NHR from NI

Document Part Number 379015A-01

NHR 9510-100 User Manual

January 25, 2024

Enabling Electrification

Your Partner in Test

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Introduction

The 9510-100 Regenerative Grid Simulator is the industry leading solution for testing and verification of high-power, grid-tied applications in compliance with regulatory testing standards. The 9510-100 has a built-in power amplifier mode for power hardware in the Loop (PHIL) applications providing further testing capability ideal for research labs. The power level is modular and scalable from 50 kW to up to 1.2 MW with a programmable frequency between 30 Hz and 120 Hz. The output can be AC, DC, or AC+DC and the AC can be single, split, or 3-phase. With this wide range of power, frequency, and phase configuration options, the 9510-100 provides the flexibility to test a broad selection of grid-tied products.

NHR 9510-100 Regenerative Grid Simulator Overview

The 9510-100 Regenerative Grid Simulator consists of a 28 in. x 39 in. x 79.25 in. cabinet that houses the following components:

- An integrated touch panel interface for manual control and for running basic tests within minutes after powering on the tester
- A remote soft panel interface installed on your PC or laptop for running complex test programs via the additional control features, such as editing waveshapes capturing waveforms, and using Macros to control test program steps
- A mounted Emergency Off (E-OFF) button
- Logic power supply for internal interlocks
- Casters for movement of the system
- Facility at the rear of the unit and UUT connections on the top of the unit
- Main facility power breaker at the lower rear of the unit

Icons

Refer to the following descriptions if one of these icons is marked on your product or used in this guide.

CAUTION: POSSIBILITY OF ELECTRIC SHOCK
Take precautions to avoid electrical shock.

CAUTION
Take precautions to avoid injury. Consult the product documentation for cautionary statements when you see this icon printed on the product. Cautionary statements are localized into French for compliance with Canadian requirements.

NOTICE Take precautions to avoid data loss, loss of signal integrity, degradation of performance, or damage to the product.

Warranty

NI 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.

Intended Usage

The NHR 9510-100 Regenerative Grid Simulator is intended for use in temperature-controlled, indoor laboratory environments only. The product provides AC or DC voltage control and measurement primarily used in evaluation, performance, functional, and endurance testing for either AC or DC products. Usage for other purposes not described in this document which result in product failure may be considered as customer abuse and therefore may not be covered under warranty.

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

ATTENTION
Les opérateurs travaillant sur l'équipement doivent être formés aux procédures de sécurité. Les dommages causés par une utilisation non conforme ne sont pas couverts par la garantie.

Safety

The NHR 9510-100 Regenerative Grid Simulator contains no internally replaceable or serviceable parts.

CAUTION: POSSIBILITY OF ELECTRIC SHOCK
Internal adjustment or component replacement is permitted by only qualified NI personnel. No internal adjustments or system access should be attempted by non-NI personnel.

ATTENTION: POSSIBILITÉ DE CHOC ÉLECTRIQUE
Seul le personnel qualifié de NI peut effectuer un ajustement interne ou le remplacement d'un composant. Aucun ajustement interne ou accès au système ne doit être effectué par du personnel autre que celui de NI.

CAUTION

Safety notice for qualified technician before servicing:

- Remove all external voltage sources.
- Disconnect power cord.
- Wait a minimum of 5 minutes to discharge internal circuits.
- Verify circuits are fully discharged.

ATTENTION

Consignes de sécurité destinées aux techniciens qualifiés avant l’entretien de l’appareil:

- Supprimer toutes les sources de tension externes.
- Débrancher le cordon d'alimentation.
- Attendre au moins 5 minutes pour que les circuits internes se déchargent.
- Vérifier que les circuits sont complètement déchargés.

The operator should observe the following general notices.

CAUTION: POSSIBILITY OF ELECTRIC SHOCK

- Internal access should be avoided because there are no serviceable parts.
- All connections should be carried out under 0 V 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 in the OFF state.

ATTENTION: POSSIBILITÉ DE CHOC ÉLECTRIQUE

- Éviter l'accès aux éléments internes (aucune pièce réparable).
- Toutes les connexions doivent être effectuées dans des conditions de 0 V.
- Toutes les connexions doivent être correctement terminées en ne laissant aucun fil exposé qui pourrait présenter un risque de choc électrique.
- Toujours supposer que la sortie présente un potentiel électrique, même lorsque l’appareil est éteint.

CAUTION

Additional Notes:

- The test equipment should be used only by trained personnel.
- Do not insert any object through the air intake.
- Avoid usage 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.

ATTENTION
Remarques supplémentaires :

- L'équipement de test ne doit être utilisé que par du personnel.
- N'insérer aucun objet dans la prise d'air.
- Dans la mesure du possible, éviter l'utilisation de liquides à proximité de l'équipement de test.
- S'assurer que la polarité est respectée lors de la connexion de l'équipement à l'appareil sous test. Une polarité inversée peut endommager l'équipement ou l'appareil sous test.

Glossary

General Terms

The following list defines the general terms used in this document.

- Unit under test (UUT) – The unit being tested.
- Input –The connection from the facility to the NHR 9510-100. The use of the term Input does not imply the direction of power flow.
- Output – The connection from the NHR 9510-100 to the UUT. The use of the term Output does not imply the direction of power flow.
- Channel – Comprised of a master output and the corresponding auxiliary output. Each channel can be configured for AC or DC operation and be configured for AC + DC operation to produce a single larger channel.
- Cabinet – The NHR 9510-100 cabinet.
- Auxiliary – A term is used specifically when cabinets are used in parallel. An Aux cabinet is one that is configured to parallel with a master cabinet to have more current and power output.
- Master – A term is used specifically when cabinets are used in parallel. A Master cabinet is one that users will directly communicate with and control. Master cabinet will then control the Aux system by itself. The end user will not need to communicate with the Aux system. You can connect a compatible auxiliary to expand the master current and power.
- Instrument – An abstraction term allowing one or more channels to be treated as a logical group. For example, if the NHR 9510-100 is configured for a single phase or 3-phase

operation, all channels are grouped into a single instrument; if three separate channels in the NHR 9510-100 are configured, the system address these channels as three separate instruments.

Units

The following units apply to this document unless otherwise noted.

Measurement	Unit	Definition
Angles	Degrees (°)	N/A
Apparent Power	Volt-Amperes (VA)	N/A
Crest Factor	N/A	Calculated as Current(AC-PEAK) divided by 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 3.33 ms
Energy	Ampere-Hours (Ah), Kilowatt-Hours (kWh), Kilovolt-Ampere-Hours (kVAh)	N/A
Frequency	Hertz (Hz)	N/A
Power Factor	N/A	Calculated as True Power divided by Apparent Power
Resistance	Ohms (Ω)	N/A
Time	seconds (s)	N/A
True Power	Watts (W)	N/A
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 3.33 ms

What is the 9510-100 Regenerative Grid Simulator and Who Is It for?

The 9510-100 Regenerative Grid Simulator is hardware featuring a built-in power amplifier mode for power hardware in the Loop (PHIL) applications. It is designed for test engineers to test and verify high-power grid-tied applications in compliance with worldwide regulatory testing standards. Use the 9510-100 Regenerative Grid Simulator to grid-tied products in research labs.

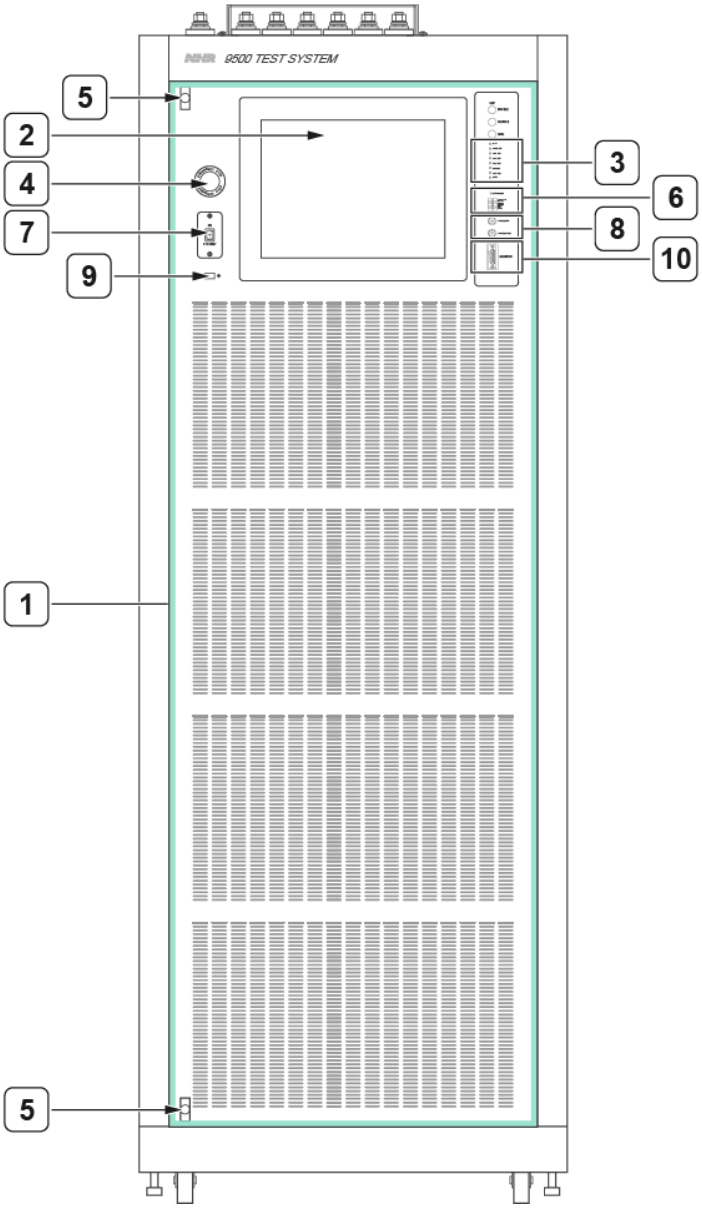
Key Features

- Optimized testing capability for power hardware in the loop (PHIL) applications
- Modular and scalable AC power level from 100 kW to 1.2 MW
  - Same unit can act as Master or parallel Auxiliary unit
  - Field expandable to allow for future increased power demands
- A programmable frequency between 30 Hz and 120 Hz
- Output: AC, DC, or AC+DC
- AC phase configuration: single, split, 3-phase, or three separate phases
- AC load option configuration: Three separate channels can be configured as regenerative AC/DC grid simulator or a 4-Quadrant AC load
- Operating envelope:
  - Extra current support for different voltage grid-tied products
  - High voltage remote voltage sense up to 866 V_{L-L} for the secondary side of high-voltage transformer
  - Wide range of power factors and range of voltage (up to 606 V_{L-L})
- High power density with small footprint
- Multiple phases and DC capability covering all utility source and load requirements
- Independent voltage and current measurement range to increase measurement accuracy
- Powerful waveform synthesizer combined with high-resolution digitizer covering extensive test and evaluation requirements
- Used for regulatory testing standards like UL 1741SA, IEEE 1547, IEC 62116, IEC 61000-4-11 (pre-compliance), 4-13, 4-14, and 4-28

9510-100 Module Views

Front View

Figure 1: NHR 9510-100 – Front Exterior View



1. Access Door
2. Touch Screen

3. LED Status Indicators
4. Emergency Off Button (E-OFF)
5. Door Release Latches
6. Digital I/O Interface
7.On/Off Switch
8. Monitor Signal Port (DSUB9) and Trigger In/Out Connections (Mini Smb)
9. USB Connection (for touchscreen use)
10. Output Disable Switch

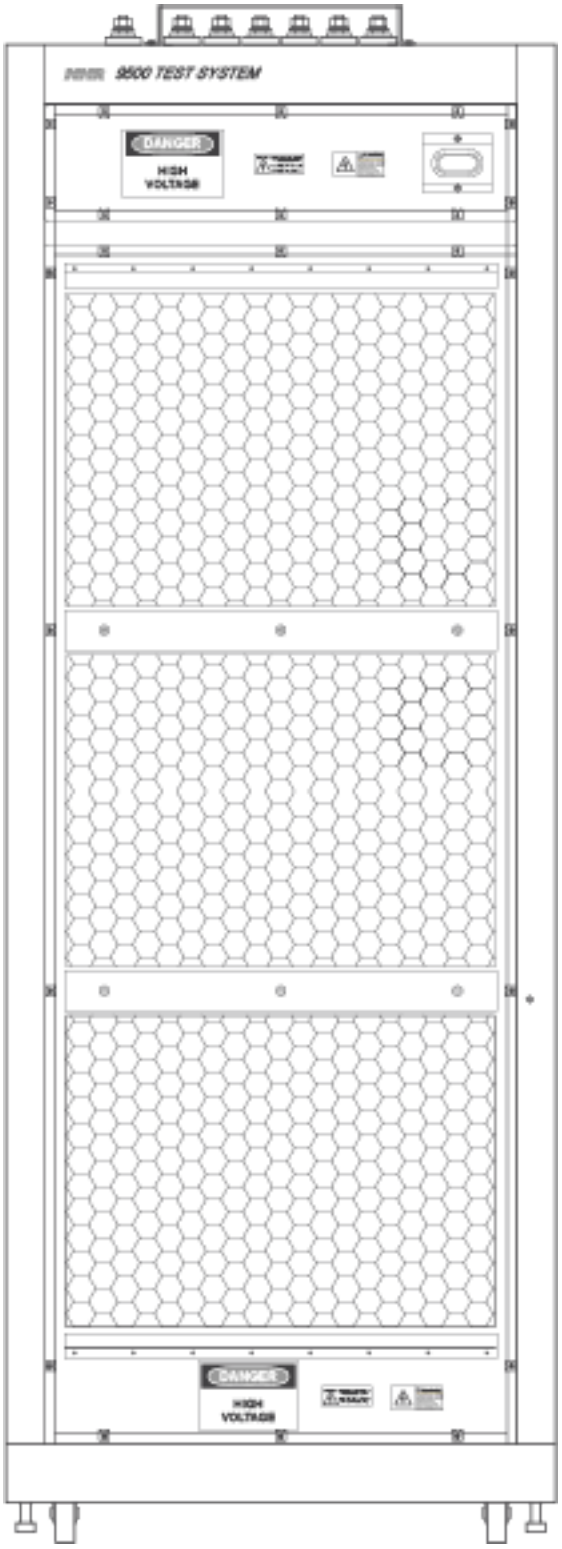
NOTE
NI recommends placing the 9510-100 on a hard surface such as concrete with a minimum of 24 inch of unrestricted air space to the front of each 9510-100 cabinet in use.

CAUTION
Avoid liquids and drinks near the front of the system. Accidental spills of any liquids may be drawn into the air-intake resulting in damage to the NHR 9510-100 cabinet.

ATTENTION
Éviter l'emploi de liquides et la consommation de boissons à proximité de la face avant du système. En cas de déversement accidentel, les liquides peuvent être aspirés dans la prise d'air et ainsi endommager l'armoire NHR 9510-100.

The access door should remain closed during normal operation. You can slide the latch pins at the top and bottom of the access door to open the front door. Open the access door to perform periodic filter inspection and replacement. This door is not interlocked because there are no high-voltage user accessible points behind this door.

Figure 2: Front Interior View – With Door Open



The following items are visible when the front door is open:

- EMI shield
- Safety screen

CAUTION: POSSIBILITY OF ELECTRIC SHOCK
Never insert metal objects and probes or allow metal fragments to be drawn into the openings of the EMI Shield and the safety screen.
There are no user-serviceable parts behind this screen.

ATTENTION: POSSIBILITÉ DE CHOC ÉLECTRIQUE
Ne jamais insérer de sondes ou d'objets métalliques et ne jamais laisser des fragments de métal s’introduire dans les ouvertures du blindage électromagnétique et de l'écran de protection.
Il n'y a pas de pièces réparables par l'utilisateur derrière cet écran.

CAUTION
Avoid liquids and drinks near the front of the system. Accidental spills of any liquids may be drawn into the air-intake resulting in damage to the NHR 9510-100 cabinet.

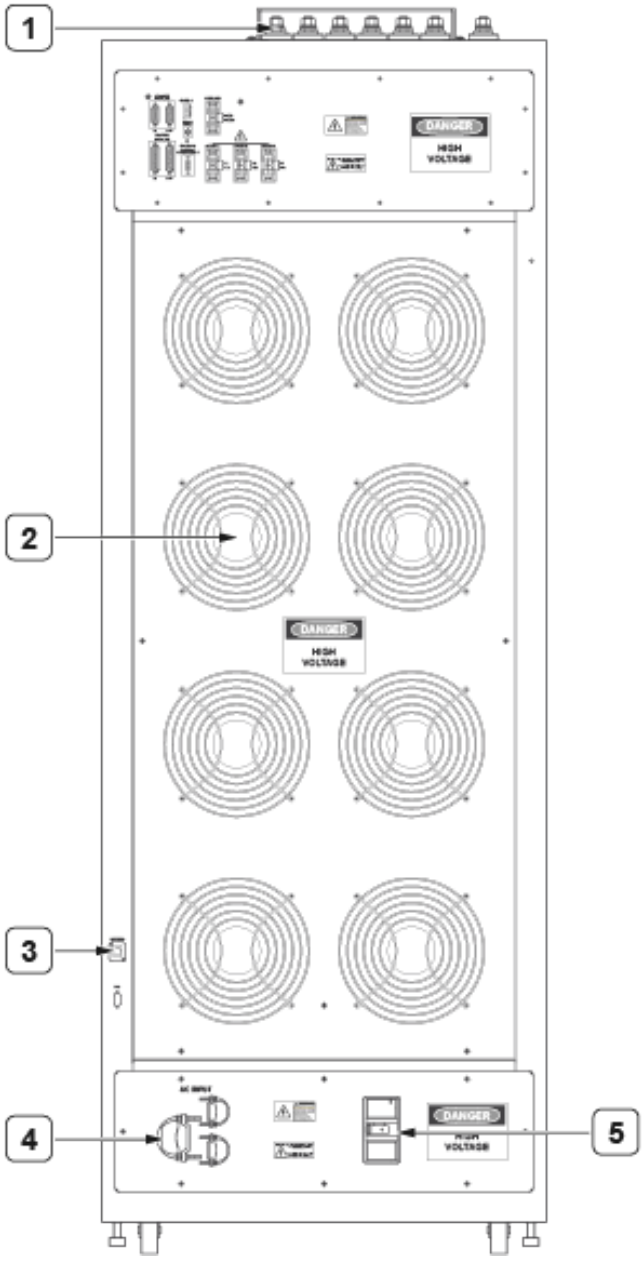
ATTENTION
Éviter l’emploi de liquides et la consommation de boissons à proximité de la face avant du système. En cas de déversement accidentel, les liquides peuvent être aspirés dans la prise d'air et ainsi endommager l’armoire NHR 9510-100.

Rear View

All access panels are not considered to be in use accessible and require the use of a tool.

Cooling air is drawn through the system and exhausted to the rear.

Figure 3: NHR 9510-100 – Rear Exterior View



1. Output Access Panel
2. Air Exhaust Fans
3. Ethernet (LAN) Communication Ports
4. Facility AC Power Connection
5. Main System Breaker

Refer to the *Installation* section for information about installing facility power.

The system output connections are both on top of the system under an access cover as well as behind the access cover to the top rear of the system. Sense leads and parallel connections are found on the rear top access panel.

All rear access panels must be installed prior to system use.

After installation, the output access cover may be opened by trained personnel to reconfigure the system if needed.

NOTE
The breaker used in the 9510-100 is rated 200 A.

NOTE
NI recommends a minimum of 30 inches of unrestricted air space to the rear of each 9510-100 in use.

CAUTION: POSSIBILITY OF ELECTRIC SHOCK
Only a qualified electrician should remove the facility service panel.

- All connections should be carried out under 0 V 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 in the OFF state.

ATTENTION: POSSIBILITÉ DE CHOC ÉLECTRIQUE
Seul un électricien qualifié est autorisé à retirer le panneau de service de l’installation.

- Toutes les connexions doivent être effectuées dans des conditions de 0 V.
- Toutes les connexions doivent être correctement terminées en ne laissant aucun fil exposé qui pourrait présenter un risque de choc électrique.
- Toujours supposer que la sortie présente un potentiel électrique, même lorsque l’appareil est éteint.

CAUTION
Only trained personnel should remove the output access cover.

- All connections should be carried out under 0 V 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 in the OFF state.

ATTENTION
Seul le personnel formé est autorisé à retirer le cache d’accès aux sorties.

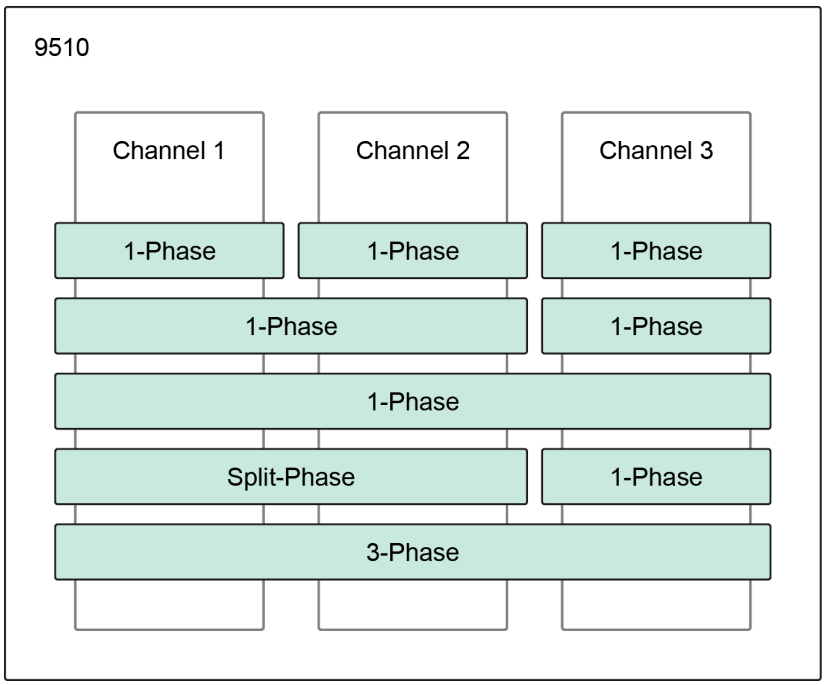
- Toutes les connexions doivent être effectuées dans des conditions de 0 V.
- Toutes les connexions doivent être correctement terminées en ne laissant aucun fil exposé qui pourrait présenter un risque de choc électrique.

- Toujours supposer que la sortie présente un potentiel électrique, même lorsque l'appareil est éteint.

System Description and Theory of Operation

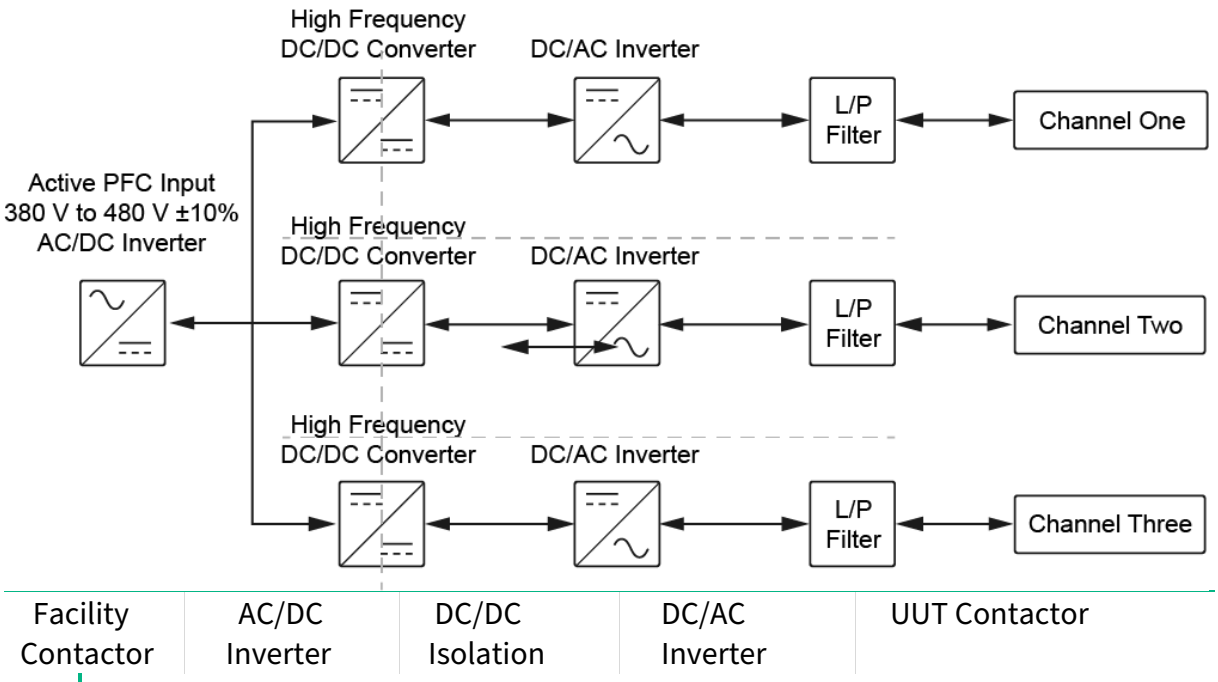
The following section clarifies the technical specifications in the following sections. These channels can be configured through software to provide different combinations of AC and DC voltage control channels.

Figure 4: System Description



The 9510-100 uses multiple power stages to manage the AC, DC, or AC+DC testing output.

Figure 5: Block Diagram



CAUTION
Do not attempt to use any internal power connections within the 9510.
Only qualified NHR service personnel shall make any changes or connections within the system cabinet. No user serviceable parts.

ATTENTION
Ne pas essayer d'utiliser les connexions d'alimentation interne au sein du 9510.
Seul le personnel de service qualifié de NHR est autorisé à effectuer des modifications ou des connexions au sein de l'armoire du système. Aucune pièce réparable par l'utilisateur.

The 9510-100 flows power in both directions between the facility input and the unit under test (UUT) output through a series of power converter stages.

The first stage is a reversible and power factor corrected AC/DC inverter ensuring that power is drawn with near unity power factor. The output from the first stage is high voltage DC.

The second stage is an isolating high-frequency DC/DC converter which provides the isolation between each output as well as between the facility input and the UUT output. The output of the second stage is regulated high voltage DC.

The third stage converts the isolated internal DC to an appropriate voltage, frequency, current, or power limited output as requested by the operator.

The system includes a set of facility contactors as input and UUT contactors as output which allow the cabinet to be electrically isolated when the system is in an off state. These contactors are not shown in the previous figure.

Additional Features

Emergency Off

The 9510-100 opens both the facility and UUT contactors and isolates itself from both the facility and UUT if one of the following conditions is met:

- The Emergency Off (E-OFF) button is pressed.
- The rear-side terminator or the control parallel cable is removed.
- The rear door is open.

An error occurs to inform the user that the E-OFF button is requested and a reset is required after removal of the E-OFF condition to return the system to operation.

User Interlock

The user interlock and disable switch are designed to control the UUT output contactor. If either of them is placed into a disabled state, the output relay is opened and cannot be closed until the interlock is placed into a ready state.

Programmable Trip Limits

The 9510-100 supports fuse-like programmable trip limits for the minimum and maximum voltages, over current (per direction), over power (per direction) and over temperature (thermocouple). Using these programming features, the 9510-100 actively monitors the conditions while executing control programs. If the value and delay time exceed limits, the cabinet self-commands an off state and opens its UUT relay to isolate itself from the UUT.

Internal Monitoring

The 9510-100 actively monitors its internal temperature and internal bus voltage, and limits the current between the internal bus and the facility power. If detecting an error, the cabinet self-commands an off state and opens both the facility and UUT contactors to isolate itself from both the facility and UUT.

Specifications

NHR 9510-100 Electrical Output Specifications

Table 1: AC Output Ratings

Operating Modes	4-Quadrant with Programmable Voltage (CV), Power Amplifier (PHIL), Optional AC Load
Output Configurations	Independent set per channel 3 x 1Φ (AC or DC), 2Φ + 1Φ (AC or DC), or 3Φ AC outputs, total of 13 modes.
Power, Max (1Φ or 3Φ)	100 kW/210 kVA[1]
Current Ranges (RMS per Φ) [2]	50, 200 A/Φ
Current Ranges (RMS 1Φ)	150, 600 A
Frequency	30 Hz to 120 Hz (10 mHz resolution)[3]
Voltage Ranges	10 V_{rms} to 175 V_{rms}, 10 V_{rms} to 350 V_{rms} L-N (Split-Phase 10 V to 125 V, 20 V to 250 V Max)
Voltage Control Accuracy	±0.15% F.S. (Max Measurement PK)
Programming Resolution	0.01 V
Load Regulation	±0.02% F.S.
Distortion (THD)[4]	0.45% (Typical) 0.65% (Max) <70 Hz no load to full load; 0.6% (Typical) 0.85% (Max) >70 Hz no load to full load
Slew Rate	1 V/µS (10% to 90% measured at 90 degree turn-on into no load or light resistive load)
Waveforms	Sine, n-Step Sine, Triangle, Clipped-Sine, Arbitrary (user defined)
Phase Angle Control	0 to 359 degrees / 0.1 degree resolution

1. The Max VA setting will be derated when system use in 1-phase (150 kVA > 60 Hz, 120 kVA above 30 Hz). Refer to the *Derating Curves* section for details.

2. Per cabinet per channel, the maximum hardware allowed peak current is 400 A. The maximum peak current might be further derated in the situation of multiple systems in parallel. Refer to the *Derating Curves* section for details.

3. Load option might require a stiff source when doing high CF.

4. THD is tested based on output 480 V L-L (277 V L-N) with resistive load.

NOTE
Only 100kW cabinet can support parallel expansion.

NOTE
These ranges therefore are multiplied by the number of parallel cabinets configured for use.

Table 2: DC Output Ratings

Operating Modes	DC Constant Voltage (CV), Optional DC Load
Average Power (1ch or 3ch)[1]	100 kW
Current Ranges (Per Ch.)	50 A, 200 A
Current Ranges (1 Ch.)	150 A, 600 A
Voltage Ranges	10 V_{dc} to 200 V_{dc}, 10 V_{dc} to 400 V_{dc}
Ripple	<800 mV_{rms} (into resistive load)

1. Instant PK power per channel will be 100 kW (300 kW per system) and it will be derated as frequency lower than 50 Hz. Refer to the *Derating Curves* section for details.

Table 3: Power Amplifier Mode (PHIL)

Control Method[1]	Analog Input ±10 V_{pk-pk} amplified to ±247.5 V_{pk-pk} (low range) and ±495 V_{pk-pk} (high range)
Latency (input-output)	50 µS typical

Operating Envelopes

Figure 6: AC Mode Operating Area per Phase in 3-Phase Mode

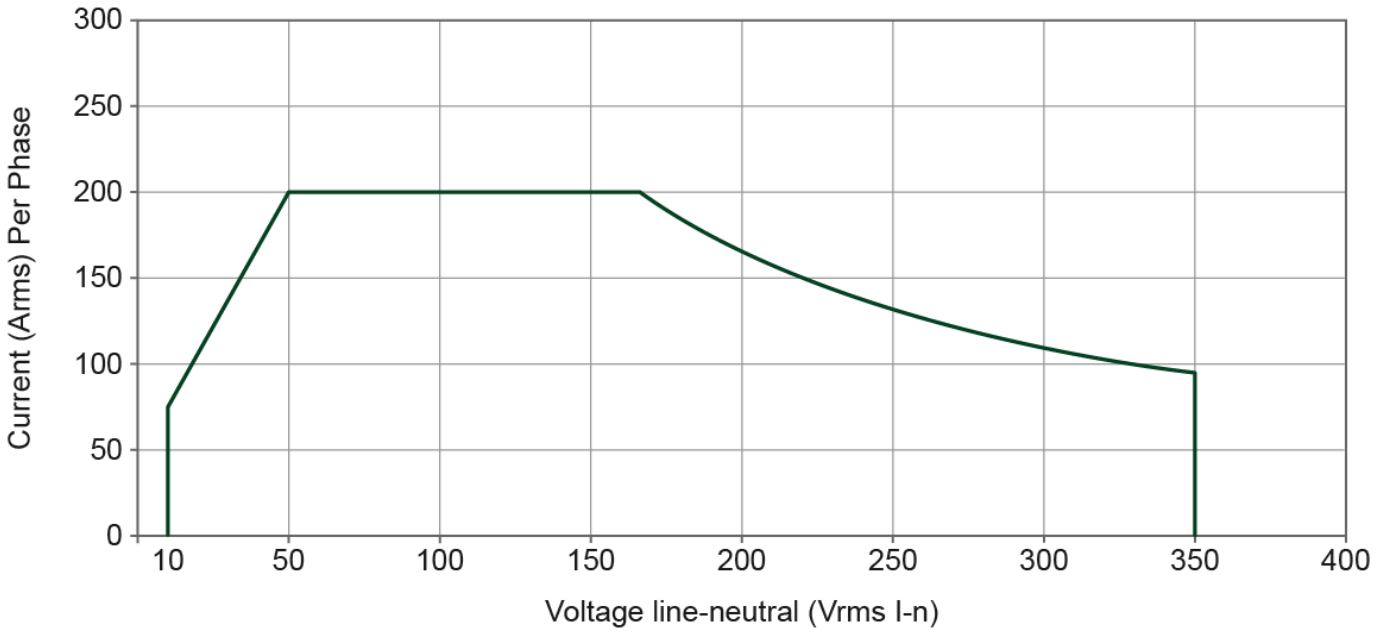
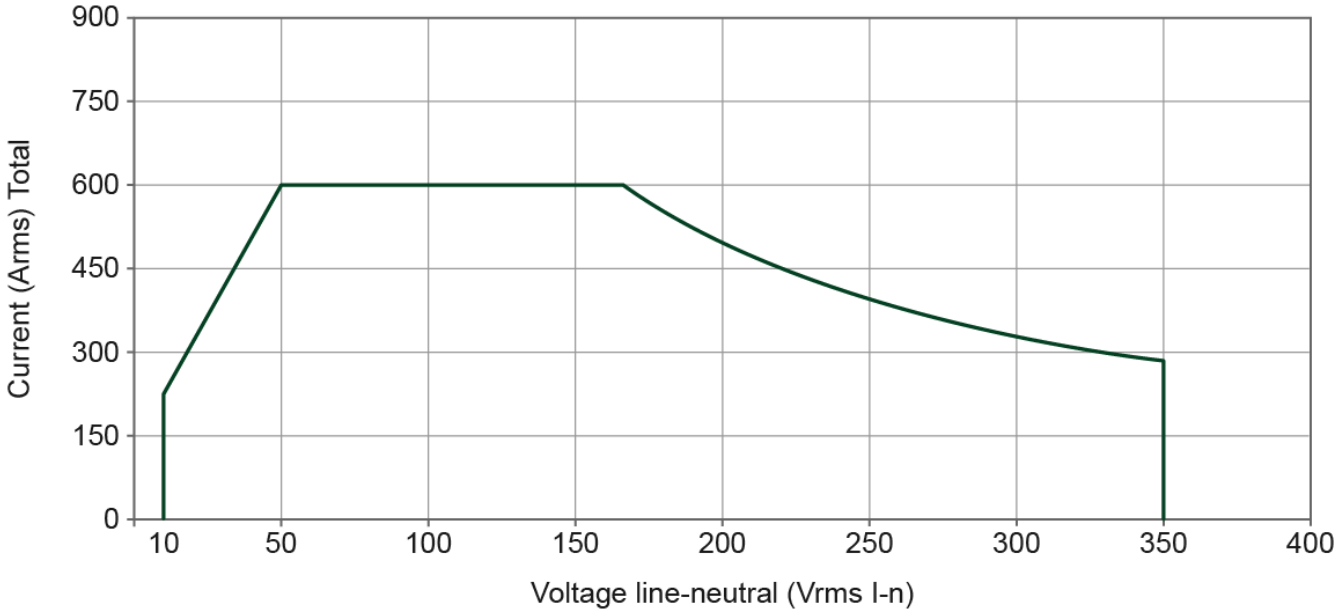


Figure 7: AC Mode Operating Area in Single-Phase Mode



Measurement Specifications

Table 4: AC and DC Measurements

Measurement Peak Voltage	424 or 707 V_{peak}
RMS or DC Measurement Accuracy	0.1% + 0.1% F.S.
Resolution	0.005% F.S.
Measurement Peak Current (per Ch.)	167 or500 A_{peak}
RMS or DC Measurement Accuracy	0.1% + 0.1% F.S.
Resolution	0.005% F.S.
Peak Power	V Range x I Range
Accuracy	0.2% + 0.2% F.S. (kW or kVA)
Resolution	0.005% F.S.
Additional Measurements	Energy (Ah, kWh, kVAh), AC Crest Factor, AC Power Factor, True Power (P), Reactive Power (Q), Waveform Capture

NOTE

Measurement specifications are valid for a default aperture window or greater, and the accuracy applies to the measurement range from 10% to 100%.

NOTE
Power factor accuracy applies to VA > 50% of max.

NOTE
F.S. (Full Scale) is the measurement peak of a certain range.

Table 5: Waveform Digitizer

Data Acquisition	Output Voltage and Current
Memory Depth	64 k Samp. (V & I per Φ)
Accuracy	0.5% Range
Sample Rate	125 k Samples/sec
Aperture Time	1 cycle to 64s

Trip, Mechanical and Facility Specifications

Table 6: Isolation and Disable Specifications

Isolation (Facility to Chassis, Output to Chassis, Facility to Output Internal Isolation)	500 V
Module Protection	Self-protecting for over-voltage, over-current, over-power, and over-temperature
Physical	Emergency Off and external Interlock
Programmable Trip Limits	Min/Max Voltage, Current (per direction), and Power (per direction) with separate limits and time delay values
Watchdog Timer	Continuously monitors control communications
Output Terminal Block Torque Rating, Nominal	240 in-lb (27 N · m)

Table 7: Physical (Single 100 kW Cabinet) and Environmental Characteristics

Connectors	2 x ½ in. stud terminals per channel (total of six) + Ground
Cabinet Dimension (H x W x D)	79.25 in. x 28 in. x 39 in. (2,012 mm x 712 mm x 990 mm)
Cabinet Weight	1,200 lbs/545 kg (100kW cabinet)
Operating Temperature	5 °C to 35 °C (up to 95% RH non-condensing)
Pollution Degree	2

Maximum Altitude	2000 m

Table 8: Input Power (Single 100 kW Cabinet)

Voltage	Universal Input – 380 V to 480 V ± 10% (L-L, 3-Phase, 50 Hz/60 Hz) Overvoltage Category II
Efficiency	>90 % typical (up to 94 % at full power)[1]
Power Factor	>0.95 typical (>0.99 at full power)
Current per Φ, Nominal	168 A at 380 V, 144 A at 400 V, 134 A at 480 V Rated for 200 A/ph branch circuit

1. Near 93% at 480VLL/100kW.

NHR 9510-100 Programmable Features

Frequency	30 Hz to 120 Hz
Accuracy	0.1% setting
Resolution	0.01 Hz
AC Voltage Ranges	175 V_{rms}, 350V_{rms}
Accuracy	0.15% F.S.
Resolution	0.01 V
Wave Shape Control	Sine, n-Step Sine, Triangle, Clipped-Sine, Arbitrary (user-defined)
Phase Angle Control	0° to 359° / 0.1° resolution
DC Voltage Ranges	+200 V_{dc}, + 400 V_{dc}
Accuracy	0.15% F.S.
Resolution	0.01 V
Voltage Noise	<800 mV_{rms} (Into Resistive Load)
Safety	Separate programmable values and trip-times for voltage, current, power and direction of power flow

NOTE
F.S. (Full Scale) is the measurement peak of a certain range.

NHR 9510-100 Output Mode

Control Mode	Voltage and Frequency
Supported Load PF	-1 (unity-sink) to 1 (unity-source)
Power Flow	AC and DC channels are always bi-directional

Digital Interface

Table 9: Control

Local User Interface	Built-in touch panel and PC-Based software tools including graphical user interface
External System Comm	LAN (Ethernet) supporting SCPI
Drivers	NI-Compliant LabVIEW Drivers
Analog Current Monitor	[-10 V, +10 V] corresponds to ± Full Measurement Scale
Analog Voltage Monitor	[-10 V, +10 V] corresponds to ± Full Measurement Scale

Derating Curves

Figure 8: Instant Peak Power Derating Curve

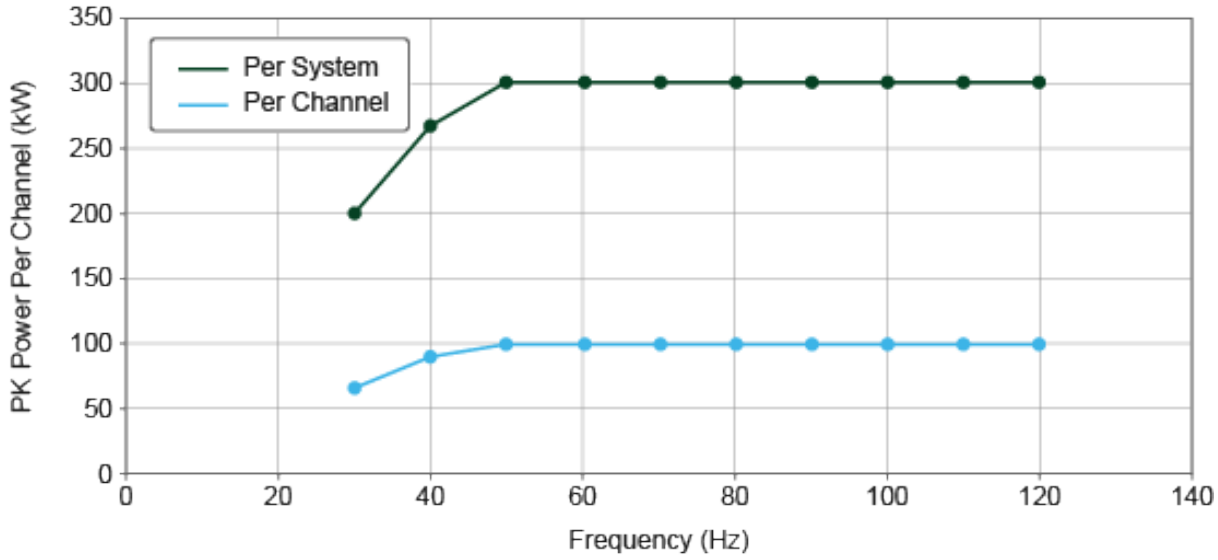


Figure 9: AC Single Phase - Maximum VA Setting Derating Curve for Mode 1

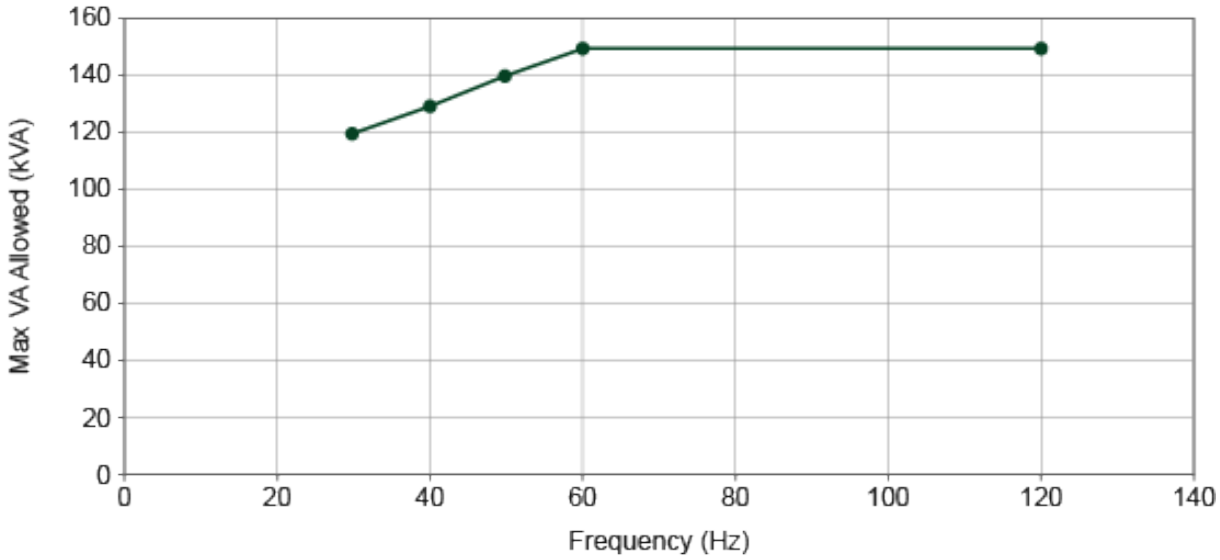
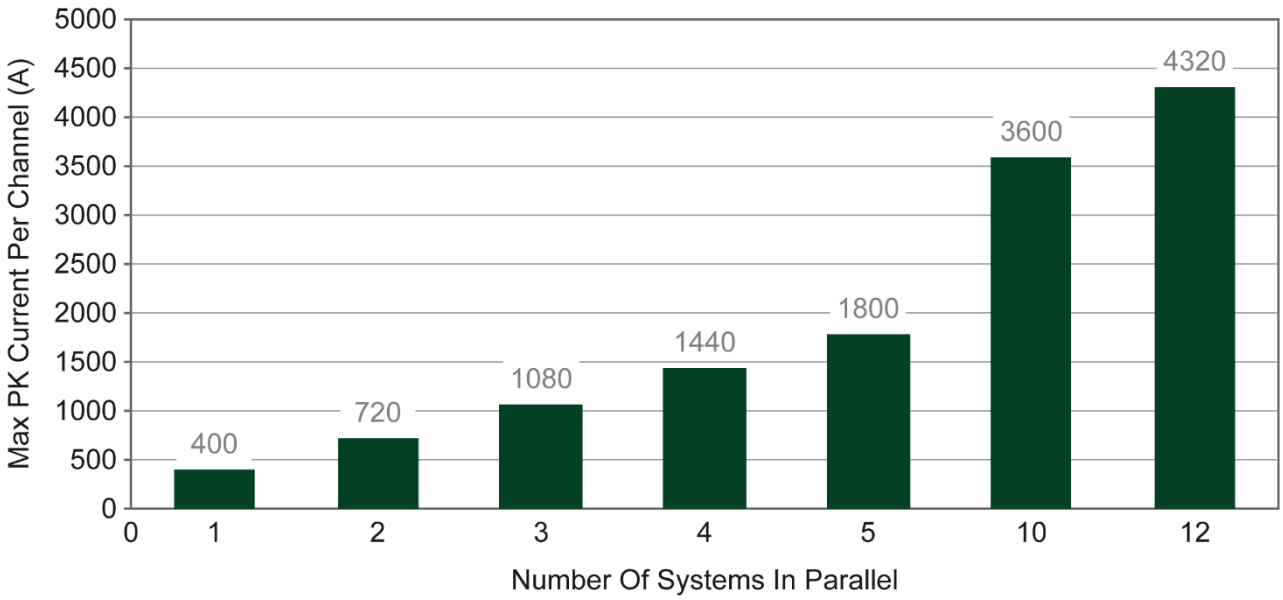


Figure 10: Peak Current Allowed Per Channel



Installation

Unpacking the System

The 9510 system was inspected and found to be free of mechanical or electrical defects before shipment. After unpacking the system, inspect for any damage or shock watch sensors which may indicate that the unit was potentially damaged during transit.

If you find damage, file a claim with the carrier immediately and notify NI Customer Support. Be sure to keep all packing materials because the system may need to be returned to NI.

CAUTION
Do not proceed with installation if the system is damaged during shipping.

ATTENTION
Ne pas procéder à l'installation si le système a été endommagé pendant le transport.

Cooling and Mounting Requirements

The NHR 9510-100 is air-cooling by fans. The air intake is from the front of the cabinet and exhausts to the rear of the cabinet. For all systems, NI recommends 24 inches (60 cm) of unrestricted air space in front of the unit and 30 inches (76 cm) of unrestricted airspace to the rear of the unit.

The system should be mounted on concrete or a similar load-bearing surface.

Recommended Service Feed, Breaker Size and Facility Wiring

NI provides only general recommendations for wire gauge and service feed capacity. NI recommends consulting a local electrician to ensure the system wire size, service feed size, and facility breakers meet local wiring codes.

NHR 9510-100 Grid Simulator	Recommended Panel Breaker	Recommended Wire Gauge
380 VAC L-L	200 A or greater	3/0 AWG (168 MCM)
400 VAC L-L	200 A or greater	3/0 AWG (168 MCM)
480 VAC L-L	160 A or greater	3/0 AWG (168 MCM)

CAUTION: POSSIBILITY OF ELECTRIC SHOCK

These recommendations should be reviewed and potentially superseded by a local electrician following local ordinances.

ATTENTION: POSSIBILITÉ DE CHOC ÉLECTRIQUE
Ces recommandations doivent être vérifiées par un électricien local, et éventuellement supplantées, conformément aux réglementations locales.

Installing AC Facility Power

Connecting facility power requires multiple steps. Fully review the following section as well as the *Installing UUT Connections* and *Turn On Checklist* sections before applying facility power.

CAUTION: POSSIBILITY OF ELECTRIC SHOCK
Connecting the system to a three phase AC facility power should be made by an electrician or other qualified personnel.

Installation requires removing safety panels which protect operators from live AC facility connections. Read this section completely before attempting installation of the system.

ATTENTION: POSSIBILITÉ DE CHOC ÉLECTRIQUE
Le raccordement du système à une source d'alimentation CA triphasée doit être effectué par un électricien ou par du personnel qualifié.

L'installation nécessite le retrait des panneaux de sécurité qui protègent les opérateurs contre les connexions CA sous tension de l’établissement. Lire entièrement cette section avant de procéder à l’installation du système.

CAUTION
There is a potential for electrical shock if the system is not properly connected to a safety ground connection.

ATTENTION
Il existe un risque d'électrocution si le système n'est pas correctement connecté à la masse.

CAUTION
NI provides only general recommendations.
It is the responsibility of the end-user to consult an electrician in order to ensure that wiring, breaker sizing, and associated power connections meet local ordinances.

ATTENTION
NI fournit uniquement des recommandations générales.

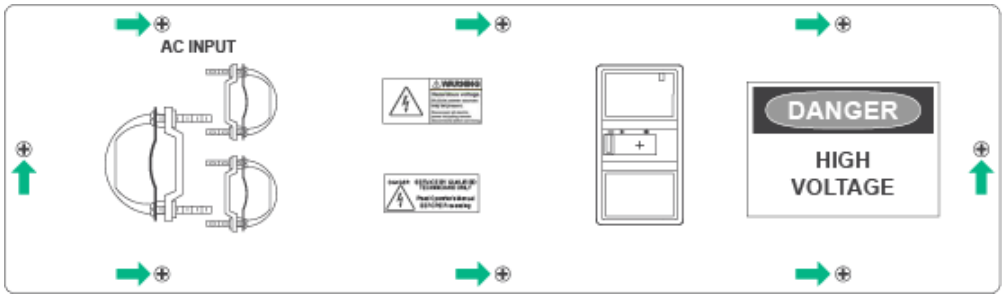
Il incombe à l'utilisateur final de consulter un électricien afin de s'assurer que le câblage, le dimensionnement du disjoncteur et les connexions d'alimentation associées sont conformes aux réglementations locales.

CAUTION
Connecting the AC Line input to an AC Line that is unable to absorb energy quickly, such as a high output impedance source, may result in voltage increase on the line during regeneration. If the voltage rises to the maximum input voltage limit, the NHR equipment shuts down. Other equipment on the same line may be damaged.

ATTENTION
La connexion de l'entrée de la ligne CA à une ligne CA incapable d'absorber l'énergie rapidement, comme une source à impédance de sortie élevée, peut entraîner une augmentation de la tension sur la ligne pendant la régénération. Si la tension augmente jusqu'à la limite de tension d'entrée maximale, l'équipement NHR s'éteint. D'autres équipements sur la même ligne risquent d'être endommagés.

1. Remove the screws holding the facility safety panel at the lower rear of the unit. The 3-phase AC facility line connects directly to the system main breaker located at the lower rear of the unit.

NOTE
Do not lose these screws as they will be needed to re-install the safety panel at the end of the installation.

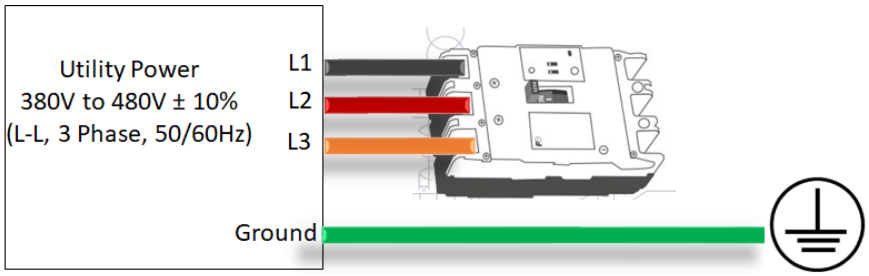


2. Push the latch to the right, carefully pull the cover straight out, and then remove the breaker wire cover.

Figure 11: Removing the AC Input Breaker Wire Cover

3. Route the wires (3-phase + ground) through the cover plate strain relief and install the 3-phase facility power wires directly into the breaker.

Figure 12: AC Input Wire Connection Diagram



NOTE
There is no phase rotation dependency for this system.

NOTE
The 9510 is equipped with a 200 A branch rated circuit breaker.

CAUTION
Do not attempt to replace or service this breaker without first consulting NI Customer Service.

ATTENTION
Ne pas essayer de remplacer ou de réparer ce disjoncteur sans avoir consulté au préalable le service clients de NI.

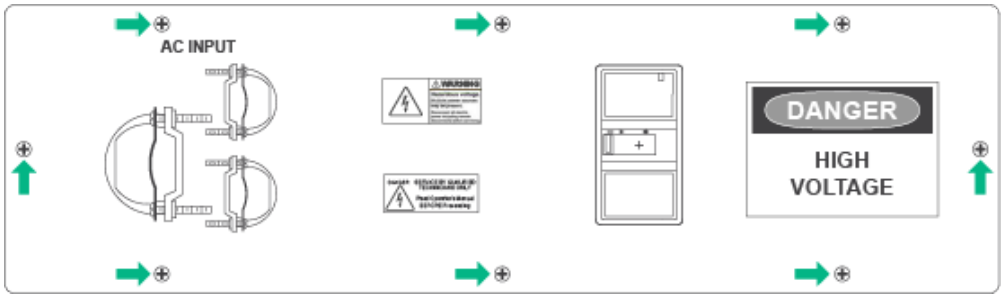
4. Torque wire connections to 204 inch-pounds.
5. Attach the ground wire to the chassis ground stud. The Ground wire should go through the left of the strain relief and system breaker at the rear of the cabinet.

CAUTION
Do not attempt to power the system without first ensuring the ground is properly installed.

ATTENTION
Do not attempt to power the system without first ensuring the ground is properly installed.

6. Replace the facility safety cover and attach the cover using the screws removed in step 1.

Figure 13: AC Facility Input Panel



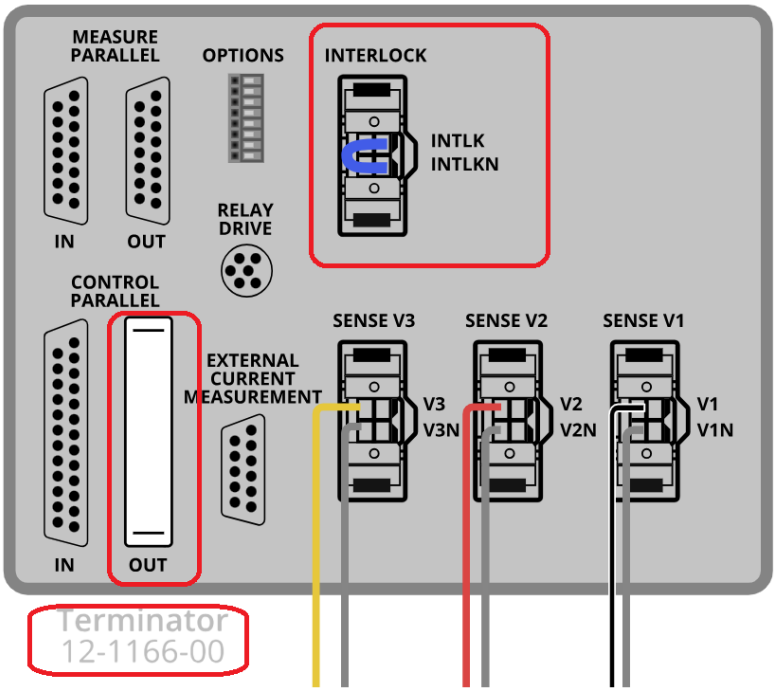
7. Tighten the strain relief and complete any additional facility wiring required.

NOTE
Review the *Installing UUT Connections* and *Turn On Checklist* topics before applying facility power.

Interlock Wiring and Control Terminal

The interlock connection is located at the top left of the cabinet rear. This connection must be shorted for normal operation.

Figure 14: Interlock Terminal and Control Parallel Terminal



When the internal terminal is disconnected (open) during operation, the 9510-100 responds by opening the output relays, stops UUT output semi-conductor switching, and generates an interlock error.

Unlike the E-OFF button, the interlock connection allows new operating commands to be accepted after the connection is re-established.

