DC

Logical Instrument Configuration and UUT Wiring

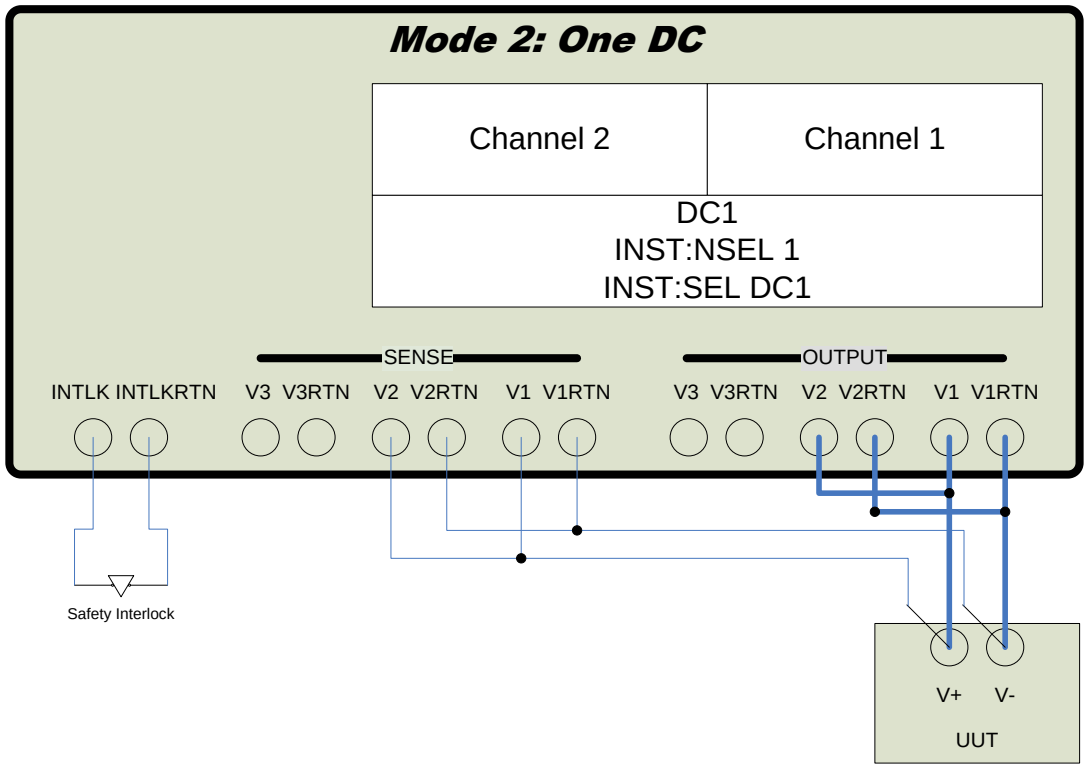


Figure 16 - Mode 2: One DC

Key Maximums for Each Logical Instrument

	Model							
DC1								
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

6.2.4 Mode 3: Two AC

Logical Instrument Configuration and UUT Wiring

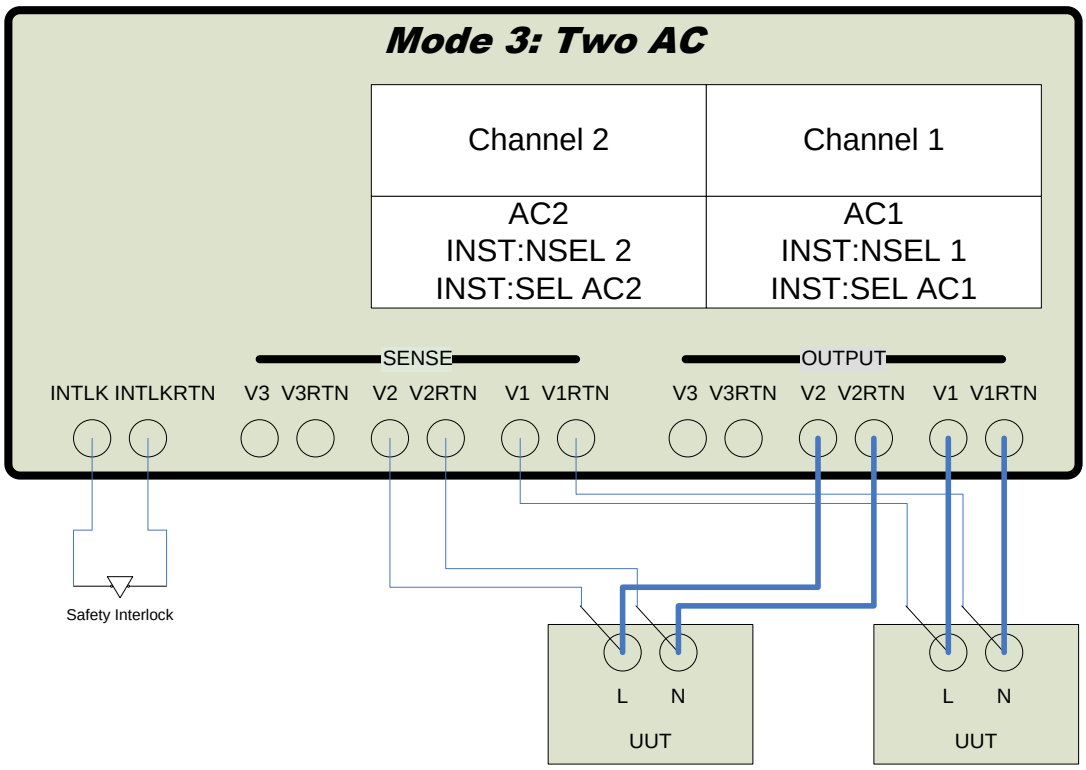


Figure 17 - Mode 3: Two AC

Key Maximums for Each Logical Instrument

	Model							
AC1								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	310 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	310 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							

