4600 AC LOAD

USER’S MANUAL

Part No. 09-0237

REVISION U

Jan 2, 2014

Document History

Rev A	**First printing**	**12/19/97**	**CAR**
Rev B	**Added calibration section**	**1/22/98**	**CAR**
Rev C	**Release ECO 14650**	**2/9/98**	**JW**
Rev D	**ECO 14684**	**4/16/98**	**CAR**
Rev E	**ECO 14756**	**6/26/98**	**CAR**
Rev F	**ECO 14803**	**10/8/98**	**VJB**
Rev G	**ECO 14857**	**021899**	**CAR**
Rev H	**ECO 15429**	**112701**	**BH**
Rev J	**ECO 15455**	**021402**	**JA**
Rev K	**ECO 15466**	**030502**	**JA**
Rev L	**ECO 16241**	**101907**	**CAR**
Rev M	**ECO 16316**	**011608**	**JA**
Rev N	**ECO 16377**	**050808**	**TCF**
Rev P	**ECO 16475**	**2/5/09**	**BL**
Rev R	**ECO 16989**	**5/24/12**	**TCF**
Rev T	**ECO 17130**	**5/9/13**	**KF**
Rev U	**ECO 17183**	**1/2/14**	**SM**

Proprietary Rights Notice

This document and the information that it contains are the property of NH Research, Incorporated. The rights to duplicate or otherwise copy this document, the rights to disclose the document and its information to others, and the right to use the information therein may be acquired only by written permission signed by a duly authorized officer of NH Research, Incorporated.

Unauthorized duplication of software and documentation provided with the test workstations violates the copyright protection provided by law. However, backup copies of programs are permitted for archives and recovery from hardware failures.

The material in this publication is current as of the release date on the cover page and is subject to change without notice. Any questions concerning the product or any questions or comments concerning this manual should be directed to the NH Research Field Service Department during normal business hours Monday through Friday at (949) 474-3900 or FAX (946) 474-7062 or www.nhresearch.com**.**

SAFETY

WARNING: LIVE CIRCUITS

NO INTERNAL ADJUSTMENT OR COMPONENT REPLACEMENT IS ALLOWED BY NON-NH RESEARCH QUALIFIED PERSONNEL. COMPLETE THE FOLLOWING BEFORE ACCESSING THE INSTRUMENT INTERNALS:

- **REMOVE ALL EXTERNAL VOLTAGE SOURCES**
- **DISCONNECT POWER CORD**
- **WAIT A MINIMUM OF 1 MINUTE TO DISCHARGE CIRCUITS**
- **VERIFY CIRCUITS ARE DISCHARGED.**

SAFETY SUMMARY

This AC Load contains high voltage and current circuits, which are potentially lethal. Because of its size and weight, mechanical stability must be ensured. The following safety guidelines must be followed when operating or servicing this equipment. These guidelines are not a substitute for vigilance and common sense. California Instruments assumes no liability for the customer’s failure to comply with these requirements. If the power source is used in a manner not specified by California Instruments, the protection provided by the equipment may be impaired. BEFORE APPLYING POWER:

1. Verify the correct voltage is applied to the unit (for example 115V).

2. The chassis must be grounded to minimize shock hazard. A chassis ground is provided at the rear panel. The chassis ground must be connected to an electrical ground through an insulated wire of sufficient gauge.

FUSES

Use only fuses of the specified current, voltage, and protection speed (slow blow, normal blow, fast blow) rating. Do not short out the fuse holder or use a repaired fuse.

DO NOT OPERATE IN A VOLATILE ATMOSPHERE

Do not operate the power source in the presence of flammable gases or fumes.

DO NOT TOUCH ENERGIZED CIRCUITS

Disconnect the power cable before servicing this equipment. Even with the power cable disconnected, high voltage can still exist on some circuits. Discharge these voltages before servicing. Only qualified service personnel may remove covers, replace components or make adjustments.

DO NOT SERVICE ALONE

Do not remove covers, replace components, or make adjustments unless another person, who can administer first aid, is present.

DO NOT EXCEED INPUT RATINGS

Do not exceed the rated input voltage or frequency. Additional hazards may be introduced because of component failure or improper operation.

DO NOT MODIFY INSTRUMENT OR SUBSTITUTE PARTS

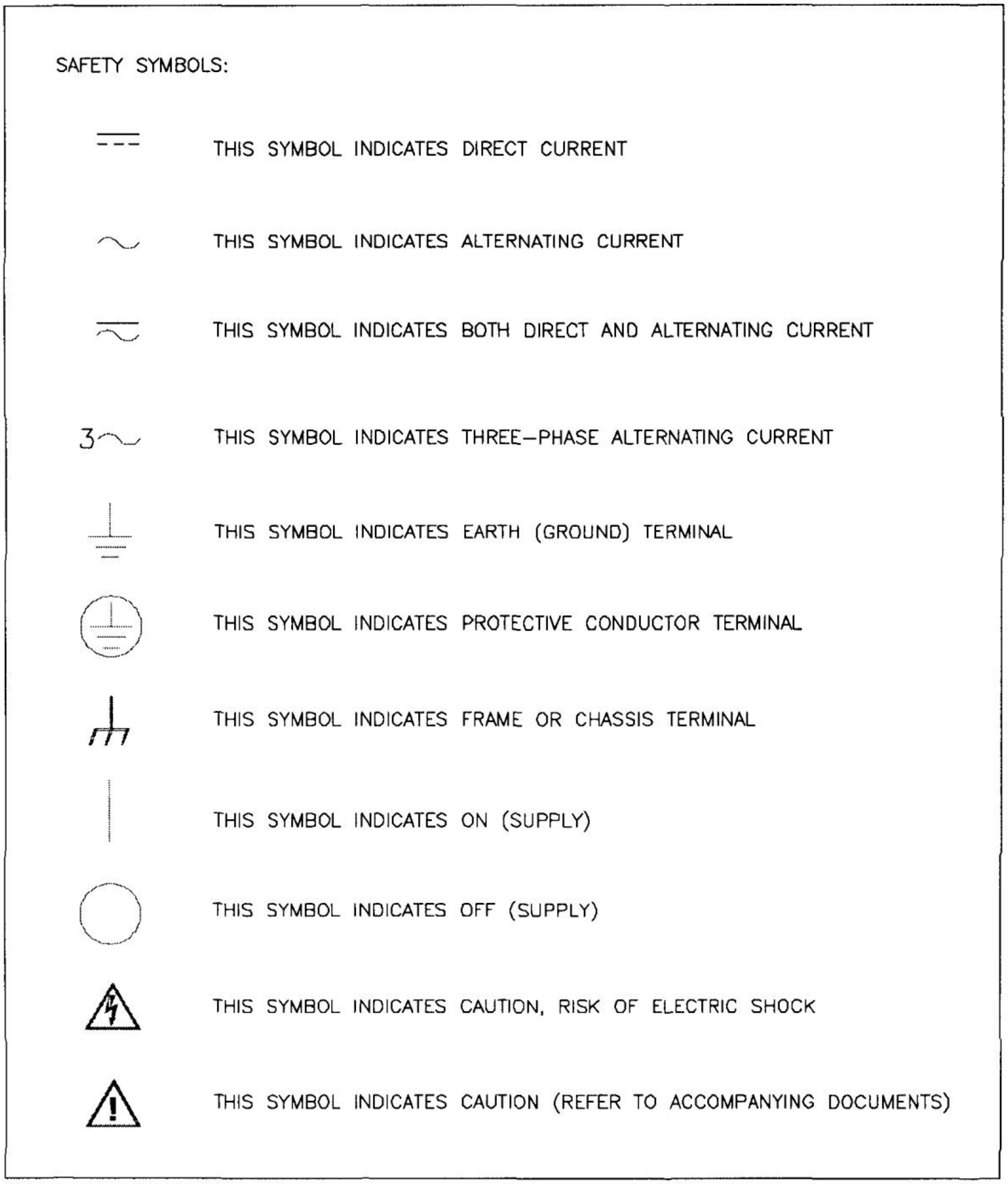
Do not modify this instrument or substitute parts. Additional hazards may be introduced because of component failure or improper operation.

MOVING THE POWER SOURCE

When moving the power source, observe the following:

1. Remove all AC power to unit.

2. Use two people to prevent injury.



SAFETY SYMBOLS:

THIS SYMBOL INDICATES DIRECT CURRENT

THIS SYMBOL INDICATES ALTERNATING CURRENT

THIS SYMBOL INDICATES BOTH DIRECT AND ALTERNATING CURRENT

THIS SYMBOL INDICATES THREE–PHASE ALTERNATING CURRENT

THIS SYMBOL INDICATES EARTH (GROUND) TERMINAL

THIS SYMBOL INDICATES PROTECTIVE CONDUCTOR TERMINAL

THIS SYMBOL INDICATES FRAME OR CHASSIS TERMINAL

THIS SYMBOL INDICATES ON (SUPPLY)

THIS SYMBOL INDICATES OFF (SUPPLY)

THIS SYMBOL INDICATES CAUTION, RISK OF ELECTRIC SHOCK

THIS SYMBOL INDICATES CAUTION (REFER TO ACCOMPANYING DOCUMENTS)

TABLE OF CONTENTS

1. INTRODUCTION

The Model 4600 family of AC Electronic Loads is designed to provide precise non-linear loading requirements for UPS and AC power supply test and evaluation applications. Manufacturers are now able to vary current, crest factor and power factor to ensure that their products are tested to worst case conditions encountered in the field. The Model 4600 offers more flexibility, enhanced reliability, less space and lower cost than an assortment of passive resistive loads.

1.1 Broad Operating Envelope

To cover the full spectrum of UPS and AC power supplies, the Model 4600 operates up to 3000W over a voltage range of 50 to 350Vac in a single-phase mode. The loading current waveform synchronizes to the voltage waveform for the set current, crest factor and power factor. This multiple Model 4600s can be connected in parallel for higher power loading or in single groups for multiphase systems.

1.2 Non Linear Loading

Programmable crest factor and power factor allows the Model 4600 to emulate a non-linear load such as a switching power supply. The Model 4600’s capability to provide a variety of loads from sinusoidal to high crest factor allows manufacturers to characterize UUT’s to worst-case conditions.

1.3 Broad Spectrum of Emulation Modes

To allow UPS’s and AC power supplies to be tested under a variety of loading conditions, the Model 4600 offers a broad spectrum of emulation modes. CC mode allows current to be drawn constantly, making it suitable for non-linear, linear and regulation loading. While CR mode allows the load to emulate a power resistor, CV allows it to emulate a shunt regulator. CP mode emulates a constant power load such as a switching power supply. Short circuit mode allows the load to test the UUT’s short circuit protection capability. Unity power factor mode causes power factor to be as close as possible to unity, useful when the input voltage is non-sinusoidal. These capabilities makes the Model 4600 a universal load, which replaces an assortment of resistive loads and short circuit, relays used currently by manufacturers.

1.4 High Accuracy Measurements

The Model 4600 accomplishes high accuracy frequency, voltage, peak voltage, current, peak current, crest factor, apparent power, true power, peak power, reactive power, power factor and resistance measurements by combining high resolution measurements with precision ranging. The ability to make all measurements internally eliminates multiple external measurement instruments plus associated signal matrixing. In this manner the load provides for a more compact, less costly and considerably faster test system. Waveforms may be graphically displayed eliminating the need for an oscilloscope.

2. SPECIFICATIONS

2.1 Ratings

Power: 3000W 0 - 37° C, 2400W 38 - 50° C
Max. Peak power: 13kW (up to 20% duty cycle)

Current: 30A rms.
Max. Peak current: 90A

Voltage: 50 to 350V rms.
Max. Peak voltage: 500V

Frequency: 45 to 440Hz

2.2 Programmable Features

Constant Current Mode
Range: 0 to 30A rms.

Accuracy: 0.2% of full scale

Resolution: 0.05% of full scale

Constant Voltage Mode
Range: 50 to 350V rms.

Accuracy: 0.2% of full scale

Resolution: 0.05% of full scale

Constant Resistance Mode
Range: 2.5 to 100Ω, 100 to 1000Ω

Accuracy: 1% of full scale, 5% of full scale

Resolution: 0.05% of full scale

Constant Power Mode
Range: 3000W 0 - 37° C, 2400W 38 - 50° C

Accuracy: 0.5% of full scale

Resolution: 0.05% of full scale

Crest factor
Range: √2 to 4.0, limited to 90A peak

Accuracy: 1% of full scale

Resolution: 0.05% of full scale

Power factor
Range: 0 to 1 lead or lag limited by Crest factor settings

Accuracy: 1% of full scale

Resolution: 0.05% of full scale

Short circuit Mode
Max. Surge current: 300A peak, up to 50msec

Max. Continuous current: 30A rms.

Max. Voltage drop: 2.5Vr.m.s.

Maximum Set Resistance = 1 / (Frequency * 1.3e-5)

Minimum Set Current = Voltage / Maximum Set Resistance

2.3 Readback Instrumentation

Frequency
Range: 45 to 440Hz

Accuracy: 0.1% of full scale

Resolution: 0.01% of full scale

Voltage
Range: 50 to 350V rms.

Accuracy: 0.1% of full scale

Resolution: 0.01% of full scale

Peak Voltage
Range: 50 to 500V

Accuracy: 0.5% of full scale

Resolution: 0.01% of full scale

Current

Range: 0 to 30A rms.

Accuracy: 0.2% of full scale

Resolution: 0.01% of full scale

Peak Current

Range: 0 to 90A

Accuracy: 0.5% of full scale

Resolution: 0.01% of full scale

Crest factor

Range: √2 to 4.0

Accuracy: 0.5% of full scale

Resolution: 0.01% of full scale

Apparent Power

Range: 0 to 10,500VA

Accuracy: 0.3% of full scale

Resolution: 0.01% of full scale

True Power

Range: 0 to 10,500W

Accuracy:

From 90 - 130VAC, 47 - 63Hz, 0.2% reading + 0.03% full scale.

From 190 - 260VAC, 47 - 63Hz, 0.2% reading + 0.06% full scale.

Other voltages and frequency 0.2% of full scale.

Resolution: 0.01% of full scale

Peak Power

Range: 0 to 45,000W

Accuracy: 1% of full scale

Resolution: 0.01% of full scale

Reactive Power

Range: 0 to 10,500VA

Accuracy: 0.3% of full scale

Resolution: 0.01% of full scale

Power factor

Range: 0 to 1

Accuracy: 0.5% of full scale

Resolution: 0.01% of full scale

Resistance

Range: 2.5 to 100Ω, 100 to 1000Ω

Accuracy: 1% of full scale, 5% of full scale

Resolution: 0.01% of full scale

2.4 Protection

Over Current

Limited by input Circuit Breaker

Limited to Set Maximum Current Limit in software

Over Voltage

Output protected for voltage transients in hardware

Over Power

Power limited at maximum average and peak rated power in hardware

Limited to Set Maximum Power Limit in software

Over Temperature

Monitors heat sink temperature in hardware

2.5 Supplemental Characteristics

2.5.1 Size

8.75”H x 16.88”W x 25”D, 40 lbs.

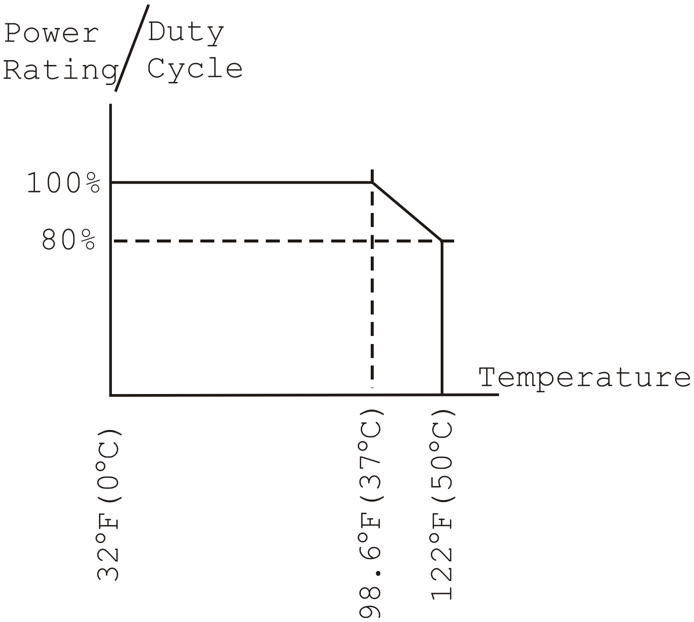
2.5.2 Remote Sensing:

Max. 2V drop between sense and load lines

2.5.3 Isolation

1000V between input and chassis ground

2.5.4 Operating temperature:



Power Rating is in percentage of full scale(3KW 1 Load).
Derate power by 1.5%/°C from 37°C to 50°C.
Duty Cycle is the ratio of time ON @100% divided by period.
Maximum period 2 minutes.

Noncondensing humidity < 75% R.H.

2.5.5 Control power input:

Ordered from factory as either	115VAC ± 10%, 47 to 63Hz, 1.4A Max.
OR	230VAC ± 10%, 47 to 63Hz, 0.7A Max.

All specifications apply for 23°C ± 5°C after 10 minute warm-up.

3. INSTALLATION

3.1 Hardware Installation

Unpack the load. Save the packing material if a need arises to return the load.

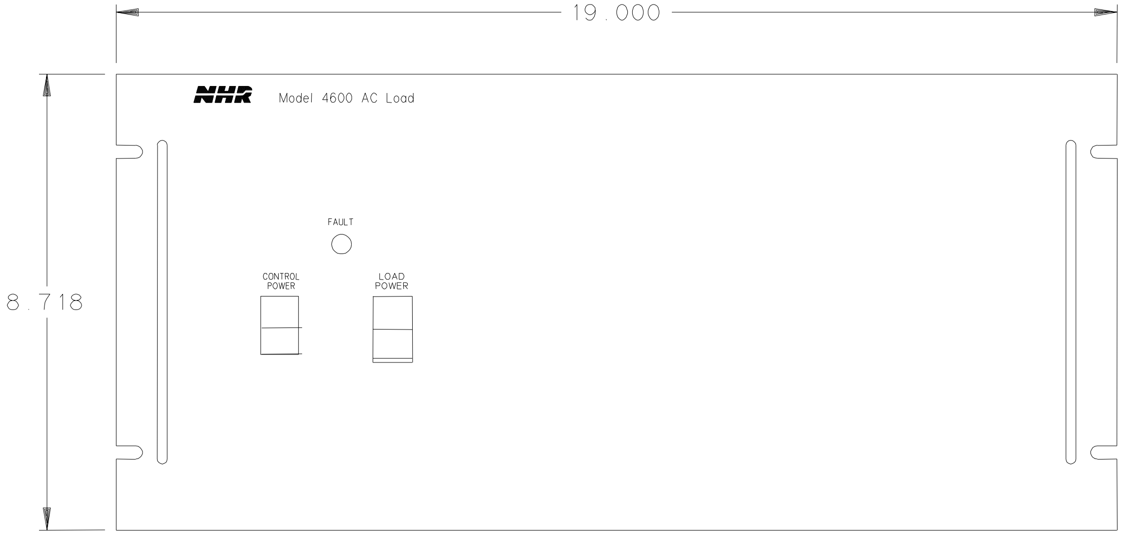
The load is designed to mount into a 19” rack. Optional slide rails are available.

Select a suitable location, which meets size, weight, temperature, airflow, control power input and load power input requirements.

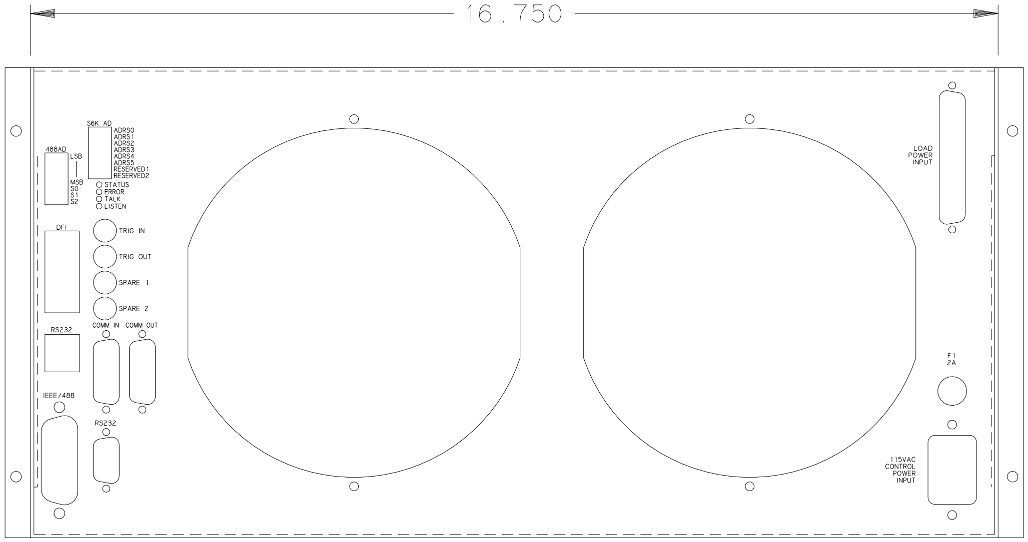
A computer to control the load must be located nearby. The length of the (RS232 or RS485) control cable limits the distance from the load to the computer. The controlling software must be set to the same computer communication port that is connected to the load. The controlling software must be set to the same address as the S6k AD switch on the load.

The remote sense wires must be connected at the power source for more accurate metering and to compensate for voltage drop across the load wires.

