

Keysight N6705C DC Power Analyzer

User's Guide

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Legal and Safety Information

Legal Notices

Safety Notices

Safety Symbols

Legal Notices

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This product complies with the WEEE Directive 2002/96/EC marketing requirement. The affixed product label (see below) indicates that you must not discard this electrical/electronic product in domestic household waste.

Product Category: With reference to the equipment types in the WEEE directive Annex 1, this product is classified as "Monitoring and Control instrumentation" product.

Do not dispose in domestic household waste.

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Safety Symbols

WARNING A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or DEATH. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

CAUTION A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.



Direct current



Alternating current



Frame or chassis terminal



Standby supply. Unit is not completely disconnected from AC mains when switch is off.



Caution, risk of electric shock



Caution, refer to accompanying documents



Earth ground terminal



The CE mark is a registered trademark of the European Community.



The ETL mark is a registered trademark of Intertek.



The RCM mark is a registered trademark of the Spectrum Management Agency of Australia.



South Korean Class A EMC Declaration

This equipment has been conformity assessed for use in business environments. In a residential environment this equipment may cause radio interference. This EMC statement applies to the equipment only for use in business environments.

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이 기기는 업무용 환경에서 사용할 목적으로 적합성평가를 받은 기기로서
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Contains one or more of the 6 hazardous substances above the maximum concentration value (MCV), 40 Year EPUP.

ISM1-A

This text indicates that the instrument is an Industrial Scientific and Medical Group 1 Class A product (CISPER 11, Clause 4).

ICES/NMB-001

This text indicates product compliance with the Canadian Interference- Causing Equipment Standard (ICES-001).

Safety Notices

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings or instructions elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Keysight Technologies assumes no liability of the customer's failure to comply with the requirements.

WARNING General

Do not use this product in any manner not specified by the manufacturer. The protective features of this product may be impaired if it is used in a manner not specified in the operating instructions.

WARNING Environmental Conditions

Never use the instrument outside of the specified environmental conditions described in the **Environmental Characteristics** of the specifications.

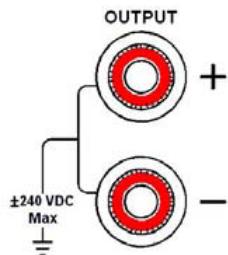
WARNING Ground the Instrument

This product is provided with protective earth terminals. To minimize shock hazard, the instrument must be connected to the AC mains through a grounded power cable, with the ground wire firmly connected to an electrical ground (safety ground) at the power outlet. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in injury or death.

WARNING Load Connections

Power supplies can output high currents and high voltages. Make sure that the load or device under test can safely handle the output current and voltage. Also, make sure that the connection leads can safely withstand the expected currents and are insulated for the expected voltages.

Power supply outputs may be connected so as to float relative to earth ground. Isolation or floating voltage ratings are indicated on the instrument, near the output connectors (see below). Do not float the power supply output on the line-voltage mains. Observe all safety markings and protection limits.



WARNING

Before Applying Power

Verify that all safety precautions are taken. All connections must be made with the unit turned off, and must be performed by qualified personnel who are aware of the hazards involved. Improper actions can cause fatal injury as well as equipment damage. Note the instrument's external markings described under "Safety Symbols".

WARNING

Some power modules generate voltages exceeding 60 VDC

Ensure that instrument connections, load wiring, and load connections are either insulated or covered so that no accidental contact with lethal output voltages can occur.

WARNING

Do Not Operate in an Explosive Atmosphere

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

WARNING

Do Not Remove the Instrument Cover

Only qualified, service-trained personnel who are aware of the hazards involved should remove instrument covers. Always disconnect the power cable and any external circuits before removing the instrument cover.

WARNING

Do Not Modify the Instrument

Do not install substitute parts or perform any unauthorized modification to the product. Return the product to a Keysight Sales and Service Office for service and repair to ensure that safety features are maintained.

WARNING

Fuses

The instrument contains an internal fuse, which is not user accessible.

WARNING

Cleaning

To prevent electric shock, always unplug the unit before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not use detergent or chemical solvents. Do not attempt to clean internally.

WARNING

In Case of Damage

Instruments that are not functioning correctly, appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

1

Quick Reference

Legal and Safety Information

Introduction to the Instrument

Front Panel Menu Reference

Command Quick Reference

Model Descriptions, Differences, and Options

Specifications and Characteristics

This document includes user, service, and programming information for the Keysight N6705C DC Power Analyzer .

Documentation and Firmware Revisions

You can download the latest version of this document at www.keysight.com/find/n6705-doc. The latest version is also available for mobile devices at www.keysight.com/find/n6705-mobilehelp. If you have feedback on this document, please contact Keysight at www.keysight.com/find/n6705-docfeedback.

This document describes firmware revision E.02.01 and up. For the latest firmware revision go to Firmware Updates in the [Keysight N6705C Series Operating and Service Guide](#) .

Contacting Keysight Technologies

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Introduction to the Instrument

[Features at a Glance](#)

[Front Panel at a Glance](#)

[Rear Panel at a Glance](#)

[Meter View](#)

[Scope View](#)

[Data Logger View](#)

[Arbitrary Waveform Preview](#)

Features at a Glance

The Keysight N6705 DC Power Analyzer is a multi-functional power system that combines the functions of a multiple-output DC voltage source with the waveform/data capturing capability of an oscilloscope and data logger.

As a multiple-output DC source, the Keysight N6705 provides up to four configurable outputs. Available power modules have power levels of 20 W through 500 W, have various voltage and current combinations, and provide a variety of performance features as described under [Model Differences](#). Each output also has arbitrary (Arb) waveform generation capability, which lets you program predefined voltage and current waveforms – or define your own waveforms. Keysight N678xA Source/Measure Units (SMU) have a multiple-quadrant power mesh with separate voltage and current priority source modes. Keysight N679xA Electronic Load Modules are single-quadrant 100 W and 200 W loads having constant current, constant voltage, constant power, and constant resistance operating capabilities.

As a measurement system, the Keysight N6705 displays the average output voltage and current in Meter View. Waveforms are displayed in Scope View, which you can adjust using vertical and horizontal controls. The Data Logger View measures and charts average and peak voltage and current measurements over an extended period.

Output Features

- **Color-coded display and output controls** – The color-coded display and output controls let you easily identify which output is being controlled.
- **Programmable voltage, current, power, or resistance** – Full programming capability is provided for the entire range of output voltage and current for all power modules. Power and resistance programming is available on Keysight N679xA load modules.
- **Low Output Noise** – Available on Keysight N676xA and N675xA power modules. Output noise is <4.5 mV peak-to-peak, which is comparable to linear supplies.

- **Arbitrary waveform generation** - This allows the output to act as a DC bias transient generator or an arbitrary waveform generator.
- **Fast up/down programming** - Available on Keysight N675xA, N676xA, and N678xA SMU power modules. ≤ 1.5 millisecond response time from 10% to 90% of the output rating.
- **Fast transient response** - Available on Keysight N675xA, N676xA, and N678xA SMU power modules. Transient response is less than 100 μ s.
- **Output autoranging capability** - Available on Keysight N676xA and N675xA power modules. Autoranging supplies the maximum rated power over a continuous range of voltage and current settings.
- **Output On/Off sequencing** - A turn-on/turn-off delay capability for each output allows output on/off sequencing.
- **Front panel binding posts** + and – output and + and – sense terminals are provided for each output. Sense terminals provide 4-wire voltage measurements.
- **Output protection** - Each output has over-voltage, over-current, and over-temperature protection. Over-voltage and over-current protection are programmable.
- **Emergency shut-off** + and – output and + and – sense terminals are provided for each output. Sense terminals provide 4-wire voltage measurements.
- **Multiple-Quadrant operation** - Available on Keysight N678xA SMU and N6783A power modules. 2-quadrant operation provides source and sink output capability. Keysight model N6784A offers 4-quadrant output operation.
- **Electronic Load operation** - Available on Keysight N679xA load modules. 100 W and 200 W input ratings are available.

Measurement features

- **Multiple-output/Single-output meter display** - Switch between a 4-output summary view and a 1-output detailed view of power analyzer information. All power modules display real-time output voltage and current measurements as well as status information.
- **Scope-like display** - Voltage and/or current waveforms of all outputs can be simultaneously displayed. Adjustable markers provide calculated measurements.
- **Data logging display** - Average, minimum, and maximum voltage and current values can be logged over an extended time period to the display. Adjustable markers provide calculated measurements.
- **Measurement functions** - Average, minimum, and maximum values are provided for all voltage and current measurements. Output power (Watts) is calculated for all outputs in single-output meter view.
- **Seamless measurement autoranging** - Available on Keysight N678xA SMU power modules. Output measurements seamlessly autorange between ranges – however, the 10 μ A current range must be selected manually.

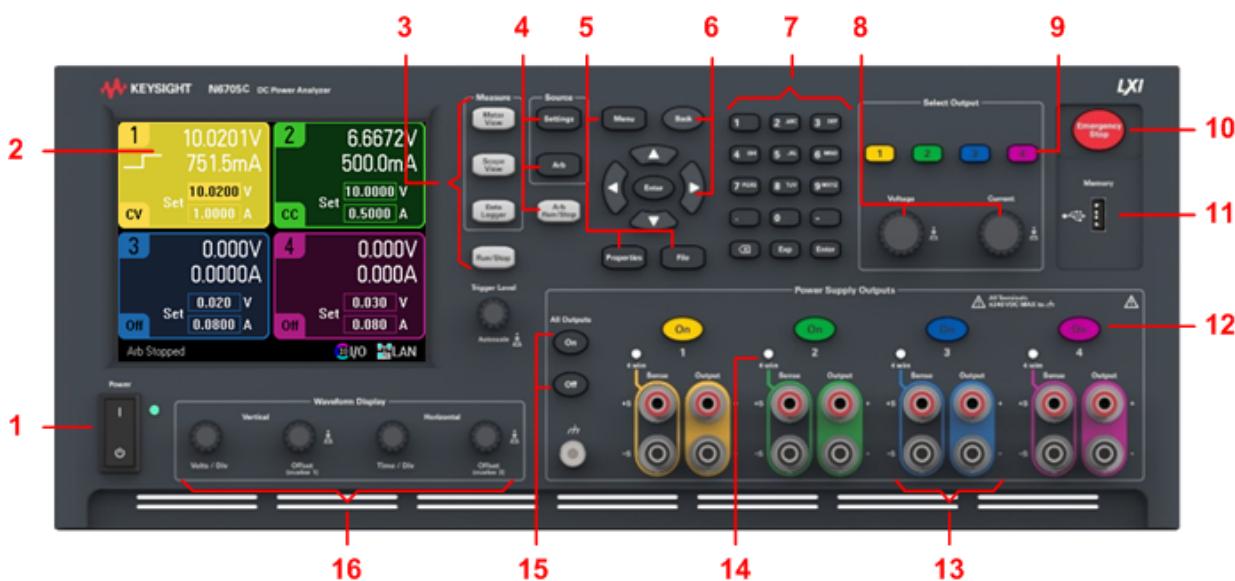
1 Quick Reference

- **Microampere current measurements** - Available on Keysight N6761A, N6762A, and N678xA SMU power modules. Current measurement can be made as low as 1 μ A in the 10 μ A range.
- **Fast Digitizing** Available on Keysight N678xA SMU power modules. 5.12 μ s/sample for one parameter; 10.24 μ s/sample for two parameters.
- **Histogram measurement** - Available on Keysight N6781A N6782A, N6785A, and N6786A SMU power modules. Provides a statistical measurement for profiling the measured current.

System features

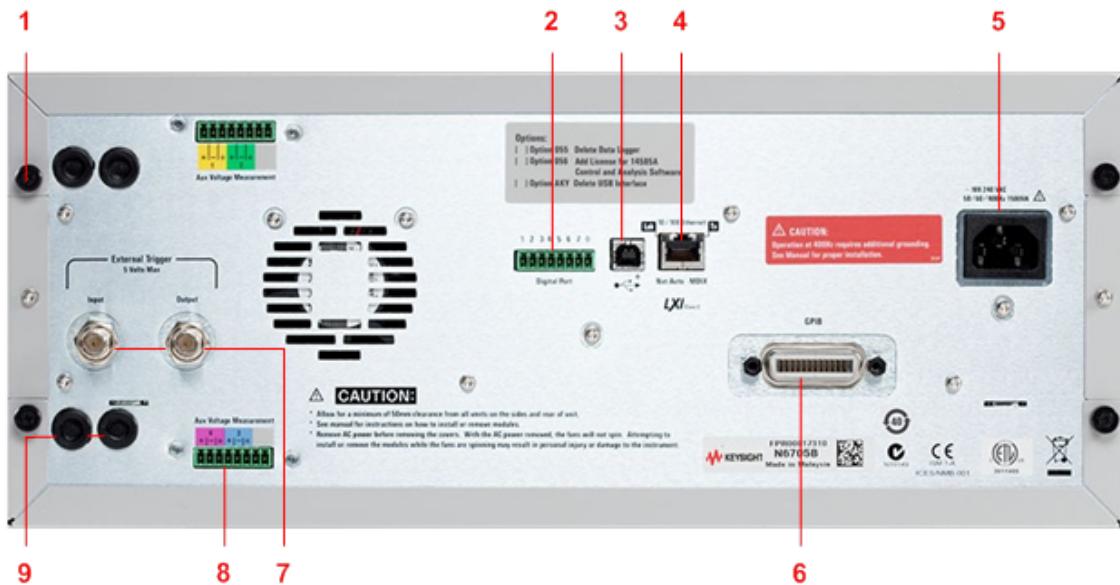
- **Choice of three interfaces** - GPIB (IEEE-488), LAN, and USB remote programming interfaces are built in.
- **Built-in Web server** - A built-in Web server lets you control the instrument directly from an internet browser on your computer.
- **SCPI language** - The instrument is compatible with the Standard Commands for Programmable Instruments (SCPI).
- **Savable instrument data** - A file management system saves display bitmaps, instrument states, scope results, arbitrary waveforms, and data log results.
- **Memory port** - Front USB port allows files to be saved to an external USB memory device.
- **Trigger connectors** - Rear panel trigger in/out BNC connectors.
- **Low acoustic noise** - Low acoustic noise for quiet bench operation.
- **Universal AC input** - Mainframes have universal input voltage capability with active power factor correction.

Front Panel at a Glance



1. **Line switch** - Turns the instrument On or Off.
2. **Display** - Displays all instrument functions - information changes based on selected function.
3. **Measure keys** - Selects the measurement function - Meter View, Scope View, or Data Logger. Run-/Stop key starts or stops the scope or data log measurement.
4. **Source keys** - Programs the source function – Source Settings or Arbitrary waveform. Arb Run-/Stop key starts or stops the arbitrary waveform function.
5. **Menu, Properties, File keys** - Menu key accesses all mode controls via a hierarchical command menu. Properties key displays information specific to the active view (this is a menu shortcut). File key lets you save the current display, instrument settings, and measurements.
6. **Navigation keys** - Navigate through the control dialog windows; press the Enter key to select a control. Back key cancels the values entered into the dialog and backs out of the control.
7. **Numeric/Alpha Entry keys** - Enters numeric and alpha values. Alpha keys automatically become active on fields that allow alpha character entry. Repeatedly pressing the key scrolls thorough the selections.
8. **Voltage/Current knobs** - Sets the voltage and current of the selected output.
9. **Select Output keys** - Selects an output to control. The lit key indicates the selected output.
10. **Emergency Stop** - Turns off all outputs without any delays; aborts any arbitrary waveforms.
11. **Memory port** - USB Memory device connector. Option AKY deletes the connector.
12. **On Keys** - Turns individual outputs On or Off; outputs are on when the key is lit.
13. **Binding posts** - The + and – output and sense binding post terminals for all outputs.
14. **4 Wire** - Indicates that 4 Wire sensing is enabled on the output.
15. **All Outputs On/Off keys** - Turns all outputs On and Off according to the specified turn-on and turn-off delay.
16. **Waveform Display controls** - Controls the scope and data logging views.
Vertical knobs control the vertical size and position. Press Offset to set marker 1. Horizontal knobs control the horizontal size and position. Press Offset to set marker 2. The Trigger knob moves the trigger level up or down. Press this knob to autoscale.

Rear Panel at a Glance



1. **Cover screw** - Facilitates top and bottom cover removal for power module installation.
2. **Digital port connector** - Connects to the 8-pin digital port. Port functions are user-configurable. Refer to [Using the Digital Control Port](#) for details.
3. **USB connector** - Connects to USB interface. May be disabled from front panel menu. Option AKY deletes the connector.
4. **LAN connector** - Connects to 10/100 Base-T interface. Left LED indicates activity. Right LED indicates link integrity. May be disabled from front panel menu.
5. **IEC 320 connector** - AC input connector. Power cord requires a ground conductor..
6. **GPIB connector** - GPIB interface connector. May be disabled from front panel menu.
7. **Trigger connectors** - BNC connectors for trigger in and trigger out signals. Refer to Trigger Commands in the Operating and Service Guide document for signal descriptions.
8. **Auxiliary connectors** - Auxiliary voltage measurement connectors. Only for use with Keysight N6781A and N6785A power modules.
9. **Wiring access ports** - Access for sense and output wire connections. Used for output connections on power modules rated >20 A. Also used for Keysight N678xA SMU power modules when extremely precise measurements or output guarding is required.

WARNING SHOCK HAZARD The power cord provides a chassis ground through a third conductor. Be certain that your power outlet is of the three-conductor type with the correct pin connected to earth ground.

Meter View

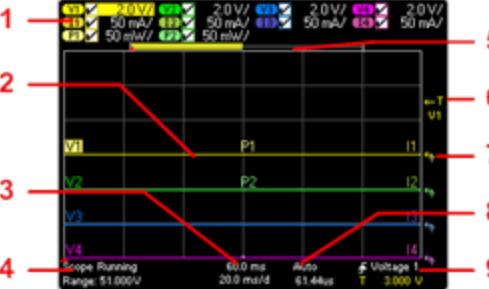


Multiple Output View

Single Output View

1. Output Identifier	Identifies the output. When an output is selected, the background becomes highlighted. The selected output is displayed in an enlarged format in single output view.
2. Output Status	Off: the output is off CV: the output is in constant voltage mode CC: the output is in constant current mode Unr: the output is unregulated CP+, CP-: a positive or negative power limit CL+, CL-: a positive or negative current limit VL+, VL-: a positive or negative voltage limit OV: over-voltage protection tripped
3. Output Meter	Displays the actual output voltage and current. Displays power in single output view.
4. Output Setting	Displays the present output voltage and current settings. Turn the front panel voltage or current knob to adjust these settings. Can also be changed using the numeric keypad.
5. Remote Status	Error – an error has occurred (press the Menu key, select Utilities, then Error Log) LAN – the LAN is connected and has been configured IO – there is activity on one of the remote interfaces
6. Model Number	Identifies the model number of the power module connected to this output.
7. Arb, Delay, & Slew Rate	Displays the Arb waveform that is presently configured for this output. If no Arb is configured, no waveform will be displayed. Also displays the Output On and Output Off delay settings as well as the slew rate setting.
8. Polarity Reverse	Indicates that the output and sense polarities are reversed.
9. Ratings & Protection	Displays the maximum voltage and current ratings of the output. Also displays the present over-voltage protection setting and whether over-current protection is on or off.
10. Other Outputs	Displays the actual voltage, current, and status of the other outputs.

Scope View

Press Scope View		
	Standard View	Marker View
1. Trace Controls	Identifies the voltage or current trace that will be displayed. Dashes (---) indicate that the specified trace is turned off. Select the trace and press Enter to turn it on or off.	
2. Output Traces	V1, V2, V3, and V4 indicate voltage traces. I1, I2, I3, and I4 indicate current traces. P1 and P2 indicate power traces. Press Trigger Level knob to autoscale all traces .	
3. Horizontal Time-base	Identifies the horizontal time-base settings. These can be adjusted using the front panel Horizontal Time/Div and Offset knobs.	
4. Scope Status	Indicates whether the scope is idle, running, or waiting for a trigger.	
5. Data Bar	The highlighted area shows how much of the entire measurement is actually shown on the display. Use the Horizontal Time/Div knob and Offset knob to adjust the display	
6. Trigger Level	Identifies the trigger level through which the waveform must pass before the scope will trigger. This can be adjusted using the Trigger Level knob.	
7. Ground	Identifies the ground reference level for the trace. This can be adjusted using the Vertical Offset knob. The initial vertical offset of each trace is set to a different level to prevent the traces from overlapping.	
8. Trigger Mode	Identifies the trigger mode setting. This can be selected by pressing the Properties key.	
9. Trigger Source	Identifies the trigger source and trigger level. Voltage 1 indicates a voltage level on output 1 is the trigger source (see #6).	
10. M1 Marker	Measurement Marker 1 enabled. Adjust using Marker 1 knob. Press knob to reset.	
11. M2 Marker	Measurement Marker 2 enabled. Adjust using Marker 1 knob. Press knob to reset.	
12. Intersect Point	Shows where the measurement markers intersect the waveform.	
13. Measurements	Shows the calculations of the waveform data between Marker 1 and Marker 2.	

Data Logger View

NOTE

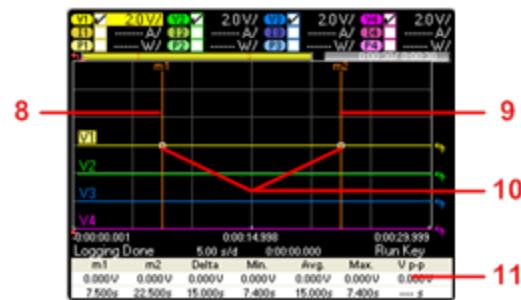
Option 055 deletes the Data Logger function on Model N6705

Press **Data
Logger**

This key
toggles
between
standard and
marker views.



Standard View



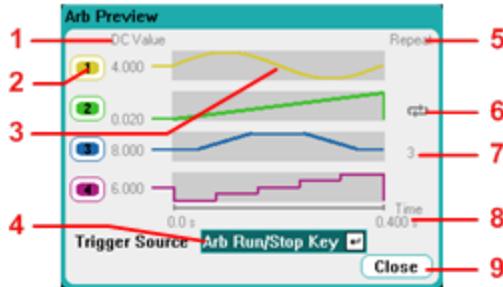
Marker View

1. Trace Controls	Identifies the voltage or current trace that will be displayed. Dashes (----) indicate that the specified trace is turned off. Select the trace and press Enter to turn it on or off.
2. Output Traces	Voltage, current, or power traces. Voltage traces V1, V2, V3 and V4 shown. Press Trigger Level knob to autoscale all traces.
3. Status	Indicates whether the Data Logger is logging data, done logging, or is empty.
4. Filename	Indicate the file to which the data is being logged.
5. Data Bar & Time Elapsed	Displays the progress of the data logger. The yellow bar indicates the visible data. Numbers to the right indicate time elapsed/total duration.
6. Time base Information	Displays the time remaining before the trigger point; the time at the center line of the grid in relation to trigger point; and the time elapsed since the trigger
7. Trigger	Identifies the trigger source and trigger offset. The trigger offset is specified in % of the total duration, but shown in seconds on the display
8. M1 Marker	Measurement Marker 1 enabled. Adjust using Marker 1 knob. Press knob to reset.
9. M2 Marker	Measurement Marker 2 enabled. Adjust using Marker 1 knob. Press knob to reset.
10. Intersect Point	Shows where the measurement markers intersect the waveform.
11. Measurements	Shows the calculations of the waveform data between Marker 1 and Marker 2.

Arbitrary Waveform Preview

Press Arb

This dialog displays the arbitrary waveforms that have been configured.



Arb Preview

1. DC Value	This column indicates the present output voltage or current setting that appears at the output before the Arb is run. The output will return to this value after the Arb complete if the Return to DC value box has been checked. If the Last Arb Value box is checked, the output will remain at the last programmed Arb value.
2. Output	This column identifies the output channel on which the associated waveform will run. Use the navigation keys to select an output if you wish to select an Arb or edit the Arb on that output channel.
3. Wave shapes	This column illustrates the waveshapes that will run on each output when the arb(s) are started. Note that all Arbs will run simultaneously.
4. Trigger Source	This dropdown list selects the trigger source for all configured Arbs.
5. Repeat	This column indicates how many times the Arb will repeat if it has been configured to repeat. If the column is blank, the Arb will only run once.
6.	Indicates that the Arb on output 2 runs continuously.
7. 3	Indicates that the Arb on output 3 repeats three times.
8. Time	Indicates the time that the longest Arb will run. In this example, all Arbs run the same amount of time.
9. Close	Closes the Arb Preview and returns to the previous measurement view.

Front Panel Menu Reference

This is an overview of the front-panel menus. For a brief tutorial, refer to Use the Front Panel Menu. Press the **Menu** key to access the front panel menus.

Menu Heading	Description
Source Settings ▶	
Voltage and Current Settings...	Configures voltage, current, power, and resistance settings, ranges, and emulation.
Protection...	Configures the over-voltage and over-current protection. Enables output coupling so ALL outputs are disabled when a fault occurs. Also clears output protection.
Advanced Protection...	Enables/disables the output inhibit function.
Output On/Off Delays...	Configures output on/off delays.
Output On/Off Coupling...	Couples specific outputs for the output on/off and delay function
Output Grouping...	Groups identical outputs for output paralleling function.
Advanced...	Configures advanced functions including slew rate, sensing, and power limit.
Ratings...	Displays power module ratings, serial number, firmware, and option information.
Arb ▶	
Arb Preview	Displays the present status of the configured arbitrary waveforms.
Arb Selection...	Selects arbitrary waveforms for each output. Arb Properties configures the selected Arb.
Meter ▶	
All Outputs Meter View	Displays the meter view of all outputs.
Single Output Meter View	Displays the meter view of the selected output.
Meter Properties...	Configures the meter view voltage and current measurement ranges.
Scope ▶	
Standard View	Displays the standard scope view including vertical, horizontal, and trigger settings.
Marker View	Displays the measurement markers and measurement calculations area.
Scope Properties...	Configures the scope traces and voltage and current measurement ranges for individual outputs. Also configures the trigger source, mode, and horizontal offset.
Marker Properties...	Configures the measurements that appear on the bottom of the display in Marker view.
Horizontal Properties...	Configures the horizontal offset reference and sample points.
Datalogger ▶	
Standard View	Displays the data log strip chart view including vertical, horizontal, and progress settings.