When the control parallel terminal is disconnected, the 9510-100 responds in the same way as the E-OFF button is pressed. You will get an E-OFF error immediately.

Installing UUT Connections

The high voltage and high power feature of the NHR 9510-100 determines that UUT connections are assumed to be semi-permanent. All UUT connections are made at the top rear of the chassis and are generally routed out of the top of the chassis.
Contact NI if you want to modify other chassis before starting installation.

CAUTION: POSSIBILITY OF ELECTRIC SHOCK
UUT initial installation should be made by an electrician or other qualified personnel.
Installation requires removing safety panels which protect operators from live DC UUT connections. Read this section completely before attempting to install the system.

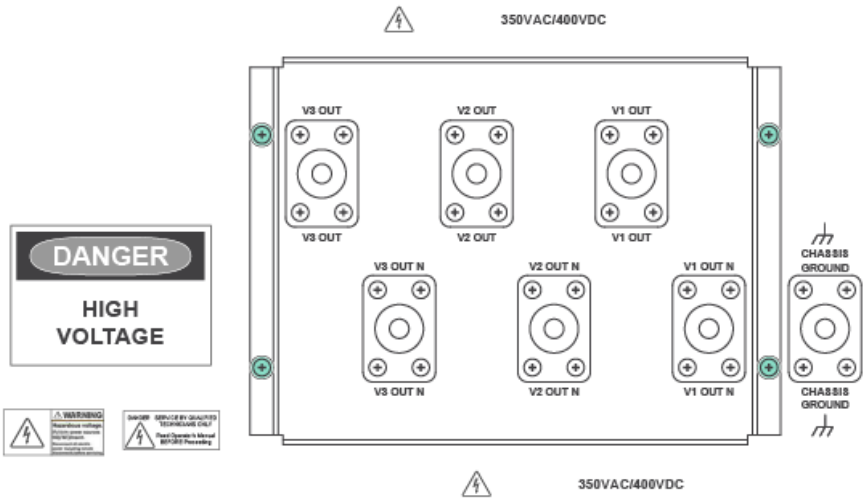
ATTENTION: POSSIBILITÉ DE CHOC ÉLECTRIQUE
L'installation initiale de l'appareil sous test doit être effectuée par un électricien ou autre personnel qualifié.
L'installation nécessite le retrait des panneaux de sécurité qui protègent les opérateurs contre les connexions CC sous tension de l'appareil sous test. Lire entièrement cette section avant de procéder à l'installation du système.

NOTE
NI provides only general recommendations.

It is the responsibility of the end-user to consult an electrician in order to ensure that wiring, breaker sizing, and associated power connections meet local ordinances.

1. Remove the four screws holding the UUT safety cover at top of the unit. Do not lose these screws because they will be used to re-install the safety panel at the end of the installation.

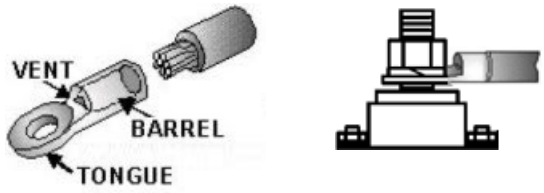
Figure 15: Top View of the Output Terminals



2. Remove the UUT safety panel. Make the cables with suitable wire strip and ½ in. lug ring.

NOTE
For the output terminal block, the recommended nominal torque rating is 240 in-lb (27 N · m).

Figure 16: UUT Wiring on Output Terminals



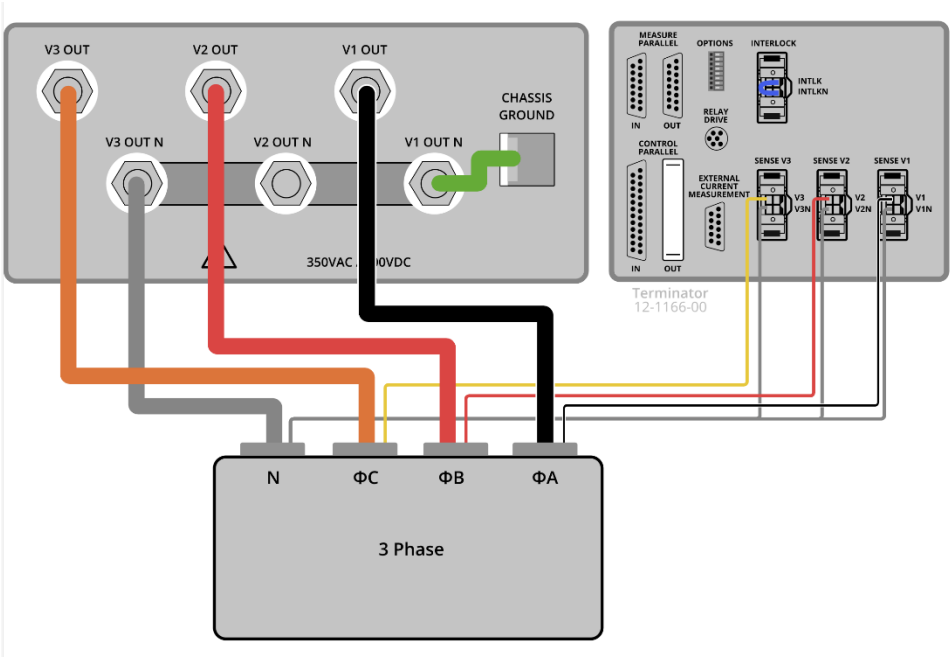
3. Install the load connections. The UUT wiring depends on the operating mode. The outputs are per channel (OUTPUT 1, 2, 3 returns V1, V2, V3 OUT or V1, V2, V3 OUT RTN). The outputs are isolated and generally need the neutrals to be connected for proper referencing. The following diagrams show examples for wiring the output.

NOTE
The following diagrams are for a single 100kW system only. For a multi-system in parallel, refer to the *Configuring the Systems in Parallel* section for details.

NOTE
NI recommends having V1/2/3_N connected to Chassis GND.

- 3-Phase UUT Load Output Connection Example

Figure 17: 3-Phase UUT Wiring with Remote Sensing



- Single phase UUT Load Output Connection Example

Figure 18: Single Phase UUT Wiring with Remote Sensing

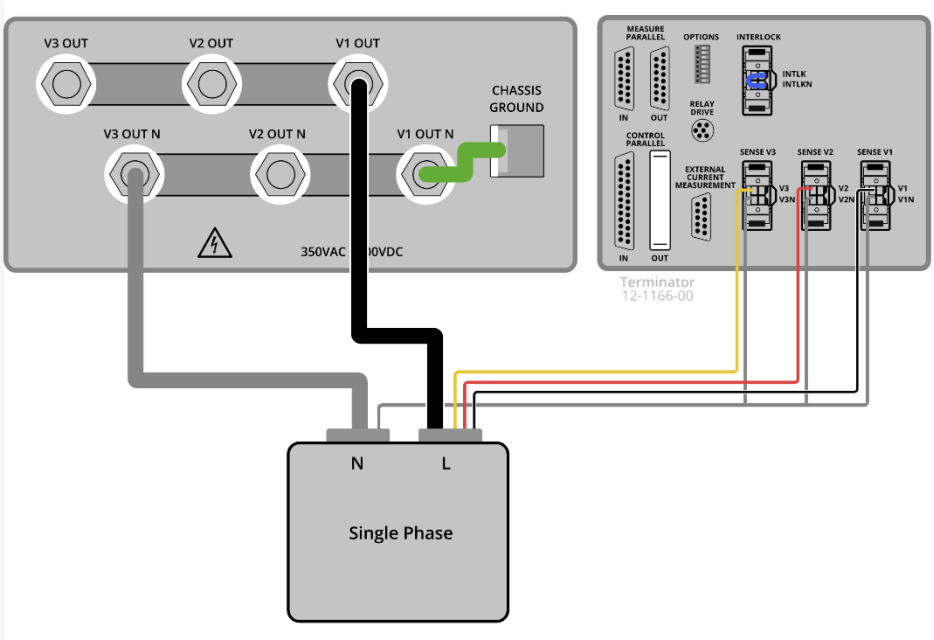
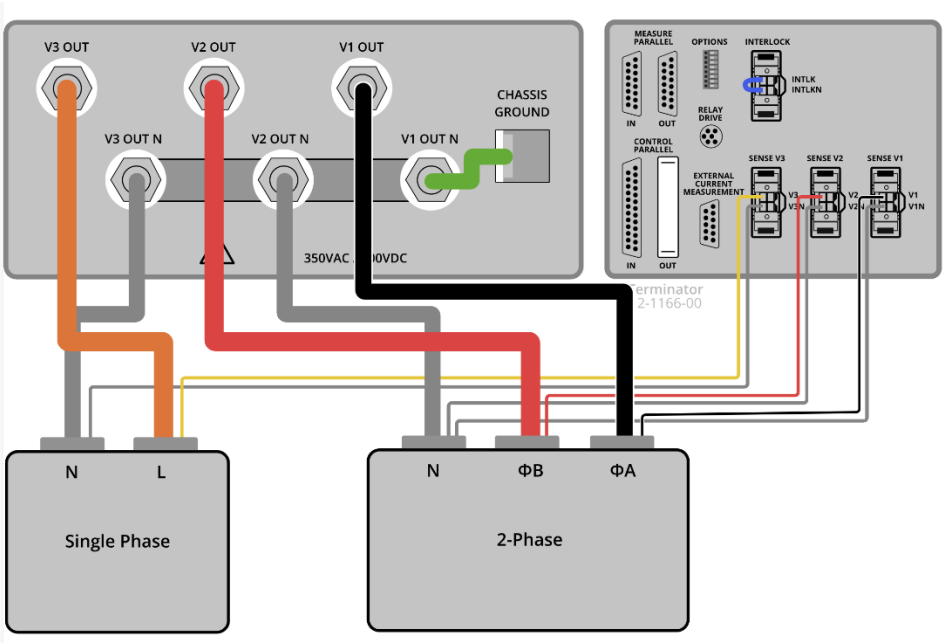


Figure 19: Split Phase + 1 Separate AC Channel UUT Wiring with Remote Sensing



4. Install the remote sense connections as the above diagrams.
5. Replace the top UUT safety cover and secure the cover with the four screws removed in step 1.

Turn On and Turn Off Checklist

Pre-Requisites of Applying External Power to the Unit

Before you apply external power, ensure that you complete the following steps:

- Verify all external panels are in place.
- Verify the front and the rear have sufficient unrestricted air-space for air cooling.
- Verify E-Stop is unlocked and in ready state.
- Verify interlock is connected.
- Verify the control parallel terminator is installed.
- Verify the back door is fully closed.
- Verify all system breakers are switched to the right in the Off position.
- Verify the ON/STANDBY switch, located under the E-OFF button, is in the Off position.
- Verify the Ready/Disable switch, under the LED status indicators, is in the Ready position.

- Verify all power and communication cable connections are tight.

Powering On the System

Complete the following steps to power on the system:

1. Turn on facility 3-phase power.
2. Switch the main breaker to the left so that the main breaker is in the On position.
3. Switch the ON/STANDBY to the On position. (This switch is located on the front door.)
4. DSP LED and CH1 LED blink indicating that the NHR 9510-100 starts its power on sequence.
5. The touch panel starts up automatically. You can notice the following on the touch panel:
   - The touch panel shows “System Initializing” before the system is fully powered on, which takes about 1 minute.
   - After the system is powered on, you can notice an obvious relay close, the GRID ON LED indicator becomes solid green, and the touch panel shows “Ready”.
   - If errors occur, the touch panel shows error message. The DSP LED will blink red.

Powering Off the System

Complete the following steps to power off the system:

1. Turn off the outputs using any controlling software application.
2. Stop and close all external applications.
3. Turn off the ON/STANDBY switch.
4. (Optional) Turn off the main system breaker.
5. (Optional) Turn off external power.

NOTE
The 9510 cabinets use internal contactors to isolate themselves from facility power when a fault occurs or when the system is powered off.

Configuring the IP Address

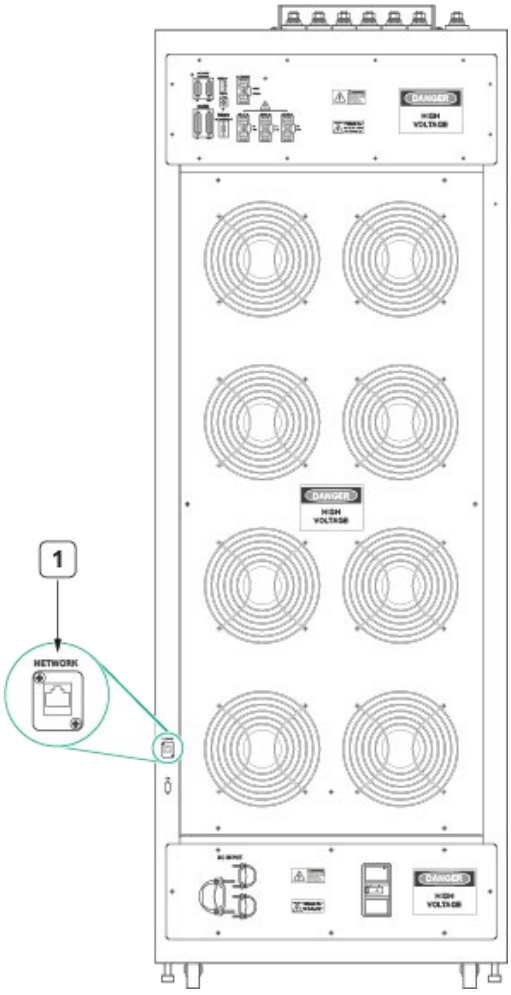
The NHR 9510-100 uses the standard 100BaseT Ethernet for external control.

Discuss with your local information technology (IT) department about the potential configurations.

NI recommends using either static IP addressing or DHCP where the MAC addresses are assigned to a fixed address to prevent confusion in later use.

Each system is shipped with a label denoting the MAC addresses and IP addresses contained in the system. You can change only the IP address and the IP address must be unique.

Figure 20. LAN Communication Location



1. LAN IN

NOTE

If we assume the controller and the NHR 9510-100 were configured with IP addresses of 192.168.0.1 and 192.168.0.2 respectively. Any additional PC or modules should have a unique IP address within the range from 192.168.0.3 to 192.168.0.254.

Connecting to a Computer with a web browsing application

Changing the IP address requires 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 one system controller is 192.168.0.1 and the 9510 is 192.168.0.3, then a remote PC would need a unique IP address between 192.168.0.3 and 192.168.0.254.

Mating Cable Type			
NH Research Part Number: 8364363	LAN Crossover Cable	Belkin	A3L791-14 (or equivalent)

NOTE
For Enerchron users: Changing the system IP address requires changing the IP address configured in Enerchron.

NOTE
NI recommends recording the new IP address on the NHR 9510-100 in case further changes are needed in the future.

Configuring IP Address for the 9510-100

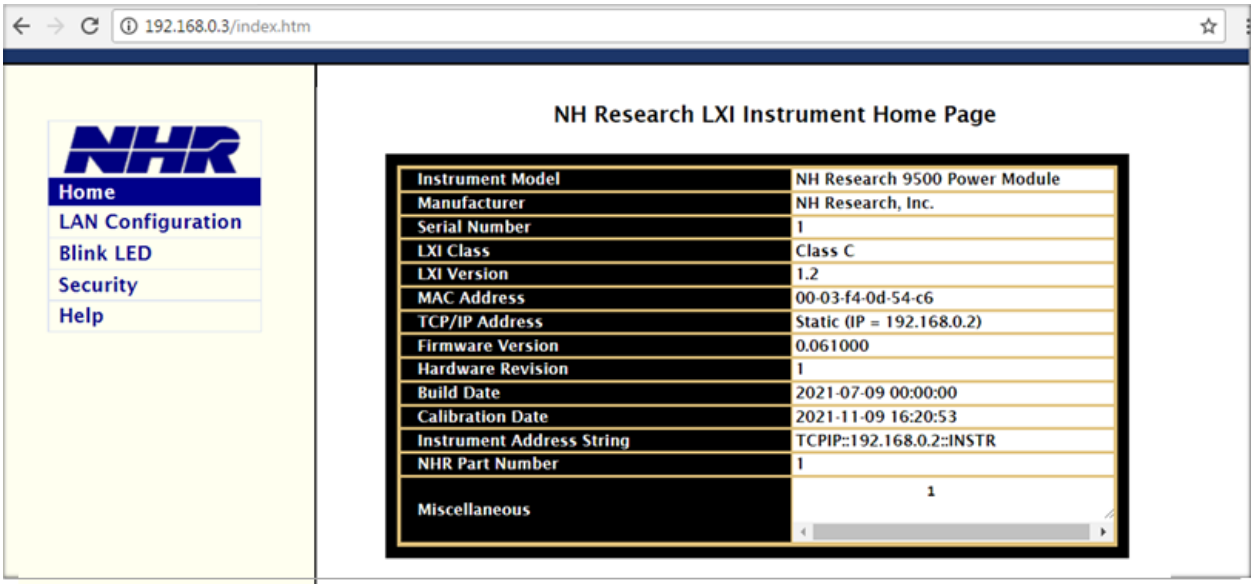
If you don’t know the cabinet IP address, complete the following steps first:

1. Turn off the ON/STANDBY switch and wait for the system to completely power down. It takes approximately 30 seconds.
2. Flip the option switch position 1 to ON (right), and then turn on the ON/STANDBY switch. This forces the cabinet to use 192.168.0.2 as the IP address. This is temporary and intends to assign an IP address to the system for configuration. Refer to the *Rear Interface Connections* section for the option dip switches location.
3. Continue setting up with the known IP as follows.

If you’ve known the cabinet IP address, complete the following steps:

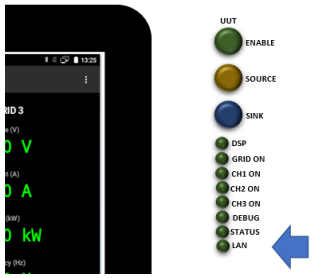
1. Open a web browser and browse to http://*(IP_ADDRESS)* where the IP address is the NHR 9510-100 system, such as http://192.168.0.3. This opens the configuration screen as the following figure shows.

Figure 21: Web Server Home Page on 9510



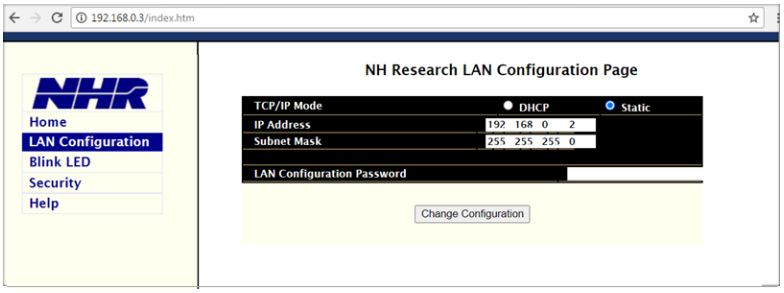
2. To ensure the web page is connected to the correct system, select **Blink LED** from the left menu. The cabinet connected to the web page blinks the LAN status indicator on the front of the system.

Figure 22: LAN LED Indicator Location



3. Confirm the 9510 is the system intended to have a new IP address.
4. Select **LAN Configuration** to adjust the LAN configuration.
   1) Select either static or DHCP as the TCP/IP mode.
   2) If you select DHCP, NI recommends that IT assign a static DHCP address based on the MAC address for proper operation.
   3) By default, the LAN Configuration Password field is blank. You can change the password using the **Security** menu.

Figure 23: IP Address Setting on Web Server



5. Flip the option dip switch position 1 to OFF (left) to prevent from applying the default IP address (192.168.0.2). The system thus uses the user-defined IP address.
6. Power cycle the cabinet to apply the new IP address.

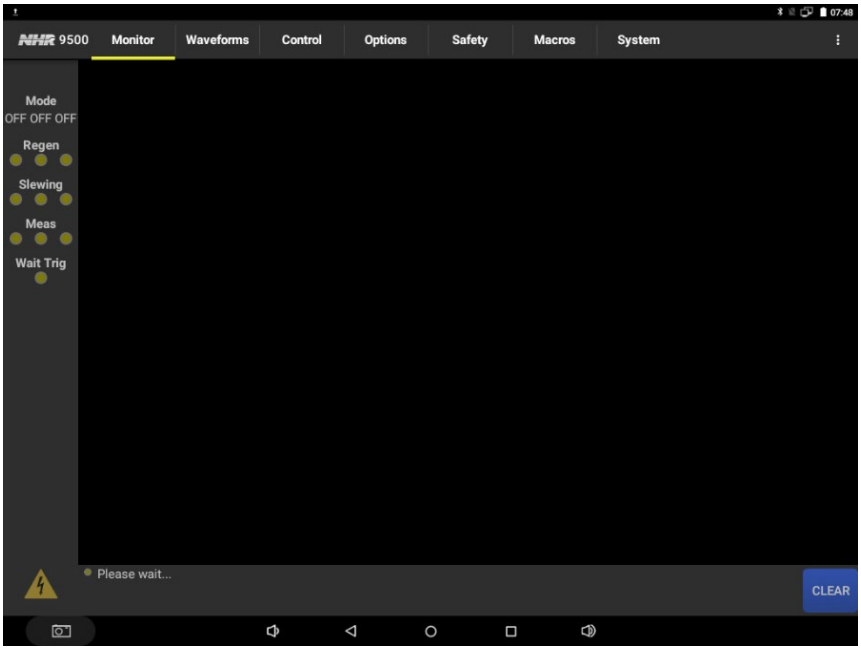
The 9510 configuration home page includes:

- Home – Includes basic information about the cabinet, including part numbers, build date, calibration date, and IP address.
- LAN Configuration – Enables you to change IP address settings.
- Blink LED – Helps identify the information on the home page belongs to which 9510.
- Security – Enables you to change the IP configuration password.
- Help – Describes the details on the home page.

Configuring the Touch Panel Controller Software

The following screen appears after a reboot.

Figure 24: Touch Screen Configuration



Complete the following steps to configure the Touch Controller.

1. Click the Menu  button at the upper right of the touch panel. The additional configuration dialog box opens.
2. Press OK and continue with the following steps to configure the Touch Controller.
3. Press **IP Address**, enter the IP Address set in *Configuring the IP Address*, and then press OK.

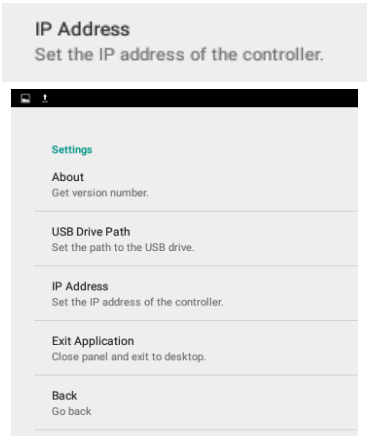
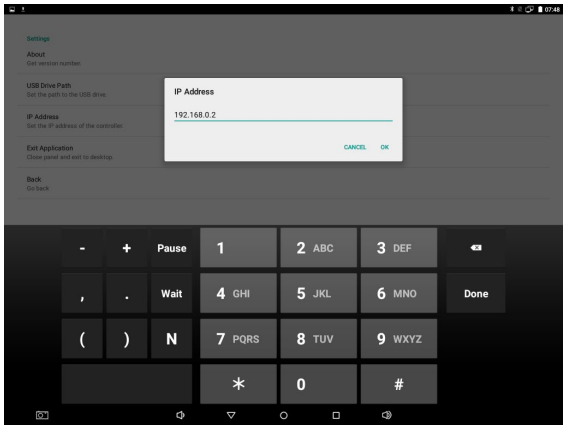
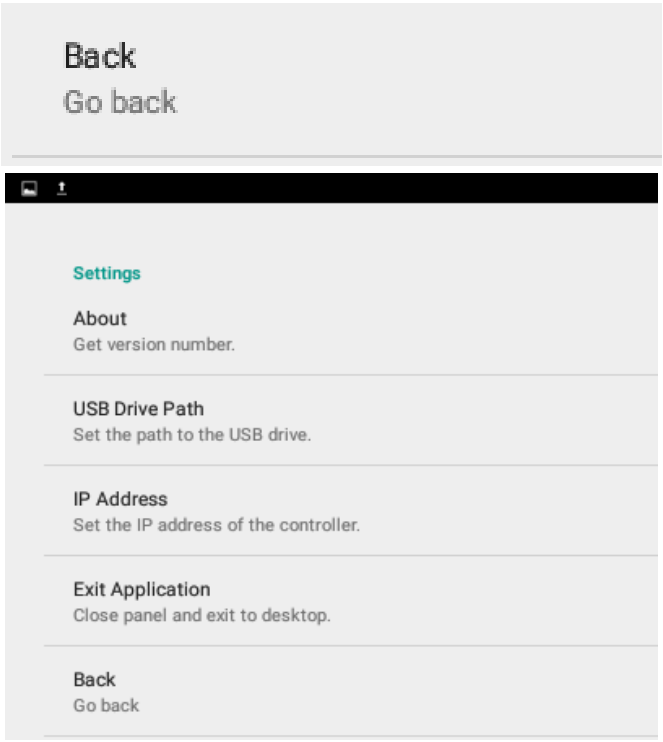


Figure 25: IP Adress Setting on Touch Screen



NOTE
This is not the IP address of the touch panel. This IP address tells the touch panel where to look for the system on the network.

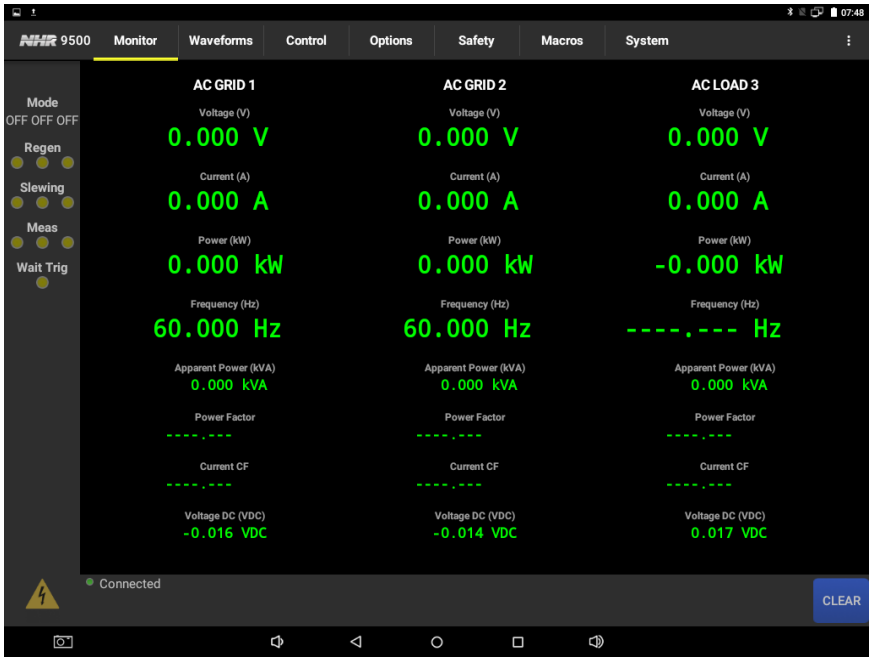
4. Press **Back**.



If the cabinet has the same domain as the Touch Controller, that is, the first three numbers of the IP address are the same, the Touch Controller loads now and is ready for use. The screen shows the monitoring data on the Monitor page.

If the domain is different or an IP address conflict is detected, the monitor does not show any value and you need to assign a unique IP address to the touch controller in the same domain.

Figure 26: Monitor Page on Touch Screen



Configuring the System Controllers (PC) IP Address

The system controller is installed with a standard windows operating system. Consult your local IT department or contact NI Customer Support to configure the system controller's IP address.

Configuring an External Application

External applications uses the Master's IP address and port number 5025. The resource ID string used for LabVIEW, VISA, and NI tools is TCPIP::IPADDRESS::5025::SOCKET

Configuring the Systems in Parallel

Connecting Hardware in Parallel

CAUTION
When cabling and working around high voltage/high power, make sure the instrument is turned off. Also, the AC input breaker located in the back of the 9500 (toward the bottom) is flipped in the off position, so that there is no AC facility power

going into the instrument. If the 9500 is connected to facility power via an external AC breaker, perform proper lock-out/tag-out procedures.

ATTENTION
Lors du câblage ou de tout type de travail à proximité d'une haute tension ou d'une puissance élevée, s’assurer que l'instrument est éteint. Par ailleurs, le disjoncteur d’entrée CA situé à l’arrière du 9500 (vers le bas) est basculé en position arrêt, de sorte qu’aucune alimentation CA n’arrive à l’instrument. Si le 9500 est connecté à l'alimentation de l'installation via un disjoncteur CA externe, suivre les procédures de consignation appropriées.

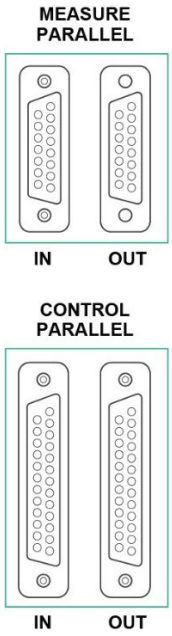
You can only configure the 9500-100 in parallel under the following conditions:

- Each cabinet needs to be 100kW cabinet.
- Each cabinet IP address need to be configured under the same subnet. For example: 192.168.0.XXX. Each cabinet needs to be configured as the same mode (Source or Load) per channel.

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

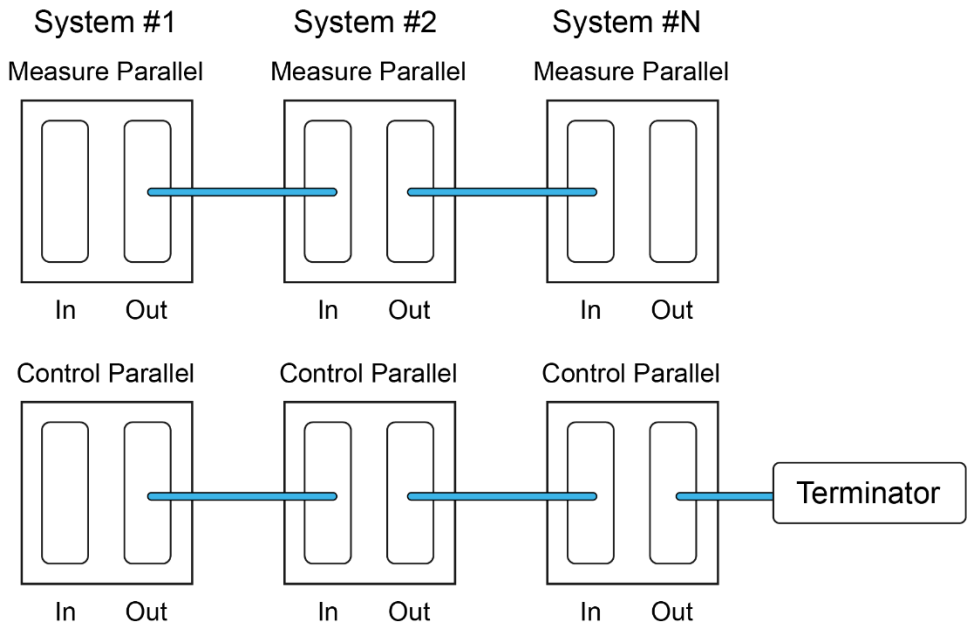
ATTENTION
Les opérateurs travaillant sur l’équipement doivent être formés aux procédures de sécurité. Les dommages causés par une utilisation non conforme ne sont pas couverts par la garantie.

Control and Measure Parallel Cable Connection



1. Remove all control and measure paralleling cables and control parallel terminators on all systems to be paralleled.
2. Use the supplied measure parallel cable connect system #1(Master) Parallel Out to system #2(Aux1) parallel In.
3. Use the supplied control parallel cable connect system #1(Master) Parallel Out to system #2(Aux1) parallel In.
4. Repeat step 2 and 3 to attach additional systems until the final system is connected.
5. Install the control parallel terminator on Control Parallel Out on the last system.

Figure 27: Control and measure parallel cables connection



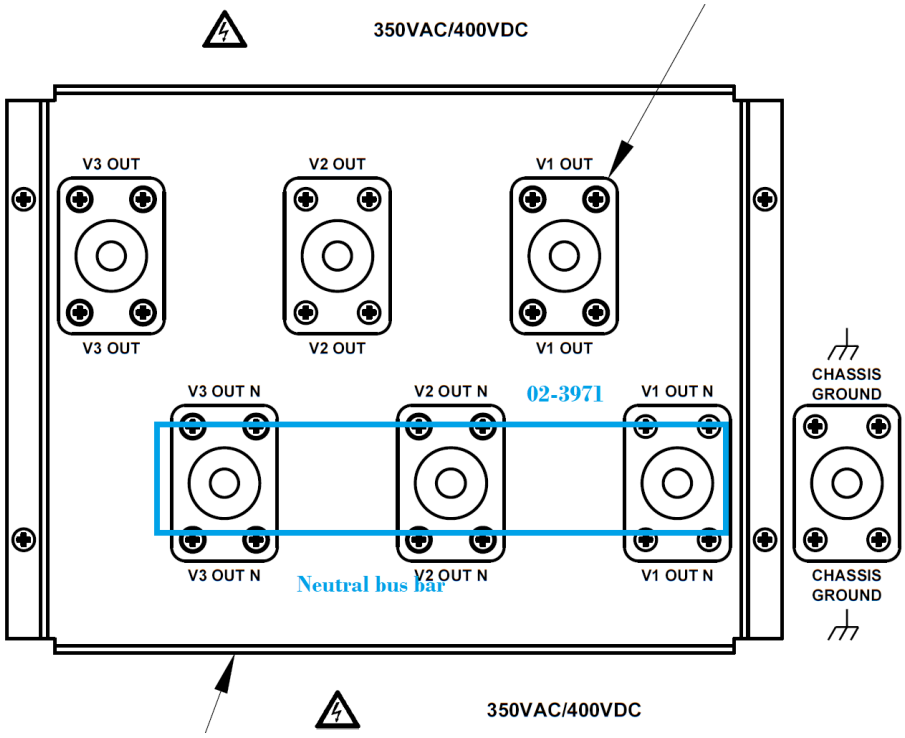
Power Output Cable Connection

Power output cable connection varies depending on your hardware configuration. This section lists the following three most typical usages of the parallel system:

- 3-phase Y connection
- 3-phase delta connection
- Single-phase connection

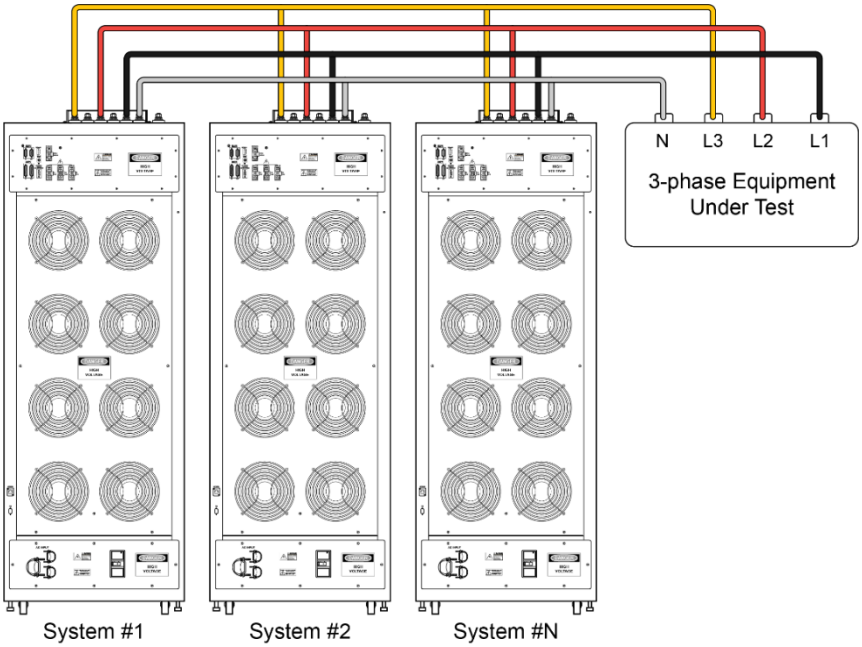
3-Phase Y Connection

1. Connect all 9500 V1 OUT, V2 OUT, V3 OUT to the Unit Under Test (L1, L2, L3).
2. Connect the 9500 V1 OUT N, V2 OUT N, V3 OUT N of each cabinet with the bus bar supplied by NI (NH Research Part Number: 02-3971). This serves as the neutral bus bar for each cabinet.
3. Connect the neutral bus bar of each cabinet to the UUT Neutral.



NOTE
NI recommends that you tie one of the cabinet neutral bus bar to Chassis GND. Do not tie the neutral bus bar to GND at multiple systems, which may cause a ground loop.

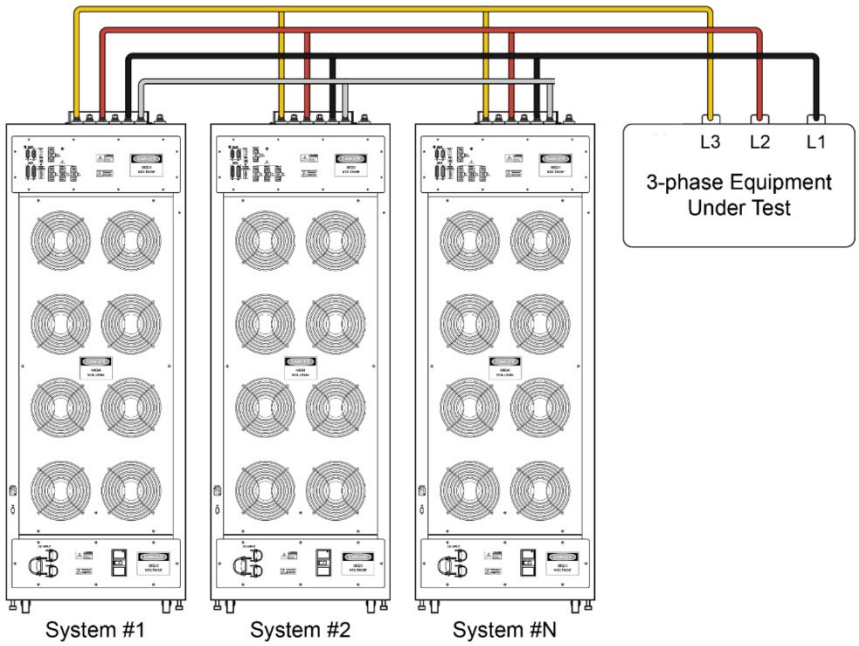
Figure 28: 3-phase Y connection



3-Phase Delta Connection

1. Connect all 9500 V1 OUT, V2 OUT, V3 OUT to the Unit Under Test (L1, L2, L3).
2. Connect the 9500 V1 OUT N, V2 OUT N, V3 OUT N of each cabinet with the bus bar supplied by NI (NH Research Part Number: 02-3971). This serves as the neutral bus bar for each cabinet.
3. Connect the neutral bus bar of the cabinet to each other with suitable cables.

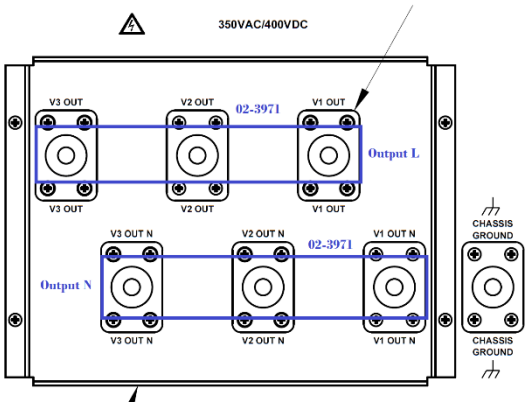
Figure 29: Example, 3-phase Delta Connection



NOTE
NI recommends that you tie one of the cabinet neutral bus bar to the Chassis GND.

Single-phase L-N connection.

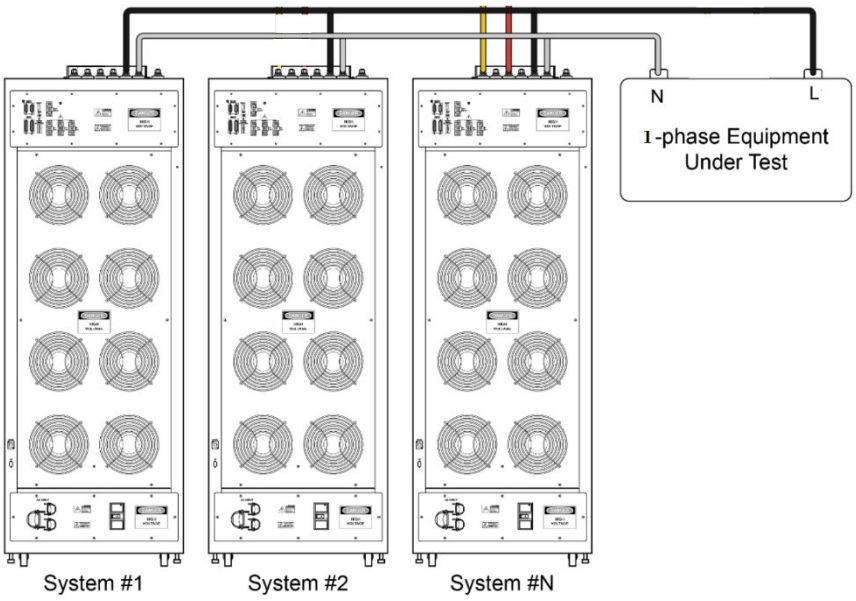
1. For each cabinet, connect V1 OUT, V2 OUT, and V3 OUT with bus bar 02-3971. This serves as the cabinet Line Output.
2. For each cabinet, connect V1 OUT N, V2 OUT N, and V3 OUT N with bus bar 02-3971. This serves as the cabinet Neutral Output.



3. Between cabinets, use suitable cables to connect the Line bus bar to the UUT Line and to Neutral bus bar to the UUT neutral.

NOTE
NI recommends that you tie one of the cabinet neutral bus bar to Chassis GND.

Figure 30: Example, 1-phase L-N Connection



NOTE
The user of 9500 is responsible to wire suitable guage of cable to the power output. The cable needs to sustain the current and voltage rating of the application.

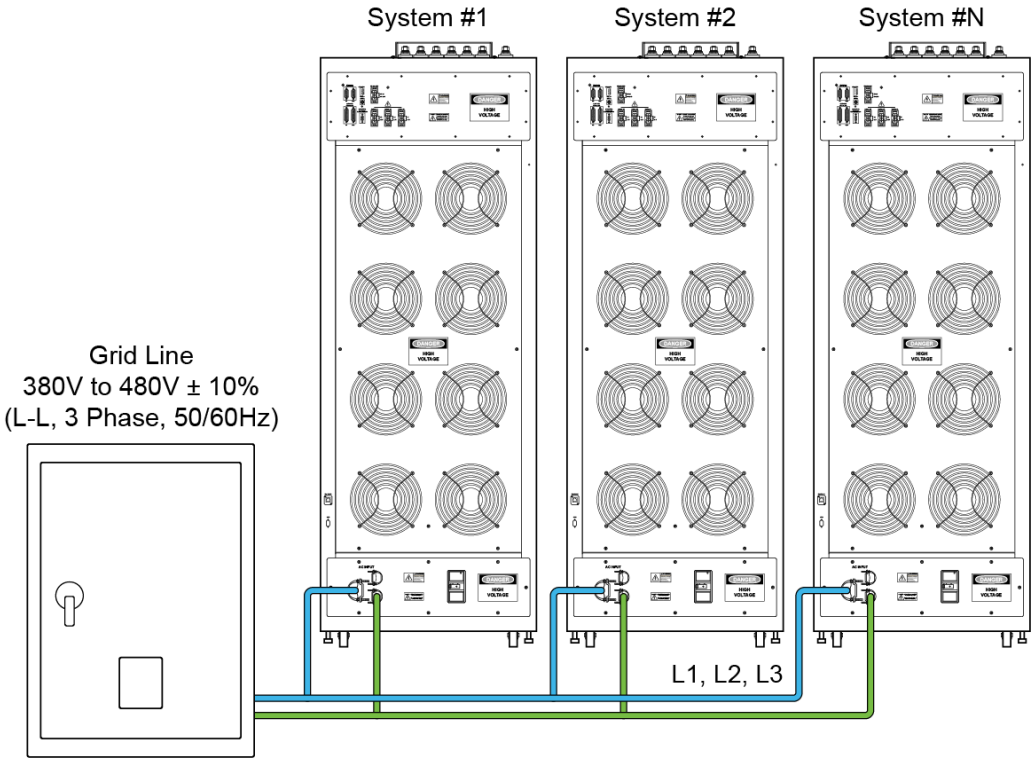
Cable Connections for Sense Line

When the system runs in parallel mode, the remote sense line is required for both master and Aux cabinets.

Input Cable Connection

Connect all 9500 Input Power Lines to AC grid lines (L1, L2, L3) and Ground.

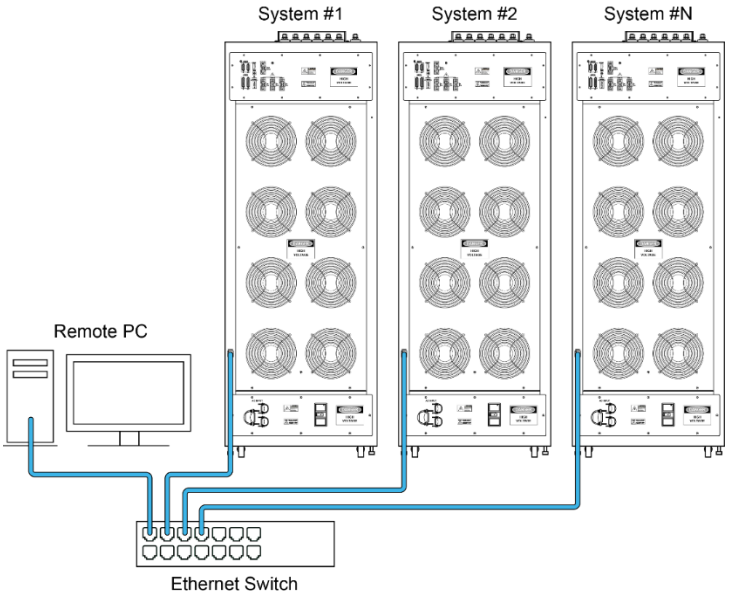
Figure 31: Input Cable Connection



Network Cable Connection

1. Connect all systems' Ethernet to a common network switch box.
2. Connect the remote or control PC's Ethernet to the same switch box.

Figure 32: Network Cable Connection



Create a parallel configuration on the controlling PC. Refer to the *Configuring the Systems in Parallel* section for details.

Configuring Parallel Systems

The 9500-100 should be paralleled only from a remote connection (external PC). You can use one of the following methods to configure parallel systems:

- Using the 9500 Parallel Utility installed in an external PC

Using the SCPI commands

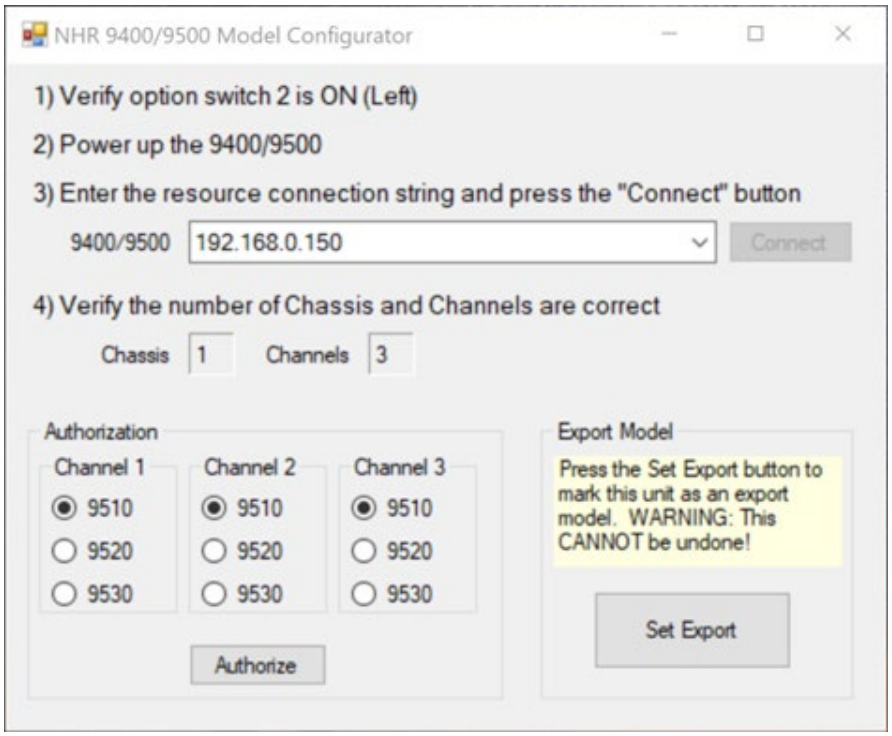
Using the 9500 Parallel Utility for Parallel Configuration

Before you begin:

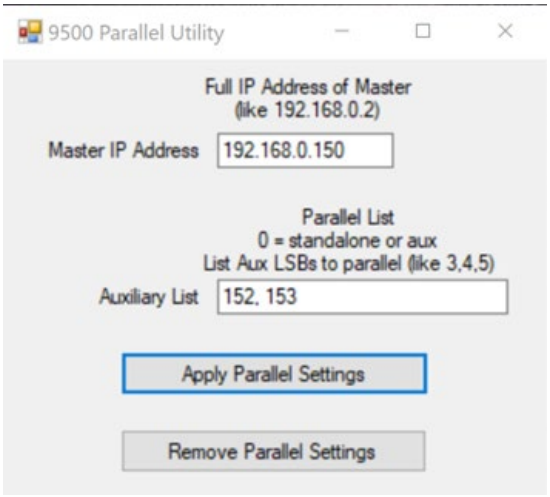
- If your 9510-100 system has the load option (9530), perform the following hardware model check or setup:

  Before running the 9500 Parallel Utility, use the NHR 9400/9500 Model Configurator to ensure that each channel of the cabinet has the same model (Source 9510; or Load 9530). Otherwise, creating parallel configuration will fail. For example, channels in the following screenshot can be set to 9510, 9530, and 9510 separately, but each cabinet has to be set in the same way.

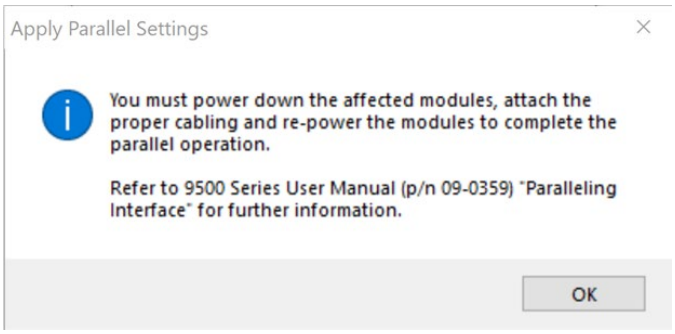
- If your 9510-100 system does not have the load option, you can perform the following step 1 directly.



1. Go to **Start**->**Programs**->**NH Research** to launch 9500 Parallel Utility.
2. Enter the subnet of the setup and the specific addresses of the master and auxiliaries. In the following example screenshot, there are four 9510-100 cabinets, where “192.168.0.150” is the IP address of the master and “152,153” is the IP address of the auxiliaries.



3. Click **Apply Parallel Settings**.
4. If you successfully perform a parallel configuration, you will receive the following message. When prompted, make the appropriate physical connections described in the *Hardware Parallel Connections* section and re-power on the cabinets.



NOTE
To apply parallel configuration, power off all the cabinets in parallel. When powering on the cabinets, power on the auxiliaries first and then power on the master.

The 9510-100 cabinets are now in a parallel configuration, and you talk to the master only when communicating to the 9510-100 system.

NOTE
You only need to set the parallel configuration once. The system remembers the settings and will automatically reconfigure the parallel setting every time you power on the cabinet.

Using SCPI Commands for Parallel Configuration

All controls and functions of the 9510-100 can be accessed by SCPI commands. Refer to the *NHR 9500 Series AC/DC Power Module Programmer's Reference Manual* (NH Research Part Number: 09-0363) for details.

Before starting, make sure the remote PC's IP address is statically assigned to the same subnet as the 9510-100. For example, the default 9510-100 IP Subnet is 192.168.0.xxx. Make sure to assign an IP address of the remote PC to the same IP subnet 192.168.0.xxx address, where 'xxx' is not the same as any of the 9510-100.

CONFigure:PARallel and CONFigure:SAVE are primarily used for paralleling. Refer to the *Configure and System Commands* section in the *NHR 9500 Series AC/DC Power Module Programmer's Reference Manual* (NH Research Part Number: 09-0363) for details.

Example: Two 9510-100 systems, 192.168.0.89 and 192.168.0.235, where .89 is set up as the master. SCPI command would only need to be sent to the master. Here would be an example sequence of putting two 9510-100 systems in parallel:

SCPI Command	Description
conf:par 0	//Query configuration status of .89, response '0' indicates standalone
conf:par 235	//Command tells .89 to add .235 as an auxiliary
conf:save	//Saves this parallel configuration
conf:par?: 235	//Query configuration status of .89, response '235' indicates 235 is an auxiliary
*rst	//Resets the 9510-100

At this point, power off the 9510-100. When powering on the systems, make sure to power on the auxiliaries first before powering on the master. The 9510-100 systems are now in parallel operation, in which you only need to control the master 9510-100.

The following example sequence details how to revert to the standalone configuration.

SCPI Command	Description
conf:par?: 235	//Query configuration status of .89, response '235' indicates 235 is an auxiliary
conf:par 0	//Command tells .89 to set as standalone
conf:save	//Saves this configuration
conf:par?: 0	//Query configuration status of .89, response '0' indicates standalone

*rst	//Resets the 9510-100

NOTE
Make sure to power off the 9510-100 systems and power them on again to complete the process.

Validating Parallel System Configuration

Use the following methods to verify that you've successfully configured the system in parallel:

1. On the touch panel of the master, tap **Options** and verify that the current range value = The number of systems in parallel × the current range of a single system.
2. On the touch panel of the auxiliaries, verify that the auxiliary IP address and **AUX** follow the NHR 9510 logo in order.

In the following example figure, the systems 192.168.0.150, 192.168.0.152, and 192.168.0.153 are configured in parallel to operate in operate in 3-phase AC Grid.

- The current range of a single system is 200 A. Therefore, on the **Options** tab of the master (192.168.0.150) touch panel, the current range is 600 A (600 A = 3 ×200 A).

- On the touch panel of the auxiliaries (192.168.0.152 and 192.168.0.153), AUX shows under the NHR 9510 logo.

Error Reporting in Parallel System

When the protection happened to one of the systems, all of the parallel systems react in the same way, such as inhibiting only the output on all systems or inhibiting the full system. The parallel systems report errors using the following rules:

- The aux systems report only its own error.
- The master system reports all the errors that happened to the master and aux systems, including the aux system identification number.

In the following example figures, the errors are reported because the E-OFF button on any of the parallel system is pressed. As the E-OFF signals are daisy-chained together, all three systems report the same error:

The aux systems (152 and 153) report:

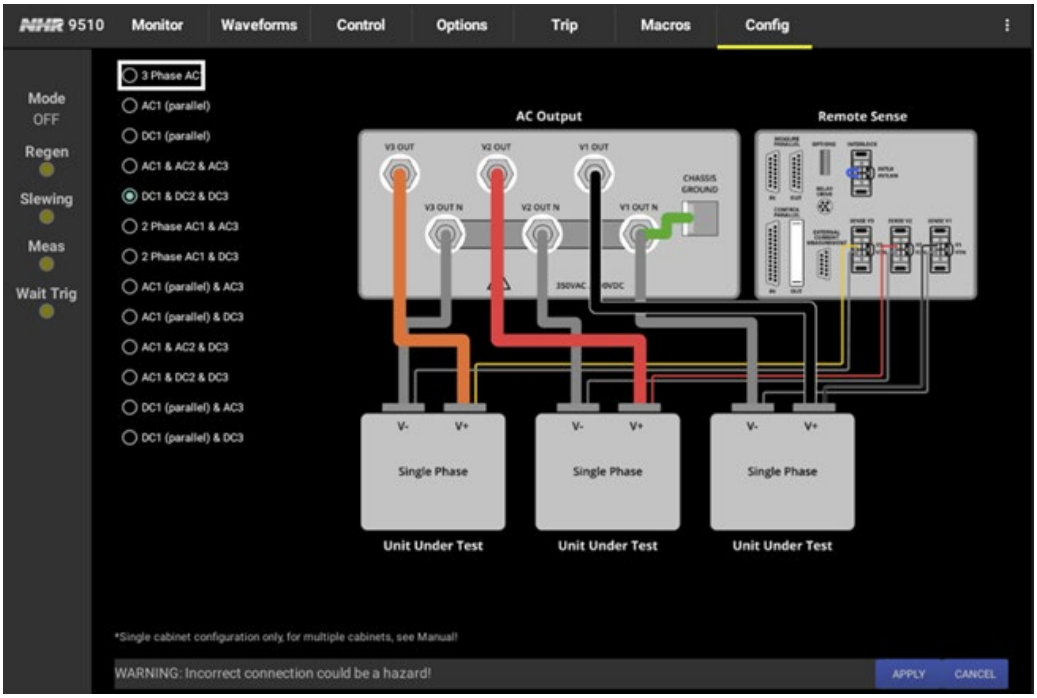
The master system (150) reports:

Updating Parallel System Configuration

In parallel systems, setting configuration on the master forces the configuration to the auxiliaries. Thus, you only need to communicate with the master.