6.2.5 Mode 4: Two DC

Logical Instrument Configuration and UUT Wiring

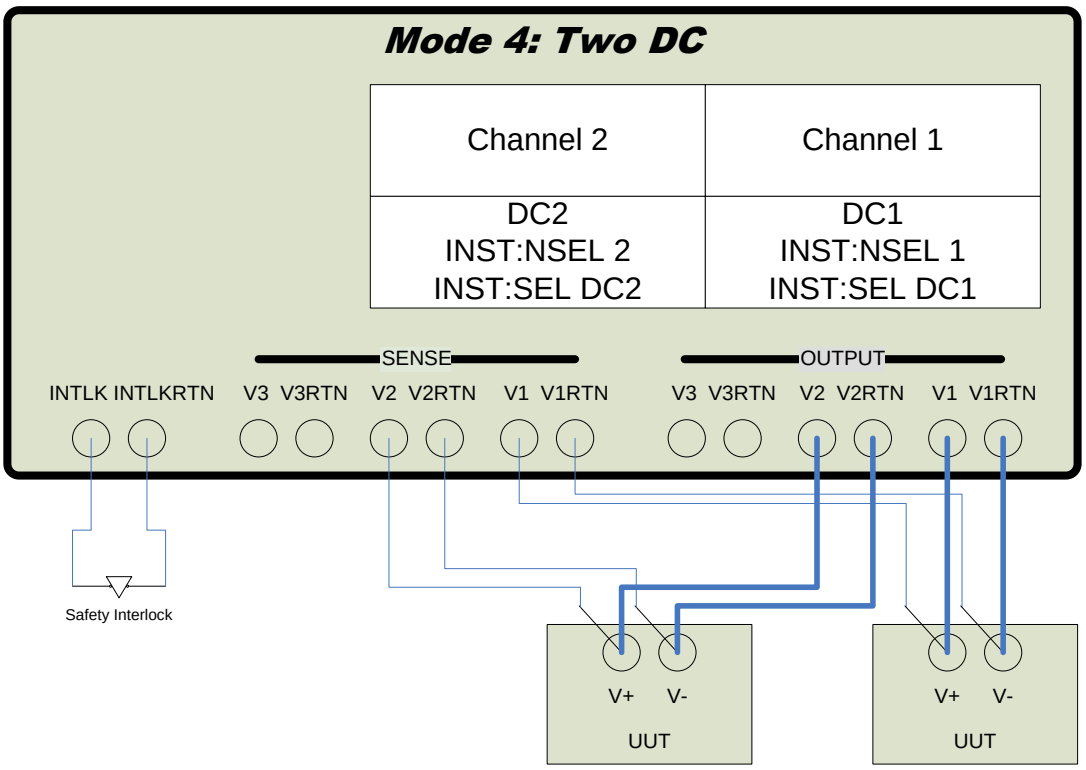


Figure 18 - Mode 4: Two DC

Key Maximums for Each Logical Instrument

	Model							
DC1								
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

6.2.6 Mode 5: One AC and One DC

Logical Instrument Configuration and UUT Wiring

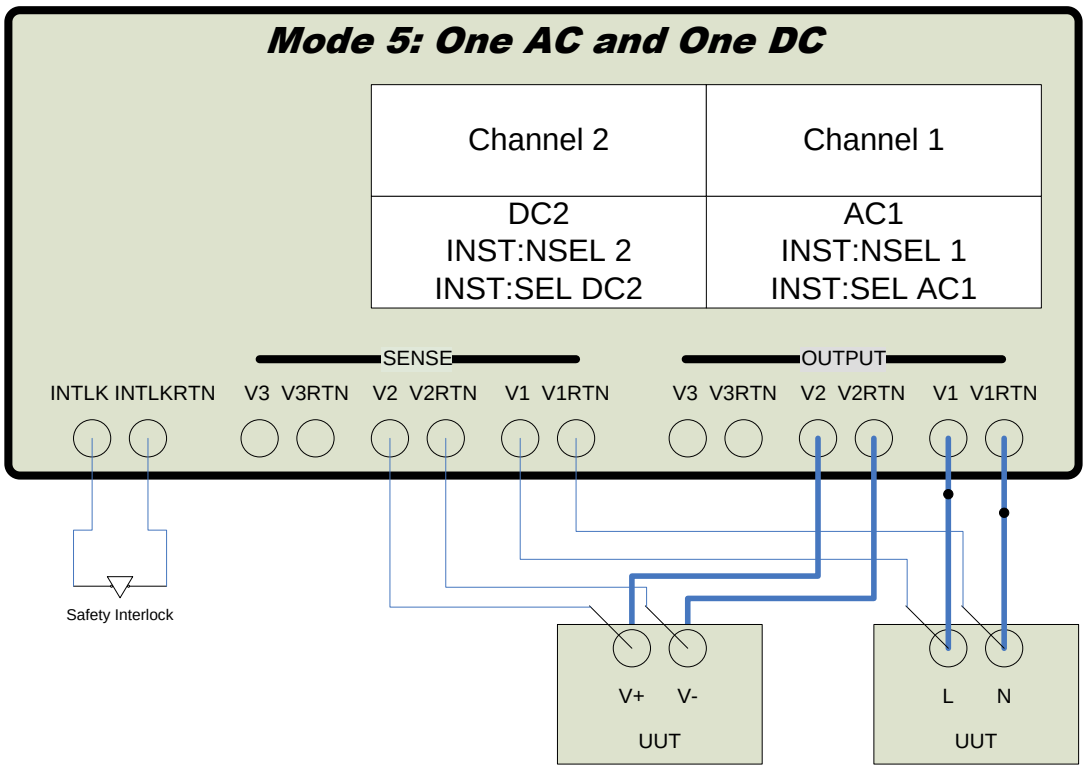


Figure 19 - Mode 5: One AC and One DC

Key Maximums for Each Logical Instrument

	Model							