1 Quick Reference

Menu Heading	Description
Marker View	Displays the measurement markers and measurement calculations area.
Datalogger Properties...	Configures the data log traces and voltage and current measurement ranges for individual outputs. Also configures the data log duration, sample period, and Min/Max values.
File Name Selection...	Specifies the filename for the next data logger acquisition.
Marker Properties...	Configures the measurements that appear on the bottom of the display in Marker view.
File ►	
Save...	Saves an instrument state or a scope measurement.
Load...	Loads an instrument state, scope data, or logged data.
Export...	Exports scope data, logged data, or a user-defined arbitrary waveform.
Import...	Imports a user-defined arbitrary waveform.
Screen Capture...	Captures the screen that was active when the File key was pressed.
File Management...	Accesses additional file functions: Show Details, Delete, Rename, Copy, New Folder.
Reset/Recall/Power-On State...	Resets the instrument to factory defaults; Saves/recalls instrument states; and specifies the power-on turn on state.
Utilities ►	
Error Log...	Lists all error messages.
IO Configuration ►	
Active LAN Status...	Displays the LAN status and active settings.
LAN Settings...	Configures the LAN interface. Enables/disables the LAN services, GPIB, and USB.
GPIB/USB...	Configures the GPIB and USB interface.
User Preferences ►	
Front Panel Preferences...	Configures screen saver, front panel key functions, and initial meter view.
Front Panel Lockout...	Password-protects the front panel keys.
Clock Setup...	Sets up the internal clock.
*IDN Setup...	Change manufacturer and model number for backward compatibility.
Administrative Tools ►	
Administrator LoginLogout	Accesses the password-protected administrative functions.
Calibration ►	Accesses the calibration functions: Turn On/Off, Voltage, Current, Miscellaneous, Date, Save, Count.
Sanitize...	Performs NISPOM secure erase of all user data.
Firmware Update...	Restricts unauthorized access by the Firmware Update Utility.

Menu Heading	Description
Install Options...	Installs additional firmware options. Requires Option key.
Change Admin Password...	Changes the administrator password.
Digital IO...	Configures the digital port. Pins can be individually configured.
Help ▶	
Overview...	A brief overview.
Quick Start ▶	How to quickly get started.
Using the Keysight N6705 ▶	How to use the Keysight N6705.
Using the Utilities ▶	How to use the utilities.
Front Panel Controls ▶	How to use the front panel controls.
Front Panel Navigation...	How to navigate the front panel display.
Module Capabilities and Ratings	How to obtain module capabilities/ratings.
About	Identifies the mainframe and the installed modules.

Command Quick Reference

Some [optional] commands have been included for clarity. All settings commands have a corresponding query.

ABORt

:ACQuire (@chanlist)	Cancels any triggered measurements.
:DLOG	Stops internal data logging.
:ELOG (@chanlist)	Stops external data logging.
:HISTogram (@chanlist)	Stops the histogram current measurement. (N6781A/82A/85A/86A)
:TRANsient (@chanlist)	Cancels any triggered actions.

CALibrate

:COUNT?	Returns the number of times the unit has been calibrated.
:CURRent	
[:LEVel] <value>, (@channel)	Calibrates the current programming.
:LIMit	
:NEGative <value>, (@channel)	Calibrates negative current limit. (N678xA SMU, N6783A-BAT)
:POSitive <value>, (@channel)	Calibrates positive current limit. (N678xA SMU, N6783A, N679xA)
:MEASure <value>, (@channel)	Calibrates the current measurement.
:PEAK (@channel)	Calibrates peak current limit (N675xA, N676xA)
:DATA <value>	Enters the calibration value read by the external meter.
:DATE <"date">, (@channel)	Stores the calibration date in nonvolatile memory.
:DPRog (@channel)	Calibrates the current downprogrammer.
:LEVel P1 P2 P3	Advances to the next level in the calibration.
:PASSword <value>	Sets a numeric password to prevent unauthorized calibration.
:RESistance 20 6, (@channel)	Calibrates the output resistance. (N6781A, N6785A)
:SAVE	Saves the calibration constants in non-volatile memory.
:STATe 0 OFF 1 ON	Enables or disables calibration mode.
:VOLTage	
[:LEVel] <value>, (@channel)	Calibrates the voltage programming.
:CMRR, (@channel)	Calibrates the voltage common mode rejection ratio. (N675xA, N676xA)
:LIMit	
:POSitive <value>, (@channel)	Calibrates positive current limit. (N678xA SMU)
:MEASure <value>, (@channel)	Calibrates the voltage measurement.
:AUXiliary, (@channel)	Calibrates the auxiliary voltage measurement. (N6781A, N6785A)

DISPlay

[:WINDOW]	
[:STATe] 0 OFF 1 ON	Turns the front panel display on or off.
:VIEW METER1 METER4	Selects 1-channel or 4-channel meter view.

FETCh		
:SCALar]		
:CURRent		
[:DC]? (@chanlist)	Returns the averaged measurement.	
:ACDC? (@chanlist)	Returns the RMS measurement (AC + DC).	
:HIGH? (@chanlist)	Returns the High level of a pulse waveform.	
:LOW? (@chanlist)	Returns the Low level of a pulse waveform.	
:MAXimum? (@chanlist)	Returns the maximum value.	
:MINimum? (@chanlist)	Returns the minimum value.	
:POWER		
[:DC]? (@chanlist)	Returns the averaged measurement. (N676xA/N678xA/N679xA)	
:MAXimum? (@chanlist)	Returns the maximum value. (N676xA/N678xA/N679xA)	
:MINimum? (@chanlist)	Returns the minimum value. (N676xA/N678xA/N679xA)	
:VOLTage		
[:DC]? (@chanlist)	Returns the averaged measurement.	
:ACDC? (@chanlist)	Returns the RMS measurement (AC + DC).	
:HIGH? (@chanlist)	Returns the High level of a pulse waveform.	
:LOW? (@chanlist)	Returns the Low level of a pulse waveform.	
:MAXimum? (@chanlist)	Returns the maximum value.	
:MINimum? (@chanlist)	Returns the minimum value.	
:ARRAY		
:CURRent		
[:DC]? (@chanlist)	Returns an array with the instantaneous measurement.	
:POWER		
[:DC]? (@chanlist)	Returns an array with the instantaneous measurement. (N676xA/N678xA/N679xA)	
:VOLTage		
[:DC]? (@chanlist)	Returns an array with the instantaneous measurement.	
:DLOG		
:AHOur? (@chanlist)	Returns the amp-hours between markers.	
:CURRent		
[:DC]? (@chanlist)	Returns the average current between markers.	
:MAXimum? (@chanlist)	Returns the maximum current between markers.	
:MINimum? (@chanlist)	Returns the minimum current between markers.	
:PTPeak? (@chanlist)	Returns the peak-to-peak current between markers	
:VOLTage		
[:DC]? (@chanlist)	Returns the average voltage between markers.	
:MAXimum? (@chanlist)	Returns the maximum voltage between markers.	
:MINimum? (@chanlist)	Returns the minimum voltage between markers.	
:PTPeak? (@chanlist)	Returns the peak-to-peak voltage between markers	
:WHOur? (@chanlist)	Returns the watt-hours between markers.	
:ELOG? <value (@chanlist)	Returns the most recent external datalog records.	
:HISTogram		(HISTogram command only applies to models N6781A/82A/85A/86A)
:CURRent 8 0.0039, (@chanlist)	Returns the cumulative histogram current data	

1 Quick Reference

FORMAT

:DATA[SCII | REAL] Specifies the format of the returned data.
.BORDer NORMal | SWAPped Specifies how binary data is transferred.

HCOPy

:SDUMP
:DATA? Returns an image of the front panel display.
:DATA
:FORMat BMP|GIF|PNG Specifies the format for front panel images returned

IEEE 488.2 Common Commands

*CLS	Clears status.
*ESE <value>	Sets standard event status enable.
*ESR?	Returns event status register.
*IDN?	Returns instrument identification.
*OPC	Enables "operation complete" bit in ESR.
*OPC?	Returns a 1 when all pending operations complete.
*OPT?	Returns option number.
*RCL <value>	Recalls a saved instrument state.
*RDT?	Returns output channel descriptions.
*RST	Resets the instrument.
*SAV <value>	Saves an instrument state.
*SRE <value>	Sets service request enable register.
*STB?	Returns the status byte.
*TRG	Generates a trigger.
*TST?	Performs a selftest, then returns results.
*WAI	Pauses additional command processing until all device commands are done.

INITiate

[:IMMediate]
:ACQuire (@chanlist) Initiates the measurement trigger system.
:DLOG <"filename"> Initiates internal data logging.
:ELOG (@chanlist) Initiates external data logging.
:HISTogram (@chanlist) Initiates histogram measurements. (N6781A/82A/85A/86A)
:TRANSient (@chanlist) Initiates the transient trigger system.
:CONTinuous
:TRANSient 0|OFF|1|ON, (@chanlist) Continuously initiates the transient trigger system.

LXI

:IDENtify
[:STATe] 0|OFF|1|ON Turns the front panel LXI identify indicator on or off.
:MDNS
[:STATe] 0|OFF|1|ON Controls the state of the mDNS server.

MEASure	
[:SCALar]	
:CURRent	
[:DC]? (@chanlist)	Takes a measurement; returns the averaged current.
:ACDC? (@chanlist)	Takes a measurement; returns the RMS current (AC + DC).
:HIGH? (@chanlist)	Takes a measurement; returns the High level of a current pulse.
:LOW? (@chanlist)	Takes a measurement; returns the Low level of a current pulse.
:MAXimum? (@chanlist)	Takes a measurement; returns the maximum current.
:MINimum? (@chanlist)	Takes a measurement; returns the minimum current.
:POWER	
[:DC]? (@chanlist)	Takes a measurement; returns the averaged power. (N676xA/N678xA/N679xA)
:MAXimum? (@chanlist)	Takes a measurement; returns the maximum power. (N676xA/N678xA/N679xA)
:MINimum? (@chanlist)	Takes a measurement; returns the minimum power. (N676xA/N678xA/N679xA)
:VOLTage	
[:DC]? (@chanlist)	Takes a measurement; returns the averaged voltage.
:ACDC? (@chanlist)	Takes a measurement; returns the RMS voltage (AC + DC).
:HIGH? (@chanlist)	Takes a measurement; returns the High level of a voltage pulse.
:LOW? (@chanlist)	Takes a measurement; returns the Low level of a voltage pulse.
:MAXimum? (@chanlist)	Takes a measurement; returns the maximum voltage.
:MINimum? (@chanlist)	Takes a measurement; returns the minimum voltage.
:ARRAY	
:CURRent	
[:DC]? (@chanlist)	Takes a measurement; returns the instantaneous current.
:POWER	
[:DC]? (@chanlist)	Takes a measurement; returns the instantaneous power. (N676xA/N678xA/N679xA)
:VOLTage	
[:DC]? (@chanlist)	Takes a measurement; returns the instantaneous voltage.
MMEMory	
:ATTRibute? <"object">, <"attribute">	Gets the attributes of a file system object.
:DATA [:DEFinite]? <"filename">, <data>	Copies file contents; response is a definite length binary block.
:DELete <"filename">	Deletes a file.
:EXPort	
:DLOG <"filename">	Exports a data log from the display to a file.
:LOAD	
:ARB:SEQUence <"filename">, (@chanlist)	Loads an Arb sequence.
:STORe	
:ARB:SEQUence <"filename">, (@chanlist)	Stores an Arb sequence.
OUTPut	
[:STATE] 0 OFF 1 ON [,NORelay], (@chanlist)	Enables or disables the output.
:COUPle	
:CHANnel [<value>, {<value>}]	Selects which channels are coupled.

1 Quick Reference

:DOFFset <value>	Sets a delay offset to synchronize coupled output state changes.
:MODE AUTO MANual	Specifies the output delay offset coupling mode.
:MAX	
:DOFFset?	Returns the delay offset required for this instrument.
:DELay	
:FALL <value>, (@chanlist)	Sets the output turn-off sequence delay.
:RISE <value>, (@chanlist)	Sets the output turn-on sequence delay.
:PMODE VOLTage CURRent, (@chanlist)	Sets the mode for turn-on/off transitions. (N6761A, N6762A)
:TMODE HIGHz LOWz, (@chanlist)	Specifies the turn-on/turn-off impedance. (N678xA SMU)
:INHibit	
:MODE LATChing LIVE OFF	Sets the operating mode of the remote inhibit digital pin.
:PON	
:STATe RST RCL0	Set the output power-on state.
:PROTection	
:CLEar (@chanlist)	Resets the latched protection.
:COUPLE0 OFF 1 ON	Enables/disables channel coupling for protection faults.
:DELay <value>, (@chanlist)	Sets the over-current protection programming delay.
:OSCillation0 OFF 1 ON, (@chanlist)	Enables/disables output oscillation protection. (N678xA SMU)
:TEMPerature	
:MARGin? (@chanlist)	Returns the margin remaining before the over-temperature trips.
:WDOG	
[:STATe] 0 OFF 1 ON	Enables/disables the I/O watchdog timer.
:DELay <value>	Sets the watchdog delay time.
:RELay	
:POLarity NORMAL REVerse, (@chanlist)	Sets the polarity of the output relays. (Option 760)
:SHORt	
[:STATe] 0 OFF 1 ON	Simulates a short circuit on the input of the load. (N679xA)
SENSe	
:CURRent	
:CCOMPensate 0 OFF 1 ON, (@chanlist)	Enables/disables capacitive current compensation. (not on N678xA SMU, N679xA)
[:DC]	
:RANGE	Selects a DC current measurement range.
[:UPPer] <value>, (@chanlist)	
:AUTO 0 OFF 1 ON, (@chanlist)	Enables/disables seamless measurement autoranging. (N678xA SMU)
:DLOG	
:CURRent	
[:DC]	
:RANGE	Selects the internal data log current measurement range.
[:UPPer] <value>, (@chanlist)	
:AUTO 0 OFF 1 ON, (@chanlist)	Enables/disables seamless measurement autoranging. (N678xA SMU)
:FUNCTION	
:CURRent 0 OFF 1 ON, (@chanlist)	Enables/disables current data logging.

:MINMax 0 OFF 1 ON	Enables/disables min/max internal data logging.
:VOLTage 0 OFF 1 ON, (@chanlist)	Enables/disables voltage data logging.
:MARKer<1 2>	
:POINT <value>	Positions the data log markers
:OFFSet <value>	Sets trigger offset as a percent from start of data log duration.
:PERiod <value>	Sets the interval between samples (replaces TINTerval).
:TIME <value>	Sets the duration of the internal data log in seconds
:TINTerval <value>	Sets the interval between samples (for backward compatibility)
:VOLTage	
[:DC]	
:RANGE	
[:UPPer] <value>, (@chanlist)	Selects the internal data log voltage measurement range.
:AUTO 0 OFF 1 ON, (@chanlist)	Enables/disables seamless measurement autoranging. (N678xA SMU)
:ELOG	
:CURRent	
[:DC]	
:RANGE	
[:UPPer] <value>, (@chanlist)	Selects the external data log current measurement range.
:AUTO 0 OFF 1 ON, (@chanlist)	Enables/disables seamless measurement autoranging. (N678xA SMU)
:FUNCTION	
:CURRent 0 OFF 1 ON, (@chanlist)	Enables/disables current data logging.
:MINMax 0 OFF 1 ON, (@chanlist)	Enables/disables min/max current data logging.
:VOLTage 0 OFF 1 ON, (@chanlist)	Enables/disables voltage data logging.
:MINMax 0 OFF 1 ON, (@chanlist)	Enables/disables min/max voltage data logging.
:PERiod <value>, (@chanlist)	Sets the integration time of the external data log measurement.
:VOLTage	
[:DC]	
:RANGE	
[:UPPer] <value>, (@chanlist)	Selects the external data log voltage measurement range.
:AUTO 0 OFF 1 ON, (@chanlist)	Enables/disables seamless measurement autoranging. (N678xA SMU)
:FUNCTION <"function">, (@chanlist)	Selects the measurement function (for backward compatibility)
:CURRent 0 OFF 1 ON, (@chanlist)	Enables/disables current measurements (replaces FUNCTION)
:VOLTage 0 OFF 1 ON, (@chanlist)	Enables/disables voltage measurements (replaces FUNCTION)
:INPUT <MAIN AUXiliary>, (@chanlist)	Selects the voltage measurement input. (N6781A, N6785A)
:HISTogram	
:CURRent	(HISTogram commands only apply to models N6781A/82A/85A/86A)
[:DC]	
:BIN	
:GAIN? 8 0.0039, (@chanlist)	Queries the LSB of the histogram in amperes per bin
:OFFSET? 8 0.0039, (@chanlist)	Queries the weight of the histogram in amperes
:RANGES? (@chanlist)	Queries the values of the bin ranges
:RANGE	
[:UPPer] <value>, (@chanlist)	Selects the internal data log voltage measurement range.
:AUTO 0 OFF 1 ON, (@chanlist)	Enables/disables seamless Elog measurement autoranging.

1 Quick Reference

:FUNCTION	
:CURRent 0 OFF 1 ON, (@chanlist)	Enables/disables current histogram.
:SWEep	
:OFFSet	Defines the offset in a data sweep for triggered measurements.
:POINTs <value>, (@chanlist)	Defines the number of points in a measurement.
:TINTerval <value>, (@chanlist)	Defines the time period between measurement samples.
:RESolution RES20 RES40	Sets the measurement resolution.
:VOLTage	
[:DC]	
:RANGE	
[:UPPer] <value>, (@chanlist)	Selects a DC voltage measurement range.
:AUTO 0 OFF 1 ON, (@chanlist)	Enables/disables seamless measurement autoranging. (N678xA SMU)
:WINDOW	
[:TYPE] HANNing RECTangular, (@chanlist)	Selects the measurement window.
[SOURce:]	
ARB	
:COUNT?	Sets the ARB repeat count.
:CURRent :VOLTage :POWER :RESISTANCE	Sets the Arb type (POWER and RESISTANCE only on N679xA)
:CDWell	
[:LEVel] <value>, {<value>}, (@chanlist)	Sets the list of the constant dwell Arb
:DWELL <value>, (@chanlist)	Sets the dwell time for the constant dwell Arb
:POINTs? (@chanlist)	Returns the number of constant-dwell Arb points
:CONVert (@chanlist)	Converts the selected Arb to a user-defined list
:EXPonential	
:END	
[:LEVel] <value>, (@chanlist)	Sets the end level of the exponential Arb
:STARt	
[:LEVel] <value>, (@chanlist)	Sets the initial level of the exponential Arb
:TIME <value>, (@chanlist)	Sets the length of the start time or delay
:TCONSTant <value>, (@chanlist)	Sets the time constant of the exponential Arb
:TIME <value>, (@chanlist)	Sets the time of the exponential Arb
:PULSe	
:END	
:TIME <value>, (@chanlist)	Sets the length of the end time
:FREQuency <value>, (@chanlist)	Sets the frequency of the pulse
:STARt	
[:LEVel] <value>, (@chanlist)	Sets the initial level of the pulse
:TIME <value>, (@chanlist)	Sets the length of the start time or delay
:TOP	
[:LEVel] <value>, (@chanlist)	Sets the top level of the pulse
:TIME <value>, (@chanlist)	Sets the length of the pulse

:RAMP	
:END	
[:LEVel] <value>, (@chanlist)	Sets the end level of the ramp
:TIME <value>, (@chanlist)	Sets the length of the end time
:RTIME <value>, (@chanlist)	Sets the rise time of the ramp
:START	
[:LEVel] <value>, (@chanlist)	Sets the initial level of the ramp
:TIME <value>, (@chanlist)	Sets the length of the start time or delay
:SINusoid	
:AMPLitude <value>, (@chanlist)	Sets the amplitude of the sine wave
:FREQuency <value>, (@chanlist)	Sets the frequency of the sine wave
:OFFSet <value>, (@chanlist)	Sets the DC offset of the sine wave
:STAIRcase	
:END	
[:LEVel] <value>, (@chanlist)	Sets the end level of the staircase
:TIME <value>, (@chanlist)	Sets the length of the end time
:NSTeps <value>, (@chanlist)	Sets the number of steps in the staircase
:START	
[:LEVel] <value>, (@chanlist)	Sets the initial level of the staircase
:TIME <value>, (@chanlist)	Sets the length of the start time or delay
:TIME <value>, (@chanlist)	Sets the length of the staircase
:STEP	
:END	
:TIME <value>, (@chanlist)	Sets the end level of the step
:START	
[:LEVel] <value>, (@chanlist)	Sets the initial level of the step
:TIME <value>, (@chanlist)	Sets the length of the start time or delay
:TRAPezoid	
:END	
:TIME <value>, (@chanlist)	Sets the length of the end time
:FTIME <value>, (@chanlist)	Sets the length of the fall time
:RTIME <value>, (@chanlist)	Sets the length of the rise time
:START	
[:LEVel] <value>, (@chanlist)	Sets the initial level of the trapezoid
:TIME <value>, (@chanlist)	Sets the length of the start time or delay
:TOP	
[:LEVel] <value>, (@chanlist)	Sets the top level of the trapezoid
:TIME <value>, (@chanlist)	Sets the length of the top of the trapezoid
:UDEFined	
:BOSTep	
[:DATA] <Bool>{,<Bool>}, (@chanlist)	Generate triggers at the Beginning Of STep
:POINts? (@chanlist)	Returns the number of BOST points
:DWELL <value>, {<value>}, (@chanlist)	Sets the user-defined dwell values
:POINts? (@chanlist)	Returns the number of dwell points

1 Quick Reference

:LEVel <value>, {<value>}, (@chanlist)	Sets the user-defined level values
:POINts? (@chanlist)	Returns the number of points
:FUNCTION <function>, (@chanlist)	Selects the Arb function (for backward compatibility)
:SHAPe <function>, (@chanlist)	Selects the Arb function (replaces ARB:FUNCTION)
:TYPE CURRent VOLTage RESISTANCE, (@chanlist)	Selects the Arb type (replaces ARB:FUNCTION)
:SEQUence	
:COUNt <value> INFinity, (@chanlist)	Sets the number of times the sequence is repeated
:LENGth? (@chanlist)	Returns the number of steps in the sequence
:QUALity? (@chanlist)	Returns the quality of the waveforms in the sequence
:RESET (@chanlist)	Resets the sequence to its power-on default setting
:STEP	
:COUNt <value> INFinity, <step#> (@chanlist)	Sets the number of times the sequence step is repeated
:CURRent <function>, <step#> (@chanlist)	Programs the waveform steps in a current sequence
:FUNCTION	
:SHAPe <function>, <step#>, (@chanlist)	Creates a new sequence step
:PACing DWEL TRIGger, <step#> (@chanlist)	Specifies the type of pacing for the step
:RESISTANCE <function>, <step#> (@chanlist)	Programs the steps in a resistance sequence
:VOLTage <function>, <step#> (@chanlist)	Programs the waveform steps in a voltage sequence
:TERMinate	
:LAST 0 OFF 1 ON, (@chanlist)	Sets the sequence termination mode
:TERMinate	
:LAST 0 OFF 1 ON, (@chanlist)	Sets the Arb termination mode

[SOURce:]

CURRent	
[:LEVel]	
[:IMMEDIATE]	
[:AMPLitude] <value>, (@chanlist)	Sets the output current.
:TRIGgered	
[:AMPLitude] <value>, (@chanlist)	Sets the triggered output current
:LIMit	
[:POSitive]	
[:IMMEDIATE]	
[:AMPLitude] <value>, (@chanlist)	Sets the positive current limit. (N678xA SMU, N6783A, N679xA)
:COUPle 0 OFF 1 ON, (@chanlist)	Sets the current limit tracking state. (N678xA SMU)
:NEGative	
[:IMMEDIATE]	
[:AMPLitude] <value>, (@chanlist)	Sets the negative current limit. (N678xA SMU, N6783A-BAT)
:MODE FIXed STEP LIST ARB, (@chanlist)	Sets the transient mode.
:PROTection	
:DElay	
[:TIME] <value>, (@chanlist)	Sets the over-current protection delay.
:STARt SChange CCTRans, (@chanlist)	Specifies what starts the over-current protection delay timer.