For example, if the master (150) configuration is set to DC1 & DC2 & DC3, configuration of all three systems (150, 152, 153) is set to DC1 & DC2 & DC3 automatically. This is different than the set model (9510 or 9530), where the set model DO needs to be set in each of the systems separately.

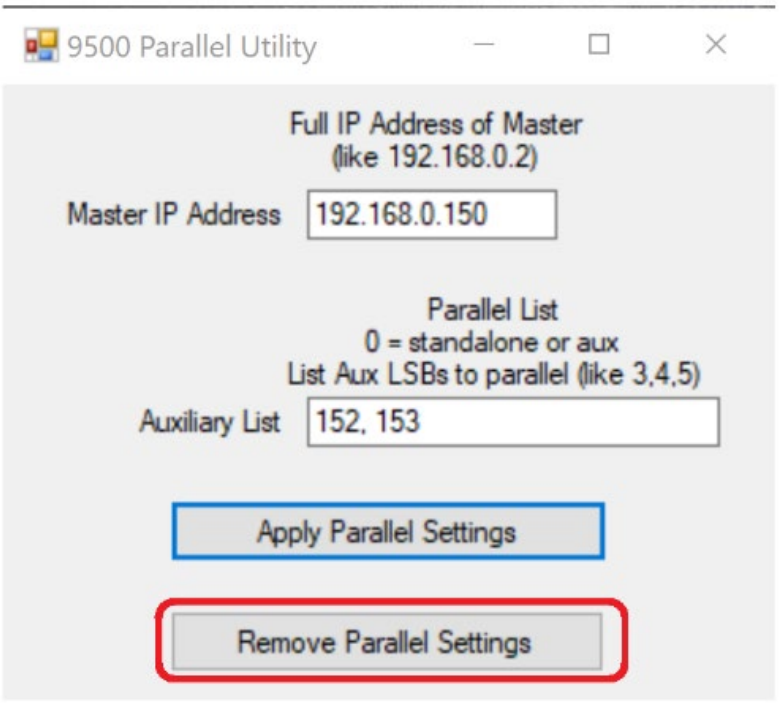
The following figure is an example of setting master (150) configuration to DC1 & DC2 & DC3.



Then, both the master (150) and the auxiliary (152, 153) systems show the configuration change as follows.

Configuring Unparallel Systems

Complete the following steps to revert the 9510-100 systems to standalone configuration:



1. Go to **Start**->**Programs**->**NH Research** to launch 9500 Parallel Utility.
2. Enter the master cabinet IP address (192.168.0.150) and the auxliary cabinet IP list (152, 153).
3. Click **Remove Parallel Settings**.
4. Power off the 9510-100 cabinets.
5. Revert the cable connections to the default standalone configuration described in the *Installing UUT Connections* section.
6. Power on the 9510-100 cabinets to complete the process.
7. Configure the 9510-100 cabinets using the NHR 9500 Panel.

Parallel Cabinets Macro Limitations

The following are limitations and restrictions for Macros when multiple 9510-100 cabinets work in parallel:

1) Macros do not support OUTPUT STATE ON/OFF function. Macros are pre-programed sequences that are 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 settings. For applications that need to turn on/off the output, they may set the output voltage to 0 V instead.

2) Macros do not support CHANGING SET MEASUREMENT RANGE on both voltage and current.

System Interfaces and Indicators

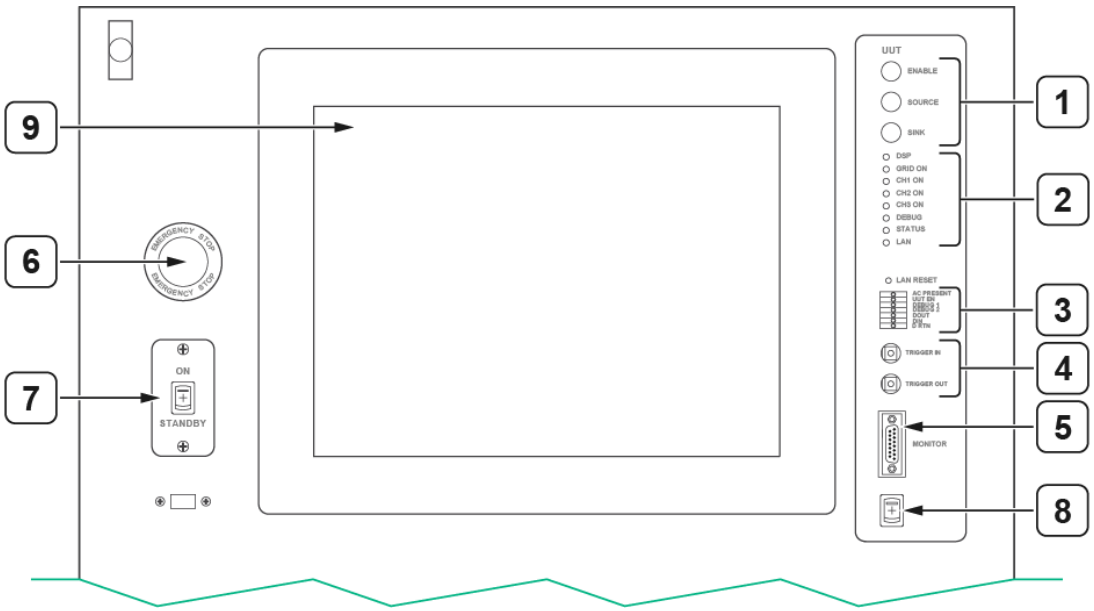
Touch Panel Interface

The touch panel interface on the cabinet front door enables direct manual control of the system without an external PC or a control device. When the system is under local control, you can use this interface to monitor voltage, current, power, frequency, and other measurements.

The indicator panel uses light-emitting-diodes (LEDs) to indicate current status.

Refer to the *Touch Panel Control* section for more information.

Figure 33: Touch Panel Interface



1. Output Status Indicators
2. System Status Indicators
3. Digital I/O Interface
4. Trigger In/Out
5. Analog Control/Monitor
6. E-Stop (EOFF)
7. ON/STANDBY Switch
8. Operation Ready/Disable Switch
9. Touch Screen

Output Status Indicators

The output status indicators on the upper right of the front door provides the following three visual indications:

- Enable – Output contactors are connected or closed. The enable LEDs neither imply that voltage is being produced nor indicates direction of power flow.
- Source – All channel powers are summed and net power is flowing from the 9510-100 to the UUT.
- Sink – All channel powers are summed and net power is flowing from the UUT to the 9510-100.

CAUTION
Always assume electrical connections may have voltage especially when the Enabled light is illuminated.

ATTENTION
Toujours supposer que les connexions électriques peuvent être sous tension, surtout lorsque le voyant Activé est allumé.

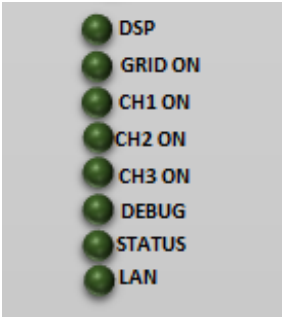
NOTE
The source and sink lights may not illuminate when the arithmetic sum of all channel powers is near zero. For example, if two channels are sourcing 2 kW each and another is sinking 4 kW, the sum is near zero and neither lights are illuminated even though the significant power is flowing on a per channel basis.

> Never use source and sink as a safety indication.

System Status Indicators

The six indicators in the upper right of front door provide a visual indication:

- DSP – Indicates the internal processor status.
- GRID ON – Illuminates when internal DC voltage reaches normal operational levels.
- CH1 ON, CH2 ON, and CH3 ON – Indicates that the channel phase is active.
- DEBUG – Is reserved for factory debugging.
- STATUS – Indicates the communication processor status.
- LAN – Illuminates when proper network connection is detected.



LED	Pattern		Indication
DSP	Blinking Slow Red		A flash error occurred. You need to re-download the firmware.
	Blinking Green		The normal operation code is running without any errors.
	Blinking Fast Red		An output-off or system-trip error occurred.
	Blinking Fast Yellow		A non-critical error occurred.
GRID ON	Solid		The system has completed the start-up or reset sequence and the internal DC is ready.
CH1 ON	After the system is powered on (GRID ON LED is ON)	Solid	Normal operation, CH1 turns on
CH2 ON		Solid	Normal operation, CH2 turns on
CH3 ON		Solid	Normal operation, CH3 turns on
CH1 ON	In the process of	Blinking	System Start up Step 0-1 Wait to discharge Caps

	powering on the system (GRID ON LED is not ON yet)	Solid	System Start up Step 2 Done Cap discharged + Bias Enabled + DC-DC PWM_En
CH2 ON		Solid	System Start up Step 3 reached: small soft Relay On
CH3 ON		Solid	System Start up Step 4 reached: Grid PWM Enabled
DEBUG LED	Solid Red		Reserved
	Blinking Red		Reserved
	Blinking Green		Reserved

NOTE
Blinking slow means that the LED is on and off once every two seconds.
Blinking fast means that the LED is on and off once every one second.

Digital I/O Interface

The digital I/O interface uses a wire terminal block with a release lever. The signals in the system are interpreted as follows:

- All signals are referenced to “D RTN”.
- All output signals are open collectors and provide an internal 1 K pull-up to +5 V_{dc}.
- All output signals may source up to 1 mA and sink up 50 mA.

This interface contains the following indicators:

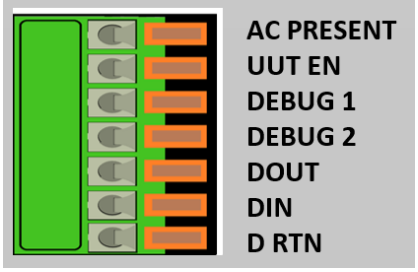
- AC PRESENT – The output indicates the presence of V_A at the output terminals.
- UUT EN – The output indicates the output contactor state.
- DEBUG 1 – Indicates whether the output error occurs.
- DEBUG 2 – Reserved.
- DOUT – The output is a general purpose digital out signal.
- DIN – The input is a general purpose digital input signal. The input voltage is 5 V nominal, and it must not exceed 5.5 V. You can use software to enable the digital input signal as a rising or falling edge trigger source.

CAUTION
If digital input signal is too high on DIN, it could cause damage to the system.

ATTENTION

> Si le signal d'entrée numérique est trop élevé sur DIN, le système risque d'être endommagé.

- D RTN – Returns signals or references for all digital I/O interfaces, which is isolated from chassis ground up to 100 V.



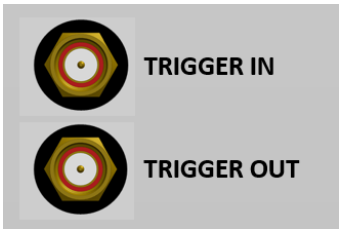
Signal	Signal level	Indication
AC Present	High	The output relay of any channel is closed and the either AC or DC voltage setting is non-zero.
	Low	Either the output relay is all open or the voltage setting is zero.
UUT_EN	High	The output relay of any channel is closed.
	Low	The output relay of all channels are open.
Debug1	High	No output-off error.
	Low	An output-off error occurred.
Debug2	High	RSV
	Low	RSV
Dout	High/Low	User Command Control. The default signal level after reset is low. Refer to the *NHR 9500 Series AC/DC Power Module Programmer's Reference Manual* (NH Research Part Number: 09-0363) for details.
Din	High/Low	User input for event trigger. User defines trigger edge.
Trigger_IN	High/Low	User input for event trigger. User defines trigger edge.
Trigger_OUT	High	Default signal after reset.
	Low	Several events pull the low trigger out signal for 1.2 ms to 3 ms, including: Command 0x31 Any channel turns on Any channel turns off Any operation setting takes effect

		Any meaningful trigger source has been detected

Trigger In and Trigger Out

This interface uses an SMB connector and provides Trigger In and Trigger Out controls. The signals are referenced as D RTN in the Digital I/O Interface and include a resistor within the range from 1 k to +5 V_{dc}.

- Trigger In – The input signal enabled through software for the rising or falling edge. The signal generates a trigger which is generally used to advance a Macro. The input voltage should not exceed 5.5. The recommended input voltage is 5 V.
- Trigger Out – The output signal enabled through software. The signal generates a positive pulse for each operating command processed which is generally used to trigger external devices, such as an oscilloscope.



Mating Cable Type	Manufacturer	NH Research Part Number
Cable Assembly	NI	12-0879-00
Connector Coax Miniature	NI	6000262
Wire Coax RG174/U	NI	8010023

Analog Monitor

Analog Output

Each cabinet provides one analog output current and voltage monitor for each channel.

For the current monitor, -10 V to +10 V corresponds to ± Full-Scale (maximum peak measurement) of the current range selected and the voltage range selected.

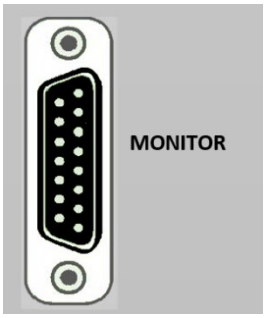
For the voltage monitor at high range, -10 V to +10 V corresponds to -500 V to 500 V.

This signal is not calibrated and is referenced to the chassis ground.

Analog Input

Each channel has an analog input signal with ±10 V_{PK-PK}. You can choose the analog output to follow the analog input.

The analog input in the 9510-100 programs for the output voltage: ±10 V_{PK-PK} represents ±247.5 V_{PK-PK} for the low range and represents ±495 V_{PK-PK} for the high range.



Pin No.	Definition
1	GND
2	VMON CH1
3	VMON CH2
4	VMON CH3
5	IMON CH1
6	IMON CH2
7	IMON CH3
8	GND
9	ANALOG IN1
10	ANALOG IN2
11	ANALOG IN3
12	SPARE TP1
13	SPARE TP2
14	SPARE TP3
15	GND

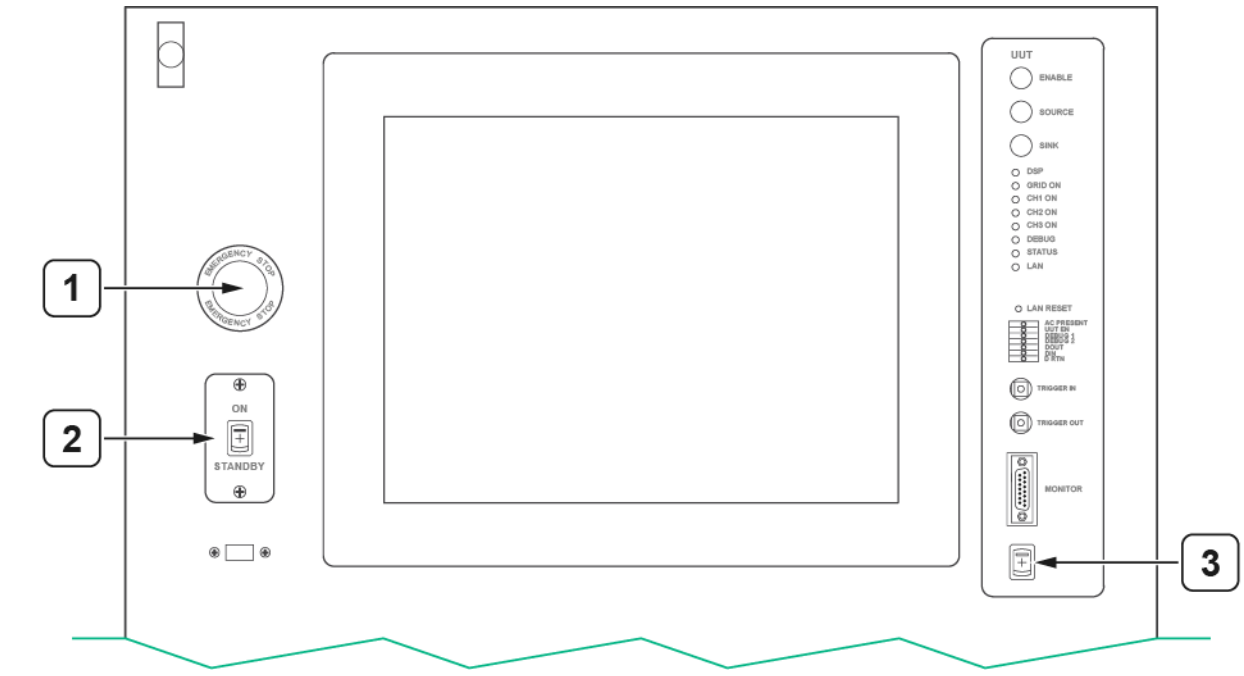
CAUTION
Always assume the output may have hazardous voltages when working with electrical conductors.

ATTENTION
Toujours supposer qu'une tension dangereuse peut être présente à la sortie lorsque l'on travaille avec des conducteurs électriques.

Switches

The 9510-100 system provides multiple switches which may be activated under normal operation.

Figure 34: Switches on the Front



1. Emergency Off (E-OFF)
2. ON/STANDBY
3. Operation Ready/Disable

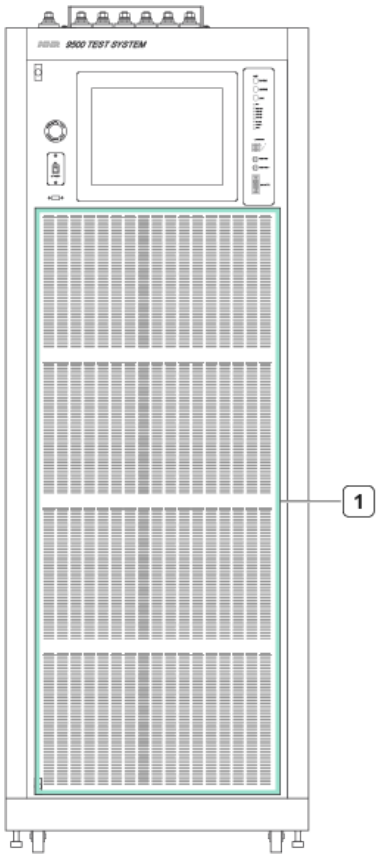
Switch	Description
Emergency Off (E-OFF)	Pressing the E-OFF button turns off the system and opens both the UUT and facility contactors. To reset this switch, twist the red button to ensure that it returns to the normal un-pressed state.
ON/STANDBY	ON: The AC power is allowed to power on the internal control circuitry and the internal low voltage DC power supplies. Then the controllers will turn on the system. STANDBY: The internal low voltage DC supplies are disabled, the control circuitry is not powered on, and all internal relay and circuitry are disabled.
OPERATION Ready/Disable	Disabled: The system output is turned off and UUT contactors are opened. Ready: Software commands are accepted only when the switch is first in the Ready position.

Main Breaker	This switch, located in the AC facility input panel, isolates all power from the system. In normal operation, this switch is not generally toggled.

Air Flow

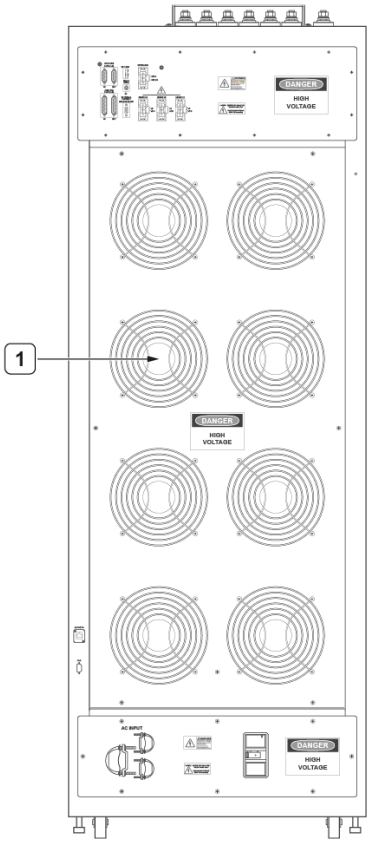
The system is cooled with ambient air. The system pulls cooling air from the air intake slots in the front and exhausts the hot air out of the exhaust fans in the rear.

Figure 35: Air Intake Slots



1. Air Intake Slots

Figure 36: Air Exhaust Fans



1. Air Exhaust Fans

CAUTION
Never insert tools, metal objects, or allow liquids to be drawn into the air intake slots.

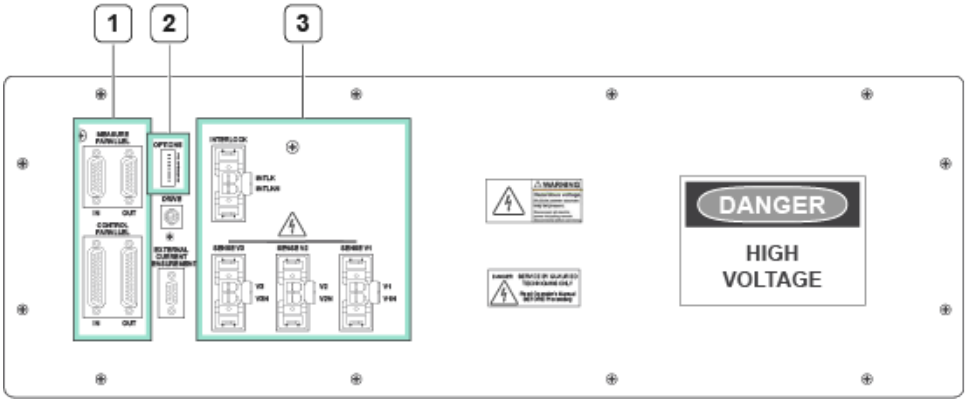
ATTENTION
Ne jamais insérer d'outils ou d'objets métalliques et ne jamais laisser pénétrer de liquide dans les fentes d'admission d'air.

NOTE
NI recommends 24 inches (60 cm) of unrestricted air space.

Rear Interface Connections

All interface connections on the rear are located behind the output access panel.

Figure 37: Rear Interface Connections



1. Parallel Interface
2. Options Dip Switch
3. Interlock and Channel Voltage Remote Sense

CAUTION
High voltage may be present behind this access panel.

Only trained personnel should remove this access panel.

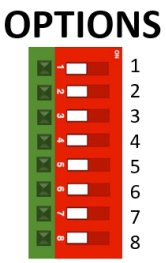
ATTENTION
Présence possible de haute tension derrière ce panneau d'accès.

Seul le personnel formé est autorisé à retirer ce panneau d’accès.

Options Dip Switches

In normal operation, the options dip switches should always be switched to the left (down) in the OFF position. Do not change the switch positions unless:

- You are specifically instructed by NI customer support.
- You are specifically instructed to change the position for completing a programming update procedure, such as the firmware update.
- You must change switch 1 position to force the IP address of the unit to 192.168.0.2 for configuration.



NOTE
Refer to the *Configuring the IP Address* section for more information about how to use switch 1.

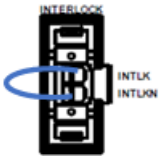
Interlock

The interlock connection is located to the right of the option dip switches. Refer to the *Rear Interface Connections* section for the location. The interlock connection must be shorted for normal operation.

When the interlock is disconnected or open during operation, the NHR 9510 responds by opening the output relays, stopping UUT output semi-conductor switching, and generating an interlock error.

Unlike the emergency-off switch, the interlock connection allows new operating commands to be accepted after the connection is re-established.

Figure 38: Interlock Connection



Parallel Interface

The parallel interface ensures all 9510-100 systems placed in parallel can use the same range, synchronize operating commands, share current, and notice safety trips, allowing all 9510-100 modules to act as a single instrument.

Figure 39: Parallel Interface

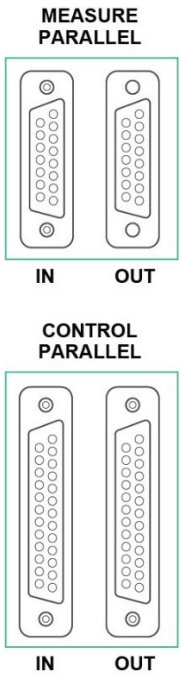


Table 10: Parallel System-To-System Cable Type

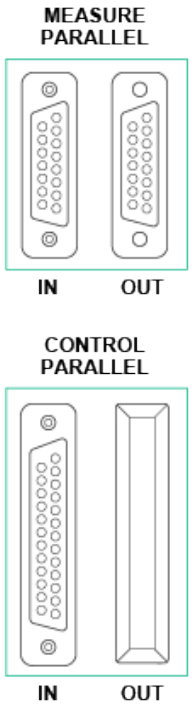
Manufacturer	Manufacturer PN
NI	12-0978-01 (Measure parallel, NH Research Part Number)
Assmann	AK137-2(Control parallel)

Terminator Installation

In systems with 100 kW or smaller, you must install the control parallel terminator (NH Research Part Number 12-1166-00) on the control output connection after unpacking it from the accessory kit. Only one terminator is required for proper operation.

In systems with larger than 100 kW, the terminator and paralleling cables are pre-installed. Refer to the *Configuring the Systems in Parallel* section for more details.

Figure 40: Terminator installed correctly



In field expansion, the parallel interface is used to add an auxiliary to a master in order to expand current capabilities.
Use only NI supplied cables.

Mating Cable Type	Manufacturer	Part Number
Control Paralleling Cable (DSUB25-MF-2M)	ASSMANN	AK137-2
Measure Paralleling Cable	NI	12-0978-01 (NH Research Part Number)
Terminator	NI	12-1166-00 (NH Research Part Number)

NOTE
Contact NI for more information adding an auxiliary.

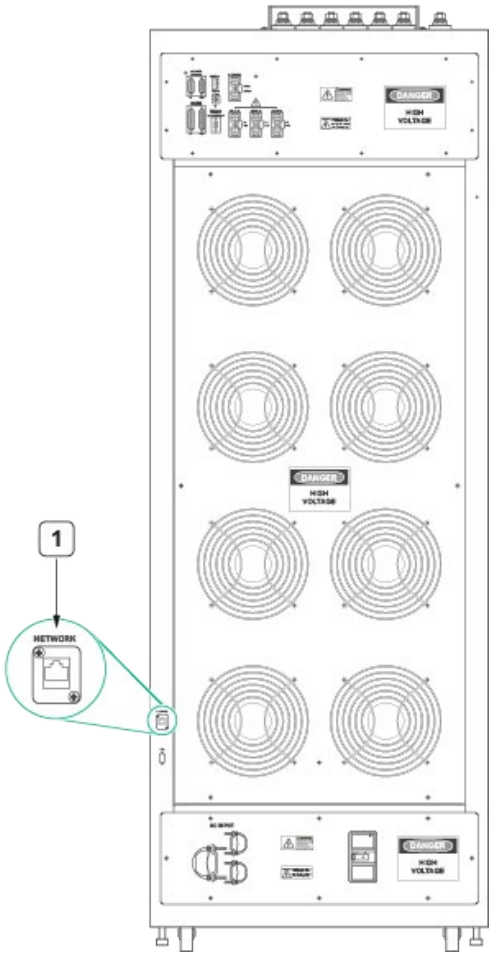
LAN Connection

The NHR 9510-100 uses the LAN connection as the primary communication from either the touch screen on the front panel or an external controller such as a PC, PLC, or a real-time system. This connection supports auto-MDIX for either a straight or crossover cable to be used.

Changing the pre-configured IP address requires a PC or other computer with web-browser. 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.

Figure 41: LAN Connection



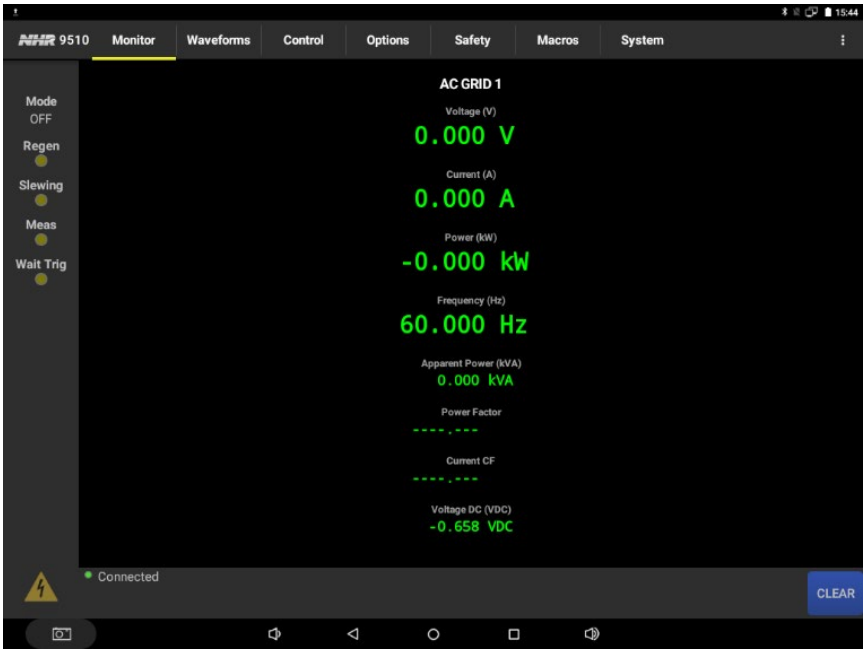
1. Ethernet (LAN) Port

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

Touch Screen Control

Use the touch screen on the touch panel to manually operate the NHR 9510 system.

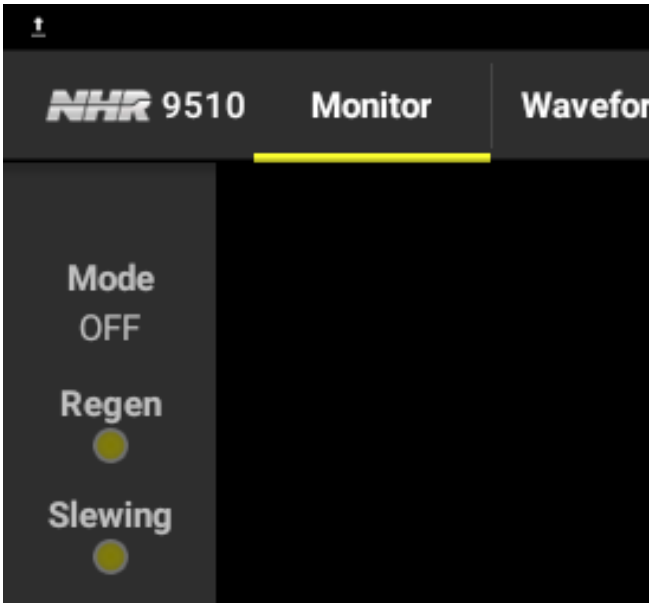
Figure 42: Touch Screen Monitor Page



System Identification

The system model number automatically appear in the upper left corner based on the detected model.

Figure 43: Model Name on Touch Screen



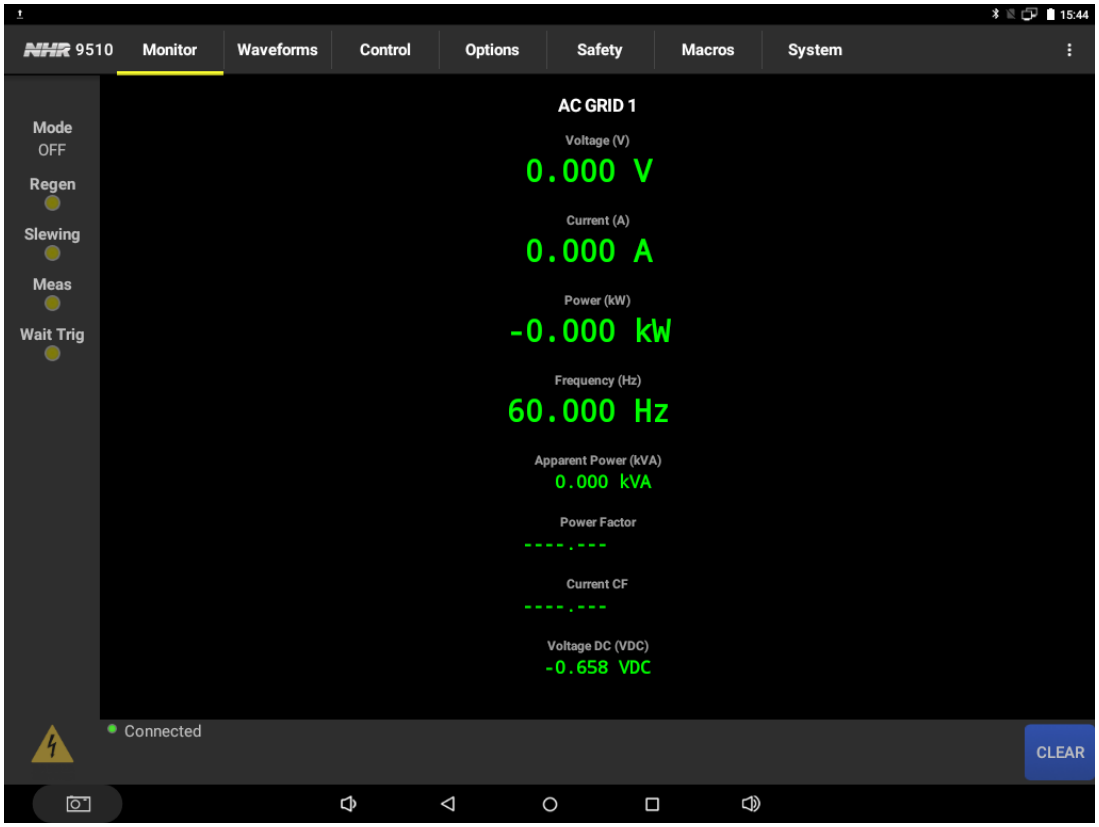
This field also indicates whether the system has detected an open remote communication port or has been remotely locked out by a remote application, such as the NHR 9500 Panel. After the touch panel detects that another application has been connected to the system, the touch panel automatically change to the “REMOTE” or “LOCK” mode.

Setting the System Hardware Configuration

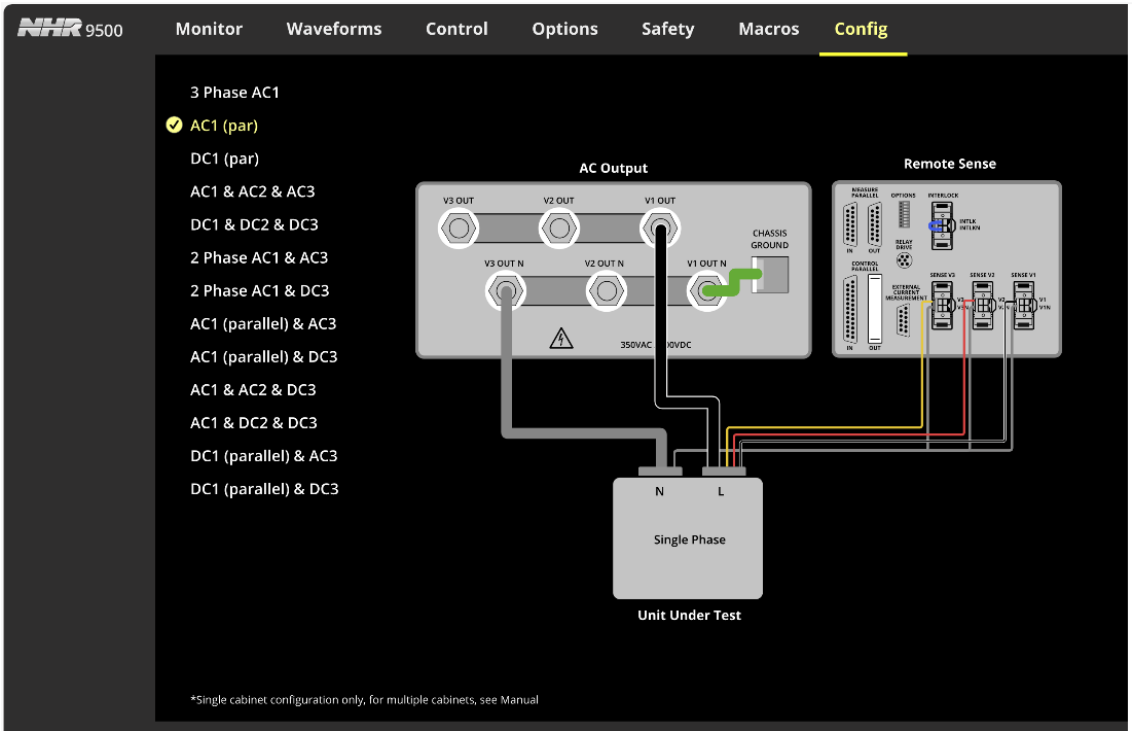
The 9510-100 provides a number of hardware configurations. Use the **System** tab on the main screen to review and select a configuration.

CAUTION
Changing the configuration is likely to require a change in fixture wiring. Review the process in this section carefully.

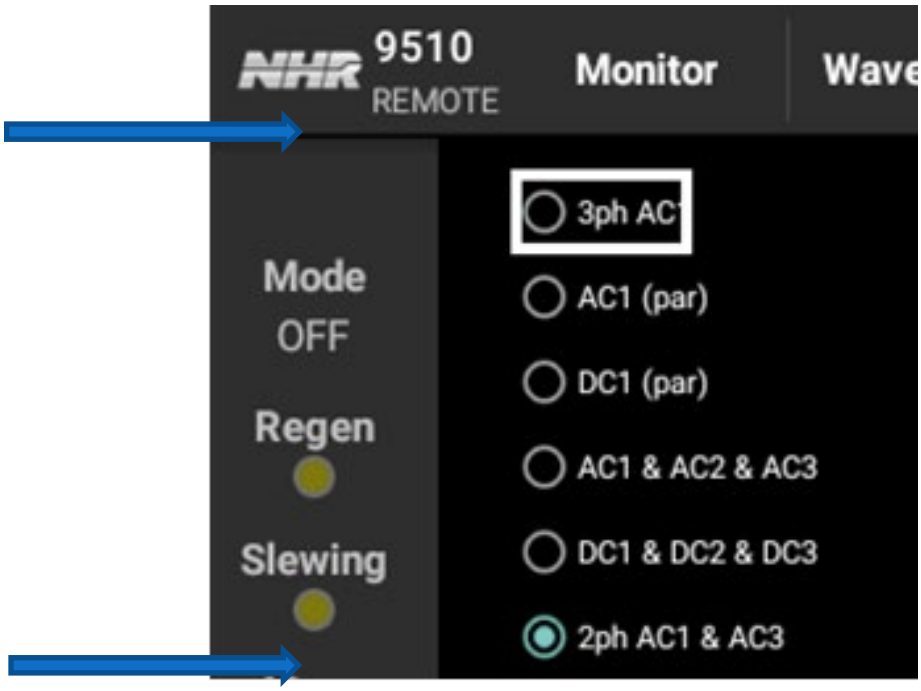
ATTENTION
Une modification de la configuration nécessitera probablement une modification du câblage de l'appareil. Examiner attentivement le processus décrit dans cette section.



Tap **Config** to view the available configuration and recommended fixture wiring.



Tap **Apply** (not shown in the previous figure) to send the configuration commands to the hardware so that the new mode can take effect. After clicking **Apply**, you can go back to any other tab, such as the **Monitor** tab to see the new configuration.



CAUTION
Changes to the new configuration disables previous safety limit settings and may require output wiring changes.

ATTENTION
Les modifications apportées à la nouvelle configuration désactivent les paramètres de limite de sécurité précédents et peuvent nécessiter des modifications du câblage des sorties.

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 using the NHR 9500 panel.

Only the **Monitor** tab and the error clear button are active when the touch screen is locked by a remote application.

Figure 44: Panel is Primary Controller

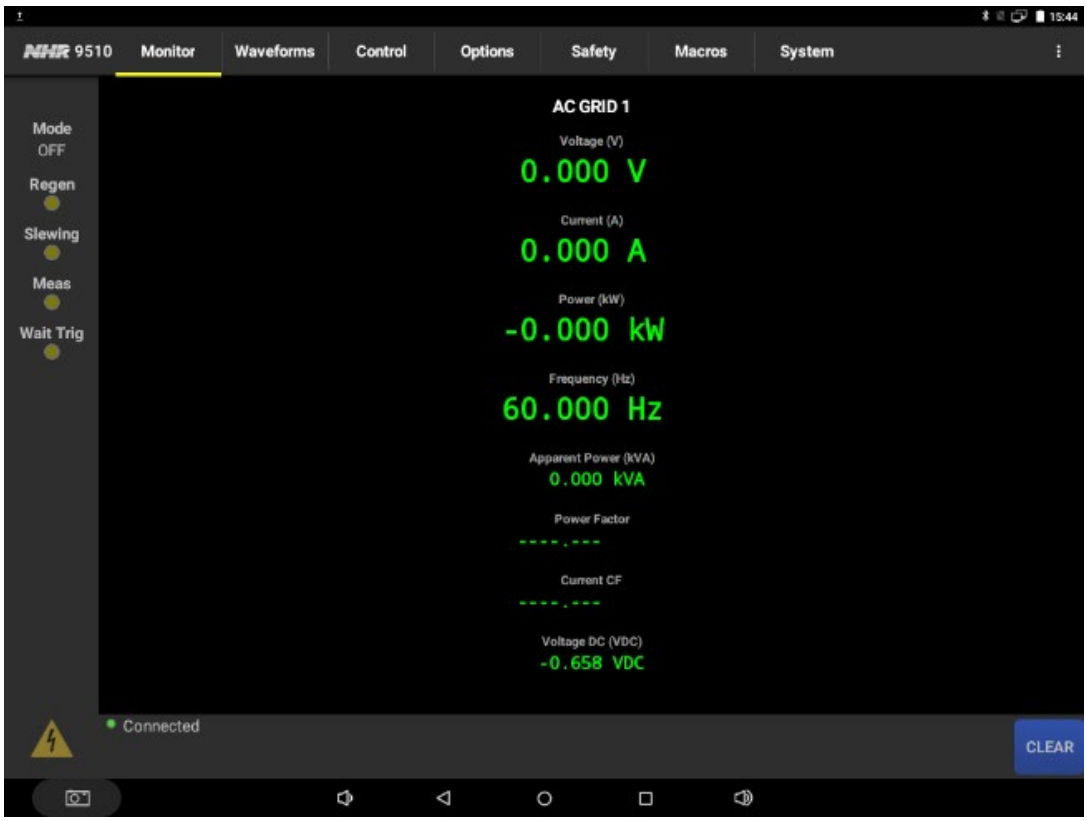
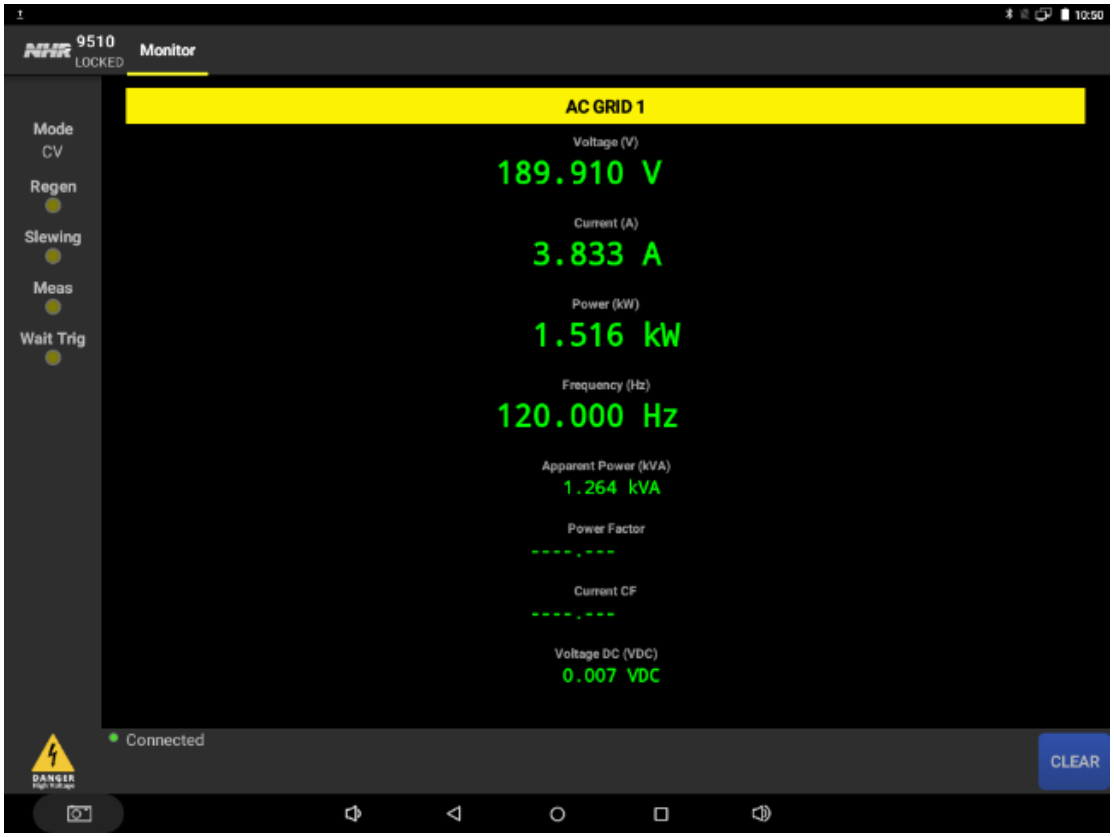


Figure 45: Panel is Locked Out (Remote Controller)

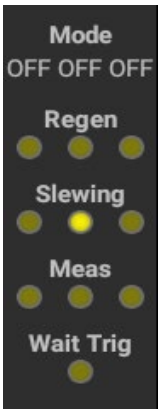


Indicators

The touch panel screen, if equipped, provides a number of indicators on the left regardless of the tab selected.

The number of indicators depends on the number of logical instruments configured in hardware operating mode. For example, a 3-ϕ AC output is a single logical instrument whereas three separate 1-ϕ AC outputs are three channels.

The following indicators are ordered from 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

This icon indicates that when lit, the output of one or more channels is active. Tap this button to turn all channels off.

CAUTION: POSSIBILITY OF ELECTRIC SHOCK
This feature is locked out in remote lockout mode. Always assume voltage may be present at the output.

ATTENTION: POSSIBILITÉ DE CHOC ÉLECTRIQUE
Cette fonctionnalité est verrouillée en mode de verrouillage à distance. Toujours supposer qu'une tension peut être présente à la sortie.

- Wait Trig – Indicates one or more instruments are waiting for a trigger before performing the next action such as taking a measurement or Macro step.
- Mode off – Indicates the logical instrument is in On/Off state or in Current Regulation mode.
- Mode CV – Indicates the logical instrument is in Constant Voltage (Regulation) mode.
- Regen – Indicates the logical instrument is converting the UUT power to into the internal DC power.
- Slewing – Indicates a slew to the new set value is occurring on the logical instrument indicated.
- Meas – Indicates a measurement is in progress on the logical instrument indicated.
- Macros Running – Indicates the Macro is executing, that is, local high-speed control is active. This indicator displays only when a Macro has been downloaded in the system.

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

Refer to the *Macros and Usage Examples* section for more information about building and using Macros.

System Status Bar

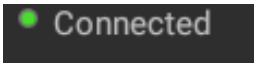
The system status bar at the bottom of the touch panel screen includes an LED indicator, the status and error messages, and a CLEAR button.

The LED indicator shows the communication and error status:

- Blinking Yellow – Indicates that communication with the system is successful.
- Blinking Red – Indicates that an error is detected.
- Any solid color (on or off) – Indicates that communication with the system fails. A reset or power cycle may be required.

The status message appears immediately to the right of the LED indicator. The status message has the following two types:

- Connected

  Example: 

- Error

  Example: 

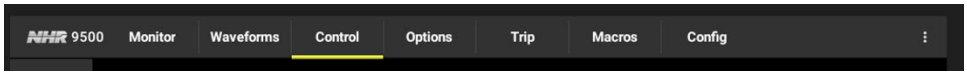
You can tap **CLEAR** to clear the displayed error.

Not all the errors can be cleared by doing so. Some of the errors must be cleared by a software reset or a power recycle.

NOTE
Not all the errors can be cleared by doing so. Some of the errors must be cleared by a software reset or a power recycle.

Touch Screen Selection Tabs

When the system is under the control of the touch panel, you can use the following available tabs at the top to select the control screens. The tab of the current shown screen is underlined in yellow.



- Monitor – Provides digital measurements for each instrument. For multi-phase instruments, tap any measurement to switch between the per phase (l-n) and multi-phase (l-l) views.

- Waveforms – Provides a waveform view of the current voltage or current output.
- Control – Provides the set control for single value, such as voltage, current, and frequency.
  You can tap the measurements to switch between the per phase (l-n) and multi-phase (l-l) control views.
- Options – Provides access to the additional set controls, such as ranges and wave-shapes, also software reset.
- Trip – Provides access to the safety trip settings.
- Macros – Provides access to the internal local high-speed control system.
- Config – Provides settings of the device configuration.
- Menu ( ) icon – Provides access to the setup menus for installation. For more information see the “installation section.”

NOTE
Change settings in the **Config** tab may require wiring changes.

When the touch panel is locked, only the **Monitor** tab is available, and other tabs are hidden to prevent local changes that may affect the testing results.

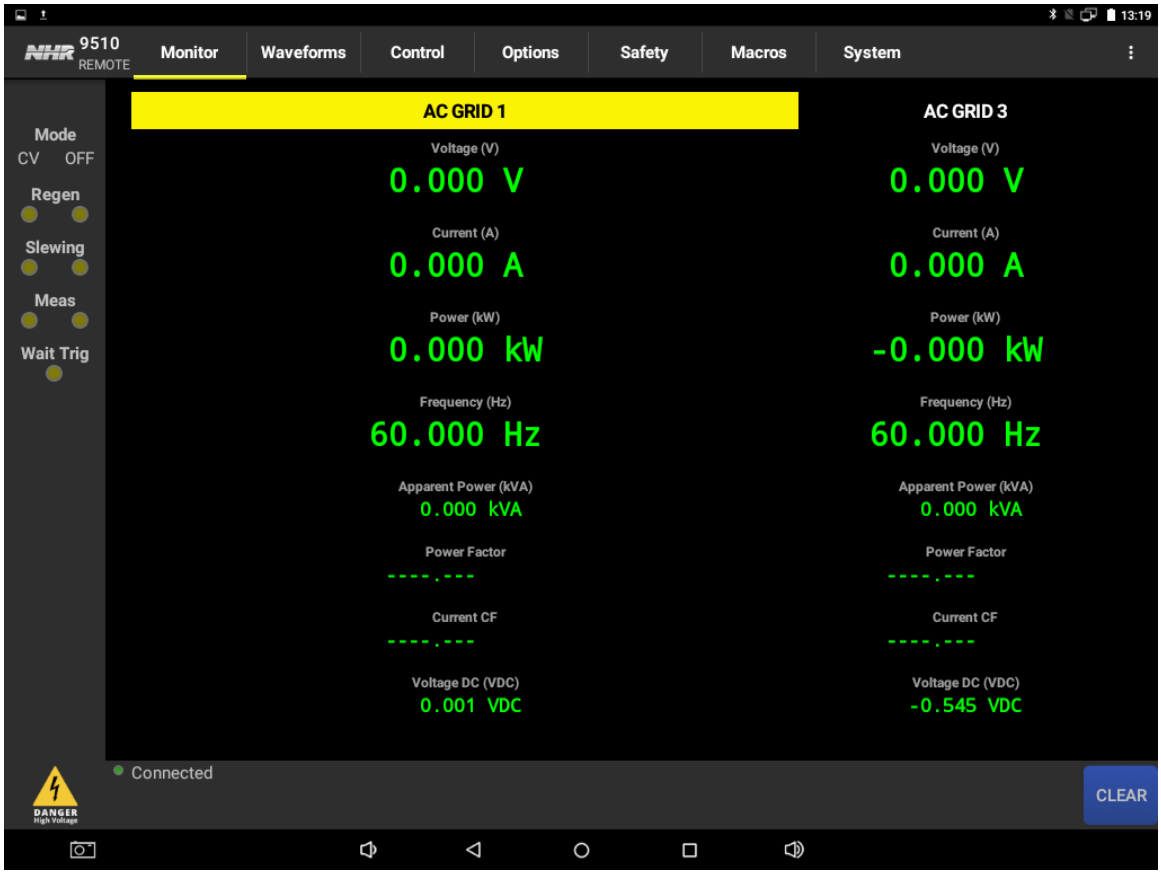
Monitor

The Monitor pane provides measurements for each configured instrument.

- In 1-ϕ and DC mode, measurements are always referred as neutral (l-n).
- In multi-ϕ mode, measurements are available as line-line or per-phase (l-n).

The Monitor screen is always available no matter when the system is controlled by the touch panel or by another external application, such as the NHR 9500 Panel.

Figure 46: Monitor Screen with a 9510 in Split Phase (2-ϕ) + 1 AC (1-ϕ) Configuration



Instrument Labels

The Monitor screen shows the instrument names based on the hardware configuration.

When the instrument name is highlighted in yellow, the instrument channel output is active.

When the instrument name is not highlighted, the instrument channel output is inactive.

The instrument label indication is a supplement to indicators on the left pane of the touch panel.

Switching Between the Line-Line and Line-Neutral Views

For multi-phase outputs, tapping any measurement can switch between the multi-phase (line-line) and per-phase (line-neutral) views.

Figure 47: 9510 Multi-Phase (L-L) View for AC Grid 1

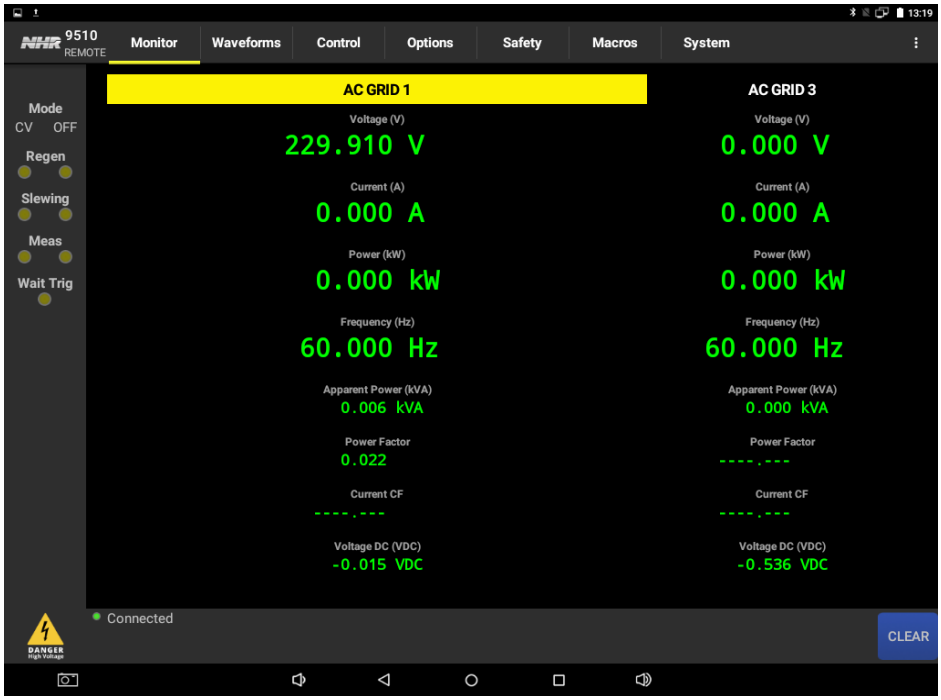
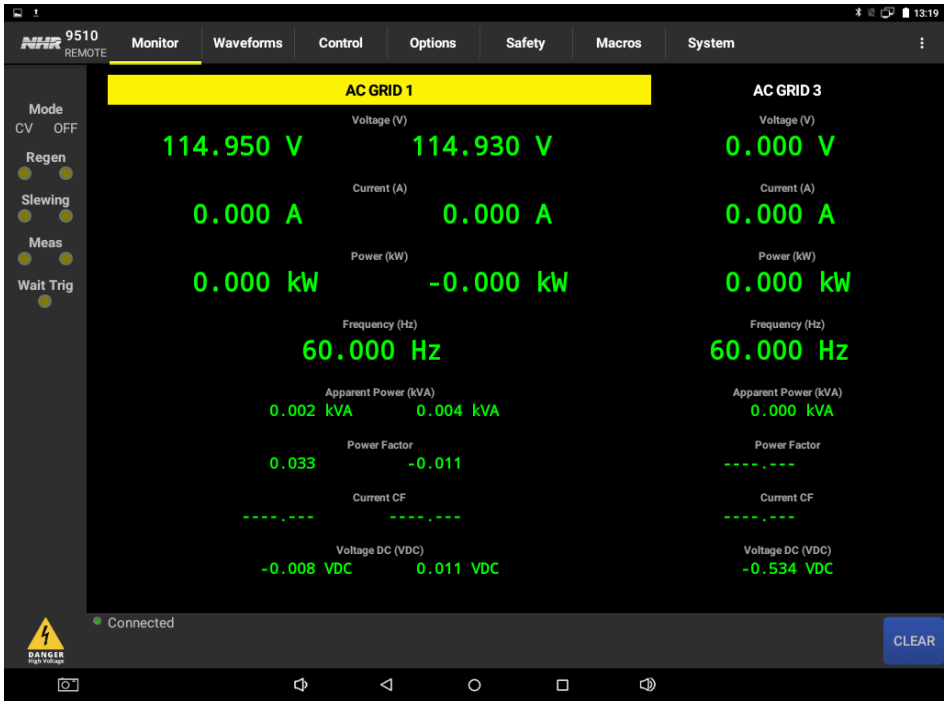


Figure 48: 9510 Per-Phase (L-N) View for AC Grid 1



In the multi-phase view, the operating mode displays an equivalent multi-phase voltage, current, and power. The following table provides additional details about the calculations used to display the multi-phase monitored values.