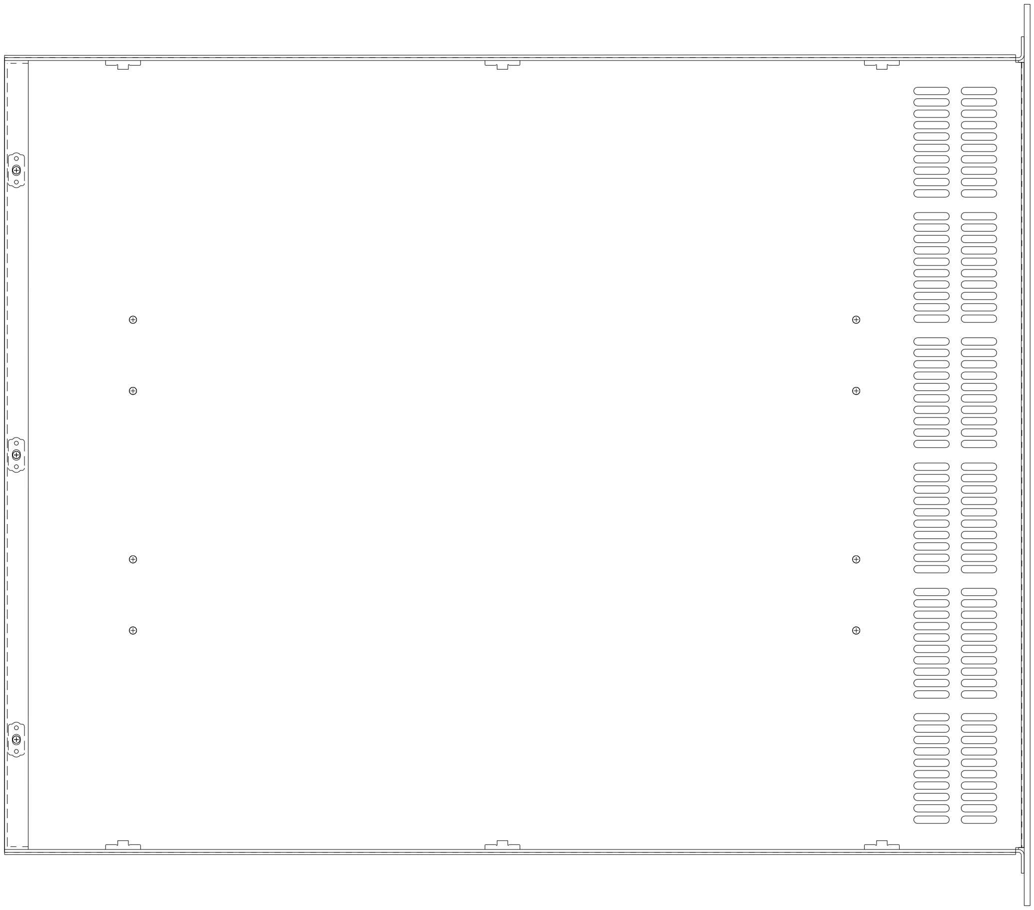
3.1.1 Front View



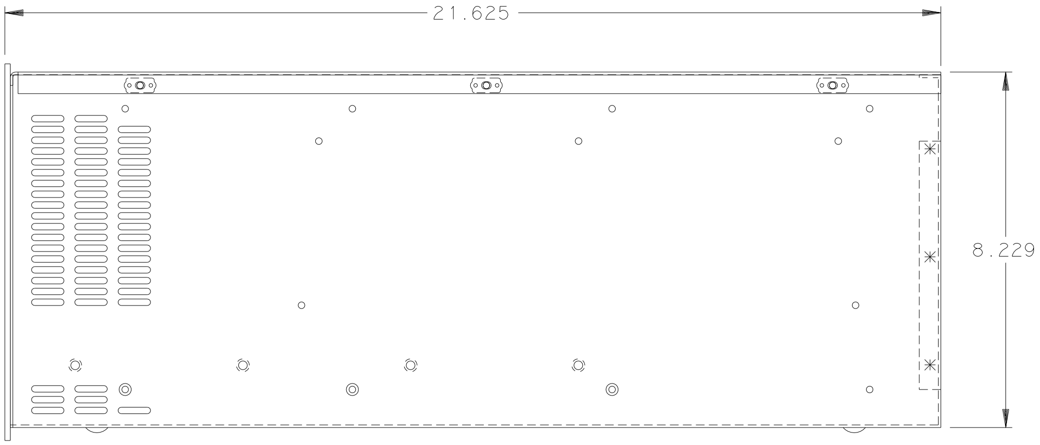
3.1.2 Rear View



3.1.3 Top View



3.1.4 Side View

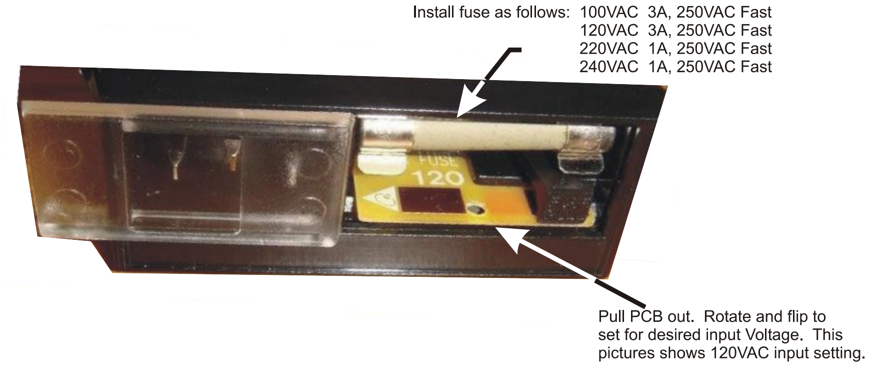


3.1.5 Connectors

3.1.5.1 Control Power Input

This supplies power to the fans and control circuits.

There are four types of chassis. 100V, 120V, 220V and 240V input. The chassis input voltage can be changed by following the picture:



3.1.5.2 Load Power Input

Single unit:

Pin	Signal	Description
A1	No Connection	
A2	Neutral	Load power input
A3	No Connection	
A4	Line	Load power input
1	No Connection	
2	Neutral Sense	Remote voltage sense
3-7	No Connection	
8	Line Sense	Remote voltage sense
9-17	No Connection	

The voltage sense wires are also located on this connector. The voltage sense wires must be connected to the load wires either at this connector or at the source. The load will not operate with these voltage sense wires disconnected. It will generate an undervoltage error.

Mating connector type is:

NH Part #	Description	Commercial Part #	Manufacturer
6200933	DSUB 17 - 4 COAX	DCM-21 WA4S	ITT CANNON
6200949	DSUB contact 40 A	DM 53744-1	ITT CANNON
6200927	DSUB shell	DCM 24660	ITT CANNON
6201309	DSUB Screw Lock	D20419-21	ITT CANNON

3.1.5.3 RS232 9pin connector

Pin	Description
2	TX
3	RX
7	RTS
5	GND

Signal levels on this connector conform to RS232C signal levels.

Mating Connector type is:

NH Part #	Description	Commercial Part #	Manufacturer
6202014	DSUB 9 Plug	DE9P	ITT CANNON
6201698	DSUB Shell	DE24657	ITT CANNON
6201309	DSUB Screw Lock	D20419-21	ITT CANNON

This connector will mate with a PC compatible nine pin RS232 port if a one to one four wire cable is used. This connection may be used for control of the load in a test system.

3.1.5.4 Comm In/Out

Pin	COMM OUT - FEMALE	Pin	COMM IN - MALE
1	TX_IN-	1	TX_IN-
2	TRIGIN+	2	TRIGIN+
3	GND	3	GND
4	TX_IN+	4	TX_IN+
5	INTLKIN+	5	INTLKIN+
6	INTLKIN-	6	INTLKIN-
7	LCLOUT0+	7	LCLIN0+
8	LCLOUT-	8	LCLIN0-
9	RX_IN-	9	RXOUT-
10	TRGOUT+	10	TRGOUT+
11	TRGOUT-	11	TRGOUT-
12	RX_IN+	12	RXOUT+
13	TRIGIN-	13	TRIGIN-
14	LCL1OUT+	14	LCLIN1+
15	LCL1OUT-	15	LCLIN1-

Signal levels on this connector are differential with levels conforming to RS422 specification.

This connector will mate with NHR S6000 type modules. This connection may be used for control of the load in a test system. If COMM IN is used, remove jumpers W5 and W6, labeled RS232.

Mating connector type is:

NH Part	Description	Commercial Part #	Manufacturer
6200844	DSUB 15 Socket (COMM IN)	DA15S	ITT CANNON
6200799	DSUB 15 Plug (COMM OUT)	DA15P	ITT CANNON
6200800	DSUB Shell	DA24658	ITT CANNON
6201309	DSUB Screw Lock	D20419-21	ITT CANNON

3.1.5.5 Trig In/Out

Connector	Description
Trigger In	Negative true TTL level signal with 1K Ohm pull up to +5V
Trigger Out	Negative true TTL level output with 39 Ohm series resistor

These are the hardware trigger input and output connectors for use with transients.

Mating Connector type is:

NH Part	Description	Commercial Part #	Manufacturer
6000262	SMB COAX 50 Ohm	131-1403-016	EF JOHNSON

This connector is used with RG178 type 50-ohm COAXIAL cable.

3.1.5.6 Hold In/Out

Connector	Description
Hold In/Out	Open collector output.

Paralleled units wait or hold until all are ready to execute new commands simultaneously. Paralleled units will work without this connection but may not execute commands simultaneously. Connect Hold Out to Hold In from one unit to the next in a daisy chain fashion for all loads in parallel. Do not connect anything else to this connector.

Mating Connector type is:

NH Part	Description	Commercial Part #	Manufacturer
6000262	SMB COAX 50 Ohm	131-1403-016	EF JOHNSON

This connector is used with RG178 type 50-ohm COAXIAL cable.

3.1.6 Adequate Ventilation

3.1.6.1 Airflow

The load will dissipate its power rating in heat.

POWER(WATTS)	HEAT(BRITISH THERMAL UNITS)
18,000W	61,416 BTU
15,000W	51,180 BTU
12,000W	40,944 BTU
9,000W	30,708 BTU
6,000W	20,472 BTU
3,000W	10,236 BTU

Allow for 400CFM per chassis of air to enter the front and exit the rear of the load. This must be cool air and NOT hot re-circulated air.

3.1.6.2 Adequate Floor Space

A minimum of 24”(61CM) floor space must be provided at the rear of the Load. Also 18”(46CM) at the front. Failure to provide adequate floor space may result in over temperature errors.

3.1.7 Master-Auxiliary Installation

Auxiliary units must be located next to the master.

3.1.7.1 Load Power Input

To Unit Under Test	AC Loads	Description
NEUTRAL	**A2 – MASTER**	**LOAD INPUT**
"	**A2 – AUXILIARY #1**	
"	**A2 - AUXILIARY #2**	
"	**A2 – AUXILIARY …**	
LINE	**A4 – MASTER**	**LOAD INPUT**
"	**A4 – AUXILIARY #1**	
"	**A4 - AUXILIARY #2**	
"	**A4 – AUXILIARY …**	
NEUTRAL SENSE	**2 – MASTER**	**LOAD SENSE INPUT**
"	**2 – AUXILIARY #1**	
"	**2 - AUXILIARY #2**	
"	**2 – AUXILIARY …**	
LINE SENSE	**8 – MASTER**	**LOAD INPUT SENSE**
"	**8 – AUXILIARY #1**	
"	**8 - AUXILIARY #2**	
"	**8 – AUXILIARY …**	

3.1.7.2 Computer Connection

Connect the controlling computer to the RS232 port or COMM IN on the master. If COMM IN is used, remove jumpers W5 and W6, labeled RS232.

Connect COMM OUT from the master to COMM IN on the auxiliary load.

3.1.7.3 BAUD Rate Selection

BAUD Rate	Jumper W11	Jumper W12
19.2k	OFF	OFF
38.4k	OFF	ON
57.6k	ON	OFF

3.1.7.4 Hold Connection

Connect HOLD OUT from the master to HOLD IN on the auxiliary load.

3.2 Software Installation

Close all programs that are currently running in windows. Insert the CD into the drive and view the contents of the disk and double click on ‘Setup’ to start the installation. Follow the instructions on the screen.

4. USER OPERATION

4.1 Hardware Operation

4.1.1 Control Power Switch and Indicator

This switch/indicator is located on the front panel. When ON, this switch/indicator will light indicating fan and control power is applied.

4.1.2 Load Power Circuit Breaker

This circuit breaker is located on the front panel. When ON, this circuit breaker connects the load to the load power input terminals.

4.1.3 S6k AD Switch

The address switch on the rear of the load is used to set a unique communication address for the load on the S6000 family serial interface. Switch ADRS0 – ADRS5 are used to set a module address. Paralleled loads must have successive module addresses.

Switch GADR0 and GADR1 are used to set a group communication address. All paralleled loads must have the same group address other than 0xFF.

Example:

Load	Description	Switch ADRS 543210	Unique Address	Switch GADR 10	Group Address
1	Master in parallel with load 2	000001	0x01	00	0xFC
2	Auxiliary in parallel with load 1	000010	0x02	00	0xFC
3	Master in parallel with load 4	000011	0x03	01	0xFD
4	Auxiliary in parallel with load 3	000100	0x04	01	0xFD
5	Master not paralleled	000101	0x05	11	0xFF

If all eight positions of this switch are off when the load is turned on, it will boot from firmware in EPROM and not from FLASH. This is useful if the firmware in FLASH has been corrupted.

4.1.4 Fault Indicator

The fault indicator is located on the front panel. A hardware fault (overtemp, overpower, no share) caused the hardware to shut down. This indicator is cleared by a hardware reset, clear error, reset and selftest commands only after the fault is removed.

4.1.5 Status Indicator

This indicator is located on the rear panel. It should blink at a 1Hz rate indicating the internal DSP is operating.

4.1.6 Error Indicator

This indicator located on the rear panel, when lit indicates a software error has occurred. It lit when the load is initially turned on and it will turn off when load is initialized or establish communication with a PC.

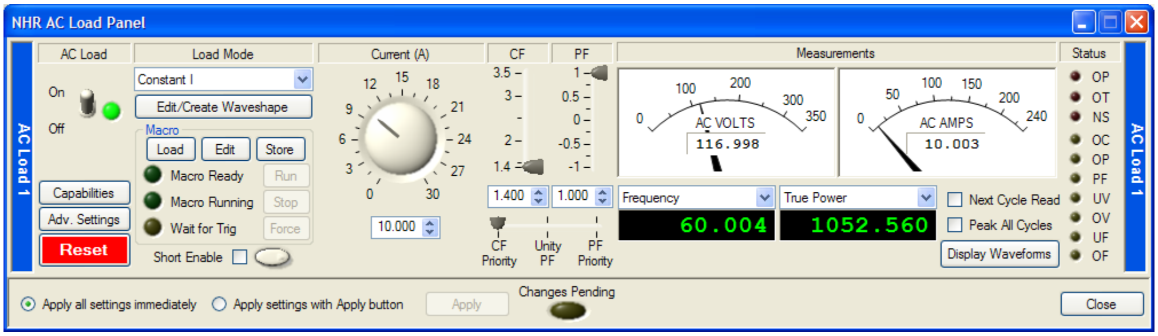
4.1.7 Talk Indicator

This indicator located on the rear panel will blink on when data is going from the load to the computer.

4.1.8 Listen Indicator

This indicator located on the rear panel will blink on when commands are going from the computer to the load.

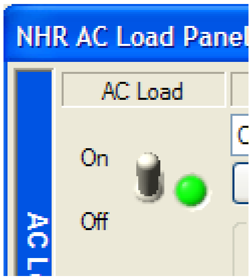
4.2 Software Operation



4.2.1 Application of Settings

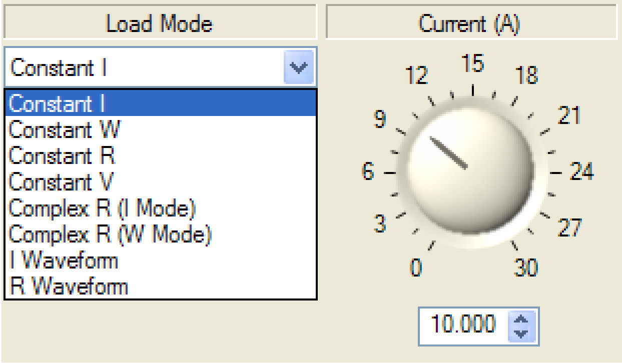
By default, all modifications made to the soft panel are applied to the load as soon as the change is made. However, you can alter this behavior to instruct the soft panel to queue up the changes and apply them to the load at one time by selecting the “Apply settings with the Apply button” option at the bottom of the panel.

4.2.2 On/Off



The load will not draw any power when in the off state.

4.2.3 Load Modes



Load Mode: Constant I

Current (A): 10.000

Select the mode of operation for the load from the "Load Mode" drop-down list. The settings dial will automatically track the selected mode.

4.2.3.1 Constant Current (I)

The amount of RMS current drawn it is a constant, regardless of the input voltage. Crest Factor and Power Factor may also be programmed.

4.2.3.2 Constant Power (W)

Varies the amount of current drawn inversely proportional with the input voltage in order to maintain a constant power. By varying the Crest Factor and the Power Factor the load emulates a very wide variety of switching power supplies.

4.2.3.3 Constant Resistance (R)

The amount of current drawn varies in direct proportion with the voltage. In this mode the load emulates a power resistor.

4.2.3.4 Constant Voltage (V)

Draws the necessary amount of current to maintain a constant voltage, emulates a shunt regulator.

4.2.3.5 Complex R (I Mode)

The load will use the applied voltage to calculate a waveshape based on the current, crest factor, and power factor properties. Unlike Constant Resistance mode, the resistance will continuously vary as the input voltage changes.

4.2.3.6 Complex R (W Mode)

The load will use the applied voltage to calculate a waveshape based on the power, crest factor, and power factor properties. Unlike Constant Resistance mode, the resistance will continuously vary as the input voltage changes.

4.2.3.7 Current (I) Waveform

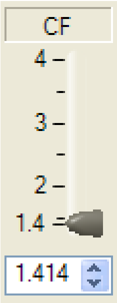
Draws current based on a user-defined waveshape. See section 4.2.10 "Custom Waveshapes" for instructions describing how to create your own waveshapes.

4.2.3.8 Resistance (R) Waveform

The amount of current drawn varies in direct proportion with the voltage, based on a user-defined waveshape. Refer to 4.2.10 “Custom Waveshapes” for instructions describing how to create your own waveshapes.

4.2.4 Other Programmable Features

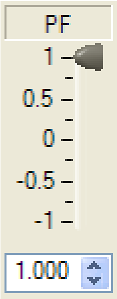
4.2.4.1 Crest Factor



1.414

Emulates different types of load characteristics (i.e. switching supplies or other nonlinear loads) in Constant Current, Constant Power, and Complex Resistance modes. Not programmable when unity power factor is selected.

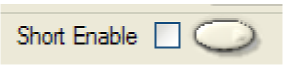
4.2.4.2 Power Factor



1.000

In conjunction with the crest factor it can be set from 0 to 1 (lead or lag) in Constant Current, Constant Power, and Complex Resistance modes. Not programmable when unity power factor is selected. Limited by crest factor setting. See section 7.12 Crest Factor and Power Factor Relationship.

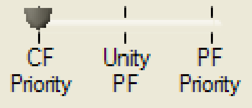
4.2.4.3 Short Circuit



Short Enable ☐

Internal SCR’s turn on to test the UUT short circuit protection capability.

4.2.4.4 Power Factor Modes



Crest Factor Priority. (CF Priority)

Crest Factor and Power Factor are Programmable. See section 7.12 Crest Factor and Power Factor Relationship.

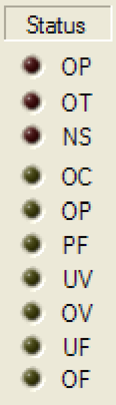
Unity Power Factor. (Unity PF)

Forces highest power factor. Programmable Crest Factor and Power Factor do not apply. Allows Constant Current and Constant Power to be programmed correctly with non-sinusoidal input voltages.

Power Factor Priority. (PF Priority)

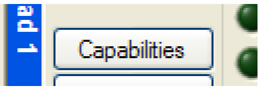
Changes Power Factor to obtain desired Power Factor without phase shifting current. Programmable Crest Factor does not apply. More closely emulates a power supply type load.

4.2.5 Status

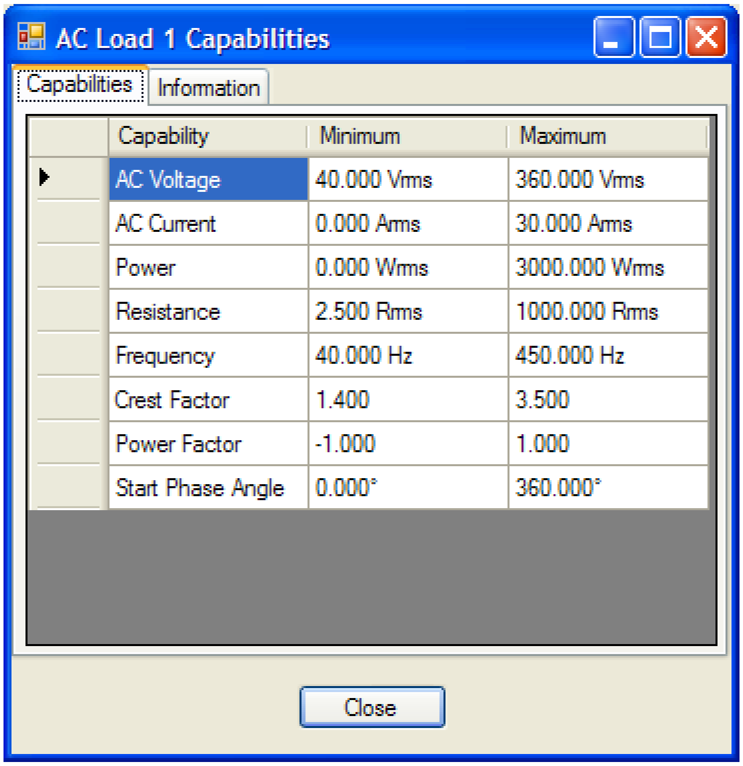


This status bar indicates instrument errors and warnings. The top three are hardware error conditions: Over Power (OP), Over Temperature (OT), and Not Sharing (NS). The warning conditions are: Over Current (OC), Over Power (OP), Power Factor (PF), Under Voltage (UV), Over Voltage (OV), Under Frequency (UF), and Over Frequency (OF). The status boxes will light if an error or warning is detected.

4.2.6 Device Capabilities

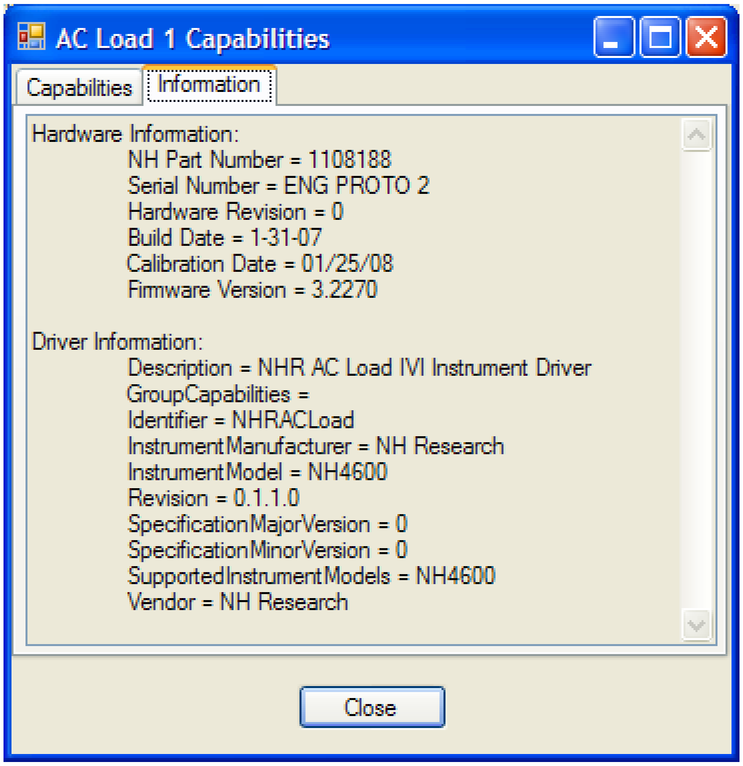


Press the “Capabilities” button to display the permissible operation ranges of the AC Load.