:STATe 0 OFF 1 ON, (@chanlist)	Enables/disables the over-current protection.
:RANGE <value>, (@chanlist)	Sets the output current range.
:SLEW	
[:POSIve]	
[:IMMediate] <value> INFinity, (@chanlist)	Sets the current slew rate. (N678xA SMU, N679xA)
[:MAXimum 0 OFF 1 ON, (@chanlist)	Enables/disables the maximum slew rate override. (N678xA SMU, N679xA)
[:COUPle 0 OFF 1 ON, (@chanlist)	Sets the current slew tracking state. (N679xA)
[:NEGative]	
[:IMMediate] <value> INFinity, (@chanlist)	Sets the negative current slew rate. (N679xA)
[:MAXimum 0 OFF 1 ON, (@chanlist)	Enables/disables the maximum slew rate override. (N679xA)
[SOURce:]	
DIGItal	
:INPut	
:DATA?	Reads the state of the digital control port.
:OUTPut	
:DATA <value>	Sets the state of the digital control port.
:PIN<1-7>	
:FUNCTION <function>	Sets the function of the pins. DIO DINPut FAULT INHibit ONCouple OFFCouple TOUTput TINPut
:Polarity POSitive NEGative	Sets the polarity of the pins.
:TOUTput	
:BUS	
[:ENABLE] 0 OFF 1 ON	Enables/disables BUS triggers on digital port pins.
[SOURce:]	
EMULation <type>, (@chanlist)	Specifies the emulation mode on models N678xA SMU. PS4Q PS2Q PS1Q BATTery CHARger CCLoad CVLoad VMETer AMETer.
[SOURce:]	
FUNCTION CURRent VOLTage RESistance POWer, (@chanlist)	Sets the output priority mode. (N678xA SMU, N679xA)
[SOURce:]	
LIST	
:COUNt <value> INFinity, (@chanlist)	Sets the list repeat count.
:CURRent	
[:LEVel] <value>{,<value>}, (@chanlist)	Specifies the setting for each list step.
:POINTs? (@chanlist)	Returns the number of list points (same as steps).
:DWELL <value>{,<value>}, (@chanlist)	Specifies the dwell time for each list step.
:POINTs? (@chanlist)	Returns the number of list points (same as steps).
:POWer	
[:LEVel] <value>{,<value>}, (@chanlist)	Specifies the setting for each list step. (N679xA)
:POINTs? (@chanlist)	Returns the number of list points (same as steps). (N679xA)
:RESistance	

1 Quick Reference

:LEVel] <value>{,<value>}, (@chanlist)	Specifies the setting for each list step. (N679xA)
:POINts? (@chanlist)	Returns the number of list points (same as steps). (N679xA)
:STEP ONCE AUTO, (@chanlist)	Specifies how the list responds to triggers.
:TERMinate	
:LAST 0 OFF 1 ON, (@chanlist)	Determines the output value when the list terminates.
:TOUTput	
:BOSTep	
[:DATA] <Bool>{,<Bool>}, (@chanlist)	Generates a trigger out at the Beginning Of STep
:POINts? (@chanlist)	Returns the number of list points (same as steps).
:EOSStep	
[:DATA] <Bool>{,<Bool>}, (@chanlist)	Generates a trigger out at the End Of STep
:POINts? (@chanlist)	Returns the number of list points (same as steps).
:VOLTage	
[:LEVel] <value>{,<value>}, (@chanlist)	Specifies the setting for each list step.
:POINts? (@chanlist)	Returns the number of list points (same as steps).
[SOURce:]	
POWER	
[:LEVel]	
[:IMMediate]	
[:AMPLitude] <value>, (@chanlist)	Sets the input power level. (N679xA)
:TRIGgered	
[:AMPLitude] <value>, (@chanlist)	Sets the triggered input power. (N679xA)
:LIMit <value>, (@chanlist)	Sets the power limit on output channels. (not on N678xA)
:MODE FIXed STEP LIST ARB, (@chanlist)	Sets the power transient mode. (N679xA)
:PROTection	
:DELAY	
[:TIME] <value>, (@chanlist)	Sets the power protection delay. (N679xA)
:STATe 0 OFF 1 ON, (@chanlist)	Enables/disables the power protection. (N679xA)
:RANGE <value>, (@chanlist)	Sets the power range. (N679xA)
:SLEW	
[:POSitive]	
[:IMMediate] <value> INFinity, (@chanlist)	Sets the power slew rate. (N679xA)
:MAXimum 0 OFF 1 ON, (@chanlist)	Enables/disables the maximum slew rate override. (N679xA)
:COUPle 0 OFF 1 ON, (@chanlist)	Sets the power slew tracking state. (N679xA)
:NEGative	
[:IMMediate] <value> INFinity, (@chanlist)	Sets the negative power slew rate. (N679xA)
:MAXimum 0 OFF 1 ON, (@chanlist)	Enables/disables the maximum slew rate override. (N679xA)
[SOURce]	
RESistance	
[:LEVel]	
[:IMMediate]	

[:AMPLitude] <value>, (@chanlist)	Sets the output resistance level. (N6781A, N6785A, N679xA)
:TRIGgered	
[:AMPLitude] <value>, (@chanlist)	Sets the triggered output resistance. (N679xA)
:MODE FIXed STEP LIST ARB, (@chanlist)	Sets the transient mode. (N679xA)
:RANGE <value>, (@chanlist)	Sets the output resistance range. (N679xA)
:SLEW	
[:POSitive]	
[:IMMEDIATE] <value> INFINITY, (@chanlist)	Sets the resistance slew rate. (N679xA)
:MAXimum 0 OFF 1 ON, (@chanlist)	Enables/disables the maximum slew rate override. (N679xA)
:COUPLE 0 OFF 1 ON, (@chanlist)	Sets the resistance slew tracking state. (N679xA)
[:NEGative]	
[:IMMEDIATE] <value> INFINITY, (@chanlist)	Sets the negative resistance slew rate. (N679xA)
:MAXimum 0 OFF 1 ON, (@chanlist)	Enables/disables the maximum slew rate override. (N679xA)
:STATE 0 OFF 1 ON, (@chanlist)	Enables/disables output resistance programming. (N6781A, N6785A)
[SOURce:]	
STEP	
:TOUTput 0 OFF 1 ON, (@chanlist)	Specifies whether a trigger out is generated when a transient step occurs.
[SOURce:]	
VOLTage	
[:LEVel]	
[:IMMEDIATE]	
[:AMPLitude] <value>, (@chanlist)	Sets the output voltage.
:TRIGgered	
[:AMPLitude] <value>, (@chanlist)	Sets the triggered output voltage.
:BWIDth	
[:RANGE] LOW HIGH1 2 3, (@chanlist)	Sets the voltage bandwidth. (N678xA SMU)
:LEVel LOW HIGH1 2 3, <frequency>, (@chanlist)	Sets the bandwidth frequency. (N678xA SMU)
:INHibit	
:VON	
[:LEVel] <value>, (@chanlist)	Current will sink if voltage is > voltage-on level. (N679xA)
:MODE LATCHing LIVE OFF	Sets the under-voltage inhibit mode. (N679xA)
:LIMit	
[:POSitive]	
[:IMMEDIATE]	
[:AMPLitude] <value>, (@chanlist)	Sets the positive voltage limit. (N678xA SMU)
:COUPLE 0 OFF 1 ON, (@chanlist)	Sets the voltage limit tracking state. (N6784A)
[:NEGative]	
[:IMMEDIATE]	
[:AMPLitude] <value>, (@chanlist)	Sets the negative voltage limit. (N6784A)
:MODE FIXed STEP LIST ARB, (@chanlist)	Sets the transient mode.

1 Quick Reference

:PROTection	
[:LOCal]	
[:LEVel] <value>, (@chanlist)	Sets the over-voltage protection level.
:DELay	
[:TIME] <value>, (@chanlist)	Sets the over-voltage protection delay. (N678xA SMU, N6783A)
:REMote	
[:POSitive]	
[:LEVel] <value>, (@chanlist)	Sets the positive remote OV protection. (N678xA SMU, N679xA)
[:NEGative]	
[:LEVel] <value>, (@chanlist)	Sets the negative remote OV protection. (N6784A)
:RANGe <value>, (@chanlist)	Sets the output voltage range.
:RESistance	
[:LEVel]	
[:IMMEDIATE]	
[:AMPLitude] <value>, (@chanlist)	Sets the voltage priority resistance level. (N6781A, N6785A)
:STATe 0 OFF 1 ON, (@chanlist)	Enables/disables the voltage priority resistance. (N6781A, N6785A)
:SENSe	
:SOURce INTERNAL EXTERNAL, (@chanlist)	Sets the state of the output remote sense relays.
:SLEW	
[:POSitive]	
[:IMMEDIATE] <value> INFINITY, (@chanlist)	Sets the voltage slew rate.
:MAXimum 0 OFF 1 ON, (@chanlist)	Enables/disables the maximum slew rate override.
:COUPle 0 OFF 1 ON, (@chanlist)	Sets the current slew tracking state. (N679xA)
[:NEGative]	
[:IMMEDIATE] <value> INFINITY, (@chanlist)	Sets the negative current slew rate. (N679xA)
:MAXimum 0 OFF 1 ON, (@chanlist)	Enables/disables the maximum slew rate override. (N679xA)
STATus	
:OPERation	
[:EVENT]? (@chanlist)	Queries the operation event register.
:CONDition? (@chanlist)	Queries the operation condition register.
:ENABLE <value>, (@chanlist)	Sets the operation enable register.
:NTRansiton <value>, (@chanlist)	Sets the negative transition filter.
:PTRansiton <value>, (@chanlist)	Sets the positive transition filter.
:PRESet	Presets all Enable, PTR, and NTR registers.
:QUESTIONable	
[:EVENT]? (@chanlist)	Queries the questionable event register.
:CONDition? (@chanlist)	Queries the questionable condition register.
:ENABLE <value>, (@chanlist)	Sets the questionable enable register.
:NTRansiton <value>, (@chanlist)	Sets the negative transition filter.
:PTRansiton <value>, (@chanlist)	Sets the positive transition filter.
SYSTem	

:CHANnel		
[:COUNT]?	Returns the number of output channels in a mainframe.	
:MODe? (@chanlist)	Returns the model number of the selected channel.	
:OPTION? (@chanlist)	Returns the option installed in the selected channel.	
:SERial? (@chanlist)	Returns the serial number of the selected channel.	
:COMMUcate		
:LAN TCPip:CONTrol?	Returns the initial socket control connection port number.	
:RLSTate LOCal REMote RWLock	Configures the remote/local state of the instrument.	
:DATE <yyyy>,<mm>,<dd>	Sets the date of the system clock.	
:ERRor?	Reads and clears one error from the error queue.	
:GROup	(GROup commands do NOT apply to models N678xA SMU)	
:CATalog?	Returns the groups that have been defined.	
:DEFine <chanlist>	Group multiple channels to create a single channel.	
:DELete <channel>	Remove the specified channel from the group.	
:ALL	Ungroups all channels.	
:PASSword		
:FPANel		
:RESET	Resets the front panel lockout password to zero.	
:PERSONa		
:MANufacturer "<manufacturer>"	Changes the manufacturer identity.	
:DEFault	Sets the manufacturer identity to the factory default.	
:MODel "<model number>"	Changes the model number.	
:DEFault	Sets the model number to the factory default.	
:REBoot	Reboots the instrument to its power-on state.	
:SECurity		
:IMMEDIATE	Clears all user memory and reboots the instrument.	
:SET <data>	Sets the instrument to the specified state.	
:SET?	Retrieves the current instrument state.	
:TIME <hh>,<mm>,<ss>	Sets the time of the system clock.	
:VERSion?	Returns the SCPI version that the instrument complies with.	
TRIGger		
:ACQuire		
[:IMMEDIATE] (@chanlist)	Triggers the measurement immediately.	
:CURRent		
[:LEVel] <value>, (@chanlist)	Sets the current trigger level.	
:SLOPe POSitive NEGative, (@chanlist)	Sets the current trigger slope.	
:SOURce <source>, (@chanlist)	Selects the trigger source for the acquisition system: BUS CURRent<1-4> EXternal PIN<1-7> TRANsient<1-4> VOLTage<1-4>	
:TOUTput		
[:ENABLE] 0 OFF 1 ON, (@chanlist)	Enables measurement triggers to be sent to a digital port pin.	
:VOLTage		
[:LEVel] <value>, (@chanlist)	Sets the voltage trigger level.	
:SLOPe POSitive NEGative, (@chanlist)	Sets the voltage trigger slope.	

1 Quick Reference

:ARB	
:SOURce <source>	Selects the trigger source for the arbitrary waveform: BUS EXternal IMMediate
:DLOG	
[:IMMediate]	Triggers the internal data logger immediately.
:CURRent	
[:LEVel] <value>, (@chanlist)	Sets the current trigger level of the data logger.
:SLOPe POSitive NEGative, (@chanlist)	Sets the current trigger slope of the data logger.
:SOURce <source>	Selects the trigger source for internal data logging: BUS CURRent<n> EXternal IMMediate VOLTage<n> ARSK OOOK
:VOLTage	
[:LEVel] <value>, (@chanlist)	Sets the voltage trigger level of the data logger.
:SLOPe POSitive NEGative, (@chanlist)	Sets the voltage trigger slope of the data logger.
:ELOG	
[:IMMediate] (@chanlist)	Triggers the external data logger immediately.
:SOURce <source>, (@chanlist)	Selects the trigger source for external data logging: BUS EXternal IMMediate PIN<1-7>
:HISTogram	(HISTogram commands only apply to models N6781A/82A/85A/86A)
[:IMMediate] (@chanlist)	Triggers the current histogram immediately.
:SOURce <source>, (@chanlist)	Selects the trigger source for current histogram: BUS EXternal IMMediate PIN<1-7>
:MEASure	
:TALign	
:CORRection	
[:STATe] 0 OFF 1 ON	Improves the alignment of measurement triggers with measurement data.
:TRANsient	
[:IMMediate] (@chanlist)	Triggers the output immediately.
:SOURce <source>, (@chanlist)	Selects the trigger source for the transient system: BUS EXternal IMMediate PIN<1-7> TRANsient<1-4>

Model Descriptions, Differences, and Options

Model Descriptions

Model Differences

Options

Model Descriptions

Model	Description
N6705C	600 W DC Power Analyzer Mainframe - without power modules
N6715C	Build-to-order DC Power Analyzer Mainframe - with installed modules
N6731B / N6741B	50 W / 100 W 5 V DC Power Module
N6732B / N6742B	50 W / 100 W 8 V DC Power Module
N6733B / N6743B / N6773A	50 W / 100 W / 300 W 20 V DC Power Module
N6734B / N6744B / N6774A	50 W / 100 W / 300 W 35 V DC Power Module
N6735B / N6745B / N6775A	50 W / 100 W / 300 W 60 V DC Power Module
N6736B / N6746B / N6776A, N6777A	50 W / 100 W / 300 W 100 V DC Power Module
N6751A / N6752A	50 W / 100 W High-Performance Autoranging DC Power Module
N6753A, N6754A / N6755A, N6756A	300 W / 500 W High-Performance Autoranging DC Power Module
N6761A / N6762A	50 W / 100 W Precision DC Power Module
N6763A, N6764A / N6765A, N6766A	300 W / 500 W Precision DC Power Module
N6781A, N6782A, N6784A	20 W Source/Measure Unit (SMU)
N6785A, N6786A	80 W Source/Measure Unit (SMU)
N6783A-BAT / N6783A-MFG	18 W / 24 W Application-Specific DC Power Module
N6791A, N6792A	100 W / 200 W Electronic Load Module

Power Model Differences

Feature (● = available)	DC Power	High-Performance	Precision
	N673xB, '4xB, '7xA	N675xA	N676xA
50 W output rating	N6731B – N6736B	N6751A	N6761A
100 W output rating	N6741B – N6746B	N6752A	N6762A
300 W output rating	N6773A – N6777A	N6753A, '54A	N6763A, '64A
500 W output rating		N6755A, '56A	N6765A, '66A
Output disconnect relays	Option 761	Option 761	Option 761
Output disconnect/polarity reversal relays ¹	Option 760	Option 760	Option 760
Arbitrary waveform generation	●	●	●
Autoranging output capability		●	●
Voltage/current turn-on priority			N6761A, '62A
Precision voltage/current measurements			●
Low voltage/current output range			N6761A, '62A
Low voltage/current measurement range			●
200 microampere measurement range ²			Option 2UA
Voltage/current scope traces	●	●	●
Simultaneous voltage/current scope traces			●
Simultaneous voltage/current data logging ³			●
Interleaved voltage/current data logging ³	●	●	
Dynamic current correction	●	N6751A, '52A	N6761A, '62A
SCPI command output list capability ⁴	●	●	●
SCPI command array readback ⁴	●	●	●
SCPI command programmable sample rate ⁴	●	●	●
SCPI command external data logging ⁴	●	●	●
Double-wide power modules (require 2 channel locations)		N6753A - N6756A	N6763A - N6766A

Note 1 Output current is limited to 10A max. on Models N6742B and N6773A with Option 760.

Option 760 is not available on Models N6741B, N6751A, N6752A, N6761A, and N6762A.

Note 2 Option 2UA is only available on Models N6761A and N6762A. It includes Option 761.

Note 3 Option 055 deletes the Data Logger function on Model N6705C.

Note 4 Only available when using the remote interfaces; not from the front panel.

N678xA Power Model Differences

Feature (● = available)	Source/Measure Units (SMU)						Application-Specific	
	N6781A	N6782A	N6784A	N6785A	N6786A	N6783A -BAT	N6783A -MFG	
Output rating	20 W	20 W	20 W	80 W	80 W	24 W	18 W	
2-quadrant operation	●	●		●	●	●	●	
4-quadrant operation			●					
Aux voltage measurement	●			●				
Output disconnect relays	●	●	●	●	●	Opt 761	Opt 761	
Arbitrary waveforms ¹	●	●	●	●	●	●	●	
Negative voltage protection	●	●	●	●	●	●	●	
Voltage or current priority	●	●	●	●	●			
CC load or CV load	●	●	●	●	●			
Voltage/current measurement only	●	●	●	●	●			
Battery emulator or charger	●			●				
Programmable resistance	●			●				
Number of voltage output ranges	3	3	3	4	4	1	1	
Number of current output ranges	3	3	4	4	4	1	1	
Number of voltage measurement ranges	3	3	3	1	1	1	1	
Number of current measurement ranges	4	4	4	3	3	2	2	
Voltage/current scope traces	●	●	●	●	●	●	●	
Simultaneous voltage/current measurements	●	●	●	●	●			
Simultaneous voltage/current data logging ²	●	●	●	●	●			
Interleaved voltage/current data logging ²						●	●	
Seamless measurement autoranging	●	●	Opt SMR	●	●			
SCPI output list capability ^{1,3}	●	●	●	●	●	●	●	
SCPI array readback ³	●	●	●	●	●	●	●	
SCPI programmable sample rate ³	●	●	●	●	●	●	●	
SCPI external data logging ³	●	●	●	●	●	●	●	
SCPI histogram measurements ³	●	●		●	●			
Double-wide power modules				●	●			

Note 1 Arbitrary waveforms and List capability are not available on the negative current output on Model N6783A.

Note 2 Option 055 deletes the Data Logger function on Model N6705.

Note 3 Only available when using the remote interfaces; not the front panel.

N679xA Load Model Differences

Feature (● = available)	Load Modules	
	N6791A	N6792A
Input rating ¹	100 W	200 W
Input terminal short capability	●	●
Arbitrary waveform generation	●	●
Under-voltage inhibit	●	●
Voltage, current, resistance, and power priority mode	●	●
Number of resistance input ranges	3	3
Number of current input ranges ²	2	2
Number of voltage input ranges ²	1	1
Number of power input ranges	2	2
Simultaneous voltage and current measurements	●	●
SCPI command output list capability ³	●	●
SCPI command array readback ³	●	●
SCPI command programmable sample rate ³	●	●
SCPI command external data logging ³	●	●
Double-wide (occupies 2 channel locations)		●

Note 1 The load module's input is referred to by the term "Output" throughout this document.

Note 2 The input and measurement ranges are coupled.

Note 3 Only available when using the remote interfaces; not from the front panel.

Options

Options	Description
Mainframe options	
AKY	Deletes the front and rear panel USB connector
RBP	Recessed front panel binding posts
055	Deletes the Data Logger function
056	Keysight 14585A Control and Analysis Software
908	Rack Mount Kit. For mounting in a 19-inch EIA cabinet. Also available as Model N6709A.
909	Rack Mount Kit with handles. Also available as p/n 5063-9222.
Power Module options	
760 1	Output disconnect/polarity reversal. Disconnects the + and – output and sense terminals. Switches the + and – output and sense polarities. Not available on N6741B, N6751A, N6752A, N676xA, N678xA.SMU, or N679xA.
761 1	Output disconnect. Disconnects + and – output and sense terminals. Standard on N678xA SMU. Not available on N679xA.
LGA	Large gate array. Required on Models N6751A, N6752A
UK6	Commercial calibration with test results data
1A7	ISO 17025 calibration certificate
2UA	200 microampere measurement range. Only on Models N6761A, N6762A.
SMR	Seamless measurement autoranging for Model N6784A. Included with Models N6781A, N6782A, N6785A, and N6786A.

Note 1 A small AC network is always present across the output terminals.

Specifications

Supplemental Characteristics

Dimension Diagrams

This section lists the supplemental characteristics of the Keysight N6705C DC Power Analyzer. Supplemental characteristics are not warranted but are descriptions of performance determined either by design or by type testing. All supplemental characteristics are typical unless otherwise noted.

Specifications and characteristics are subject to change without notice.

NOTE Complete specifications and supplemental characteristics information for all power modules are included in the [Keysight N6700 Modular Power System Family Specifications Guide](#).

Supplemental Characteristics

Characteristic	Keysight N6705C
Maximum total power available for power modules:	600 W
Front panel output terminals maximum current rating:	20 A
BNC trigger connectors IO: Maximum voltage: Minimum input pulse: Output pulse:	Digital TTL level compatible 5 V > 6 ns, positive going; > 90 ns, negative going 10 µs, negative-going
USB current ratings Front panel USB: Rear panel USB:	200 mA 300 mA
Data storage of internal flash memory:	4 Gbytes
Protection Response INH Input: Fault on coupled output:	5 µs from receipt of inhibit to start of shutdown < 10 µs from receipt of fault to start of shutdown
Command Processing Time:	≤ 1 ms from receipt of command to start of output change

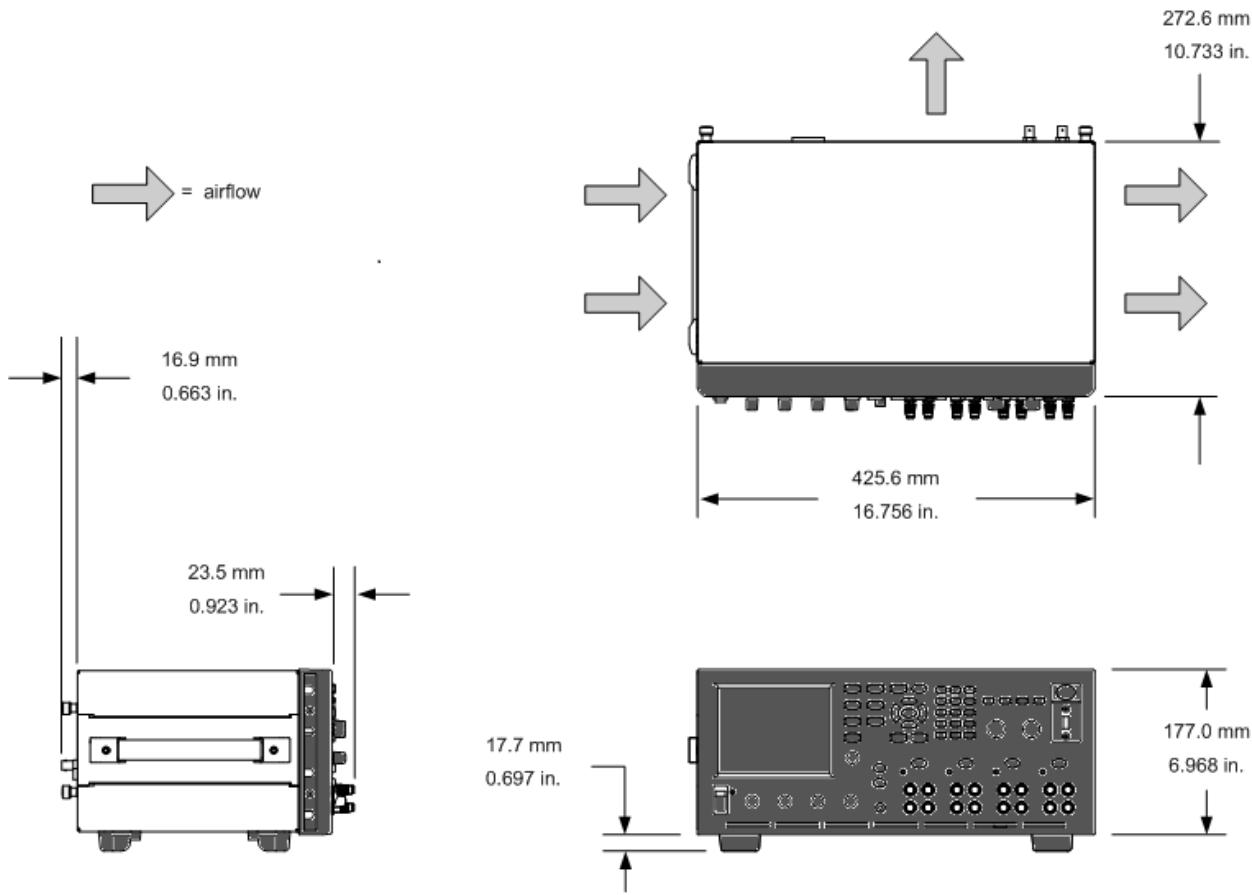
Characteristic	Keysight N6705C
Digital Control Characteristics	
Maximum voltage ratings	+16.5 VDC/-5 VDC between pins (pin 8 is internally connected to chassis ground).
Pins 1 and 2 as FLT output	Maximum low-level output voltage = 0.5 V @ 4 mA Maximum low-level sink current = 4 mA Typical high-level leakage current = 1 mA @ 16.5 VDC
Pins 1 - 7 as digital/trigger outputs (pin 8 = common)	Maximum low-level output voltage = 0.5 V @ 4 mA; 1 V @ 50 mA; 1.75 V @ 100 mA Maximum low-level sink current = 100 mA Typical high-level leakage current = 0.8 mA @ 16.5 VDC
Pins 1 - 7 as digital/trigger inputs and pin 3 as INH input (pin 8 = common)	Maximum low-level input voltage = 0.8 V Minimum high-level input voltage = 2 V Typical low-level current = 2 mA @ 0 V (internal 2.2k pull-up) Typical high-level leakage current = 0.12 mA @ 16.5 VDC
Interface Capabilities	
LXI Core 2011:	10/100/1000 Base-T Ethernet (Sockets, VXI-11 protocol, Web interface)
USB 2.0 (USB-TMC488):	Requires Keysight IO Library version M.01.01 or 14.0 and up
10/100/1000 LAN:	Requires Keysight IO Library version L.01.01 or 14.0 and up
Built-in Web server:	Requires a Web browser
GPIB:	SCPI - 1993, IEEE 488.2 compliant interface
Regulatory Compliance:	
EMC:	Complies with European EMC Directive for test and measurement products: IEC/EN 61326-1; CISPR 11, Group 1, class A; AS/NZS CISPR 11; ICES/NMB-001
	Complies with Australian standard and carries C-Tick mark This ISM device complies with Canadian ICES-001 Cet appareil ISM est conforme à la norme NMB-001 du Canada
Safety:	Complies with European Low Voltage Directive and carries the CE-marking. Conforms to US and Canadian safety regulations.
Environmental	
Operating environment:	Indoor use, installation category II (for AC input), pollution degree 2
Temperature range:	0°C to 55°C (output current is derated 1% per °C above 40°C)
Relative humidity:	Up to 95% (non-condensing)
Altitude:	Up to 2000 meters
Storage temperature:	-30°C to 70°C
Acoustic Noise Declaration	
This statement is provided to comply with the requirements of the German Sound Emission Directive, from 18 January 1991	Sound Pressure L _p < 70 dB(A), At Operator Position, Normal Operation, According to EN 27779 (Type Test). Schalldruckpegel L _p < 70 dB(A), Am Arbeitsplatz, Normaler Betrieb, Nach EN 27779 (Typ-prüfung).
Output Terminal Isolation:	No output terminal may be more than 240 VDC from any other terminal or chassis ground.
	N6781A/N6785A Note: When using the AUX measurement input terminals on Models N6781A and N6785A, no output or input terminal may be more than ±60 VDC from any other terminal or chassis ground.