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

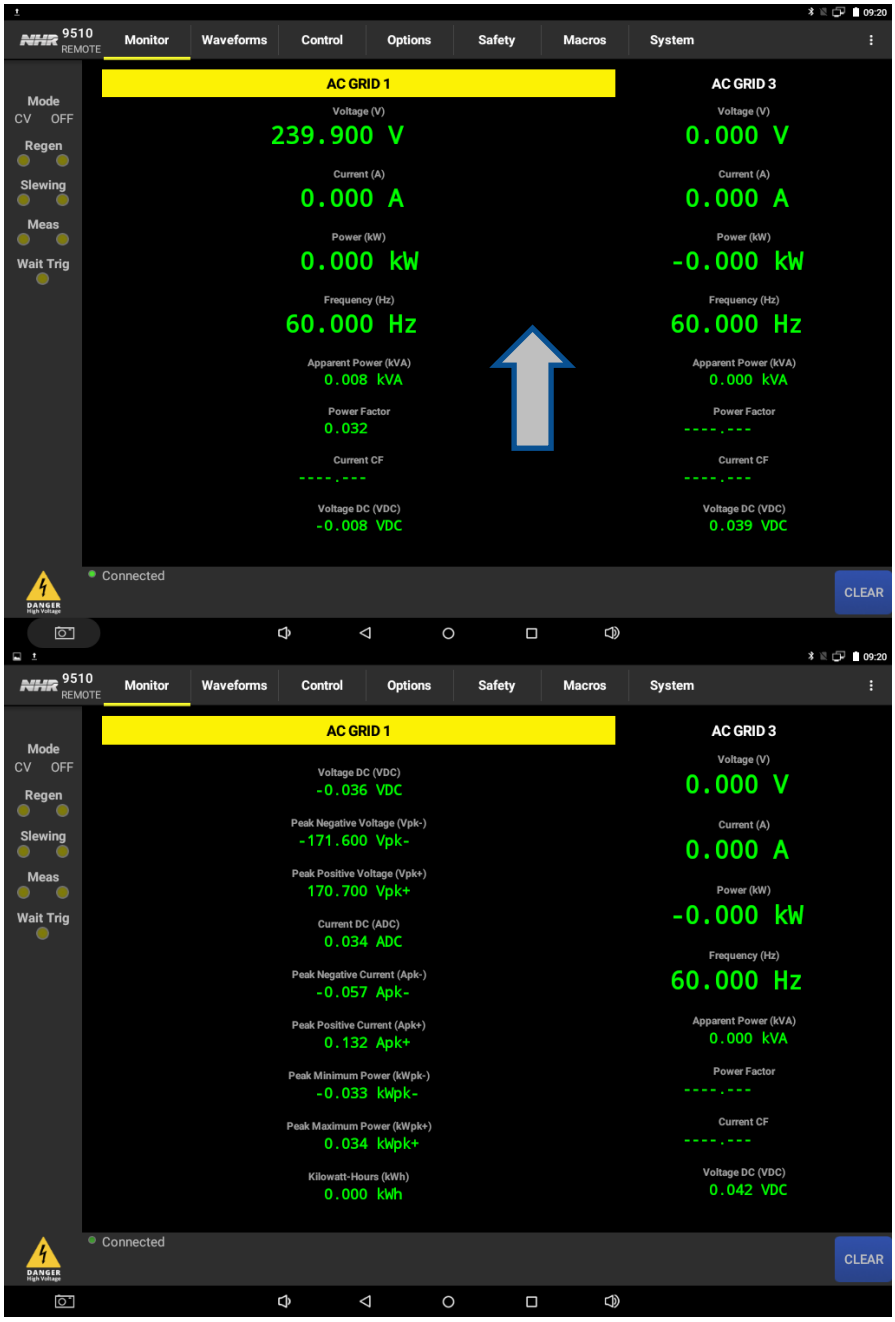
Hardware Mode	Multi-Phase View	Per Phase View
3-Phase (3-ϕ)	Voltage shown as $V_{Aϕ\ l\text{-}n} \cdot \sqrt{3}$	Voltage Shown as L-N per ϕ
	Average of line currents A_{RMS}	Actual line currents per ϕ
Split Phase (2-ϕ)	Voltage shown as $V_{Aϕ\ l\text{-}n} + V_{Bϕ\ l\text{-}n}$	Voltage Shown as L-N per 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

In the previous table, +Peak and –Peak voltage, current, and power are always displayed per ϕ. Frequency is indicated for instruments configured for AC outputs.

Scrolling to View All Measurements

The touch screen integrates the Android swipe capability that enables you to view the entire list of measurements. Because the Monitor pane cannot display all the measurements on one page, you need to keep touching the screen and scroll up and down to view all the available measurements.

Figure 49: Scrolling up for more measurements on AC GRID 1

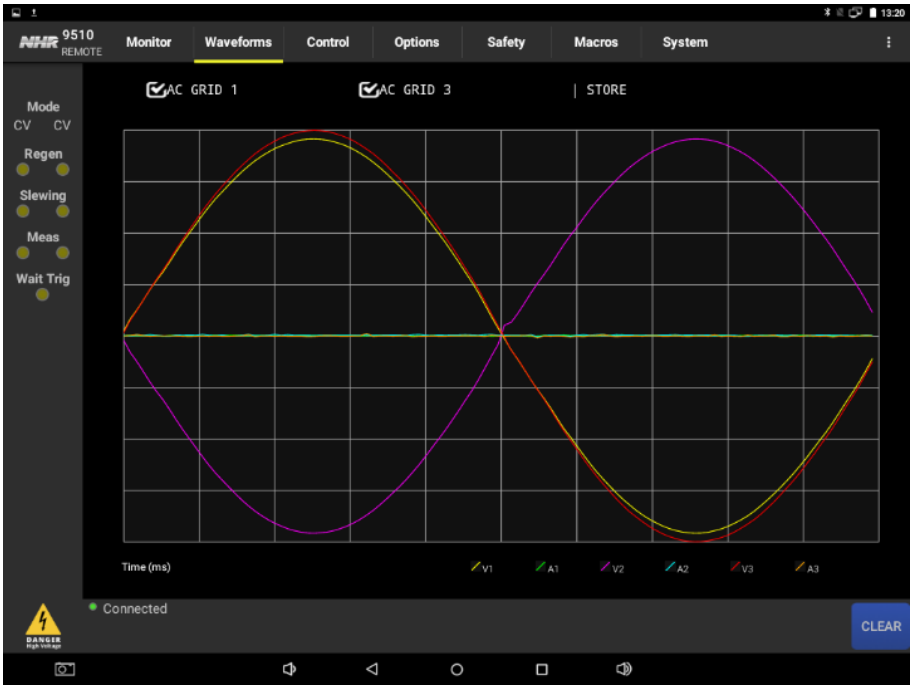


Waveform

The Waveform pane visualizes the voltage and current for the configured instruments. The displayed waveform synchronizes to the 0° start angle of the output and displays one cycle (AC) or 10 mS (DC).

Tap the **Waveform** tab to check the output waveform for your instruments.

Figure 50: Split Phase (2-ϕ) shown with A-Phase Using a n-Step Sine Output



Control

The Control pane enables you to update a single value of any instrument. In the single phase, updates to a single parameter, such as voltage or frequency, apply to only this phase. In the multi-phase, updates, such as returning to a balanced voltage, can apply to all phases or the specified phases.

You can use the Macros pane to adjust multiple phases simultaneously and apply changes to the settings based on timing or cycle count.

Figure 51: Control Pane for a Split Phase (2-ϕ) + 1 AC (1-ϕ) Configuration

Turning ON/Off the Output

Select or clear the checkbox above the instrument label to turn on or off the output. This checkbox is a supplement to the left indicators displayed on the screen and the active measurements below.

Figure 52: Example of an Active (ON) Channel

Figure 53: Example of an Active (OFF) Channel

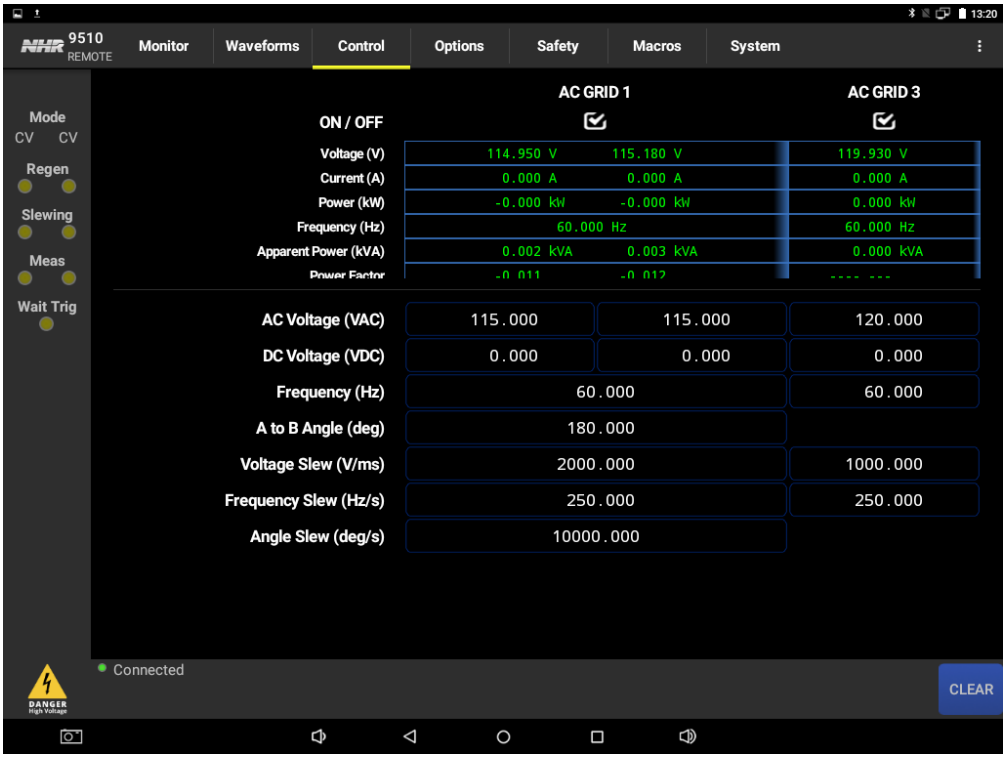
Measurements Panels

Measurements Panel

Tapping any measurements in the Measurements panel can switch between the multi-phase (line-line) and per-phase (line-neutral) views.

Figure 54: 9510 Line-Line control for AC Grid 1

Figure 55: 9510 Per Phase (L-N) control for AC Grid 1



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

The example above shows a 240 $VAC_{rms(l-l)}$ split phase in multi-phase control resulting in 240 / 2 or 120 $VAC_{rms(l-n)}$ per phase with an A to B phase angle of 180°. By comparison, the single phase channel (AC GRID 3) is programmable with its own line-neutral settings.

Refer to the *Single Phase AC and DC Outputs - Per Channel Relationships* and *Multi-Phase AC Outputs - Per Channel Relationships* sections for more information.

The touch screen integrates the Android swipe capability that enables you to view or select the entire list of measurement settings. Because the Measurements panel cannot display all the measurements on one page, you need to keep touching the screen and scroll up and down to view all the available measuring values.

Figure 56: Scrolling up for more 9510 measurements (3-ϕ shown)

Settings Panel

Settings Panel

Use the Settings panel to change the settings.

Tapping any measurements in the Settings panel can switch between the multi-phase (line-line) and per-phase (line-neutral) views.

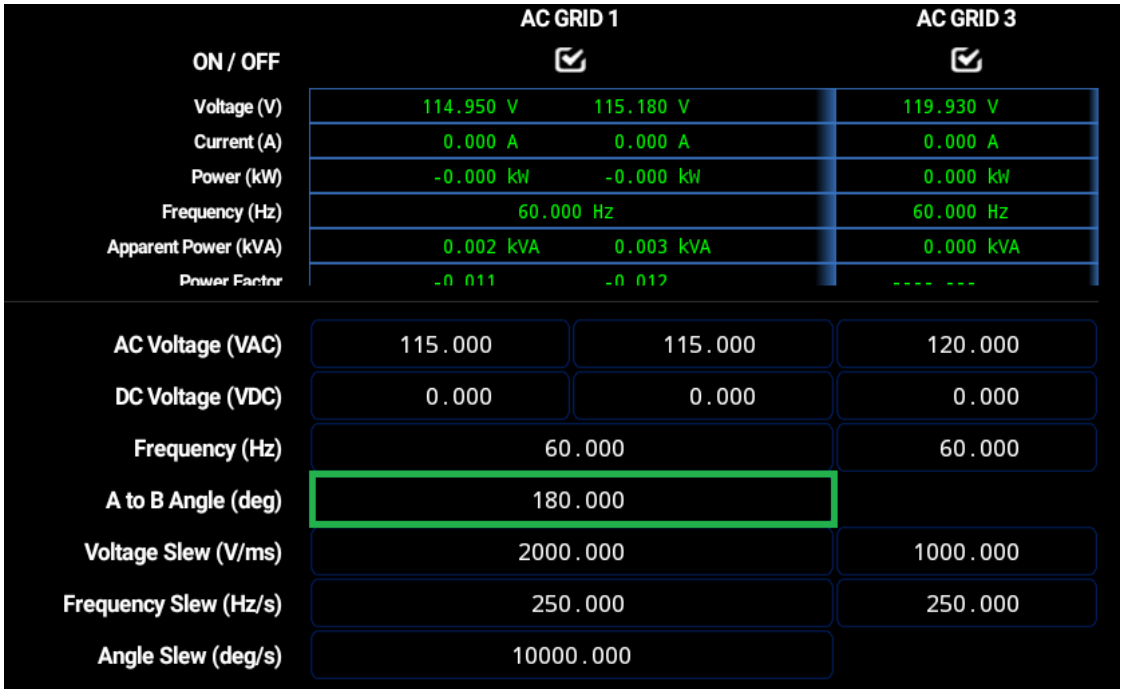
The touch screen integrates the Android swipe capability that enables you to view or select the entire list of measurement settings. Because the Settings panel cannot display all the settings on one page, you need to keep touching the screen and scroll up and down to view all the settings.

Change Output Settings

Tapping setting values to change settings. You can use the numeric keypad to directly enter a value or use the live-update feature.

NOTE
Only the settings appropriate for the hardware operating mode selected are displayed.

For example, in Split-ϕ + 1 AC the single AC channel has no phase angle relationship.

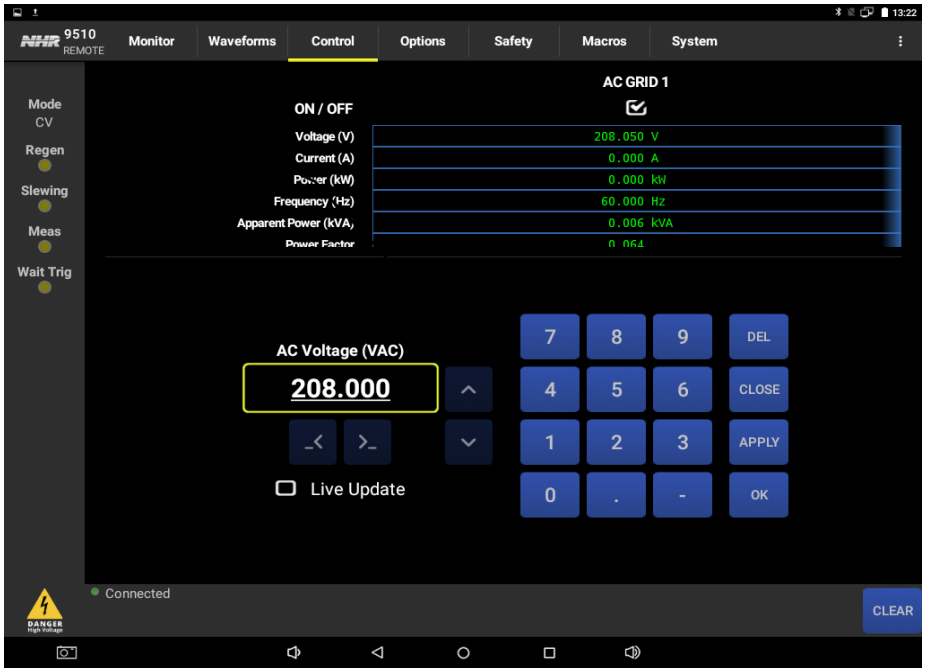


Using the Direct Value Entry

1. Tap a measurement value. For example, tap 230 to update the AC Voltage value.

NOTE
For multi-ϕ, this is line-line (voltage); for single-ϕ or per-ϕ, this is line-neutral.

2. Enter the value using numeric keypad.



- DEL – Deletes the last number entered.
- CLOSE – Closes the numeric keypad without applying any changes.
- APPLY – Applies changes and keep the numeric keypad open.
- OK – Applies changes and close the numeric keypad.

NOTE
Switch between the multi-phase and per-phase views before updating the settings. Refer to the *Measurements Panels* and *Settings Panel* sections for more information about switching control from line-line to line-neutral.

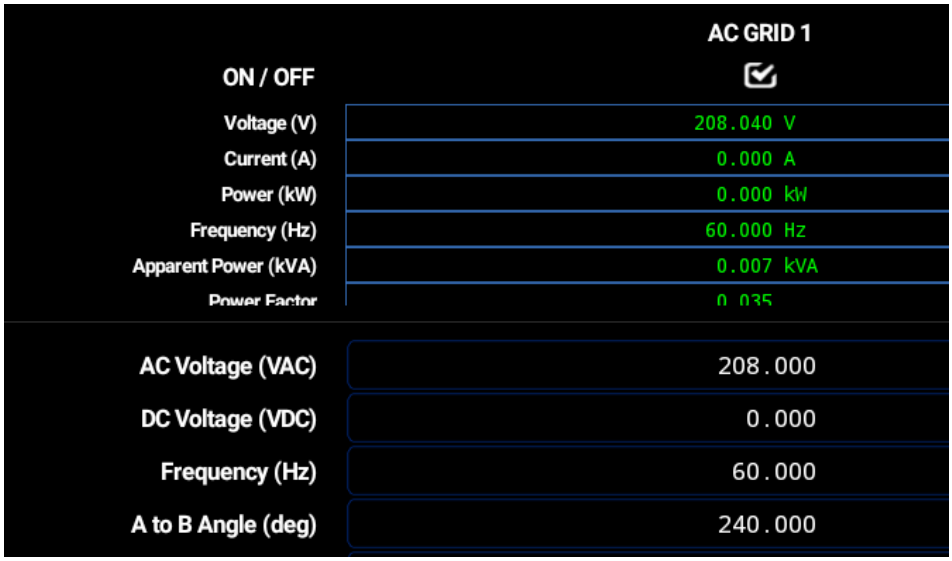
NOTE
Always enter the single-phase and per-phase view settings as line-neutral.

Multi-phase settings, such as the voltage setting, are generally entered as line-line. Refer to the *Single Phase AC and DC Outputs - Per Channel Relationships* and *Multi-Phase AC Outputs - Per Channel Relationships* sections for more information.

Using the Live-Update Feature

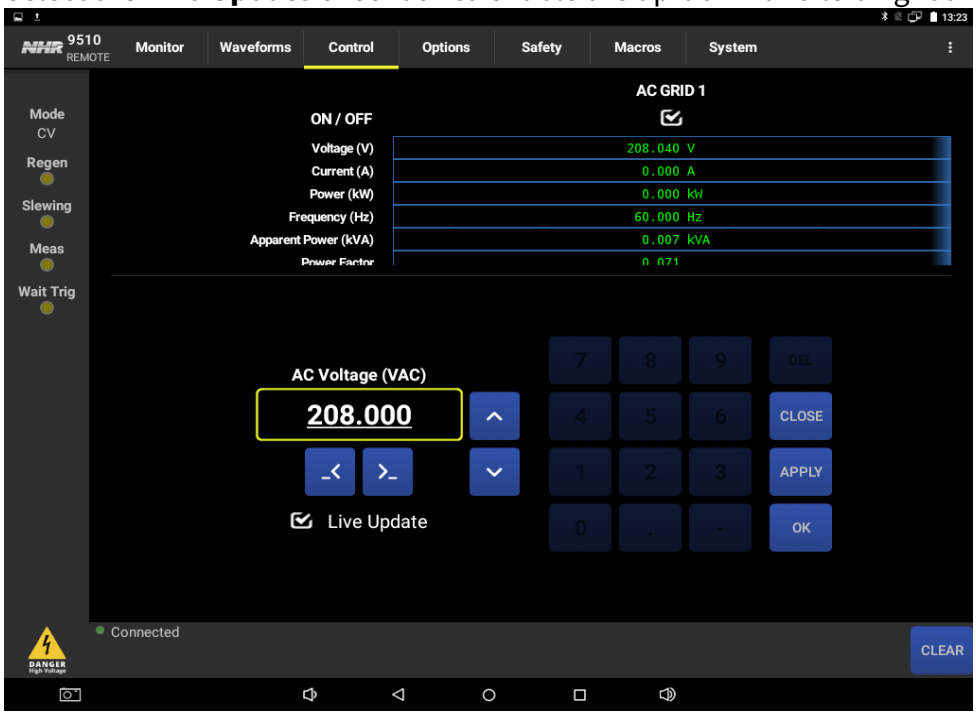
The NHR 9500 Panel allows the live update function.

1. Tap the measurement value. For example, tap 208 to update the AC Voltage value.



NOTE
For multi-ϕ, this is line-line (voltage); for single-ϕ or per-ϕ, this is line-neutral.

2. Select the **Live Update** checkbox to enable the up-down and left-right arrow buttons.

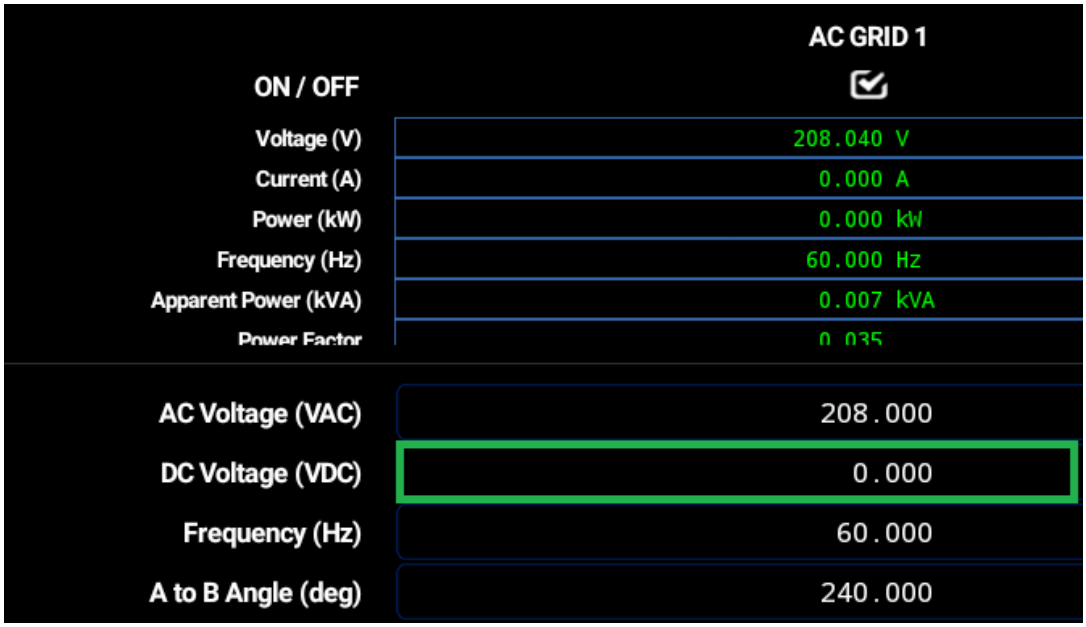


3. Use the left and right arrow buttons to select the digit to update.
4. Use the up and down arrow buttons to increase or decrease the selected digit.

NOTE
Each increase or decrease of value is sent to the hardware.

Adjusting Output DC Offset

The 9510-100 supports both AC and DC Mode. The peak voltage cannot exceed the maximum value, which is $\sqrt{2} * VAC\ RMS\ Peak$.



Options

The Options pane provides settings which allow one or more fixed values rather than user-specified values in the Control pane. This pane operates in a similar way to the Control pane except that the Options pane provides a menu choice for a selected value rather than a value entry.

You can also change all of the settings on the Macros pane.

Figure 57: Options Screen for 9510 in split phase (2-ϕ) + 1 AC (1-ϕ) Configuration

Turning the Output On/Off

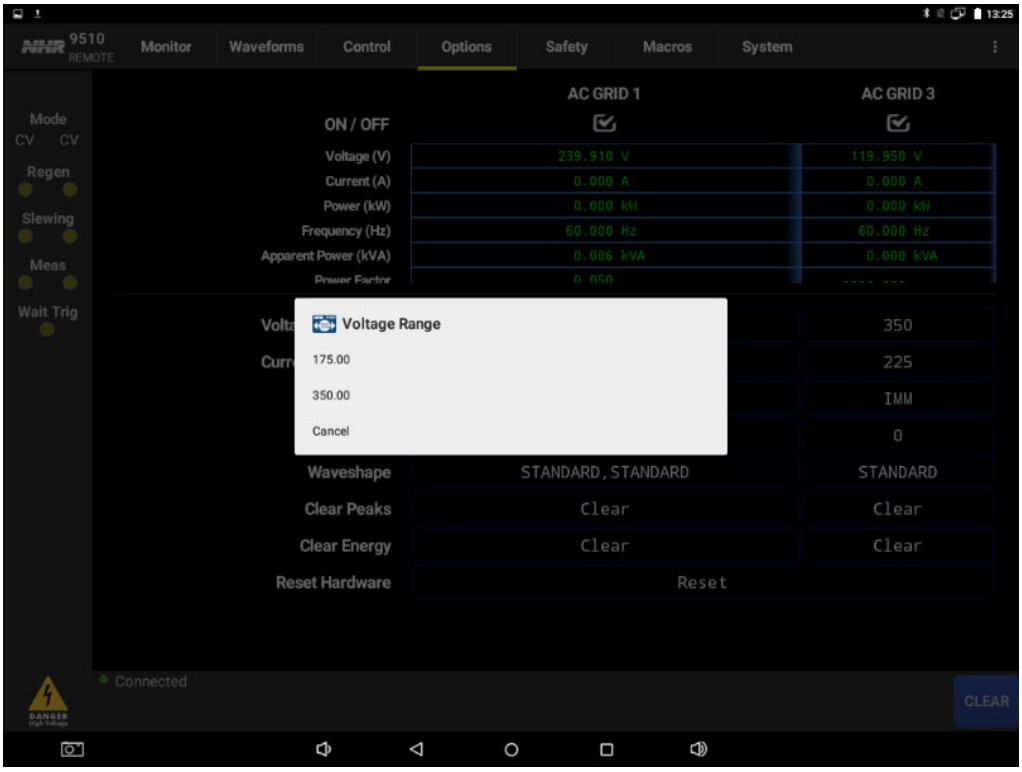
Select or clear the checkbox above the instrument label to turn on or off the output. This checkbox is a supplement to the left indicators displayed on the screen and the active measurements below.

Figure 58: Example of an Active (ON) Channel

Figure 59: Example of an Inactive (OFF) Channel

Adjusting Output Options

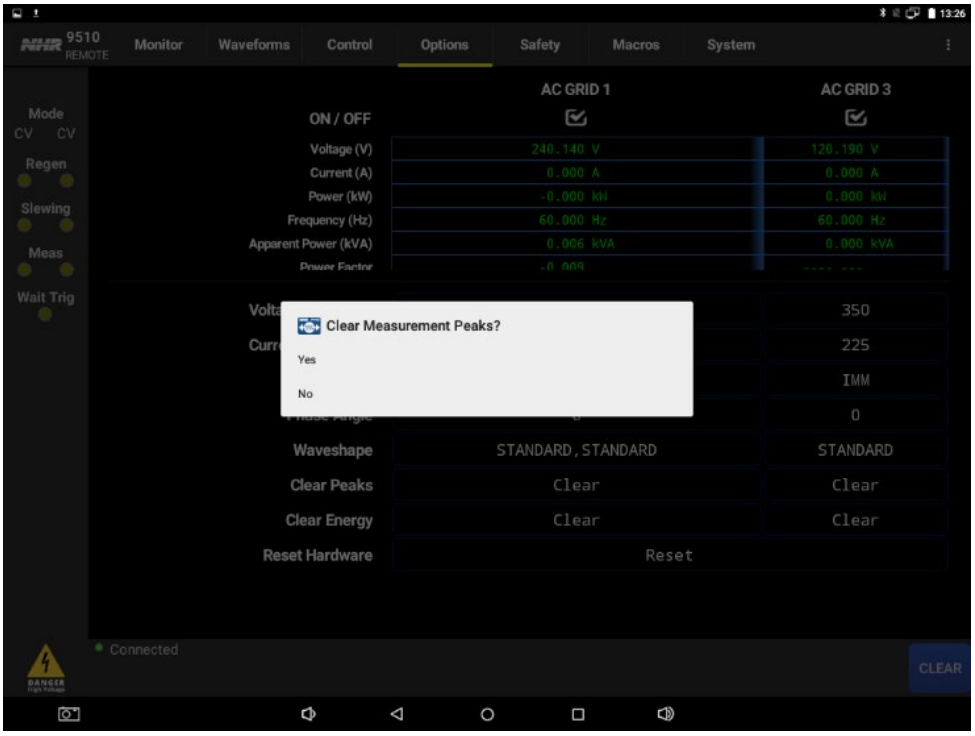
Tapping the measurements opens a pop-up window to change the value from the value options.



NOTE
Voltage Range is always displayed as line-line for multi-ϕ instruments and line-neutral for single-ϕ instruments. The Options pane allows switching between multi-ϕ and per-ϕ views, which enables you to apply a user-wave shape to an individual phase.

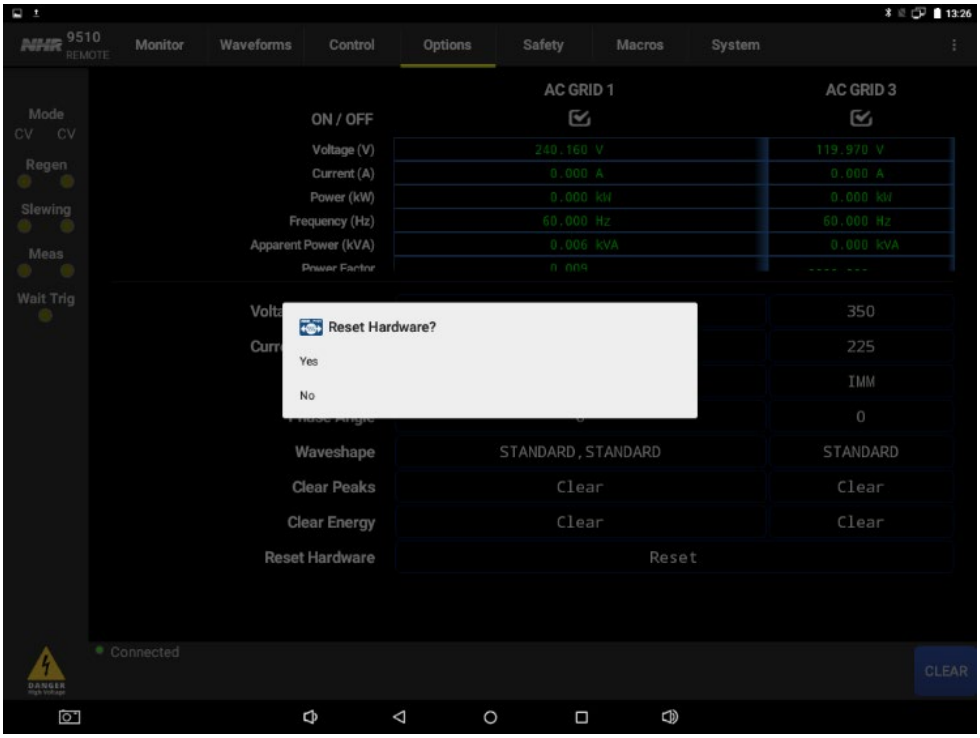
Clearing Accumulated Measurements

Tap **Clear** to clear accumulated measurements, including peak voltage, current, power, and energy. After tapping **Clear**, a dialog box prompts you for confirmation before clearing the measurements.



Resetting Hardware

Tapping **Reset** to reset the hardware. After tapping **Reset**, a dialog box prompts you for confirmation before resetting the hardware.



Resetting hardware turns off all outputs, returns the system to a power-on state, reverts all wave shapes to the pre-programmed wave shapes, and sets ranges and settings to the default.

Safety limits are preserved during reset. NI recommends that before turning on the output again, ensure the system is fully prepared, including ranges, safety limits, and operating modes.

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

ATTENTION
Toujours supposer que la tension est présente à la sortie, même après une réinitialisation du matériel.

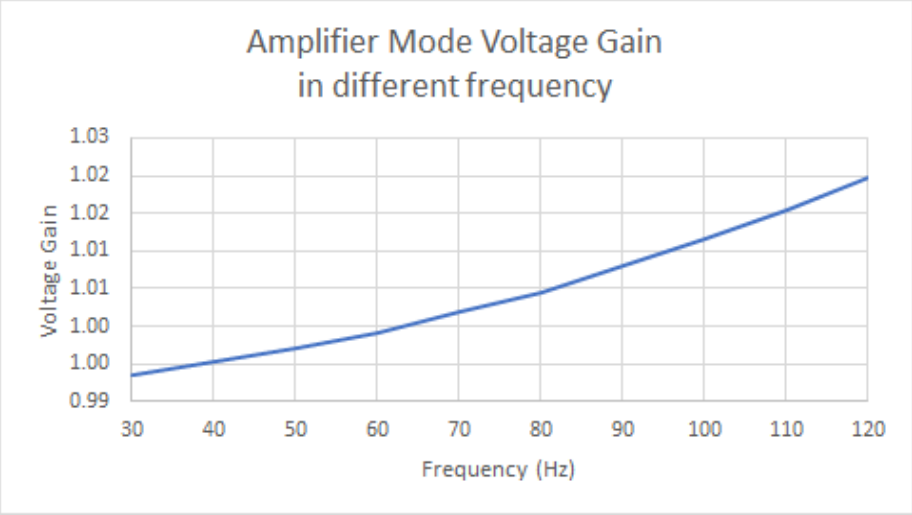
Analog Follower in PHIL Testing

The 9510-100 is externally controllable via a low latency, per-phase analog input. This feature amplifies control signals from real-time simulation systems for power hardware in the loop (PHIL) testing. The dual range output ensures the maximum flexibility and accuracy in PHIL simulations.

Each 9510 channel has an analog input signal with ±10 V PK-PK. You can choose the output to follow the analog input. The analog input programs for the output voltage, ±10 V PK-PK representing ±247.5 V PK-PK ($\sqrt{2} \times V_{rms\_Range\_Max}$) for low range and ±495 V PK-PK ($\sqrt{2} \times V_{rms\_Range\_Max}$) for high range.

Table 11: Analog Follower Control Bandwidth and Latency

Analog input control bandwidth	30 Hz to 120 Hz
Latency	50 µs



Analog Follower Measurement

The measurement circuit measures and tries to phase lock the output frequency. All the measurement and waveform captured by the control panel are still valid. However, the fundamental frequency of the analog input should be within the range from 30 Hz to 120 Hz to ensure the frequency tracking (phase lock loop) is working. If the fundamental frequency is outside of the range, the analog follower still works but the measurement may not work. The higher harmonics is not limited within the range from 30 Hz to 120 Hz.

Analog Follower Limitation

The maximum harmonic frequency analog input is 1 kHz. Harmonic frequency higher than the maximum can cause oscillation due to the internal filter circuitry. In that case, the NHR system turns off the output to protect itself.

The harmonic frequency and amplitude must conform to the following rules. Otherwise, the system turns off the output and protects itself:

$$A_1 \times f_1 + A_2 \times f_2 + \cdots + A_n \times f_n \leq 62000$$

Where:

$A_1 \ldots A_n$ is the amplitude of each frequency component, including fundamental.

$F_1 \ldots f_n$ is the frequency of each component, including fundamental.

For example, if a waveform has the fundamental of 60 Hz and 350 V, and has a harmonic of 50 V and 500 Hz, the waveform works because

$$350 \times 60 + 50 \times 500 = 46000 < 62000$$

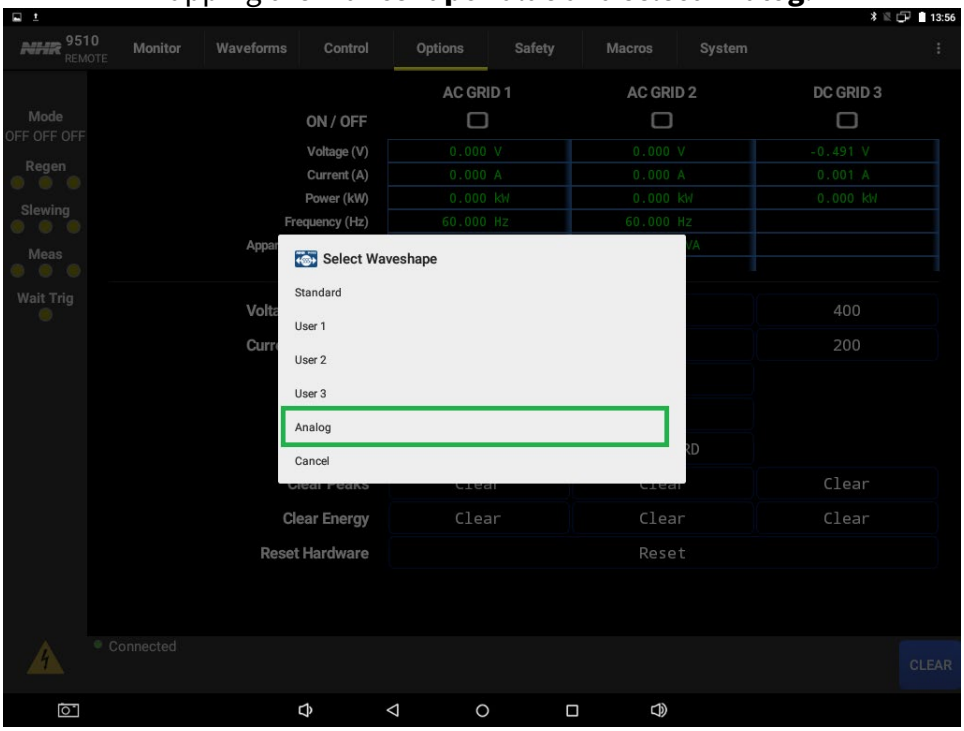
However, if the fundamental frequency is updated to 120 Hz, the system turns off the output to protect itself because:

$$350 \times 120 + 50 \times 500 = 67000 > 62000$$

Pin No.	Definition
1	GND
2	VMON CH1
3	VMON CH2
4	VMON CH3
5	IMON CH1
6	IMON CH2
7	IMON CH3
8	GND
9	ANALOG IN1
10	ANALOG IN2
11	ANALOG IN3
12	SPARE TP1

13	SPARE TP2
14	SPARE TP3
15	GND

Tapping the **Waveshape** value and select **Analog**.



Safety Trip

The touch screen provides programmable trip limits to limit UUT damage due to operator errors. Similar to a programmable fuse, trip limits command the system to disable and disconnect from the UUT when the programmed level exceeds the time specified. The setting value should be greater than the expected nominal value so that the trip process is faster when the actual value exceeds the threshold.

NOTE
Trip limits are sent to the hardware when another screen tab is selected. You can make changes on one pane and then select another pane for safety trip.

CAUTION
Changing hardware operating modes disables all trip limit values. Ensure safety limits are implemented before turning on the output.

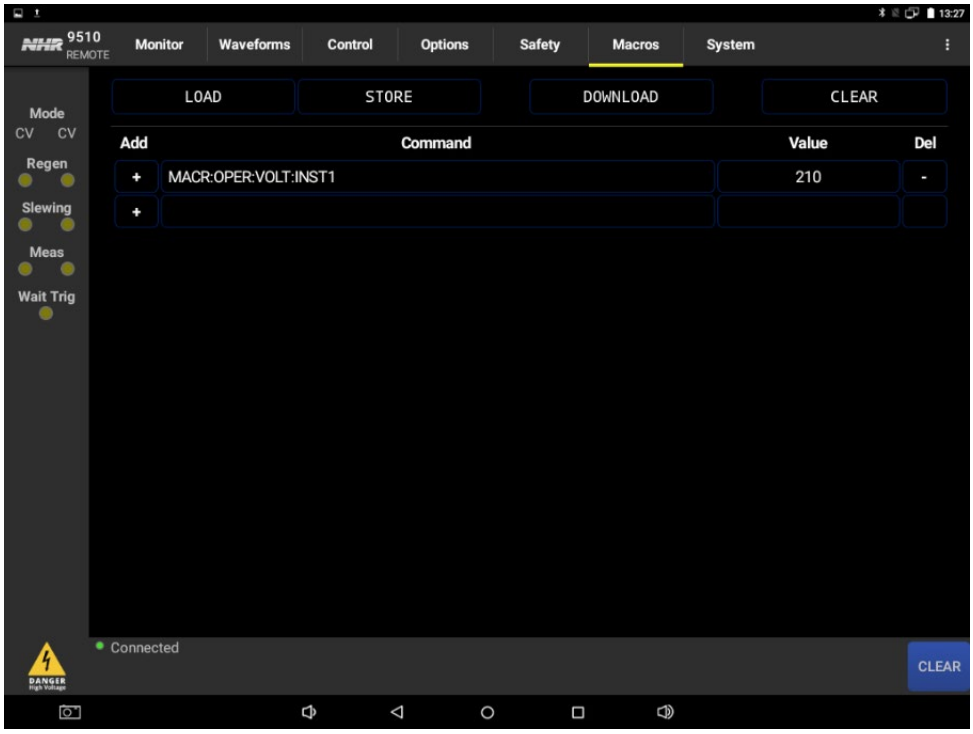
ATTENTION
Une modification du mode de fonctionnement du matériel désactive toutes les valeurs des limites de mise en sécurité. S’assurer que les limites de sécurité sont mises en œuvre avant d'activer la sortie.

The touch screen integrates the Android swipe capability that enables you to view the entire list of the settings. Because the Safety pane cannot display all the settings on one page, you need to keep touching the screen and scroll up and down to view all the available settings.

Figure 60: Scrolling for more settings (9510 Split-ϕ + 1AC)

Macros

Macros are pre-programed sequences which are 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.



- LOAD – Retrieves a previously generated and stored Macro file.
- STORE – Saves the current Macro file for later use.
- DOWNLOAD – Downloads the current Macro file to the hardware.
- CLEAR – Clears the settings on the Macros pane and the Macro file loaded in hardware.
- Add – Adds a new Macro step above the current step. Tap + to add a step.
- Value – Specifies the Macro step value from the value choices.
- Del – Deletes the selected Macro step. Tap - to delete the step.

Refer to the *Macros and Usage Examples* section for details.

Single Phase AC and DC Outputs - Per Channel Relationships

The 9500 may have the outputs configured to operate as either single phase AC or DC. Additionally, these modes support parallel multiple channels to create a single larger AC or DC channels. For example, a 9510-100 operating as a 100kW 3-phase grid simulator would use three channels. These settings also apply to per-phase settings for multi-phase outputs where the channel count is always equal to 1.

Table 12: Set and Measurements Relationship: DC and AC (1-ϕ and per-ϕ)

Parameter	Set Points		Measurements
	Set Value	Get Value	Get Value
Voltage (V_{DC} / $V_{RMS\ L\text{-}N}$)	SET	$SET_{(CH1)}$	$MEAS_{(CH1)}$
Apparent Power (kVA)	N/A	N/A	$V_{meas} \cdot I_{meas}$
Crest Factor	N/A	N/A	N/A
Power Factor	N/A	N/A	$\frac{Power_{meas}}{Apparent\ Power_{meas}}$
Voltage-Peak [1] Current-Peak [1]	Same as VSET Same as ISET	Programmed Value	N/A

[1] Instantaneous set values used in safety settings as AC Line-Neutral value or DC.

Table 13: Slew Rates: DC or AC Single-Phase Only

Parameter	Set Value Per Channel (Set_{ch})	Get Value
Voltage (V/s)	$SLEW$	$SLEW_{(CH1)}$
Frequency (Hz/s)	$SLEW$	$SLEW$

NOTE
Slew rates are set at a per instrument level. For multi-phase outputs, refer to the *Multi-Phase AC Outputs - Per Channel Relationships* section for more information.

Multi-Phase AC Outputs - Per Channel Relationships

The 9500 may have the outputs configured to operate as either 3-phase or split-phase output with an additional single phase AC or DC channel. You can use this mode to set or measure the output of the multiple phases in a single step.

Table 14: Set & Measurements Relationships: Multi-Phase

Parameter	Set Points		Measurements
	Set Value (Per ϕ)	Get Value	Get Value
Voltage 2-ϕ ($V_{RMS\ L\text{-}L}$)	$\frac{1}{2} \cdot SET$	$\sum SET_{\varphi}$	$\sum MEAS_{\varphi}$
Voltage 3-ϕ ($V_{RMS\ L\text{-}L}$)	$\frac{1}{\sqrt{3}} \cdot SET$	$\sqrt{3} \cdot \frac{\sum SET_{(\varphi)}}{3}$	$\sqrt{3} \cdot \frac{\sum MEAS_{(\varphi)}}{3}$
Power (kW) [1]	$\frac{1}{\#_{\varphi}} \cdot SET$	$\sum SET_{(\varphi)}$	$\sum P_{mease(\varphi)}$
Apparent Power (kVA)	N/A	N/A	$\sum (V_{meas(\varphi)} \cdot I_{meas(\varphi)})$
Crest Factor	N/A	N/A	$MAX\left(\frac{I_{PEAK(\varphi)}}{I_{RMS(\varphi)}}\right)$

Power Factor	N/A	N/A	$\frac{Power_{meas}}{Apparent\ Power_{meas}}$
Voltage-Peak 2-ϕ [1] Voltage-Peak 3-ϕ [1]	Same as VSET	Programmed Value	N/A
Current-Peak [1]	Same as ISET	Programmed Value	N/A

[1] Instantaneous set value used in safety settings as AC Line-Neutral value or DC.

Table 15: Slew Rates: Multi-Phase

Parameter	Slew (Per ϕ)	Get Value
Voltage 2-ϕ ($V_{RMS\ L\text{-}L}$/s)	$\frac{1}{2} \cdot SLEW$	$2 \cdot SLEW_{(CH1)}$
Voltage 3-ϕ ($V_{RMS\ L\text{-}L}$/s)	$\frac{1}{\sqrt{3}} \cdot SLEW$	$\sqrt{3} \cdot SLEW_{(CH1)}$
Frequency (Hz/s)	$SLEW$	$SLEW$

Taking Screenshots

It's possible to take screenshots and save them to the USB drive. Insert USB thumb drive into the unit's USB slot.

After a few seconds, the Screenshot button will appear at the bottom right corner of the screen:

Each time you press this button, a new screenshot is taken and saved on to USB drive at the following location: NHR9500/Screenshots. The screenshot files are named Screenshot_Date_Time.png.

NHR 9500 Panel

NI provides the NHR 9500 Panel, a PC-based tool, along with each 9510 system for manual control of the hardware. Alternatively, the 9510-100 system can be controlled through communications terminals, such as HyperTerminal, using SCPI commands, or through any software package that is able to issue SCPI commands, VXI-11, or LabVIEW VIs.

Find the provided utilities and documentation using the following methods.

Windows 7	Start → All Programs → NH Research → 9500 Series
Windows 10	• Start → All Programs → NH Research

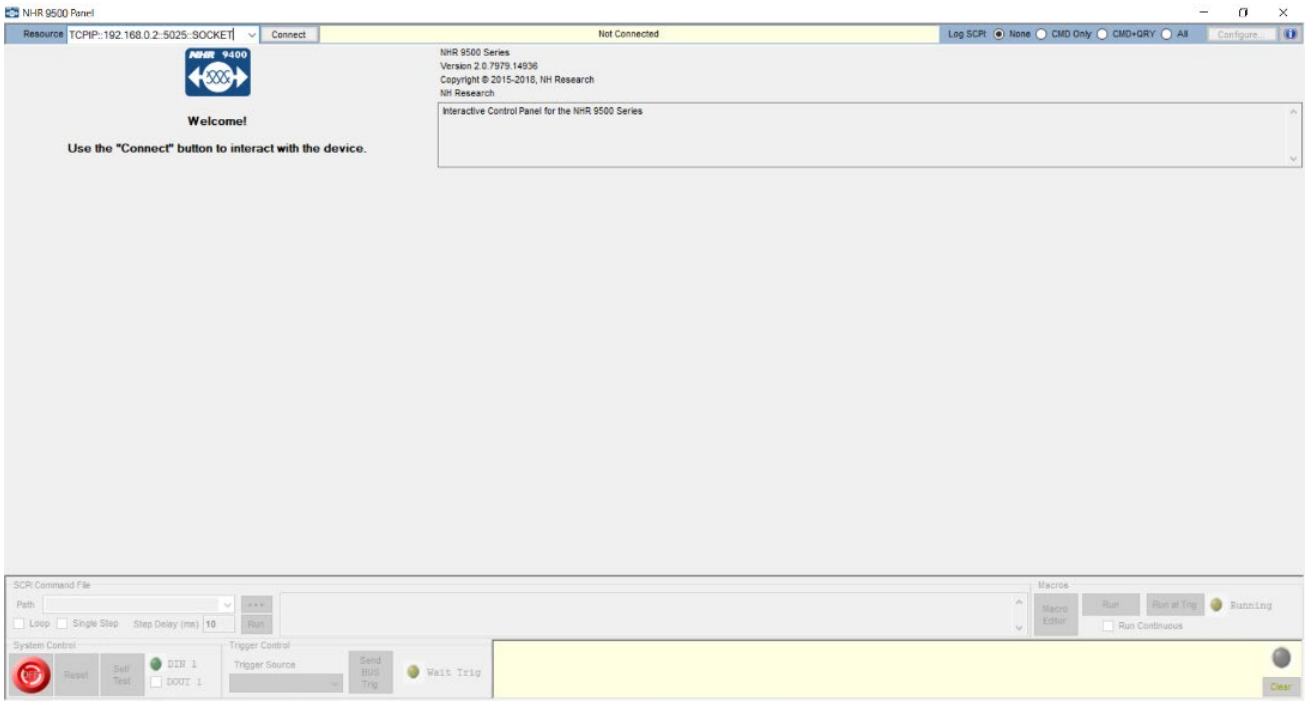
- C:\Program Files (x86)\NH Research\NHR 9500 Utilities\

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

Launching the NHR 9500 Panel

Launch the NHR 9500 Panel using the following method.

Windows 7	Start → All Programs → NH Research → 9500 Series
Windows 10	Start → All Programs → NH Research



Connecting the NHR 9500 Panel to System

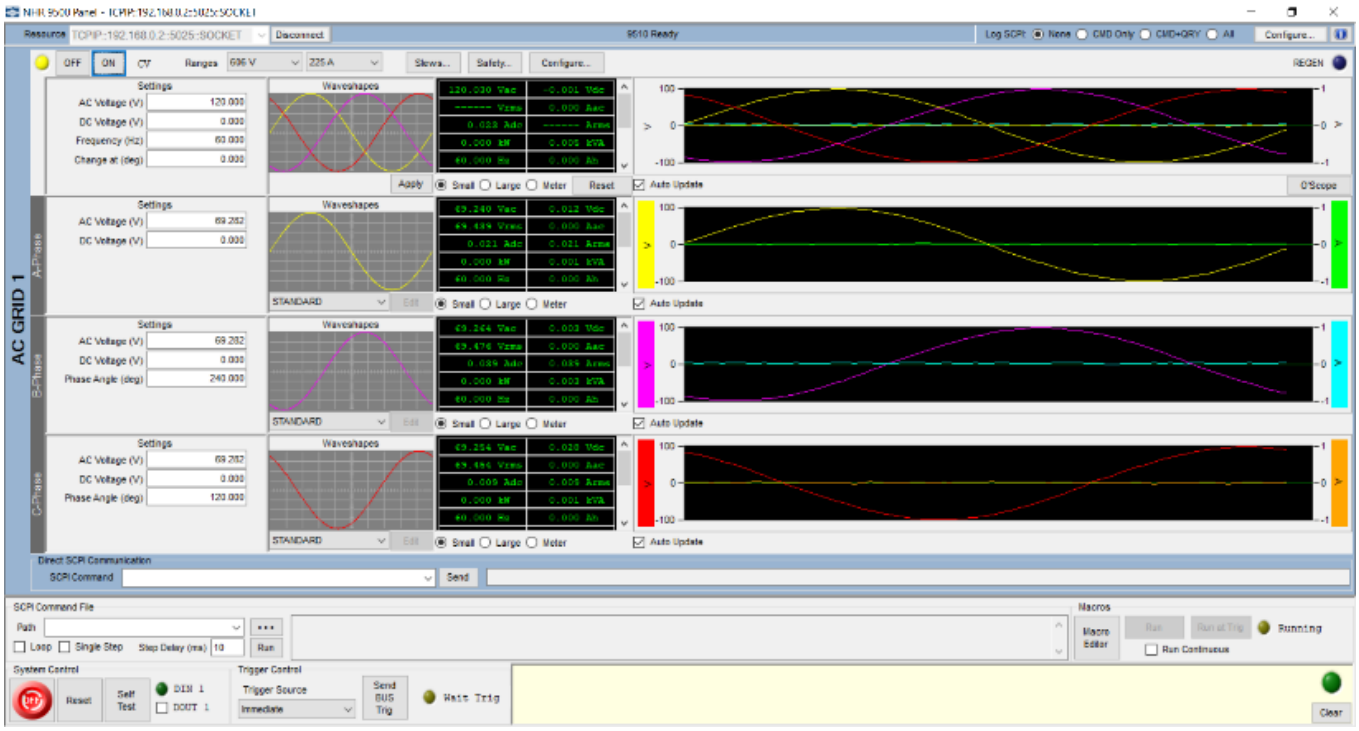
The NHR 9500 Panel requires the IP address to connect to the system. Find the IP address on a label on the rear of the system and you can change the IP address by following *Configuring the Master Module* in the *Installation* section.

0. Enter the IP address in the following form: TCPIP::(*IP_ADDRESS*)::5025::SOCKET
1. Press **Connect**.

The NHR 9500 Panel connects to the system and then displays the active hardware operating mode and active settings.

NOTE
Connection to the software does not reset the hardware.

Figure 61: NHR 9500 Panel Connected to NHR 9510 Model in 3-ϕ Mode

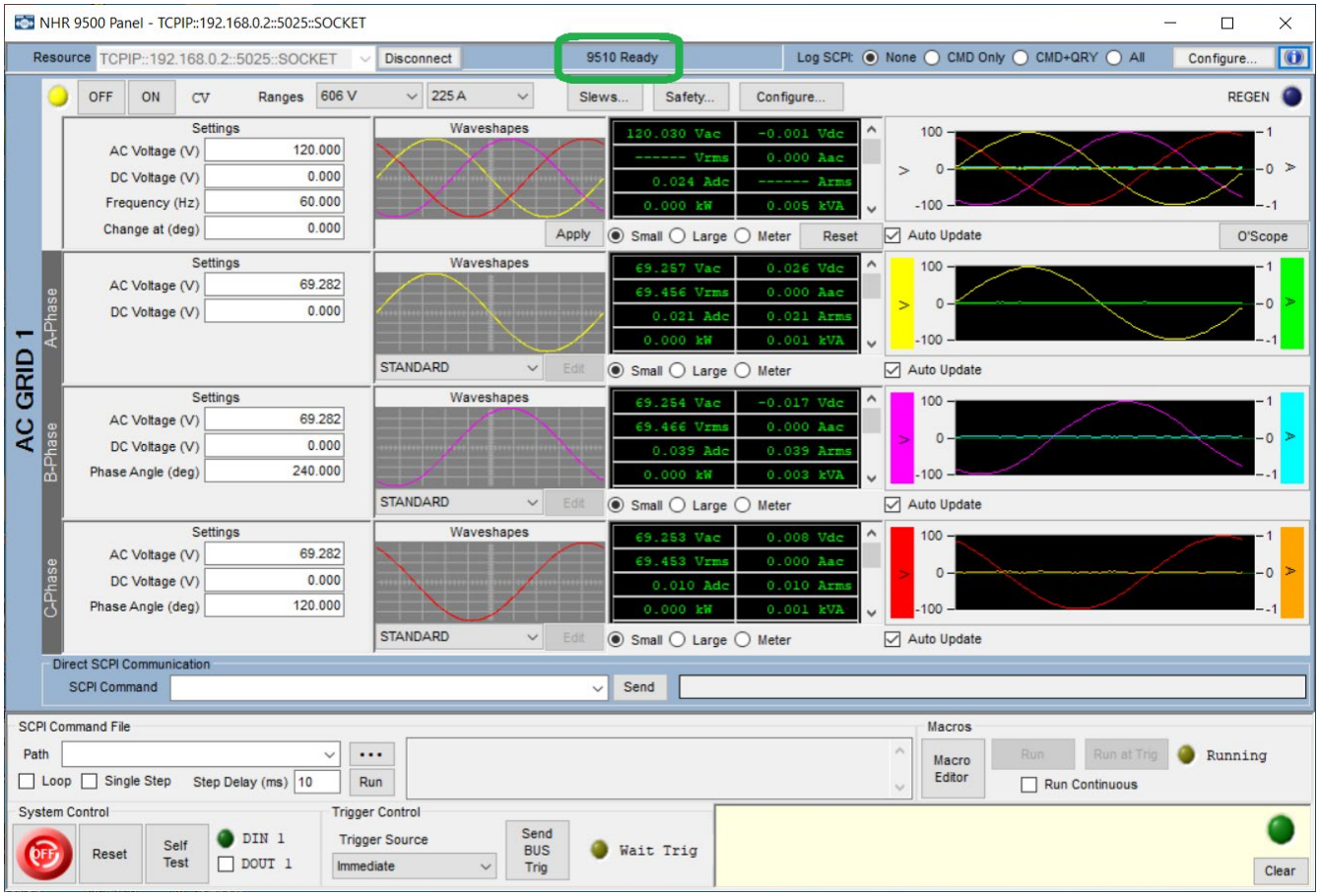


System-Level Controls

The NHR 9500 Panel includes a number of controls that apply to all instruments in a system.