Capability	Minimum	Maximum
AC Voltage	40.000 Vrms	360.000 Vrms
AC Current	0.000 Arms	30.000 Arms
Power	0.000 Wrms	3000.000 Wrms
Resistance	2.500 Rrms	1000.000 Rrms
Frequency	40.000 Hz	450.000 Hz
Crest Factor	1.400	3.500
Power Factor	-1.000	1.000
Start Phase Angle	0.000°	360.000°

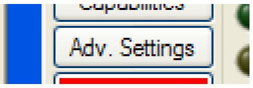
Press the “Information” tab to view hardware and driver information:



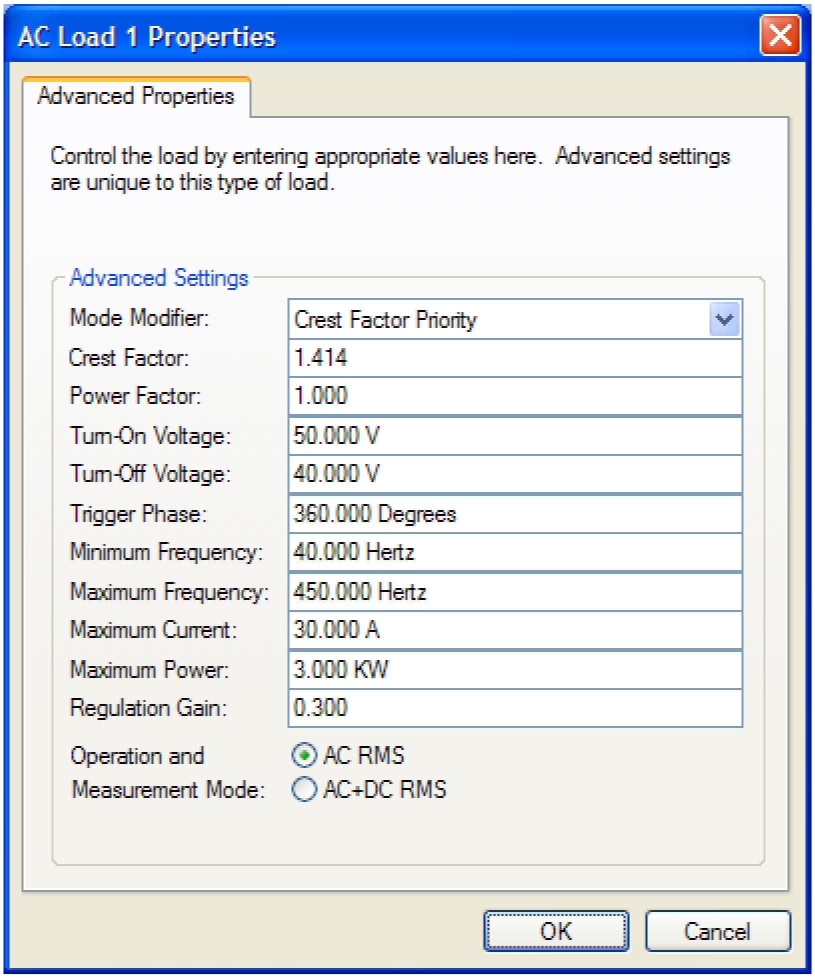
Hardware Information:
NH Part Number = 1108188
Serial Number = ENG PROTO 2
Hardware Revision = 0
Build Date = 1-31-07
Calibration Date = 01/25/08
Firmware Version = 3.2270

Driver Information:
Description = NHR AC Load IVI Instrument Driver
GroupCapabilities =
Identifier = NHRACLoad
InstrumentManufacturer = NH Research
InstrumentModel = NH4600
Revision = 0.1.1.0
SpecificationMajorVersion = 0
SpecificationMinorVersion = 0
SupportedInstrumentModels = NH4600
Vendor = NH Research

4.2.7 Advanced Settings



The advanced settings allow you to customize specific operational characteristics of the AC Load



Control the load by entering appropriate values here. Advanced settings are unique to this type of load.

Advanced Settings

Mode Modifier: Crest Factor Priority
Crest Factor: 1.414
Power Factor: 1.000
Turn-On Voltage: 50.000 V
Turn-Off Voltage: 40.000 V
Trigger Phase: 360.000 Degrees
Minimum Frequency: 40.000 Hertz
Maximum Frequency: 450.000 Hertz
Maximum Current: 30.000 A
Maximum Power: 3.000 KW
Regulation Gain: 0.300
Operation and Measurement Mode: ● AC RMS ○ AC+DC RMS

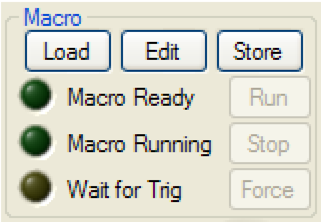
- The Mode Modifier controls how Crest Factor and Power Factor are used. The load must be in Constant Current or Constant Power mode or the mode modifier is ignored. See section 7.12 Crest Factor and Power Factor Relationship.
- Crest Factor – Crest factor is peak current divided by RMS current. When a crest factor of 1.414 is programmed, the load creates a sinusoidal current waveform. When a higher crest factor is programmed the load creates a modified sinusoidal current waveform with the correct crest factor.
- Power Factor – Power factor is true power divided by apparent power. For a resistive load the power factor is 1. If the power factor programmed is positive it will be a leading power factor. If the power factor programmed is negative it will be a lagging power factor.

- Turn-On Voltage – the minimum voltage the load must detect before it will start drawing current.
- Turn-Off Voltage – the maximum voltage the load must detect and not stop drawing current. When the voltage goes below Turn-Off Voltage, the load turns off until the voltage goes above Turn-On Voltage.
- Trigger Phase – determines the phase angle of the AC voltage that commands are executed. For example, if current changes are to only happen at a zero crossing set the trigger phase to either 0.0 or 180.0 degrees. If the phase angle is set to 360.0 degrees commands are executed as soon as they are received (they do not wait for the trigger phase).
- Minimum Frequency – the lowest frequency the load will detect and draw current.
- Maximum Frequency – the highest frequency the load will detect and draw current.
- Maximum Current – sets the maximum current the load will draw regardless of other programmed values and modes
- Maximum Power – sets the maximum power the load will draw regardless of other programmed values and modes
- Regulation Gain – sets the gain of the correction circuit. For example, if the load is set to 12.0 amps in Constant Current mode and it measures 11.9 amps, a regulation gain of 0.05 will cause the load to increase the current by 5% of 0.1 amps until the desired setting is reached.
- Operation and Measurement Mode – determines if measurements will include or exclude any DC component. A perfectly symmetrical AC signal centered about zero will have no DC component and therefore there will be no apparent difference in measurements regardless of this setting. However, if there is a DC component, measurements will differ.

4.2.8 Resetting

Resets the load hardware to default values.

4.2.9 Macro



Queues up to 100 commands and when triggered executes them locally (internal DSP). This allows very fast changes (every cycle if needed) in current, which can reveal precious information about the regulation, output voltage and current, peak capabilities etc. of the UUT in just one test. The commands can be executed as a single shot or as a loop.

When the load is ready to execute a macro, the “Macro Ready” light will be lit. Press “Run” to execute the macro. While the macro is running, the “Macro Running” light will be lit. Press “Stop” to halt the macro before it ends, or to stop a continuous macro. The load will be in an undetermined state when a macro is manually stopped.

The “Wait for Trig” light will be lit when the macro is waiting for a trigger event. Press “Force” to generate a system trigger to manually generate the event.

4.2.9.1 Load Macro

The macro steps can be loaded from a text file. Any currently loaded macro steps are replaced by the contents of the file. The format is as follows (the underlined character is the minimum text necessary to define the action):

The first line indicates the trigger action that will begin the macro. The choices are “PhaseAngle”, which will start immediately once the input voltage phase angle matches the “Trigger Phase” advanced property, “SystemTrigger”, where the macro will wait until a system trigger is received, or “VoltageInput”, where the macro will start when the input voltage starts below the “Turn-Off Voltage” then rises and exceeds the “Turn-On Voltage” or starts above the “Turn-On Voltage” then falls below the “Turn-Off Voltage” advanced properties.

The second line indicates the power factor priority mode. Choose from “CrestFactor”, “PowerFactor” or “UnityPowerFactor”. See section 7.12 Crest Factor and Power Factor Relationship.

The remaining lines are used to define the macro steps. Each step specifies a mode and value, crest factor, power factor, trigger and cycle count. The file may contain up to 100 macro steps.

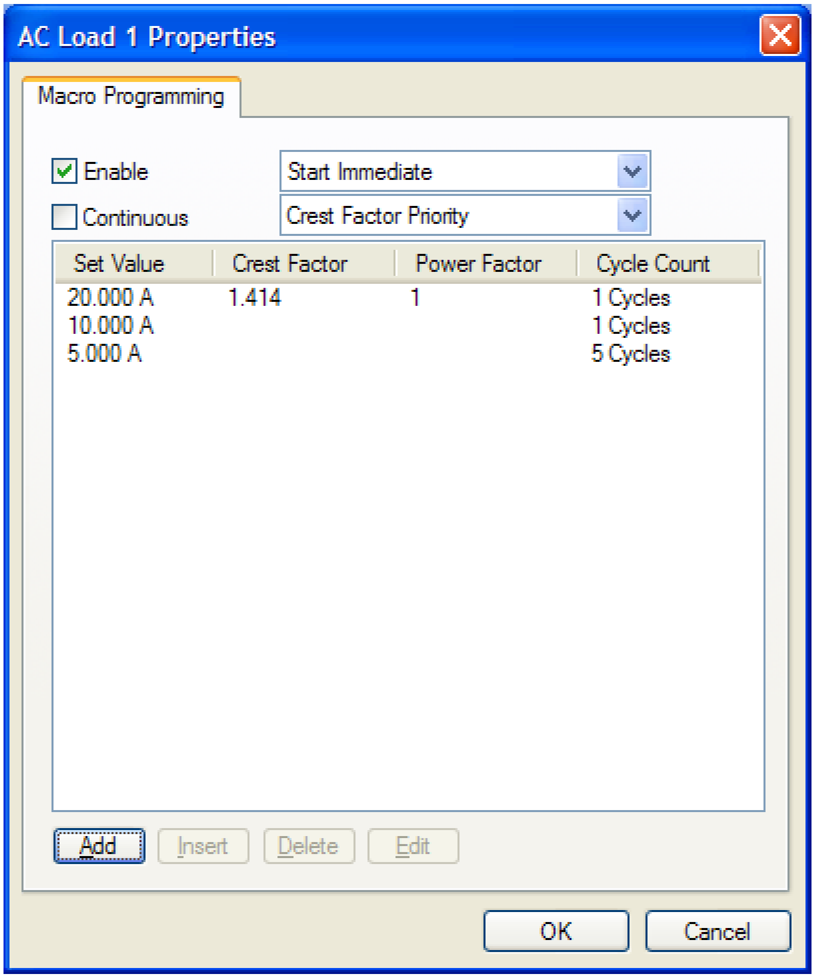
The “mode” is either “Current”, “Resistance”, “Power” or “Voltage”; the “value” is in whole units corresponding to the mode; the trigger is “PhaseAngle”, “SystemTrigger” or “VoltageInput”. The crest factor field is ignored if the priority mode is not “CrestFactor”. Both the crest factor and power factor fields are ignored if the priority mode is “UnityPowerFactor”. The cycle count indicates the number of cycles the step will dwell when the trigger source is “PhaseAngle”; otherwise it is ignored.

The following is an example of turn on inrush current where the first cycle is 20A, the second cycle is 10A and the remaining cycles are 5A. The macro that will start immediately ("PhaseAngle"), and use crest factor priority. The three steps execute one after another without waiting for a trigger. At the end of the sequence, the load will remain in the last defined state.

```
PhaseAngle
CrestFactor
Current     20.000      1.414       1.000       PhaseAngle       1
Current     10.000      1.414       1.000       PhaseAngle       1
Current     5.000       1.414       1.000       PhaseAngle       5
```

4.2.9.2 Edit Macro

Press this button to display an editor where the macro can be defined interactively.



☑ Enable

☐ Continuous

Start Immediate

Crest Factor Priority

Set Value	Crest Factor	Power Factor	Cycle Count
20.000 A	1.414	1	1 Cycles
10.000 A			1 Cycles
5.000 A			5 Cycles

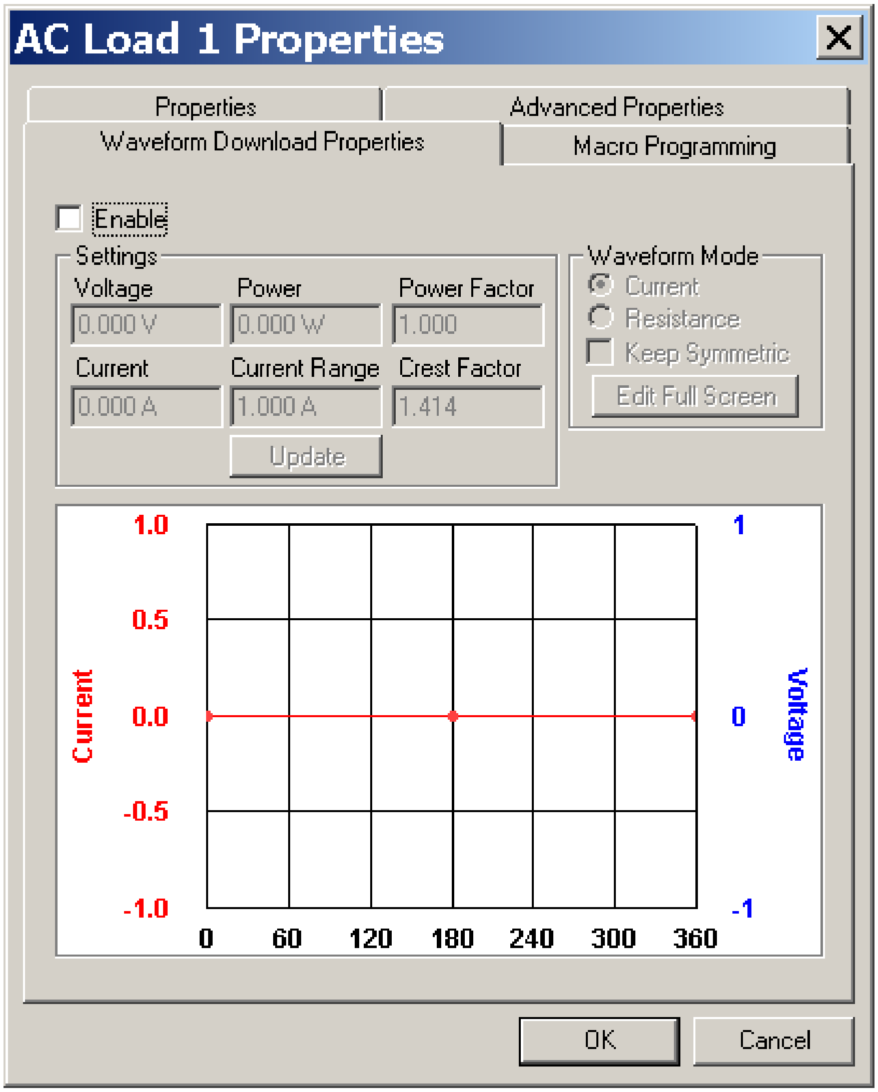
You can also edit a pre-existing macro by loading it from a file before pressing the Edit button.

4.2.9.3 Save Macro

When the "save" button is pressed, the contents of the loaded macro are saved to disk. The user is prompted for a name and location of the file.

4.2.10 Custom Waveshapes

The NHR AC Load has the ability to download user-defined waveshapes. Enabling this property allows the user to create the waveform to be downloaded.



☐ Enable

Settings

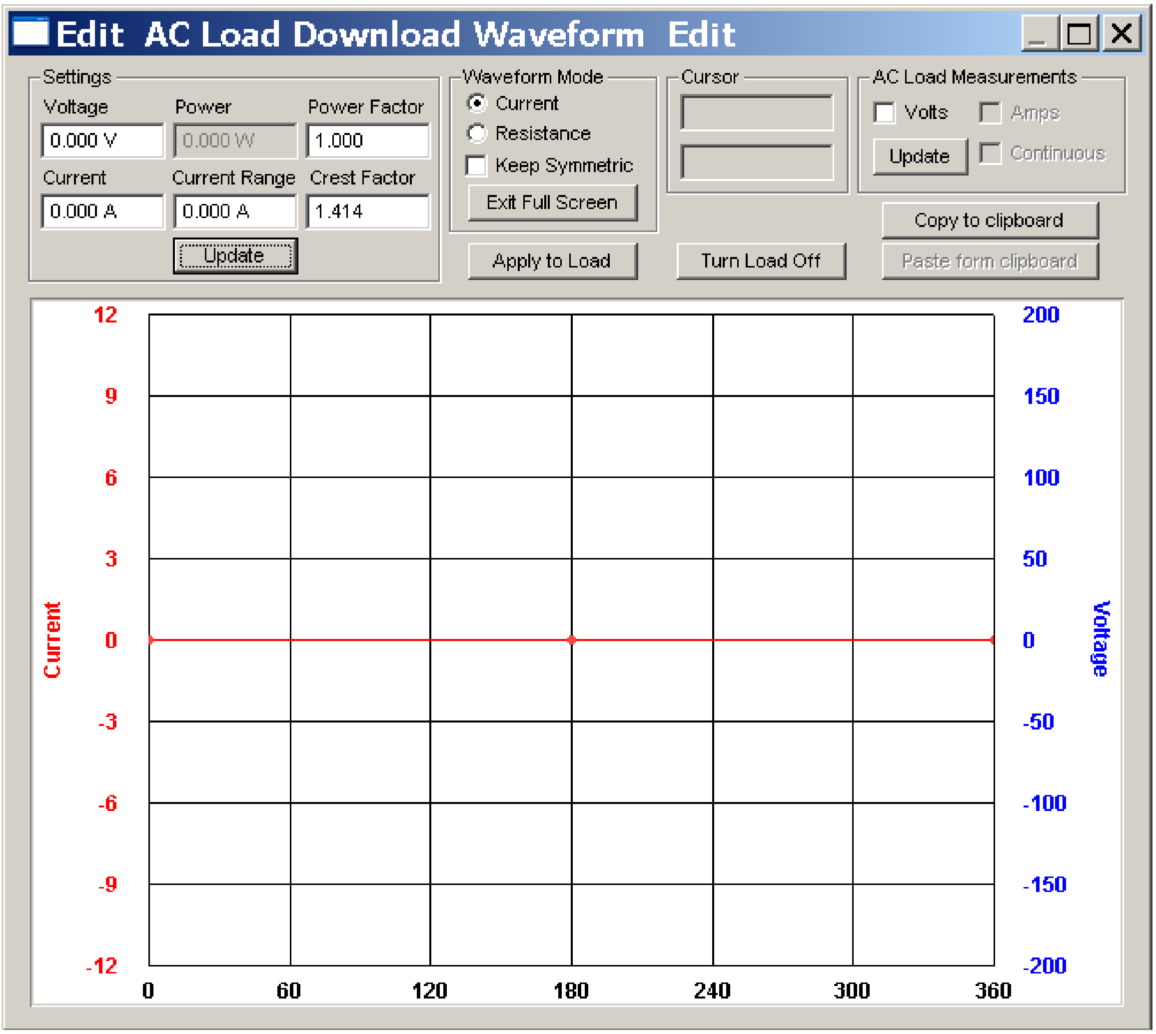
Voltage: 0.000 V
Power: 0.000 W
Power Factor: 1.000
Current: 0.000 A
Current Range: 1.000 A
Crest Factor: 1.414

Waveform Mode

● Current
○ Resistance
☐ Keep Symmetric

4.2.10.1 Full Screen Editing

After checking the Enable check box, clicking on the Edit Full Screen button brings up an editing dialog that displays all the editing controls.



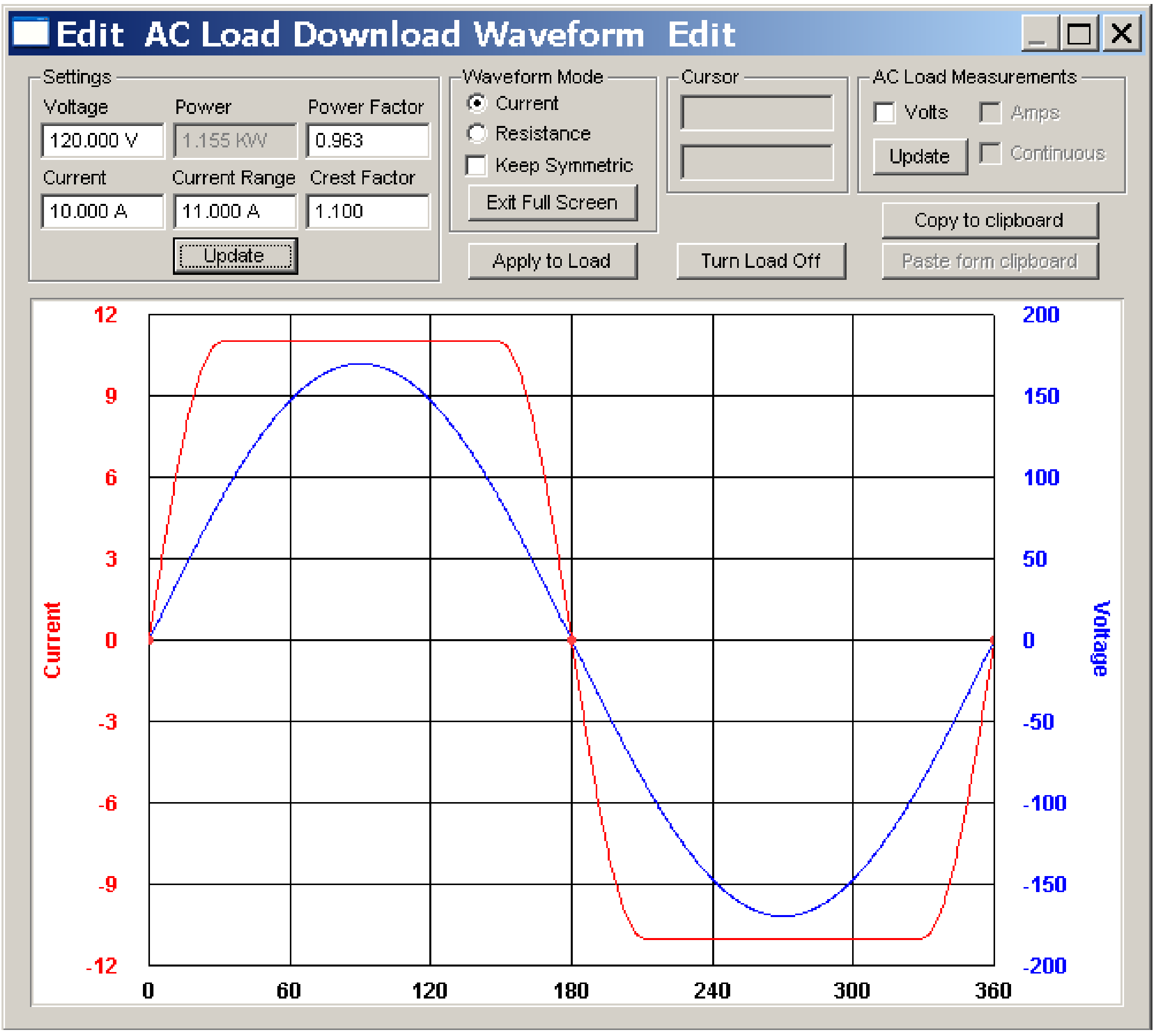
Voltage 0.000 V
Power 0.000 W
Power Factor 1.000
Current 0.000 A
Current Range 0.000 A
Crest Factor 1.414

● Current
○ Resistance
☐ Keep Symmetric

☐ Volts
☐ Amps
☐ Continuous

4.2.10.2 Generating Waveshapes

Smooth waveforms can be generated by editing the fields in the Settings group and then clicking the “Update” button. Setting the Voltage field to 120V will draw a sine wave with an RMS value of 120V. Setting the Current field to 10A will draw a sine wave with an RMS value of 10A. Increasing the Crest Factor will make more narrow current peaks. Decrease the Crest Factor and the Current waveform becomes more of a square wave.