AC1								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	310 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

6.3 One Channel Power Module

The one channel power module has 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.

6.3.1 Mode 0: One AC

Logical Instrument Configuration and UUT Wiring

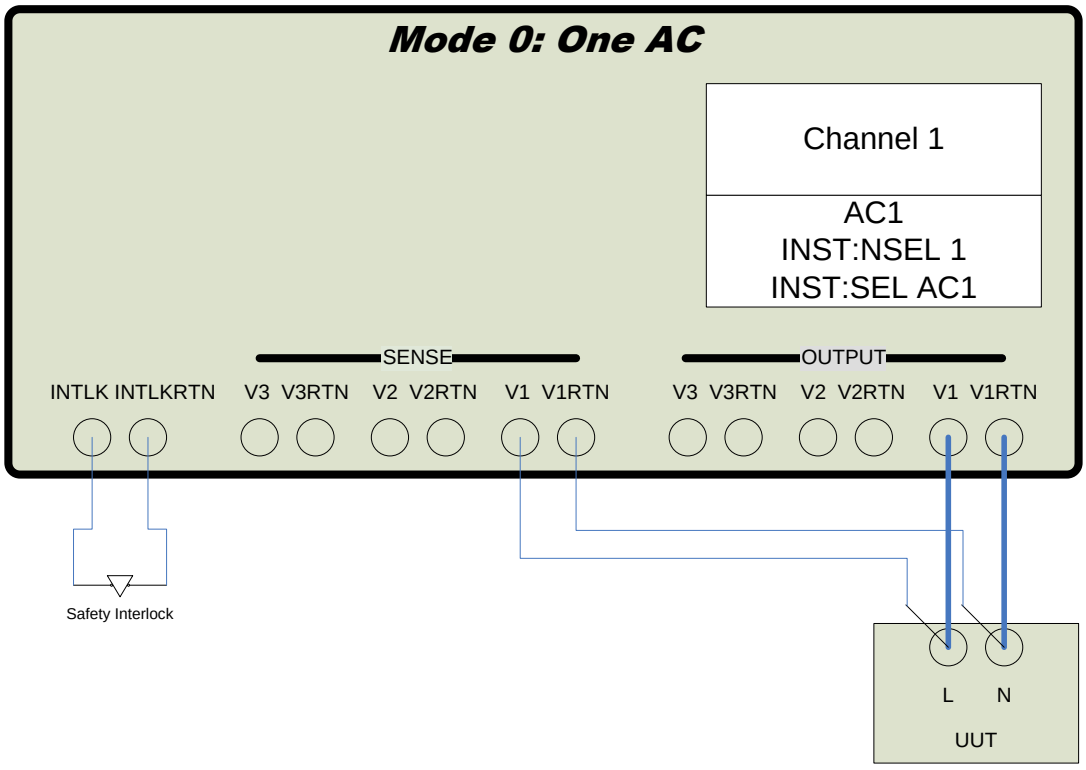


Figure 20 - Mode 0: One AC

Key Maximums for Each Logical Instrument

	Model							
AC1								
Max Power	4 kW	8 kW	12 kW	16 kW	20 kW	24 kW	28 kW	32 kW
Max Voltage	310 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							