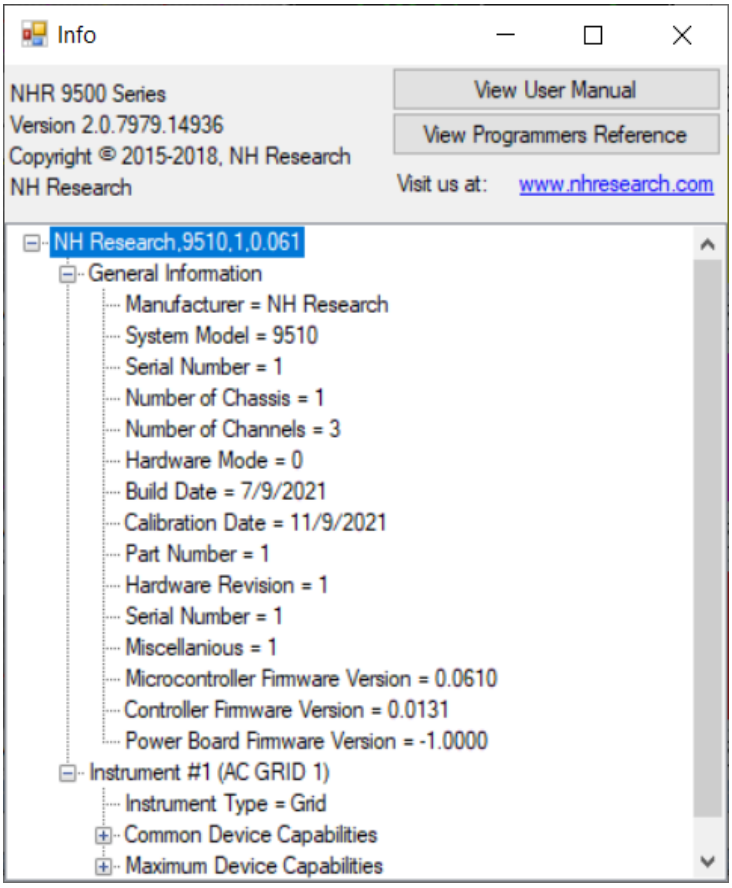
System Identification

After the system is connected to the NHR 9500 Panel, the model number and the maximum power level for the system display in the toolbar on the top.
Contact NI if the system model and the power level is not correct.



System Information

Click **Information** () on the upper right corner to view the system information. The Info window displays information about the system and instruments as the following screenshot shows.



Changing the Hardware Configuration

Changing the output hardware configuration affects the entire system.

CAUTION
Changing the operating mode typically requires changes in the output connections to the UUT.
Previously established safety limits are also cleared.
Read this section completely before proceeding.

ATTENTION
Une modification du mode de fonctionnement nécessite généralement de modifier les connexions de sortie vers l'appareil sous test.
Lire entièrement cette section avant de continuer.
Les limites de sécurité précédemment établies sont également effacées.

CAUTION

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

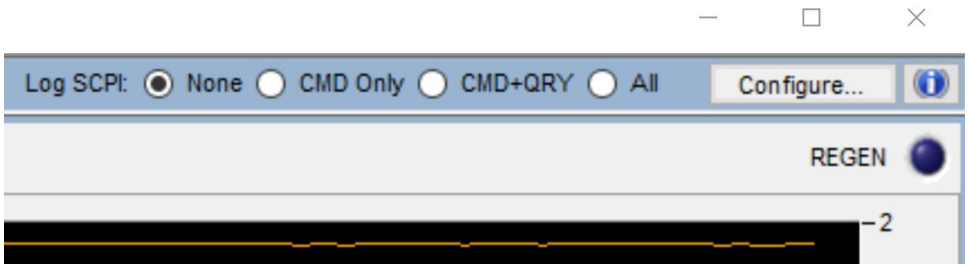
ATTENTION
Le câblage et la configuration doivent toujours être effectués lorsque la sortie est dans l'état OFF et qu'aucune alimentation externe n'est appliquée à l'appareil sous test.

The 9510-100 provides a total number of 13 hardware configurations to simplify programming and user experience.

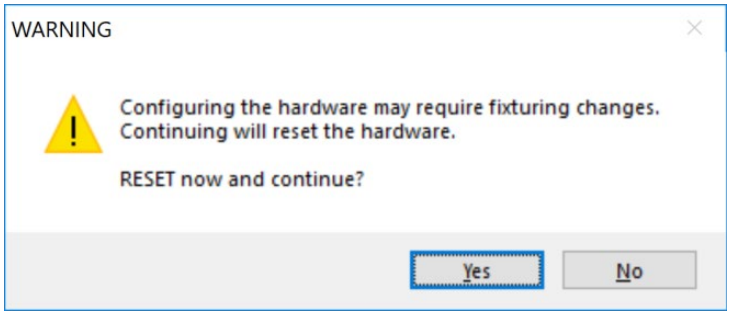
NOTE
Review this section completely along with wiring changes before proceeding.

Complete the following steps to configure the hardware configuration:

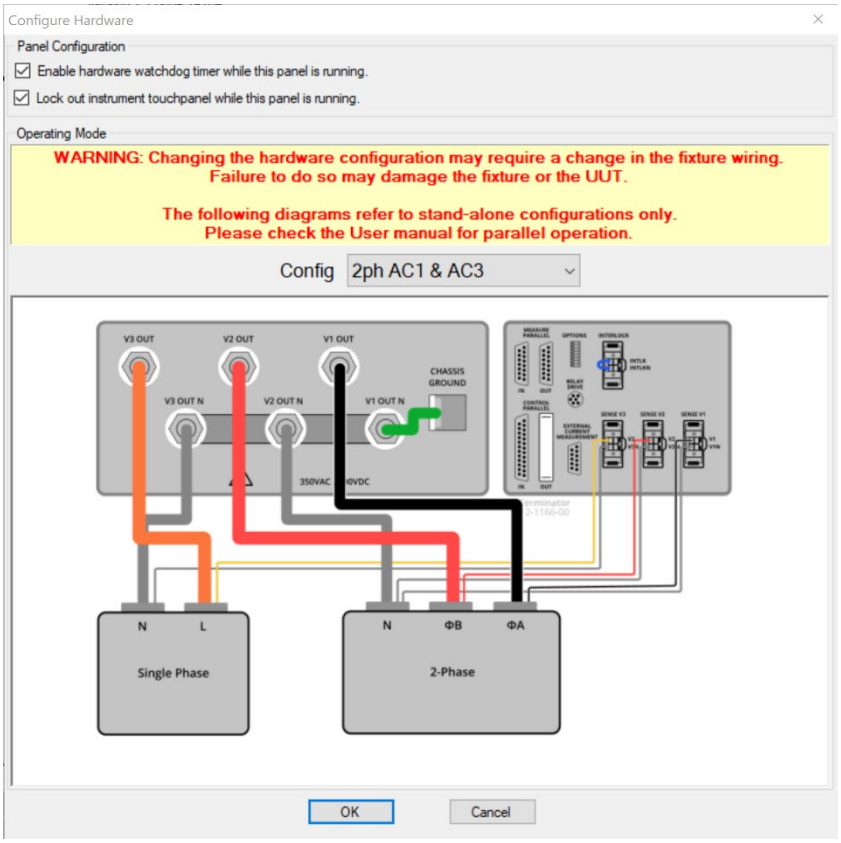
1. Click **Configure** on the top right corner of the NHR 9500 Panel.



2. When prompted, click **Yes** in the dialog to execute a software reset.



3. In the following dialog, click the **Config** drop-down arrow to view the complete list of the hardware configurations and select the configuration based on your needs, and then click **OK**.

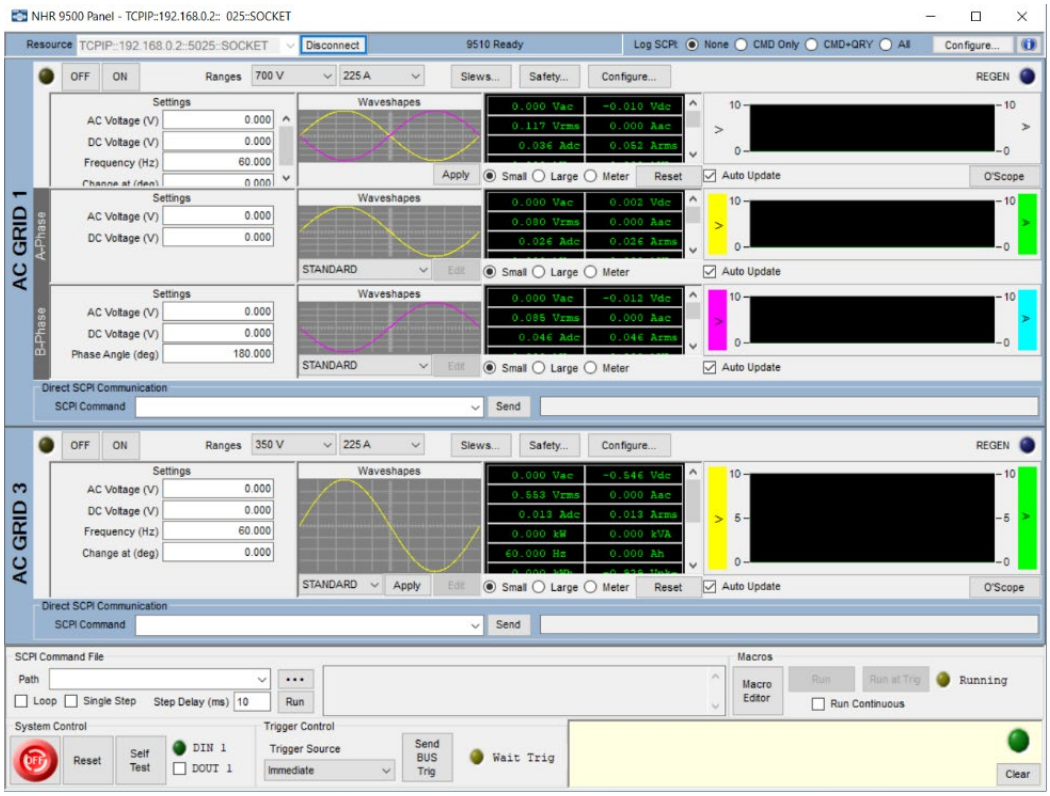


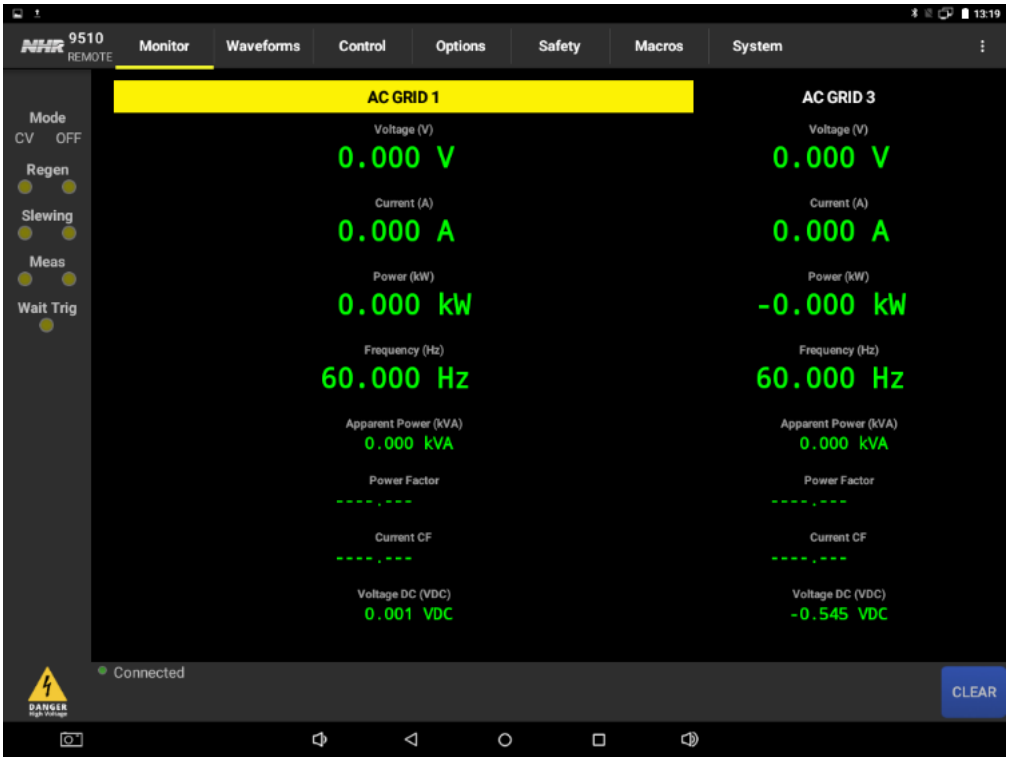
Then the NHR 9500 Panel goes back to the normal operation with selected hardware configuration.

CAUTION
Changes to the new hardware configuration disables any previously established settings including safety limits and may require output wiring changes.

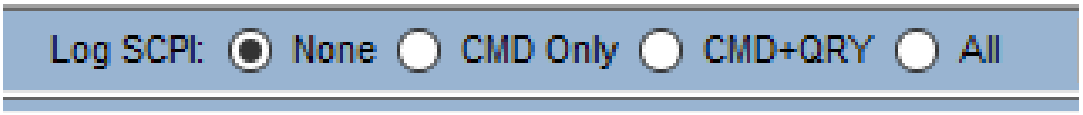
ATTENTION
Les modifications apportées à la nouvelle configuration du matériel désactivent tous les paramètres précédemment établis, y compris les limites de sécurité, et peuvent nécessiter des modifications du câblage des sorties.

When the new hardware configuration applies to the hardware. Both the NHR 9500 Panel and the system touch screen automatically adjusts the views to the new hardware configuration.


NHR 9500 Panel - TCPIP::192.168.0.2:: 025::SOCKET
Resource
TCPIP::192.168.0.2::5025::SOCKET
Disconnect
9510 Ready
Log SCPI
None
CMD Only
CMD+QRY
All
Configure...
AC GRID 1
A-Phase
B-Phase
OFF
ON
Ranges
700 V
225 A
Slews...
Safety...
REGEN
Settings
AC Voltage (V)
DC Voltage (V)
Frequency (Hz)
Phase Angle (deg)
Waveshapes
Apply
Small
Large
Meter
Reset
Auto Update
O'Scope
STANDARD
Edit
Direct SCPI Communication
SCPI Command
Send
AC GRID 3
350 V
Change at (deg)
SCPI Command File
Path
Loop
Single Step
Step Delay (ms)
Run
Macros
Macro Editor
Run
Run at Trig
Running
Run Continuous
System Control
Reset
Self Test
DIN 1
DOUT 1
Trigger Control
Trigger Source
Immediate
Send BUS Trig
Wait Trig
Clear


13:19
NHR 9510 REMOTE
Monitor
Waveforms
Control
Options
Safety
Macros
System
Mode
CV OFF
Regen
Slewing
Meas
Wait Trig
AC GRID 1
AC GRID 3
Voltage (V)
0.000 V
Current (A)
0.000 A
Power (kW)
0.000 kW
-0.000 kW
Frequency (Hz)
60.000 Hz
Apparent Power (kVA)
0.000 kVA
Power Factor
----.---
Current CF
Voltage DC (VDC)
0.001 VDC
-0.545 VDC
Connected
DANGER
CLEAR

Logging SCPI Communication



You can record any interactions between the panel and the instrument. Select any log SCPI mode except **None**, and you are prompted for a file name used to record the interaction.

Select **None** after selecting the log SCPI mode, the file is 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. The recorded information is most compact and most useful to generate command scripts.
- CMD+QRY – Records all SCPI commands and queries but does not record the responses to queries. Select this mode if you want to see the results of queries when playing back the file.
- All – Records all SCPI commands, queries, and responses to queries.

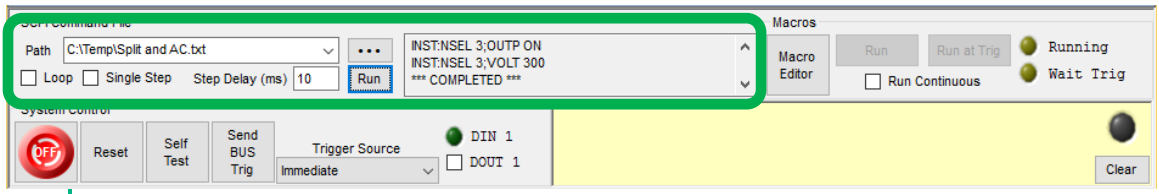
Use this feature in the following situations:

- Create a script to preset the instrument as desired. Select **CMD Only** or **CMD+QR**, and then interact with the unit using the panel. Every interaction is recorded. After complete, select **None**. In the SCPI Command File section, the file is loaded to run, and the recorded information is played back.
- Create a log to help diagnose an issue. Select **All** to record the commands and queries with the responses. After complete, select **None** and review the file with a text editor.

NOTE
You can also play back this file as a SCPI command file.

External SCPI Command File

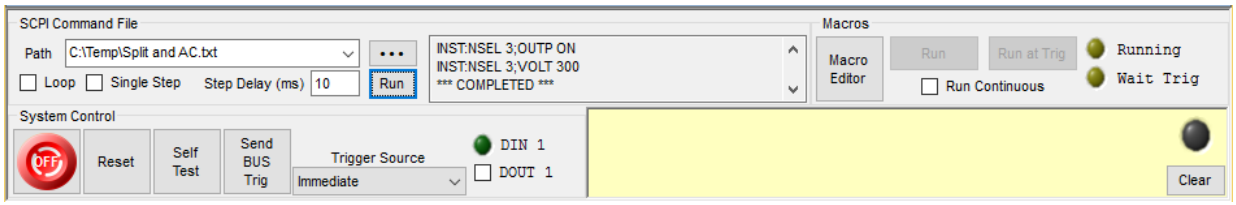
The NHR 9500 Panel allows a plain text (.txt) file containing SCPI commands to read and execute. The executed commands and query responses are recorded in the status window to the right.



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

Refer to the *NHR 9500 Series AC/DC Power Module Programmer's Reference Manual* (NH Research Part Number: 09-0363) for a list of commands appropriate for the 9510-100.

Macros

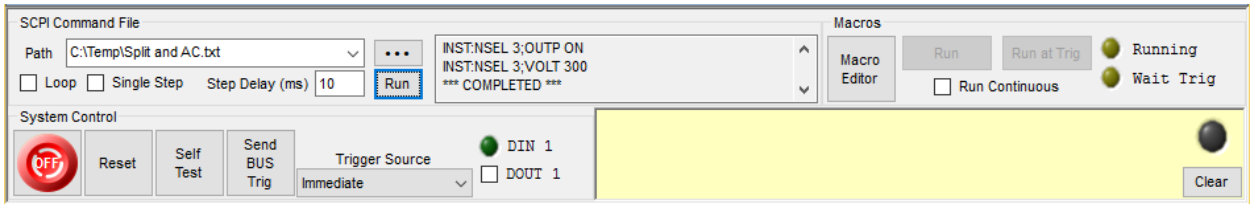


Macros are predefined sequences loaded to the hardware and executed locally. This ensures rapid fire timing and accurate cycle counting when needed.

Buttons in this section are used with Macros and the LEDs indicates the Macro operating state.

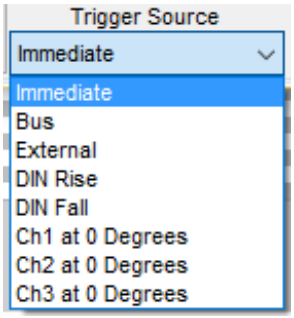
Refer to the *Macros and Usage Examples* section for details.

System Controls



The OFF button – Quickly turns off all output channels. This is different from an E-OFF output because any channel may be turned on again without requiring a reset command to be issued.

- Reset – Sends a hardware reset command to the system. All channels return to the default settings.
- Self-Test – Checks the calibration number integrity.
- Send Bus Trig – Sends the command *TRG to the system. This causes the hardware to trigger if it is waiting for the trigger source that is set to be a bus trigger.
- Trigger Source – Sets the trigger source used when starting a triggered Macro and capturing a triggered waveform. There are the following trigger source options:

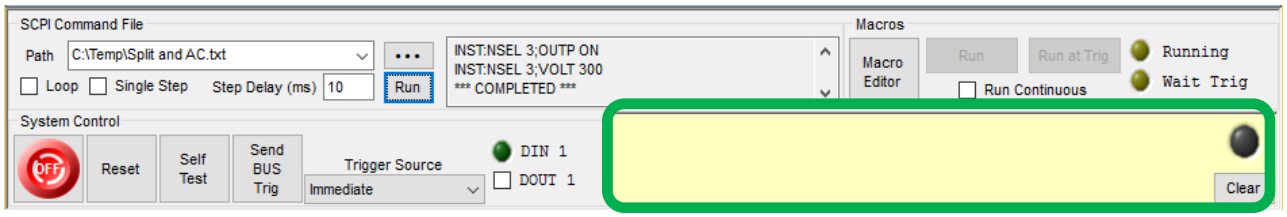


- Immediate – Triggers immediately without waiting.
- BUS – Triggers after receiving the *TRG command.
- Others are as named.

- DIN 1 – Specifies the digital input indicator.
- DOUT 1 – Specifies the digital output control.

Error Message Queue

Error message queue appears on the lower right corner. During normal operation, this section is blank. When an error is detected, the error message with the additional instructions appears in this section, and the LED becomes flashing red.



Click **Clear** to clear most error messages.

Safety trips and internal fault detections require additional user intervention, such as providing a reset after the issue is resolved.

Instrument-Level Controls

Instrument Controls and Measurements

The NHR 9500 Panel supports channel combination to an instrument.

The output channels can be configured into groups resulting in one or more virtual instruments. For example, a 9510 model with three channels can be configured as a single 3-phase, three separate 1-phases, or a split-phase with an additional AC channel.

Figure 62: 9510 3-Phase (with per phase)

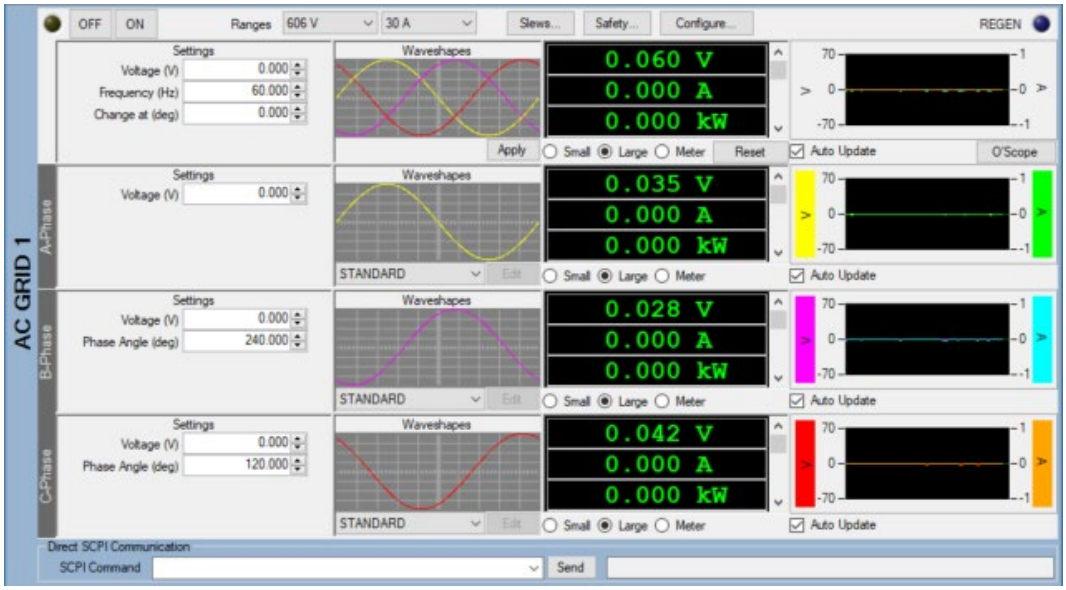
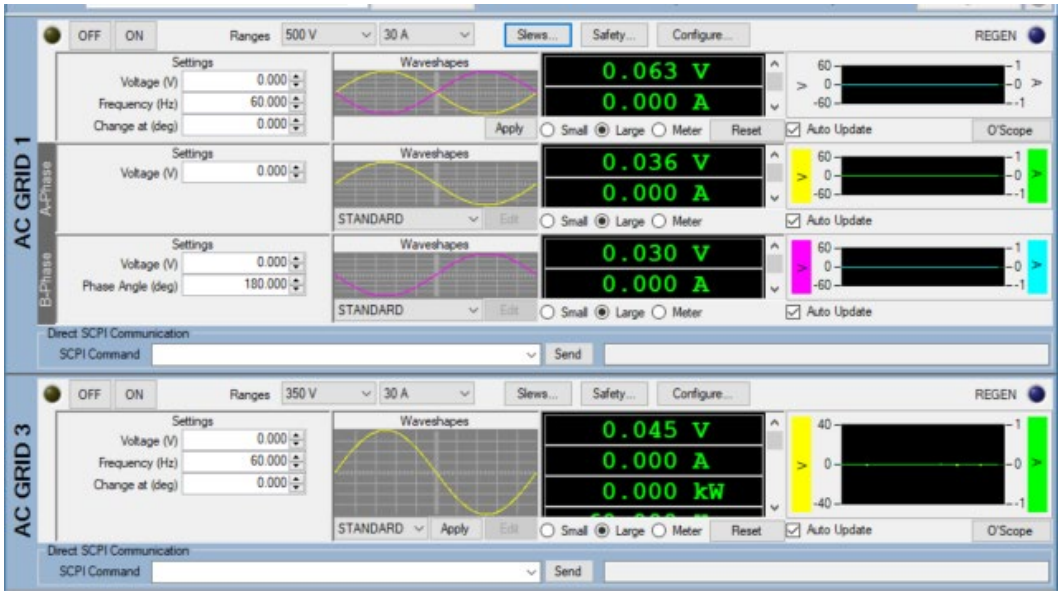


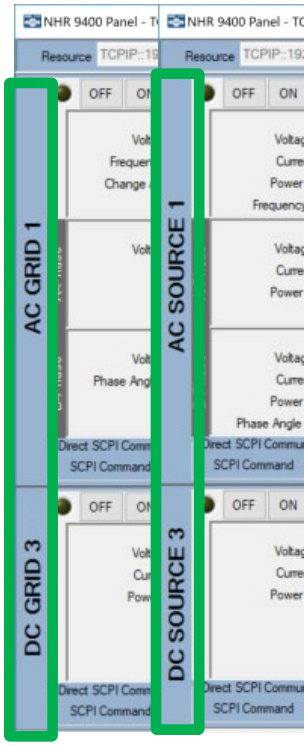
Figure 63: 9510 Three 1-Phase Channels

Figure 64: 9510 One Split-Phase Channel with One AC Channel



Instrument Labels

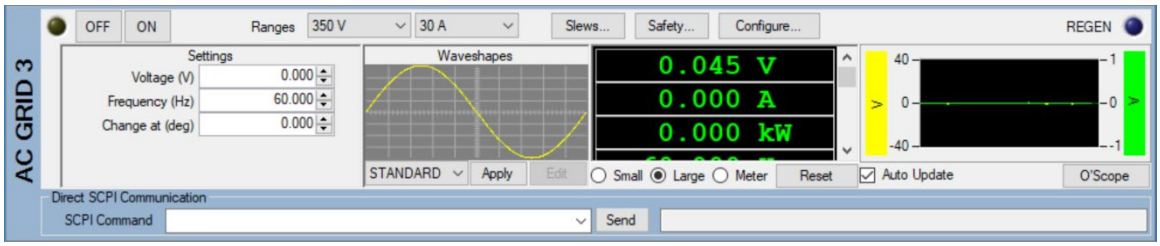
The vertical columns on the left indicates the instrument logical name or the phase name if configured as multi-phase.



Instrument Output Controls

Each instrument provides multiple controls including safety, turn on/off, command phase angle triggers, slew rates, and ranges.

Figure 65: 9510 Single-Phase Channel



- OFF/ON – Activates or deactivates the output. The output state is shown by a LED indicator and the current output regulation mode, such as CV or OFF.
- Ranges – Depending on the selected hardware mode, voltage and current ranges are automatically scaled for Line-Line or Line-Neutral options or for the system size, respectively.
- Slews – Provides access to programmable slew rates.
- Safety – Provides access to the programmable safety limits.
- Configure – Provides access to the additional options, including phase angle trigger behavior.
- Busy  icon – Indicates that an operation is pending when present.
- REGEN – Indicates that power is being absorbed by the UUT and transferred back to the facility.

Adjusting Slew Rates

Click **Slews** to display the Set Slew Rates dialog. Slew rates provide a ramped linear control between two setting values.

Figure 66: Slew Rate Options– 9510 for 1-ϕ AC

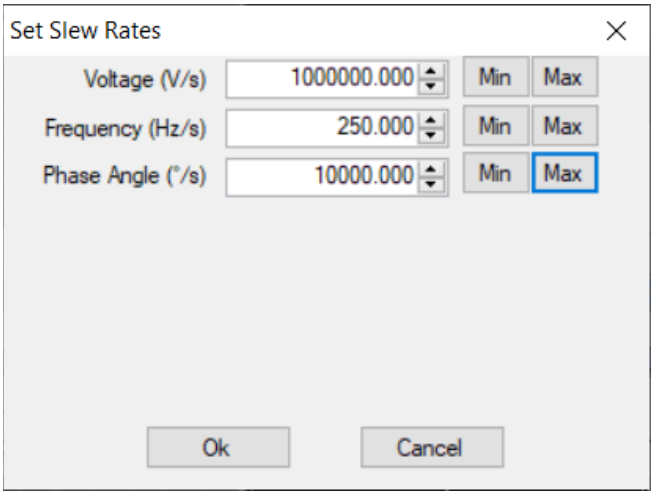
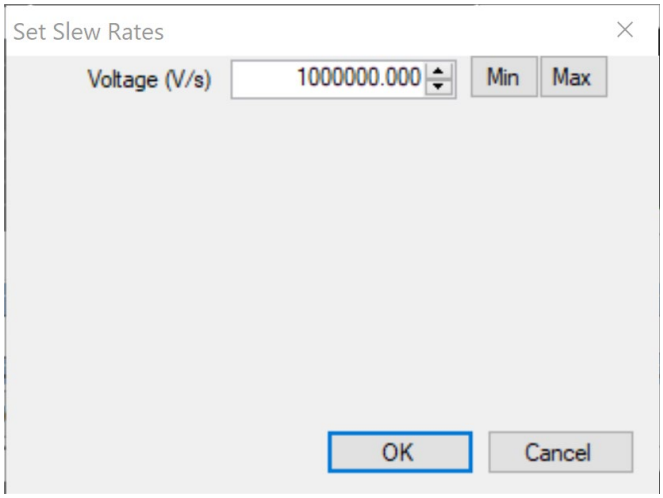


Figure 67: Slew Rate Options – 9510 for DC



NOTE
Only slew rates that apply to the active hardware configuration are enabled.

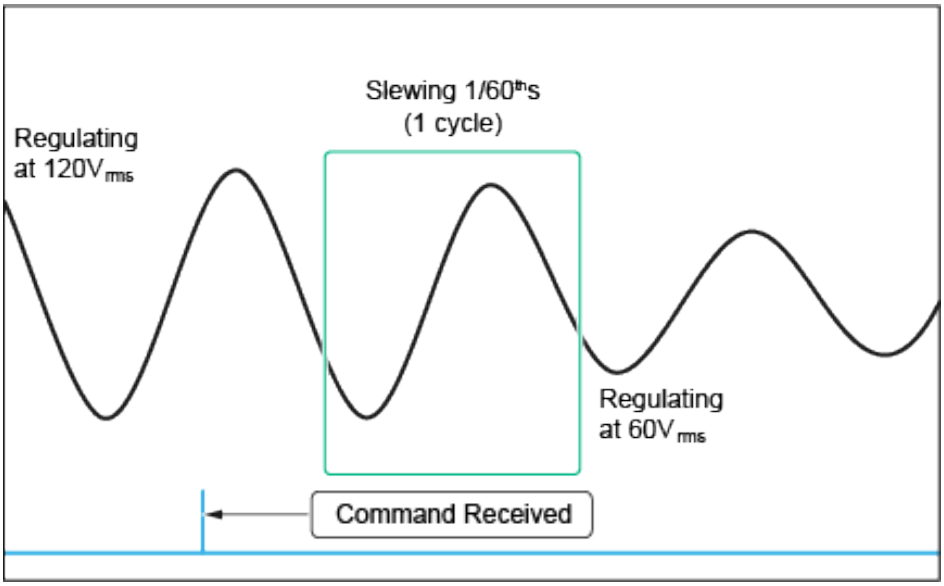
NOTE
Refer to the *Installation* section for more information about multi-phase and parallel channel slew rate definitions and relationships.

Slew Rate Example

A 9510-100 is operating as a one-phase supplying 120 VAC_{rms}/60 Hz. The slew rate is set to 3600 V_{rms} /sec as the current. The next setting is to apply at 0° phase angle.

If the 9510-100 is set to regulate to 60 V_{rms}, a 60 V change takes 1/60th of a second (1 cycle at 60 Hz). Then the result is that a 1 cycle linear slew from 120 V_{rms} to 60 V_{rms}.

Figure 68: 9510 Output Linear Slew in Oscilloscope



Adjusting Safety

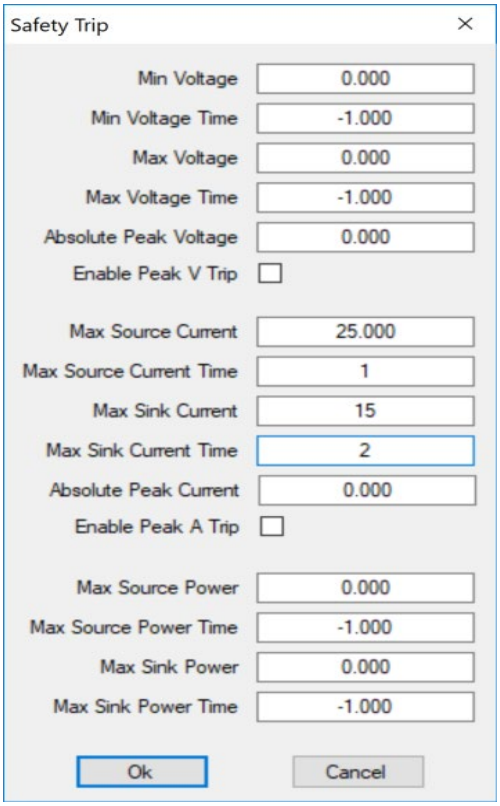
Click **Safety** to display the safety trip settings panel.

Safety limits function as a programmable breaker that 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. In the following example screenshot, the maximum source current from 9510 to the UUT is set to 25 A_{rms} with a time constant of 1s. Like a circuit breaker or fuse, if the current far exceeds 25 A_{rms}, the time constant is shortened automatically based on the energy being transferred.

A maximum sink current from UUT allows a separate limit to be set based on the direction of power flow. In the following example screenshot, the maximum sink current is set to 15 A_{rms} with a time constant of 2s.

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



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

Setting a time allowed to 0, which means to trip instantly, may result in noise causing a safety trip. NI recommends setting 0.1 for a fast acting fuse and 0.5 for a slow-blow fuse equivalent.

Set the safety limits outside of the normal operating parameters to limit UUT damage due to operator error or UUT failure. The safety limits should be used in the same way that a fuse or circuit breaker is used in a similar application.

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

Instrument Configuration Options

Click **Configure** for each instrument to open the Configure Instrument dialog.

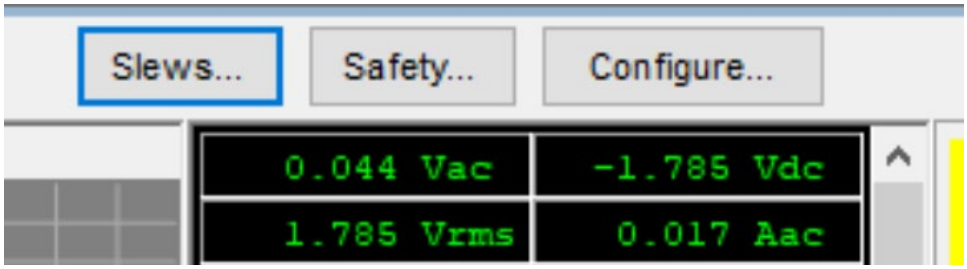
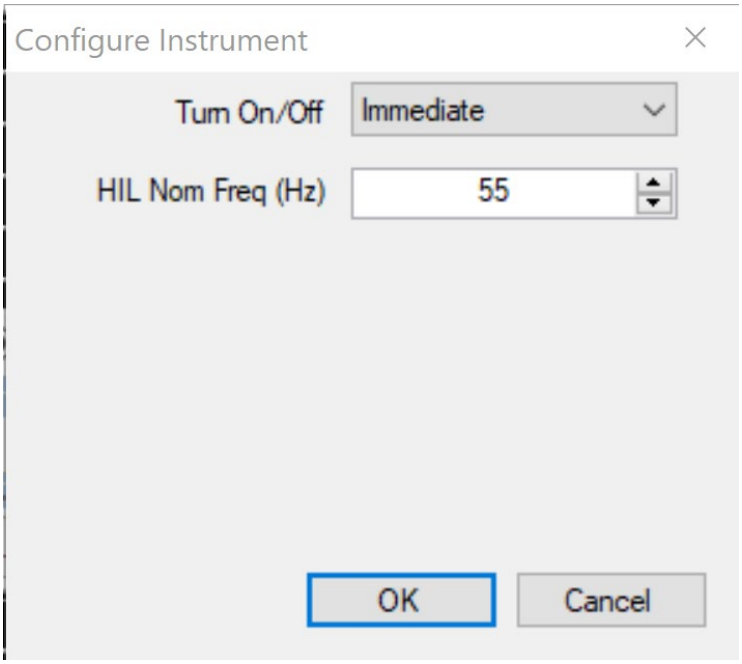


Figure 69: 9510 Output Configuration Panel



Turn On/Off – Specifies when the commanded settings changes are executed.

- Immediate – The settings are applied immediately.
- Sync – The settings are applied at phase angle triggered based on the change at *(deg.)* angle specified in output controls.

HIL Nom Freq (Hz) – Specifies the fundamental frequency for the PHIL function.

The following examples demonstrate the differences between the asynchronous and synchronous mode. All the examples show a transition from 120 V_{rms} to 60 V_{rms}.

Figure 70: Asynchronous: Command applied when received

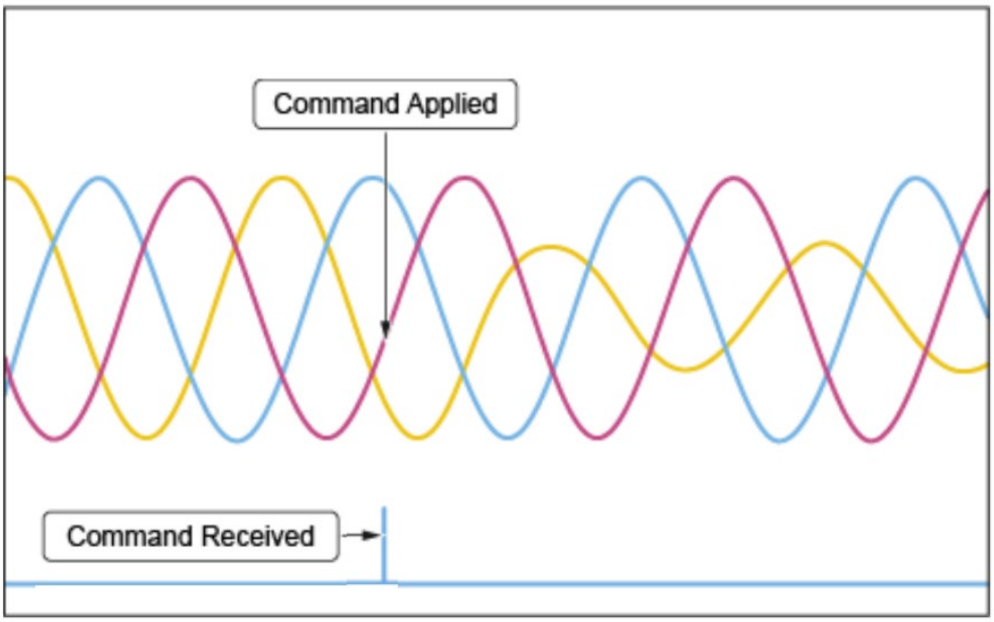


Figure 71: Synchronous with A: Change at (0°)

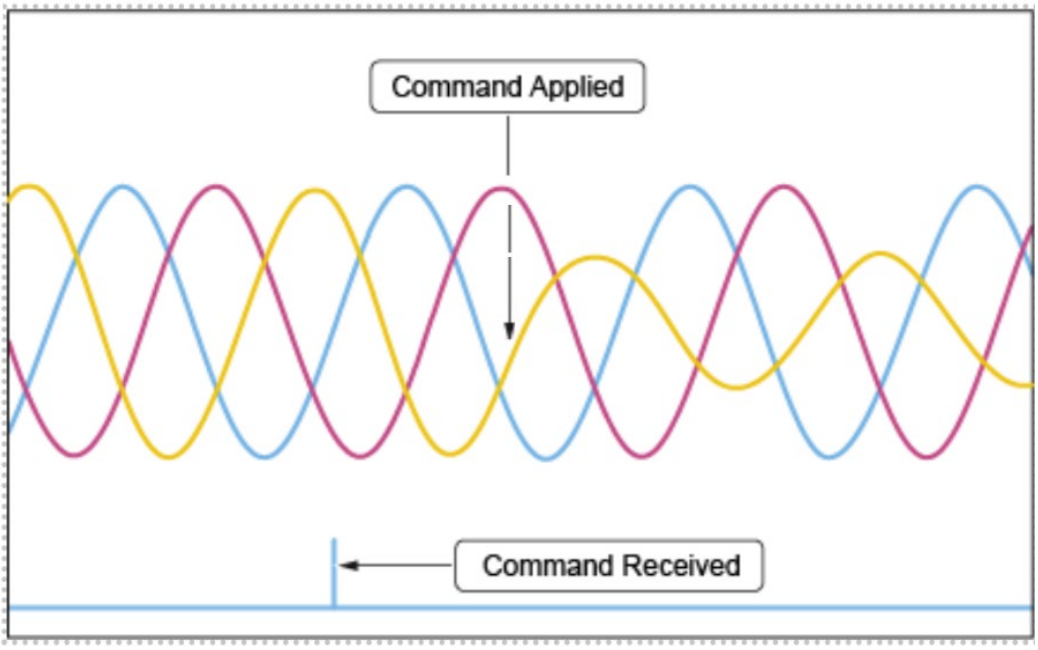
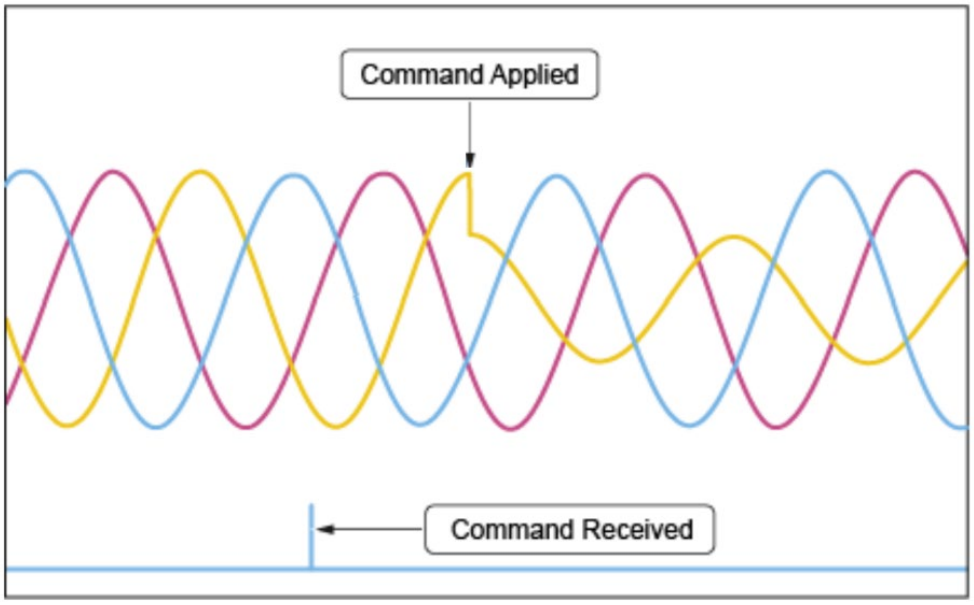


Figure 72: Synchronous with A: Change at (90°)



Establishing Per-Phase and Multi-Phase Regulation Limits

When an instrument is set to 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.

In the following example, a 9510 can be configured for split-ϕ (AC GRID 1) with a 240 $VAC_{rms(L-L)}$/60 Hz (line-line) output where each phase is automatically set to 120 $VAC_{rms(L-N)}$ and the B-phase has a phase angle of 180°. You can adjust any of these settings. In addition, the same system has a second instrument, AC GRID 3, which is programmed as a 1-phase 100 $VAC_{rms(L-N)}$/50 Hz output.

Figure 73: Split Phase (L-L) with per phase (L-N)

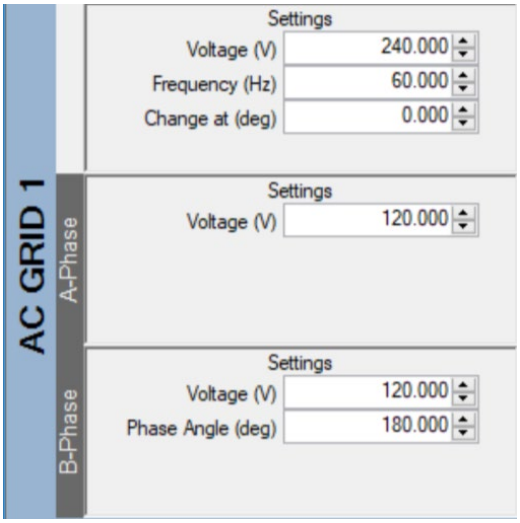
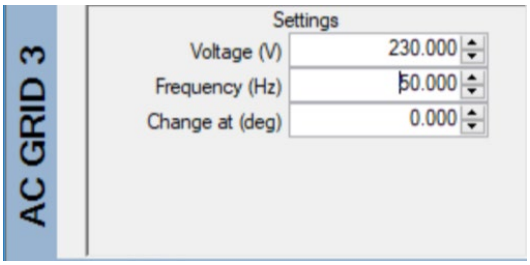


Figure 74: Single Phase (L-N)



The NHR 9500 Panel automatically provides the programmable feature based on the supplied model (9510) and hardware configuration selected.

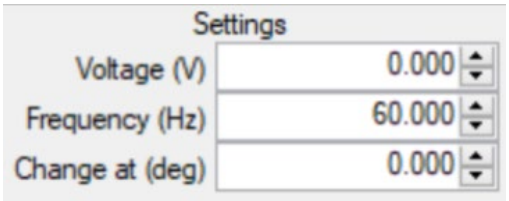
NOTE
For AC outputs, the change at *(deg)* is the trigger angle when operating in synchronous Mode. Refer to the *Instrument Configuration Options* section for more information about synchronous and immediate commands.

Programming Single-Phase AC Setting

The 9510 maintains the output voltage at the specified frequency. Change at degrees specifies the phase angle trigger when operating in a synchronous mode.

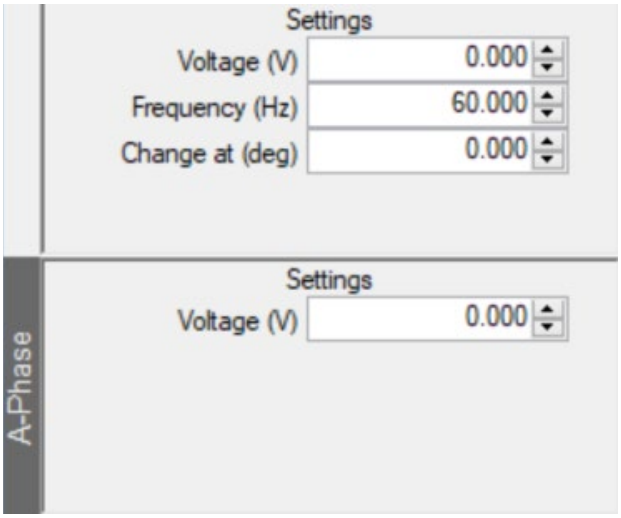
Single-phase voltage setting are expressed as $VRMS_{L\text{-}N}$.

Figure 75: 9510 AC Single-Phase Settings



Programming Multi-Phase AC Limits

Figure 76: 9510 AC Multi-Phase Settings



The 9510 provides a multi-phase programming mode to simplify the programming of multiple output channels when a balanced operating mode is desired.

Per-phase values, which are labeled as something like A-phase or B-phase, are programmed using $VRMS_{L-N}$ similar to single-phase AC.

B-phase or C-phase additionally permits adjustments to the phase angle relationship with A-phase.

Multi-phase voltages are expressed as $VRMS_{L-N}$.

In split-phase mode, Programming 240 $VRMS_{L-L}$ programs both A-phase and B-phase to 120 $VRMS_{L-N}$ because the phases are assumed to be 180° out of phase.

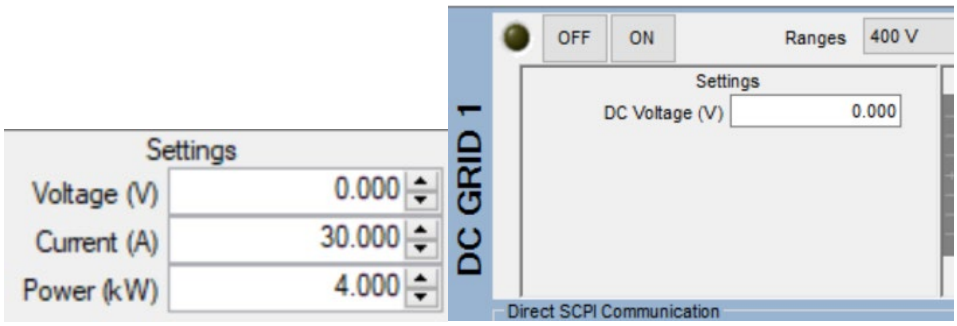
The voltages are assumed to be 180° out of phase.

In 3-phase mode, Programming 208 $VRMS_{L-L}$ programs both A-phase and B-phase to 120 $VRMS_{L-N}$ because the phases are assumed to be 120° out of phase.

NOTE
Refer to the *Installation* section for details more about multi-phase programming relationships.

Programming DC Settings

The 9510 programs instrument channels configured for DC voltage output identically. The unit supports only voltage programming.



The 9510 is a DC grid and maintains the output voltage allowing current to flow in either direction. Current may flow to the sourcing UUT or may flow from the UUT into the sinking 9510.

Selecting AC Output Wave Shapes

The 9510 provides a standard (sine) and three user programmable voltage 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 regulation limits specified previously. For multi-phase operation, the relative phase angle is also considered when using user-defined wave shapes.

You can view the thumbnail representation of the wave shape before click **Apply**.

Figure 77: Wave Shape Controls

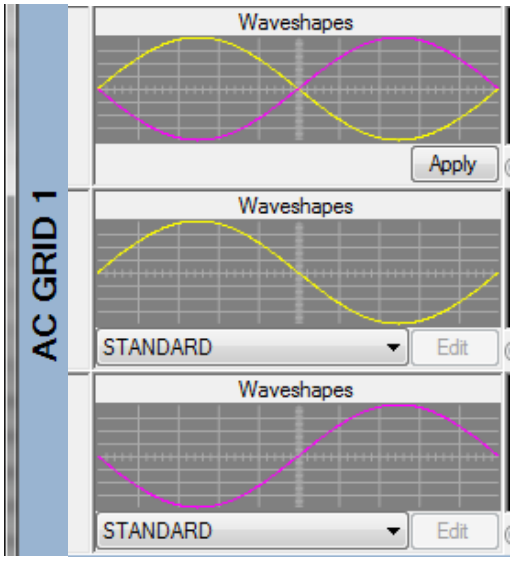
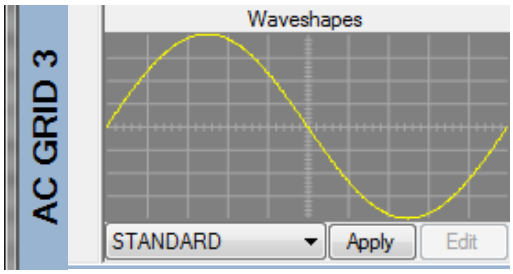


Figure 78: Single-Phase Wave Shape Controls

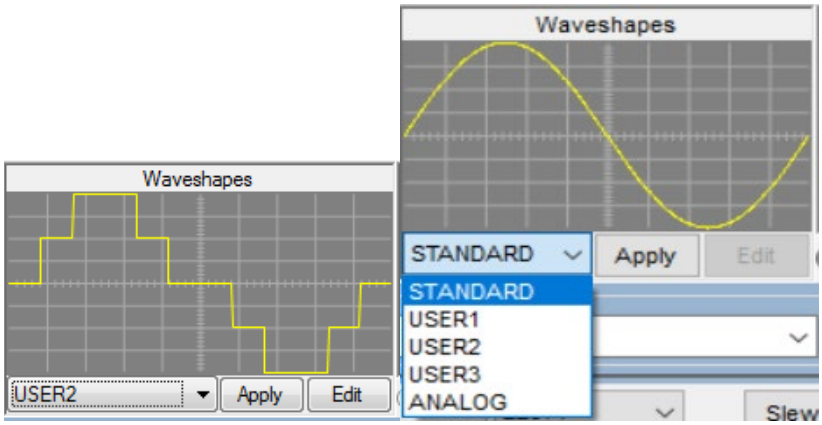


Selecting a Wave Shape

Use the drop-down list below the current wave shape to select an alternative output wave shape, and then click **Apply** to change the output wave shape immediately. Click **Edit** to modify the user wave shapes.

There are following options:

- Standard (sine)
- User-definable
- Analog (HIL)



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

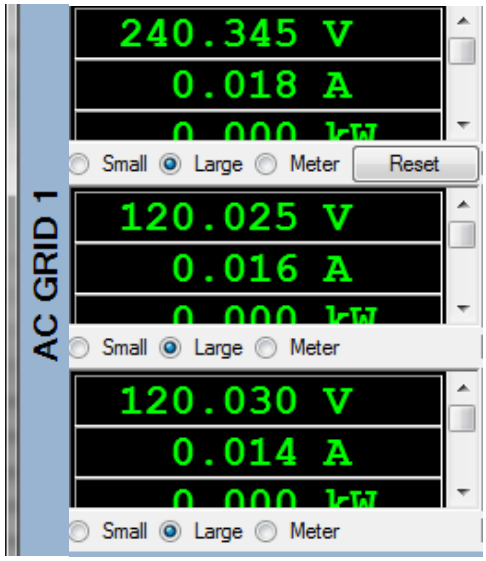
- USER 1: Triangle
- USER 2: n-Step Sine
- USER 3: Clipped Sine
- ANALOG: HIL (Hardware In Loop)

Refer to the *Editing an Output Wave Shape* section for more information about the wave shape editor.

Measurements

The 9510-100 provides a number of last-cycle measurements. All of the measurements, including voltage, current, and power, for any given phase, are synchronously captured.

Figure 79: Split-Phase (L-L) with Per-Phase (L-N)



You can adjust the font size to display as many measurements as the screen size allows, and set separate font size and meter views for the per phase and multi-phase measurements.

Figure 80. Single Phase (L-N)

NOTE
Refer to the *Installation* section for more about multi-phase measurement relationships.