Edit AC Load Download Waveform Edit

Settings

Voltage: 120.000 V
Power: 1.155 KW
Power Factor: 0.963
Current: 10.000 A
Current Range: 11.000 A
Crest Factor: 1.100

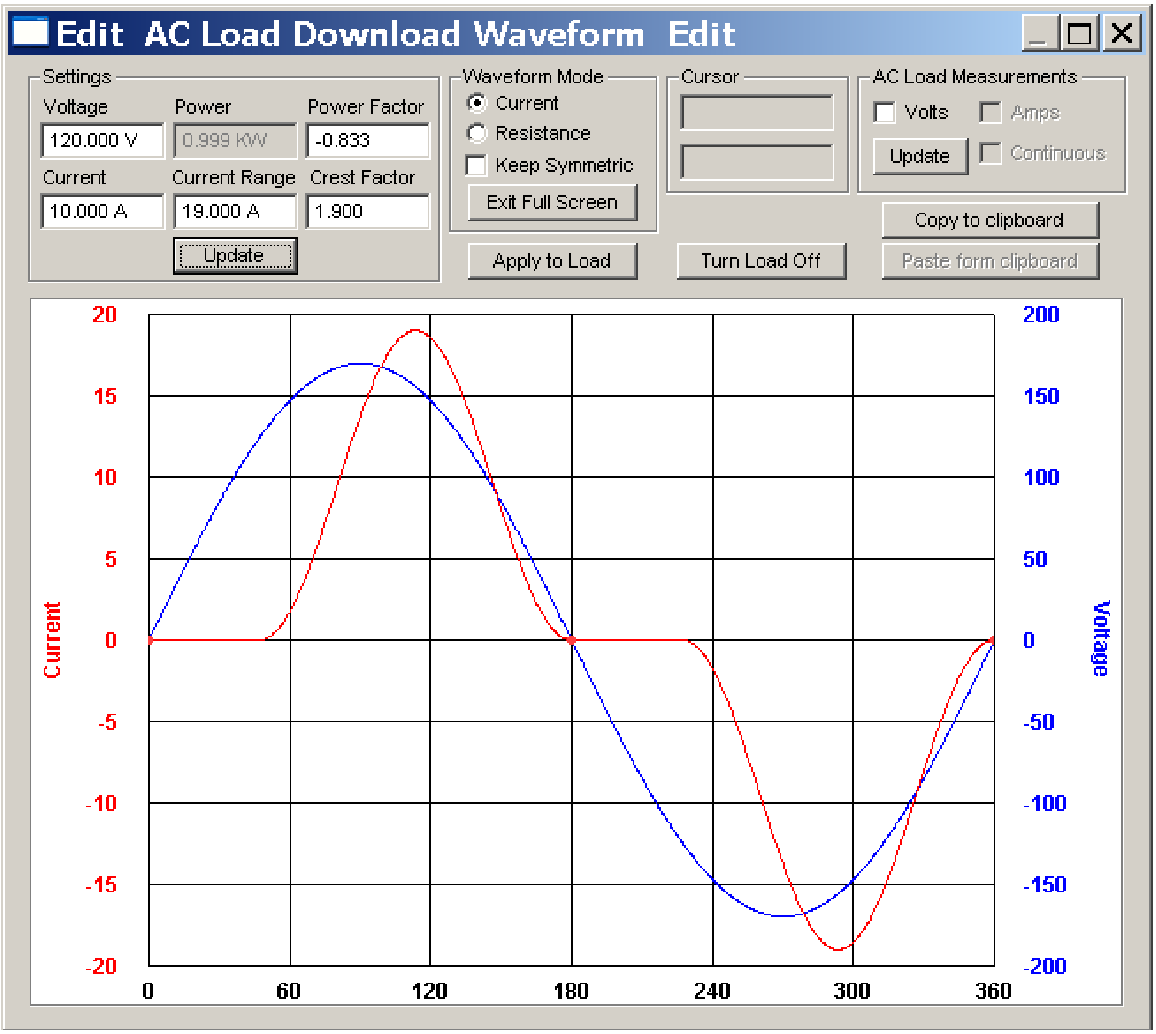
Waveform Mode

● Current
○ Resistance
☐ Keep Symmetric

AC Load Measurements

☐ Volts
☐ Amps
☐ Continuous

When the Crest Factor is about 1.66 and greater, the Power Factor can shift the Current waveform. Positive values cause the current to lead the voltage and negative values cause the current to lag the voltage. Large Power Factors center the waveform while small Power Factors shift. Clicking the Update button not only draws the best waveform to fit the settings, it also recalculates the actual Power Factor of the waveform and will increase the current range if it is required.



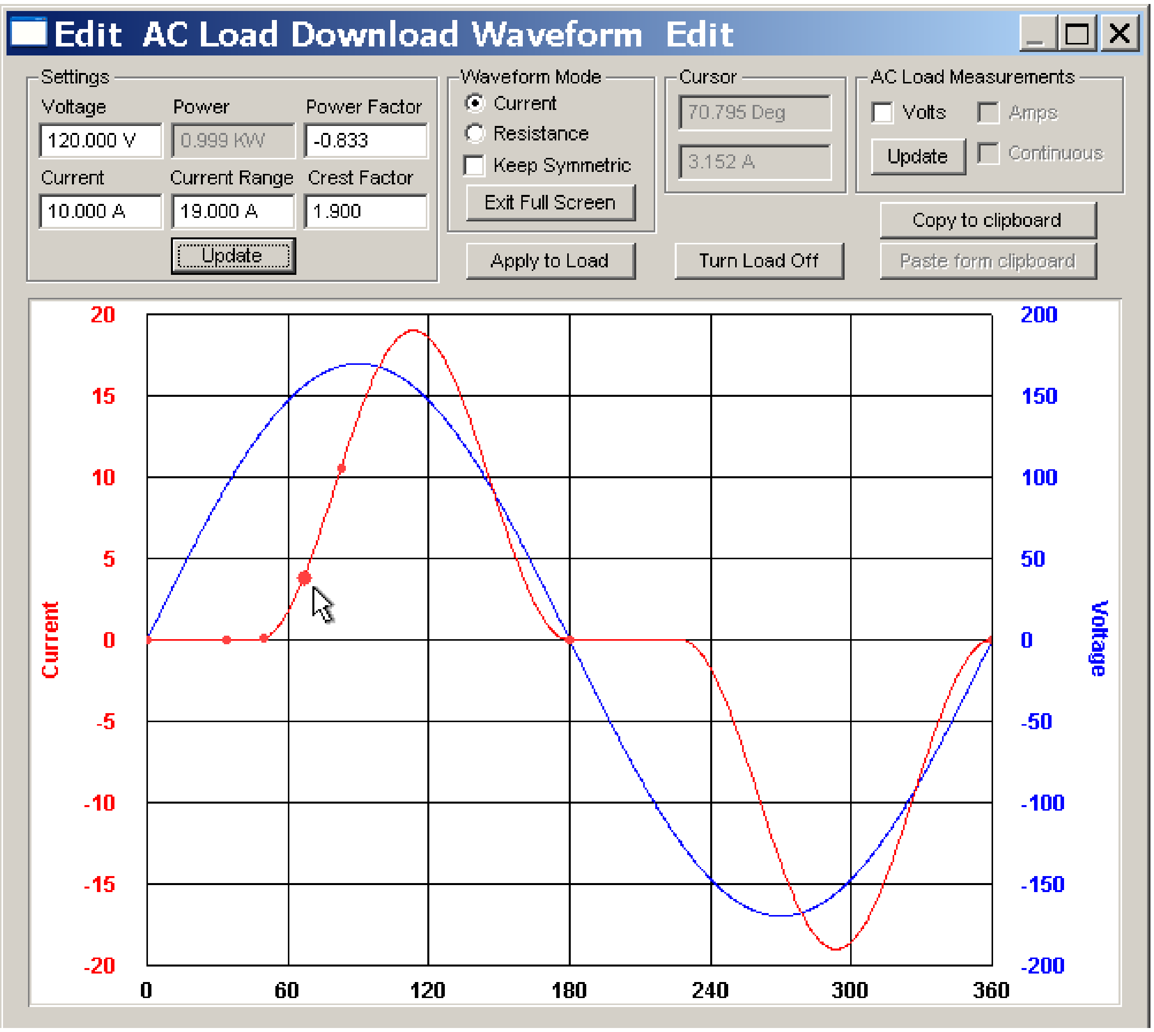
Voltage: 120.000 V
Power: 0.999 KW
Power Factor: -0.833
Current: 10.000 A
Current Range: 19.000 A
Crest Factor: 1.900

● Current
○ Resistance
☐ Keep Symmetric

☐ Volts
☐ Amps
☐ Continuous

4.2.10.3 Adding Anchor Points

With the mouse in the edit array and between 0 and 360 degrees, a left click will add an anchor to the current waveform. There are three anchors that are always on the waveform. They are at 0, 180, and 360 degrees and all must be at 0.0A. These three anchors cannot be selected and cannot be moved. Any other anchor can be selected by moving the mouse to it and the anchor will get larger.



Settings
Voltage 120.000 V
Power 0.999 KW
Power Factor -0.833
Current 10.000 A
Current Range 19.000 A
Crest Factor 1.900

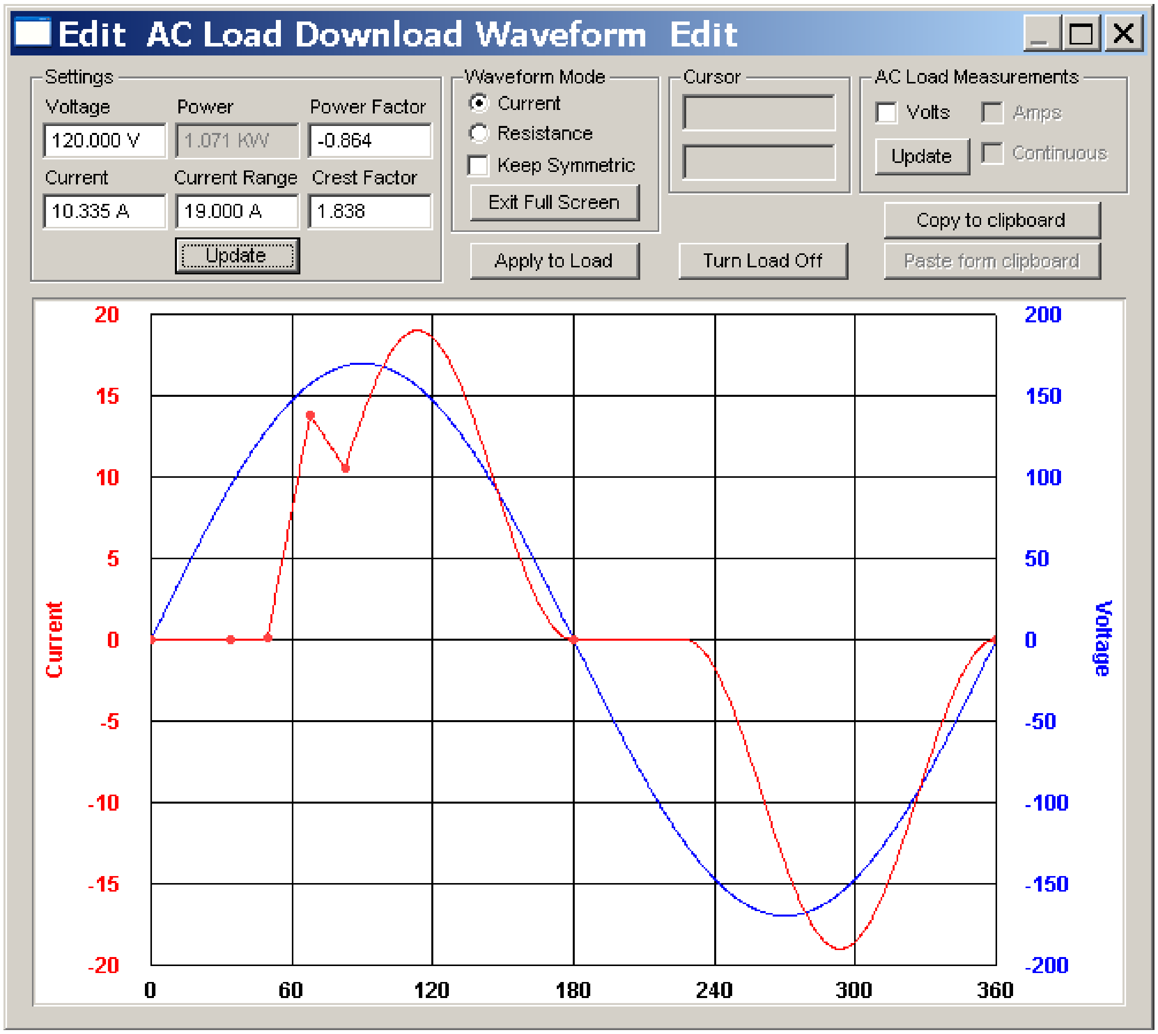
Waveform Mode
● Current
○ Resistance
☐ Keep Symmetric

Cursor
70.795 Deg
3.152 A

AC Load Measurements
☐ Volts
☐ Amps
☐ Continuous

4.2.10.4 Moving Anchor Points

To move an anchor, select the anchor by moving the mouse near and hold the left mouse button down. Move the mouse to the new location and let the left mouse button up. The waveform becomes straight lines from the selected anchor to the nearest anchors on each side.



Edit AC Load Download Waveform Edit

Settings

Voltage: 120.000 V
Power: 1.071 KW
Power Factor: -0.864
Current: 10.335 A
Current Range: 19.000 A
Crest Factor: 1.838

Waveform Mode

● Current
○ Resistance
☐ Keep Symmetric

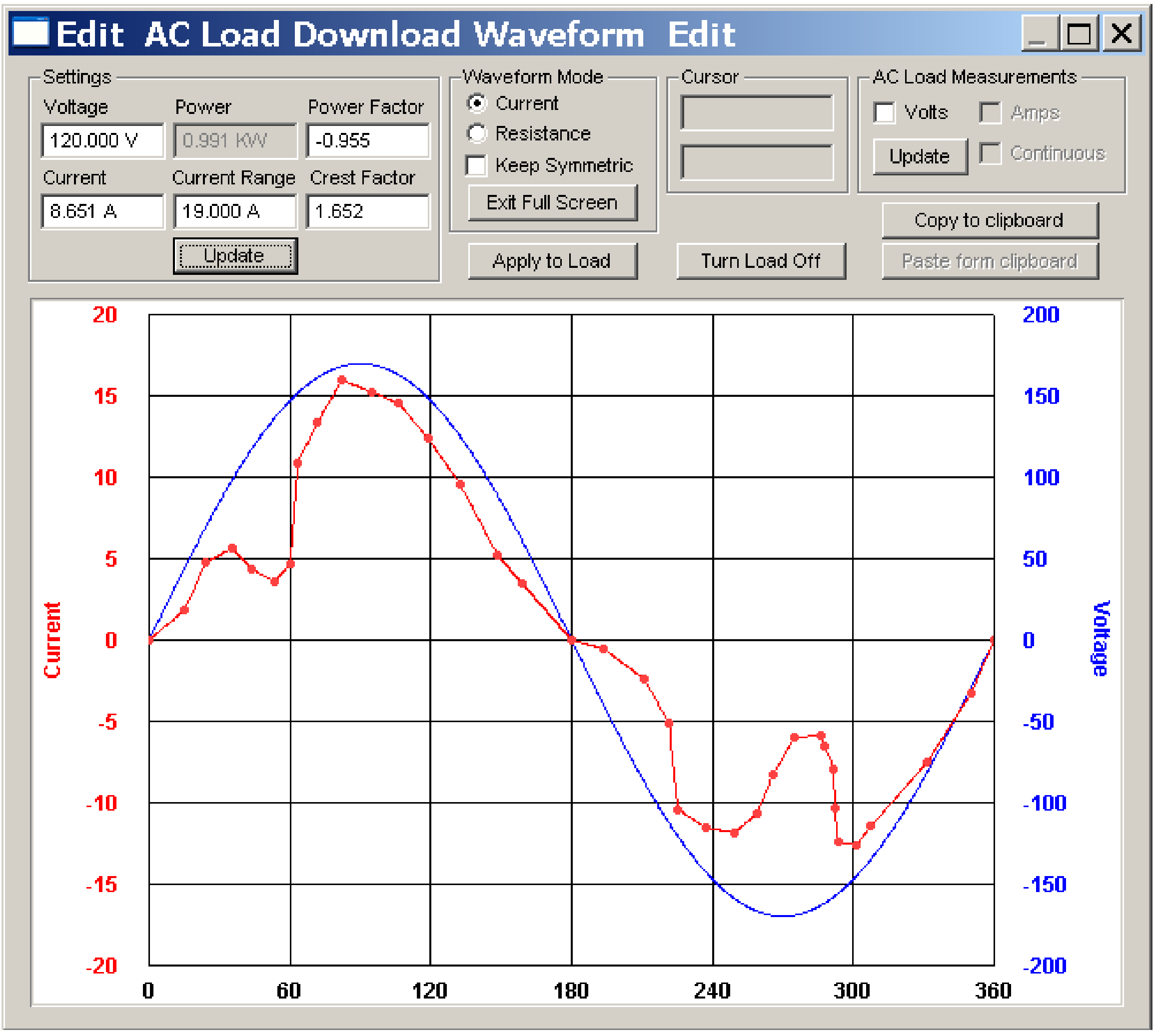
Cursor

AC Load Measurements

☐ Volts
☐ Amps
☐ Continuous

An anchor is not allowed to pass another anchor. An anchor on the left side of 180 degrees is not allowed below zero or above the Current Range displayed in the Settings group. An anchor on the right side of 180 degrees is not allowed above zero or below the negative Current Range displayed in the Settings group.

To make a waveform for the load, add and move anchors until the waveform is defined.



Edit AC Load Download Waveform Edit

Settings

Voltage: 120.000 V
Power: 0.991 KW
Power Factor: -0.955
Current: 8.651 A
Current Range: 19.000 A
Crest Factor: 1.652

Waveform Mode

● Current
○ Resistance
☐ Keep Symmetric

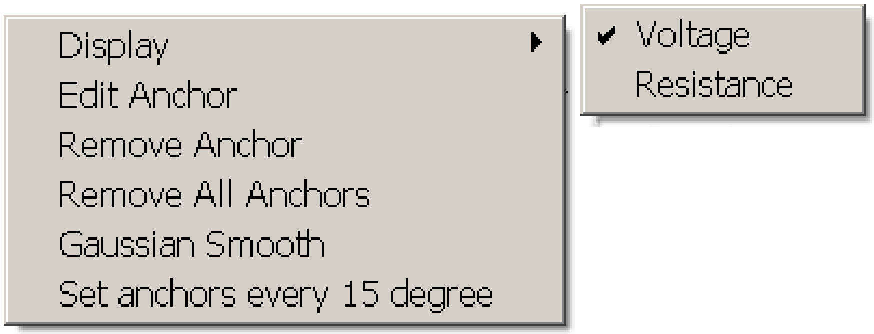
Cursor

AC Load Measurements

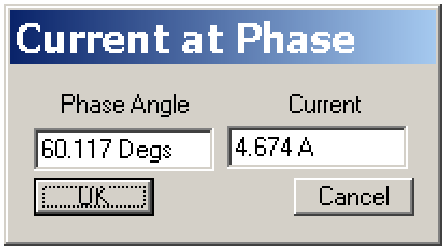
☐ Volts
☐ Amps
☐ Continuous

4.2.10.5 Editing Anchor Points

Right clicking the mouse, while it is in the drawing area, will bring up a menu for editing the waveform.

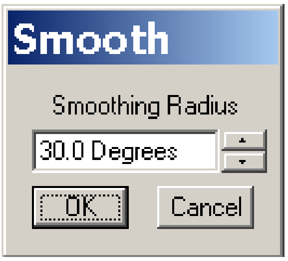


- Display: Selects which waveforms are to be displayed. Note that the Current waveform is always displayed.
- Edit Anchor: If an anchor is selected, brings up a form to define the positioning of the anchor. Note that there are 1024 values evenly distributed across 360 degrees.



Phase Angle 60.117 Degs
Current 4.674 A

- Remove Anchor: If an anchor is selected, deletes the anchor.
- Remove All Anchors: Removes all anchors.
- Gaussian Smooth: Smoothes the waveform by using the Gaussian or binomial algorithm. Note that excessive smoothing will result in a sine wave.



Smoothing Radius 30.0 Degrees

- Set anchors every 15 degrees: Adds anchors every 15 degrees starting at 15 degrees.