6.3.2 Mode 1: OneDC

Logical Instrument Configuration and UUT Wiring

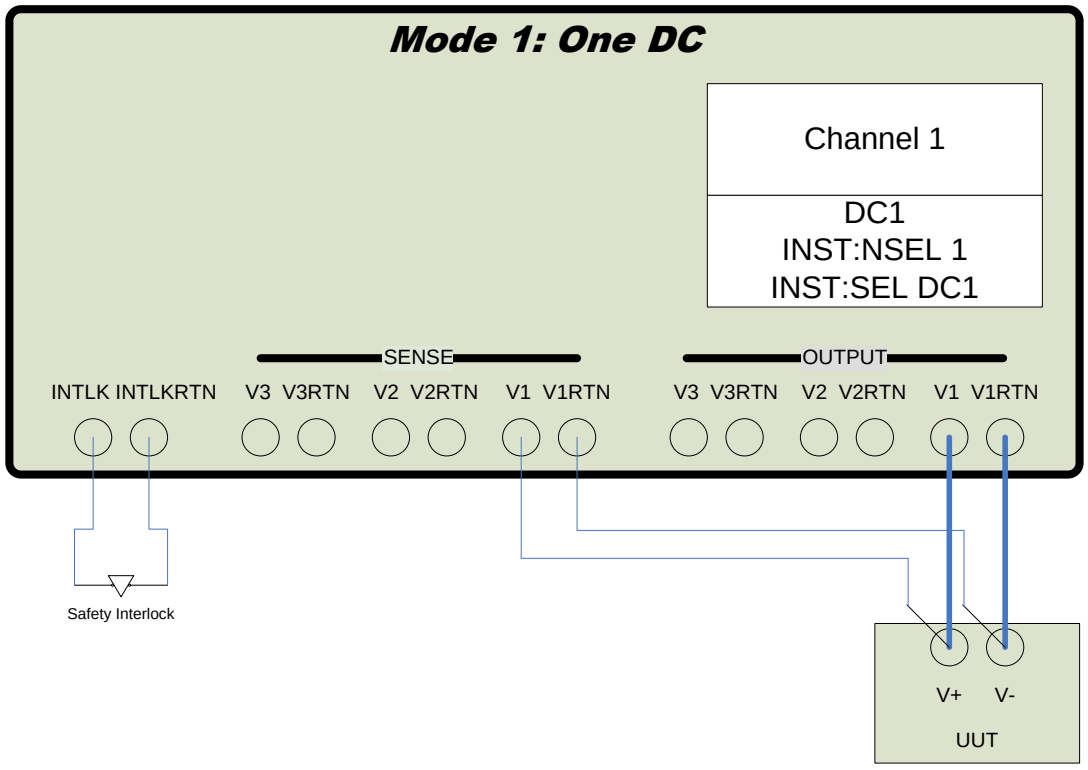


Figure 21 - Mode 1: One DC

Key Maximums for Each Logical Instrument

	Model							
DC1								
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

7. APENDIX – ADDITIONAL INFORMATION

7.1 Overview

The NHR Model 9400 Series AC/DC Power Module is a family of high efficiency, high power density, power regenerative, rack mountable, and low noise distortion, DC/single/multi-phase power source which provides precise output regulation and advanced measurement.

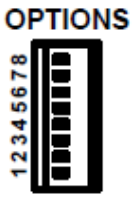
7.1.1 Aux Sys Address Setup

There is an Auxiliary System Address Dipswitch for each 9400 systems. Position 1-4 are used to set system address, position 8 is used to setup firmware download (normally down). If there are multiple 9400 systems in parallel, each system needs to set at different address. This Dipswitch is preset at factory. By default, when only one 9400 system work as an instrument, switch 1-4 will be set at down position (value 0). System will generate a configuration error if the Dipswitch is set wrong.

7.1.2 Emergency-OFF Connector Setup

User need to jumper pin1 and pin2 of the Emergency-Off connector to turn on the system. This connector provides a way to quickly turn off the system with an outside switch at emergency. When pin1 and pin2 are disconnected, all the input relay and output relay will open, and all the semi-conductors will stop switching. System will generate an Emergency Off error and be latched off even if the jumper is back. Recycle power or a reset command can clear the error.