1 Quick Reference

Characteristic	Keysight N6705C
AC Input	
Input ratings:	~ 100 VAC – 240 VAC; 50/60/400Hz
Input range:	86–264 VAC; 47–63Hz; 380–420 Hz
Power Consumption:	1440 VA
Power Factor (Note 1):	0.99 @ nominal input and rated power
Fuse:	Internal fuse - not customer accessible
Net Weight	
N6705C with 4 modules:	16 kg / 35 lbs.
Single-wide module (typical):	1.23 kg / 2.71 lbs
Dimensions:	Refer to the dimension diagrams in the following section.

Note 1: Under full load at 400 Hz, power factor drops from 0.99 @ 120 VAC to as low as 0.76 @ 265 VAC. Power factor degrades further under no load conditions.

Dimension Diagrams



2

Installation

Preliminary Information

Installing the Power Analyzer

Connecting the Power Cord

Connecting the Outputs

Remote Sense Connections

Parallel and Series Connections

BNC Connections

Auxiliary Measurement Connections

Interface Connections

Preliminary Information

Check for Items Supplied

Inspect the Unit

Review Safety Information

Observe Environmental Conditions

Check for Items Supplied

Before getting started, check the following list and verify that you have received these items with your unit. If anything is missing, please contact your nearest Keysight Sales and Support Office.

Mainframe Items	Description	Part Number
Power Cord	A power cord suitable for your location.	Call Keysight Sales & Support Office
Digital Connector plug	8-pin connector for connecting signal lines to the digital port.	Keysight 1253-6408 Phoenix Contact MC 1,5/8-ST-3,5
AUX Measurement Connector plug (2)	8-pin connector plug for the auxiliary measurement inputs. Only used with Models N6781A and N6785A.	Keysight 1253-6408 Phoenix Contact MC 1,5/8-ST-3,5
Spare grommets	Two spare grommets for rear panel sense and load wiring.	Keysight 0400-1009
Automation-Ready CD	Contains Keysight IO Libraries Suite.	Keysight E2094N
Quick Start Tutorial	A tutorial to help you quickly get started.	Keysight N6705-90005
T-10 Torx tool	Tool for installing or removing power modules.	Keysight 8710-2416
DC Power Module Items	Description	Part Number
8 A Output Connector plug	One 8 A, 8-pin connector plug for connecting power and sense leads. Only used in Models N678xA SMU.	Keysight 1253-6408 Phoenix Contact MC 1,5/8-ST-3,5
12 A Output Connector plug	One 12 A, 4-pin connector plug for connecting power and sense leads. Used in all except N6731B, N6741B, N6753A-N6756A, N6763A-N6766A, N6773A, N678xA SMU, N6791A, N6792A.	Keysight 1253-5826 Phoenix Contact MSTB 2,5/4-STF
20 A Output Connector plug	One 20 A, 4-pin connector plug for connecting power and sense leads. Only used in N6731B, N6741B, N6754A, N6756A, N6764A, N6766A, N6773A, N6791A.	Keysight 1253-6211 Phoenix Contact PC 4/4-ST-7,62
50 A Output Connector plug	One 50 A, 2-pin connector plug for connecting power leads. Only used in N6753A, N6755A, N6763A, N6765A, N6792A.	Keysight 1253-7187 Molex 39422-0002
AUX Measurement connector plug	A 2-pin connector plug for connecting the auxiliary measurement inputs. Only used in N6781A and N6785A.	Keysight 1253-8485 Phoenix Contact FMC 1,5/2-ST-3,5
Small Sense Jumpers	Two small jumpers for local sensing at the output connector. Used in all except N6731B, N6741B, N6753A-N6756A, N6763A-N6766A, N6773A, N678xA SMU, N6791A, N6792A.	Keysight 8120-8821 Phoenix Contact EPB 2-5(1733169)

DC Power Module Items	Description	Part Number
Large Sense Jumpers	Two large jumpers for local sensing at the output connector. Only used in N6731B, N6741B, N6754A, N6756A, N6764A, N6766A, N6773A, N6791A.	Keysight 0360-2935 Phoenix Contact 3118151
Sense Connector	A 4-pin connector for connecting sense leads. Wires (p/n 5185-8847) are used for local sensing. Only used in N6753A, N6755A, N6763A, N6765A.	Keysight 1253-5830 Phoenix Contact MC 1,5/4-ST-3,5
Module Cal. Certificate	A certificate of calibration referenced to the serial number.	N/A

Inspect the Unit

When you receive your power analyzer, inspect it for any obvious damage that may have occurred during shipment. If there is damage, notify the shipping carrier and nearest Keysight Sales and Support Office immediately. Refer to www.keysight.com/find/assist.

Until you have turned on and checked out the power analyzer, save the shipping carton and packing materials in case the unit has to be returned.

Review Safety Information

This Keysight N6705C DC Power Analyzer is a Safety Class 1 instrument, which means it has a protective earth terminal. That terminal must be connected to earth ground through a power source equipped with a ground receptacle.

Refer to the **Safety Summary** page at the beginning of this guide for general safety information. Before installation or operation, review this guide for safety warnings and instructions. Safety warnings for specific procedures are located at appropriate places throughout this Guide

WARNING Some power modules generate voltages exceeding 60 VDC. Ensure that instrument connections, load wiring, and load connections are either insulated or covered so that no accidental contact with lethal output voltages can occur.

Observe Environmental Conditions

WARNING Do not operate the instrument in the presence of flammable gases or fumes.

The environmental conditions of the power analyzer are documented under **Environmental Characteristics**. Basically, the unit should only be operated indoors in a controlled environment.

The dimensions of your instrument as well as an outline diagram are also documented under **Specifications**. A fan cools the power analyzer by drawing air through the sides and exhausting it out the side and back. The instrument must be installed in a location that allows sufficient space at the sides and back of the unit for adequate air circulation.

Installing the Power Analyzer

Power Module Installation

High-Current Output Connections

Ferrite Core Installation - for Keysight N6792A only

Bench Installation

Rack Installation

Redundant Ground for 400 Hz Operation

Power Module Installation

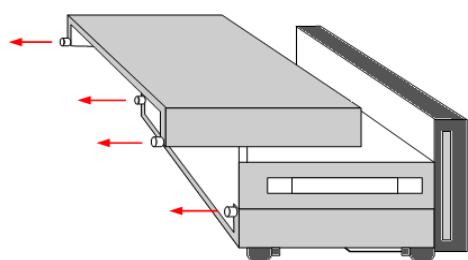
NOTE The information in this section applies if you have purchased an N6705 mainframe without the power modules installed, or if you are adding a power module to the mainframe.

CAUTION **Equipment Damage** Turn the mainframe off and disconnect the power cord before installing or removing power modules. Observe all standard electrostatic discharge precautions before handling electronic components.

Tools required: T10 Torx driver; Small flat-blade screwdriver; 5.5 mm hex wrench

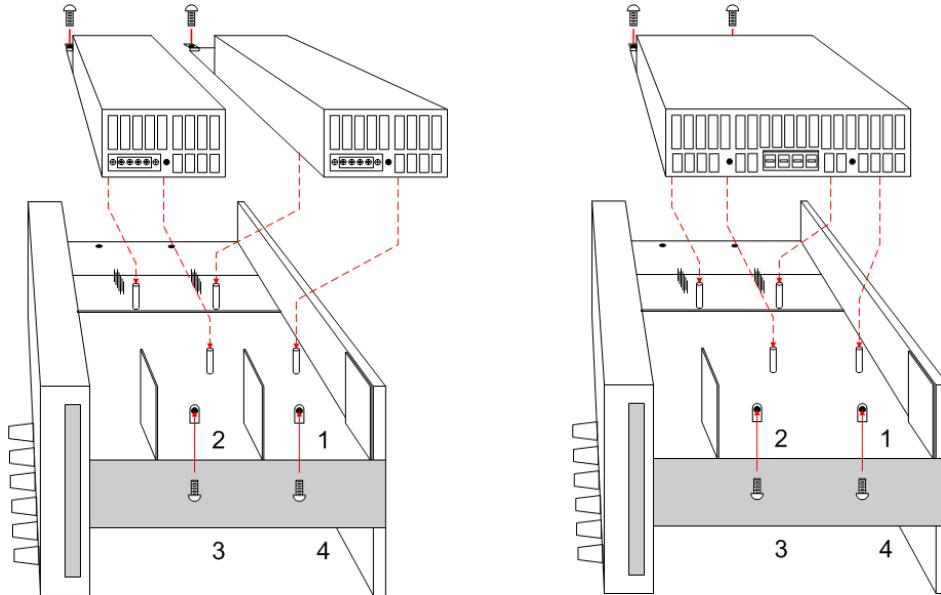
Step 1. Remove the top and bottom covers.

Loosen the thumb-screws to remove the covers. Slide the covers back. Turn the unit upside-down to remove the bottom cover.



Step 2. Place the power modules in the mainframe.

Align the power module over the pins and gently push it down onto the connector. Install the screws at each end of the power module. The torque specification for the screws is 9 inch-pounds.



The location of the power modules inside the mainframe determines their front panel output and programming channel assignments. For example, modules installed in channel 1 will be connected to the wire harness for output 1. Modules installed in channel 4 will be connected to the wire harness for output 4.

NOTE

When installing a double-wide power module, you must first remove the center deflector. Use a T10 Torx to remove the top deflector; use a 5.5 mm hex to remove the bottom deflector. Install the deflector in the storage location on the opposite side. You can only connect the double-wide power module to output 1 or output 3.

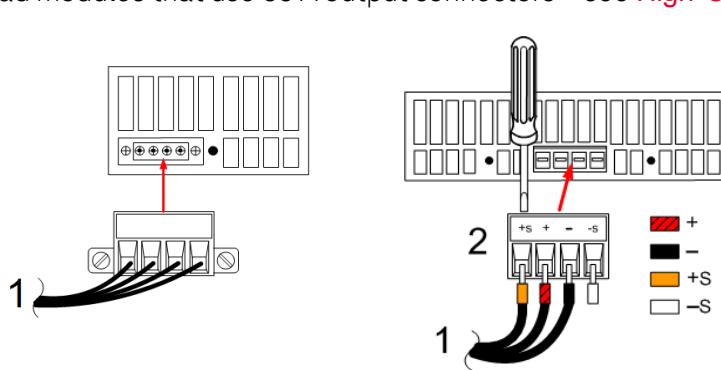
Step 3. Connect the front panel wire harness.

For power modules that use 12 A output connectors – Simply push the 12 A connector plug into the power module. Tighten the locking screws on the connector.

For power modules that use 20 A output connectors – Remove the 12 A connector plug from the harness and install the 20 A connector plug provided with the power module. Observe the output color code. Tighten all connector screws. Install the connector in the module.

For power and load modules that use 50 A output connectors – see [High-Current Output Connections](#).

1. To front panel binding post
2. 20 A connector

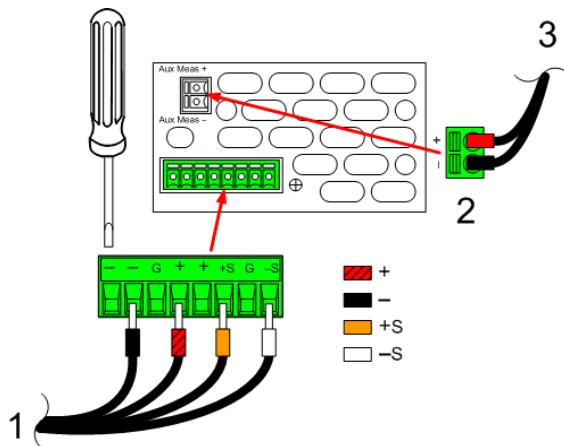


2 Installation

For Keysight N678xA SMU power modules – Remove the 12A connector plug from the wire harness and install the 8-pin connector plug provided with the power module. Install the front panel cable wires in the output connector as shown. Observe the output color code. Tighten all connector screws.

For Keysight N6781A and N6785A power modules, also connect the auxiliary measurement cable. Remove the cable from its rear panel storage location and insert the connector into the power module. The cable's color code corresponds to the AUX voltage measurement label on the rear panel.

1. To front panel binding post
2. Aux Meas connector
3. To rear panel connector



Step 4. Finish the installation.

Place any unused cable harnesses in the clip ring located between the power modules and the front panel. Install the top and bottom covers. Push the covers into place and tighten the thumbscrews.

High-Current Output Connections

NOTE

This information only applies to power modules with output current ratings of 50 A, and load modules with input current ratings of 40 A.

CAUTION

Do not connect the front panel cable assembly to the high-current output power modules. Because the front panel binding posts have a maximum current rating of 20 A, they are not available for use with high-current power modules.

High-current (> 20 A) connections are made using the rear panel access ports of the mainframe. These access ports have a thin rubber membrane which can be pierced using the load wires.

User-supplied load and sense wires must be used to connect to the output and sense connector plugs on the high current power module. The sense connector is shipped with jumpers installed for local sensing.

Step 1. Route the load wires through the rear panel.

Push the high-current load wires through the rear panel access port. If you are using remote sensing, route the sense wires though the second access port. Twist each wire pair.

Step 2. Connect the wires to the power module.

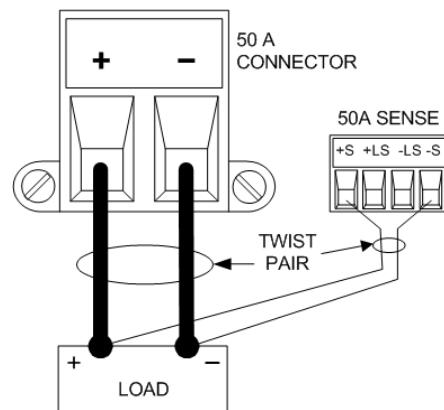
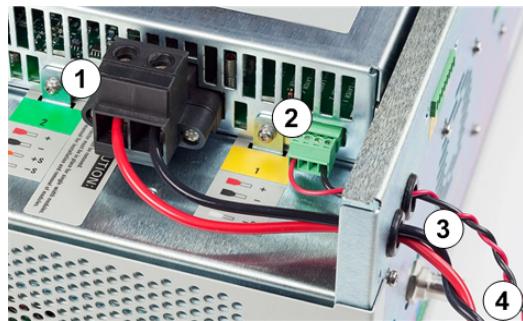
Connect the load wires to the output connector of the power module as shown. Connect the remote sense wires to the +S and -S terminals on the sense connector.

CAUTION The +LS and -LS terminals are ONLY used for local sense connections to the +S and -S terminals. Do not connect the +LS and -LS terminals in any other way.

Step 3. Finish the installation.

Place any unused cable harnesses in the clip ring located between the power modules and the front panel. Install the top and bottom covers. Push the covers into place and tighten the thumbscrews.

1. 50 A output connector
2. Sense connector
3. Twist leads
4. To load



Ferrite Core Installation - for Keysight N6792A only

NOTE

Compliance to radio frequency interference (RFI) standards requires a ferrite core to be installed on the load leads of the load module. The core is supplied with the module and does not affect the functionality of the module.

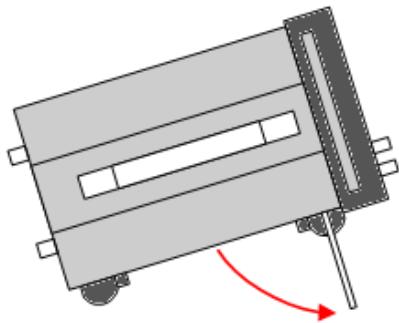
1. Locate the core along the length of the cables and pass the load cables through the core once
2. Clip the ferrite core onto the load cables as close as possible to the back of the unit. The recommended distance from the connector to the core is 4 cm.
3. Attach the tywrap to the load wires to prevent the core from sliding away from the back of the unit.



Bench Installation

CAUTION Do not block the air intake and exhaust at the sides, or the exhaust at the rear of the unit. Refer to the dimension diagram in the [Specifications](#) section.

Minimum clearances for bench operation are 2 inches (51 mm) along the sides and back. For easier display viewing and binding post access, you can tilt the front of the unit up by rotating the extension bar down.



Rack Installation

CAUTION Use Rack Mount kit (Option 908 or Option 909 with handles) to rack mount the instrument. Installation instructions are provided with the rack mount kit

Power analyzer mainframes can be mounted in a 19-inch EIA rack cabinet. They are designed to fit in four rack-units (4U) of space.

Remove the feet before rack mounting the unit. Do not block the air intake and exhausts at the sides and rear of the unit.

Redundant Ground for 400 Hz Operation

At 400 Hz AC input operation, the leakage current of the unit exceeds 3.5 mA. This requires the installation of a permanent, redundant ground from the instrument chassis to earth ground. This ensures that ground will always be connected and that any leakage current will be diverted to ground.

Refer to [BNC Connectors](#) later in this section for installation instructions.

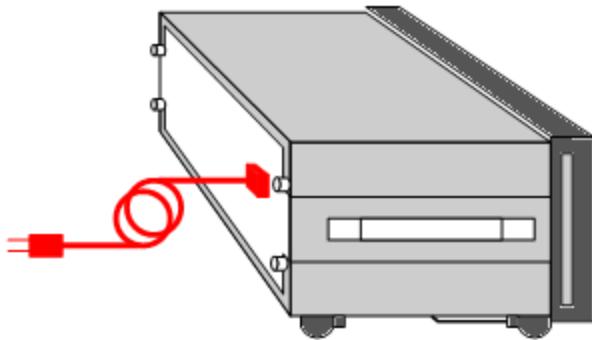
Refer to the [Specifications](#) section for power factor statistics at 400 Hz operation.

Connecting the Power Cord

WARNING FIRE HAZARD Use only the power cord that was supplied with your instrument. Using other types of power cords may cause overheating of the power cord, resulting in fire.

SHOCK HAZARD The power cord provides a chassis ground through a third conductor. Be certain that your power outlet is of the three-conductor type with the correct pin connected to earth ground.

Connect the power cord to the IEC 320 connector on the rear of the unit. If the wrong power cord was shipped with your unit, contact your nearest Keysight Sales and Support Office.



The AC input on the back of your unit is a universal AC input. It accepts nominal line voltages in the range of 100 VAC to 240 VAC. The frequency can be 50 Hz, 60 Hz, or 400 Hz.

NOTE The detachable power cord may be used as an emergency disconnecting device. Removing the power cord will disconnect AC input power to the unit.

Connecting the Outputs

Binding Posts

Wire Sizing

Keysight N678xA SMU Wiring

Multiple Load Wiring

Positive and Negative Voltages

Protecting Sensitive Loads

Load Capacitor Response Times

NOTE Keysight N679xA Load Module input terminals are referred to as "Outputs" throughout this document.

N679xA

Binding Posts

WARNING SHOCK HAZARD Turn off AC power before making rear panel connections. All wires and straps must be properly connected with the binding posts securely tightened.

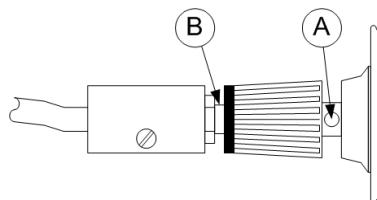
Some power modules generate voltages in excess of 60 VDC. Ensure that instrument connections, load wiring, and load connections are either insulated or covered so that no accidental contact with lethal output voltages can occur.

The binding posts accept wires sizes up to AWG 14 in location (A). Securely fasten all wires by hand-tightening the binding posts. You can insert standard banana plugs into the front of the connectors as shown in (B). A chassis ground binding post is located on the front panel for convenience.

Maximum current rating:

(A) = 20 A

(B) = 15 A



For power and load modules that have current ratings greater than 20 A – see [High-Current Output Connections](#).

Wire Sizing

WARNING FIRE HAZARD Select a wire size large enough to carry short-circuit current without overheating (refer to the following table). To satisfy safety requirements, load wires must be heavy enough not to overheat while carrying the short-circuit output current of the unit. Keysight Model N678xA SMU wiring is described in the following section.

Along with conductor temperature, you must also consider voltage drop when selecting wire sizes. The following table lists the resistance for various wire sizes and the maximum lengths to limit the voltage drop to 1.0 V per lead for various currents.

Note that the minimum wire size required to prevent overheating may not be large enough to prevent over-voltage tripping or maintain good regulation. Under most conditions, the load wires should also be heavy enough to limit the voltage drop to no more than 1.0 V per lead.

To help prevent nuisance tripping of the over-voltage circuit, select a wire size sufficient to handle the FULL output current of the unit no matter what the intended load current or current limit setting.

Load lead resistance is also an important factor relating to the CV stability of the instrument when remote sensing capacitive loads. If high capacitance loads are expected, you should not use wire gauges heavier than 12 to 14 AWG for long runs of load lead.

Wire Size		Metric size (Note1)		Resistance	Max length to limit voltage to 1 V/lead			
					for 5 A	for 10 A	for 20 A	for 50 A
AWG	2 wires bundled	4 wires bundled	Ω per foot	Wire length in feet				
	20	7.8	6.9	0.0102	20	x	x	x
	18	14.5	12.8	0.0064	30	15	x	x
	16	18.2	16.1	0.0040	50	25	x	x
	14	29.3	25.9	0.0025	80	40	20	x
	12	37.6	33.2	0.0016	125	63	30	x
	10	51.7	45.7	0.0010	200	100	50	20
	8	70.5	62.3	0.0006	320	160	80	32
Area in mm ²	2 wires bundled	4 wires bundled	Ω per meter	Wire length in meters				
	0.5	7.8	6.9	0.0401	5	x	x	x
	0.75	9.4	8.3	0.0267	7.4	x	x	x
	1	12.7	11.2	0.0200	10	5	x	x
	1.5	15.0	13.3	0.0137	14.6	7.2	x	x
	2.5	23.5	20.8	0.0082	24.4	12.2	6.1	x
	4	30.1	26.6	0.0051	39.2	19.6	9.8	3.9
	6	37.6	33.2	0.0034	58	29	14.7	5.9
	10	59.2	52.3	0.0020	102	51	25	10.3

Notes:

1. Capacity for AWG wires from MIL-W-5088B. Maximum ambient temperature: 55°C. Maximum wire temperature: 105°C
2. Capacity for metric wires from IE Publication 335-1.
3. Capacity of aluminum wire is approximately 84% of that listed for copper wire.
4. "x" indicates wire is not rated for the maximum output current of the power module.
5. Because of wire inductance considerations, it is also recommended that you keep your load leads twisted, tie wrapped, or bundled together and less than 50 feet (14.7 meters) in length per lead.

Keysight N678xA SMU Wiring

NOTE Because of the effect of wire inductance, the wire length information given in the previous table does not apply to Models N678xA SMU.

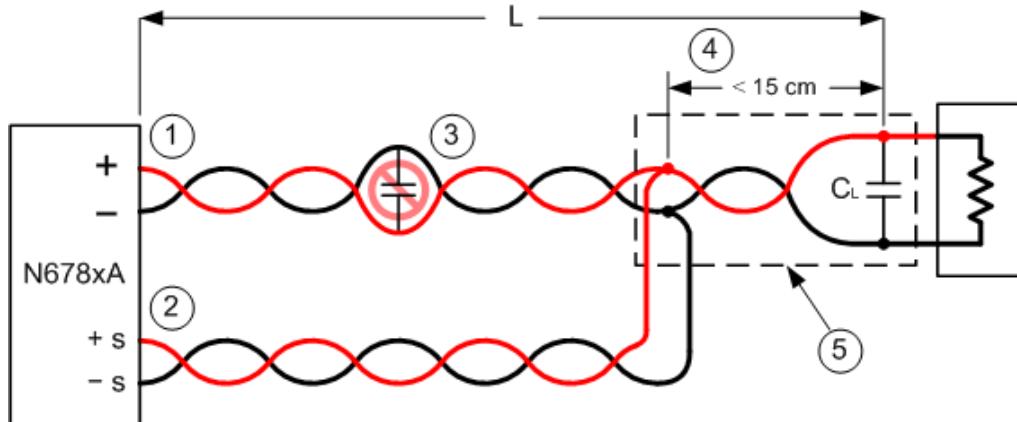
To minimize the effect of wire inductance, the following table describes the allowable load lead length for several common output wire types. Using longer (or shorter) wire lengths than those indicated in the table may cause output oscillation.

Cable Type	To module connector	
	Length in feet	Length in meters
Twisted pair (AWG 14 or smaller)	1 to 4.25 feet	0.3 to 1.3 meters
50 ohm coaxial (RG-58)	2 to 10 feet	0.6 to 3 meters
10 ohm coaxial (inductance per cable foot \leq 32 nH)	8.5 to 33 feet	2 to 10 meters

High Bandwidth Modes with Remote Sensing

The following wiring requirements apply when using Keysight Models N678xA SMU in the High bandwidth modes with remote sensing.

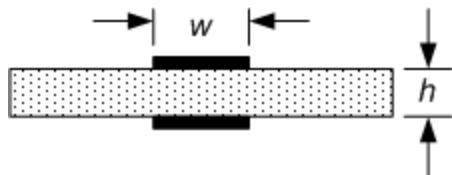
Refer to [Output Bandwidth](#) for more information about the bandwidth settings.



1. Load wires must be twisted-pair or coax and must not be twisted along with the sense wires. Refer to the above table for length (L).
2. Sense wires must be twisted-pair or coax and must not be twisted with the load wires.
3. No capacitors are allowed within the sense-compensated load path.
4. If the load capacitor (CL) is not located at the sense point, the distance from the sense point to the load capacitor cannot exceed 15 cm and must be twisted-pair, coax, or pc traces.

5. If the test fixture consists of pc traces, the positive and negative traces should be directly facing on adjacent layers.

To minimize inductance, the width (w) of the traces should be at least as great as the thickness of the dielectric (h). It is better to make the traces much wider than this minimum requirement in order to minimize the DC resistance.



Low Bandwidth Mode with Remote or Local Sensing

All previously stated wiring requirements still apply in Low bandwidth mode except for the following.