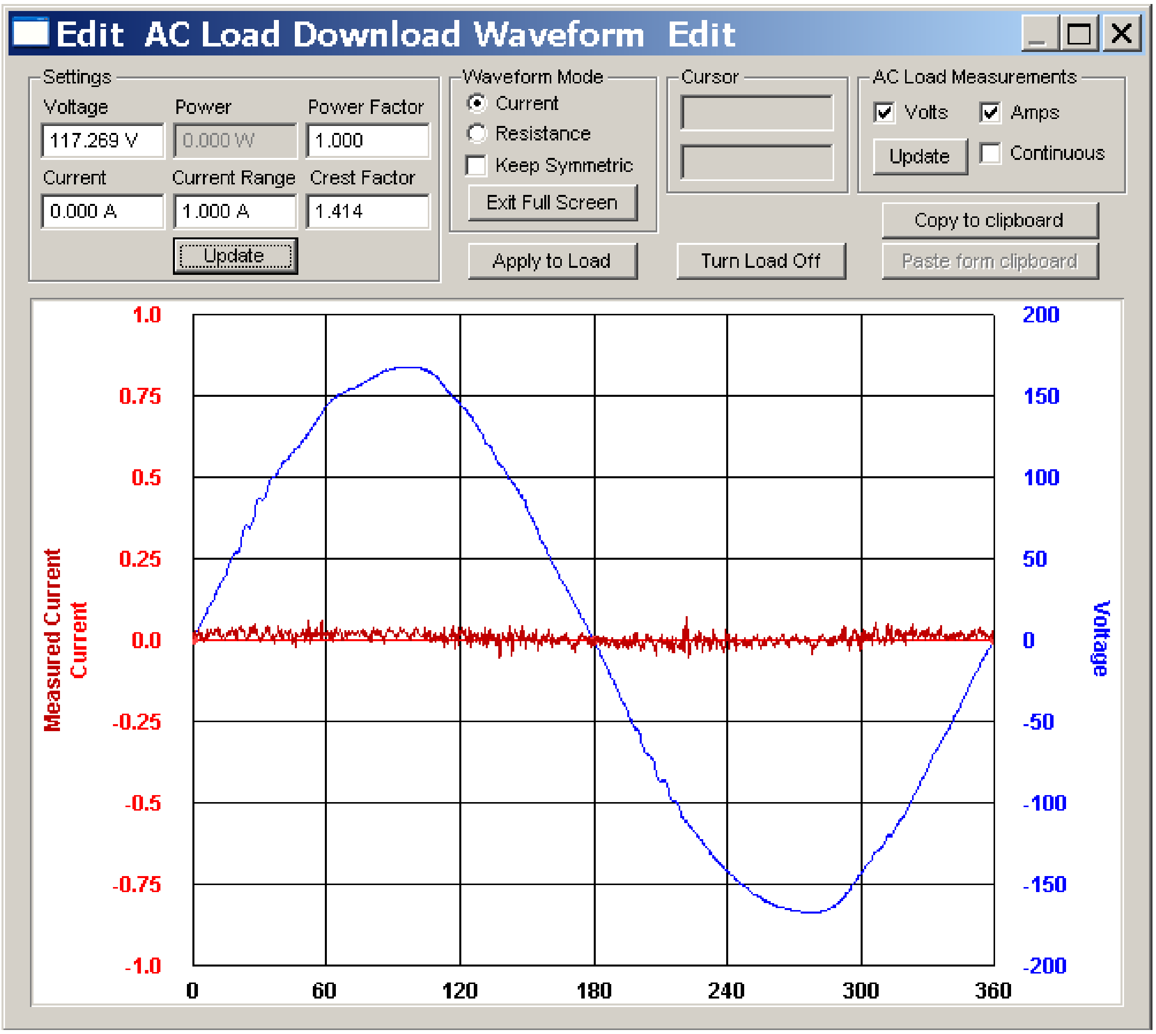
Waveforms can be created that exceed the capabilities of the AC Load. The load cannot perform a rise/fall time as fast as can be drawn. The load cannot draw current that the source does not supply. The load recalibrates its internal measurements immediately after every voltage zero crossing. During that time, the load is busy and may distort the current waveform.

4.2.10.6 Tutorial

Since the AC Load might distort the voltage waveform and might try to draw more current than is available, creating downloadable waveforms should be performed online with the actual hardware to be tested. Be sure to turn on sources and all other devices needed to create the environment required for the waveform test.

From the Download Waveform Properties tab, check the Enable check box and click the “Edit Full Screen” button. Under the “AC Load Measurements” group, check the Volts check box, check the Amps check box, and click the Update button.

The result should look something like this:



Edit AC Load Download Waveform Edit

Settings

Voltage: 117.269 V

Power: 0.000 W

Power Factor: 1.000

Current: 0.000 A

Current Range: 1.000 A

Crest Factor: 1.414

Waveform Mode

● Current

○ Resistance

☐ Keep Symmetric

Cursor

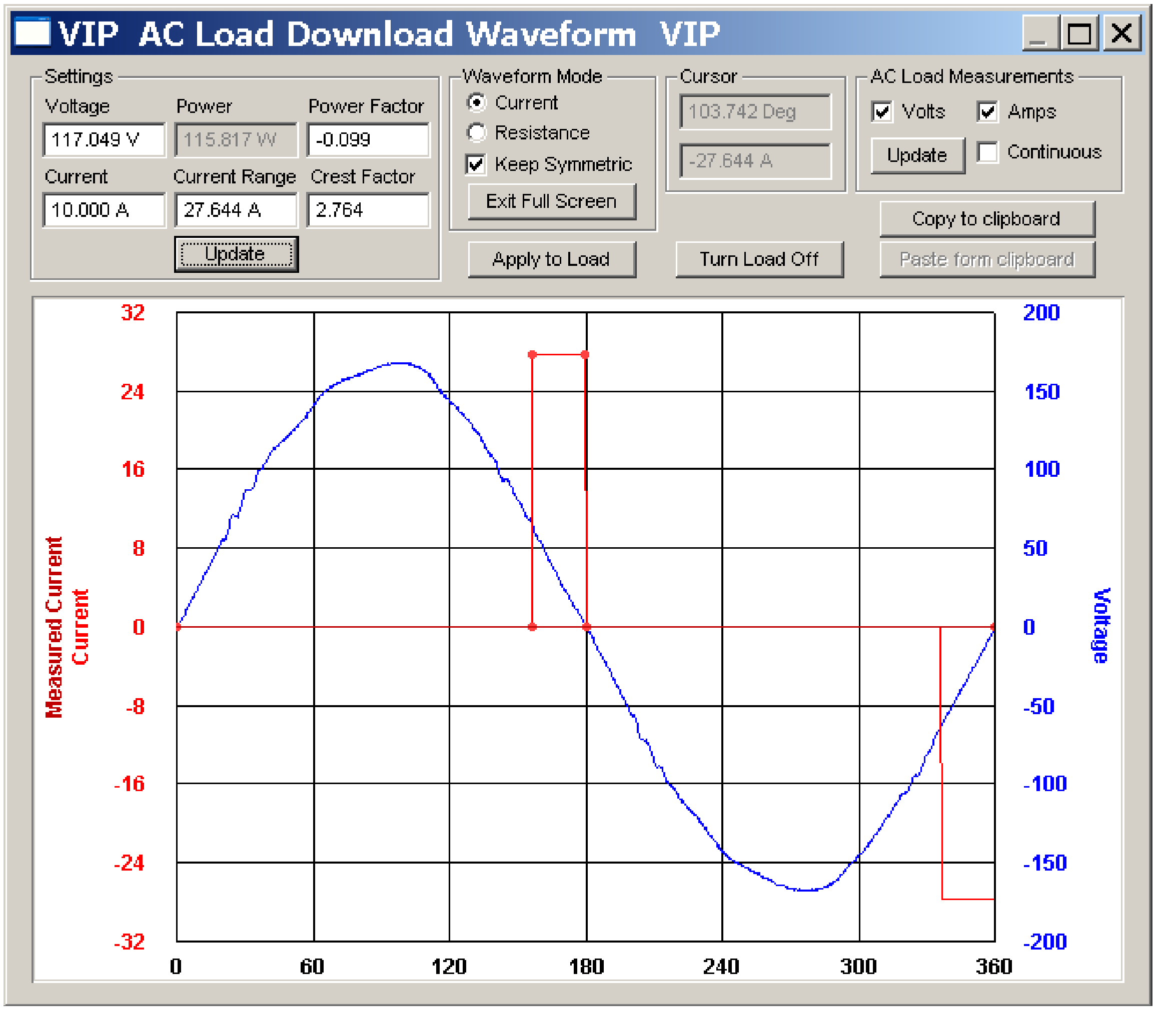
AC Load Measurements

☑ Volts ☑ Amps

☐ Continuous

Create the desired current waveform by adding anchors and dragging them until the desired waveform is complete. The Waveform Mode group has a Keep Symmetric check box. Checking this will keep the positive and negative waveforms identical and insure that the average DC current is zero.

In this example, we will create a waveform that is too extreme for the source to accommodate:



VIP AC Load Download Waveform VIP

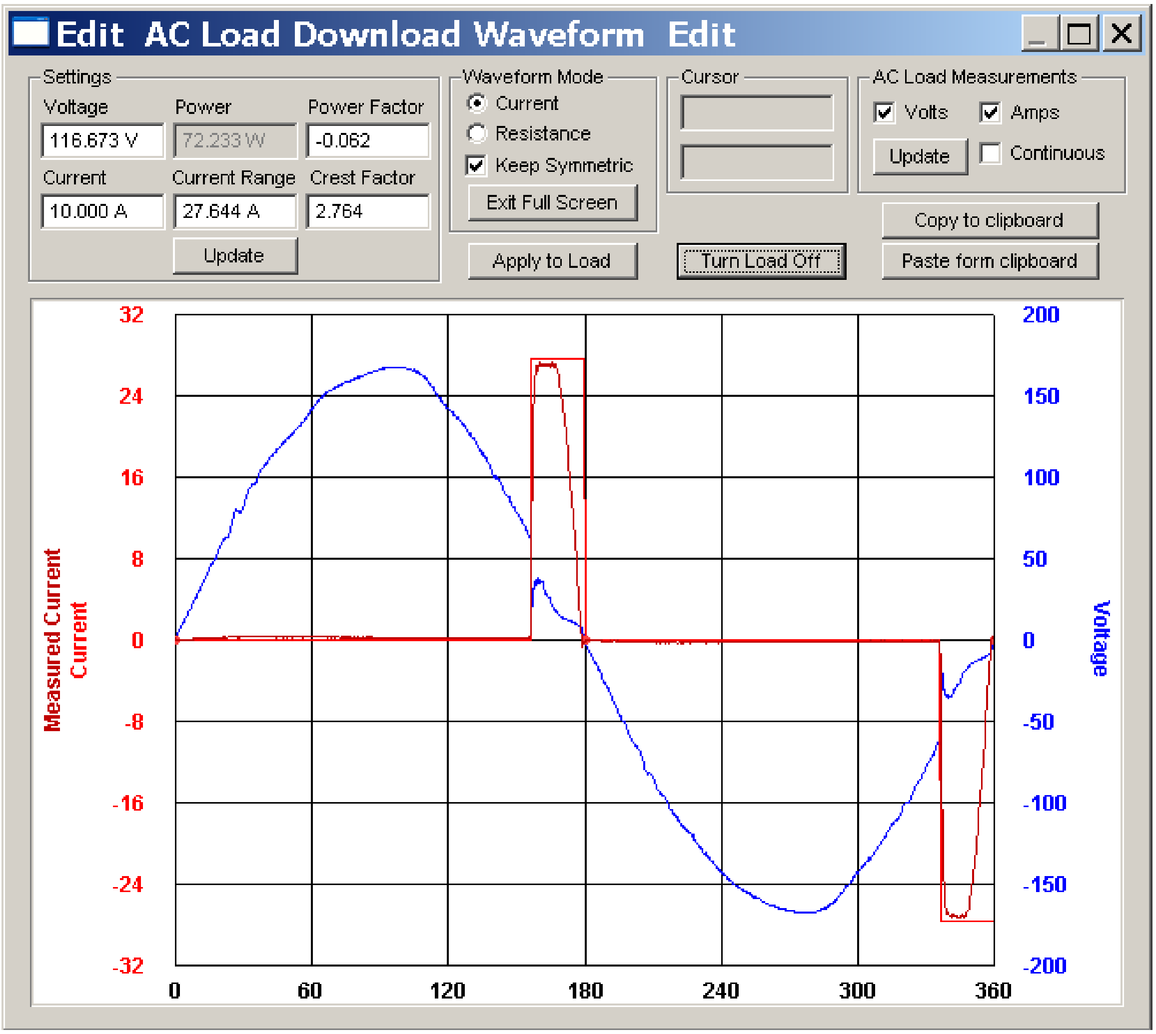
Settings
Voltage: 117.049 V
Power: 115.817 W
Power Factor: -0.099
Current: 10.000 A
Current Range: 27.644 A
Crest Factor: 2.764

Waveform Mode
● Current
○ Resistance
☑ Keep Symmetric

Cursor
103.742 Deg
-27.644 A

AC Load Measurements
☑ Volts ☑ Amps
☐ Continuous

The waveform can be tested by clicking the “Apply to Load” button, the “Update” button, and the “Turn Load Off” button. “Apply” sends the waveform to the load and puts the load in Current waveform mode. “Update” reads the actual Voltage and Current waveforms and displays them. “Turn Load Off” puts the load in off mode so that the UUT and other hardware are not working while deciding on what kind of waveform to use.



Settings

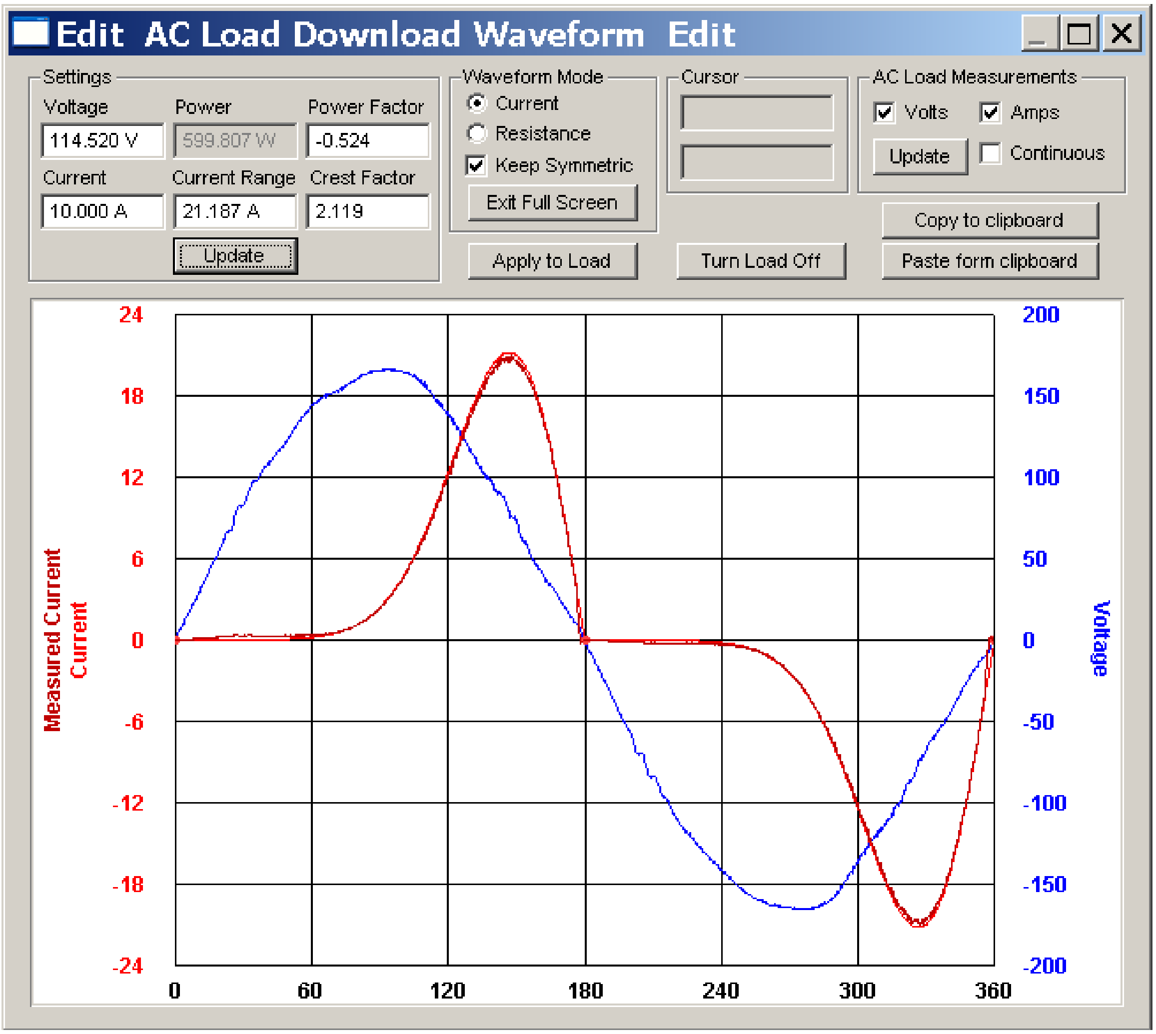
Voltage: 116.673 V
Power: 72.233 W
Power Factor: -0.062
Current: 10.000 A
Current Range: 27.644 A
Crest Factor: 2.764

Waveform Mode
● Current
○ Resistance
☑ Keep Symmetric

AC Load Measurements
☑ Volts
☑ Amps
☐ Continuous

This waveform has too abrupt of a current change. It is distorting the voltage waveform. Also, the high current is too close to zero crossing for the source to supply the requested current.

Smooth for 90 degrees using the Gaussian Smooth function and reapply to hardware. Smoothing the waveform shifts the current away from zero crossing, where there is not enough voltage to draw much current. Smoothing also removes abrupt transitions that cause the voltage to overshoot or undershoot.



Settings

Voltage 114.520 V

Power 599.807 W

Power Factor -0.524

Current 10.000 A

Current Range 21.187 A

Crest Factor 2.119

Waveform Mode

● Current

○ Resistance

☑ Keep Symmetric

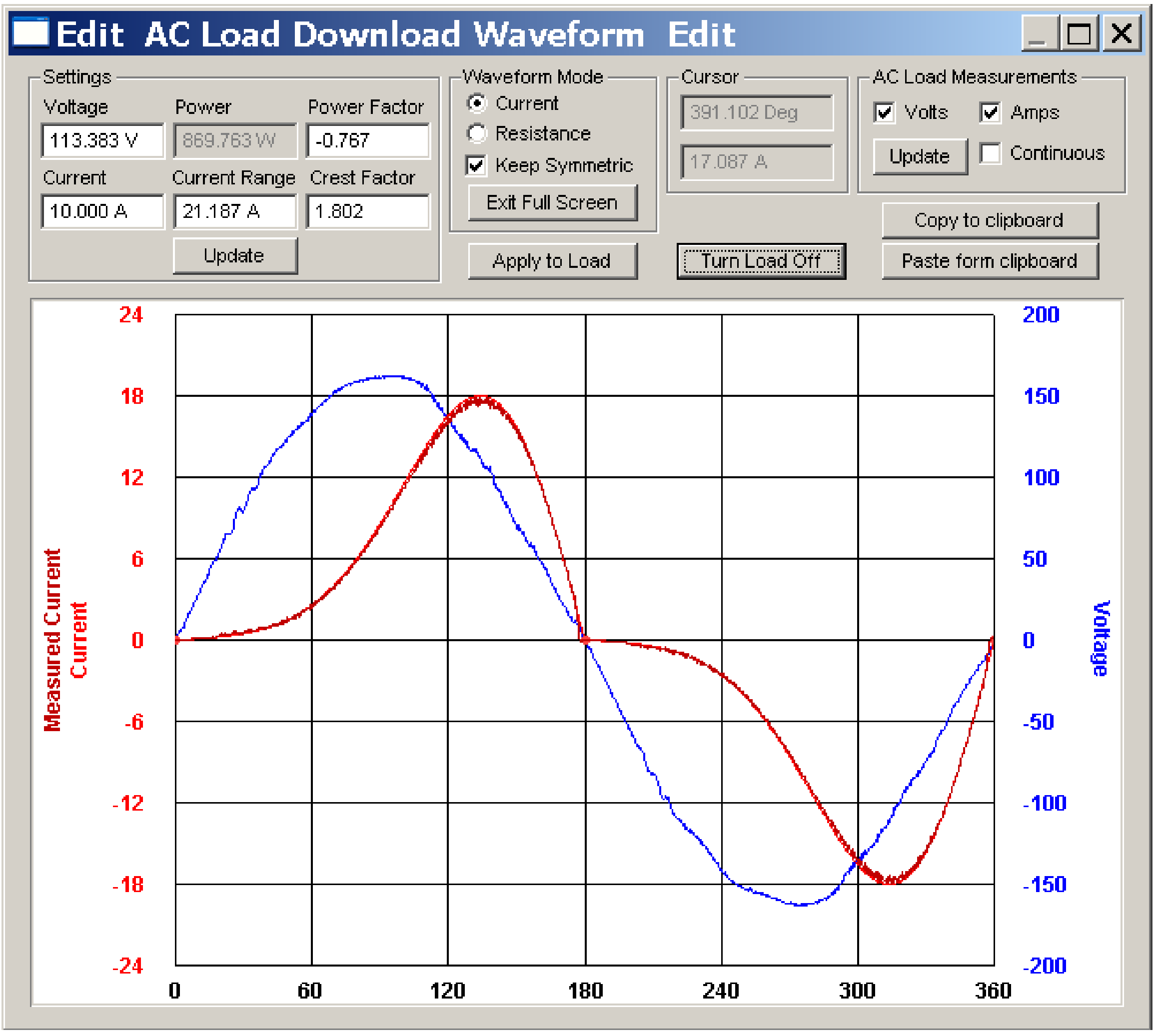
AC Load Measurements

☑ Volts ☑ Amps

☐ Continuous

Click “Copy to clipboard” to save a temporary copy. This is a good method for saving a waveform to retrieve later.

Smooth for another 90 degrees and reapply to hardware.