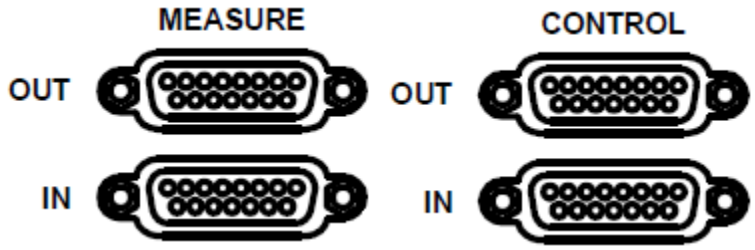
7.1.3 Option Dipswitch Setup



Switch 8	This switch along with switch 8 of the Aux Sys Address setup, determine if user want to update the Controller-Board/Slave-Board firmware or normal operation. Switch Up: Download (update) firmware for Controller Board or

	Slave Boards. Switch Down: Normal Operation This switch has to be set before unit turn on
Switch 7-6	Reserved (default to 0)
Switch 5	Debug/NHR use only
Switch 4-2	Reserved (default to 0)
Switch 1	Set the IP Address This switch has to be set before unit turn on

7.1.4 Parallel Connectors



When there are multiple units in parallel, the measurement parallel connector and the control parallel connector need to be connected in parallel (daisy chained together).

FOR MASTER UNIT, IT IS REQUIRED TO PUT ON THE CAN BUS TERMINATOR ON THE CONTROL IN. THE CAN BUS TERMINATOR IS PROVIDED IN THE INSTALATION KIT.

IT IS REQUIRED TO USE THE NHR PROVIDED CABLE FOR THE PARALLEL.

7.1.5 Key Features

7.1.5.1 Output Isolation and Flexible Mode Configuration

The output of the 9400 Power Module is isolated from the line supply and chassis ground. Control communication is also isolated between the host computer and any Power Module outputs. Each Channel output is also isolated from each other. This allow very flexible configuration of the output to be Three Phase, or Single Phase, or Single Phase Split, or even one phase as AC and one phase as DC. See the “Hardware Modes” section for more information on the all of the possible configurations!

7.1.5.2 Power Flow Bi-Directional and Power Regenerative

As a Power Source, the NHR Model 9400 will provide precise output voltage regulation. Moreover, each of its channels/phases can source or sink current. When sourcing current, the power will flow from the grid to the Unit Under Test (UUT), or when sinking current,

the power will flow back to the grid rather than dissipate as heat. This makes 9400 series a great test instrument for testing grid tied inverters.

7.1.5.3 Near Unity Power Factor

The regenerative AC/DC Power Module uses power factor correction to sink or source maximum rated power to or from a three phase grid.

7.1.5.4 High Efficiency and High Power Density

NHR Model 9400 uses the latest SCI MOSFET technology and has very high efficiency (up to 92%) and high Power density (up to 1.92W per cubic inch)

7.1.5.5 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.

7.1.5.6 Programmable Limits

The 9400 series Power Module has programmable current, voltage, and power limits.

7.1.5.7 Safety Features to Protect the Operator

- **Interlock Connector:** Each 9400 Power Module provides a separate 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 available for each 9400 power module. Pin 1 and 2 of the connector has to be shorted to turn on the unit. This allows the user to have a circuitry with immediately shut down Emergency Off Button.

7.1.5.8 Safety Features to Protect the UUT

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
- A hardware emergency-off circuitry

7.2 Configuration

After powering up the unit, the user should verify the desired configuration of the following. These can be set and saved as the power up default with the included PC software tools or through the programming interface. The following should be modified while the output is off:

- Set the hardware configuration mode. This will determine if a channel is in AC or DC mode and whether it is paralleled with other channels.
- Select if you will be using internal or external sense.
- If you are configuring a channel in AC mode and you wish to use an Auto Transformer to boost the output/input voltage set it to use an autotransformer.

7.3 LED Indicators

LED Indicator	Description
Enable	This indicator will light whenever the output relay is closed, enabling voltage to the output connector pins.
Source	This indicator will light whenever the power flow is from Grid to UUT
Sink	This indicator will light whenever the power flow is from UUT to Grid
DSP	This indicator will blink green about once per second while powered on to indicate normal operation of the DSP. This indicator will blink yellow about once per second indicating a nonfatal error. This indicator will blink red about once per second indicating a fatal error, the output is off. If this indicator stops blinking, the DSP is not running correctly and a reset will be required.
Grid On	This indicator on the front panel will light when internal power supply voltage is present.
Multi-Phase	Off – System does not work in multi-phase mode On – System works in multi-phase mode
Single Phase	Off – System does not work in single phase mode On – System works in single phase mode
Status	This indicator will blink yellow about once per second while powered on to indicate normal operation of the microcontroller. If this LED stops blinking, the microcontroller is not running correctly and a power on reset will be required. This indicator will alternately blink yellow/red when the microcontroller detects any of several errors, either in hardware, DSP communication, or command execution. This indicator will indicate it is communicating with the network controller PC with an alternating green/yellow or non-steady yellow blinking pattern.
LAN	This indicator will be on when a good network connection is established. It will turn off if the network cable is unplugged, or a network IP conflict is detected. It can be set to blink in response to a control button available on the web page served by the instrument.