The 15 cm maximum limit between the sense point and the load capacitor (see #4) does not apply when using Low bandwidth mode.

Guard Connections

The purpose of a cable guard is to eliminate the effects of leakage current that can exist in the current path of the external test circuit. The cable guard can be used when the test fixture requires guarding and the power analyzer is sourcing or measuring DC currents under 1 μ A. Without a guard, leakage currents in the test circuit could affect the accuracy of the micro-amp measurements. Guarding is generally not required when measuring currents 1 μ A and greater.

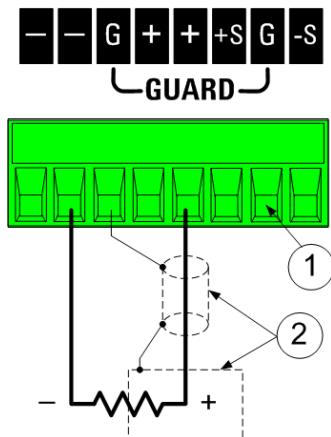
NOTE You cannot connect to the front panel binding posts when using the Guard. You must route ALL wires (guard, load, and sense) through the rear panel access ports of the mainframe. Refer to the diagram under [High Current Output Connections](#) for more information. These access ports can also be used when extremely precise output measurements are required.

As shown in the following figure, cable guards are available at the internal connector of Keysight Models N678xA SMU. The guard is typically used to drive the shields of cables and test fixtures. It provides a buffered voltage that is at the same potential as the + output terminals of the module connector. The guard current is limited to about 300 μ A.

2 Installation

1. N678xA SMU connector

2. Guard shield (can be the shield of a coaxial cable)

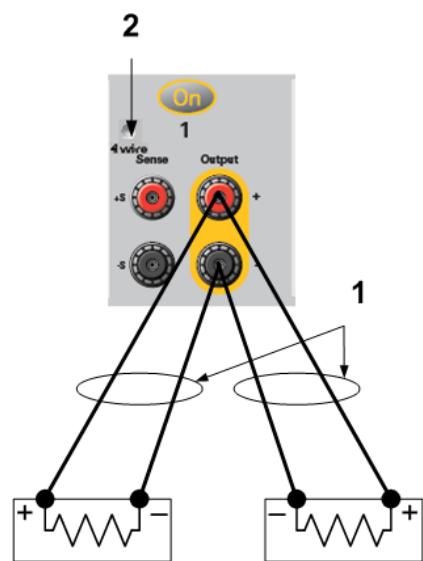


Multiple Load Wiring

If you are using local sensing and are connecting multiple loads to one output, connect each load to the output terminals using separate load wires as shown.

1. Twist leads

2. 4-wire disabled
(indicator is off)



This minimizes mutual coupling effects and takes full advantage of the power module's low output impedance. Keep each wire-pair as short as possible and twist or bundle the wires to reduce lead inductance and noise pickup. The goal is to always minimize the loop area or physical space between the + and - load wires from the power analyzer to the load. Keep the load leads under 14.7 meters (50 feet) per lead because of inductance effects

Note that Keysight Models N678xA SMU have additional wiring restrictions as previously discussed under [Keysight N678xA SMU Wiring](#).

If load considerations require the use of distribution terminals that are located away from the instrument, connect the output terminals to the remote distribution terminals by a pair of twisted or bundled wires. Connect each load to the distribution terminals separately. Remote voltage sensing is recommended under these circumstances. Sense either at the remote distribution terminals or, if one load is more sensitive than the others, directly at the critical load.

Positive and Negative Voltages

Either positive or negative voltages with respect to ground can be obtained from the output by grounding (or "commoning") one of the output terminals. Always use two wires to connect the load to the output regardless of where or how the system is grounded. The instrument can be operated with any output terminal ± 240 VDC including output voltage from ground.

NOTE Keysight Models N678xA SMU are optimized for grounding the negative output terminal. Grounding the positive terminal may result in increased current measurement noise and a reduction in current measurement accuracy.

Protecting Sensitive Loads from AC Power Switching Transients

NOTE This only applies if you are connecting loads that are highly sensitive to voltage or current transients to the output of the power analyzer. If your load is connected directly to the output of the power analyzer and is not connected to chassis ground in any way, you do not need to worry about AC power switching transients appearing at the output of the power analyzer.

Operating the AC line switch can inject common mode current spikes into the DC output leads, resulting in voltage spikes that may damage loads that are highly sensitive to voltage or current transients. Note that any electronic device meeting international standards for EMI compliance is likely to generate similar current spikes. This situation arises from the presence of EMI filters at both the AC input and the DC output. These filters typically include common mode capacitors connected to the chassis of the power analyzer. Since the AC input has an earth ground, any load that is also earth-grounded provides a possible return path for common mode currents.

To help mitigate common mode current spikes at the output when the unit is turned on or off:

1. Install a separate bonding wire from the load's common point, to the ground terminal of the power analyzer. This provides a lower impedance path that helps direct injected currents away from the DC output leads (and the sensitive load).
2. Disconnect the load from the output before turning the power analyzer on or off will **always** protect the load from common mode currents.

Load Capacitor Response Times

When programming with an external capacitor, voltage response time may be longer than for purely resistive loads. Use the following formula to estimate the additional up-programming response time:

$$\text{Response Time} = \frac{(\text{Added Output Capacitor}) \times (\text{Change in } V_{\text{out}})}{(\text{Current Limit Setting}) - (\text{Load Current})}$$

Note that programming into an external output capacitor may cause the power analyzer to briefly enter constant current or constant power operating mode, which adds additional time.

4-Wire Sense Connections

Wiring

Open Sense Leads

Over-Voltage Protection Considerations

Output Noise Considerations

Wiring

The power analyzer includes built-in relays that connect or disconnect the \pm sense terminals from their corresponding \pm output terminals. As shipped, the sense terminals are internally connected to the output terminals. This is referred to as Local sensing.

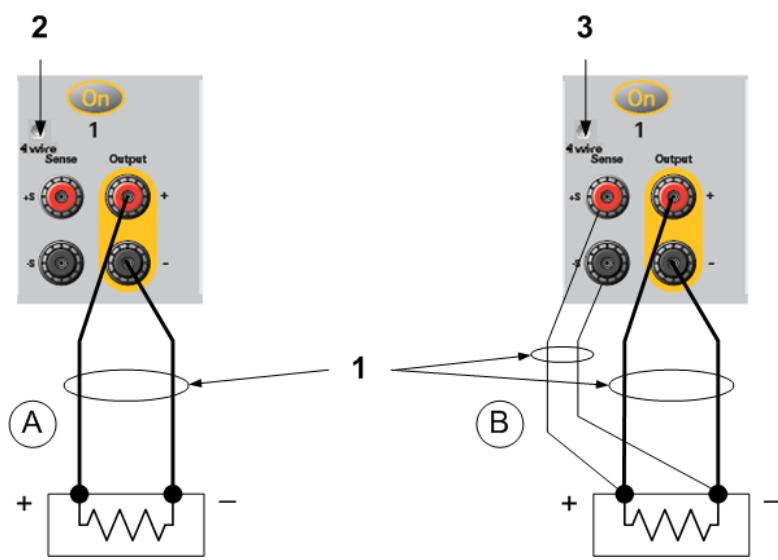
4-wire, or remote sensing improves the voltage regulation at the load by monitoring the voltage at the load rather than at the output terminals. This automatically compensates for the voltage drop in the load leads, which is especially useful for CV operation with load impedances that vary or have significant lead resistance. Because remote sensing is independent of other power analyzer functions, it can be used regardless of how the instrument is programmed. Remote sensing has no effect during CC operation.

The following figures illustrate load connections using local sensing (A), and **4-wire** remote sensing (B). When the 4-wire indicator above the sense terminals is on, it indicates that the sense terminals must be connected to the load.

1. Twist leads

2. 4-wire disabled
(indicator is off)

3. 4-wire enabled
(indicator is on)



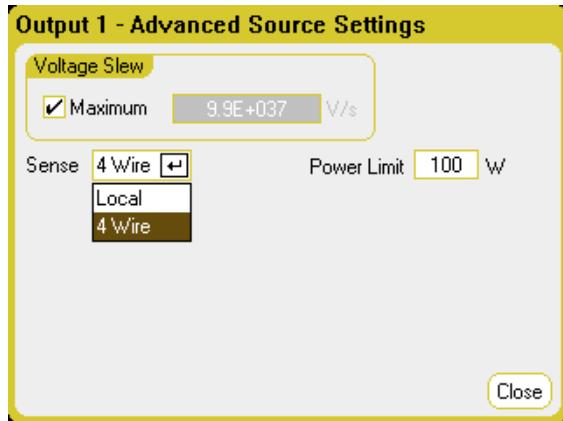
Connect the load to the output terminals using separate connecting wires. Keep the wire-pair as short as possible and twist or bundle it to reduce lead inductance and noise pickup. Keep the load leads under 14.7 meters (50 feet) per lead because of inductance effects.

Connect the sense leads as close to the load as possible. Do NOT bundle the sense wire-pair together with the load leads; keep the load wires and sense wires separate. The sense leads carry only a few

milliamperes of current and can be a lighter gauge than the load leads. However, any voltage drop in the sense leads can degrade the voltage regulation of the instrument. Try to keep the sense lead resistance less than about $0.5\ \Omega$ per lead (this requires 20 AWG or heavier for a 50 foot length).

Keysight Models N678xA SMU require remote sensing when using any of the High output bandwidth modes discussed under [Output Bandwidth](#). Also, these models have additional wiring restrictions as discussed under [Keysight N678xA SMU Wiring Requirements](#).

After turning the unit on, activate 4-wire remote voltage sensing by pressing the **Settings** key. Navigate to and select **Advanced**. In the Sense dropdown list select **4-Wire**.



Open Sense Leads

The sense leads are part of the output's feedback path. Connect them in such a way so that they do not inadvertently become open circuited. The power analyzer includes protection resistors that reduce the effect of open sense leads during 4-wire-sensing. If the sense leads open during operation, the power analyzer returns to the local sensing mode, with the voltage at the output terminals approximately 1% higher than the programmed value.

Over-Voltage Protection Considerations

You must take into account any voltage drop in the load leads when setting the over-voltage trip point. This is because the OVP circuit senses at the output terminals and not at the sense terminals. Due to the voltage drop in the load leads, the voltage sensed by the OVP circuit could be higher than the voltage being regulated at the load.

OVP for Keysight N678xA SMU (local OVP)

For Keysight Models N678xA SMU only, the OVP circuit senses at the 4-wire sense terminals rather than at the output terminals. This allows for more precise overvoltage monitoring directly at the load. Since incorrect sense terminal wiring could defeat this feature, there is also a local OVP function.

The local OVP function tracks the programmed OVP setting and trips if the voltage at the + and - output terminals rises more than 1.5 V above the programmed OVP setting. The local OVP also trips if the voltage at the output terminals exceeds 7.5 V on the 6 V range and 21.5 V on the 20 V range.

Output Noise Considerations

Any noise picked up on the sense leads will appear at the output terminals and may adversely affect CV load regulation. Twist the sense leads or use a ribbon cable to minimize the pickup of external noise. In extremely noisy environments it may be necessary to shield the sense leads. Ground the shield at the power analyzer end only; do not use the shield as one of the sensing conductors.

The noise specifications documented in the [Keysight N6700 Modular Power System Family Specifications Guide](#) apply at the output terminals when using local sensing. However, voltage transients may be produced at the load by noise induced in the leads or by load current transients acting on the inductance and resistance of the load lead. If it is desirable to keep voltage transient levels to a minimum, place an aluminum or tantalum capacitor, with an approximate value of 10 μF per foot (30.5 cm) of load lead, right across the load.

Parallel and Series Connections

Parallel Connections

Series Connections

Parallel Connections

CAUTION

Equipment Damage Only connect power supplies that have identical voltage and current ratings in parallel. Keysight Models N678xA SMU may be paralleled, but ONLY when operated in Current Priority mode. Voltage Priority operation is not allowed.

Connecting power supplies in parallel provides a greater current capability than can be obtained from a single unit.

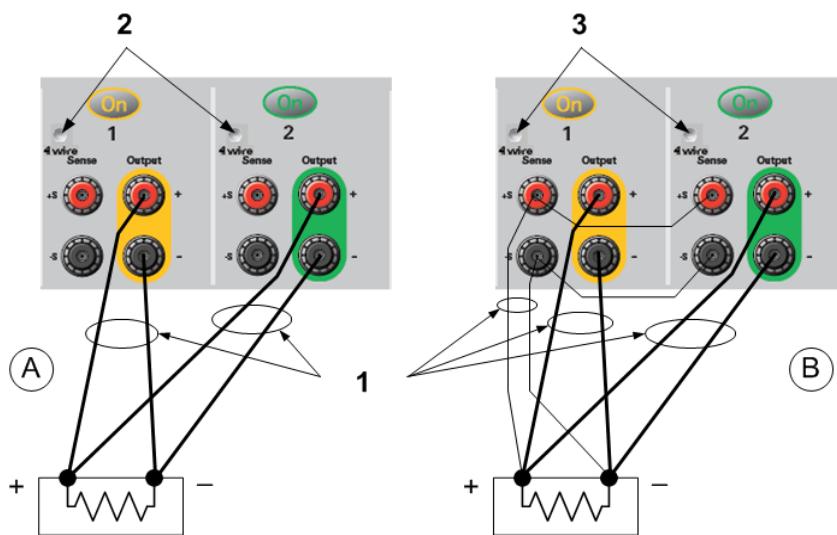
The following figures show how to connect two outputs in parallel. The figure on the left illustrates local sensing. If voltage drop in the load leads is a concern, the figure on the right shows how to connect the sense leads directly at the load (4-wire sensing).

Once outputs have been connected in parallel, they can be configured or “grouped” to act as a single, higher-power output. This applies when programming via the front panel or using SCPI commands. How to group outputs that have been connected in parallel is discussed under Output Groups. The output grouping function is not available for N678xA SMU power modules.

1. Twist leads

2. 4-wire disabled
(indicator is off)

3. 4-wire enabled
(indicator is on)



Effect on Specifications

Specifications for outputs operating in parallel can be obtained from the specifications for single outputs. Most specifications are expressed as a constant or as a percentage (or ppm) plus a constant. For parallel operation, the percentage portion remains unchanged while constant portions or any constants are changed as indicated below. For current readback accuracy and temperature coefficient of current readback, use the minus current specifications:

Current: All parallel specifications referring to current are twice the single output specification except for programming resolution, which is the same for both single output and parallel output operation.

Voltage: All parallel specifications referring to voltage are the same as for a single output except for CV load effect, CV load cross regulation, CV source effect, and CV short term drift. These are all twice the voltage programming accuracy (including the percentage portion) at all operating points.

Load Transient Recovery Time: Load transient specifications are typically twice the single output.

Series Connections

WARNING

SHOCK HAZARD Floating voltages must not exceed 240 VDC. No output terminal may be more than 240 VDC from chassis ground.

CAUTION

Only connect outputs that have identical voltage and current ratings in series. Keysight Models N678xA SMU and N6783A cannot be connected in series.

To prevent currents from damaging the power analyzer when the load is connected, always turn series-connected outputs on and off together. Do not leave one output on while the other is off. Outputs connected together in series cannot be grouped.

NOTE

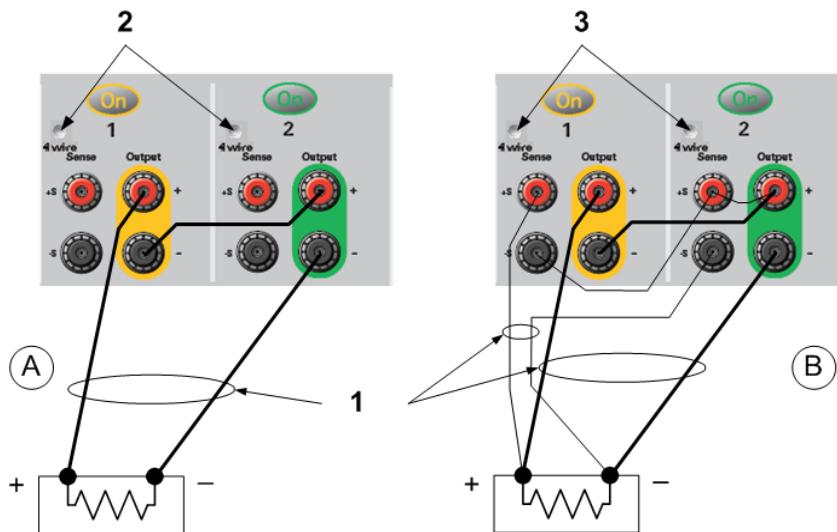
You can only use the series-connected outputs in “standard” power supply mode. You cannot generate arbitrary waveforms, make scope measurements or use data logging on outputs that are connected in series.

Connecting outputs in series provides a greater voltage capability than can be obtained from a single output. Because the current is the same through each element in a series circuit, outputs connected in series must have equivalent current ratings.

The following figures show how to connect two outputs in series to a single load. If voltage drop in the load leads is a concern, the figure on the right shows how to connect the sense leads directly at the load (4-wire sensing). Connecting the +S terminal of output 2 to the -S terminal of output 1 and connecting a jumper between +S and + on output 2 compensates for the IR drop in the load lead from output 2 to output 1.

To program outputs connected in series, first program the current limit of each output to the total desired current limit point. Then program the voltage of each output so that the sum of both voltages equals the total desired operating voltage. The simplest way to accomplish this is to program each output to one half of the total desired operating voltage.

1. Twist leads
2. 4-wire disabled (indicator is off)
3. 4-wire enabled (indicator is on)

**NOTE**

The operating mode of each output is determined by the output's programmed settings, operating point, and load condition. Because these conditions may change during series operation, the front panel status indicator will reflect these changes. This is normal. Momentary status changes are also normal.

Effect on Specifications

Specifications for outputs operating in series can be obtained from the specifications for single outputs. Most specifications are expressed as a constant or a percentage (or ppm) plus a constant. For series operation, the percentage portion remains unchanged while constant portions or any constants are changed as indicated.

Voltage: All series specifications referring to voltage are twice the single output specification except for programming resolution, which is the same as for a single output.

Current: All series specifications referring to current are the same as for a single output except for CC load effect, CC load cross regulation, CC source effect, and CC short term drift. These are twice the current programming accuracy (including the percentage portion) at all operating points.

Load Transient Recovery Time: Load transient specifications are typically twice the single output.

BNC Connections

The rear panel BNC connectors let you apply trigger signals to the instrument as well as generate trigger signals from the instrument. This also applies to the [Digital Control Port](#).

Input - allows a positive- or negative-going external signal to trigger the instrument. The positive pulse must have a minimum pulse width of >6 nanoseconds. The negative pulse must have a minimum pulse width of >90 nanoseconds. Trigger input signals are used by the Arb, Scope, and Data Logger functions.

Output - generates a negative-going 10 microsecond pulse when a triggered event has occurred on the instrument.



Information on configuring external triggers is found under Trigger Commands in the Operating and Service Guide document. The electrical characteristics are described under [Supplemental Characteristics](#).

Installing a Redundant Ground for 400 Hz Operation

Operation at 400 Hz requires the installation of a redundant ground from the instrument chassis to earth ground. The redundant ground must be permanently attached to the unit as well as to the earth ground point.

The following procedure describes how to make the permanent connection at the unit using one of the two rear panel BNC connectors. The user must ensure the integrity and permanence of the connection at the earth ground point.

The following customer-supplied hardware is required:

- Ground wire (14/16 AWG)
- Uninsulated ring terminal for attaching wire to unit (Tyco p/n 328976 or equivalent)
- Hardware for attaching wire to earth ground point

The following customer-supplied hardware is required:

- 5/8 inch nut driver

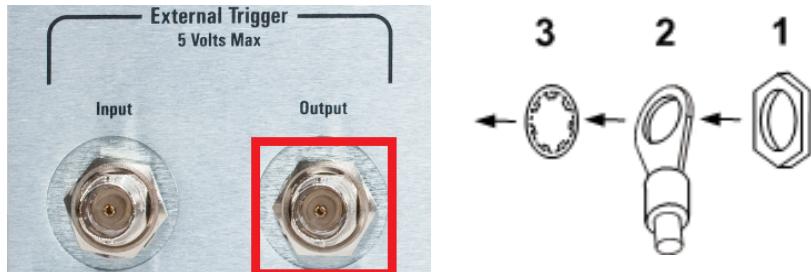
Step 1. Use the nut driver and remove the hex nut (1) from only one of the BNC connectors. Do not remove the lock washer located behind the hex nut.

Step 2. Crimp the ring terminal (2) onto the end of the ground wire

Step 3. Place the ring terminal onto the threaded BNC connector. Make sure that the lock washer (3) is in place before installing the ring terminal.

Step 4. Tighten the hex nut onto the ring terminal.

Step 5. Attach the other end of the redundant ground wire to a convenient earth ground point.



Auxiliary Measurement Connections

NOTE

This information only applies when Models N6781A and N6785A are installed in the mainframe.

The auxiliary voltage measurement inputs are located on the rear panel of the Keysight N6705C. These are primarily used for battery voltage rundown measurements, but are also suitable for general purpose DC measurements.

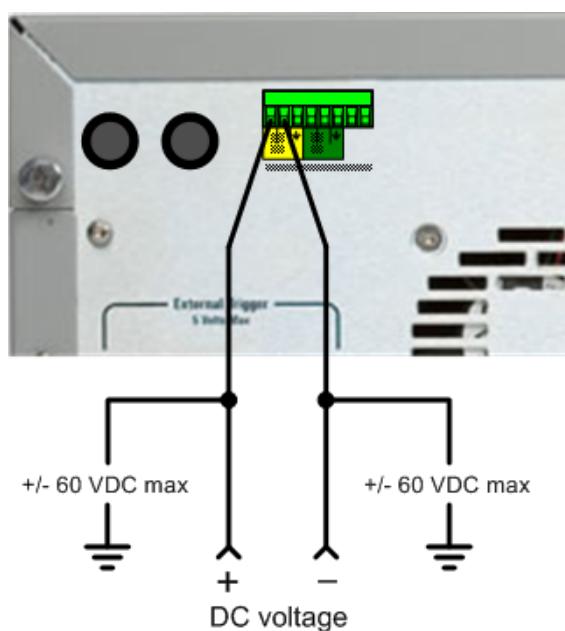
The auxiliary voltage measurement inputs are isolated from other commons. They have a bandwidth of about 2 kHz. There is one input range: -20 to +20 VDC.

Two 8-pin connectors and quick-disconnect plugs are provided for accessing up to four potential auxiliary voltage measurement inputs. The connectors accept wires sizes from AWG 14 to AWG 30. Note that wire sizes smaller than AWG 24 are not recommended. Disconnect the connector plug to make your wire connections.

As shown in the following figure, auxiliary voltage measurements cannot be made on test points that are at a greater potential than ± 60 VDC from ground. Refer to [Auxiliary Voltage Measurements](#) for more information.

CAUTION

When using the auxiliary voltage measurement input, no front panel output terminal or rear panel input terminal may be more than ± 60 VDC from any other terminal and chassis ground.



Interface Connections

GPIB Connections

USB Connections

LAN Connections - site and private

Digital Port Connections

This section describes how to connect to the various communication interfaces on your power analyzer. For further information about configuring the remote interfaces, refer to **Remote Interface Configuration**.

NOTE If you have not already done so, install the Keysight IO Libraries Suite, which can be found at www.keysight.com/find/iolib. For detailed information about interface connections, refer to the Keysight Technologies USB/LAN/GPIB Interfaces Connectivity Guide included with the Keysight IO Libraries Suite.

GPIB Connections

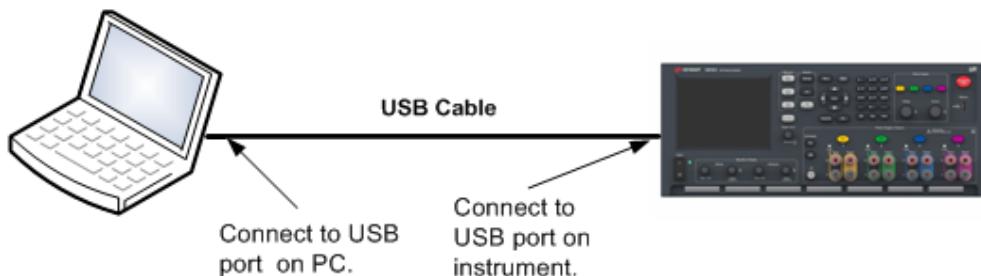
The following figure illustrates a typical GPIB interface system.



1. If you do not have a GPIB interface card installed on your computer, turn off your computer and install the GPIB card.
2. Connect your instrument to the GPIB interface card using a GPIB interface cable.
3. Use the Connection Expert utility of the Keysight IO Libraries Suite to configure the GPIB card's parameters.
4. The power analyzer is shipped with its GPIB address set to 5. Use the front panel menu if you need to change the GPIB address.
5. You can now use Interactive IO within the Connection Expert to communicate with your instrument, or you can program your instrument using the various programming environments.

USB Connections

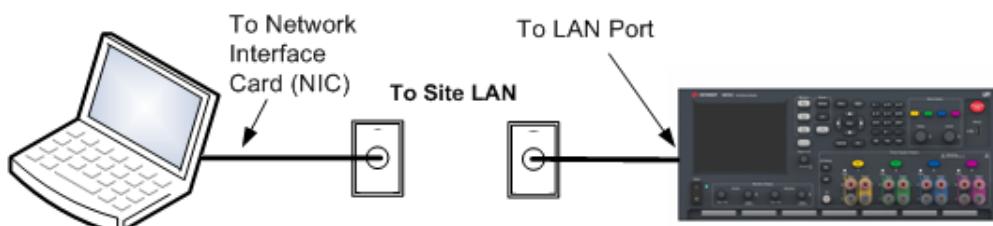
The following figure illustrates a typical USB interface system.



1. Connect your instrument to the USB port on your computer using a USB cable.
2. With the Connection Expert utility of the Keysight IO Libraries Suite running, the computer will automatically recognize the instrument. This may take several seconds. When the instrument is recognized, your computer will display the VISA alias, IDN string, and VISA address. This information is located in the USB folder. You can also view the instrument's VISA address from the front panel menu.
3. You can now use Interactive IO within the Connection Expert to communicate with your instrument, or you can program your instrument using the various programming environments.