Output Thumbnail Waveform Capture

The NHR 9500 Panel tool uses the internal digitizer to synchronously capture and display one-cycle for all voltage and current waveforms per instrument, which provides a real-time view of both the voltage and current behaviors of the UUT.

Figure 81: Split Phase (L-L) with Per Phase (L-N)

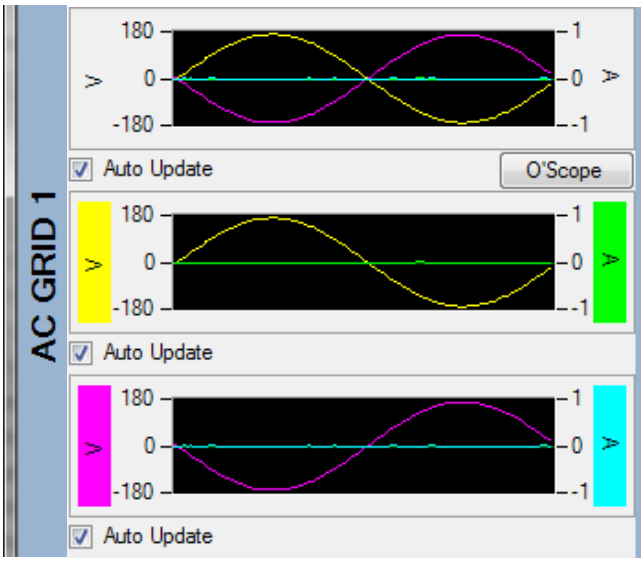
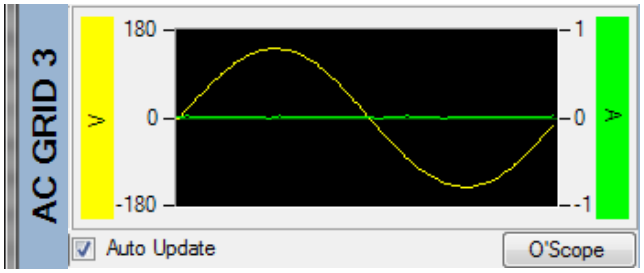


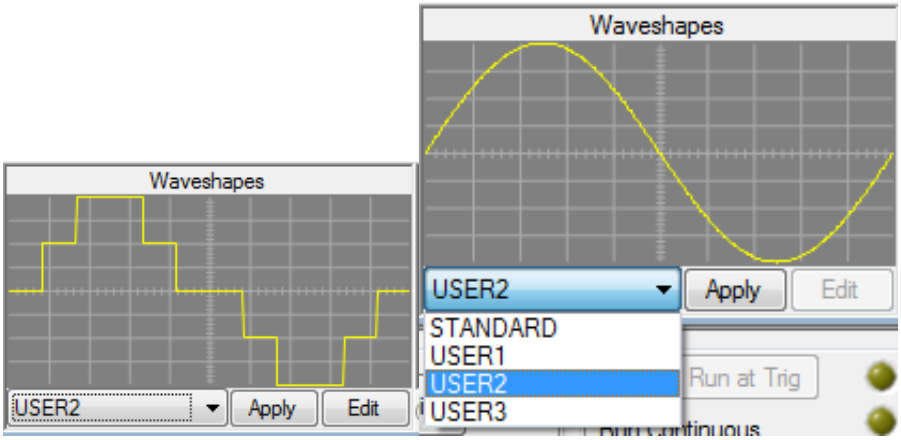
Figure 82: Single Phase (L-N)



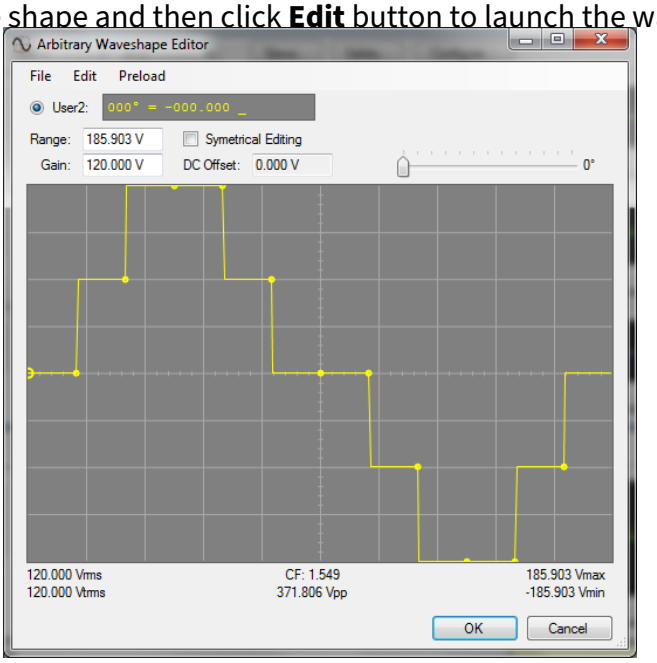
Click **O'Scope** to launch the O'Scope Panel for higher resolution views. Refer to *System-Level Controls* for details about the built in digitizer and O'Scope Panel.

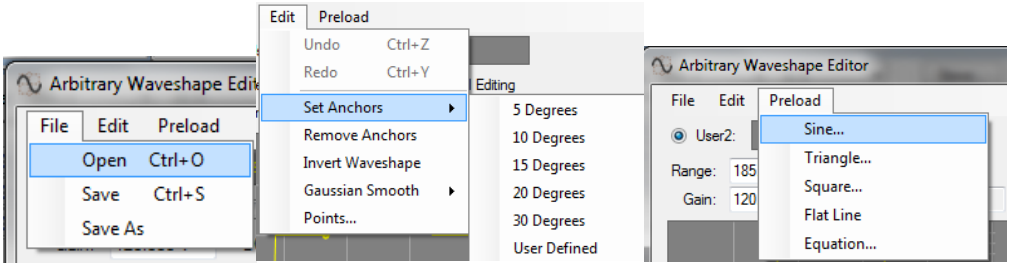
Editing an Output Wave Shape

In addition to the standard (sine) output wave shape, the NHR 9510 Series provides three user-definable wave shapes.



Select a user wave shape and then click **Edit** button to launch the wave shape editor.





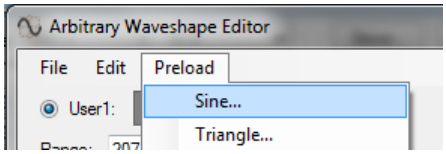
- **File** – Enables you to save wave shapes and recall them or to copy the wave shape to other phases.
- **Edit** – Enables you to edit the wave shape on a point-by-point basis using anchors for a graphical approach or by points for direct value settings.
- **Preload** – Enables you to preload a pre-defined wave shape, use an equation, or generate a wave shape with harmonics.

Wave Shape Examples: Line Slap

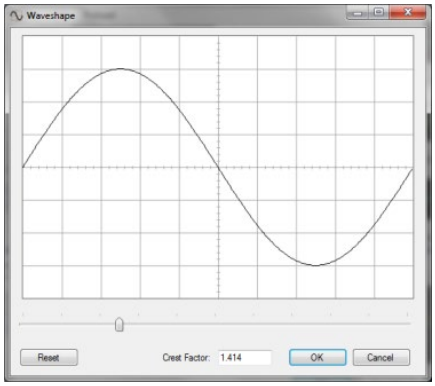
A line slap is an AC disturbance when two power lines are momentarily shorted together. This is represented by a narrow pulse which may transition across the 0 V reference.

Use the NHR 9500 Panel to generate this type of wave shape.

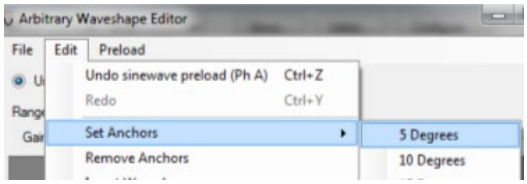
1. Select **User 1** and click **Edit** to edit the user wave shape.
2. Click **Preload** → **Sine** to load a sine shape to modify.



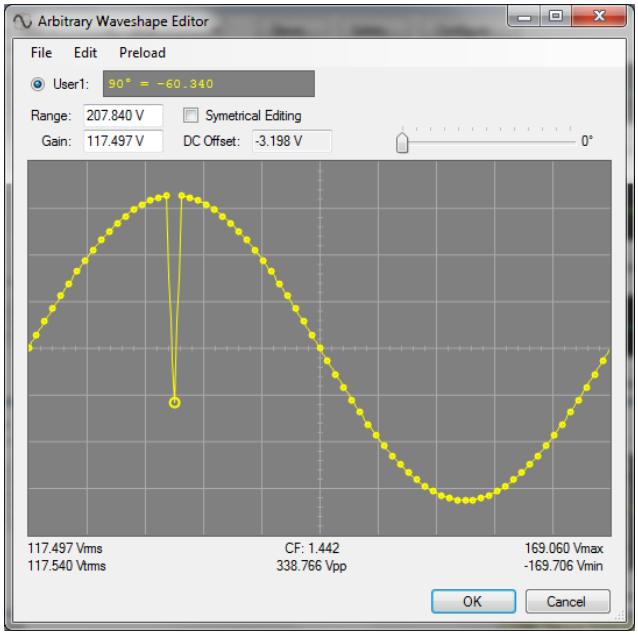
3. In the Waveshape dialog, modify the wave shape, such as adjusting the crest factor. The following example screenshot uses a standard sine as the starting point.



4. Click **OK** to close this dialog.
5. Click **Edit** → **Set Anchors** → **5 Degrees** to place anchors on the wave shape so that you can graphically adjust the wave shape.



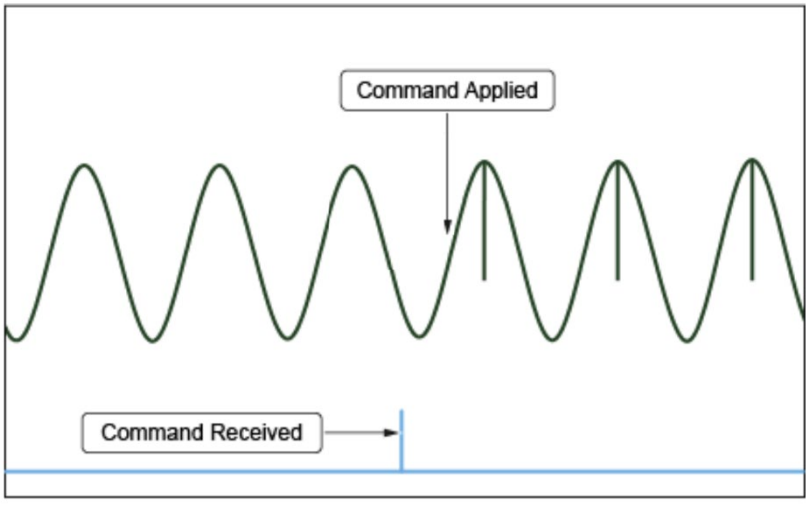
6. Grab the 90° anchor and drag it down to the desired level. The angle and amplitude are shown in text and graph.



7. Click **OK** to load the updated wave shape into User 1.
8. After the wave shape has been loaded into User 1 and is now selectable, click Apply to set the output to follow this new wave shape.

The 9510-100 uses this new wave shape for every new cycle. You can create, download, and select any arbitrary wave shape for any output.

Figure 83: Synchronous: Command at Change at (0deg) Angle



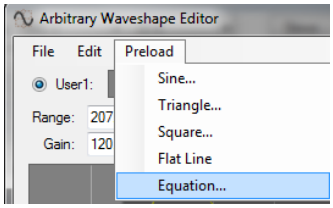
NOTE
You can use Macros to select wave shapes and adjust regulation limits for single cycle-based or timed output control.

> This example for timed or cycle-based transitions is also provided in *Switching Wave Shapes* in the *Macros and Usage Examples* section.

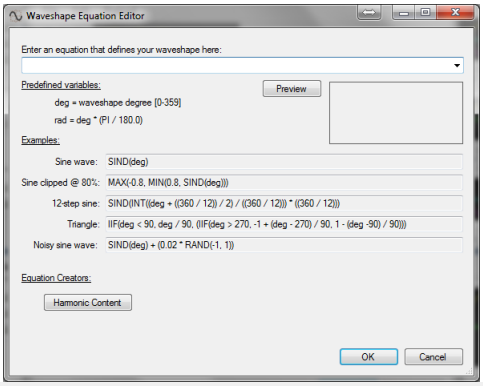
Wave Shape Example: Formula

The NHR 9500 Panel provides direct manipulation of a wave-shape formula, which enables you to specify the exact parameters mathematically.

Refer to the *Wave Shape Example: Harmonics Entry* section for a simple harmonic table approach automatically generating the mathematical formula needed.

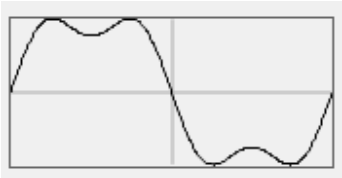


1. Select **User 1** and click **Edit** to edit the user wave shape.
2. Click **Preload** → **Equation** to load a sine shape to modify.
3. In the pop-up dialog, you can specify a wave-shape formula with a number of example formulas. Enter the formula.



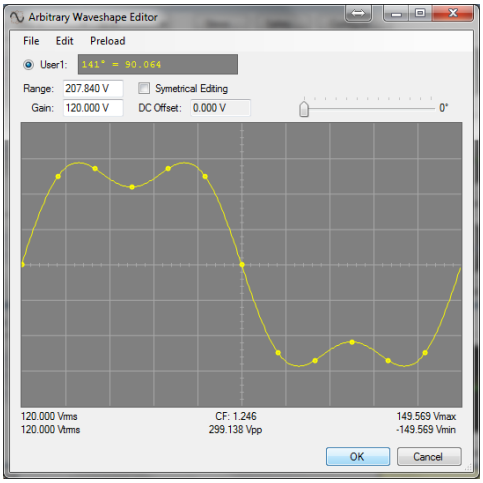
This formula is equivalent to $A \cdot \sin(\omega) + 0.3 \cdot A \cdot \sin(3\omega)$.

4. Click **Preview** to see a graphical representation of the newly generated wave shape.



5. Click OK to close this dialog.

6. On the wave shape editor, the pre-loaded wave shape is displayed. You can modify the wave shape based on your needs.

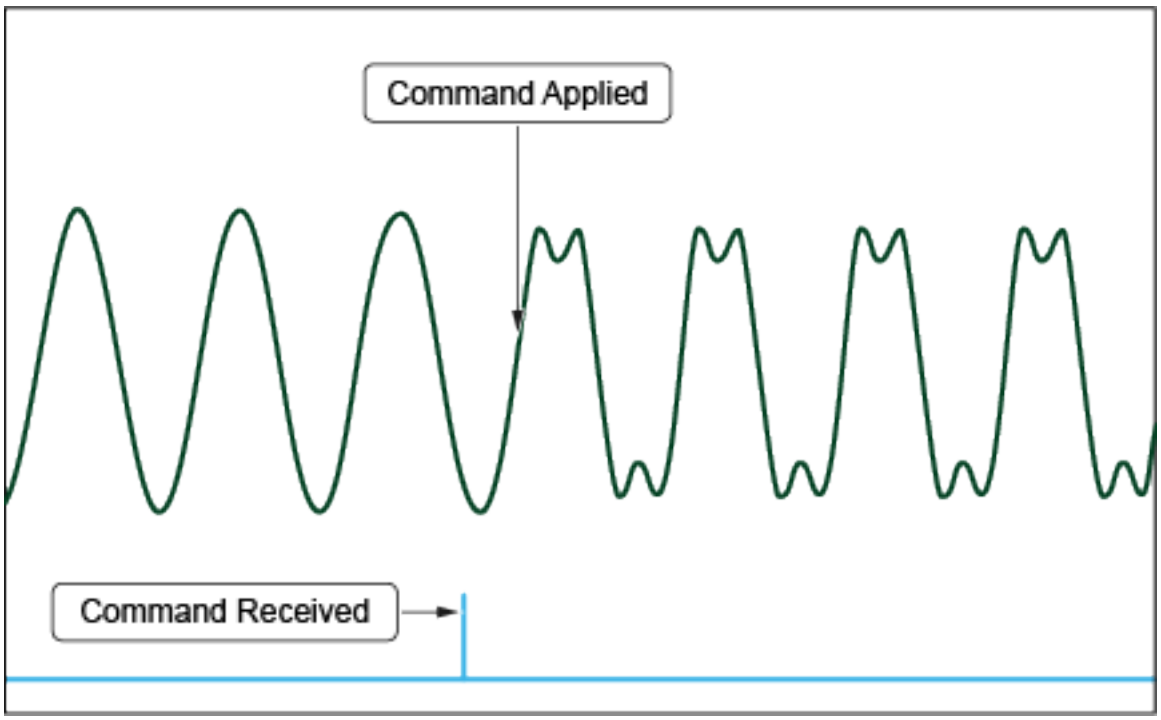


7. If no further modification is needed, click **File** → **Save** to save the wave shape for later use.
8. Click **OK** to load this wave-shape to User 1.
9. After the wave shape has been loaded into User 1 and is now selectable, click **Apply** to set the output to follow this new wave shape.

The 9510-100 uses this new wave shape for every new cycle. You can create, download, and select any arbitrary wave shape for any output.

NOTE
Wave shapes are automatically scaled for voltage and frequency using normal setting controls.

Figure 84: Synchronous: Command at Change at (deg) Angle



NOTE
Wave shapes are normalized and downloaded to the module. The 9510-1000 then compares the RMS of the wave shape with the programmed RMS to properly scale the output voltage.

This allows the wave shape to follow the output frequency, reach the desired RMS level, and permit slew rate control.

The NHR 9500 Panel supports a wide range of mathematical operations to generate a formula-based wave shapes. All operations and functions are case insensitive.

Table 16: 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 a circle to its diameter	Pi	3.14159…

The NHR 9500 Panel supports comparisons as well as random number generation.

Table 17: 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 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 returns 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)

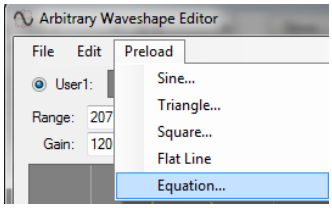
  Returns the same random number as the one previously generated.
- rand(a, b)

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

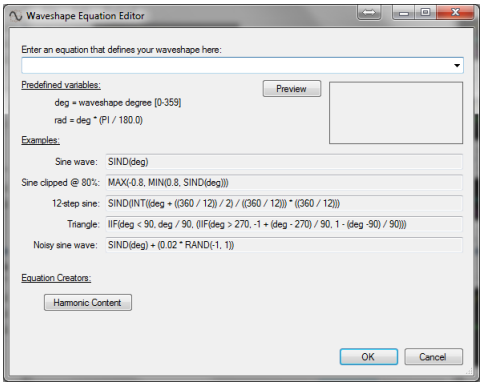
Wave Shape Example: Harmonics Entry

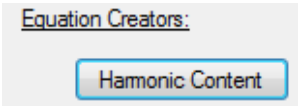
The NHR 9500 Panel provides direct entry of the value and phase angle for individual harmonics. The result is a pre-built wave-shape formula that can be further edited as described in the previous topics.

1. Select **User 1** and click **Edit** to edit the user wave-shape.

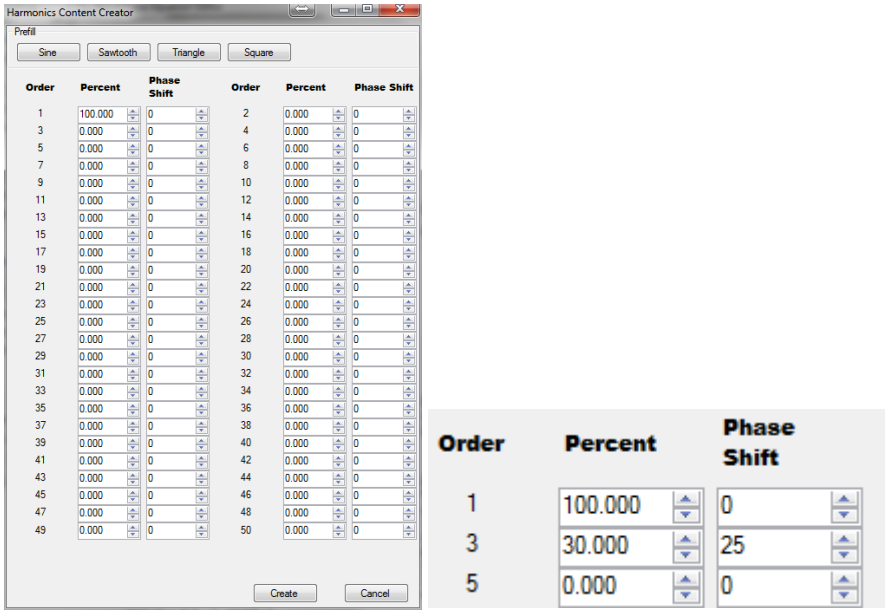


2. Click **Preload** → **Equation** to load a sine shape to modify.
3. In the pop-up dialog, you can specify a wave-shape formula with a number of example formulas. Click **Harmonic Content**.





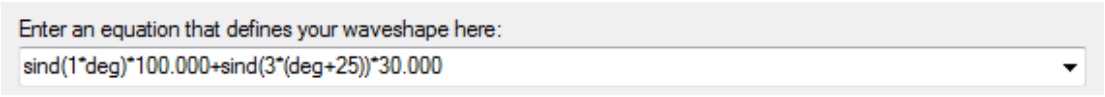
4. In the Harmonics Content Creator dialog, you can prefill the harmonics table using standard shapes or specify individual harmonics. In the following example screenshot, the 1st order harmonic is set to 100 with a 0° phase angle and the 3rd harmonic is set to 30 with a 25° phase angle by entering the values in the appropriate fields.



5. Click **Create**.

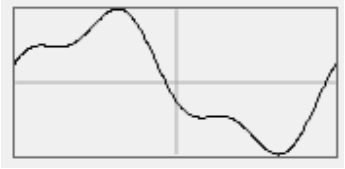
> **NOTE**
> You can use percent or actual values from a power meter in **Percent**. The wave shape is normalized allowing the 9510 to automatically scale the output based on the wave shape equivalent RMS and the programmed RMS level.

6. The harmonics equation is displayed in the equation field. You can edit the equation based on your needs.

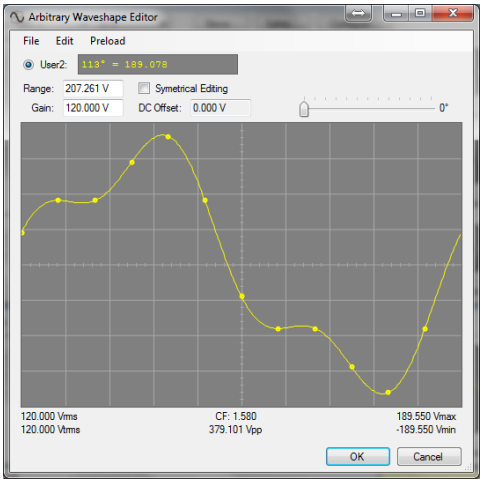


The above formula is equivalent to $A \cdot \sin(\omega) + 0.3 \cdot A \cdot \sin\,(3\omega + 25^0)$.

7. Click **Preview** to see a graphical representation of the newly generated wave-shape.



8. Click **OK** to close the editor.
9. On the wave shape editor, the pre-loaded wave-shape is displayed. You can modify the wave shape based on your needs.



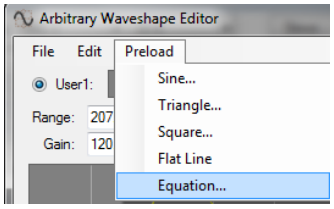
10. If no further modification is needed, click **File** → **Save** to save the wave shape for later use.
11. Click **OK** to load this wave shape to User 1.

Wave Shape Example: Simulating Phase Jump

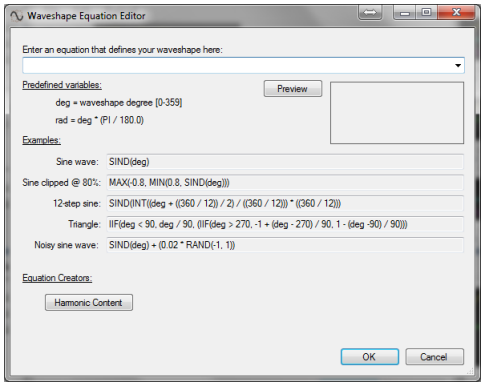
The NHR 9510-100 supports a programmed phase-jump for simulations where the frequency is matched but the relative amplitude or phase angles jump.

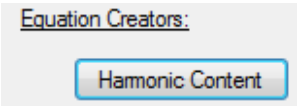
This is programmed similar to harmonics where the fundamental is shifted by a specified phase angle.

1. Select **User 1** and click **Edit** to edit the user wave shape.
2. Click **Preload** → **Equation** to load a sine shape to modify.

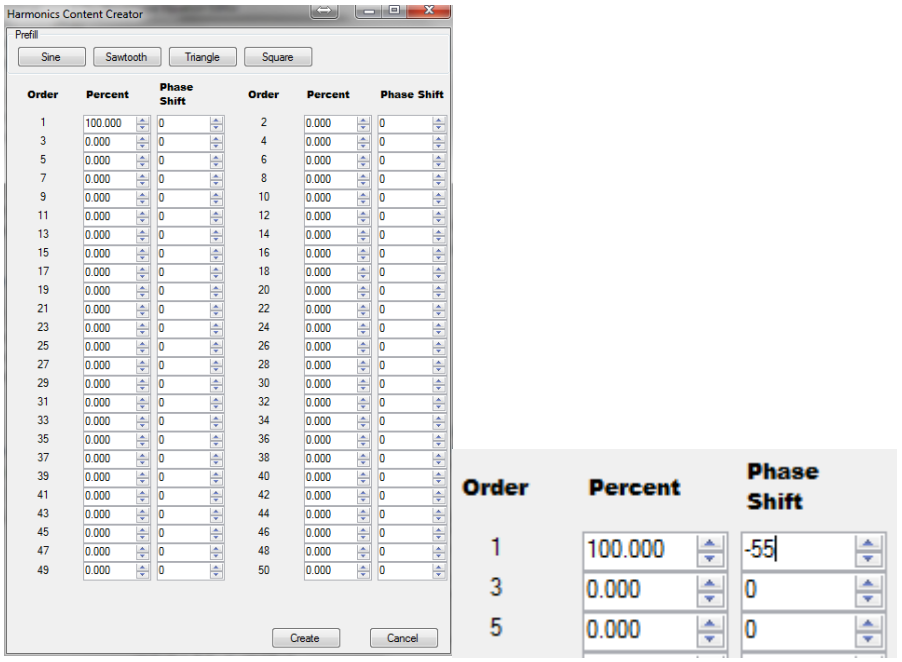


3. In the pop-up dialog, you can specify a wave-shape formula with a number of example formulas. Click **Harmonic Content**.





4. In the Harmonics Content Creator dialog, you can prefill the harmonics table using standard shapes or specify individual harmonics. In the following example screenshot, the 1st order harmonic is set to 100 with a -55° phase angle, and all other harmonics are set to 0. This generates a phase-shifted wave shape in User 1.

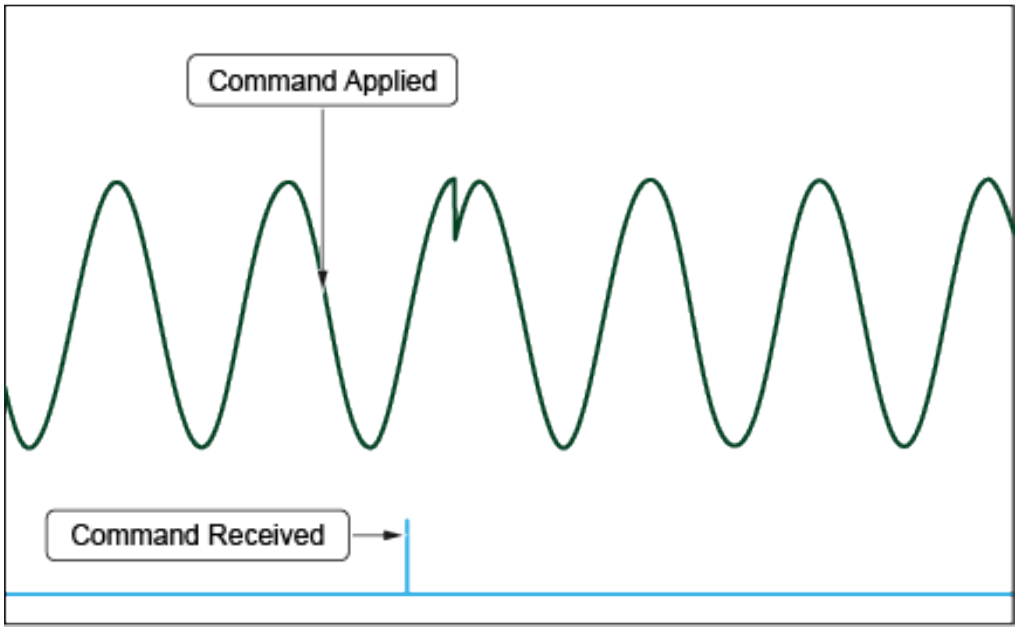


5. The User 1 now contains a sinusoidal wave shape that is 55° offset from the standard wave shape. On the main panel, specify the frequency, amplitude, and the change at (deg) angle for the wave-shape to use.

NOTE
When the system is in synchronous mode, the new wave shape is applied at the Change at (deg) angle. When the system is operating in immediate mode, the wave shape is applied when the command was received.

Refer to the *AC Synchronization Angle* section for more information.

Figure 85: Synchronous: Command at change at (90°)



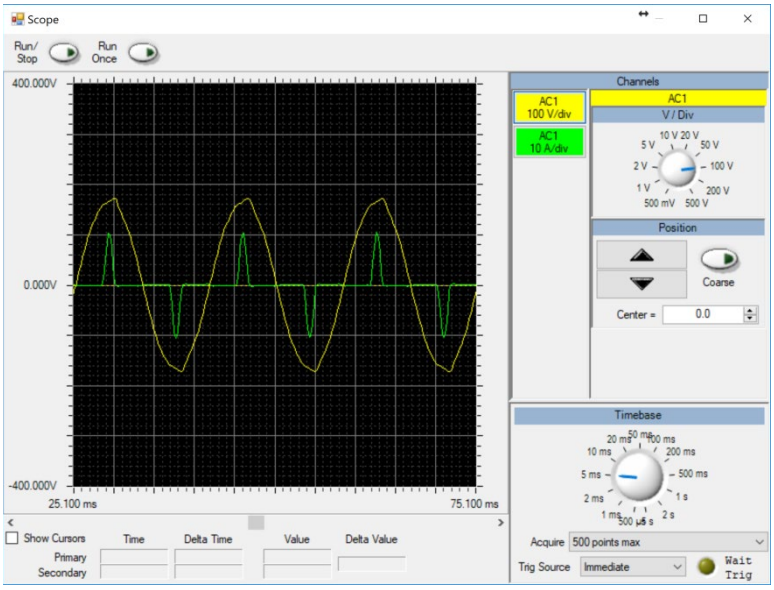
You can create, download, and select any arbitrary wave shape for any output.

NOTE
You can use Macros to simultaneously switch amplitude, frequency, wave shape, and relative phase angles for multi-phase outputs.

Accessing Oscilloscope View

Click **O'Scope** to open the oscilloscope panel.

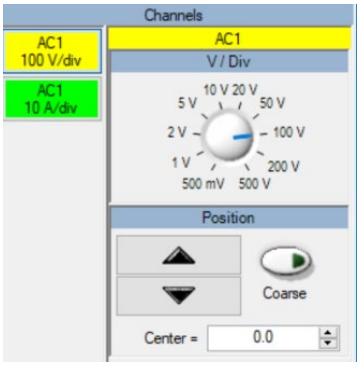
This utility provides access to the internal hardware digitizer and functions similar to an oscilloscope including measurement cursors, horizontal time control, and vertical voltage and current control.



All captures start at the 0° reference phase angle for self-phase in single phase operation or the 0° reference phase angle for A-phase in multi-phase operation.

Adjusting Vertical Scale and Position

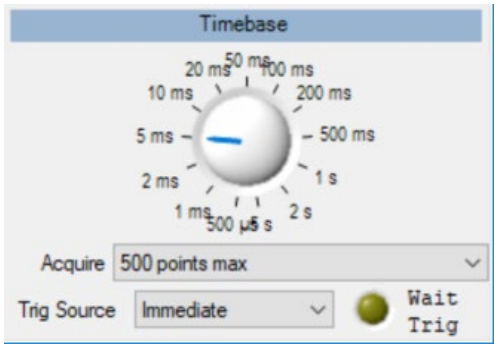
The Oscilloscope allows separate scales per measurement channel and vertical positioning of each channel. Select the channel, rotate the knob, and then adjust the position.



Adjusting the Time-Base and Number of Samples

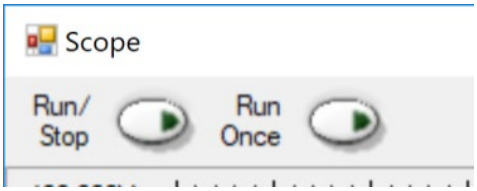
The Oscilloscope function captures between 500 µS and 5 s per division (1 mS up to 50 s). You can specify the maximum number of points between 500 and 50,000 points which are uniformly distributed across the entire capture time.

After a capture, you can adjust the timebase to zoom in or out a waveform. You can also use the scroll bar under the displayed waveform to adjust the horizontal view.



Capturing the Output

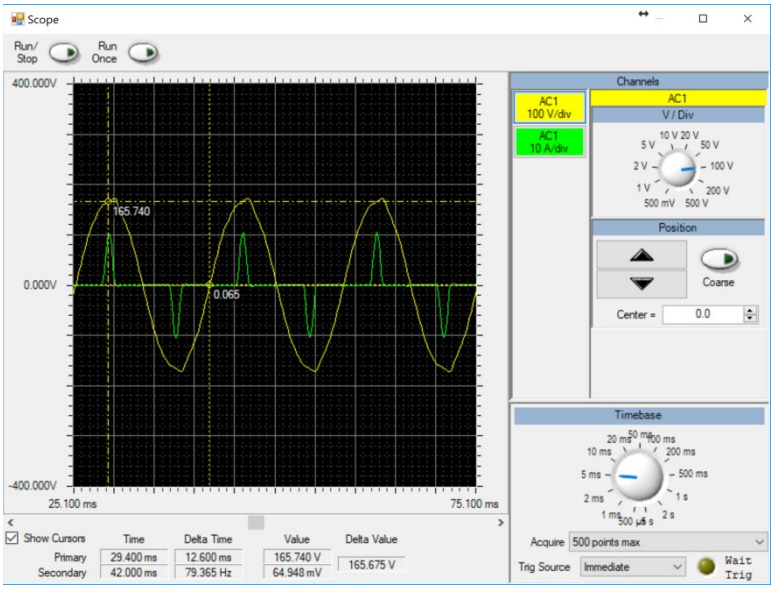
Similar to the normal mode of an oscilloscope, the **Run/Stop** button enables you to arm, trigger at the 0° reference, download the waveform data, and re-arm to capture the output again.



Similar to the single sequence mode of an oscilloscope, the **Run Once** button enables you to arm, trigger at the 0° reference, and download the waveform data only once.

Cursors

Select **Show Cursors** to activate cursors. Left-click to place the primary cursor and right-click to place the secondary cursor.



At the bottom of the panel, you can view the time and value of each cursor and the delta in time, frequency, and value in text. You can also view the value of each cursor near the cursor measurement location on the waveform.

Store Waveform Data

Click **Store** on the upper-right of the dialog stores the waveform data in a .csv file to be imported into a spreadsheet program, such as Excel.

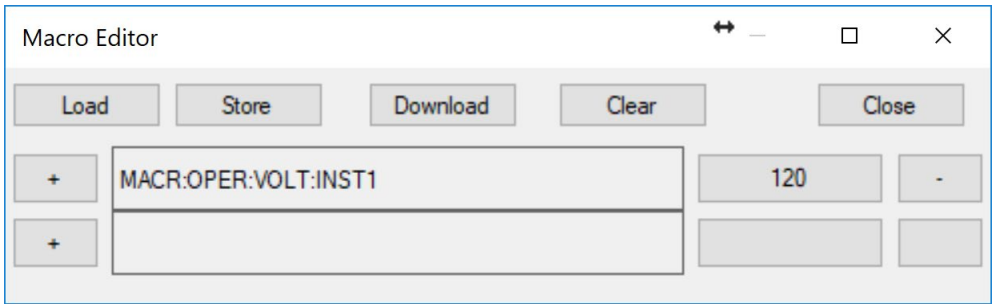
The **Store** button is not shown in the previous figure.

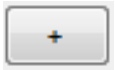
Closing the Oscilloscope View

Click the the close window  button to close the oscilloscope view.

Macros and Usage Examples

Macros are pre-programmed sequences which are 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.



- Load – Retrieves a previously generated and stored Macro file.
- Store – Saves the current Macro file for later use.
- Download – Downloads the current Macro file to the hardware.
- Clear – Clears the settings in the editor and the Macro file loaded in hardware.
-  – Adds a new Macro step above the current step.
-  – Specifies the value.
-  – Deletes the selected Macro step.

NOTE
Macros are entered in a similar manner on the touch panel.

> Ensure you read the following sections about instrument-level control options before programming a Macro.

Macro Organization

Macros are organized identically when implemented on the touch panel of the NHR 9500 Panel software, and have a nearly identical structure when programmed using SCPI or LabVIEW VIs.

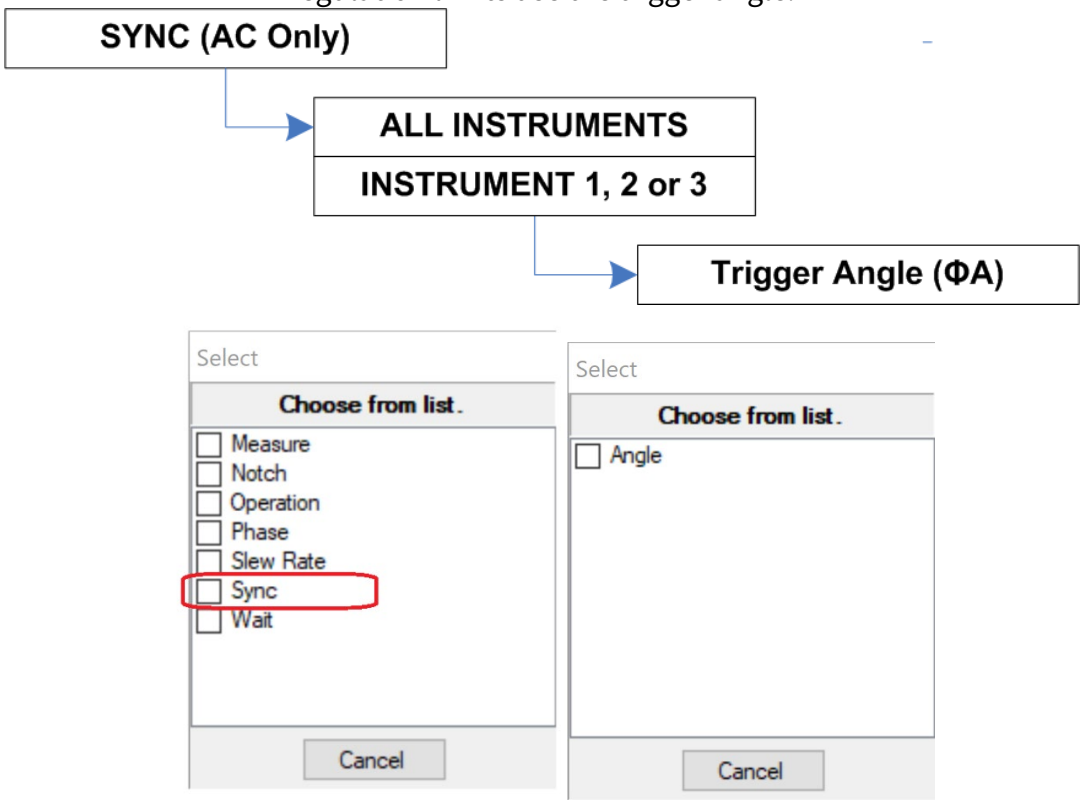
Refer to the *NHR 9500 Series AC/DC Power Module Programmer's Reference Manual* (NH Research Part Number: 09-0363) for the appropriate syntax and detailed descriptions of each command.

Macro Timing Control

AC Synchronization Angle

Macros permit changing the trigger angle used by the system.
When the channel is configured for immediate execution, the cycle counter uses the trigger angle to provide a synchronization angle before applying a new time-based regulation limit.

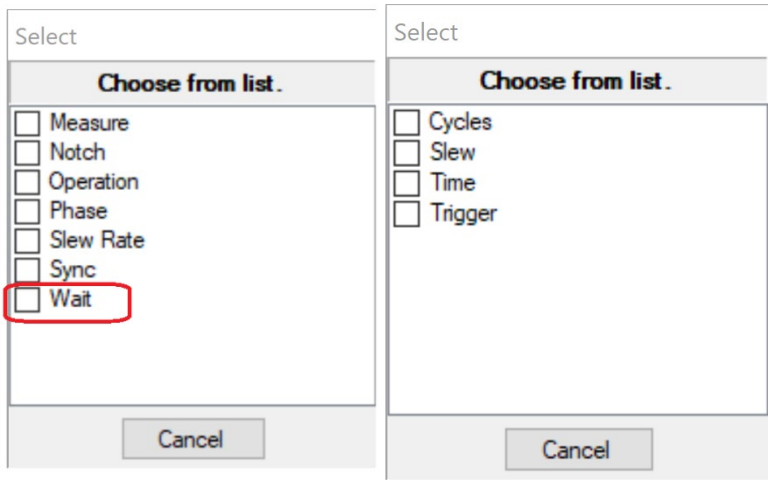
When the channel is configured for synchronous execution, both the cycle counter and regulation limits use the trigger angle.



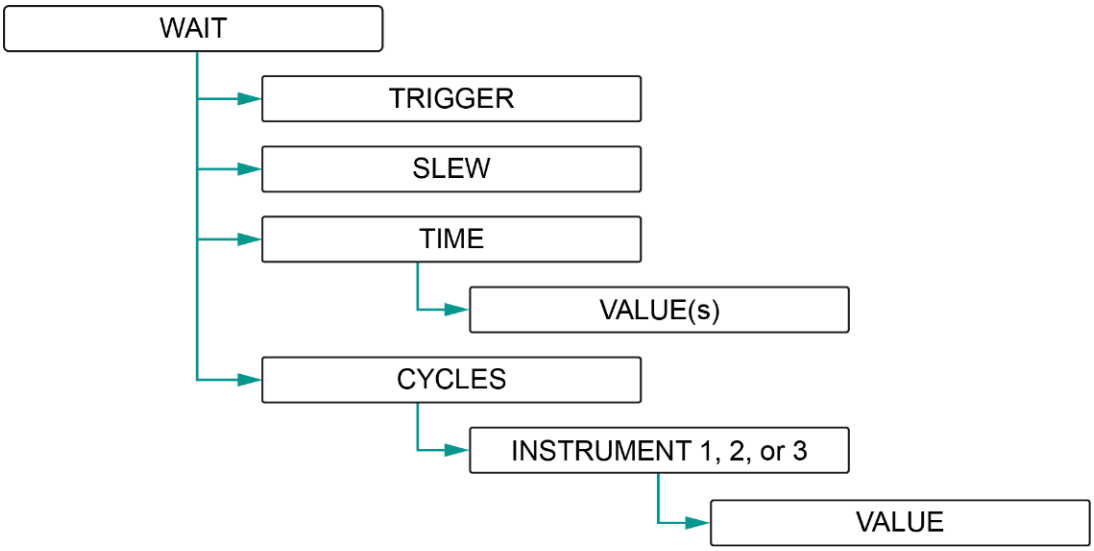
Refer to the *Waits* section for more information about cycle counting and the output characteristics based on Synchronous or Immediate modes.

Waits

Macros can be set to wait for a trigger within a specified period of time until the slew is complete, or until a number of cycles are complete.



- Wait Trigger – Is set externally to the Macro and pauses the Macro until the trigger is received.
- Wait Slew – Pauses the Macro until all the outputs finish changes based on slew rate.
- Wait Time – Pauses the Macro within a specified period of time in seconds.
- Wait Cycles – Pauses the Macro until the specified number of crossings of the trigger angle is accomplished.



NOTE
Wait time and wait cycle can ±1 cycle tolerance.

The following table illustrates an example of sequence to execute when a 9510 model is configured for single-phase AC outputs and operates at 230 V_{RMS} and 50 Hz.

Sequence Steps	Immediate Execution	Synchronous Execution
Wait → Cycle → Instrument1 1	Waits for the next angle. (Assume the elapsed time after angle is 0 mS)	
Operation → Voltage → Instrument1 100	Executes command. (The elapsed time is 0 mS.)	Executes at the next angle. (The elapsed time is 20 mS.)
Wait → Cycle →Instrument1 1	Waits for the next angle. (The elapsed time is 20 mS.)	Waits for the next angle. (The elapsed time is 40 mS.)
Operation → Voltage → Instrument1 230	Executes command. (The elapsed time is 20 mS.)	Executes at the next angle. (The elapsed time is 60 mS.)

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 9510 operating in 3-phase mode:

Sequentially Issued Commands	Command Description	Merged
Operation → Voltage → Channel1 120 Operation → Voltage → Channel2 60	Sets A phase to 120 V_{RMS} Sets B phase to 60 V_{RMS}	Yes
Operation → Voltage → All 208	Sets A/B/C to 120 V_{RMS}	No
Operation → Voltage → Channel1 60 Operation → Voltage → Channel2 120	Sets A phase to 60 V_{RMS} Sets B phase to 120 V_{RMS}	Yes
Operation → Voltage → Channel1 120 Operation → Voltage → Channel1 120	Sets A phase to 120 V_{RMS} ???? (Indicating unknown macro)	Depends on the next command

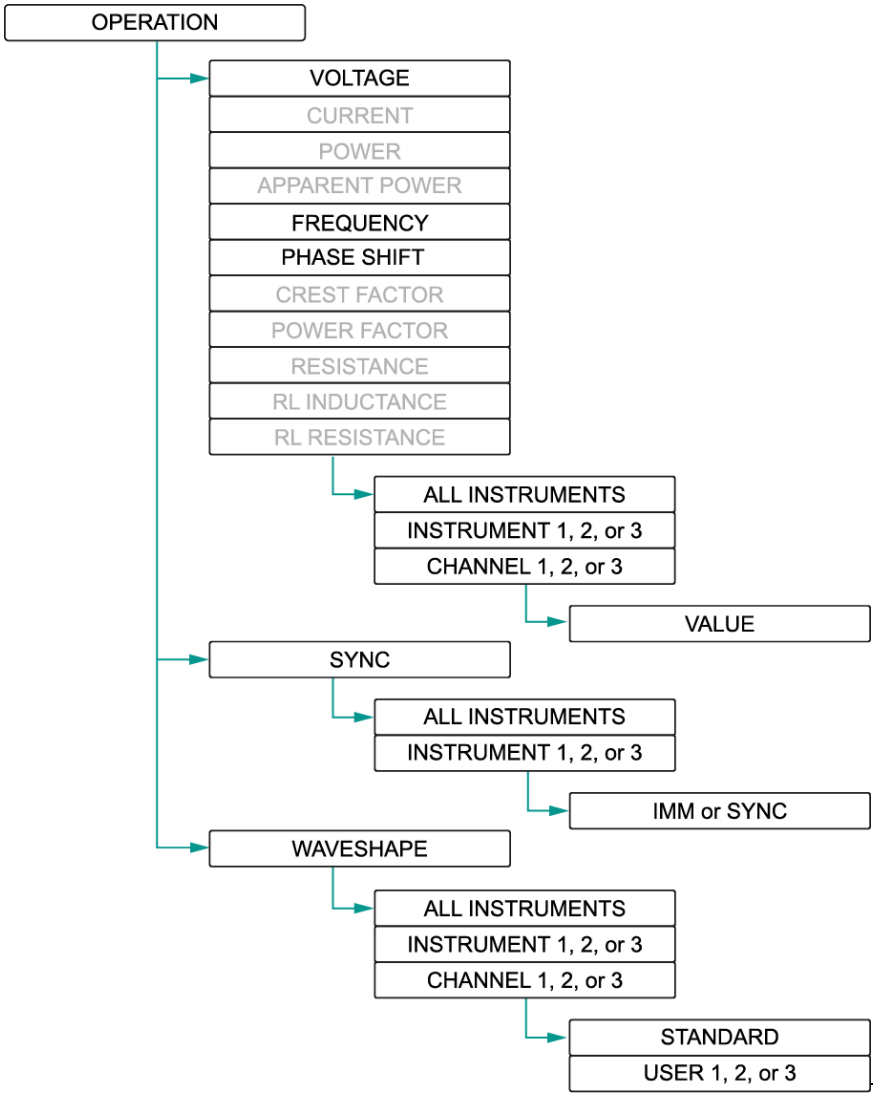
Operation

You can configure the operational settings in the operation section. The Macro language is independent of the hardware connected so the available options are not appropriate for setting frequency in DC or for testing all models, such as INST3 on a single-phase system.

Normally, operation settings in a Macro are applied in the order received. To force the system to apply multiple settings at the same time, you can set the OPERATION / APPLY MODE to WAIT. This stops all operation settings until an OPERATION / APPLY command is received. If OPERATION / APPLY MODE is WAIT, you must include the OPERATION / APPLY command after update any settings, otherwise the updates will not be applied.

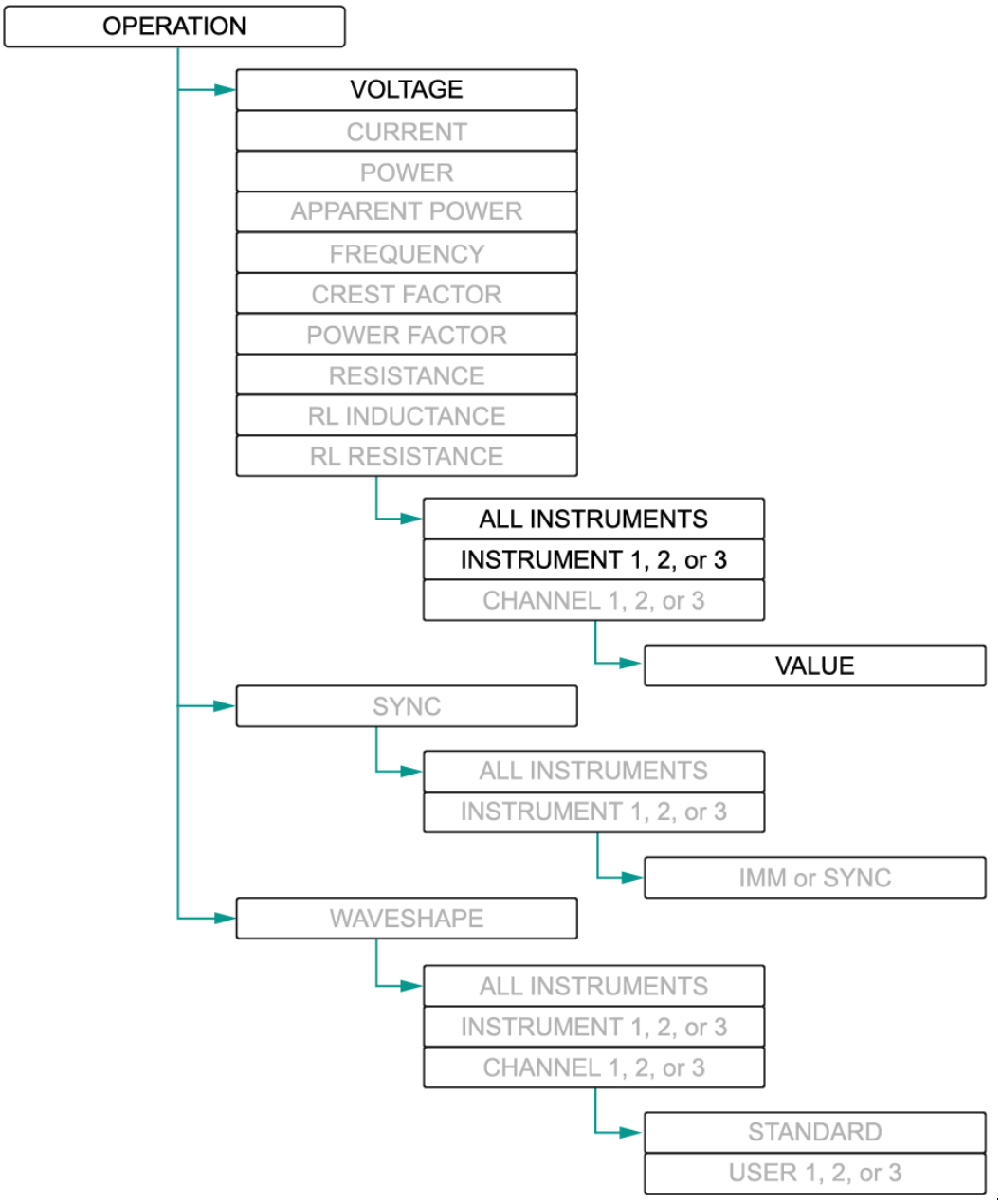
Set OPERATION / APPLY MODE to IMM to automatically apply the operation settings.

Figure 86: Operation - AC Regulation Limits



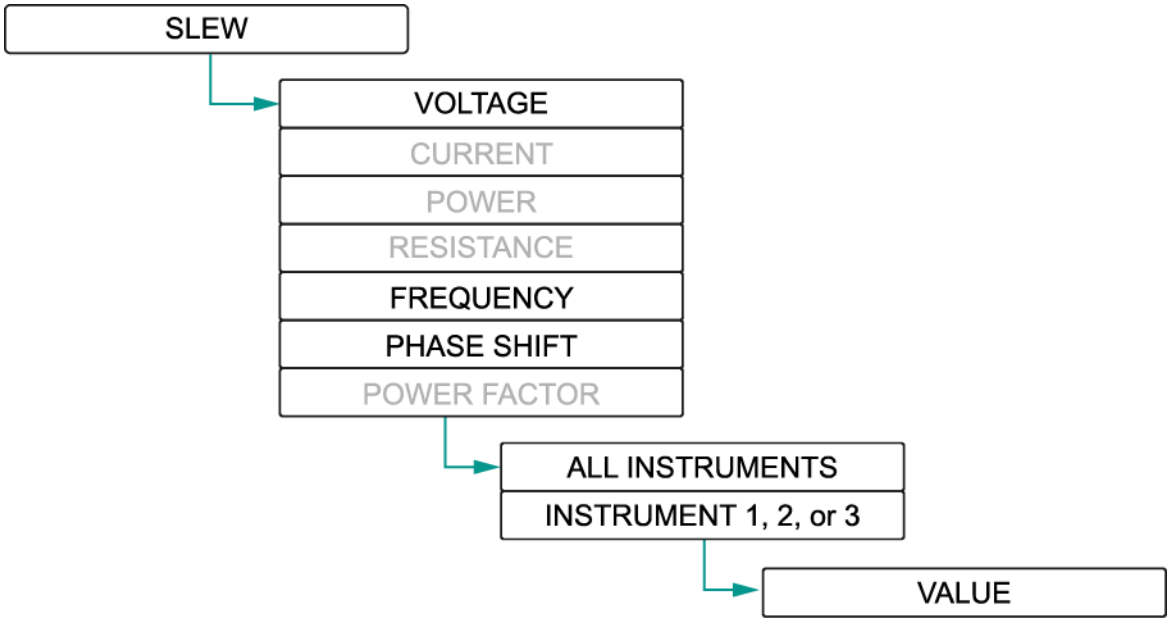
Operation - DC Regulation Limits

DC outputs are programmable with voltage.



Slew Rate Controls

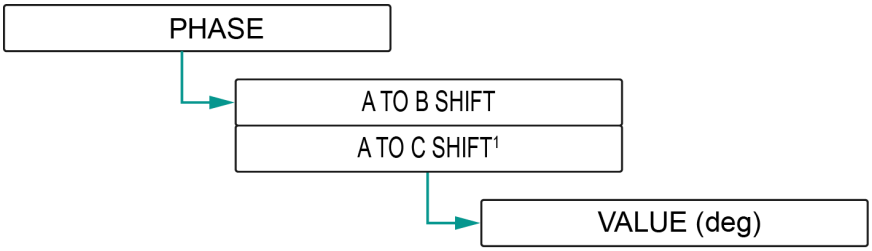
Slew rates can be adjusted and take effect immediately after execution.



NOTE
Frequency and phase shift apply to only AC outputs.

Multi-Phase Relative Angle Adjustment

Macros can adjust the relative phase angles for multi-phase AC outputs. The following commands act immediately and start slewing the phase angle relationship of the outputs based on SLEW:PHASE.