7.4 Important Terminology

7.4.1 Output

Output is the generic term applied to the connection from the 9400 to the UUT (unit under test). Output, however, should not be construed to imply power flow direction. The output when connected to a UUT can be used to source or sink current.

7.4.2 Power Module

Power module is the generic name for the 9400. Since the 9400 can act as a DC source, an AC source, and is bi-directional with energy flowing to or from the grid it cannot simply be referred to as a source or a load.

7.4.3 Channel

The9400 has one to three internal power sections, known as channels, which can be configured for AC or DC operation. Each channel is 4 to 32 kW so a 12 kW 9400 will have three 4kWchannels while a 96 kW 9400 will have three 32 kW channels. Channels 2 & 3 can be paralleled with channel 1. When in AC mode, the channels are also referred to as Phase A, B, and C.

7.4.4 Instrument

A configured power module will have from one to three logical instruments. The logical instruments may be referred to by an instrument number or by an instrument name. For example, in hardware mode 3 (3ac source outputs) there are three logical instruments named AC1, AC2, and AC3 also known as instruments 1, 2 and 3.

7.4.5 UUT

The unit under test connected to the logical instrument's output.

7.4.6 Units

Unless otherwise stated, units are as follows:

Voltage	Volts (V)
Current	Amperes (A)
Resistance	Ohms (Ω)
True power	Watts (W)
Apparent power	Volt-Amperes (VA)
Frequency	Hertz (Hz)
Energy	Ampere-Hours (Ah), Kilowatt-Hours (kWh), Kilovolt-Ampere-Hours (kVAh)
Angles	degrees (°)
Time	seconds (s)