Settings

Voltage 113.383 V

Power 869.763 W

Power Factor -0.767

Current 10.000 A

Current Range 21.187 A

Crest Factor 1.802

Waveform Mode

● Current

○ Resistance

☑ Keep Symmetric

Cursor

391.102 Deg

17.087 A

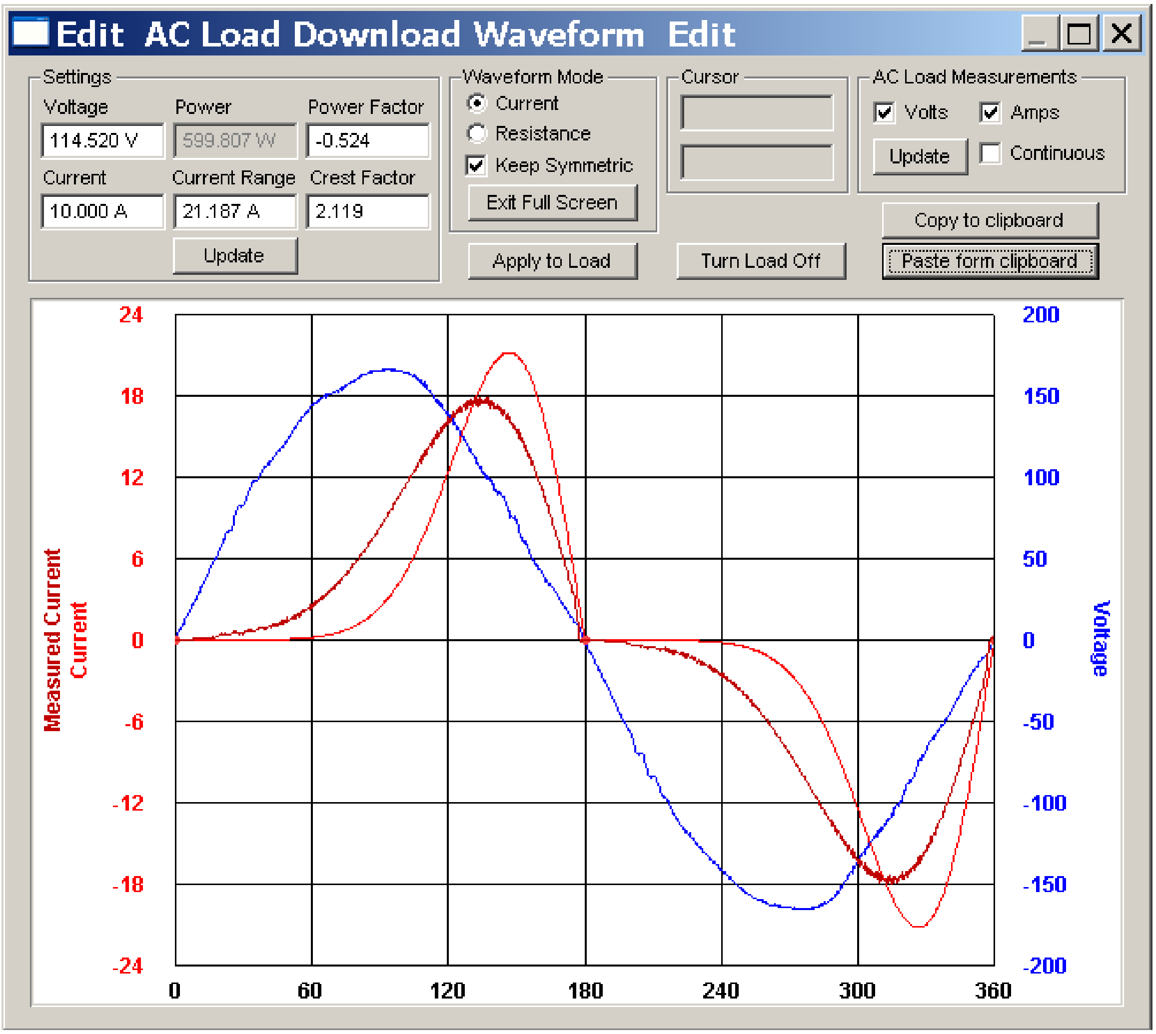
AC Load Measurements

☑ Volts

☑ Amps

☐ Continuous

Retrieve the saved waveform by clicking Paste from clipboard but do not retry.



Edit AC Load Download Waveform Edit

Settings

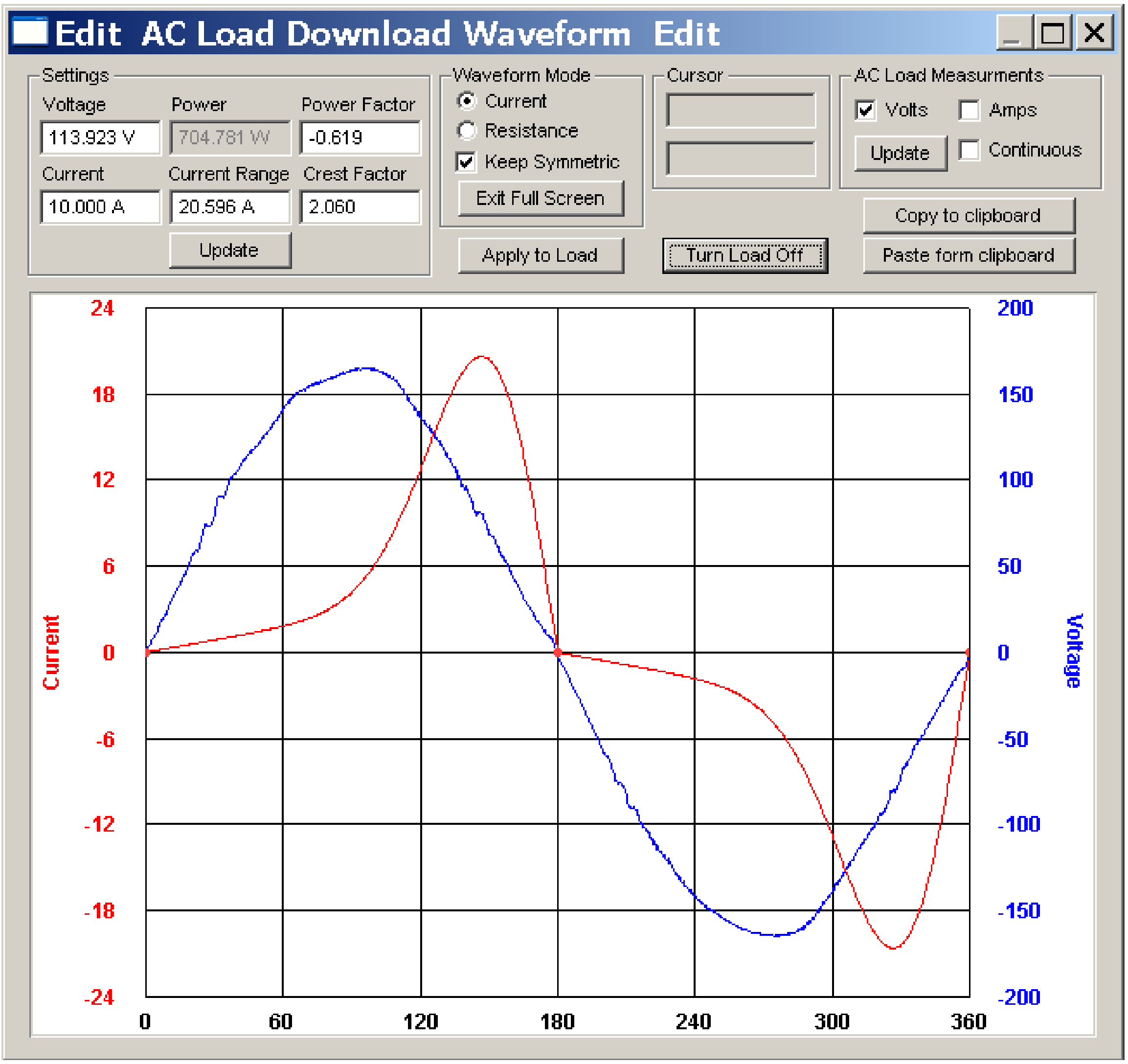
Voltage: 114.520 V
Power: 599.807 W
Power Factor: -0.524
Current: 10.000 A
Current Range: 21.187 A
Crest Factor: 2.119

Waveform Mode
● Current
○ Resistance
☑ Keep Symmetric

AC Load Measurements
☑ Volts ☑ Amps
☐ Continuous

This shows the difference between the last two waveforms.

Remove the measured current waveform by unchecking the Amps check box in “AC Load Measurements”.



Edit AC Load Download Waveform Edit

Settings

Voltage: 113.923 V

Power: 704.781 W

Power Factor: -0.619

Current: 10.000 A

Current Range: 20.596 A

Crest Factor: 2.060

Waveform Mode

● Current

○ Resistance

☑ Keep Symmetric

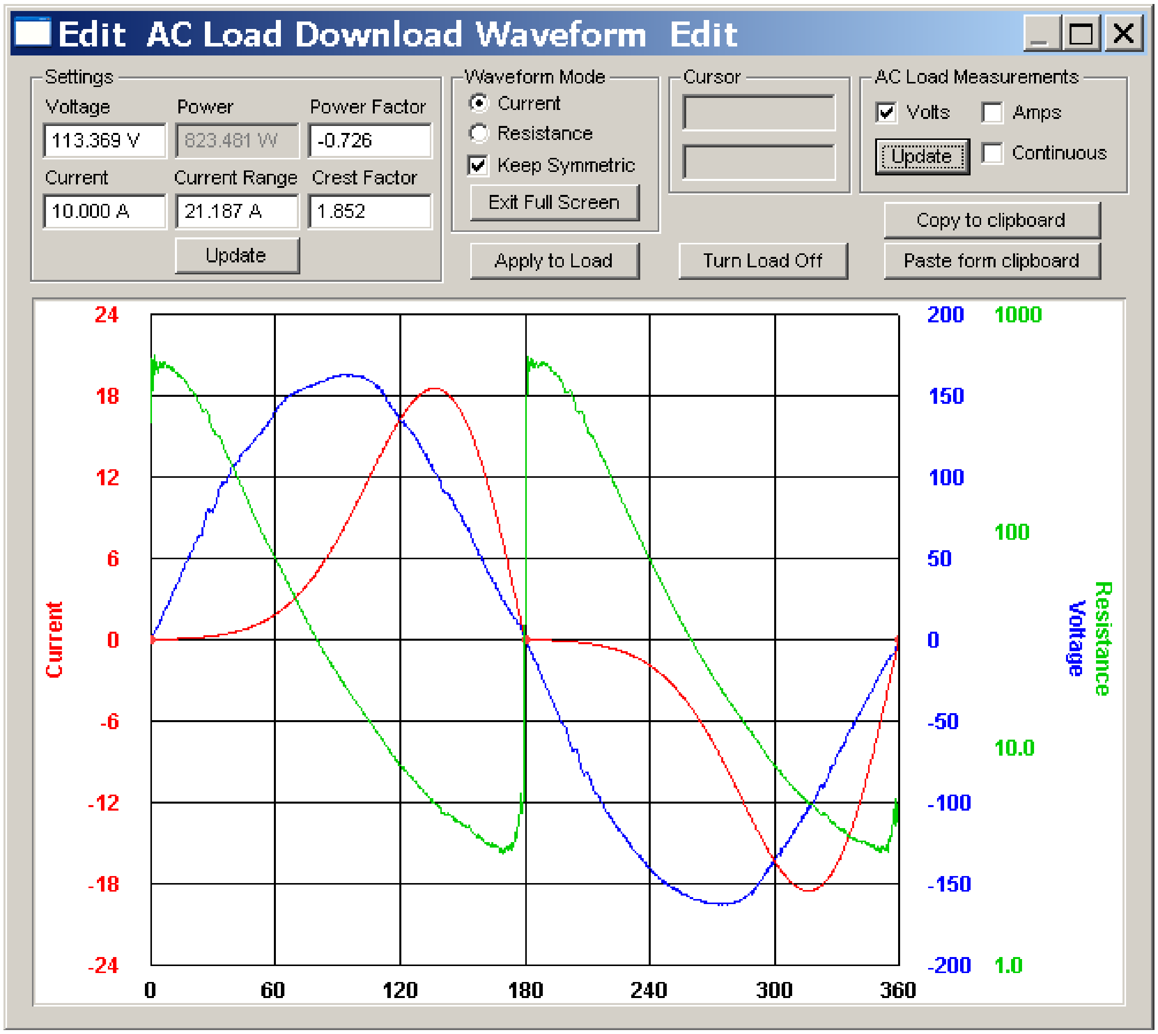
AC Load Measurments

☑ Volts

☐ Amps

☐ Continuous

To consider this waveform as a resistance waveform, display the resistance waveform: right click in the graph area, select Display, and select Resistance.



Edit AC Load Download Waveform Edit

Settings

Voltage: 113.369 V
Power: 823.481 W
Power Factor: -0.726
Current: 10.000 A
Current Range: 21.187 A
Crest Factor: 1.852

Waveform Mode

● Current
○ Resistance
☑ Keep Symmetric

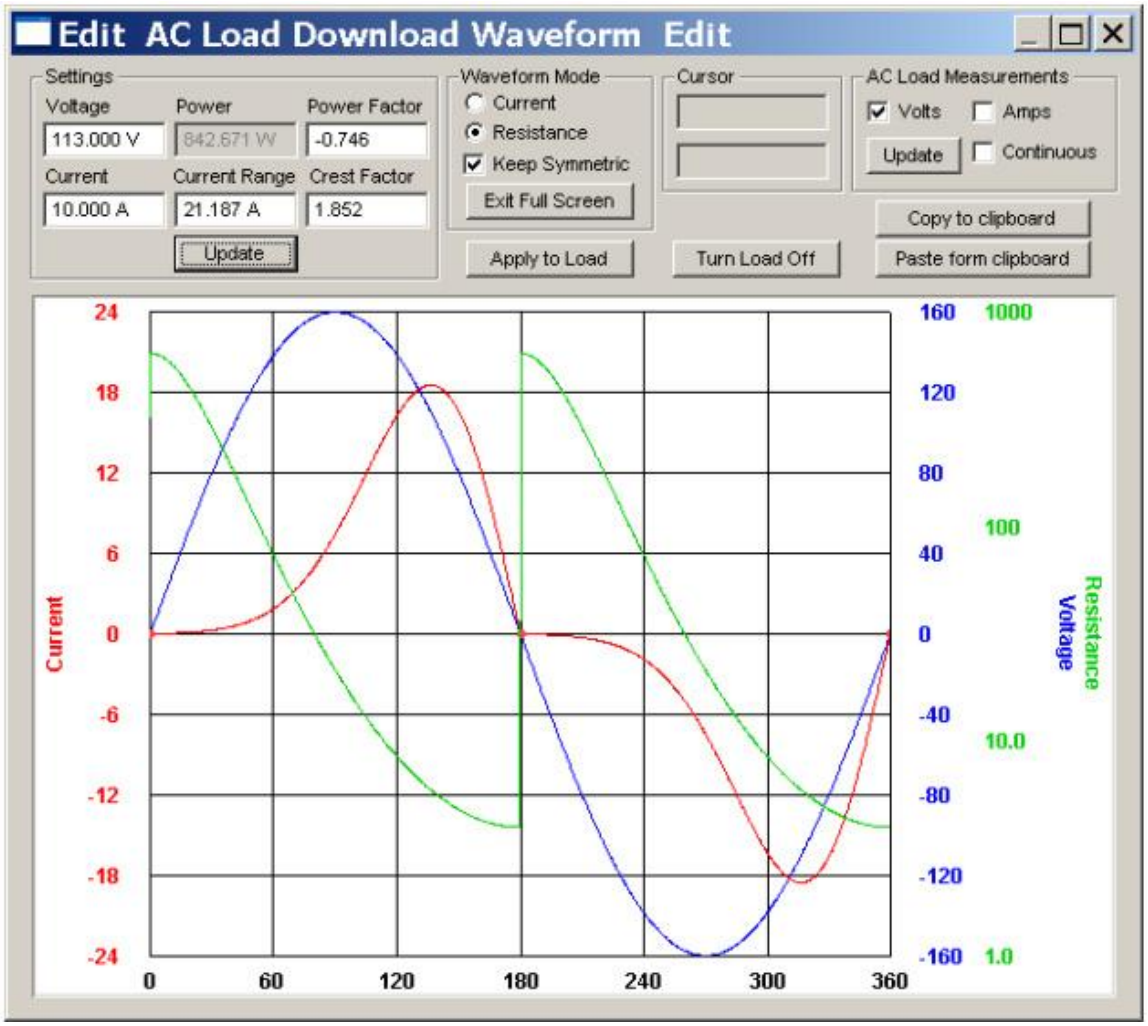
AC Load Measurements

☑ Volts
☐ Amps
☐ Continuous

The resistance waveform cannot be edited directly. It is generated from the voltage and current waveforms. Pay close attention to the resistance scale, it is logarithmic.

Two observations to notice: The unloaded AC voltage is around 117 volts RMS but with this 10.0 amp RMS load the RMS voltage is between 113 and 114 volts. And, noise in the actual voltage is also in the resistance waveform.

To create a smooth resistance waveform, set the voltage to 113.0 volts and click the Update button in the “Settings” group. Select Resistance in the Waveform Mode group.


Edit AC Load Download Waveform Edit

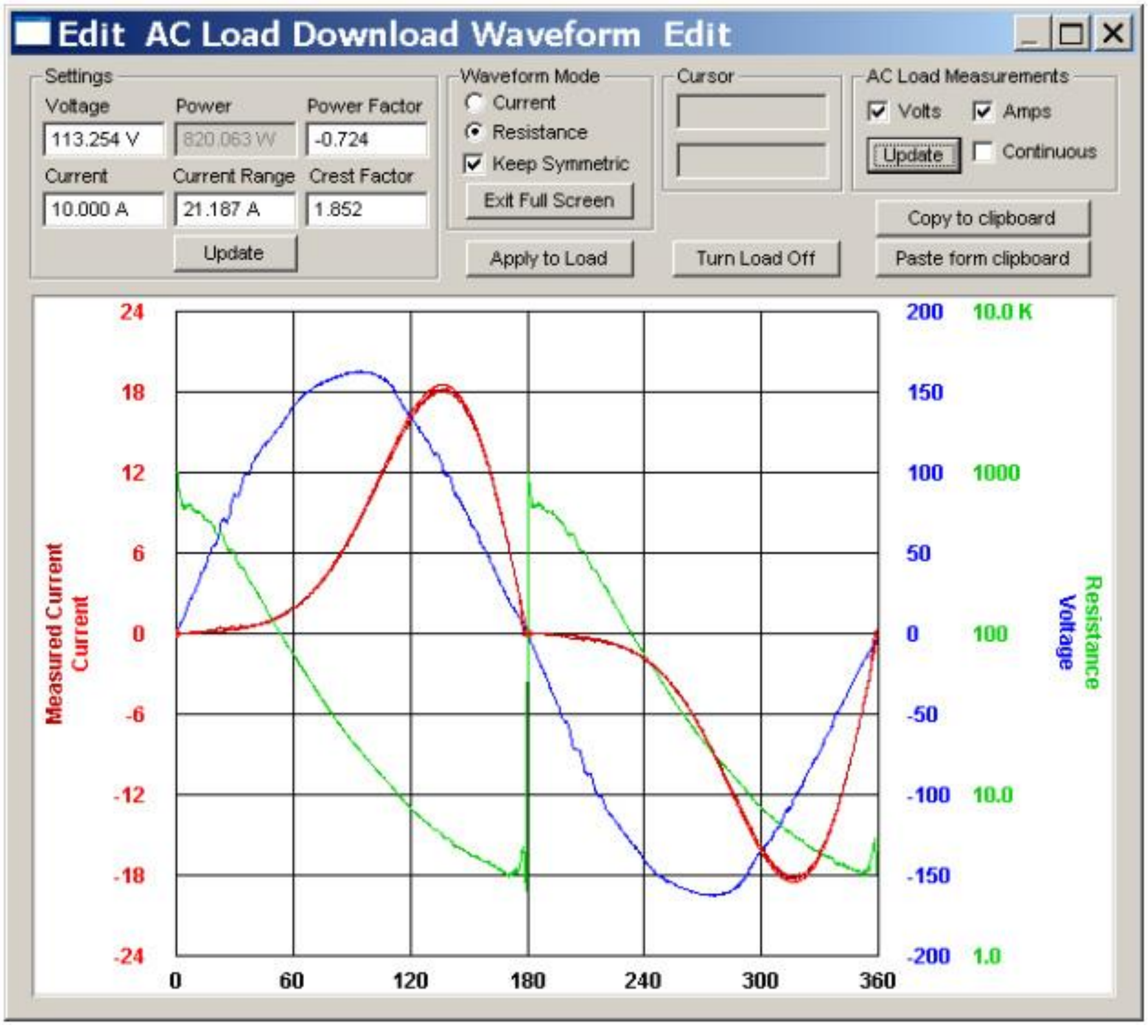
Settings
Voltage: 113.000 V
Power: 842.671 W
Power Factor: -0.746
Current: 10.000 A
Current Range: 21.187 A
Crest Factor: 1.852

Waveform Mode
○ Current
● Resistance
☑ Keep Symmetric

AC Load Measurements
☑ Volts
☐ Amps
☐ Continuous

The perfect voltage sine wave has generated a much smoother resistance. Click the Copy to clipboard button. You may want to restore it later.

To view the result, select Volts and Amps in the Measurements group, click the “Apply to Load” button, the “Update” button, and the “Turn Load Off” button.