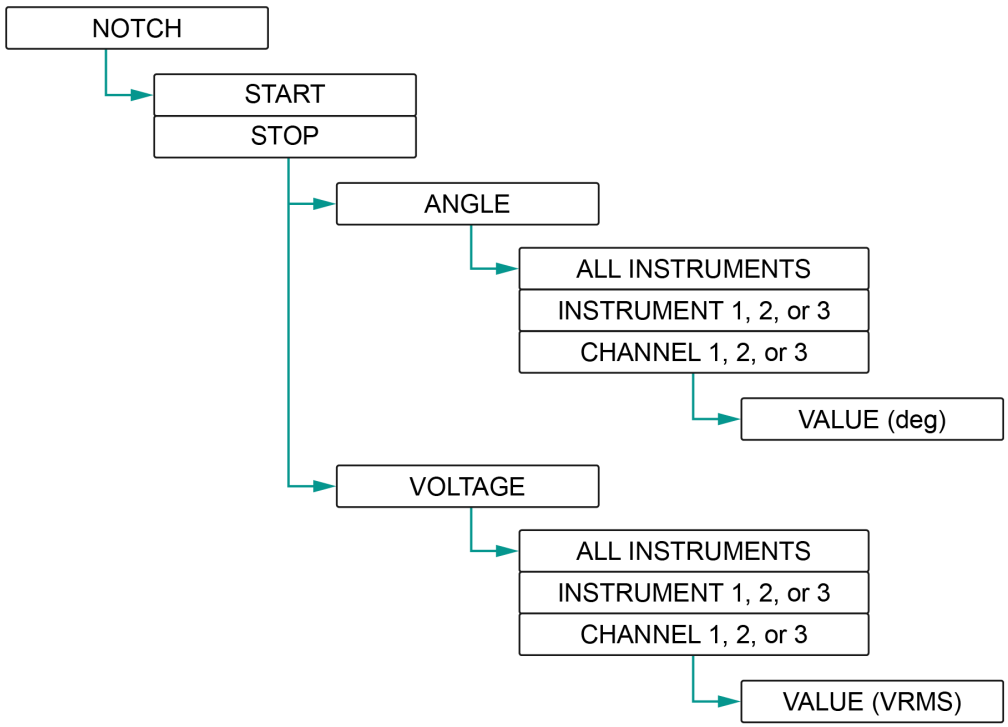
[1]Applies to 3 - Φ Outputs Only

Sub-Cycle Voltage Notches

Creating a sub-cycle notch requires the following four commands to be issued:

- Notch → Start → Angle
- Notch → Start → Voltage
- Notch → Stop → Angle

- Notch → Stop → Voltage



These commands are compressed into a single command and are executed based on the synchronization mode selected. Compared to using an immediate time-based method, using notch takes less hardware Macro command space and provides a higher precision. The following table illustrates examples with the frequency of 50 Hz.

Using Notch (1 HW command)	Using Immediate Mode (6 HW Commands)
Notch → Start → Angle 60 Notch → Start → Voltage 60 Notch → Stop → Angle 270 Notch → Stop → Voltage 120	Operation → Sync → Instrument 1 IMM Sync → Instrument1 60 Wait → Cycle → Instrument1 1 Operation → Voltage → Instrument1 60 Wait → Time 0.1 Operation → Voltage → Instrument1 120

Macro Programming – Infrequently Used Commands

Though infrequently used, the following commands in this section are supported in Macros.

Accessing the Measurement System

You can use a Macro to:

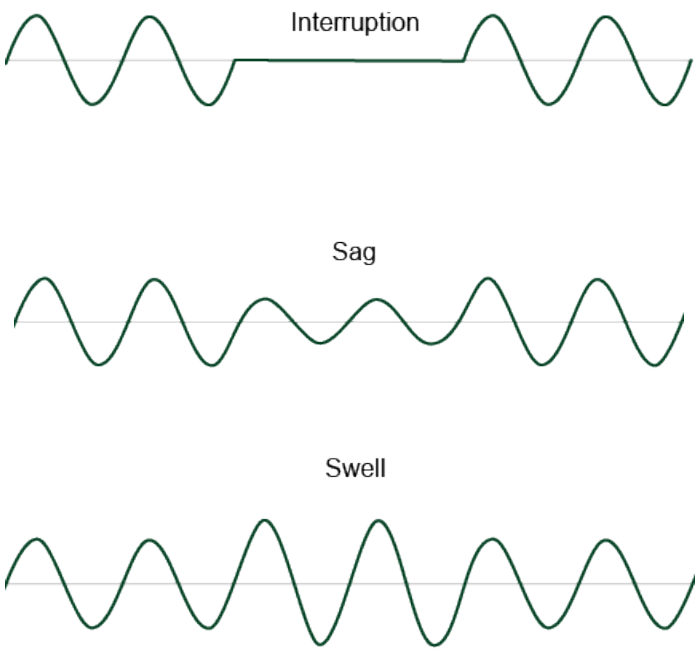
- **Trigger an internal measurement** using the following command:
  - INIT IMM (Initiate Immediate)
  - INIT TRIG (Initiate Trigger)

    When instructed, the system takes an internal measurement using the previously set aperture settings. You can use your application to download the results and digitized waveforms.
- **Reset** the accumulated measurement values.

9510 Macro Usage Examples

Simulating Voltage Interruptions, Sags, and Swells

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

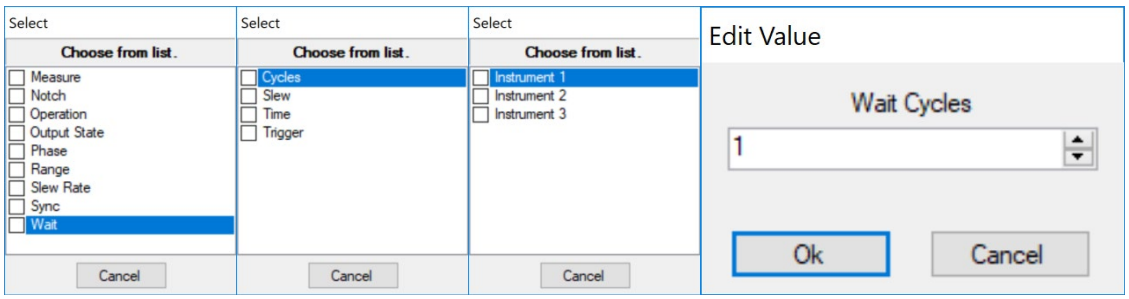


To simulate an interruption, sag, or swell for either an amount of time or cycle(s), complete the following steps:

1. Open the Macro Editor and click the add ()icon beside the first empty cell to insert the first step.

   The first step is commonly selected if the Macro executes commands immediately or synchronously with the A phase or self-phase for 1 phase outputs. This setting applies to only the following Macro commands and does not affect the manual operation.

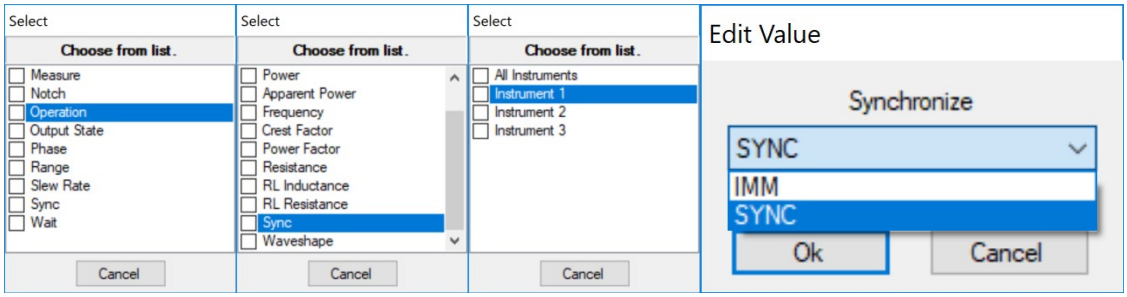
2. To set the number of cycles to occur before the disturbance, select **Wait**, **Cycles**, your instrument, and then enter the number of wait cycles.



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

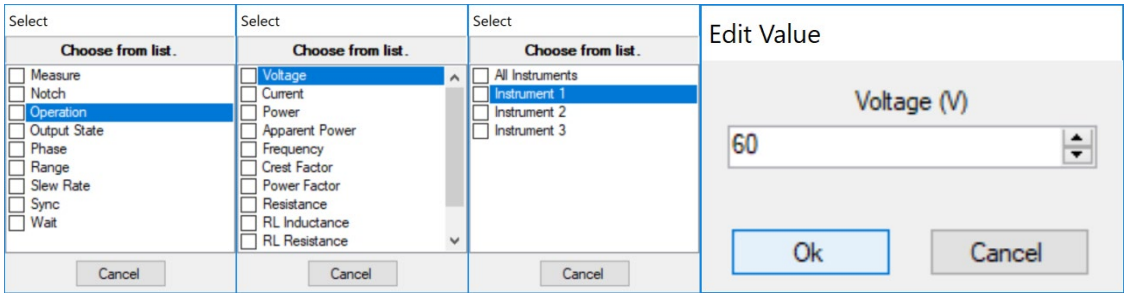
   This step ensures that some number of cycles occur before the change is applied and aligns the following changes based on the change at (deg) angle specified. You can also adjust this angle in the Macro before waiting for the pre-disturbance cycles to complete.

3. To set whether the changes occur immediately or synchronously at the set angle, select **Operation**, **Sync**, your instrument, and then select **IMM** or **SYNC** based on your needs.

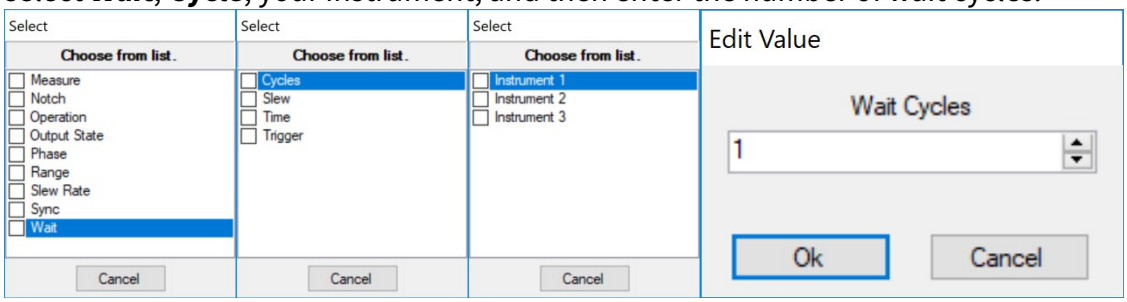


- Immediate (IMM) – Specifies that all the following operation commands are applied immediately after any wait time or cycles expire.
- Synchronous (SYNC) – Specifies that the following operation commands are applied at the next changed at (deg) phase after the wait expires. In general, the command applies on the next cycle.

4. To set the disturbance voltage, click the next open cell and select **Operation**, **Voltage**, your instrument or ϕ, and then enter the voltage value.

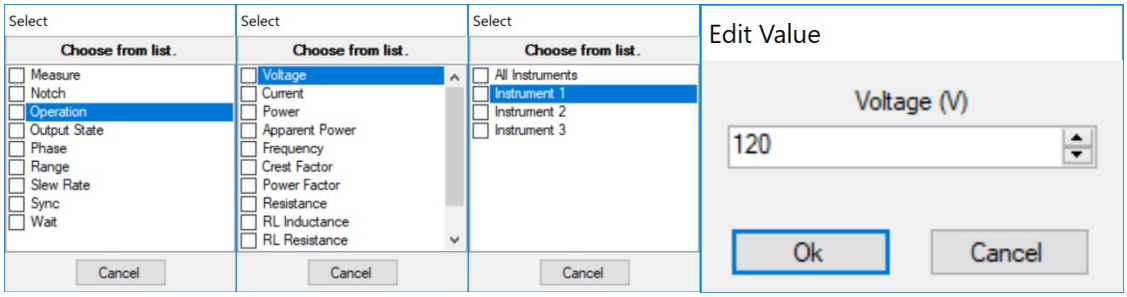


5. To specify the time or cycles when the disturbance is to occur, click the next open cell and select **Wait**, **Cycle**, your instrument, and then enter the number of wait cycles.



NOTE
In IMM Mode: Wait time is the actual time.
In SYNC Mode: Wait time is rounded up to the next complete cycle.

6. To return the output to nominal, select the next open cell and select **Operation**, **Voltage**, your instrument or ϕ, and then enter the voltage value.



The Macro is now complete.

Figure 87: Immediate Mode

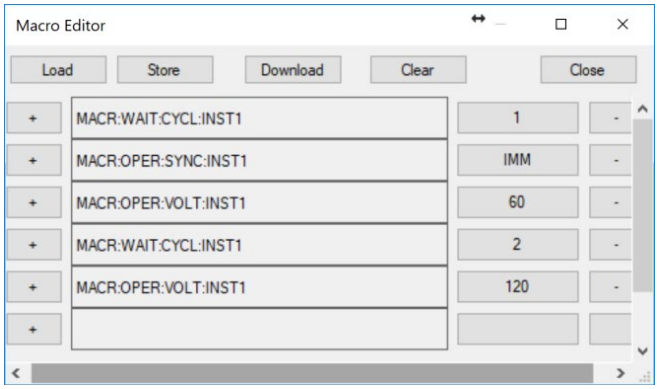
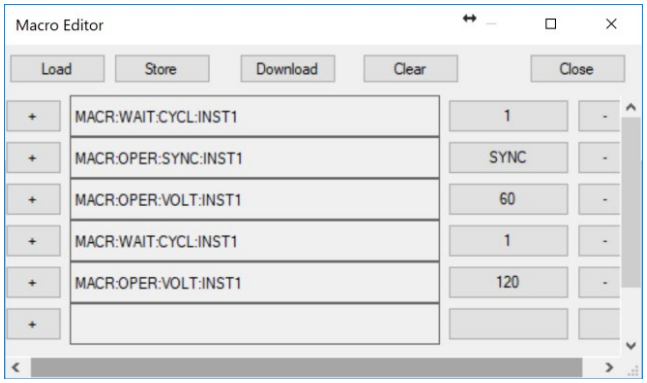
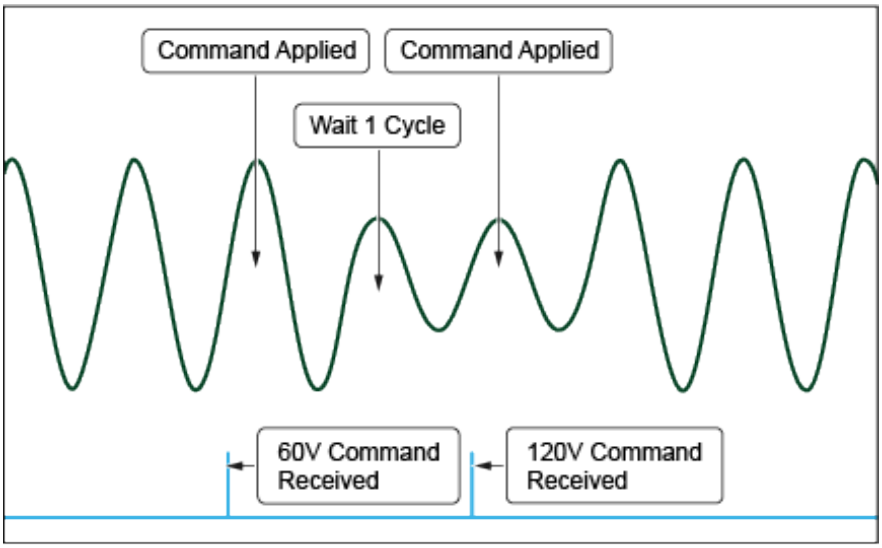


Figure 88: Synchronous Mode



Run the previous Macro, the results is shown in the following output.

Figure 89: Synchronous: Command applied at change at (deg) angle (90 deg)



NOTE
This figure shows the synchronous mode where the command is applied, waits for 1 full cycle, and then releases the next command (120 V) that is applied at the next change at (deg) angle.

Multi-Phase Output Interruptions, Sags, and Swells

You can use the previous steps to adjust individual phases or all phases of a multi-phase output. The following figures show that the Macro is used to produce a two-cycle sag on an individual phase, on both phases simultaneously, and on both phases with the sag starting at 90°, respectively.

Figure 90: Affecting only one phase (split-phase)

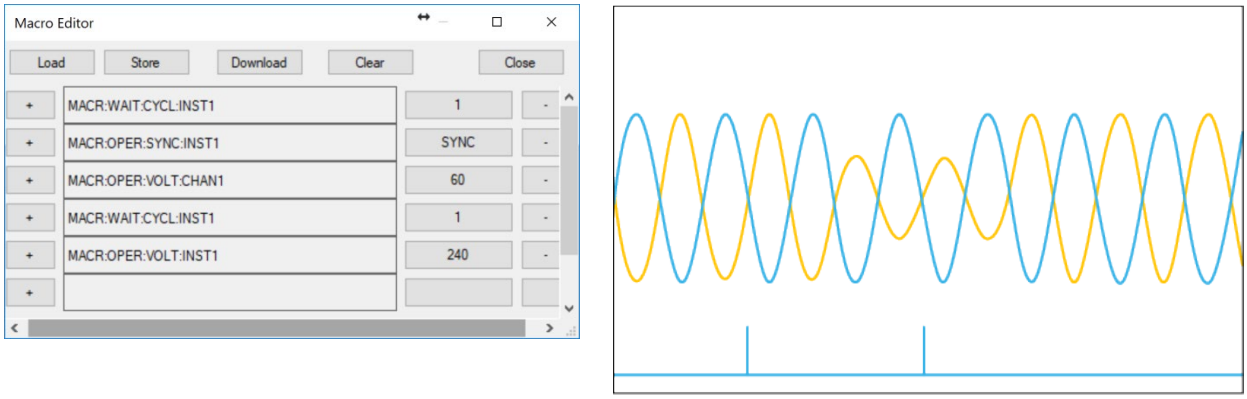


Figure 91: Affecting both phases (split-phase)

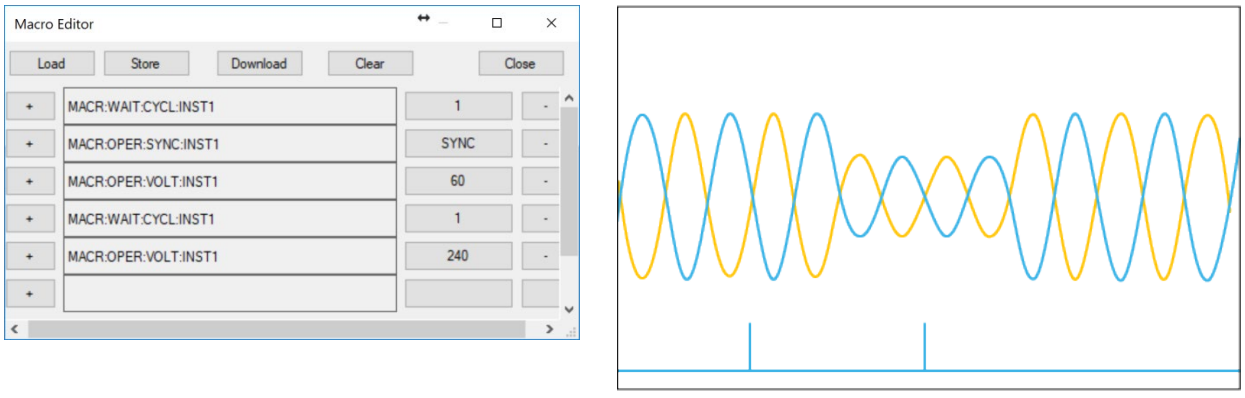
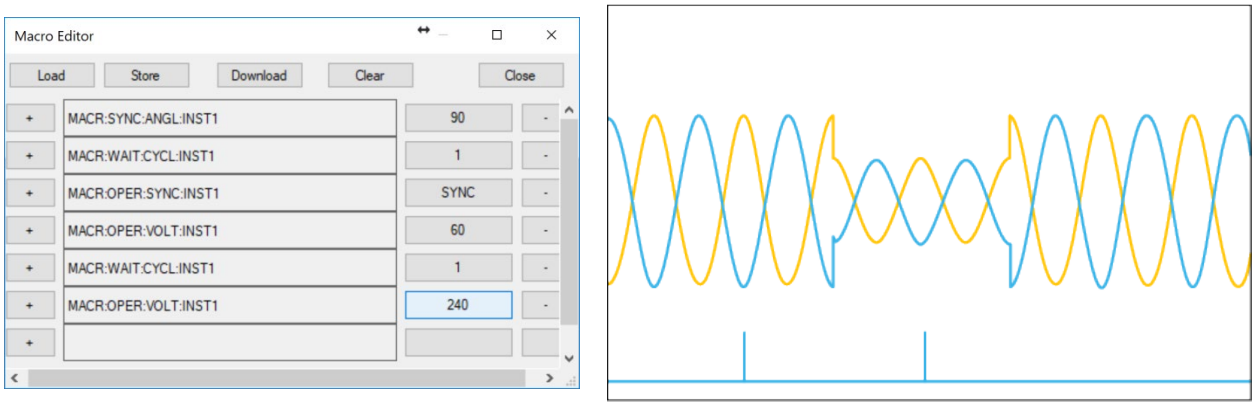


Figure 92: Affecting both phases with 90° change angle



Simulating Sub-Cycle Changes

This section describes how to use a Macro-notch to provide precise control of the amplitude, phase angle, and slew rate of a sub-cycle disturbance. Multiple methods are available for simulating sub-cycle changes. You can choose the method that suits your needs best based on the characteristics of the sub-cycle change desired.

Immediate Mode and Wait Time Method

Use this approach to program disturbances that cross over the 90° internal reference for the A-phase in multi-phase operation or the self-phase for single phase operation. To implement this approach, use the examples in the *Simulating Voltage Interruptions, Sags, and Swells* topic and select **Wait** and then **Time** when specify the time or cycles in step 5.

Selecting an Alternate (User) Wave Shape

Use this approach to simulate disturbances with quick changes, such as line slap. Refer to the *Switching Wave Shapes* section for more details.

Macro Notch

A notch allows precise and slew-rate controlled sub-cycle changes between the 0° and 360° internal reference for the A-phase in multi-phase operation or the self-phase for single phase operation. Notch can be used along with any wave-shapes resulting in a precise control of the amplitude, phase angle, and slew rate of change to make up the disturbance.

A notch consists of four programming steps including:

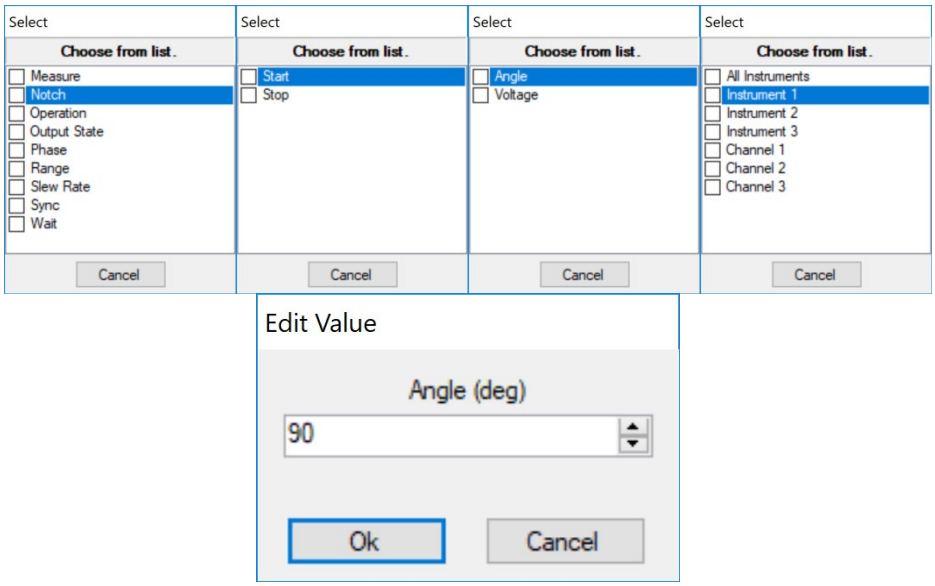
- Start Angle
- Starting Voltage
- End Angle
- Ending Voltage

Slew rate is applied from the pre-notch voltage to the starting voltage and from the starting voltage to the ending voltage.

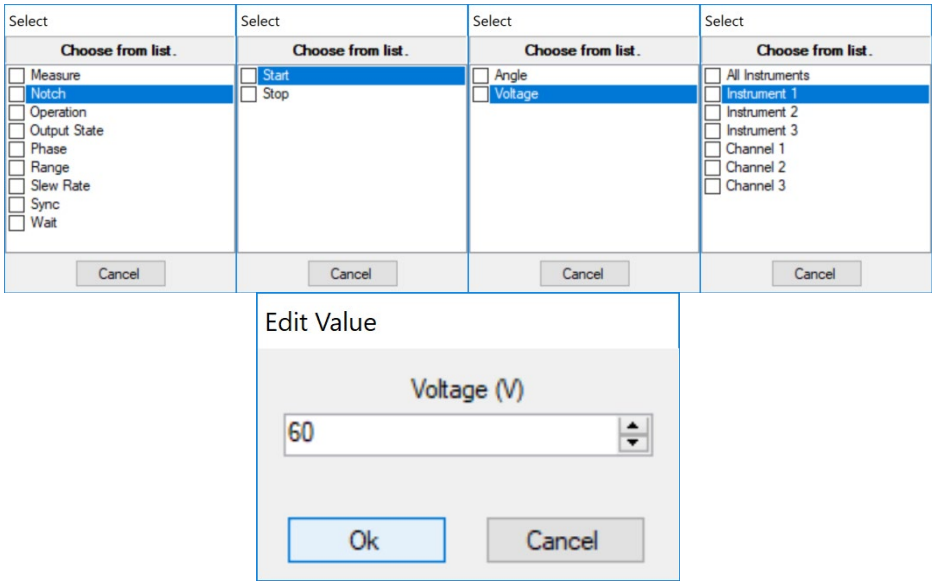
To simulate a notch, complete the following steps:

Open the Macro Editor and click the add () icon beside the first empty cell to insert the first step.

1. To set the starting angle for creating the notch, select the first cell, select **Notch**, **Start**, **Angle**, *your Instrument*, and then enter the start angle.



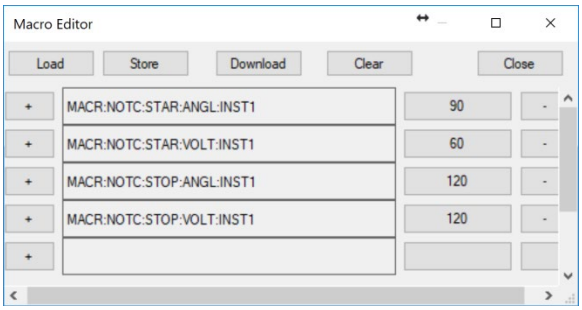
2. To set the starting voltage that the notch should reach, select the next cell, select **Notch**, **Start**, **Voltage**, *your instrument* or ϕ, and then enter the target voltage.



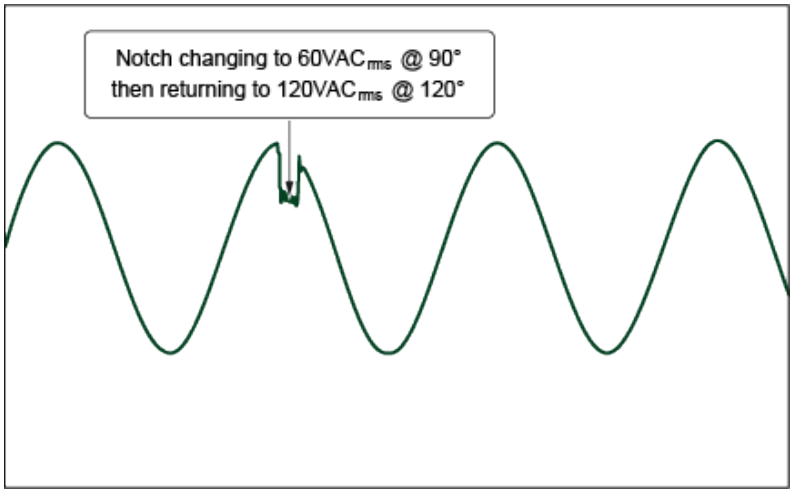
3. Repeat step 2 and step 3 to set the stop angle and voltage. In the following screenshot, the stop angle and voltage is 120° and 120 VAC_{rms}.

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

The Macro is now complete. The following figure is an example of Macro notch settings.

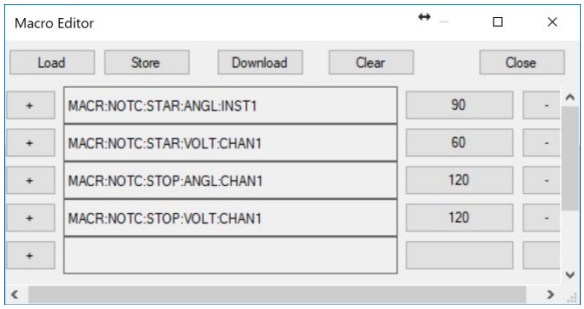


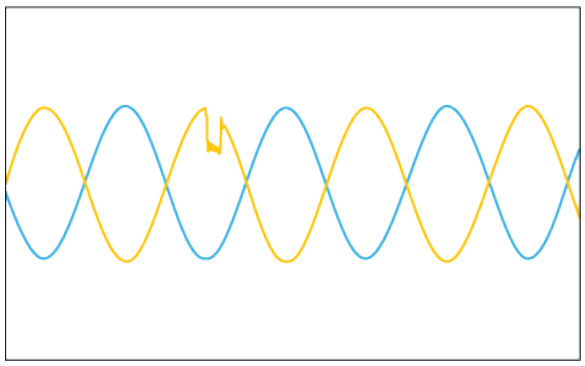
The following figure shows the output of running the previous Macro.



Multi-Phase Notches

Use the same process to notch individual phases of a multi-phase output. The following figures show a notch applied to A-phase of a split phase output using the same Macro setting in the previous example.





Switching Waves Shapes

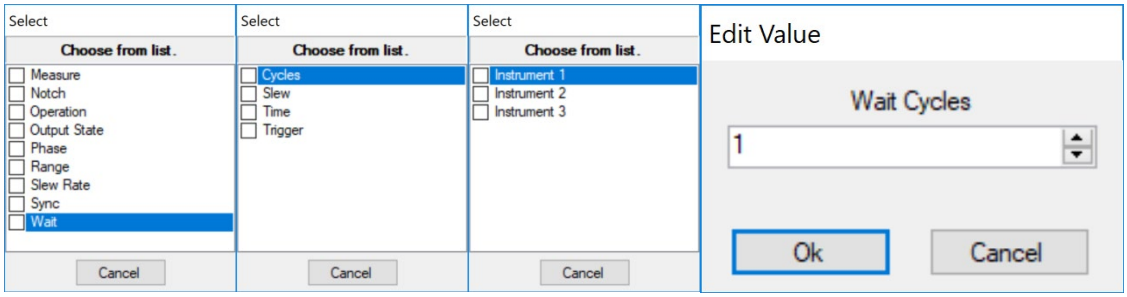
This section describes how to use a Macro to switch wave shapes based on cycles or time. Switching wave shapes is commonly used for a line-slap simulation and may also be used to switch in a noisy sin, a harmonic distorted wave shape, or any other wave shape which has been loaded into the module.

Complete the following steps to switch between wave shapes:

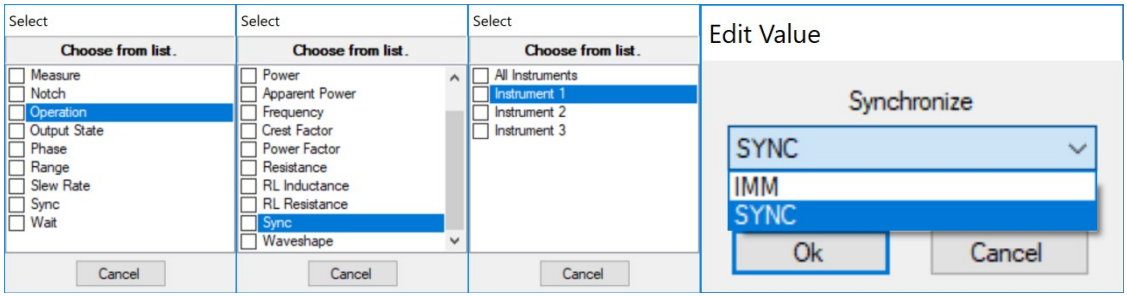
1. Ensure the custom voltage wave shape is loaded into USER 1. Refer to *Editing an Output Wave Shape* for more information.

NOTE
This Macro switches between the standard (sin) and a pre-loaded user voltage wave shapes. This technique allows any of the pre-loaded wave shapes to be applied in a similar manner.

2. Open the Macro editor and click the click the add () icon beside first empty cell.
3. To set the number of cycles to occur before the disturbance, select **Wait**, **Cycle**, your instrument, and then enter the number of wait cycles.

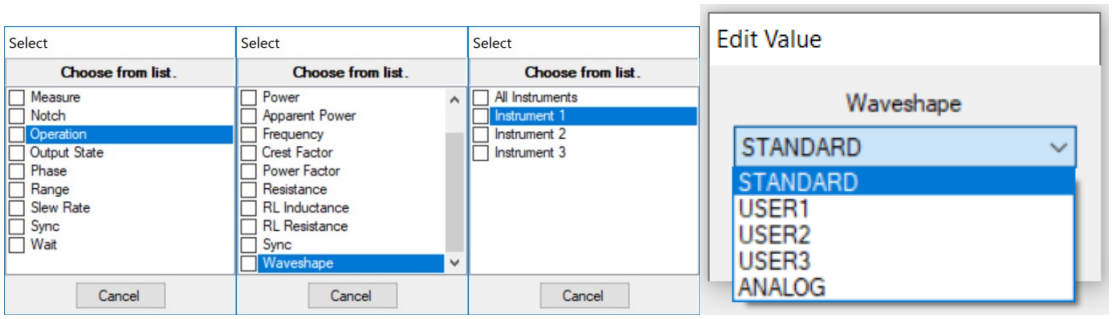


4. To set whether the changes occur immediately or synchronously at the set angle, select **Operation**, ***Sync***, *your instrument*, and then select **IMM** or **SYNC** based on your needs.

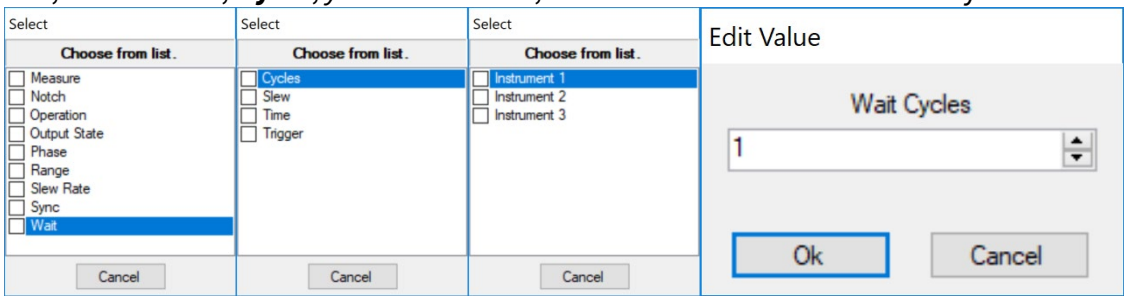


- Immediate (IMM) – Specifies that all the following operation commands are applied immediately after any wait time or cycles expire.
- Synchronous (SYNC) – Specifies that the following operation commands are applied at the next changed at (deg) phase after the wait expires. In general, the command applies on the next cycle.

5. To set the new output wave shape to be used, select **Operation**, **Waveshape**, *your instrument* or ϕ, and then select the output shape.

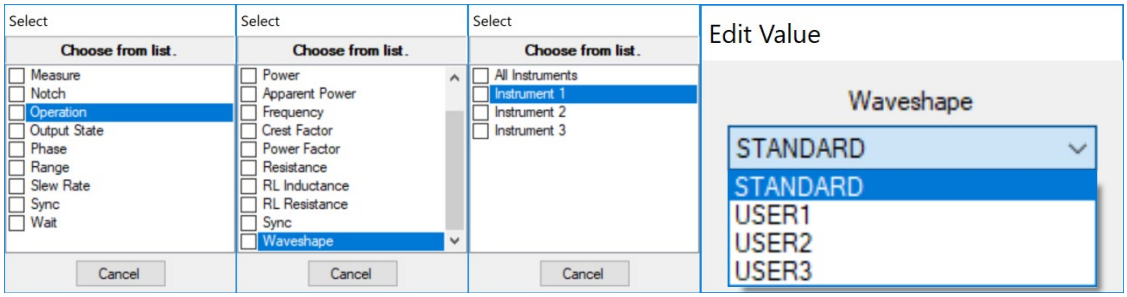


6. **Optional**: To set the time or cycles when the disturbance is to occur, click the next blank cell, select **Wait**, **Cycle**, *your instrument*, and then enter the number of cycles.

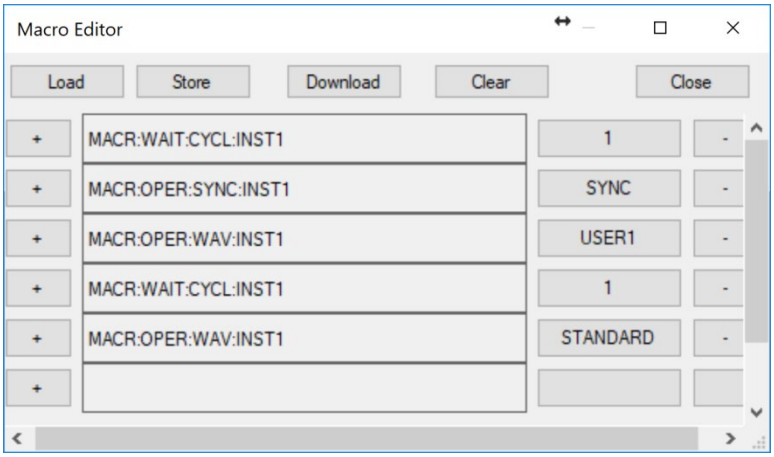


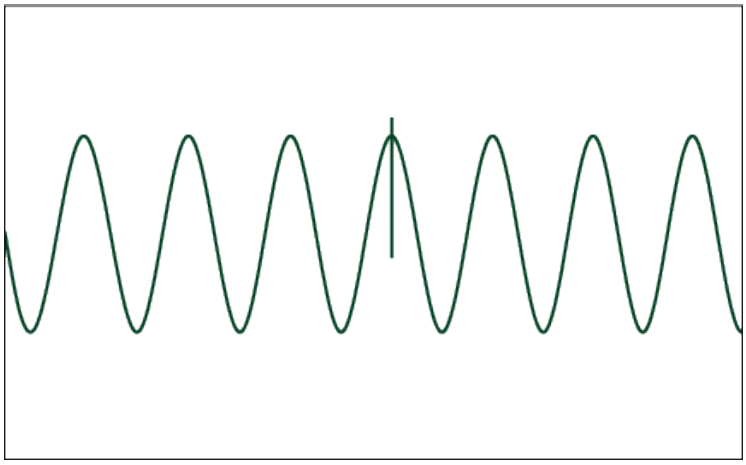
NOTE
In Synchronous (SYNC) operation: Wave shapes requested for the same phase are applied on sequential cycles and do not need a cycle counter.

7. To set the next output wave shape to be used, select **Operation**, **Waveshape**, *your instrument* or ϕ, and then select the output shape.



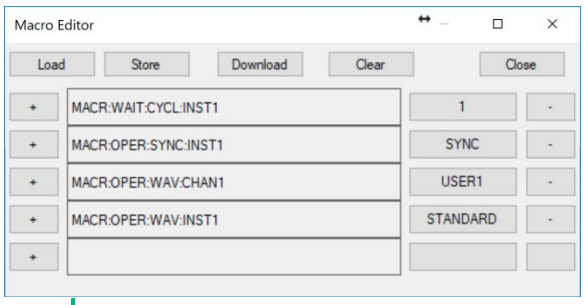
The Macro is now complete. The following figures are an example of changing a one-cycle wave shape from previous shape to USER1 to STANDARD.

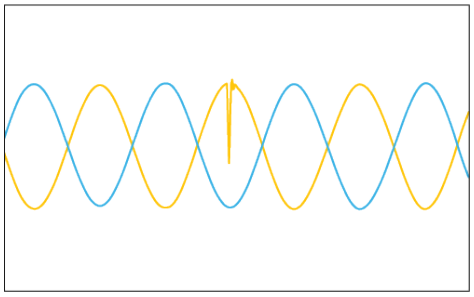




Multi-Phase– Changing a Single Phase

The same approach can be used on any phase of a multi-phase output as the following figure shows.



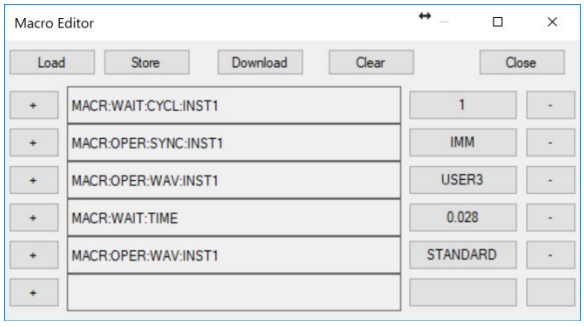


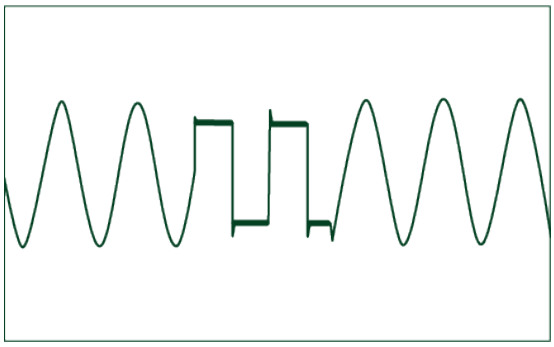
NOTE
In Synchronous (SYNC) operation: Wave shapes requested for the same phase are applied on sequential cycles and do not need a cycle counter.

Using Time-Based Changes

Waiting for a specific time generally requires setting the synchronize mode to immediate (IMM) to ensure an immediate change after the timer expires. By comparison, synchronous (SYNC) operation allows the timer to expire and applies the next operation command at the next change at (deg).

Change the Macro settings as the following figures shows. This example uses USER 3, which is pre-loaded with a square wave.





9510-100 Hardware Modes

To organize the channels, setting a mode with the NHR 9500 Panel PC tool or through any programming interface. Setting the mode allows you to determine if it is a three output AC source, a single output DC source, or anything in-between. There are a total of 13 hardware modes available for 9510 power module. After configuration, the hardware operating mode persists through all resets and power cycles.

Available hardware modes depend on the number of channels installed. Refer to the corresponding sections for details.

Refer to the *NHR 9500 Series AC/DC Power Module Programmer's Reference Manual* (NH Research Part Number: 09-0363) for more information.

CAUTION: POSSIBILITY OF ELECTRIC SHOCK
The fixture wiring must match the selected hardware operating mode. Failure to ensure may result in damage to the 9500 series, fixture-wiring, or the UUT.

ATTENTION: POSSIBILITÉ DE CHOC ÉLECTRIQUE
Le câblage de l'appareil doit correspondre au mode de fonctionnement du matériel sélectionné. Le non-respect de ces instructions peut endommager les appareils de la série 9500, le câblage des appareils ou l'appareil sous test.

9510 (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 NI’s recommended wiring for each mode.

9510 (3-Channel Version) - Mode 0: One 3-Phase AC

Figure 93: Logical Instrument Configuration and UUT Wiring in Mode 0: One 3-Phase AC

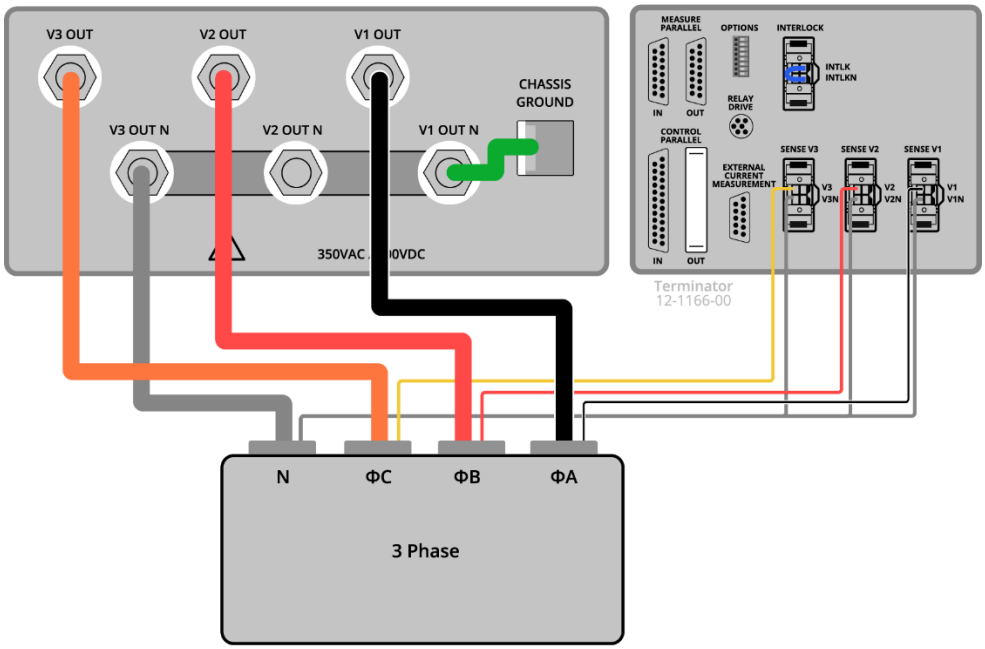


Table 18: 9510-100 Key Maximums

3-Phase AC 1 (par)	9510-100
Max Power	100 kW
Max Voltage	350 V_{rms} Line-Neutral, 606 V Line-Line
Max Current/Phase	200 A_{rms}

9510 (3-Channel Version) - Mode 1: One AC

Figure 94: Logical Instrument Configuration and UUT Wiring in Mode 1: One AC

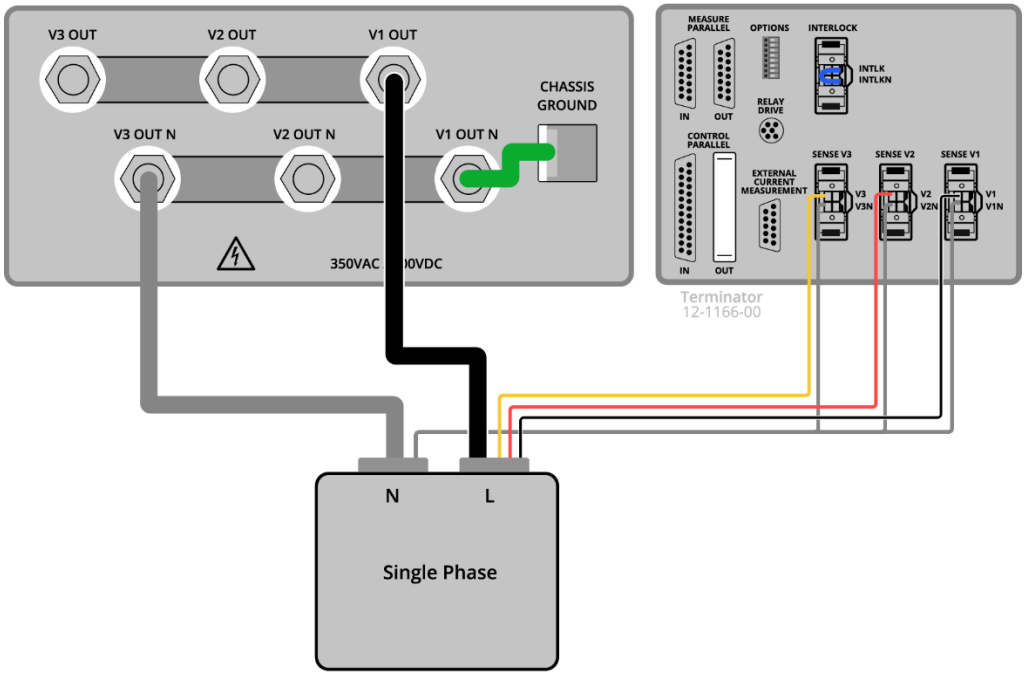


Table 19: 9510-100 Key Maximums

AC 1 (par)	9510-100
Max Power	100 kW
Max Voltage	350 V_{rms} Line-Neutral
Max Current	600 A

9510 (3-Channel Version) - Mode 2: One DC

Figure 95: Logical Instrument Configuration and UUT Wiring in Mode 2: One DC

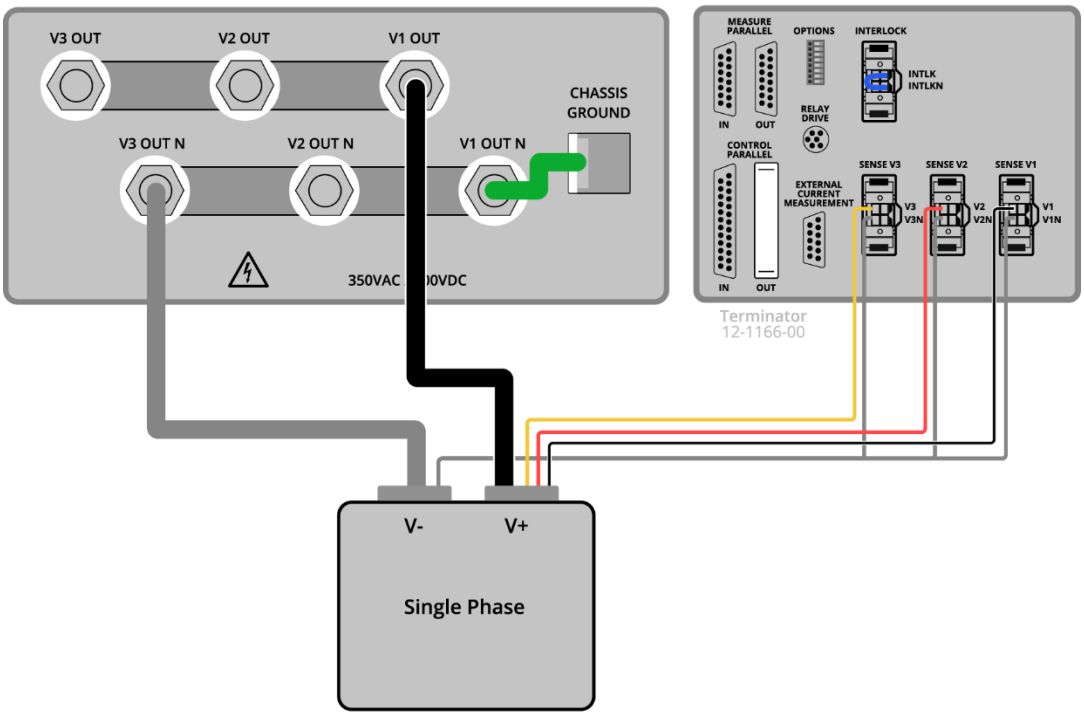


Table 20: 9510-100 Key Maximums

DC 1 (par)	9510-100
Max Power	100 kW
Max Voltage	400 VDC
Max Current	600 A

9510 (3-Channel Version) - Mode 3: Three AC

Figure 96: Logical Instrument Configuration and UUT Wiring in Mode 3: Three AC

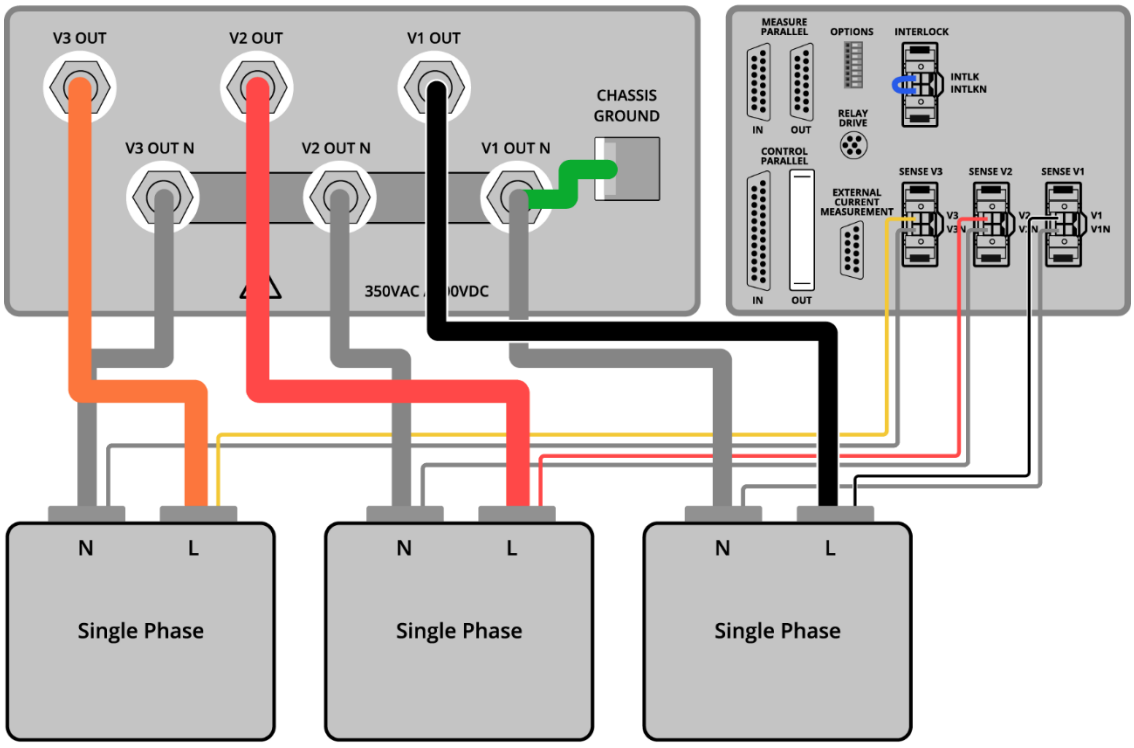


Table 21: 9510-100 Key Maximums

AC 1, AC 2, and AC 3 (par)	9510-100
Max Power per Channel	33.3 kW
Max Voltage	350 V_{rms} Line-Neutral
Max Current per Channel	200 A_{rms}

9510 (3-Channel Version) - Mode 4: Three DC

Figure 97: Logical Instrument Configuration and UUT Wiring in Mode 4: Three DC

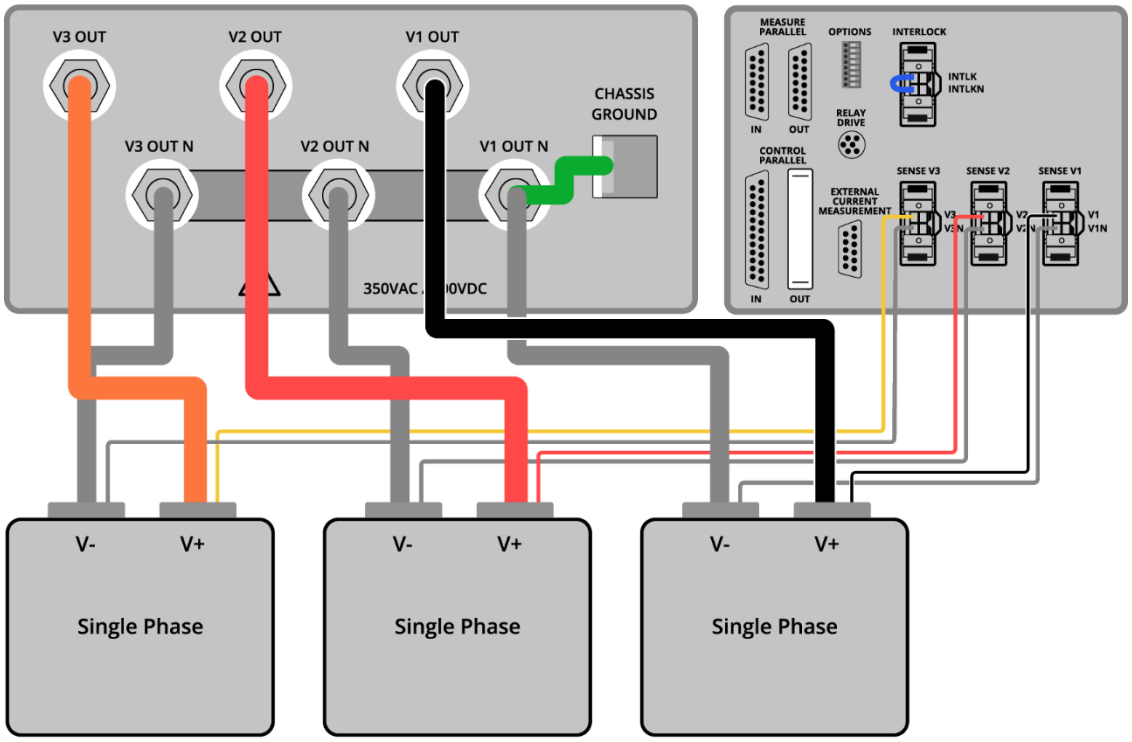


Table 22: 9510-100 Key Maximums

DC1, DC2, and DC3	9510-100
Max Power per Channel	33.3 kW
Max Voltage	400 VDC
Max Current per Channel	200 A