LAN Connections - site and private

A **site LAN** is a local area network in which LAN-enabled instruments and computers are connected to the network through routers, hubs, and/or switches. They are typically large, centrally-managed networks with services such as DHCP and DNS servers. The following figure illustrates a typical site LAN system.



1. Connect the instrument to the site LAN or to your computer using a LAN cable. The as-shipped instrument LAN settings are configured to automatically obtain an IP address from the network using a DHCP server (DHCP is set On). The DHCP server will register the instrument's hostname with the dynamic DNS server. The hostname as well as the IP address can then be used to communicate with the instrument. The front panel **Lan** indicator will come on when the LAN port has been configured.

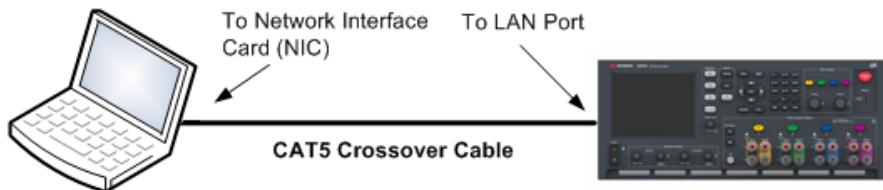
NOTE If you need to manually configure any instrument LAN settings, refer to [Remote Interface Configuration](#) for information about configuring the LAN settings from the front panel of the instrument.

2. Use the Connection Expert utility of the Keysight IO Libraries Suite to add the power analyzer and verify a connection. To add the instrument, you can request the Connection Expert to discover the instrument. If the instrument cannot be found, add the instrument using its hostname or IP address.

NOTE If this does not work, refer to “Troubleshooting Guidelines” in the Keysight Technologies USB/LAN/GPIB Interfaces Connectivity Guide included with the Keysight IO Libraries Suite.

3. You can now use Interactive IO within the Connection Expert to communicate with your instrument, or you can program your instrument using the various programming environments. You can also use the Web browser on your computer to communicate with the instrument as described under [Using the Web Interface](#).

A **private LAN** is a network in which LAN-enabled instruments and computers are directly connected, and not connected to a site LAN. They are typically small, with no centrally-managed resources. The following figure illustrates a typical private LAN system.



1. Connect the instrument to the computer using a LAN crossover cable. Alternatively, connect the computer and the instrument to a standalone hub or switch using regular LAN cables.

NOTE Make sure your computer is configured to obtain its address from DHCP and that NetBIOS over TCP/IP is enabled. Note that if the computer had been connected to a site LAN, it may still retain previous network settings from the site LAN. Wait one minute after disconnecting it from the site LAN before connecting it to the private LAN. This allows Windows to sense that it is on a different network and restart the network configuration.

2. The factory-shipped instrument LAN settings are configured to automatically obtain an IP address from a site network using a DHCP server. You can leave these settings as they are. Most Keysight products and most computers will automatically choose an IP address using auto-IP if a DHCP server is not present. Each assigns itself an IP address from the block 169.254.nnn. Note that this may take up to one minute. The front panel Lan indicator will come on when the LAN port has been configured.

NOTE Turning off DHCP reduces the time required to fully configure a network connection when the power analyzer is turned on. To manually configure the instrument LAN settings, refer to [Remote Interface Configuration](#) for information about configuring the LAN settings from the front panel of the instrument.

2 Installation

3. Use the Connection Expert utility of the Keysight IO Libraries Suite to add the power analyzer and verify a connection. To add the instrument, you can request the Connection Expert to discover the instrument. If the instrument cannot be found, add the instrument using its hostname or IP address.

NOTE

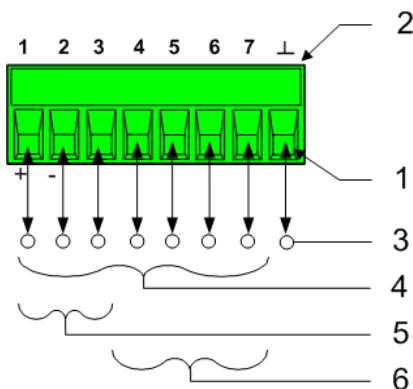
If this does not work, refer to “Troubleshooting Guidelines” in the Keysight Technologies USB/LAN/GPIB Interfaces Connectivity Guide included with the Keysight IO Libraries Suite.

4. You can now use Interactive IO within the Connection Expert to communicate with your instrument, or you can program your instrument using the various programming environments. You can also use the Web browser on your computer to communicate with the instrument as described under [Using the Web Interface](#).

Digital Port Connections

An 8-pin connector and a quick-disconnect connector plug are provided on each instrument for accessing the five digital control port functions. The digital control connector accepts wires sizes from AWG 14 to AWG 30. Note that wire sizes smaller than AWG 24 are not recommended. Disconnect the connector plug to make your wire connections.

1. Insert wires
2. Tighten screws
3. Signal common
4. Digital IO signals
5. FLT/INH signals
6. Output couple controls



NOTE

It is good engineering practice to twist and shield all signal wires to and from the digital connectors. If shielded wire is used, connect only one end of the shield to chassis ground to prevent ground loops.

Pin Functions

The following table describes the possible pin configuration for the digital port functions. For a complete description of the electrical characteristics of the digital I/O port, refer to the product [Specifications](#).

Pin Function	Available configurable pins
Digital I/O and Digital In	Pins 1 through 7
External Trigger In/Out	Pins 1 through 7
Fault Out	Pins 1 and 2
Inhibit In	Pin 3
Output State	Pins 4 through 7
Common	Pin 8

In addition to the configurable pin functions, the active signal polarity for each pin is also configurable. When Positive polarity is selected, a logical true signal is a voltage high at the pin. When Negative polarity is selected, a logical true signal is a voltage low at the pin.

For more information on configuring the digital port functions, refer to [Using the Digital Control Port](#).

3

Using the Source/Load Functions

Turning the Unit On

Using the Power Analyzer

Generating Arbitrary Waveforms

Using the Protection Functions

This section contains instructions on how to operate your Keysight N6705C DC Power Analyzer. The specific functions described in this section are listed above.

Equivalent SCPI commands to program a specific function are included at the end of each topic. However some functions such as the front panel Scope View, Data Logger View, and some Administrative functions do not have equivalent SCPI commands. **Command Quick Reference** lists all of the SCPI commands that can be used to program the instrument

Turning the Unit On

NOTE

When the power analyzer is first turned on, it may take about 30 seconds or so to initialize the instrument before it is ready for use.

Step 1. Turn the Unit On

After you have connected the line cord, turn the unit on using the Line switch. The front panel display lights up after a few seconds. The power analyzer's Meter View is shown in the following display.



A power-on selftest occurs automatically when you turn the unit on. This assures you that the instrument is operational. If selftest fails, or if other operating problems occur with your instrument, the front panel Error indicator comes on. See [View the Error Log](#).

Step 2. Select an Output

Press one of the four Select Output keys to select an output to control. The lit key identifies the selected output. All subsequent output-specific front panel commands are sent to the selected output.



NOTE

Keysight N679xA Load Module input terminals are referred to as "Outputs" throughout this document. [N679xA](#)

Step 3. Set the Output Voltage and Current

Enter the voltage and current values directly in the numeric entry fields (the Set fields) while in Meter View. Use the navigation keys to select the field, then use the numeric entry keys to enter the value. The value becomes active when you press Enter.



Turn the Voltage and Current knobs. The output voltage or current setting changes when they are turned. The output also changes if it is enabled. These knobs are active in Meter View, Scope View, and Data Logger mode.

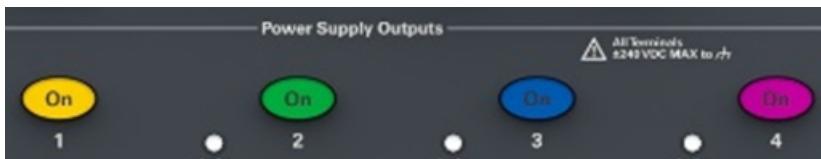


Push the voltage and current knobs to access a pop-up dialog that lets you:

1. Lock/Unlock the knobs.
2. Select limit parameters or select limit tracking on Keysight N678xA SMU and N6783A.

Step 4. Enable the Output

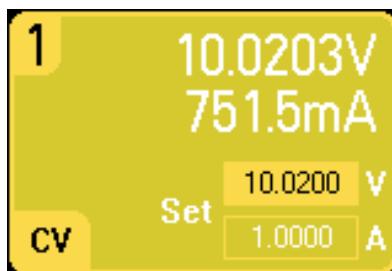
Press the color-coded **On** key to enable an individual output. When an output is on, the **On** key for that output is lit. When an output is off, the **On** key is not lit. The All Outputs **On** and **Off** keys turn all outputs on or off simultaneously.



The state of a disabled output (output off) is a condition of zero output voltage and zero source current

NOTE The red **Emergency Stop** key turns all outputs off immediately without any output off delays.

When an output is enabled, the power analyzer continuously measures and displays the output voltage and current of each output in Meter View.



From the remote interface:

A channel parameter is required with each SCPI command to select an output. For example, (@1) selects output 1, (@2,4) selects output 2 and 4, and (@1:4) selects outputs 1 through 4. The output list must be preceded with an @ symbol and be enclosed in parentheses () .

To set only output 1 to 10.02 V and 1 A:

```
VOLT 10.02,(@1)
CURR 1,(@1)
```

To set the output voltage of all outputs to 10 V:

```
VOLT 10.02,(@1:4)
```

To enable only output 1 and output 3:

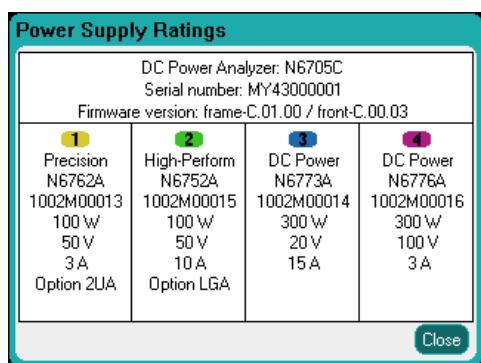
```
OUTP ON,(@1,3)
```

To measure the output voltage and current of output 1:

```
MEAS:VOLT? (@1)
MEAS:CURR? (@1)
```

View Instrument Identification

You can quickly view the output ratings, model numbers and options of all power modules installed in your instrument. You can also view the mainframe serial number and firmware revisions. Press the **Settings** key and then press the **Properties** key. The Power Supply Ratings window will appear.



The serial numbers of the power modules are located on their respective top covers. Press **Meter View** to return to the meter view.

From the remote interface:

For the power analyzer mainframe, you can programmatically query the model number, serial number, firmware revision, backup and active firmware. Send the following query:

```
*IDN?
```

For power modules, you can programmatically query the model number, serial number, installed options, voltage, current and power rating. Send the following commands:

SYST:CHAN:MOD?(@1)

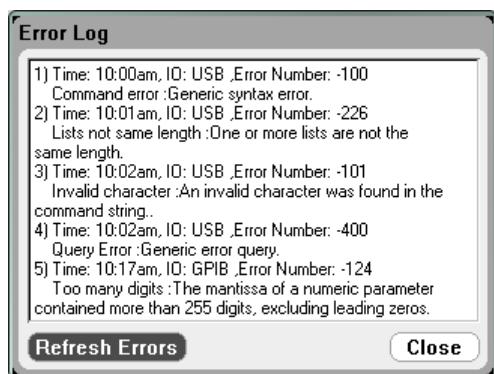
SYST:CHAN:OPT?(@1)

SYST:CHAN:SER?(@1)

NOTE You have the ability to change the identity of the mainframe. This functionality is only intended for compatibility with previous "A" and "B" version mainframes. To change the identity refer to ***IDN Setup**.

View the Error Log

To display the error log, press the **Menu** key, scroll and select **Utilities**, then **Error Log**.



- Errors are stored in the order they are received. The error at the end of the list is the most recent error.
- If there are more errors than can fit in the queue, the last error stored is replaced with -350, "Error queue overflow". No more errors are stored until you remove errors from the queue. If there are no errors, the instrument responds with +0, "No error".
- Except for selftest errors, errors are cleared when exiting the Error Log menu or when cycling power.

If you suspect that there is a problem with the power analyzer, refer to the Troubleshooting section in the Operating and Service Guide document. Press **Meter View** to return to the Meter View.

From the remote interface:

The following command reads and clears one error from the error queue:

SYST:ERR?

Using the Power Analyzer

[Programming N673xB-N677xA Source Settings](#)

[Programming N678xA SMU Source Settings](#)

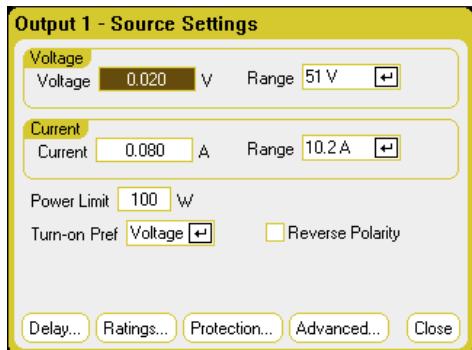
[Programming N679xA Load Settings](#)

[Configuring an Output Turn-On/Turn-Off Sequence](#)

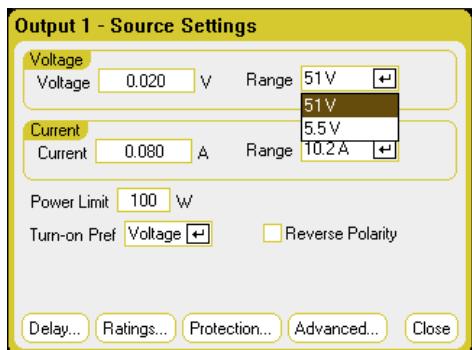
Programming N673xB-N677xA Source Settings

Output Voltage and Current

Press the **Settings** key to access the Source Settings window. Use the navigation keys to highlight the Voltage or Current fields. Then enter the voltage and current values with the numeric keys. As previously explained in [Turning the Unit On](#), you can use the Voltage and Current knobs to fine tune the values in these fields. Press **Enter** to enter the value.



Voltage or Current Range – For outputs with multiple ranges, you can select a lower range if you need better output resolution. Use the navigation keys to highlight the Range field. Press the Enter key to access the dropdown range list. Use the navigation keys to select the desired output range.



Additional Source Settings

Along with setting the output voltage and current and ranges, you can program a number of additional source settings, which are module and option dependent.

Power Limit - For the majority of power analyzer configurations, full power is available from all installed power modules. However, it is possible to configure a mainframe in which the combined power module ratings exceed the 600 W power rating of the mainframe. The power limit field lets you reduce the power that can be sourced from an individual output, thereby preventing the combined power from exceeding the mainframe's power rating. To set a lower power limit, select the Power Limit Field and enter the power limit value in Watts. Refer to [Power Limit Operation](#) for more information.

Turn-on Pref - The turn-on preference function only applies to Keysight Models N6761A and N6762A. This specifies the preferred mode for output on/off transitions. It allows output state transitions to be optimized for either constant voltage or constant current operation. In the Turn-on Pref drop-down list, select either Voltage or Current. Selecting Voltage minimizes output on/off voltage overshoots in constant voltage operation. Selecting Current minimizes output on/off current overshoots in constant current operation.

Reverse Polarity – This control only applies if the power module has Option 760 installed. Check Reverse Polarity to reverse the polarity of the output and sense terminals. Uncheck to return the relay polarity to normal. The output is briefly turned off while the output and sense polarities are switched. Refer to [Model Differences](#) for Option 760 availability and current limitations. When the output and sense polarities are reversed, the following symbol appears on the front panel display: 

From the remote interface:

To set only output 1 to 10.02 V and 1 A:

```
VOLT 10.02,(@1)
CURR 1,(@1)
```

To select a lower voltage or current range on output 1, program a value that falls within the range:

```
VOLT:RANG 5,(@1)
CURR:RANG 1,(@1)
```

To set the power limit of outputs 1 and 2 to 50 W, and outputs 3 and 4 to their maximum settings:

```
POW:LIM 50,(@1,2)
POW:LIM MAX,(@3,4)
```

To set the Keysight N6761A turn on preference to current priority:

```
OUTP:PMOD CURR,(@1)
```

To reverse the relay polarity on units with Option 760:

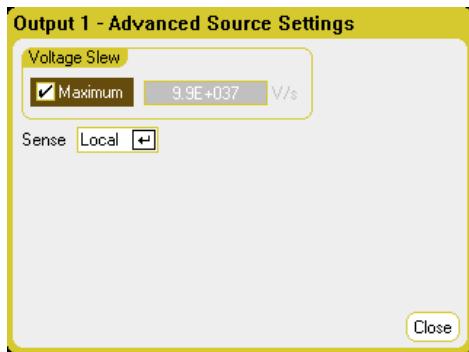
```
OUTP:REL:POL REV,(@1)
```

To return the relay polarity to normal:

```
OUTP:REL:POL NORM,(@1)
```

Advanced Source Settings

Advanced properties are configured in the Advanced Source Settings window. Press the **Settings** key to access the Source Settings window. Navigate to and select the Advanced button.



Voltage Slew – The voltage slew rate determines the rate at which the voltage changes to a new setting. To program a voltage slew rate, enter the rate (V/s) in the Voltage Slew field. Check Maximum to program the fastest rate. Note that the maximum slew rate is limited by the analog performance of the output circuit. The minimum slew rate is model-dependent and is a function of the full-scale voltage range.

Sense – The default sense setting is Local, where the sense terminals are connected directly to the output terminals. If you are using remote voltage sensing as explained under **4-Wire Sense**, you must disconnect the sense terminals from the output terminals. Use the navigation keys and select the Sense dropdown list. Selecting the 4-Wire item disconnects the sense terminals from the output terminals. This lets you use remote voltage sensing.

From the remote interface:

To set the voltage slew rate to 5 Volt/second:

`VOLT:SLEW 5,(@1)`

To set the fastest voltage slew rate:

`VOLT:SLEW INF,(@1)`

To query the minimum voltage slew rate:

`VOLT:SLEW? MIN,(@1)`

To set the front panel sense terminals of output 1 to local sensing, and output 2 to remote sensing:

`VOLT:SENS:SOUR INT,(@1)`

`VOLT:SENS:SOUR EXT,(@2)`

To query the setting of the front panel sense terminals (INT=local sensing; EXT=remote sensing):

`VOLT:SENS:SOUR? (@1)`

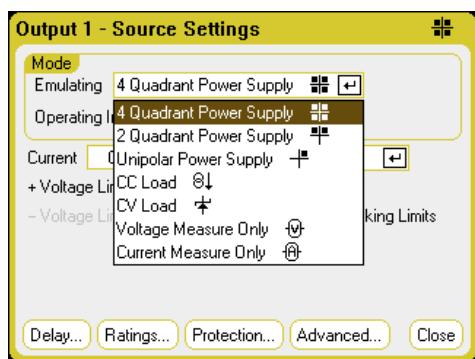
Programming N678xA SMU Source Settings

NOTE Use the Source Settings window to access the specialized operating modes of the Keysight N678xA SMU modules **N678xA SMU**.

Emulating Modes

The Emulating dropdown list lets you access the specialized operating modes of the Keysight N678xA SMU. Press the **Settings** key to access the Source Settings window. Use the navigation keys to select one of the emulating modes.

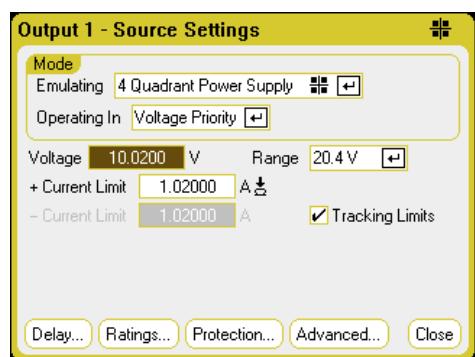
Information about the Voltage Measure Only and Current Measure Only modes is discussed under **N678xA SMU Meter-Only Modes**.



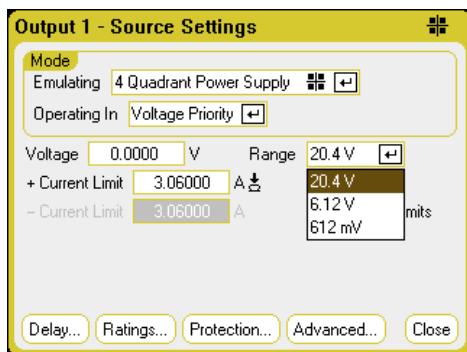
Output Voltage and Current

Use the navigation keys to highlight the Voltage or Current fields. Then enter the voltage and current values with the numeric keys. As previously explained in **Turning the Unit On**, you can use the Voltage and Current knobs to fine tune the values in these fields. Press **Enter** to enter the value.

As explained in subsequent sections, programming output voltage and current limit, or output current and voltage limit, is determined by the Voltage Priority or Current Priority selection.

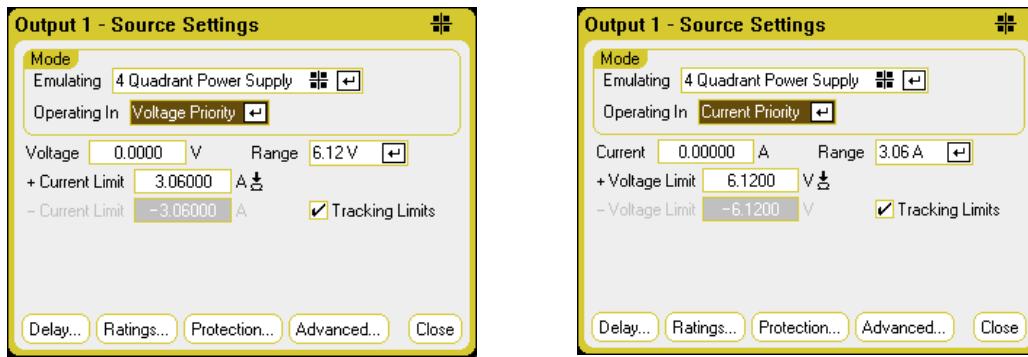


Voltage or Current Range - For outputs with multiple ranges, you can select a lower range if you need better output resolution. Use the navigation keys to highlight the Range field. Press the Enter key to access the dropdown range list. Use the navigation keys to select the desired output range.



4-Quadrant Power Supply

4-quadrant operation is only available on Keysight N6784A. Operation is allowed in all four output quadrants. The following figures show the 4-quadrant settings.



Operating in – selects either Voltage Priority or Current Priority. In voltage priority the output is controlled by a bi-polar constant voltage feedback loop, which maintains the output voltage at its positive or negative setting. In current priority the output is controlled by a bi-polar constant current feedback loop, which maintains the output source or sink current at its programmed setting. Refer to [N678xA Multi-Quadrant Operation](#) for a detailed description of voltage and current priority.

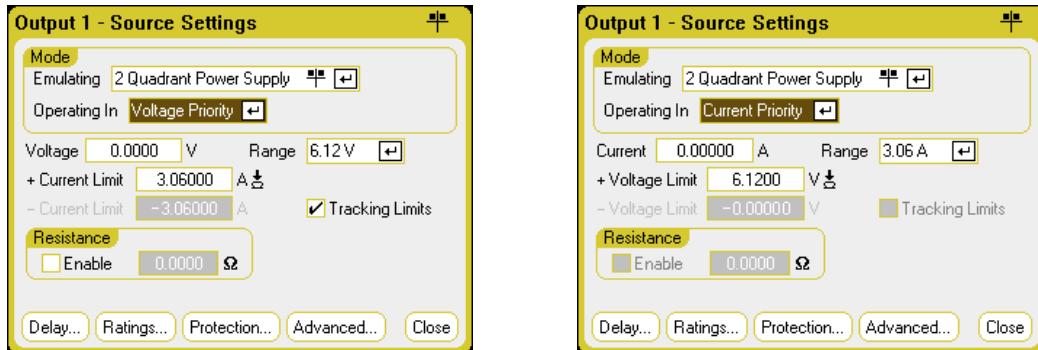
NOTE When switching between Voltage Priority and Current Priority, the output is turned off and the output settings revert to their Power-on or RST values.

Depending on the priority mode, you can specify either the output Voltage or Current setting, as well as the appropriate output Range. You can also specify a Voltage Limit or Current Limit, which limits the selected parameter at the specified value. In voltage priority mode, the output voltage remains at its programmed setting as long as the load current is within the positive or negative limit. In current priority mode, the output current remains at its programmed setting as long as the output voltage is within its positive or negative limit setting.

Tracking Limits – lets the negative voltage or current limit track the positive voltage or current limit setting. By default, the negative limit will track the positive limit value. Un-check this box if you want to program asymmetrical positive and negative limits. If asymmetrical limits are programmed and tracking is turned on, the negative value is changed to track the positive limit.

2-Quadrant Power Supply

This operating mode is restricted to two quadrants (+V/+I and +V/-I). The following figures show the 2-quadrant settings.



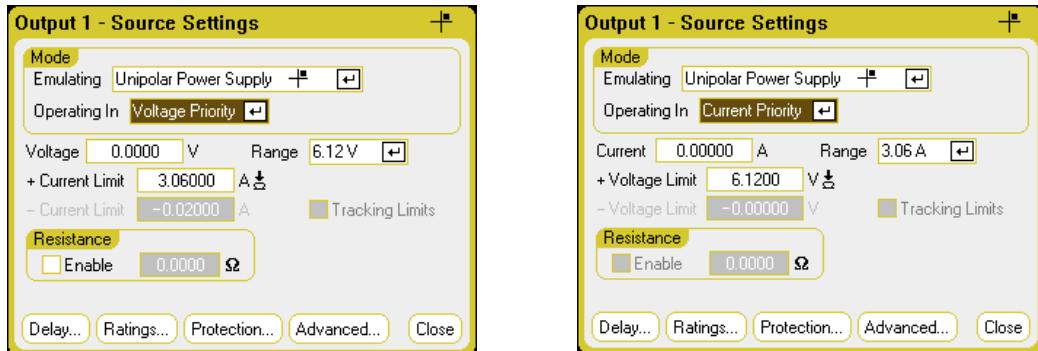
Operating in – selects either Voltage Priority or Current Priority. This selection determines which controls are displayed.