Edit AC Load Download Waveform Edit

Settings

Voltage: 113.254 V

Power: 820.063 W

Power Factor: -0.724

Current: 10.000 A

Current Range: 21.187 A

Crest Factor: 1.852

Waveform Mode

○ Current

● Resistance

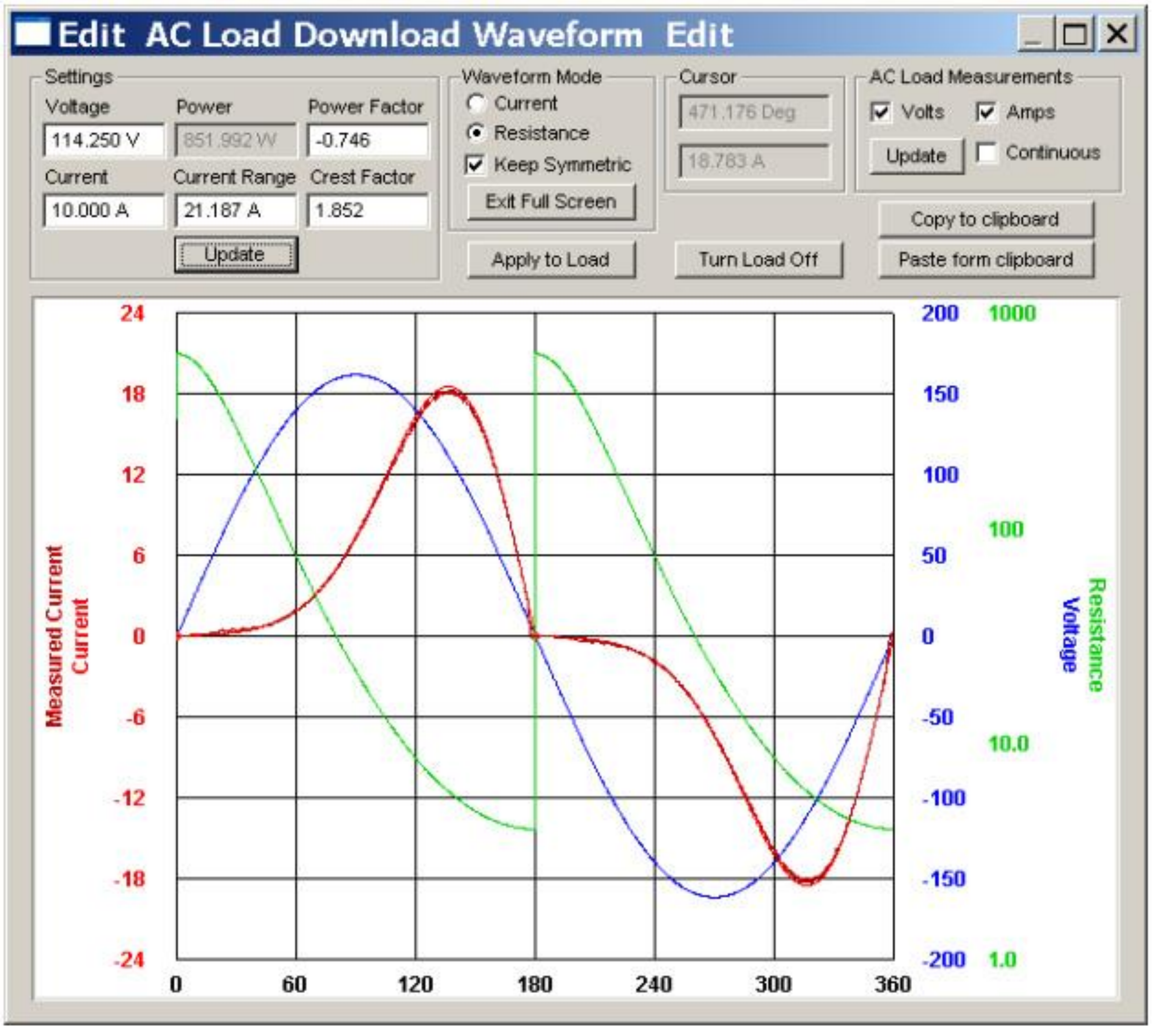
☑ Keep Symmetric

AC Load Measurements

☑ Volts ☑ Amps

☐ Continuous

Set Voltage to 113.9 and click Update, to see a better view of the resistance. Repeat applying the waveform and resetting the voltage until the desired result is repeatable.



Edit AC Load Download Waveform Edit

Settings

Voltage: 114.250 V

Power: 851.992 W

Power Factor: -0.746

Current: 10.000 A

Current Range: 21.187 A

Crest Factor: 1.852

Waveform Mode

○ Current

● Resistance

☑ Keep Symmetric

Cursor

471.176 Deg

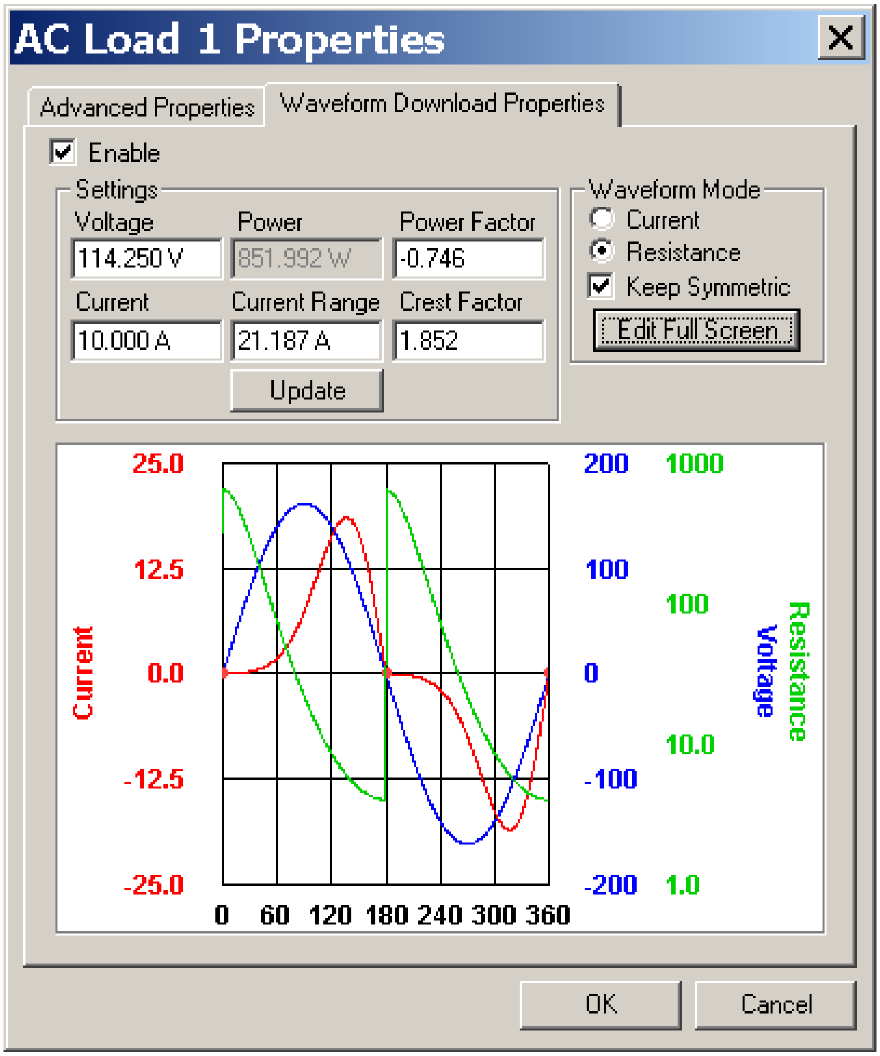
18.783 A

AC Load Measurements

☑ Volts ☑ Amps

☐ Continuous

Click the Exit Full Screen button.



AC Load 1 Properties

☑ Enable

Settings

Voltage: 114.250 V

Power: 851.992 W

Power Factor: -0.746

Current: 10.000 A

Current Range: 21.187 A

Crest Factor: 1.852

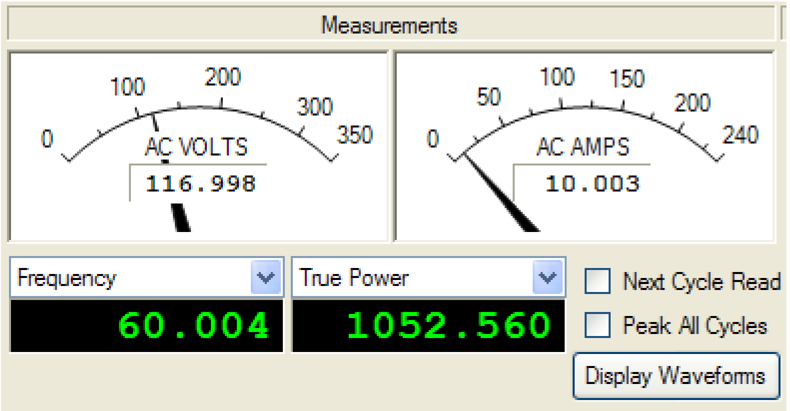
Waveform Mode

○ Current

● Resistance

☑ Keep Symmetric

4.2.11 Metering



Measurements

AC VOLTS 116.998

AC AMPS 10.003

Frequency: 60.004

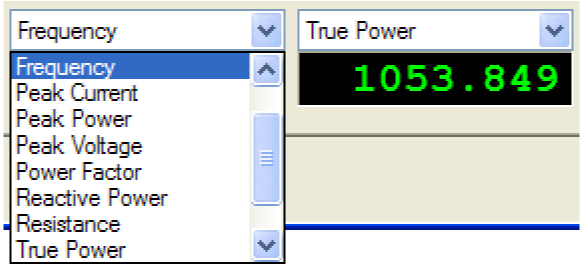
True Power: 1052.560

☐ Next Cycle Read

☐ Peak All Cycles

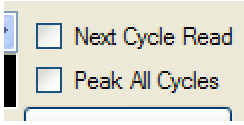
The technique used for measurements is Synchronous Sampling. This method yields maximum speed and accuracy (one-cycle measurements).

4.2.11.1 Read back Capabilities



True RMS Current, True RMS Voltage, True Power, Peak Power, Crest Factor, Peak Current, Peak Voltage, Apparent Power, Resistance, Power Factor, Frequency and Reactive Power are all metered.

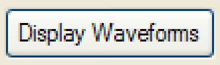
4.2.11.2 Metering Modes



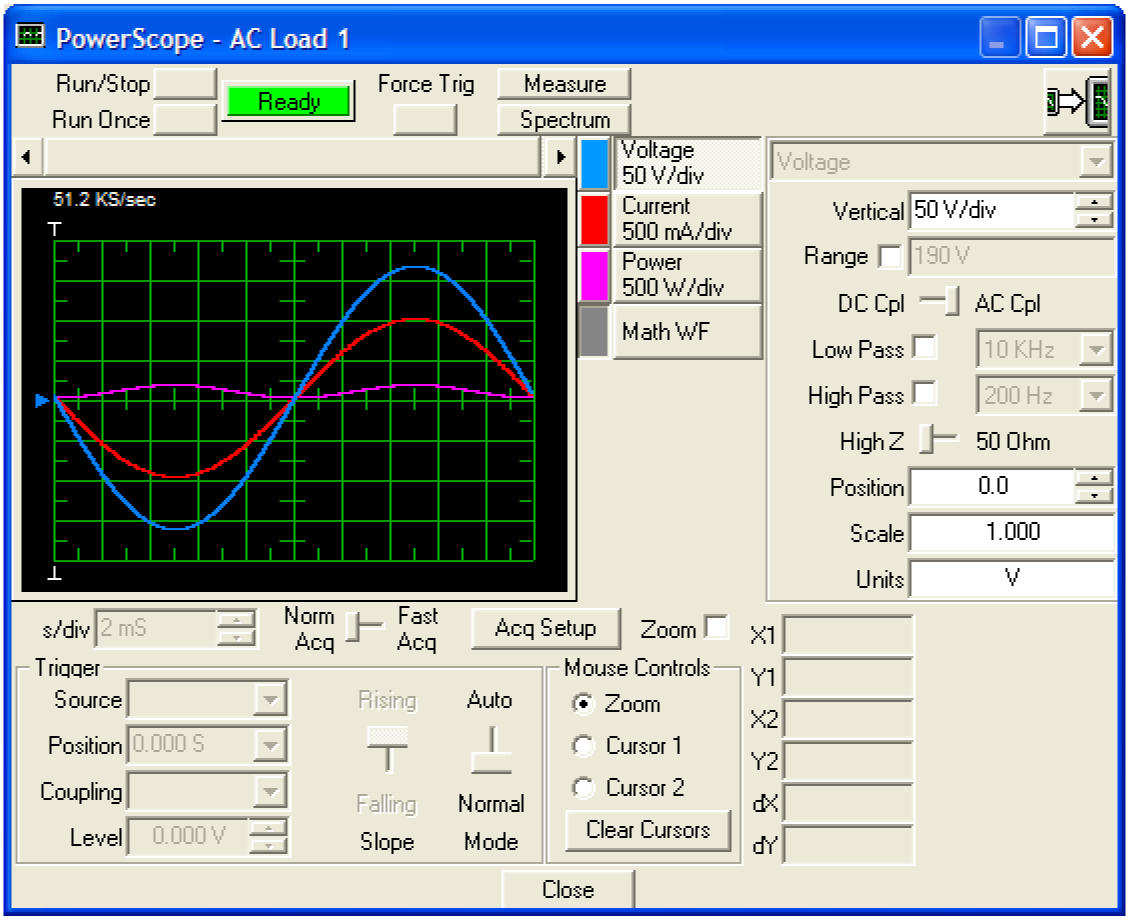
By default the last several measurements made are averaged and returned. This may be up to 2 cycles old, but is returned immediately. If “Next Cycle Read” is selected, a new measurement is made and returned after the command is sent.

Peak measurements are reset each cycle. If “Peak All Cycles” mode is selected, the largest peak measurement is saved. This is useful for inrush measurements.

4.2.11.3 Waveform Capture



One cycle of current, voltage and/or power waveforms may be graphically displayed eliminating the need for an oscilloscope.



Voltage 50 V/div

Current 500 mA/div

Power 500 W/div

Voltage

Vertical 50 V/div

Range ☐ 190 V

DC Cpl / AC Cpl

Low Pass ☐ 10 KHz

High Pass ☐ 200 Hz

High Z / 50 Ohm

Position 0.0

Scale 1.000

Units V

s/div 2 mS

Norm Acq / Fast Acq

Zoom ☐

Source

Position 0.000 S

Coupling

Level 0.000 V

Slope

Mode

● Zoom

○ Cursor 1

○ Cursor 2

X1

Y1

X2

Y2

dX

dY

5. PROGRAMMING

5.1 General

NH Research provides an IVI-compliant instrument driver with the softpanel, along with support files for various popular development environments. The driver contains functions for selecting, configuring, taking measurements from and controlling the instrument.

Complete, context-sensitive help is provided for every method and property via a compiled HTML help file, `NHRACLoad.chm`, which is located in `C:\Program Files\IVI\Drivers\NHRACLoad`.

Samples are located in the `C:\NHR\NHR AC Load\Samples` folder.

5.2 Microsoft .NET Languages

You use the IVI-COM instrument driver to control the load in a .NET program. Interop assemblies are used in .NET environments, such as C# and VB.NET, to access COM components. The necessary interop assembly is deployed and registered on the system during software installation. The “Samples” folder contains a C# program that illustrates the use of the load driver in the .NET environment, along with the source code for the softpanel.

5.3 Microsoft Visual Basic 6.0

You use the IVI-COM instrument driver to control the load in a VB6 program. References to COM drivers are used in VB6 to gain access to the load hardware. The necessary driver is deployed and registered on the system during software installation. The “Samples” folder contains a VB6 program that illustrates the use of the load driver in this environment.

5.4 National Instruments LabVIEW

A palette set providing direct access to each of the instrument driver functions is included with the software installation. NOTE: for LabVIEW to see the palette, you must copy or move the `NHRACLoad` folder located in `C:\NHR\NHR AC Load\Samples\LabVIEW\instr.lib` into the LabVIEW instrument sub-folder, which is usually located in `C:\Program Files\National Instruments\LabVIEW X.X\instr.lib`.

From a LabVIEW block diagram, traverse the Instrument I/O and Instrument Driver menus to find the NHR AC Load palette. The “Samples” folder contains several LabVIEW samples.

Alternately, a LabVIEW programmer can access the IVI-COM driver directly using LabVIEW’s support for ActiveX drivers.

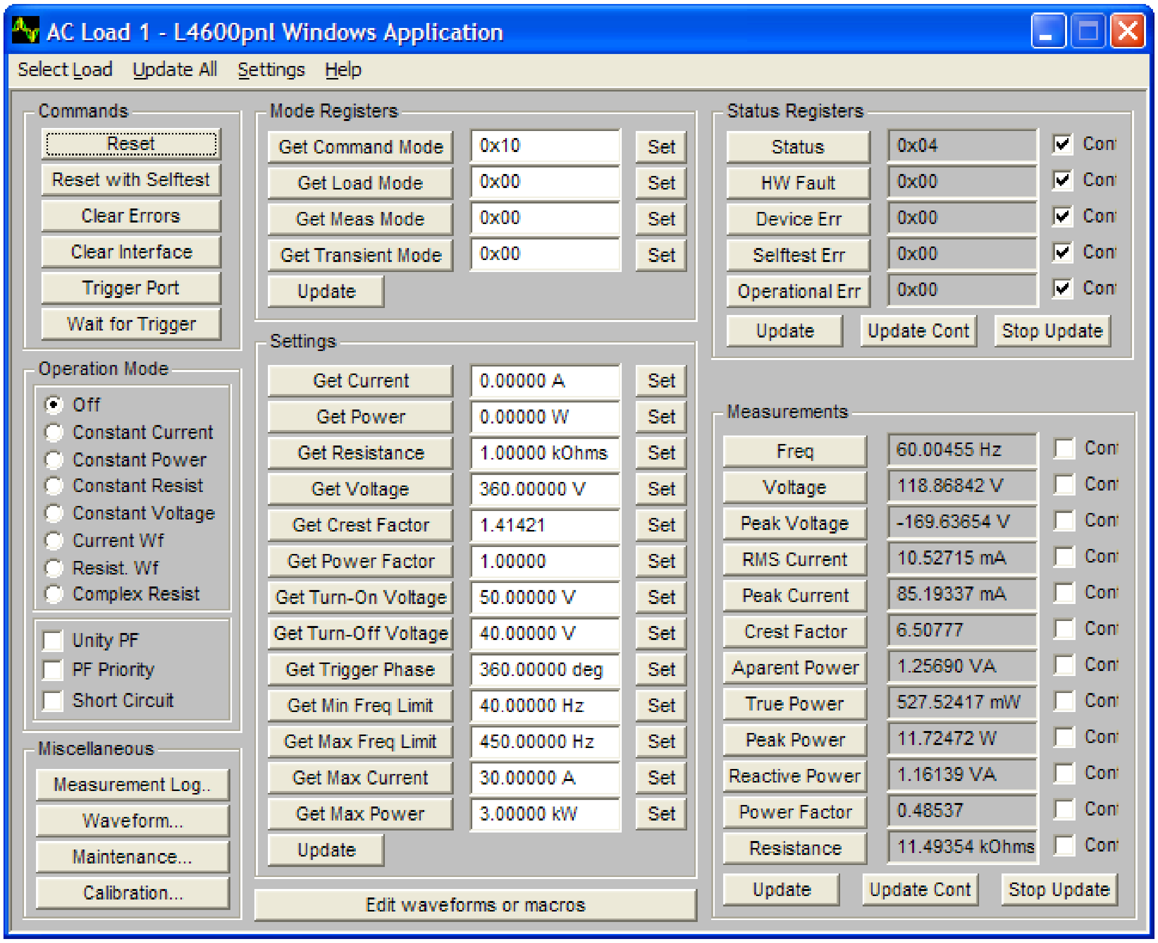
5.5 National Instruments LabWindows/CVI

A function panel providing access to the driver is included with the software installation. The “Samples” folder contains a LabWindows program that illustrates the use of the load driver in this environment. NOTE: depending upon where you install the files, you may have to browse for the instrument function panel (`NHRACLoad.fp`, usually located in `C:\Program Files\IVI\Drivers\NHRACLoad`) before the sample will compile.

6. CALIBRATION

WARNING!!!!! THIS SECTION IS FOR EXPERIENCED USERS WITH A DETAILED UNDERSTANDING OF THE SYSTEM HARDWARE AND SOFTWARE. POSSIBLE IRREPAIRABLE UUT DAMAGE OR CORRUPTION OF THE LOADS FLASH MEMORY MAY RESULT FROM INAPPROPRIATE SETTINGS.

6.1 Maintenance Panel



Operation Mode

- ● Off
- ○ Constant Current
- ○ Constant Power
- ○ Constant Resist
- ○ Constant Voltage
- ○ Current Wf
- ○ Resist. Wf
- ○ Complex Resist

- ☐ Unity PF
- ☐ PF Priority
- ☐ Short Circuit

Mode Registers

Get Command Mode	0x10	Set
Get Load Mode	0x00	Set
Get Meas Mode	0x00	Set
Get Transient Mode	0x00	Set

Settings

Get Current	0.00000 A	Set
Get Power	0.00000 W	Set
Get Resistance	1.00000 kOhms	Set
Get Voltage	360.00000 V	Set
Get Crest Factor	1.41421	Set
Get Power Factor	1.00000	Set
Get Turn-On Voltage	50.00000 V	Set
Get Turn-Off Voltage	40.00000 V	Set
Get Trigger Phase	360.00000 deg	Set
Get Min Freq Limit	40.00000 Hz	Set
Get Max Freq Limit	450.00000 Hz	Set
Get Max Current	30.00000 A	Set
Get Max Power	3.00000 kW	Set

Status Registers

Status	0x04	☑ Con
HW Fault	0x00	☑ Con
Device Err	0x00	☑ Con
Selftest Err	0x00	☑ Con
Operational Err	0x00	☑ Con

Measurements

Freq	60.00455 Hz	☐ Con
Voltage	118.86842 V	☐ Con
Peak Voltage	-169.63654 V	☐ Con
RMS Current	10.52715 mA	☐ Con
Peak Current	85.19337 mA	☐ Con
Crest Factor	6.50777	☐ Con
Aparent Power	1.25690 VA	☐ Con
True Power	527.52417 mW	☐ Con
Peak Power	11.72472 W	☐ Con
Reactive Power	1.16139 VA	☐ Con
Power Factor	0.48537	☐ Con
Resistance	11.49354 kOhms	☐ Con

6.2 Equipment Required

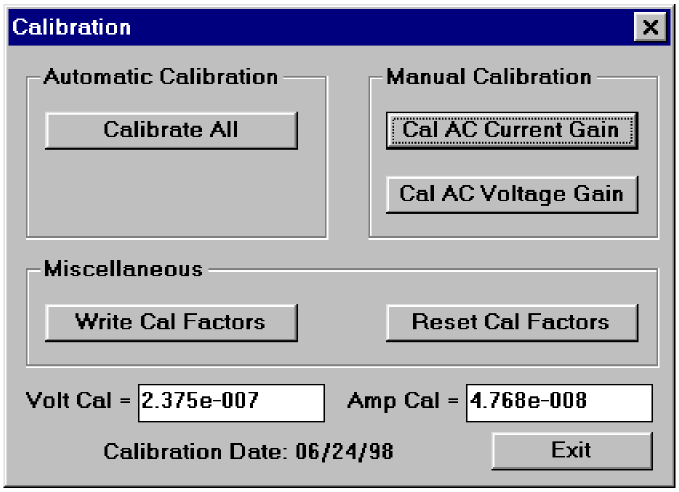
Xitron Power Analyzer model 2501AH with high accuracy option or Yokogawa Power Analyzer model WT2000 or equivalent.

6.3 Procedure

From the start menu ‘programs’ select ‘NH Research’. Click on ‘L4600 Maintenance Panel’. If you have more than one load, use the “Select Load” menu to choose the desired load.

Click on the calibration button to obtain the calibration panel.

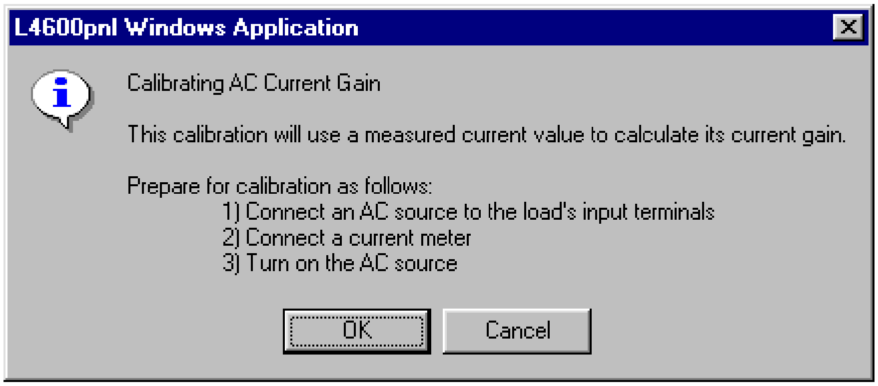
Click on “Calibrate All” and follow instructions.