9510 (3-Channel Version) - Mode 5: One 2-Phase AC and One AC

Figure 98: Configuration and UUT Wiring in Mode 5: One 2-Phase AC and One AC

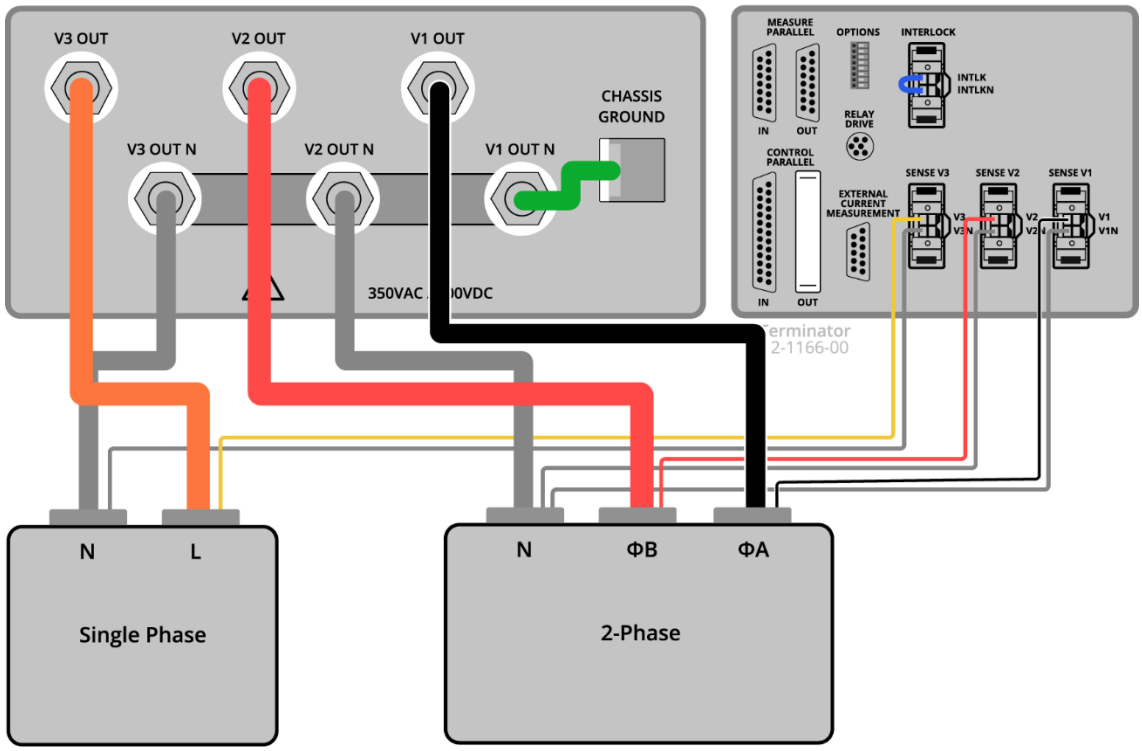


Table 23: 9510-100 Key Maximums in 2-Phase AC1

2-Phase AC1	9510-100
Max Power	66.6 kW
Max Voltage	250 V_{rms} Line-Neutral, 500 V_{rms} Line to Line
Max Current per Phase	200 A_{rms}

Table 24: 9510-100 Key Maximums in AC3

AC3	9510-100
Max Power per Channel	33.3 kW
Max Voltage	350 V_{rms} Line-Neutral

Max Current per Channel	200A_{rms}

9510 (3-Channel Version) - Mode 6: One 2-Phase AC and One DC

Figure 99: Configuration and UUT Wiring in Mode 6: One 2-Phase AC and One DC

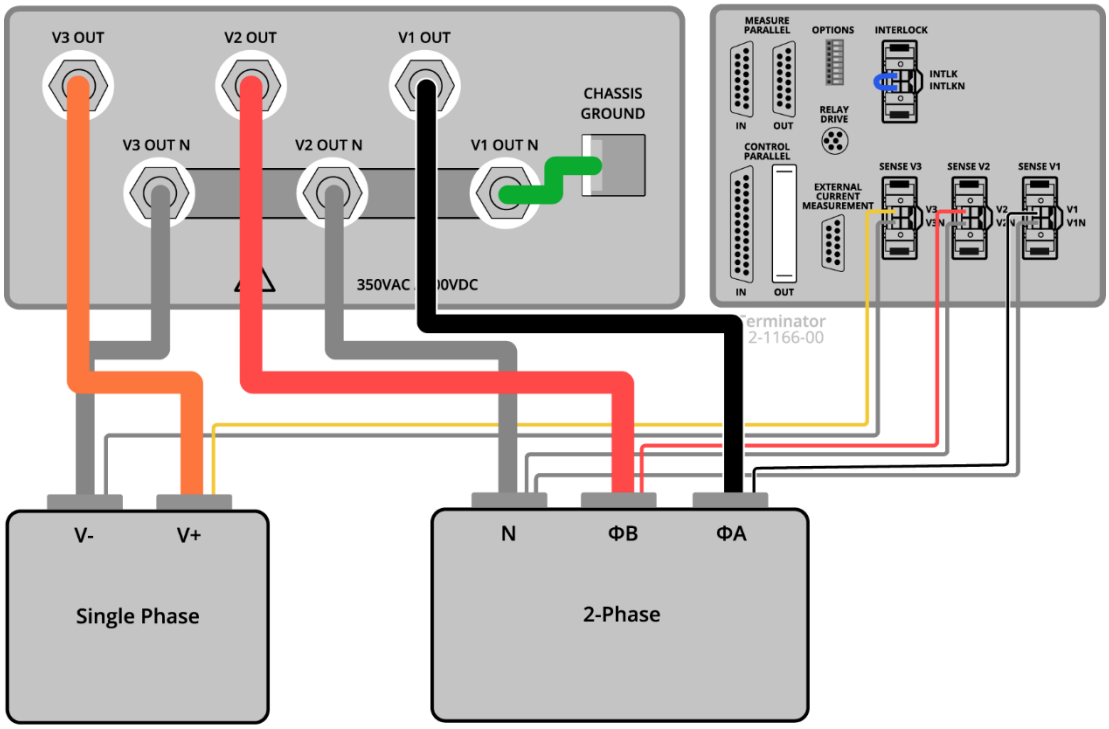


Table 25: 9510-100 Key Maximums in 2-Phase AC1

2-Phase AC1	9510-100
Max Power	66.6 kW
Max Voltage	250 V_{rms} Line-Neutral , 500 V_{rms} Line to Line
Max Current per Phase	200 A_{rms}

Table 26: 9510-100 Key Maximums in 2-Phase DC3

2-Phase DC3	9510-100
Max Power	33.3 kW
Max Voltage	400 VDC
Max Current	200 A

9510 (3 Channel Version) - Mode 7: Two AC

Figure 100: Configuration and UUT Wiring in Mode 7: Two AC

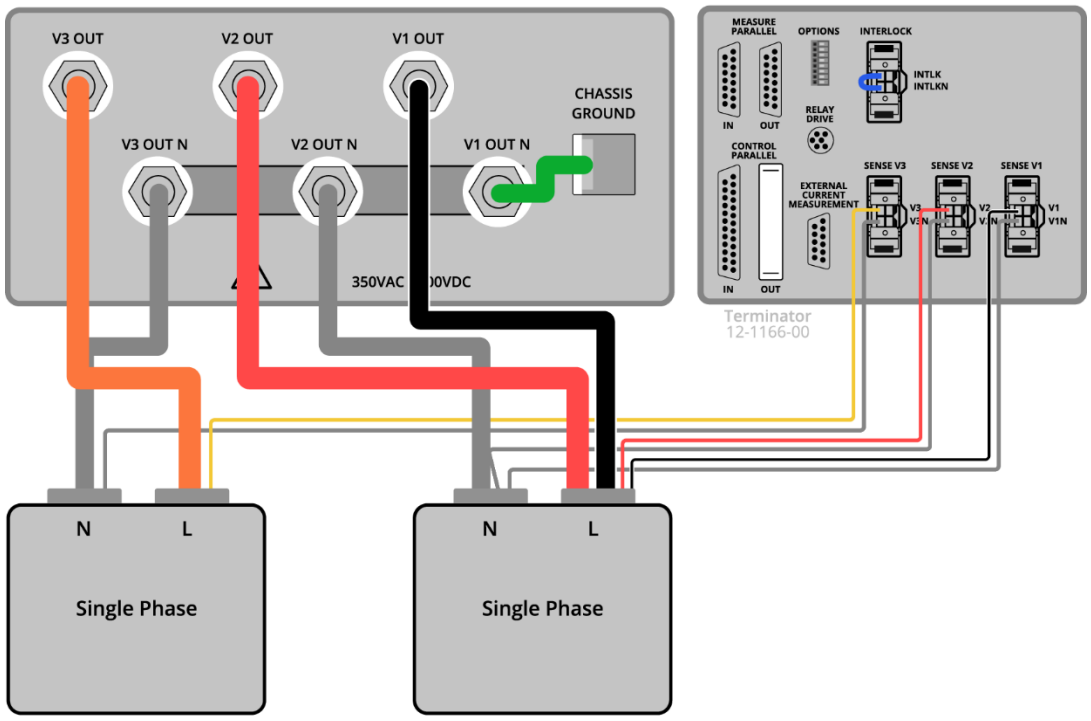


Table 27: 9510-100 Key Maximums in AC1 (par)

AC1 (par)	9510-100
Max Power	66.6 kW
Max Voltage	350 V_{rms} Line-Neutral
Max Current per Phase	400 A_{rms}

Table 28: 9510-100 Key Maximums in AC3

AC3	9510-100
Max Power per Channel	33.3 kW
Max Voltage	350 V_{rms} Line-Neutral
Max Current per Channel	200 A_{rms}

9510 (3-Channel Version) - Mode 8: One AC and One DC

Figure 101: Configuration and UUT Wiring in Mode 8: One AC and One DC

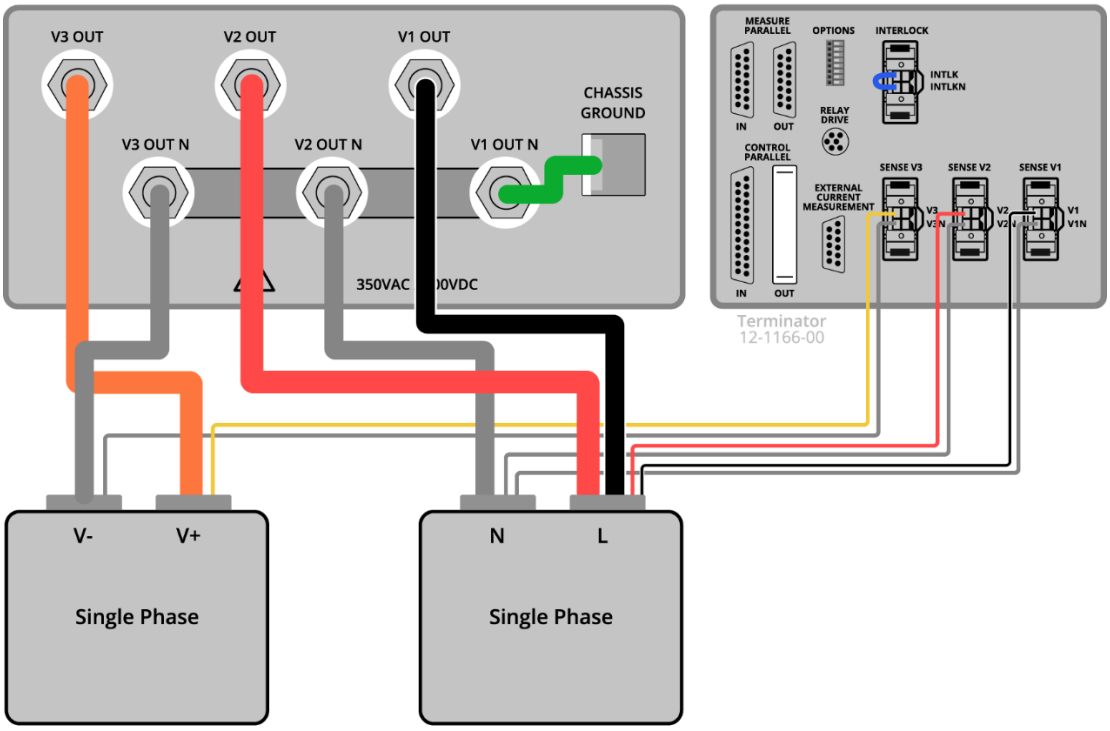


Table 29: 9510-100 Key Maximums in AC1 (par)

AC1 (par)	9510-100
Max Power	66.6 kW
Max Voltage	350 V_{rms} Line-Neutral
Max Current per Phase	400 A_{rms}

Table 30: 9510-100 Key Maximums in DC3

DC3	9510-100
Max Power	33.3 kW
Max Voltage	400 VDC
Max Current	200 A

9510 (3-Channel Version) - Mode 9: Two AC and One DC

Figure 102: Configuration and UUT Wiring in Mode 9: Two AC and One DC

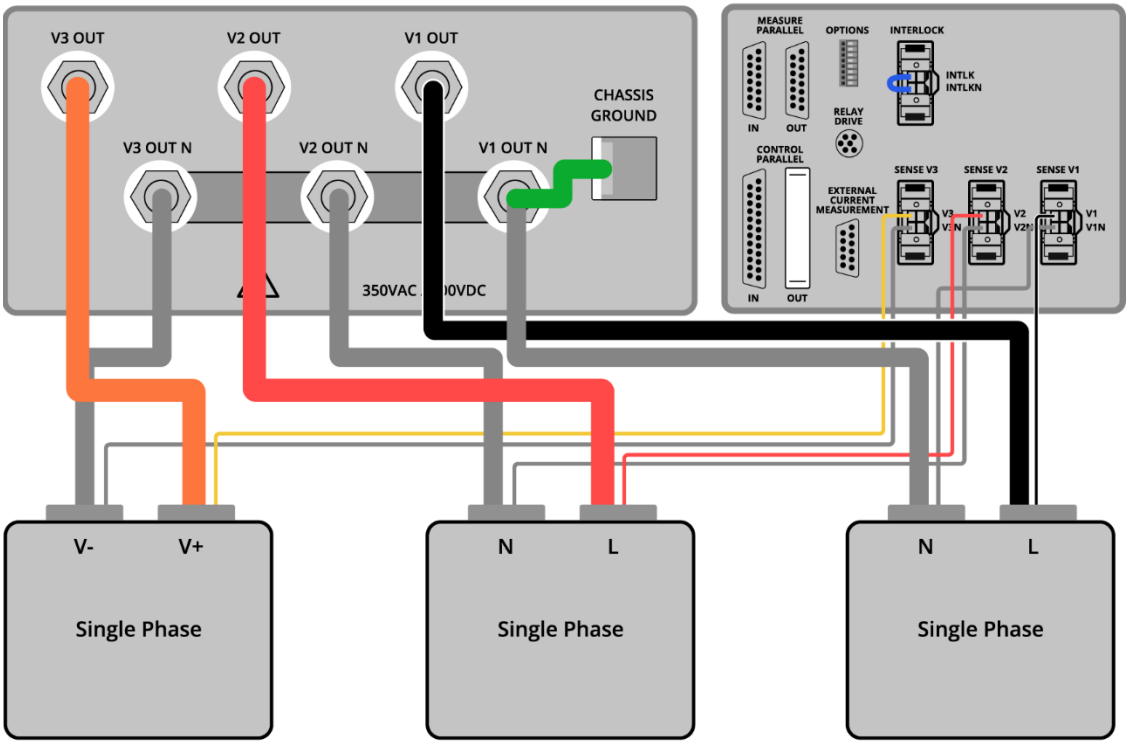


Table 31: 9510-100 Key Maximums in AC1

AC1 and AC2	9510-100
Max Power per Channel	33.3 kW
Max Voltage	350 V_{rms} Line-Neutral
Max Current per Channel	200 A_{rms}

Table 32: 9510-100 Key Maximums in AC3

AC3	9510-100
Max Power	33.3 kW
Max Voltage	400 VDC
Max Current	200 A

9510 (3-Channel Version) - Mode 10: One AC and Two DC

Figure 103: Configuration and UUT Wiring in Mode 10: One AC and Two DC

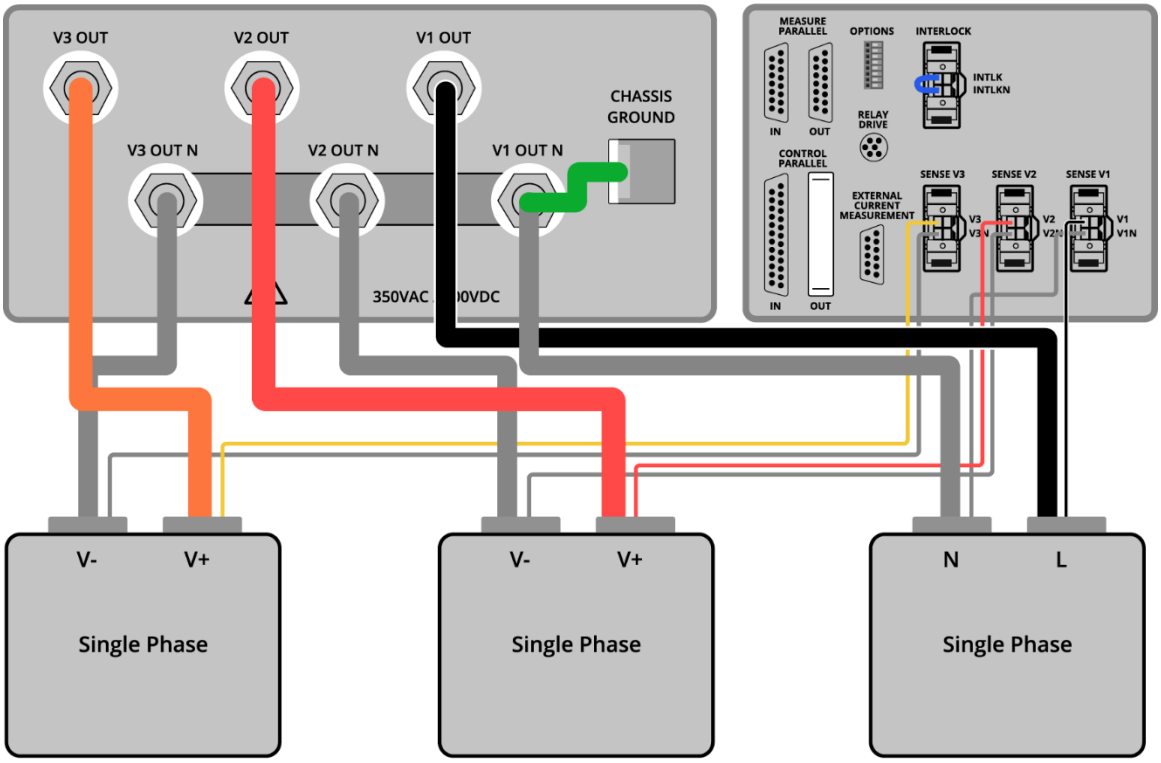


Table 33: 9510-100 Key Maximums in AC1

AC1	9510-100
Max Power per Channel	33.3 kW
Max Voltage	350 V_{rms} Line-Neutral
Max Current per Channel	200 A_{rms}

Table 34: 9510-100 Key Maximums in DC2 and DC3

DC2 and DC3	9510-100
Max Power	33.3 kW
Max Voltage	400 VDC
Max Current	200 A

9510 (3-Channel Version) - Mode 11: One DC and One AC

Figure 104: Configuration and UUT Wiring in Mode 11: One DC and One AC

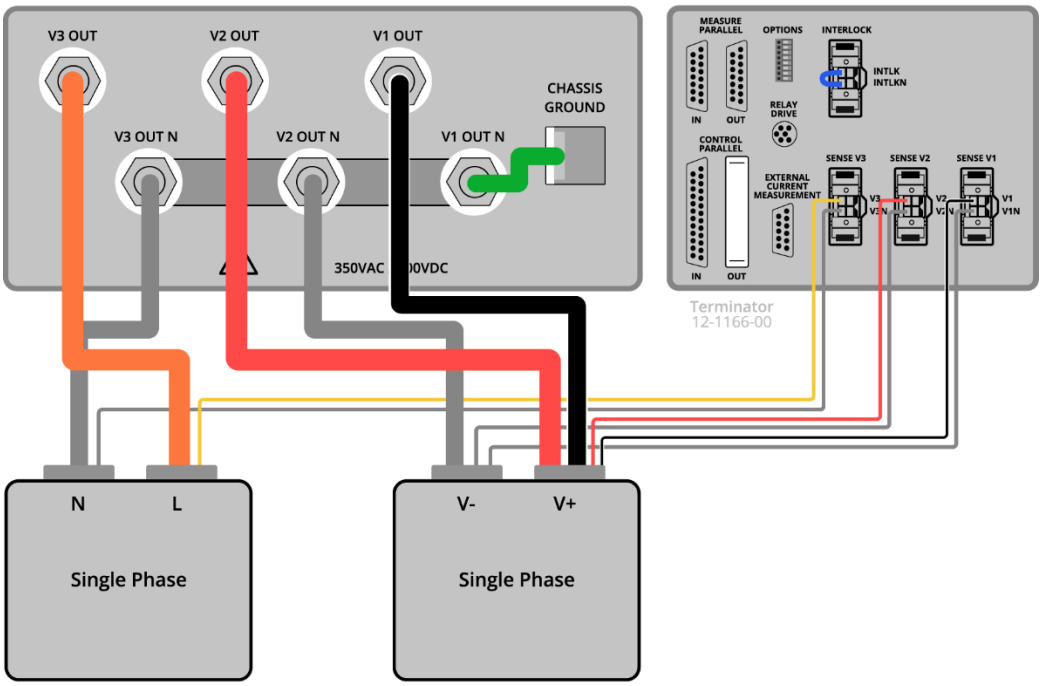


Table 35: 9510-100 Key Maximums in DC1 (par)

DC 1 (par)	9510-100
Max Power	66.6 kW
Max Voltage	400 VDC
Max Current	400 A

Table 36: 9510-100 Key Maximums in AC3

AC3	9510-100
Max Power per Channel	33.3 kW
Max Voltage	350 V_{rms} Line-Neutral
Max Current per Channel	200 A_{rms}

9510 (3-Channel Version) - Mode 12: Two DC

Figure 105: Configuration and UUT Wiring in Mode 12: Two DC

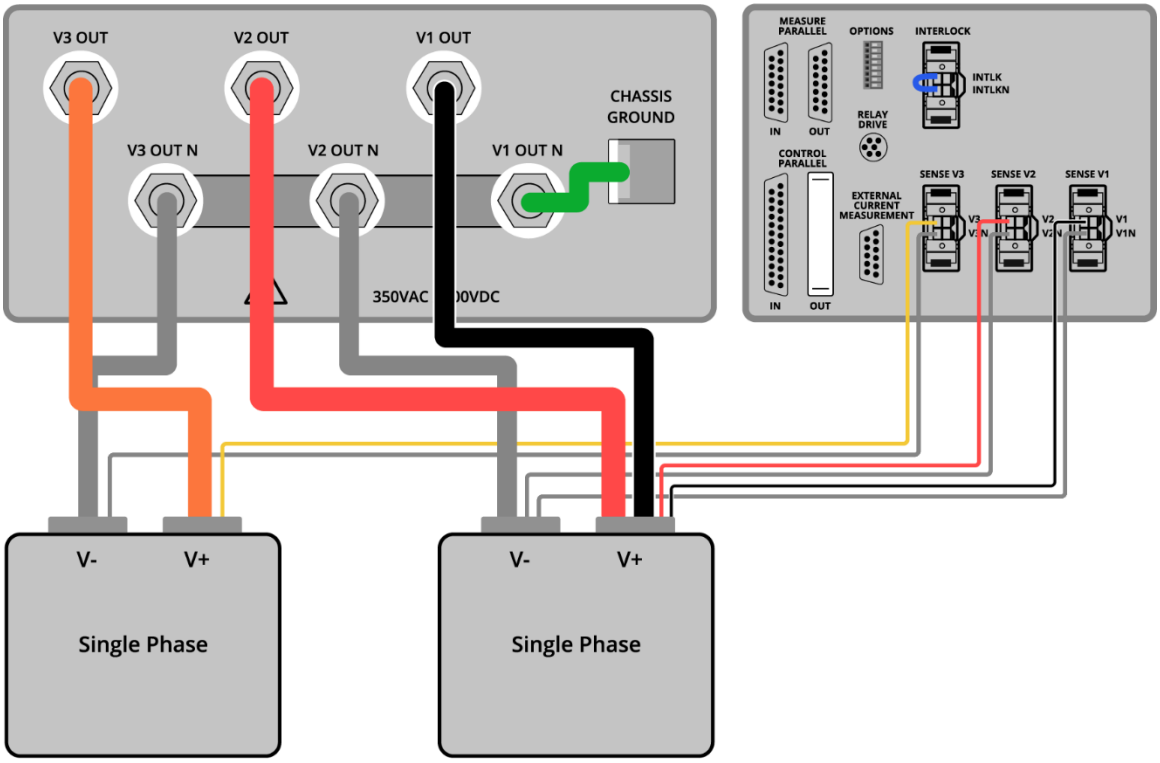


Table 37: 9510-100 Key Maximums in DC1 (par)

DC1 (par)	9510-100
Max Power	66.6 kW
Max Voltage	400 VDC
Max Current	400 A

Table 38: 9510-100 Key Maximums in DC3

DC3	9510-100
Max Power	33.3 kW
Max Voltage	400 VDC
Max Current	200 A

Maintenance

Firmware Updates

There are three separate processors and firmware levels that may periodically require NI to issue a firmware update. 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 provides only a high level guide for NI support personnel or customers who have already performed a firmware update.

NOTE
Discuss the firmware update process with NI customer support before performing an update.

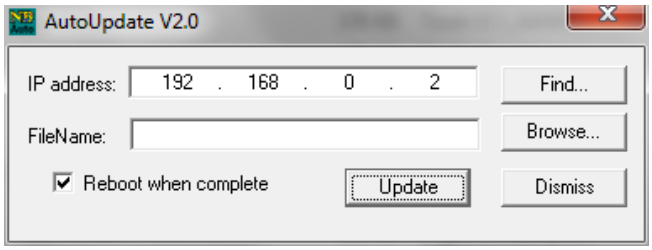
Updating the Network Processor

The network processor or a net burner provides the communication between the LAN interface and the internal processors. This processor decodes the SCPI commands and converts them to the command interface used within the 9500 series, including the 9510-100.

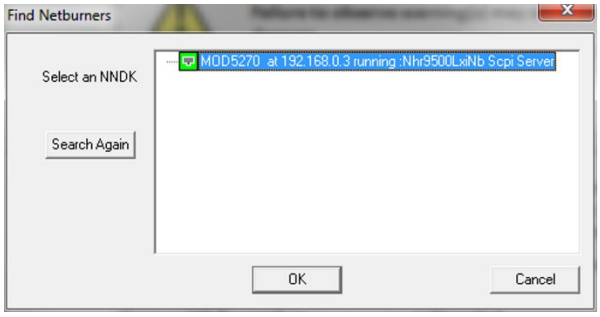
Use AutoUpdate.exe, on the local PC where the 9500 Tools were installed to update the processor.

Contact NI customer support if needed.

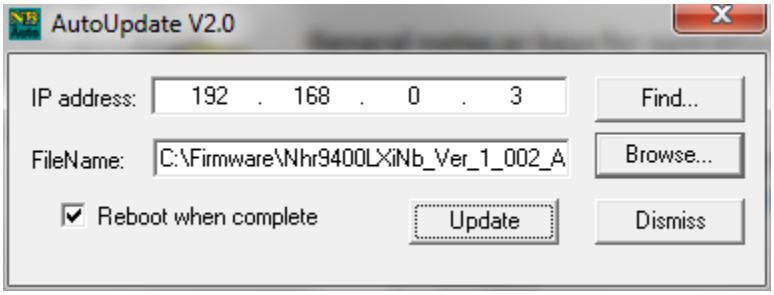
1. Close all external applications and launch AutoUpdate.exe. The following window appears.



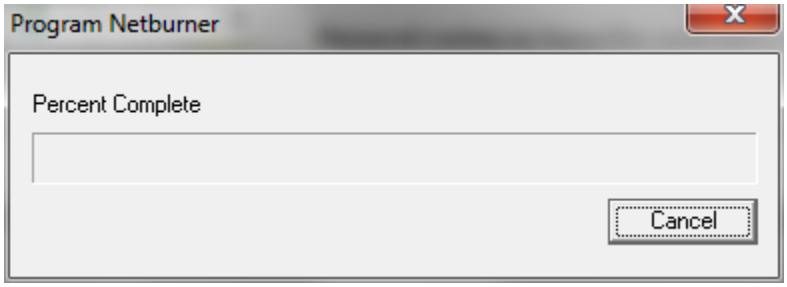
2. Enter the correct IP address or click **Find** to locate net-burner processors. The 9500 Tool shows that it is running Nhr9500LxiNb SCPI Server.

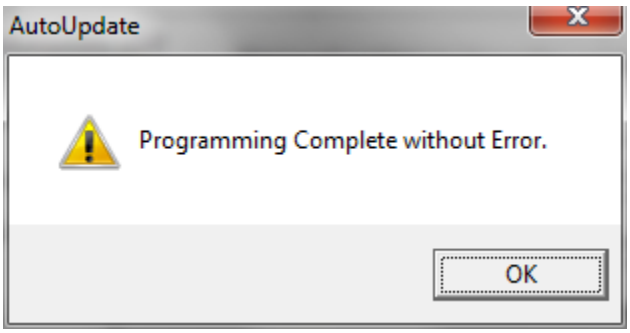


3. Click **Browse** to locate the firmware file provided by customer support.



4. Click **Update**. The utility shows a progress bar and then a message indicating the programming is complete.





5. Close the update utility and cycle power on the 9500.

Updating the Internal Processors

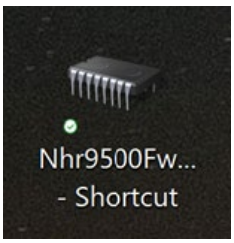
This topic provides only a high level guide for NI support personnel or customers who have already performed a firmware update.

Before updating the firmware, ensure that:

- All external control programs, including NHR 9500 Panel, are closed.
- The system is powered off.

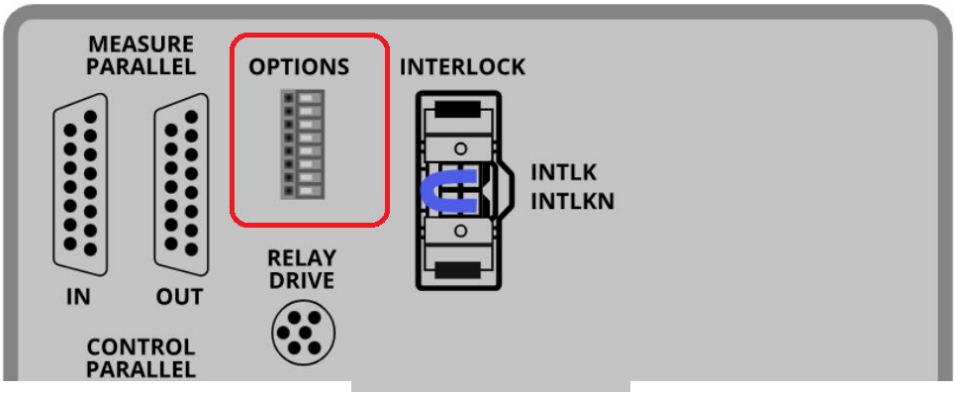
Use one of the following methods to find the firmware update utility:

- Go to Start → All Programs → NH Research → 9500 Series → NHR 9500 Firmware Update
- Browse to the following directory on the local hard drive: C:\Program Files (x86)\NH Research\NHR 9500\Utilities\Nhr9500FwUpdate.exe

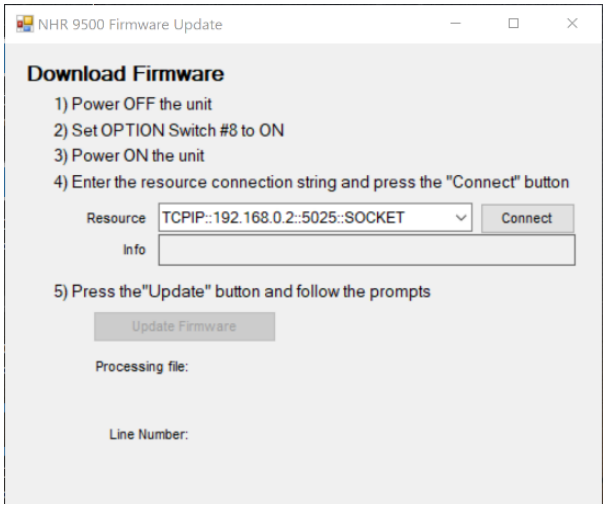


Complete the following steps to update the internal processors:

1. Power off the unit.
2. Set the options dip switch 8 to ON. The options dip switch is located at the rear interface, and position 8 is the bottom one. Refer to the *Options Dip Switches* section details.



3. Ensure that the LAN cable is connected.
4. Power on the unit and launch the firmware update utility.



5. Enter the resource connection string in the following form: “TCPIP::(ipaddress)::SOCKET”

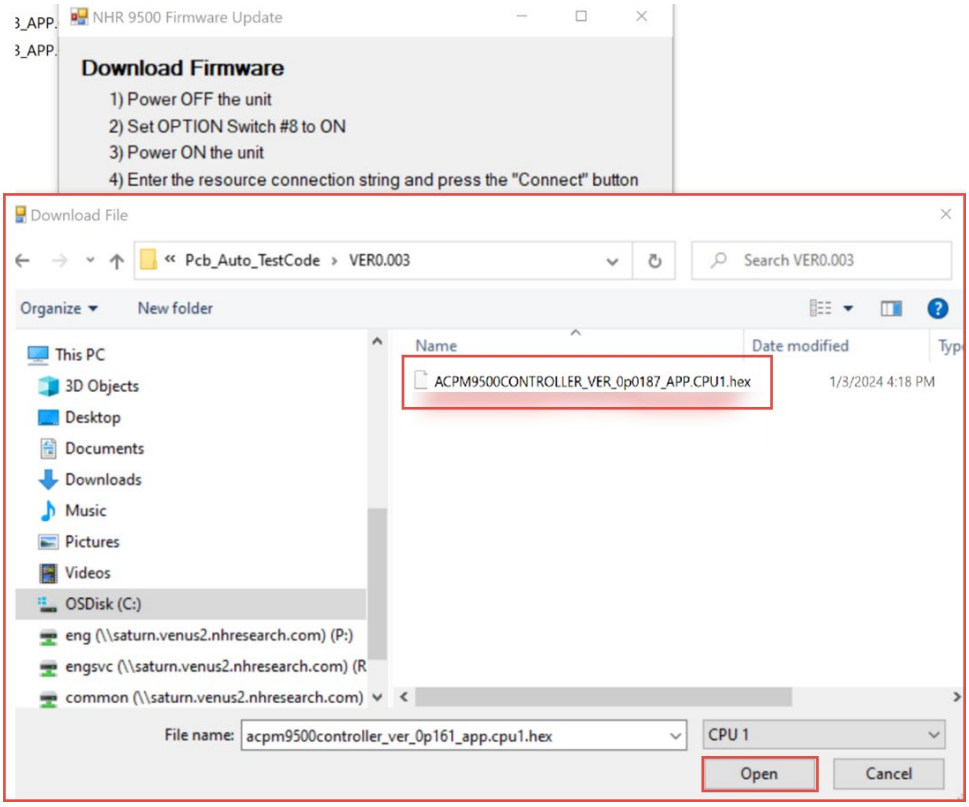
   IP ADDRESS 192.168.0.2 shown in the previous figure is an example. The TCP/IP address is specified on the back label and you can change it by following the steps in the *Configuring the IP Address* topic.

   NOTE
   Ensure that you use double colons in the resource ID string.

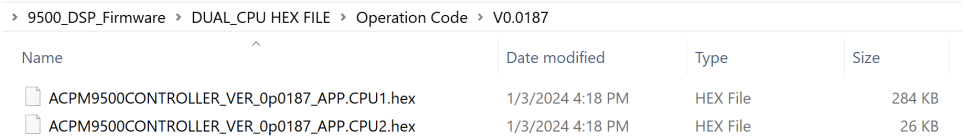
6. Click **Connect**. The system connects successfully or displays an error message. If an error occurs, close the firmware update utility, fix the error, and try again.

7. After connection succeeds, click **Update Firmware**.
8. In the pop-up Download File window, browse to locate the firmware file (filename.CPU1.hex) provided by NI customer support and click **Open**. Then the download starts.

   It generally takes a few minutes to download the controller board firmware. A Download Complete message appears after the software is successfully downloaded.

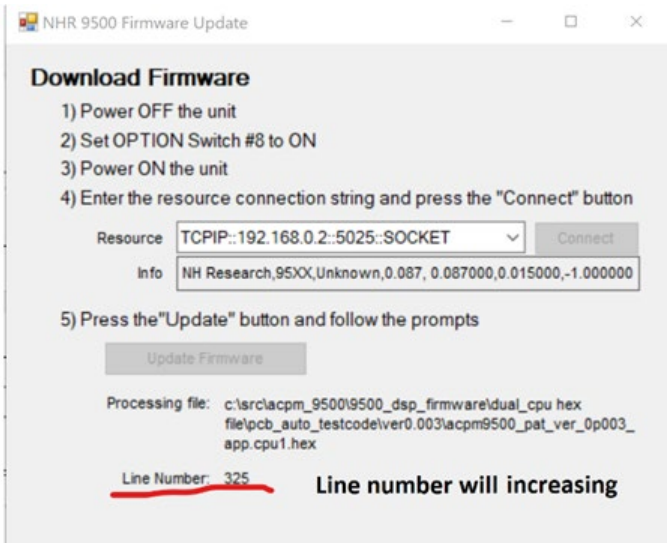


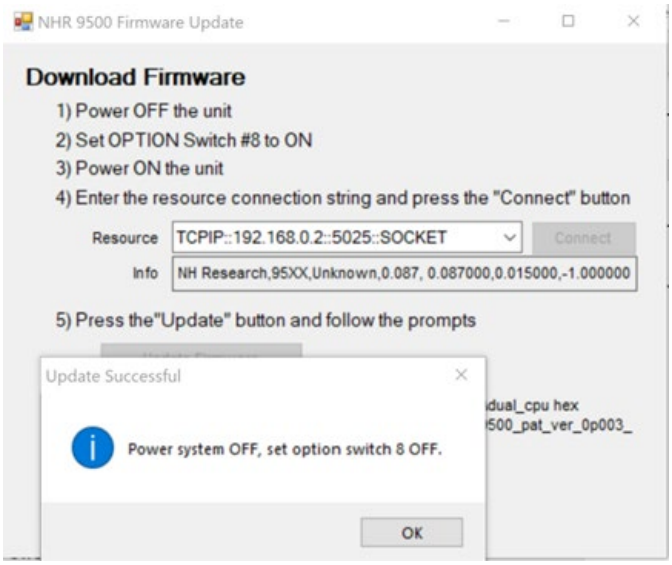
The 9500 series uses a dual-core DSP, and therefore NI provides two files in case there is a need for DSP firmware update. These two files has the same filename except the suffix before the file extension: one is named *filename*.CPU1.hex and the other is named *filename*.CPU2.hex . You must put these two files in the same directory as the following screenshot shows.



Only the first file shows in the Download File pop-up window. You need to select only the first file and the firmware update utility can automatically find the second file with the same filename.

9. Wait until a successful download message is prompted.





10. Close the firmware update utility, return the options dip switch 8 back to the OFF (Left) state, and power off the 9510 system.

NOTE
Do not change any other options dip switches.

Upgrading the Firmware

You can upgrade the NHR 9500 Panel Firmware in Android using a basic USB thumb drive.

Complete the following steps to upgrade the firmware.

Preparing the drive

The NHR 9500 Panel Firmware is provided as an Android installation package file with .apk file extension. The typical name of the file is 9500Panel-XXX.apk.

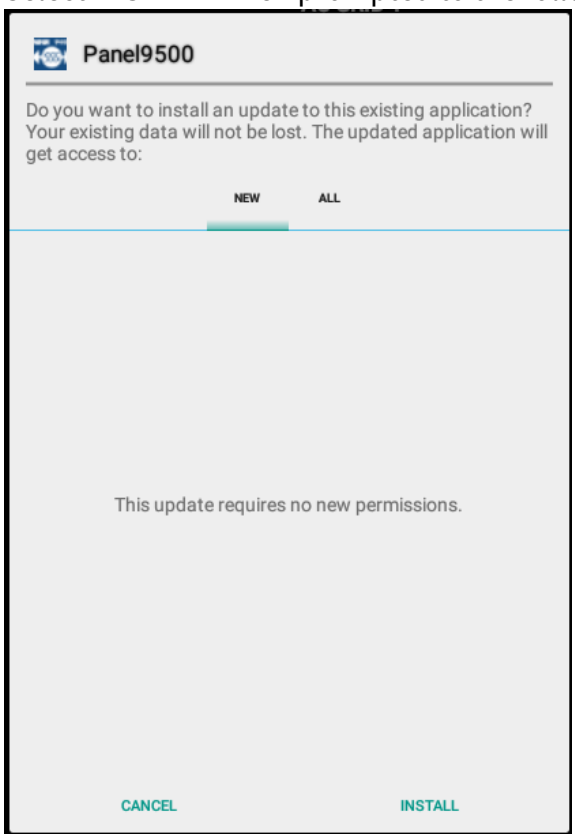
The following directory structure needs to be created on the thumb drive: NHR9500/Firmware.

Copy the .apk file into the Firmware directory on the drive. Eject the drive from PC/Laptop.

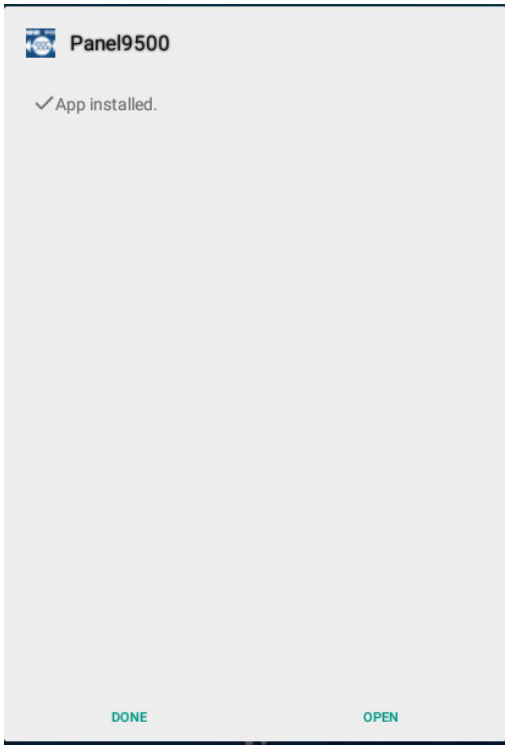
Performing an Actual Upgrade Process

1. Insert the drive into the USB slot at the front of the unit.
2. The touch panel detects the drive and check for the newer version of firmware.
3. If the firmware version on the drive is newer than the one installed on the touch panel, the following message will be prompted. Select **Yes** if you want to upgrade.

4. Select **INSTALL** when prompted to the following message in Android:



5. Wait until the upgrade is successfully complete.



After upgrading the NHR 9500 Panel Firmware, power cycle the 9510-100.

Periodic Maintenance

NI recommends the following periodic maintenance schedule that may need to be modified based on the environment or specific customer needs.

Maintenance	Period
Cleaning	Semi-Annual (every 6 months)
Calibration	Annual

Periodic Cleaning

CAUTION
Always turn off facility power to the 9510 before attempting to inspect or clean the system.

Failure to do so can result in a hazardous condition.

ATTENTION
Toujours mettre le 9510 hors tension avant de procéder à l’inspection ou au nettoyage du système.

Le non-respect de cette consigne peut entraîner une situation dangereuse.

The 9510 should be inspected externally for dust buildup in the front air intakes and the rear exhaust fans. Cleaning the system should only be performed with facility power turned off. The system exterior 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.

CAUTION
Ensure any residual moisture is completely dry before reconnecting facility power or using the system.

ATTENTION
S'assurer qu'il ne reste aucune trace d'humidité avant de reconnecter l'alimentation de l'installation ou d'utiliser le système.

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

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

CAUTION
Do not open the system to clean internal components.

ATTENTION
Ne pas ouvrir le système pour nettoyer les composants internes.

Periodic Calibration

NI recommends an annual calibration cycle. NI provides a utility that allows a customer or external calibration laboratory to perform the calibration. Otherwise, contact NI customer support to discuss options for NHR personnel to perform the calibration on-site.

Use one of the following methods to find the calibration utility:

- Go to Start → All Programs → NH Research → 9500 Series → NHR 9500 Calibration
- Browse to the following directory on the local hard drive: C:\Program Files (x86)\NH Research\NHR 9500\Utilities\Nhr9500Cal.exe

Refer to *NHR 9500 Calibration Manual* (NH Research Part Number: 09-0346) for more information.

SCPI Programmers Reference

Refer to the *NHR 9500 Series AC/DC Power Module Programmer's Reference Manual* (NH Research Part Number: 09-0363) for more information.

Error Codes

Command Errors (-100 to -199)

Index	Error Message	Description, Possible Reasons
-100	Command error	Indicates that a syntax error, 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 that 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 that 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 or executing a Macro. This error occurs 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.

NHR Common Device Errors (-1200 to -1299)

Index	Error Message	Description, Possible Reasons, and Fixes
-1286	Mode Prerequisite Is Not Met	This error may be caused by the following reasons: • The system output was not in the off state before sending some commands. For example, this error occurs if the system

		tries to change hardware configuration when output is still on. • Macro was disabled when the Macro-only commands are sent.
-1287	Set Parameter Is Out Of Range	Indicates that the set value exceeded the hardware limit. The out-of-range setting was ignored.
-1288	Command Not Recognized	Indicates that the received SCPI command was not defined or recognizable.
-1289	Calibration Data Checksum Error	Indicates that calibration data in the flash drive was corrupted. You can still use the system after this error occurs but the measurement accuracy is affected. The system automatically checks the calibration data saved in flash drive during start-up. Using command *CLS to clear this error and perform re-calibration to solve the issue.
-1290	Macro Queue Full	Indicates that the number of macro commands in the list exceeded the macro queue limit.
-1291	Flash Memory Error	Indicates that erasing and programming the calibration data to flash drive failed during cabinet calibration. Clear the error and then re-calibrate the cabinet.
-1292	Command Sync Timeout	Indicates that the external wiring, especially the control parallel cable, had issues when multiple systems were configured in parallel. This error typically occurs when trying to turn on/off output or switch range.
-1293	PCB Over Temperature	Indicates that one of the internal power PCBs was over temperature, which can be caused by fan clog or air filter clog.
-1294	Current/Power Sharing Error	Indicates that when multiple cabinets were operating in parallel, one of the cabinets delivered more current/power than other cabinets.
-1295	Disable Switch Error	Indicates that the Ready/Disable switch was in Disable state when trying to turn on one of the channels. Turn the switch to Ready state.
-1296	Parallel Output Error	Indicates that when multiple cabinets were in parallel, one of the cabinets detected that the other cabinet had a hardware error and had turned off the output. For example, if cabinets A, B, C were in parallel, this error occurred for cabinets A and B when cabinet C has an OT error.

-1297	Interlock Open	Indicates that the interlock connector, which should be shorted, was open when you tried to turn on any channels. Check the wiring on the interlock connector.
-1298	DSP Watchdog Trip	Indicates that the internal controller processor (DSP controller) had lost communication to the Network processor (Net-burner). Power recycle the system to fix the error.

Use the *CLS command (the clearing-error command) to clear the errors in the previous table, except for –1298, which needs recycle power to clear the error. Do not use the *RESET command to clear the errors. Although sending the *CLS command can clear the error but the error will occur again if you do not find the cause and fix the error.

NHR Channel Device Errors (-1300 to -1399)

Index	Error Message	Description, Possible Reasons, and Fixes
-1360	Reserved	Reserved
-1361	High-Z Standby Error	This is a 9530 (load option) specific error. This error occurred when the source that the 9530 is connected to was on and off too frequently in a short time, indicating that the source is unstable or has too high impedance.
-1362	Output Voltage Is Ringing	Indicates that the oscillation occurred for cabinet output voltage, which may be caused by the control loop conflict of the 9500 system and the UUT. Contact NI support for help.
-1363	Voltage Sense Lead Error	This error is normally caused by mis-wiring of the sense lead. Check whether you connect the sense wire or reverse the sense leads.
-1364	Safety RMS Under Voltage Trip	This error occurs in the following situations: • The Safety trip - Under Voltage (RMS) is set and enabled (trip time >= 0); • The output voltage RMS is monitored; • The channel is on and output voltage is less than the setting for a certain time.
-1365	Safety RMS Over Voltage Trip	This error occurs in the following situations: • The Safety Trip - Over Voltage (RMS) is set and enabled (trip time >= 0);

		• The output voltage RMS is monitored; • When the voltage is over the setting for a certain time.
-1366	Safety RMS Current Trip(Source)	This error occurs in the following situations: • The Safety trip – OC RMS Sourcing is set and enabled (trip time >= 0); • The output current RMS is greater than setting for a certain time; • Power flow direction is sourcing.
-1367	Safety RMS Current Trip(Sink)	This error occurs in the following situations: • The Safety trip – OC RMS Sinking is set and enabled (trip time >= 0); • The output current RMS is greater than setting for a certain time; • Power flow direction is sinking.
-1368	Safety Peak Over Voltage Trip	Indicates that peak output voltage was greater than safety setting or hardware limit.
-1369	Safety Peak Over Current Trip	Indicates that peak output current was greater than safety setting or hardware limit.
-1370	Safety Overpower Trip (Source)	This error occurs in the following situations: • The Safety trip – Over Power Avg Sourcing is set and enabled (trip time >= 0); • The output power avg is greater than setting for a certain time; • Power flow direction is sourcing.
-1371	Safety Overpower Trip (Sink)	This error occurs in the following situations: • The Safety trip – Over Power Avg Sinking is set and enabled (trip time >= 0); • The output power avg is greater than setting for a certain time; • Power flow direction is sinking.
-1372	Reserved	Reserved
-1373	Set Parameter Out of Range	Indicates that some command sets a value outside the hardware limit. The out-of-range setting was ignored.
-1374	Reserved	Reserved

-1375	Reserved	Reserved
-1376	Average power exceeds hardware limit	Indicates that the average output power was over the hardware limit.
-1377	K board peak current error	There are two output power boards per channel per cabinet. This error indicates that power board #2 exceeded its peak limit.
-1378	J board peak current error	There are two output power boards per channel per cabinet. This error indicates that board #1 exceeded its peak limit.
-1379	K board RMS current error	There are two output power boards per channel per cabinet. This error indicates that board #2 exceeded its RMS limit.
-1380	J board RMS current error	There are two output power boards per channel per cabinet. This error indicates that board #1 exceeded its RMS limit.
-1381	K board average current error	There are two output power boards per channel per cabinet. This error indicates that board #2 exceeded its window average limit.
-1382	J board average current error	There are two output power boards per channel per cabinet. This error indicates that board #1 exceeded its window average limit.
-1383	Mode pre-requisite not set	Indicates that a command for a channel was received without the mode prerequisite set. For example, this error occurs if you select a user waveform when the channel is configured to be DC output, or if you re-configure the channel when it is still on.
-1384	Current is not sharing J-K	There are two output power boards per channel per cabinet. This error indicates the current is not shared between the two power boards in the same cabinet.

NOTE
Errors in the previous table do not require a *RESET command to clear. Use the *CLS (clearing-error) command to clear the error.

Device Errors Require Reset to Clear (100 to 199)

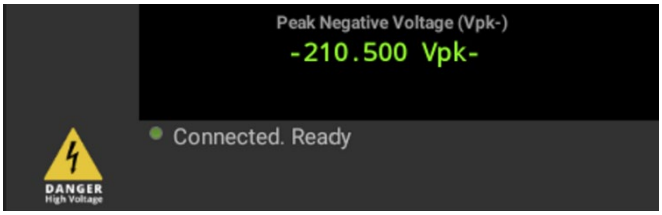
Index	Error Phrases	Description, Possible Reasons, and Fixes
101	E-Off Button Pressed	Indicates that either E-OFF button on the front door was pressed, the back door was not fully closed, or the control out terminator was loose
102	AC Line Input Under Voltage	Indicates that the input grid AC voltage dropped below its minimum. To protect itself, the 9500 system turns off and

		waits for a RESET command. This error is normally caused by grid voltage fluctuation.
103	AC Line Input over Voltage	Indicates that the input grid AC voltage rises over its maximum. To protect itself, the 9500 system turns off and waits for a RESET command. This error is normally caused by grid voltage fluctuation.
104	Peak over Current for a Grid PCB	Indicates that the 9500 system detected an overcurrent condition, which may be caused by several reasons: • Grid AC line voltage fluctuation • Output peak power fluctuation • A noise that caused the measurement circuitry to have a false trip • Hardware issues
105	Grid DC Bus over Voltage	Indicates that the 9500 system DC internal bus voltage rose above the hardware safety limit, which may be caused by several reasons: • Large output power fluctuation • Hardware issues: For example, the DC bus sense circuitry fails to measure correctly.
106	Grid DC Bus Under Voltage	Indicates that the 9500 system DC internal bus voltage dropped below the hardware safety limit, which can be caused by several reasons: • Large output power fluctuation • Hardware issues: For example, the DC bus sense circuitry fails to measure correctly.
107	AC Line Frequency Abnormal	Indicates that the 9500 system detected the frequency outside the hardware safety limit, which is normally caused by an unstable grid.
108	Grid DC Bus Failed to Turn On	Indicates that the pre-charge step is not successful due to possible hardware issues with the following: Pre-charge resistors located at the bottom tray Grid power boards This error normally happens at 9500 cabinet power on, when the internal caps are charged to an operating DC voltage.
109	LVPS Under Voltage for a UUT PCB	Indicates that the output UUT power boards gate drive circuit detected a lower-than-expected control (gate drive) voltage.
110	Peak over Current for a UUT PCB	Indicates that one of the UUT power boards detected an overcurrent condition.

111	Fuse-Open for a PCB	Indicates that one of the DC-DC boards detected an open fuse. There are two fuses on the DC-DC board: one is connected to the primary (the grid side), the other is connected to the secondary (the UUT side).
112	UUT DC Bus over Voltage for a PCB	Indicates that one of the UUT power boards DC bus voltage dropped under the hardware safety limit, which may be caused by: • Large output power fluctuation • Hardware problem on the DC-DC power boards
113	UUT DC Bus Under Voltage for a PCB	Indicates that one of the UUT power boards DC bus voltage rose above the hardware safety limit, which may be caused by: • Large output power fluctuation • Hardware problem on the DC-DC power boards
114	Reserved	Reserved
115	Peak over Current for a DC-DC PCB	Indicates that one of the DC-DC boards detected an overcurrent condition, which may be caused by: • Large output power fluctuation • Hardware problem on the DC-DC power boards
116	LVPS Under Voltage for a DC-DC PCB	Indicates that the DC-DC isolation boards gate drive circuit detected a lower-than-expected control (gate drive) voltage.
117	LVPS Under Voltage for a Grid PCB	Indicates that the grid power boards gate drive circuit detected a lower-than-expected control (gate drive) voltage.

Use the *RST command to clear all errors in the previous table. Before using the *RST command, please fix the error first. For example, if an “E-OFF button pressed” error occurs, ensure the E-OFF button on the front door is released, the back door is fully closed, and the control parallel out terminator is installed before using the*RST command to clear the error.

Sending the *RST command will force the cabinet to go through the full start-up sequence, which typically takes one minute. This is similar to restarting a computer. Users have to wait for the process to finish before reusing the system. During the start-up, the front panel message bar shows “Connected. Initializing” ; and when the cabinet is ready to use, the message bar shows “Connected. Ready”.



Errors that Require Special Actions (200 to 299)

Index	Error Phrases	Description, Possible Reasons, and Fixes
201	Device Number Error	Indicates that invalid firmware files were downloaded. You must re-download the internal processor (DSP) firmware to clear the error. Refer to the *Updating the Internal Processors* section for more details.
202	Download Firmware Checksum Error	Indicates that the firmware saved in the flash drive was corrupted. You must re-download the internal processor (DSP) firmware to clear the error. Refer to the *Updating the Internal Processors* section for more details.
203	Reserved	Reserved
204	Reserved	Reserved
207	Auxiliary Mode Mismatch	Indicates that auxiliary cabinets hardware modes did not match the master cabinet hardware modes. Ensure every cabinet in parallel has the same hardware modes. Refer to the *Configuring the Systems in Parallel* section for more details.
208	Auxiliary Module Offline	Indicates that the auxiliary cabinets did not respond during parallel initialization. Ensure that the IP addresses of the master and the auxiliary cabinets are correctly set, and that the Ethernet cables are connected correctly. Refer to the *Configuring the Systems in Parallel* section for more details.
210	NetBurner Watchdog Trip	Indicates that the master cabinet microcontroller watchdog timer was tripped. Make sure the Ethernet cables are connected correctly.
211	Auxiliary Communication Error	Indicates that one of the auxiliary cabinets stopped responding to the master cabinet. Check the following to fix the error: • Ensure that the Ethernet cables are connected correctly for each cabinet. • If you are using a network switch, reset the network switch power or try another switch. • Ensure that the auxiliary system microcontroller is working and the DSP light on the front door is blinking.

NI Services

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Visit ni.com/register to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.
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