The other settings in 2-quadrant mode are the same as the settings in 4-quadrant mode except that you cannot program negative voltages or negative voltage limits. Because of this, voltage tracking is not available in Current Priority mode. Note that the negative voltage limit is fixed at -10 mV. Refer to [N678xA Multi-Quadrant Operation](#) for a detailed description of voltage and current priority.

Resistance – This is only available on Keysight Models N6781A and N6785A. Output resistance programming is primarily used in battery emulation applications, and only applies in Voltage Priority mode. Values are programmed in Ohms, from -40 mΩ to +1 Ω.

1-Quadrant Power Supply (unipolar)

This mode emulates a typical one quadrant or unipolar power supply with limited down-programming. The following figures show the 1-quadrant settings.



Operating in – selects either Voltage Priority or Current Priority. This selection determines which controls are displayed.

In 1-quadrant mode you cannot program negative voltages, negative currents, negative voltage limits, or negative current limits. Because of this, voltage tracking and current tracking are not available. Note that there is limited 2-quadrant operation with the negative current limit being fixed at 10% to 20% of the output current rating.

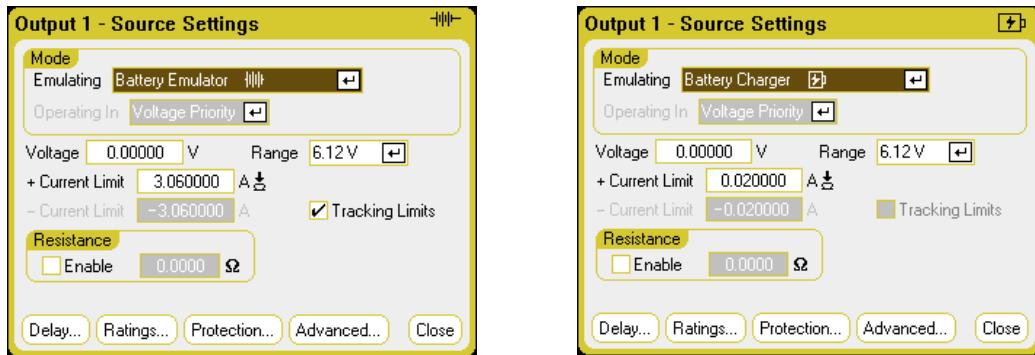
3 Using the Source/Load Functions

Resistance - This is only available on Keysight N6781A and N6785A. Output resistance programming is primarily used in battery emulation applications, and only applies in Voltage Priority mode. Values are programmed in Ohms, from $-40\text{ m}\Omega$ to $+1\text{ }\Omega$.

Battery Emulator/Battery Charger

NOTE This information only applies to Models N6781A and N6785A. N6781A, N6785A

A battery emulator imitates a battery's charging and discharging functions. A battery charger imitates a battery charger; it cannot sink current like a battery. The following figures show the Battery emulator/Battery charger settings.

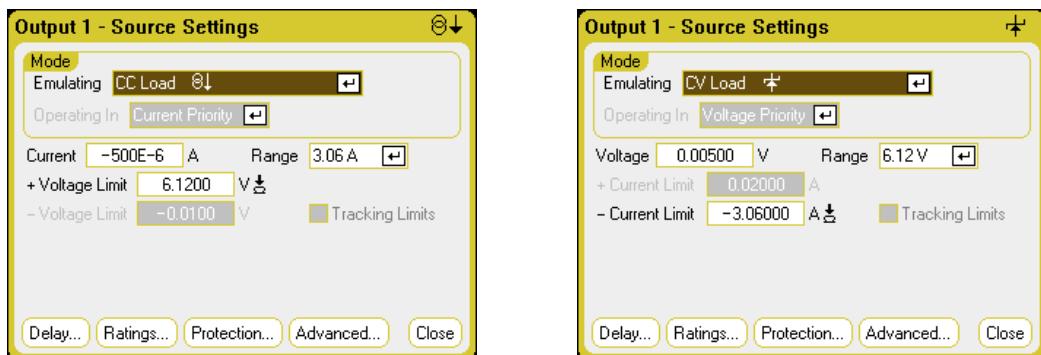


Battery Emulator - lets you specify the battery voltage and range as well as the + and – current limits. The output resistance is programmable, from $-40\text{ m}\Omega$ to $+1\text{ }\Omega$. Voltage Priority mode is locked. The voltage setting is limited to positive values. The + and – current limits are set to their maximum values. The – current limit setting sets the current limit when the battery is being charged.

Battery Charger - lets you specify the charge voltage and range as well as the positive current limit. Voltage Priority mode is locked. Because the battery charger can only source current, the voltage and current settings are limited to positive values.

CC Load/CV Load

The CC Load emulates a constant-current load. The CV Load emulates a constant-voltage load. The figures below show the CC and CV load settings.



CC load - lets you specify the input Current and Range as well as the + Voltage Limit. Current Priority mode is locked. Remember to set the input current to a negative value. The + Voltage Limit should normally be set to its maximum value. The – Voltage limit is not programmable. In Meter mode, the measurement polarities and current settings are shown as negative values.

CV load - lets you specify the input Voltage and Range as well as the – Current Limit. Voltage Priority mode is locked. Set the input voltage to a positive value. The – Current Limit should normally be set to its maximum negative value. The + Current Limit is not programmable. In Meter mode, the measurement polarities and current settings are shown as negative values.

From the remote interface:

To specify the 4-quadrant, 2-quadrant, or 1-quadrant power supply emulation setting:

EMUL PS4Q,(@1)

EMUL PS2Q,(@1)

EMUL PS1Q,(@1)

To set the voltage priority mode:

FUNC VOLT,(@1)

To set the output voltage to 5 V in the high voltage range:

VOLT 5,(@1)

VOLT:RANG 20,(@1)

To set the positive current limit of output 1 to 1 A:

CURR:LIM 1,(@1)

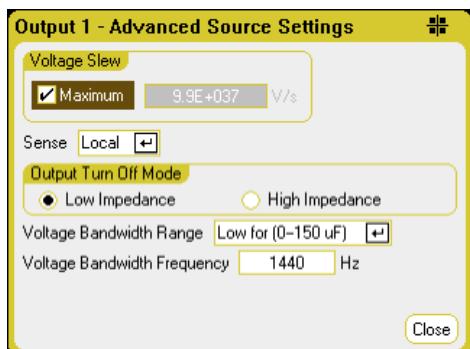
To set the negative current limit, turn limit coupling (tracking) off. Then set the negative current limit:

CURR:LIM:COUP OFF,(@1)

CURR:LIM:NEG 0.5,(@1)

Advanced Source Settings

Advanced properties are configured in the Advanced Source Settings window. Press the **Settings** key to access the Source Settings window. Navigate to and select the Advanced button.



3 Using the Source/Load Functions

Voltage Slew – The voltage slew rate determines the rate at which the voltage changes to a new setting. The voltage slew control is only available in Voltage Priority mode. To program a voltage slew rate, enter the rate (V/s) in the Voltage Slew field. Check Maximum to program the fastest rate. Note that the maximum slew rate is limited by the analog performance of the output circuit. The minimum slew rate is model-dependent and is a function of the full-scale voltage range.

Current Slew – The current slew rate determines the rate at which the current changes to a new setting. The current slew control is only available in Current Priority mode. To program a current slew rate, enter the rate (A/s) in the Current Slew field. Check Maximum to program the fastest rate. Note that the maximum slew rate is limited by the analog performance of the output circuit. The minimum slew rate is model-dependent and is a function of the full-scale current range.

Sense – The default sense setting is Local, where the sense terminals are connected directly to the output terminals. If you are using remote voltage sensing as explained under [4-Wire Sense](#), you must disconnect the sense terminals from the output terminals. Use the navigation keys and select the Sense dropdown list. Selecting the 4-Wire item disconnects the sense terminals from the output terminals. This lets you use remote voltage sensing.

Output Turn-Off Mode – This is only available in Voltage Priority mode. It lets you specify high impedance or low impedance mode at output turn-on/turn-off.

Low impedance – at turn-on the output relays are closed after which the output is programmed to the set value. At turn-off the output is first programmed to zero, after which the output relays are opened.

High impedance – at turn-on the output is programmed to the set value after which the output relays are closed. At turn-off the output relays are opened while the output remains at its set value. This reduces current pulses that may be undesirable in some applications.

Voltage Bandwidth Range – This is only available in Voltage Priority mode. Voltage bandwidth range settings allow you to optimize output response time with capacitive loads. Refer to [Output Bandwidth](#) for more information.

Voltage Bandwidth Frequency – This is only available in Voltage Priority mode. The frequency field lets you enter a different frequency limit for the specified range. Refer to [Output Bandwidth](#) for more information.

From the remote interface:

To set the voltage slew rate to 5 Volt/second:

```
VOLT:SLEW 5,(@1)
```

To set the current slew rate to 1 Amp/second:

```
CURR:SLEW 1,(@1)
```

To query the minimum voltage or current slew rate:

```
VOLT:SLEW? MIN,(@1)  
CURR:SLEW? MIN,(@1)
```

To set the front panel sense terminals to local sensing:

```
VOLT:SENS:SOUR INT,(@1)
```

To set the front panel sense terminals to remote sensing:

VOLT:SENS:SOUR EXT,(@1)

To query the setting of the front panel sense terminals (INT=local sensing; EXT=remote sensing):

VOLT:SENS:SOUR?,(@1)

To set the output turn-off mode to the high impedance setting:

OUTP:TMOD HIGHZ,(@1)

To set the output voltage bandwidth of output 1 to the default setting:

VOLT:BWID LOW,(@1)

Programming N679xA Load Settings

NOTE

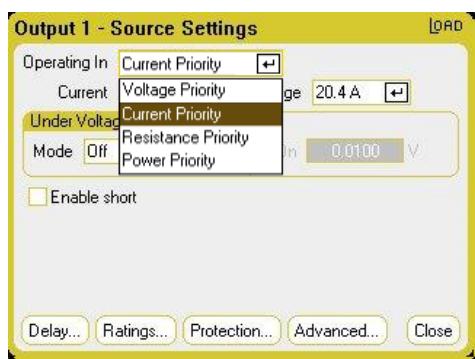
Use the Source Settings window to access the specialized operating modes of the Keysight N679xA Load modules **N679xA**. Load module input terminals are referred to as "Outputs" throughout this document.

Priority Modes

The **Operating In** dropdown list lets you select the priority mode of the Keysight N679xA Load module. Use the navigation keys to select one of the four priority modes. Then press Enter.

NOTE

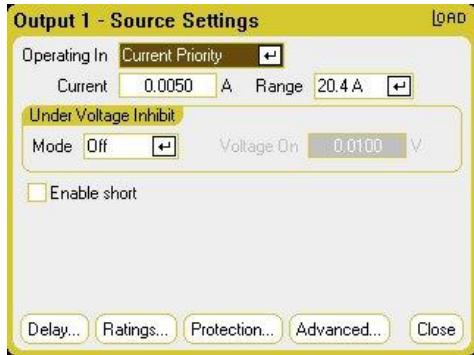
When switching between Priority modes, the load input is turned off and the Load settings revert to their Power-on or RST values.



Current Priority Mode

In this mode, the Load module will sink a current in accordance with the programmed value regardless of the input voltage. Note that a programmable voltage limit is not available. If the DUT imposes a voltage above the voltage rating of the module, the overvoltage protection will trip.

3 Using the Source/Load Functions



Current - Lets you enter a current value with the numeric keys. You can use the Current knob to adjust the value in this field. Press Enter to enter the value.

Range - Lets you select from two overlapping current ranges. The low range provides better resolution at low current settings.

Under Voltage Inhibit - When the under-voltage inhibit function is enabled by selecting a mode, the load will not sink current until the input voltage rises above the voltage-on setting.

Off - turns the under-voltage inhibit function off.

Live - turns the input off whenever the voltage drops below the voltage-on setting. *Turns the input back on when the voltage reaches the voltage-on setting.*

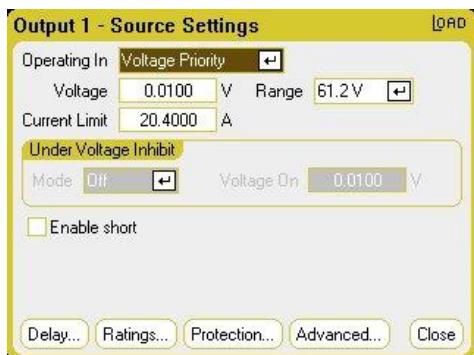
Latched - lets the load sink current when the voltage subsequently drops below the voltage-on setting. An under-voltage inhibit condition is annunciated by the UVI status bit.

NOTE Under-voltage inhibit is not available when load modules are grouped or when the unit is operating in voltage priority mode.

Enable short - Lets you short the input terminals. This simulates a short circuit on the input of the load. It works in all priority modes and temporarily overrides input and slew settings. Note that the output on/off and the output protection functions take precedence over an input short. An input-short condition is annunciated by the SH status bit.

Voltage Priority Mode

In this mode, the load will sink enough current to control the DUT voltage to the programmed value. The module acts as a shunt voltage regulator when operating in voltage priority mode.



Voltage - Lets you enter a voltage value with the numeric keys. You can use the Voltage knob to adjust the value in this field. Press Enter to enter the value.

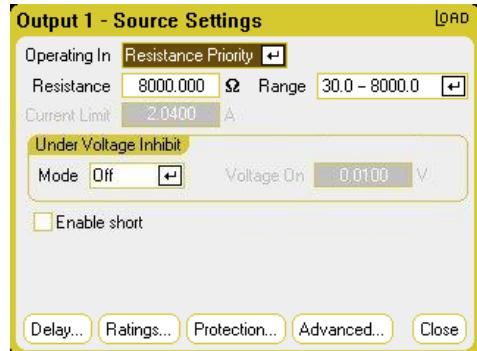
Range - There is only one voltage range.

Current Limit - You can specify a current limit that limits the input current when in voltage priority mode. It is programmable up to the rated current, with an over-range of 2%.

Refer to [Current Priority Mode](#) for descriptions of the Under Voltage Inhibit and Enable short controls.

Resistance Priority Mode

In this mode, the load will sink a current linearly proportional to the voltage in accordance with the programmed resistance value.



Resistance - Lets you enter a resistance value with the numeric keys. Press Enter to enter the value.

Range - Lets you select from three overlapping resistance ranges. The lower ranges provide better resolution at low resistance settings. The following ranges can be selected:

	N6791A	N6792A
High resistance range	from 30 Ω to 8 kΩ	from 15 Ω to 8 kΩ
Medium resistance range	from 2 Ω to 100 Ω	from 2 Ω to 100 Ω
Low resistance range	from 0.08 Ω to 3 Ω	from 0.04 Ω to 3 Ω

Current Limit - the current limit is fixed at the specified setting.

NOTE When changing ranges, the load input will be turned off, then back on again.

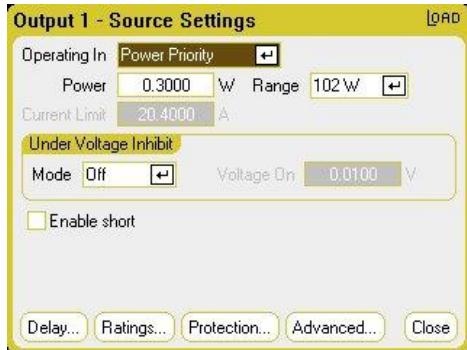
Refer to [Current Priority Mode](#) for descriptions of the Under Voltage Inhibit and Enable short controls.

Power Priority Mode

In this mode, the module will maintain the output power at the specified programmed power level.

Note that the module has an independent power limit loop that regulates the output power at the limit setting - either 100 W or 200 W, with an over-range of 10%.

3 Using the Source/Load Functions



Power - Lets you enter a power value with the numeric keys. Press Enter to enter the value.

Range - Sets the power range. The value that you enter must be the highest value in Watts that you expect to source. The following ranges can be selected:

	N6791A	N6792A
High power range	from 0.3 W to 100 W	from 0.5 W to 200 W
Low power range	from 0.04 W to 10 W	from 0.1 W to 20 W

Refer to [Current Priority Mode](#) for descriptions of the Under Voltage Inhibit and Enable short controls.

From the remote interface:

To specify the load priority mode:

```
FUNC VOLT,(@1)  
FUNC CURR,(@1)  
FUNC RES,(@1)  
FUNC POW,(@1)
```

To set the voltage to 10 V, the current to 5 A, the resistance to 100 Ω, and power to 50 W:

```
VOLT 10,(@1)  
CURR 5,(@1)  
RES 100,(@1)  
POW 50,(@1)
```

Optionally, set a current limit value of 5 A while in voltage priority mode:

```
CURR:LIM 5,(@1)
```

To select a lower current, power, or resistance range, program a value that falls within the range:

```
CURR:RANG 5,(@1)  
RES:RANG 50,(@1)  
POW:RANG 5,(@1)
```

To short the input terminals:

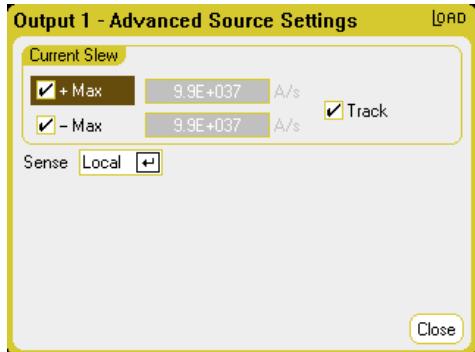
```
OUTP:SHOR ON,(@1:2)
```

To program a low-voltage limit (under-voltage inhibit) of 2 V, and enable the inhibit mode:

```
VOLT:INH:VON 2,(@1)
VOLT:INH:VON:MODE LIVE,(@1)
```

Advanced Source Settings

Advanced properties are configured in the Advanced Source Settings window. Press the **Settings** key to access the Source Settings window. Navigate to and select the Advanced button. The following dialog illustrates the advanced settings for Current Priority mode.



+Max and -Max - specifies the maximum or fastest allowable slew rate when checked. Unchecking these boxes lets you enter a slower slew rate in the appropriate fields. Separate slew settings can be programmed for Current Priority, Voltage Priority, Resistance Priority, and Power Priority modes

Track - lets the negative slew rate track the positive slew rate when checked. Un-check this box if you want to program asymmetrical positive and negative slew rates. If asymmetrical rates are programmed and tracking is turned on, the negative value is changed to track the positive value.

Sense - The default sense setting is Local, where the sense terminals are connected directly to the input terminals. If you are using remote voltage sensing as explained under **4-Wire Sense**, you must disconnect the sense terminals from the input terminals. Selecting the 4-Wire item from the dropdown disconnects the sense terminals from the output terminals. This lets you use remote voltage sensing.

From the remote interface:

To set the current slew rate to 2 Amps/second:

```
CURR:SLEW 5,(@1)
```

To set the negative current slew, turn coupling (tracking) off. Then set the negative current slew:

```
CURR:SLEW:COUP OFF,(@1)
CURR:SLEW:NEG 3,(@1)
```

To set the front panel sense terminals to remote sensing:

```
VOLT:SENS:SOUR EXT,(@1)
```

To query the setting of the front panel sense terminals:

```
VOLT:SENS:SOUR? (@1)
```

Configuring an Output Turn-On/Turn-Off Sequence

Turn-on and turn-off delays control the turn-on/turn-off timing of the outputs in relation to each other.

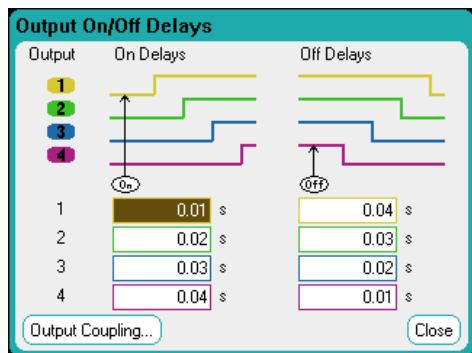
NOTE You can also synchronize Output On/Off delays across multiple mainframes. Refer to [Output Couple Controls](#) for further information.

Set the output voltage and current of the output channels

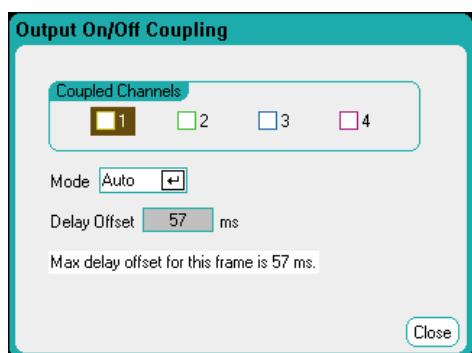
Refer to [Turning the Unit On](#) and set the output voltage and current values of all sequenced outputs.

Configure the turn-on turn-off delays

Press the Settings key twice to access the Output On/Off Delays window. Enter the On Delays and Off Delays for all outputs that will participate in the output on/off delay sequence. Values can range from 0 to 1023 seconds.



All power modules have an internal turn-on delay that applies from the time that the command to turn on the output is received until the output actually turns on. This turn-on delay is automatically added to the On Delays values. The turn-on delay does not apply when outputs turn off. To view the delay, select the Output Coupling button.

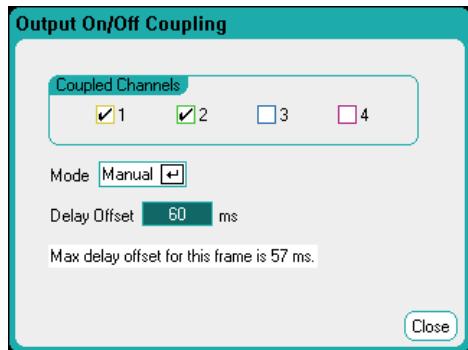


Normally, the firmware automatically calculates the delay offset based on the longest minimum turn-on delay of the installed power modules. However, if you will be excluding some outputs from participating in an output on/off delay sequence as described Step 3, the delay offset may be different based on the outputs that you will actually be sequencing. The minimum turn-on delays of the power modules are documented in the [Keysight N6700 Modular Power System Family Specifications Guide](#).

Couple selected outputs

NOTE This step is only required if you will be excluding some outputs from participating in an output on/off delay sequence, or if you are coupling multiple mainframes. If all four outputs on a single mainframe are to be used in the sequence, you can skip this step.

In the Output On/Off Delays window, navigate to and select the Output Coupling Button.



Under Coupled Channels, select the outputs that will be coupled. Outputs excluded from an output on/off delay sequence can be put to other uses. Turning the output on or off on any coupled output will cause all coupled outputs to turn on or off according to their user-programmed delays.

Mode – If the Mode setting is set to Auto, the delay offset is automatically calculated by the firmware based on the outputs that are coupled. This is displayed in the Delay Offset field. To manually program a different delay offset, change the Mode setting to Manual.

Delay Offset – Manually specifying a delay offset lets you configure longer turn-on delays than the automatically calculated delay offset. This is useful if you are sequencing turn-on/turn-off delays across multiple mainframes as discussed under **Output Couple Controls**. Also, if you are using the scope to view the output sequence, you may choose longer turn-on delays to make the internal delay offset line up with the grid on the display. Note however, that if you program a shorter delay than the automatic delay offset, you may experience improper synchronization across all outputs.

Max delay offset for this frame – This field displays the maximum delay offset required for all the power modules that are installed in the power analyzer.

Use the All Outputs On and Off keys

Once output delays have been set, use the All Outputs **On** key to start the On delay sequence. Use the All Outputs **Off** key to start the Off delay sequence.

NOTE The All Outputs On/Off keys will turn ALL outputs on or off, whether they are configured to participate in an output on/off delay sequence or not.

From the remote interface:

To program turn-on and turn-off delays for channels 1 through 4:

3 Using the Source/Load Functions

```
OUTP:DEL:RISE 0.01,(@1)
OUTP:DEL:RISE 0.02,(@2)
OUTP:DEL:RISE 0.03,(@3)
OUTP:DEL:RISE 0.04,(@4)
OUTP:DEL:FALL 0.04,(@1)
OUTP:DEL:FALL 0.03,(@2)
OUTP:DEL:FALL 0.02,(@3)
OUTP:DEL:FALL 0.01,(@4)
```

To only include outputs 1 and 2 in a sequence and specify a different delay offset:

```
OUTP:COUP:CHAN 1,2
OUTP:COUP:DOFF:MODE MAN
OUTP:COUP:DOFF 0.050
```

To query the delay offset of the slowest power module in the mainframe (the maximum delay offset):

```
OUTP:COUP:MAX:DOFF?
```

To turn on two coupled outputs in a sequence:

```
OUTP ON,(@1:2)
```

Generating Arbitrary Waveforms

Arbitrary Waveform Description

Configuring Step Arbs

Configuring Ramp Arbs

Configuring Staircase Arbs

Configuring User-Defined Arbs

Configuring Sine Arbs

Configuring Pulse Arbs

Configuring Trapezoid Arbs

Configuring Exponential Arbs

Configuring Constant-Dwell Arbs

Configuring an Arb Sequence

Configuring Parameters Common to all Arbs

Running the Arbs

Importing and Exporting Arb Data

Arbitrary Waveform Description

Each output on the power analyzer can be modulated by the built-in arbitrary waveform generator function. This allows the output to act as a DC bias transient generator or an arbitrary waveform generator. The maximum bandwidth is based on the type of power module that is installed. This is documented in the [Keysight N6700 Modular Power System Family Specifications Guide](#).

The arbitrary waveform generator has a variable dwell period, where each point in the waveform is defined by the current, voltage, power, or resistance setting along with the dwell time or duration to stay at that setting. Waveforms can be generated by specifying only a small number of points. For example, a pulse would only take three points to define it. However, sine, ramp, trapezoid, and exponential waveforms have 100 points assigned to the portion of their waveform that continuously changes. Constant-dwell waveforms can have up to 65,535 points assigned to them.

Each waveform can be repeated for a specific number of times, or continuously. For example, to generate a pulse train of 10 identical pulses, you can program one pulse and then repeat it 10 times.