Volt Cal = 2.375e-007

Amp Cal = 4.768e-008

Calibration Date: 06/24/98

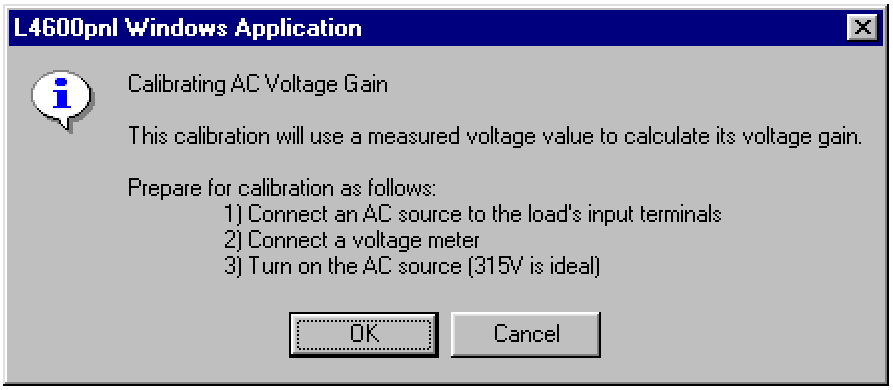


Calibrating AC Current Gain

This calibration will use a measured current value to calculate its current gain.

Prepare for calibration as follows:

1) Connect an AC source to the load's input terminals
2) Connect a current meter
3) Turn on the AC source



Calibrating AC Voltage Gain

This calibration will use a measured voltage value to calculate its voltage gain.

Prepare for calibration as follows:

1) Connect an AC source to the load's input terminals
2) Connect a voltage meter
3) Turn on the AC source (315V is ideal)

Set calibrating current and voltage to 90% of maximum rating.

Save the calibration data by writing the calibration factors to FLASH RAM.

Verify measured current and voltage is the same as actual ± metering accuracy.

Calibration is now complete.

7. THEORY OF OPERATION

7.1 Architecture

The load contains a Texas Instruments TMS320C32, a 32 bit floating point digital signal processor. The DSP with a Motorola MC68681 UART uses RS232 or RS485 serial ports for the command/response interface. The DSP uses FLASH PROM for code, calibration, configuration data, hardware control registers and DMA's for output waveform generation and measurement. The DSP boot kernel is in a "read only" EPROM separate from the FLASH memory. The DSP performs all setup, control, synchronization and measurement functions for the AC waveform, control hardware initialization and setup via memory mapped control/status registers.

The load accepts commands using the S6000 command protocol. Using the set commands and/or writing control words into the appropriate registers programs operation of the load. Reading the appropriate registers provides operational feedback.

To facilitate future firmware versions, all of the DSP code, configuration and calibration data is stored in FLASH memory, which can be downloaded over the serial interface.

High accuracy is obtained by the use of 16-bit instrument grade digital to analog converters and analog to digital converters.

7.2 Memory

7.2.1 Memory Map

CPU Address	Memory	Data	Description
000000-000FFF			Internal DSP boot loader
001000-00FFFF	32	32	EPROM
010000-03FFFF	32	32	Do not access, EPROM
040000-07FFFF	32	32	Not used
080000-1FFFFF			Do not access
200000-23FFFF	32	32	Not used
240000-27FFFF	32	32	Analog to digital converters
280000-7FFFFF			Do not access
800000-807FFF			Reserved
808000-8097FF	32	32	Peripheral bus
809800-80FFFF			Reserved
810000-81000F	32	32	UART
810010-811FFF	32	32	Do not access, UART
812000-813FFF	32	32	Digital inputs
814000-815FFF	32	32	Digital outputs
816000-817FFF	32	32	Frequency register
818000-819FFF	32	32	Reference DAC
81A000-81BFFF	32	32	Not used
81C000-81DFFF	32	32	Not used
81E000-81FFFF	32	32	Not used
820000-82FFFF			Do not access
830000-87FDFF	32	32	Reserved
87FE00-87FFFF	32	32	Internal RAM
880000-887FFF	32	32	SRAM, 32k word by 32 bit
888000-89FFFF	32	32	Do not access, RAM
900000-90FFFF	32	16	SRAM, 64k word by 16 bit
910000-97FFFF	32	16	Do not access, RAM
980000-9FFFFF	32	16	Not used
A00000-A07FFF	16	32	Flash prom, 32k word by 32 bit
A08000-A3FFFF	16	32	Do not access, Flash prom
A40000-C7FFFF	16	32	Do not access
C00000-C0FFFF	16	16	Flash prom, 64k word by 16 bit
C10000-C3FFFF	16	16	Do not access, Flash prom
C40000-C7FFFF	16	16	Do not access
C80000-CFFFFF	32	16	Waveform DAC
D00000-FFFFFF			Do not access

Memory is not fully decoded. Using a “do not access” address may access another device and cause undesired operation. CPU and external address may be different. “Memory” is memory width and “Data” is data size loaded into a STROB register.

7.2.2 EPROM

A single chip 64k by 8 bit EPROM is connected to data lines D7-0. It contains a full version of code.

7.2.3 Analog to Digital Converters

A 16-bit analog to digital converter used to measure voltage ‘VADC’ is connected to data lines D31-16. A 16-bit analog to digital converter used to measure current ‘AADC’ is connected to data lines D15-0. The DMA reads both the VADC and AADC simultaneously as one 32-bit word and writes the data into RAM.

7.2.4 Peripheral Bus

Internal to the DSP is DMA0, DMA1, timer0, timer1, serial port and external port registers.

7.2.5 UART

A Motorola MC68681 is connected to data lines D7-0. It is used for RS232 and RS485 serial communications. It is also used for triggering and fault detection.

7.2.6 Digital Inputs

A 16-bit register ‘DIN’ connected to data lines D31-16 is used for reading hardware status bits and the address switch.

7.2.7 Digital Outputs

A 16-bit register ‘DOUT’ connected to data lines D31-16 is used for writing hardware status bits.

7.2.8 Frequency

A 16-bit register ‘FREQ’ connected to data lines D31-16 writes to a 16-bit binary rate multiplier ‘BRM’. This BRM generates the ADC_CLK and DAC_CLK. This clock is a power of 2 multiple of the load frequency.

7.2.9 Reference Digital to Analog Converter

A 16-bit digital to analog converter connected to data lines D31-16. Scales output waveform.

7.2.10 Internal RAM

The DSP contains internal RAM, which is 512-word by 32-bit. The stack starts here and may grow into external RAM.

7.2.11 SRAM

There are four 32k word by 8 bit SRAM chips. The same RAM may be accessed as a single 32-bit word or two separate 16-bit words depending upon the address. 32 bit is used for code and data. 16 bit is used for the output waveform.

7.2.12 Flash PROM

Two 64k by 8 bit Flash PROM chips are used. They are connected to data lines D15-0. They contain a full version of code and calibration factors.

7.2.13 Waveform Digital to Analog Converter

A 16-bit digital to analog converter connected to data lines D15-0 generates the output waveform. Data is copied from RAM to this DAC by a DMA.

7.3 Reset

During a reset the MCBL/MP* pin is high, this causes the DSP to enter boot loader mode. INT0 is low, INT1-3 is high, and this causes the boot loader to read code from EPROM and write it to RAM. Program execution begins in RAM. If Flash ROM checksum is correct, a newer version of code is copied from Flash ROM into RAM. By setting the address switch to 0, code will not be copied from Flash ROM to RAM.

7.4 Interrupts

7.4.1 INT0

A positive zero crossing on the load-input terminals causes an INT0 interrupt. The CPU measures phase error, uses timer0 to measure the period of input voltage waveform and synchronize the load current waveform to the input voltage waveform.

7.4.2 INT1

The BRM generates the DAC_CLK, which is connected to INT1. This interrupt causes DMA0 to read the VADC and AADC then copy the data to RAM and DMA1 to copy a new step of waveform data to the waveform DAC.

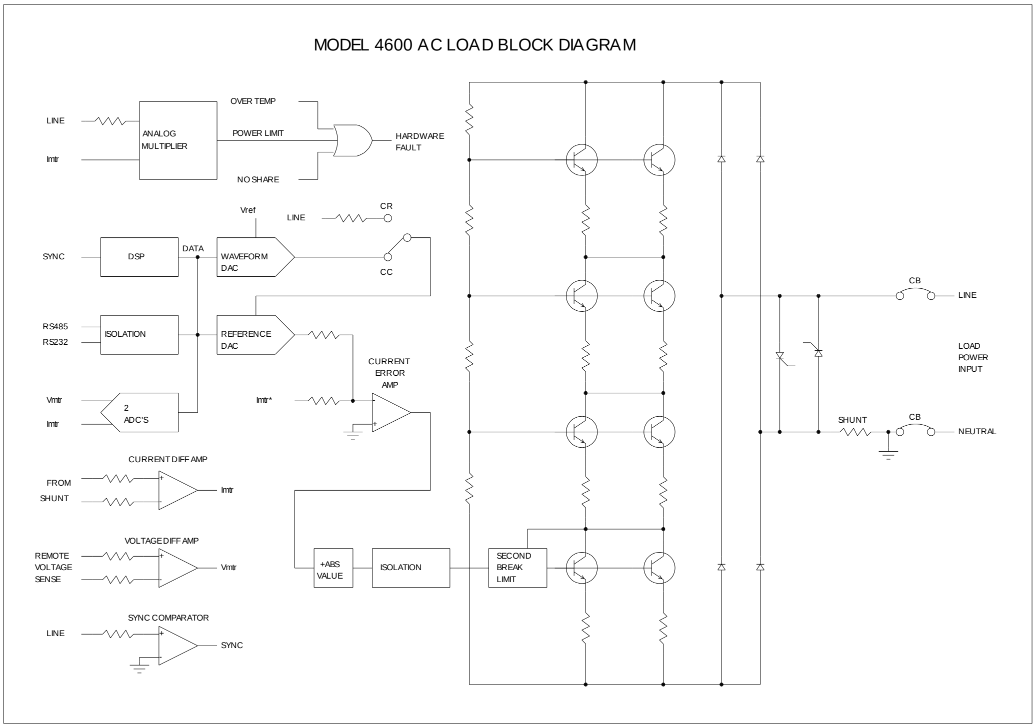
7.4.3 INT2

Not used.

7.4.4 INT3

The CPU handles communications, triggering and fault interrupts generated by the UART on INT3.

7.5 Block Diagram



7.6 Synchronization

The load power input voltage waveform is scaled down by 50 to 1 then converted to a square wave by a comparator. The output of this comparator is the sync signal.

7.7 Frequency Metering

The period of the sync signal is measured, inverted then displayed as frequency.

7.8 Voltage Metering

The voltage at the remote voltage sense terminals is scaled down 50 to 1 by a differential amplifier. This signal is then sent to the voltage 16bit analog to digital converter and sampled synchronously at a power of 2 multiple of the input frequency. The DSP then calculates AC rms voltage and other metering values.

7.9 Current Metering

The current through the shunt generates a voltage, which is scaled up 100 to 1 by a differential amplifier. This signal is then sent to the current 16bit analog to digital converter and sampled synchronously at a power of 2 multiple of the input frequency. The DSP then calculates AC rms current and other metering values.

7.10 Hardware CR Mode

The hardware emulates a resistor in this mode. The hardware is in this mode when constant resistance or voltage mode is programmed. The hardware is in this mode when constant current or constant power is programmed and unity power factor is on. The load does **not** respond to the programmed crest factor or power factor.

Voltage from the load power input is scaled down 50 to 1 and feed into the reference DAC. The reference DAC scales this signal to obtain the desired resistance.

The current error amp compares the output of the reference DAC to the metered current and generates the signal required to drive the power transistors.

7.11 Hardware CC Mode

The DSP generates a waveform with the desired crest factor and power factor in this mode. The hardware is in this mode when constant current or constant power is programmed and unity power factor is off.

The DSP generates a waveform at the output of the waveform DAC. This waveform synchronizes to the input voltage using the sync signal. The waveform is scaled by the reference DAC to obtain the desired current.

The current error amp compares the output of the reference DAC to the metered current and generates the signal required to drive the power transistors.

7.12 Crest Factor and Power Factor Relationship

This section discusses the relationship between crest factor and power factor. This only applies when the input voltage is sinusoidal, unity power factor is off and the load is in constant current or constant power mode. For non-sinusoidal input voltages select unity power factor mode.

Crest factor is peak current divided by RMS current. When a crest factor of 1.414 is programmed, the DSP creates a sinusoidal current waveform. When a higher crest factor is programmed the DSP creates a modified sinusoidal current waveform with the correct crest factor. The DSP can directly create the desired crest factor.

Power factor is true power divided by apparent power. For a resistive load the power factor is 1. Assuming a constant voltage RMS and constant current RMS, as crest factor increases, power factor decreases because apparent power remains constant and true power decreases. True power decreases because current is not flowing during the entire cycle.

For a given crest factor there is only a limited range of possible power factors. The load cannot directly create the desired power factor; it can only attempt to meet the desired power factor. The programmed power factor is achieved by programming an appropriate crest factor and the DSP will phase shift the current. As crest factor increases the range of possible power factor decreases.

For example:

With a crest factor of 1.414, the only power factor allowed is 1.

With a crest factor of 2, the power factor may range from 0.6 to 0.8.

With a crest factor of 3, the power factor may range from 0.2 to 0.5.

If a higher power factor is desired, program a lower crest factor. If a lower power factor is desired, program a higher crest factor.

If the power factor programmed is positive it will be a leading power factor. If the power factor programmed is negative it will be a lagging power factor.

7.13 Power Section

The load power input is connected to a circuit breaker.

The circuit breaker is connected to the shorting SCR’s and the AC side of a diode bridge.

The DC side of the Diode Bridge is connected to the power transistor array.

The power transistor array consists of four load boards in series. Each load board has 28 power transistors in parallel.

7.14 Protection Circuitry

The following protection is provided in hardware, and may also be redundant by the DSP.

7.14.1 Circuit Breaker

An input circuit breaker is provided. This CB will trip if input current exceeds ratings.

7.14.2 Overvoltage

Overvoltage protection is provided in two stages.

During the first stage the load will turn on and clamp voltages above rating. The load will act like a zener diode.

If the energy is greater than the load can absorb, the second stage is turning on the shorting SCR’s. This is an overvoltage crowbar.

7.14.3 Overtemperature

A temperature switch is located on each of the four load boards. Any one will shut down the load.

7.14.4 Overpower

The DSP will not allow the load to draw more than rated power. If the remote sense wires are not properly connected the load cannot calculate the actual power dissipated.

In hardware an analog multiplier creates an average true power signal that will shut down the load if rated input power is exceeded.

7.14.5 No Share

The four load boards should dissipate equal energy. If they are not close enough this circuit will shut down the load.

7.14.6 Second Break Limit

The power transistors have an average and peak power rating. This circuit limits peak power dissipated to the peak power rating. This will **not** shut down the load; it will just limit peak power.

8. TROUBLE SHOOTING

8.1 Load Power Circuit Breaker Trips

This circuit breaker will trip when:

Input current is exceeded during short mode. Reduce short circuit current.

The over voltage protection crowbar turned on. Reduce input voltage.

The diode bridge or power transistor array has shorted. Return for repair.

8.2 Fault Lamp Lit

This lamp is lit when one of the following hardware faults has occurred:

Overtemperature, one of the four load boards has overheated. Allow more and cooler air to flow through the load. If the load is clogged with dirt, vacuum the dirt out.

Overpower, the hardware analog multiplier detected an average true power greater than rated input power. The remote sense wires may not be connected correctly and the DSP cannot calculate power correctly. The load may need to be calibrated.

No share, the load boards are not sharing power equally. A load board may be shorted or an internal wiring error. Return for repair.

When the hardware fault has been removed and clear errors command is issued, the lamp will go out.

8.3 Status Lamp Not Blinking

Verify that the control power switch/lamp is on and lit. This indicates control power is present at the control board.

If control power is present and the status lamp is not blinking at a 1 hertz rate, the DSP is not functioning properly.

Try switching all eight positions of the “S6k AD” switch to the off position. Remove and reapply control power. This will cause a reboot from EPROM. If the status lamp is still not blinking, return for repair.

8.4 Error Lamp Lit

This lamp will light when a software error occurs. Usually the controlling computer will read the error and clear it quickly.

If this lamp is lit and no computer communication has occurred, a selftest error has occurred. Connect the load to a controlling computer to read the error.

If all eight positions of this switch are off when the load is turned on, it will boot from firmware in EPROM and not from FLASH. The lamp will be on because of an EPROM error. Set the “S6k AD” switch to the proper address to allow computer communication. This will allow new firmware to be downloaded into flash if previously corrupted.

8.5 No Computer Communication

Verify the communication cable is connected from the computer to the load. Either RS232 or RS485 (COMM IN) may be used.

Verify the computer software is set to the correct COMM port.

Verify the “S6k AD” switch is set to the same address as the software on the controlling computer.

Verify the status lamp is blinking.

When data is transmitted from the controlling computer to the load, the listen lamp will blink on with each byte.

When data is transmitted from the load to the controlling computer, the talk lamp will blink on with each byte.

8.6 Zero Frequency

This indicates that the load cannot measure the input frequency and will not operate. Verify input power is connected and the input circuit breaker is ON.

8.7 Negative Power Displayed

The remote sense wires are reversed.

8.8 Under Voltage

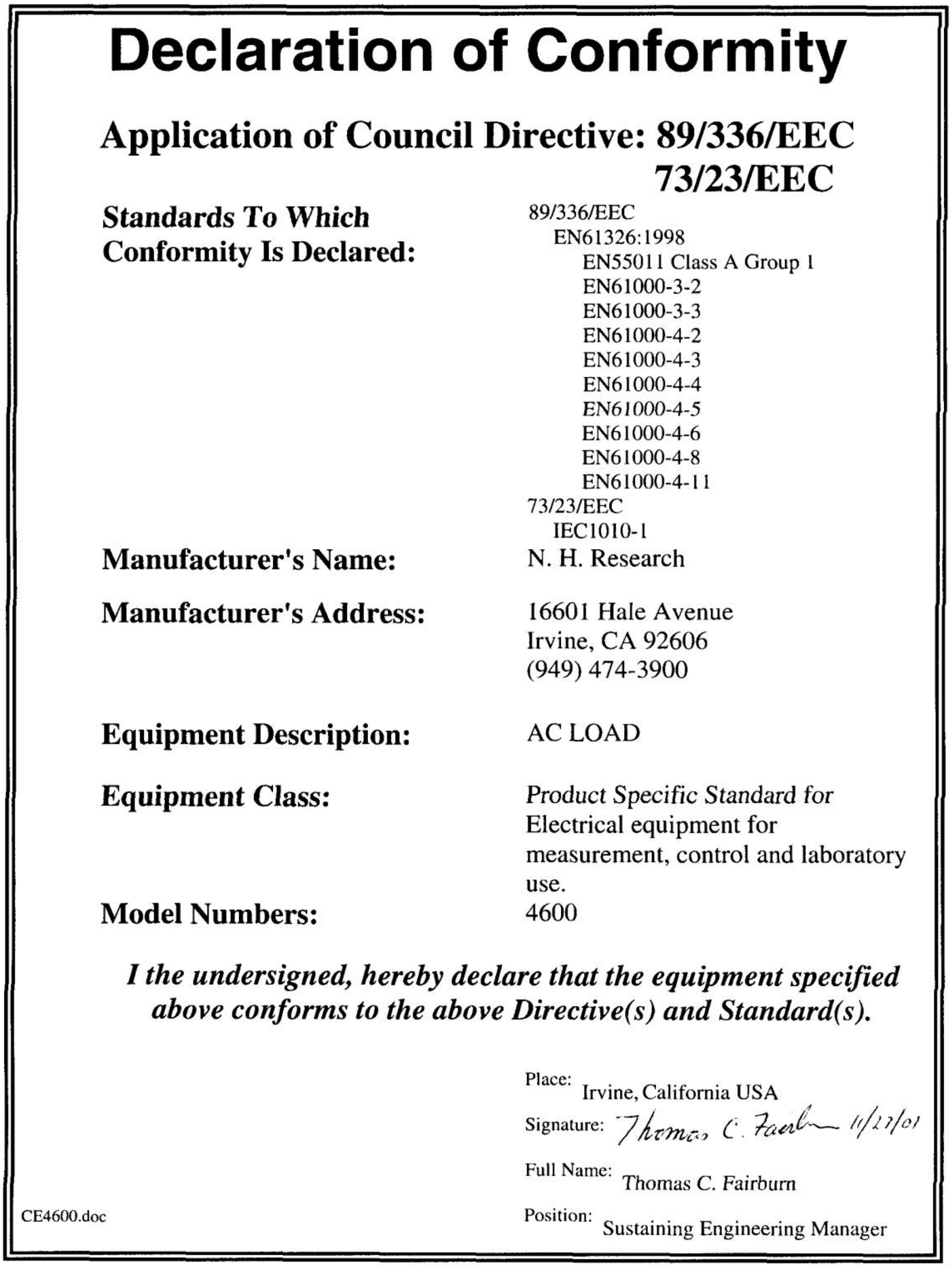
If the remote sense wires are not connected, the load will sense an under voltage and not operate.

9. SERVICE

9.1 Cleaning

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

10. CE CERTIFICATION



Declaration of Conformity

Application of Council Directive: 89/336/EEC
73/23/EEC

Standards To Which Conformity Is Declared:

- 89/336/EEC
  - EN61326:1998
    - EN55011 Class A Group 1
    - EN61000-3-2
    - EN61000-3-3
    - EN61000-4-2
    - EN61000-4-3
    - EN61000-4-4
    - EN61000-4-5
    - EN61000-4-6
    - EN61000-4-8
    - EN61000-4-11
- 73/23/EEC
  - IEC1010-1

Manufacturer's Name: N. H. Research

Manufacturer's Address:
16601 Hale Avenue
Irvine, CA 92606
(949) 474-3900

Equipment Description: AC LOAD

Equipment Class: *Product Specific Standard for* Electrical equipment for measurement, control and laboratory use.

Model Numbers: 4600

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

Place: Irvine, California USA
Signature: Thomas C. Fairburn 11/27/01
Full Name: Thomas C. Fairburn
Position: Sustaining Engineering Manager

CE4600.doc