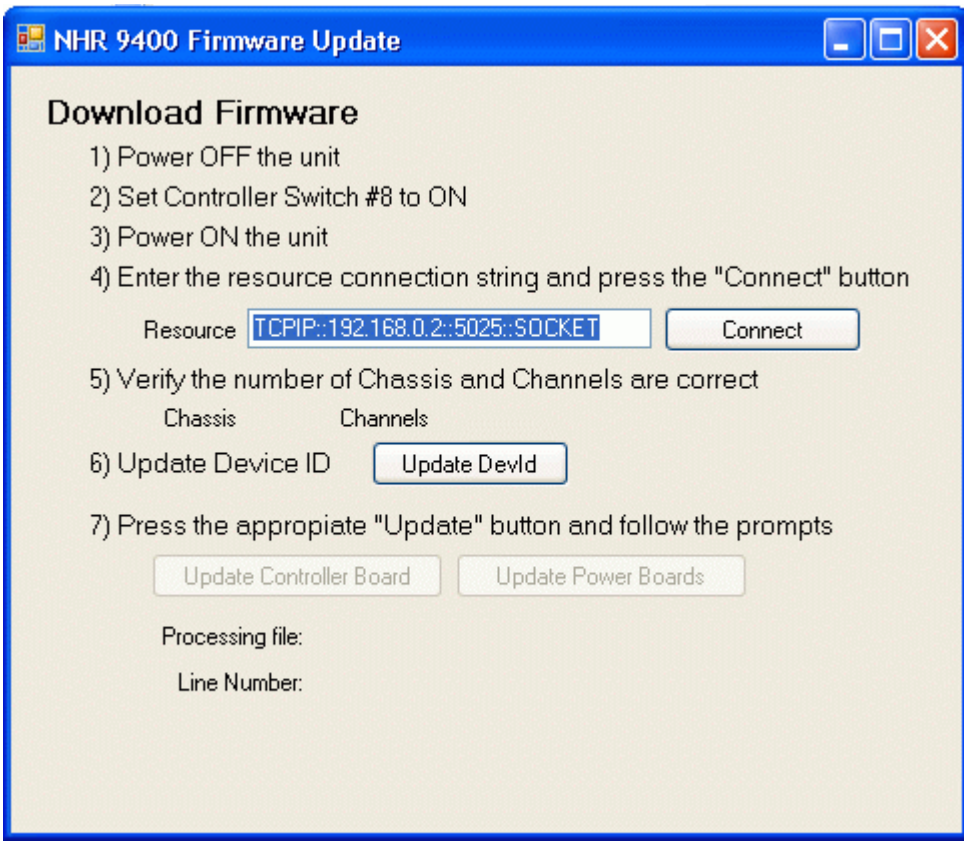
8. SERVICE

8.1 Firmware Updates

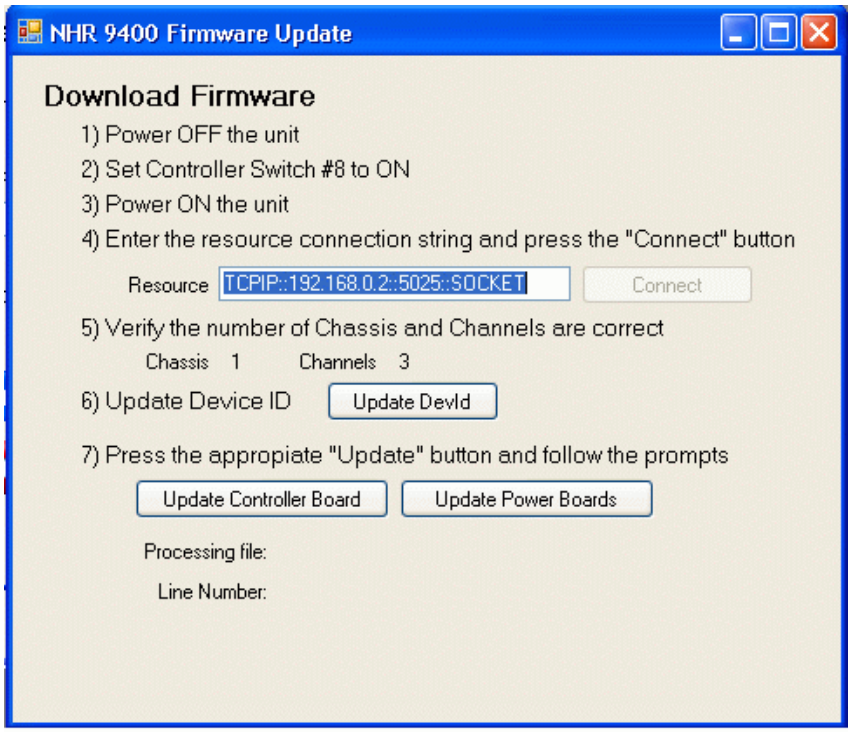
NHR provides the firmware update utility to allow user to update the firmware for the controller board and power boards. Before update the firmware, make sure:

1. Power off the unit.
2. Set switch 8 of the power module address Dipswitch up.
3. Make sure the LAN cable is connected.
4. Power on the unit.

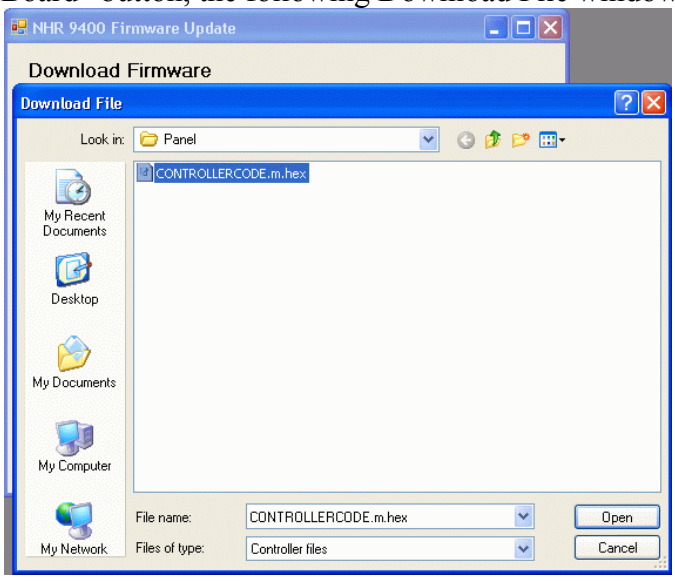
The firmware update utility is included on the DVD. Press Windows Start, then "NH Research", "9400 Series", and select "NHR 9400 Firmware Update".



5. Enter the resource connection string and press "Connect" button, and then the dialog box will show how many Chassis and Channels are detected. In this example, one chassis and 3 channels is detected (9400-12). User need to verify if it is correct:

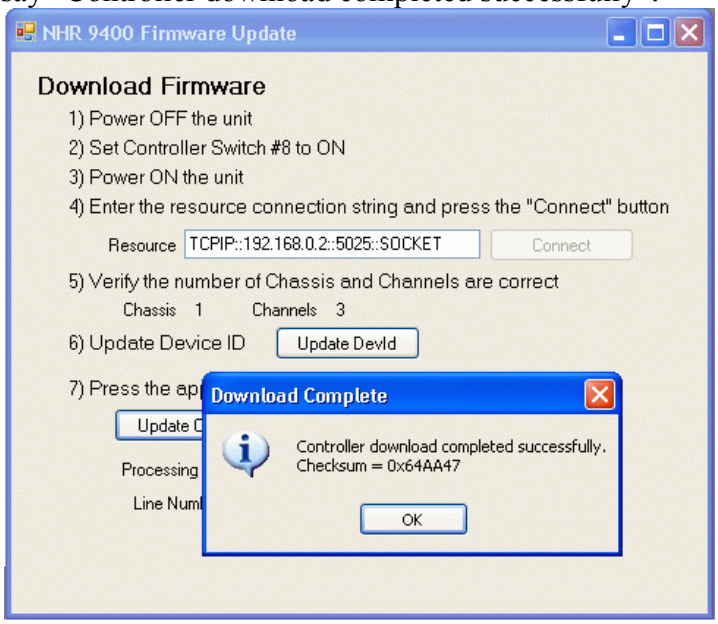


6. Step 6 is normally used by factory only, so the user can skip this step. If needed, step 6 will update the device ID. The device ID is used to verify if the firmware selected is correct. The device ID input here will be compared with a device ID in the firmware code. If they do not match, possibly a wrong firmware document is selected, it will generate an error if that is the case.
   To update the controller board firmware, click the "Update Controller Board" button, the following Download File window will show up:

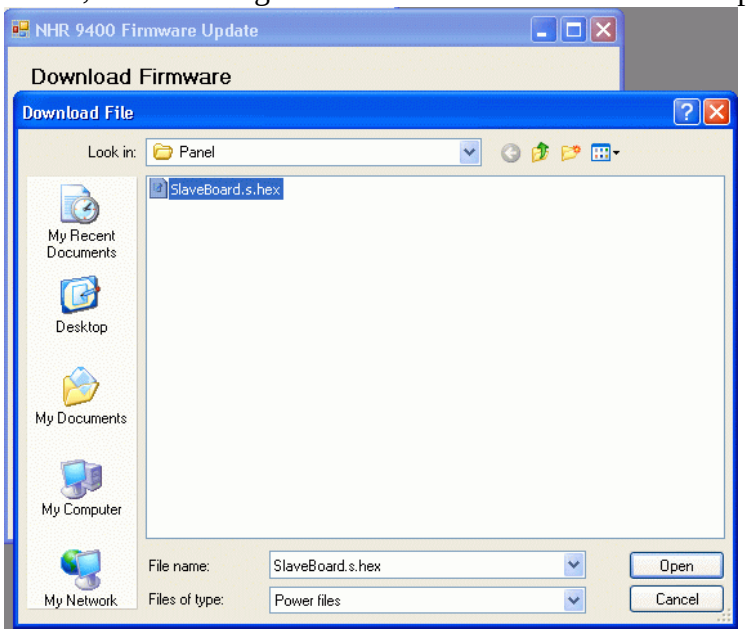


7. Selected the file for the controller board (filename.m.hex). Then press "Open". It normally takes 1-2 minutes to download the controller board

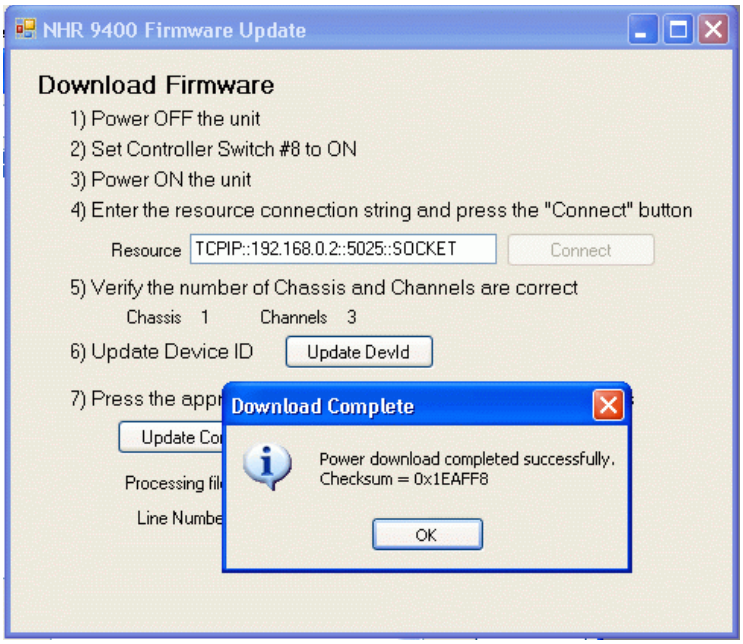
code. At the end of the download, if it is successful, a pop up window will say “Controller download completed successfully”:



8. To update the power boards’ firmware, click the “Update Power Board” button, the following Download File window will show up:



9. Selected the file for the power board (filename.s.hex). Then press “Open”. It normally takes 5 minutes to download the power board code. At the end of the download, if it is successful, a pop up window will say “Power download completed successfully”:



8.2 Periodic Maintence - Cleaning

The exterior of the 9400 may be cleaned with a cloth dampened with a mild detergent and wrung out. Disconnect mains power to the 9400 before cleaning. Do not spray water or other cleaning agents directly on the unit.