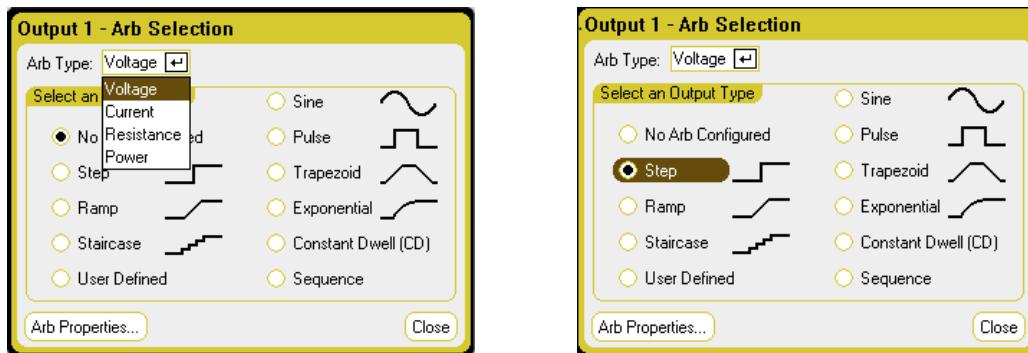
For the user-defined waveforms, you can specify up to 511 step-points for each waveform. You can specify a different dwell time for each of the step-points. The output will step through the user-defined values, staying at each point for the programmed dwell time, and then moving on to the next point.

You can combine a number of individual arbitrary waveforms into an Arb sequence, as long as the total number of points of all waveforms does not exceed 511 points.

Configuring Step Arb

Step 1. Select the Arb Type and Shape. Power and resistance types apply to **N679xA**:

Press the **Arb** key twice or press the **Arb** key and then **Properties** to access the Arb Selection window. In the Arb Type dropdown, select the Arb type. Then select Step.

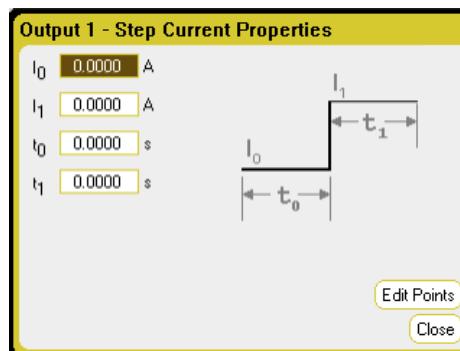


Step 2. Configure the Step Properties.

Press the **Properties** key or select the Arb Properties button. Then program the following parameters:

The I_0 and I_1 parameters shown apply to the Current Arb type.

The V_0 , V_1 , P_0 , P_1 , R_0 , and R_1 parameters apply to the respective Voltage, Power and Resistance Arb types.



Parameter	Description
Start Setting (I_0 , V_0 , P_0 , or R_0)	The setting before the step.
End Setting (I_1 , V_1 , P_1 , or R_1)	The setting after the step.
Delay (T_0)	The delay after the trigger is received but before the step occurs.
End Time (T_1)	The time the output remains at the end setting after the step occurs.

Step 3. Configure the final steps common to all Arb.

Refer to [Configuring Parameters Common to all Arb](#)s at the end of this section.

From the remote interface:

Select the Arb Type and Shape:

```
ARB:FUNC:TYPE VOLT,(@1)
ARB:FUNC:SHAP STEP,(@1)
```

Enter the values for the level before and after a voltage step:

ARB:VOLT:STEP:STAR 0,(@1)

ARB:VOLT:STEP:END 5,(@1)

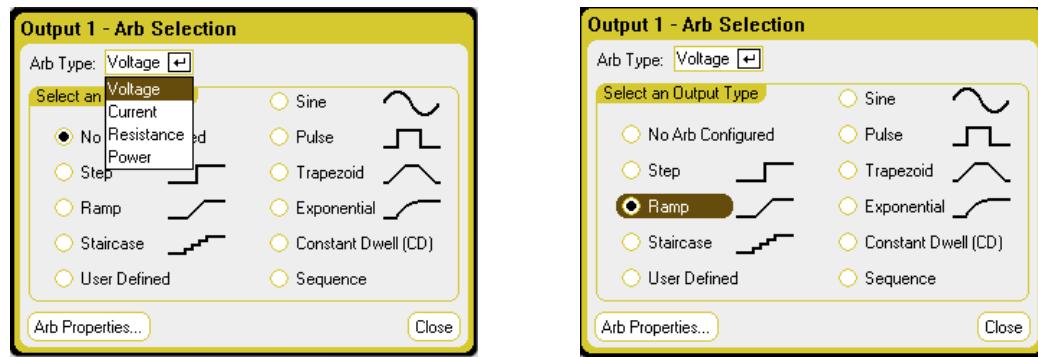
Enter the delay time before the step:

ARB:VOLT:STEP:STAR:TIM 0.01,(@1)

Configuring Ramp Arbs

Step 1. Select the Arb Type and Shape. Power and resistance types apply to N679xA:

Press the **Arb** key twice or press the **Arb** key and then **Properties** to access the Arb Selection window. In the Arb Type dropdown, select the Arb type. Then select Ramp.

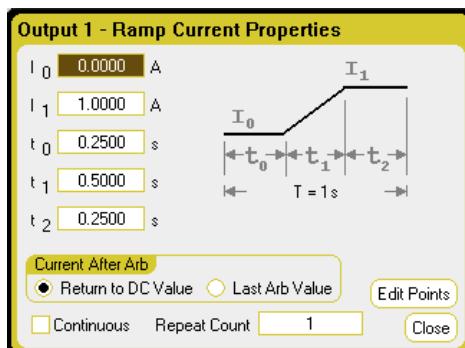


Step 2. Configure the Ramp Properties.

Press the **Properties** key or select the Arb Properties button. Then program the following parameters:

The I_0 and I_1 parameters shown apply to the Current Arb type.

The V_0 , V_1 , P_0 , P_1 , R_0 , and R_1 parameters apply to the respective Voltage, Power and Resistance Arb types.



Parameter	Description
Start Setting (I_0 , V_0 , P_0 , or R_0)	The setting before the ramp.
End Setting (I_1 , V_1 , P_1 , or R_1)	The setting after the ramp.
Delay (T_0)	The delay after the trigger is received but before the ramp starts.
Ramp Time (T_1)	The time that the output ramps up.
End Time (T_2)	The time the output remains at the end setting after the ramp completes.

Step 3. Configure the final steps common to all Arb's.

Refer to [Configuring Parameters Common to all Arb's](#) at the end of this section.

From the remote interface:

Select the Arb Type and Shape:

ARB:FUNC:TYPE VOLT,(@1)

ARB:FUNC:SHAP RAMP,(@1)

Enter the values for the level before and after a voltage ramp:

ARB:VOLT:RAMP:STAR 0,(@1)

ARB:VOLT:RAMP:END 5,(@1)

Enter the time before the pulse, the time of the pulse, and the time after the pulse:

ARB:VOLT:RAMP:STAR:TIM 0.25,(@1)

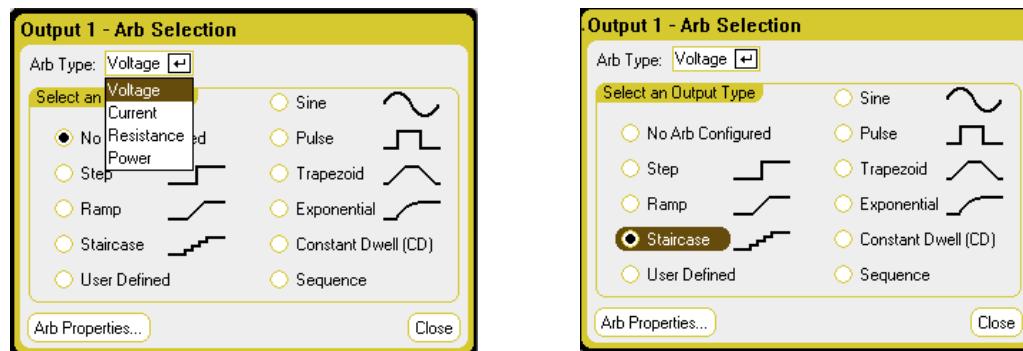
ARB:VOLT:RAMP:RTIM 0.5,(@1)

ARB:VOLT:RAMP:END:TIM 0.01,(@1)

Configuring Staircase Arb's

Step 1. Select the Arb Type and Shape. Power and resistance types apply to N679xA:

Press the **Arb** key twice or press the **Arb** key and then **Properties** to access the Arb Selection window. In the Arb Type dropdown, select the Arb type. Then select Staircase.

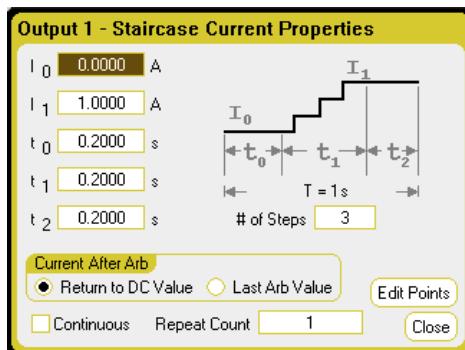


Step 2. Configure the Staircase Properties:

Press the **Properties** key or select the Arb Properties button. Then program the following parameters:

The I_0 and I_1 parameters shown apply to the Current Arb type.

The V_0 , V_1 , P_0 , P_1 , R_0 , and R_1 parameters apply to the respective Voltage, Power and Resistance Arb types.



Parameter	Description
Start Setting (I_0 , V_0 , P_0 , or R_0)	The setting before the staircase.
End Setting (I_1 , V_1 , P_1 , or R_1)	The setting after the final step. The difference between the start and end setting is divided equally between steps.
Delay (T_0)	The delay after the trigger is received but before the staircase starts.
Step Time (T_1)	The time to complete all staircase steps.
End Time (T_2)	The time the output remains at the end setting after the staircase completes.
# of Steps	The total number of staircase steps.

Step 3. Configure the final steps common to all Arb.

Refer to [Configuring Parameters Common to all Arb](#)s at the end of this section.

From the remote interface:

Select the Arb Type and Shape:

```
ARB:FUNC:TYPE VOLT,(@1)
ARB:FUNC:SHAP STA,(@1)
```

Enter the values for the level before and after a voltage staircase:

```
ARB:VOLT:STA:STAR 0,(@1)
ARB:VOLT:STA:END 5,(@1)
```

Enter the time before the staircase, the stair-time of the ramp, and the time after the staircase:

```
ARB:VOLT:STA:STAR:TIM 0.2,(@1)
ARB:VOLT:STA:TIM 0.2,(@1)
ARB:VOLT:STA:END:TIM 0.2,(@1)
```

Enter the total number of staircase steps:

```
ARB:VOLT:STA:NST 3,(@1)
```

Configuring User-Defined Arbs

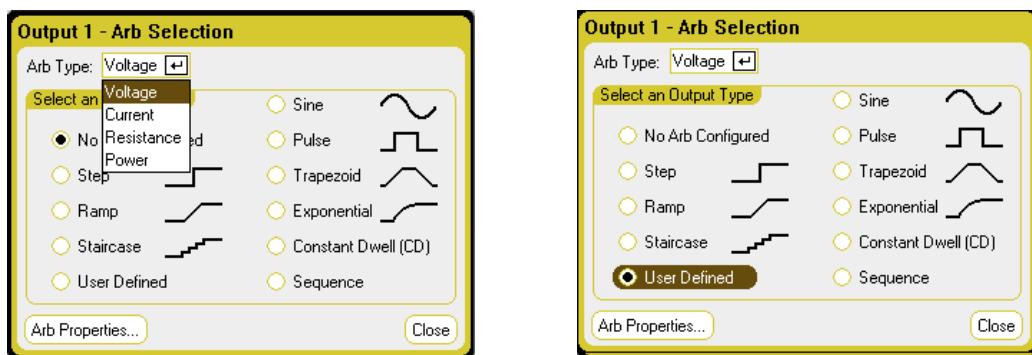
User-defined Arbs can contain up to 511 current, voltage, power, or resistance steps that are entered individually in the User-defined Properties window. Power and resistance steps apply to **N679xA**:

You can populate the User-defined Arb with values from a previously configured "standard" Arb and then edit the steps in the User-defined Properties window. To convert one of the standard Arbs to a user-defined Arb, refer to [Configuring Parameters Common to all Arbs](#) at the end of this section.

You can also import a User-defined Arb that was previously created using a spreadsheet as explained later in this section under [Importing and Exporting Arb Data](#).

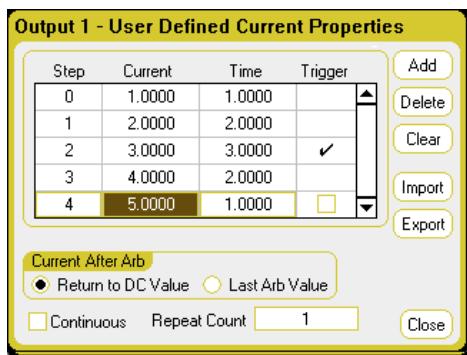
Step 1. Select the Arb Type and Shape. Power and resistance types apply to **N679xA**:

Press the **Arb** key twice or press the **Arb** key and then **Properties** to access the Arb Selection window. In the Arb Type dropdown, select the Arb type. Then select User-Defined.



Step 2. Configure the User-Defined Properties:

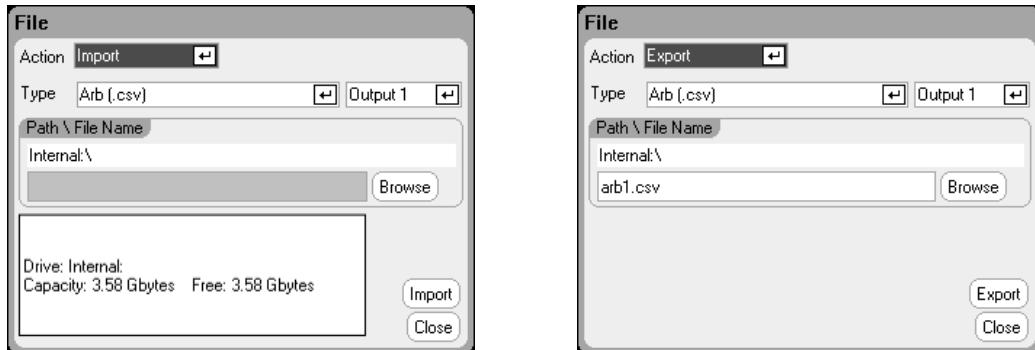
Press the **Properties** key or select the Arb Properties button. Then program the following parameters:



Parameter	Description
Step <n>	Each step of the waveform includes a current, voltage, power, or resistance parameter, dwell time, and trigger option. The total number of steps determines the length. Use the ▲ ▼ navigation keys to scroll through the steps.
Current, Voltage, Power, or Resistance	The current, voltage, power, or resistance value of the step.
Time	The time that the output stays at the step.
Trigger	Generate an external trigger signal at the start of the step when checked.
Add	Inserts a step below the selected step; values are copied from the previous step.
Delete	Deletes the presently selected step.
Clear	Clears values in all steps.
Import (.csv format)	Imports a current or voltage Arb list (see below).
Export (.csv format)	Exports a current or voltage Arb list (see below).

Step 3. Import or export User-Defined Arb data:

Select the Import button to import the file. Select the Export button to export the file. Then provide the following information:



Parameter	Description
Action	The Import or Export action.
Type	The Arb file type is .csv
Output1	When importing, the output on which the Constant-dwell Arb will run. When exporting, the output from which the Arb is exported.
Path/Filename	The path and filename of the Arb. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel.
Browse	Specifies the location where the import file is located or where the export file will be placed.
Import	Imports the file.
Export	Exports the file.

3 Using the Source/Load Functions

Refer to under **Importing and Exporting Arb Data** later in this section for information on how to create .csv current or voltage data files.

Step 3. Configure the final steps common to all Arbs.

Refer to **Configuring Parameters Common to all Arbs** at the end of this section.

From the remote interface:

Select the Arb Type and Shape:

ARB:FUNC:TYPE VOLT,(@1)

ARB:FUNC:SHAP UDEF,(@1)

Enter the voltage values and dwell-times for five voltage steps:

ARB:VOLT:UDEF:LEV 1,2,3,4,5,(@1)

ARB:VOLT:UDEF:DWEL 1,2,3,2,1,(@1)

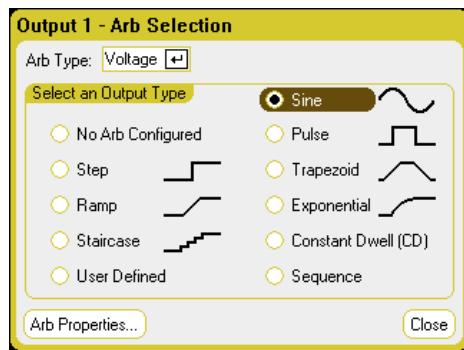
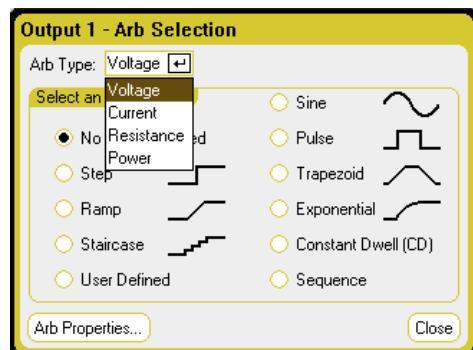
Generate an external trigger signal at the start of a voltage step (the trigger is generated at the start of step #3):

ARB:VOLT:UDEF:BOST 0,0,1,0,0,(@1)

Configuring Sine Arbs

Step 1. Select the Arb Type and Shape. Power and resistance types apply to N679xA:

Press the **Arb** key twice or press the **Arb** key and then **Properties** to access the Arb Selection window. In the Arb Type dropdown, select the Arb type. Then select Sine.

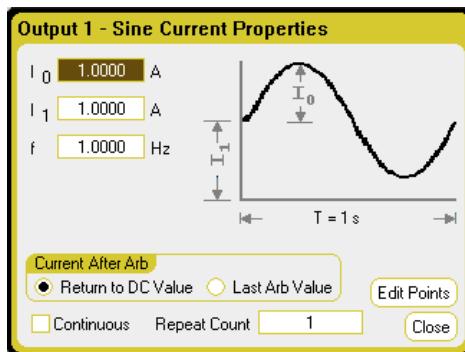


Step 2. Configure the Sine Properties:

Press the **Properties** key or select the **Arb Properties** button. Then program the following parameters:

The I_0 and I_1 parameters shown apply to the Current Arb type.

The V_0 , V_1 , P_0 , P_1 , R_0 , and R_1 parameters apply to the respective Voltage, Power and Resistance Arb types.



Parameter	Description
Amplitude (I_0 , V_0 , P_0 , or R_0)	The amplitude or peak value.
Offset (I_1 , V_1 , P_1 , or R_1)	The offset from zero. For power modules that do not generate negative values, the offset must be \geq Amplitude.
Frequency (f)	The frequency of the sine wave.

Step 3. Configure the final steps common to all Arb's.

Refer to [Configuring Parameters Common to all Arb's](#) at the end of this section.

From the remote interface:

Select the Arb Type and Shape:

```
ARB:FUNC:TYPE VOLT,(@1)
ARB:FUNC:SHAP SIN,(@1)
```

Enter the values for the voltage amplitude, offset from zero, and frequency:

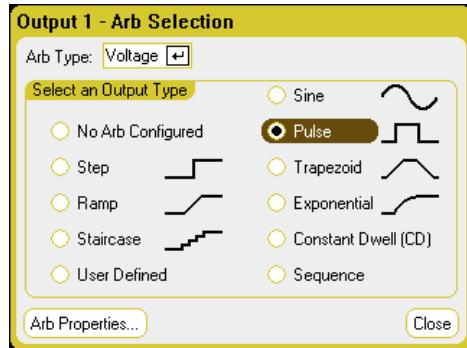
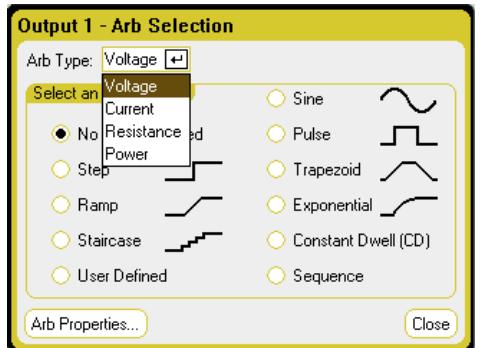
```
ARB:VOLT:SIN:AMPL 5,(@1)
ARB:VOLT:SIN:OFFS 5,(@1)
ARB:VOLT:SIN:FREQ 1,(@1)
```

Configuring Pulse Arb's

Step 1. Select the Arb Type and Shape. Power and resistance types apply to N679xA:

Press the **Arb** key twice or press the **Arb** key and then **Properties** to access the Arb Selection window. In the Arb Type dropdown, select the Arb type. Then select Pulse.

3 Using the Source/Load Functions

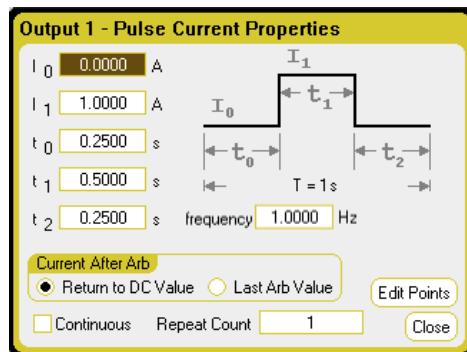


Step 2. Configure the Pulse Properties:

Press the **Properties** key or select the Arb Properties button. Then program the following parameters:

The I_0 and I_1 parameters shown apply to the Current Arb type.

The V_0 , V_1 , P_0 , P_1 , R_0 , and R_1 parameters apply to the respective Voltage, Power and Resistance Arb types.



Parameter	Description
Start Setting (I_0 , V_0 , P_0 , or R_0)	The setting before and after the pulse.
Pulse Setting (I_1 , V_1 , P_1 , or R_1)	The amplitude of the pulse.
Delay (T_0)	The delay after the trigger is received but before the pulse starts.
Pulse Width (T_1)	The width of the pulse.
End Time (T_2)	The time the output remains at the end setting after the pulse completes.
Frequency	Enter a frequency value directly. this will change the (T_0), (T_1), (T_2) parameters

Step 3. Configure the final steps common to all Arb's.

Refer to [Configuring Parameters Common to all Arb's](#) at the end of this section.

From the remote interface:

Select the Arb Type and Shape:

ARB:FUNC:TYPE VOLT,(@1)

ARB:FUNC:SHAP PULS,(@1)

Enter the values for the level before and the top of a voltage pulse:

ARB:VOLT:PULS:STAR 0,(@1)

ARB:VOLT:PULS:TOP 10,(@1)

Enter the time before the pulse, the time of the pulse, and the time after the pulse:

```
ARB:VOLT:PULS:STAR:TIM 0.25,(@1)
ARB:VOLT:PULS:TOP:TIM 0.5,(@1)
ARB:VOLT:PULS:END:TIM 0.25,(@1)
```

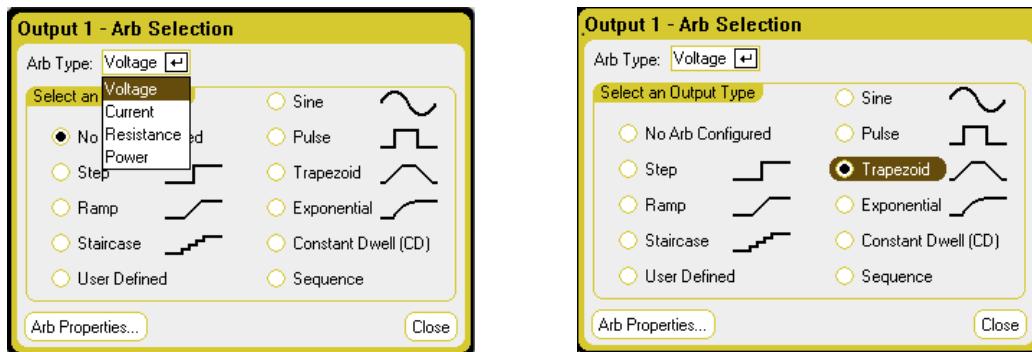
Enter the frequency of the pulse:

```
ARB:VOLT:PULS:FREQ 1,(@1)
```

Configuring Trapezoid Arbs

Step 1. Select the Arb Type and Shape. Power and resistance types apply to N679xA:

Press the **Arb** key twice or press the **Arb** key and then **Properties** to access the Arb Selection window. In the Arb Type dropdown, select the Arb type. Then select Trapezoid.

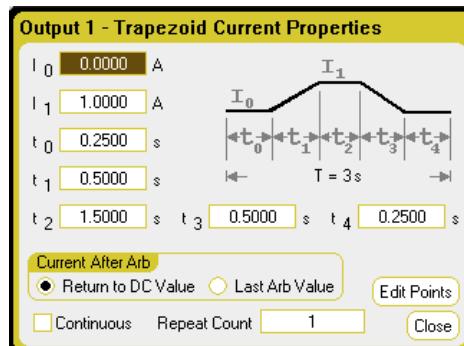


Step 2. Configure the Trapezoid Properties:

Press the **Properties** key or select the Arb Properties button. Then program the following parameters:

The I_0 and I_1 parameters shown apply to the Current Arb type.

The V_0 , V_1 , P_0 , P_1 , R_0 , and R_1 parameters apply to the respective Voltage, Power and Resistance Arb types.



Parameter	Description
Start Setting (I_0 , V_0 , P_0 , or R_0)	The setting before and after the trapezoid.
Peak Setting (I_1 , V_1 , P_1 , or R_1)	The peak setting.
Delay (T_0)	The delay after the trigger is received but before the trapezoid starts.
Rise Time (T_1)	The time that the trapezoid ramps up.

Parameter	Description
Peak Width (T_2)	The width of the peak.
Fall Time (T_3)	The time that the trapezoid ramps down.
End Time (T_4)	The time the output remains at the end setting after the trapezoid completes.

Step 3. Configure the final steps common to all Arbs.

Refer to [Configuring Parameters Common to all Arbs](#) at the end of this section.

From the remote interface:

Select the Arb Type and Shape:

ARB:FUNC:TYPE VOLT,(@1)

ARB:FUNC:SHAP TRAP,(@1)

Enter the values for the level before and during the top of a voltage trapezoid:

ARB:VOLT:TRAP:STAR 0,(@1)

ARB:VOLT:TRAP:TOP 5,(@1)

Enter the time before the trapezoid, the rise-time, fall-time, top-time, and the time after the trapezoid:

ARB:VOLT:TRAP:STAR:TIM 0.25,(@1)

ARB:VOLT:TRAP:RTIM 0.5,(@1)

ARB:VOLT:TRAP:FTIM 0.5,(@1)

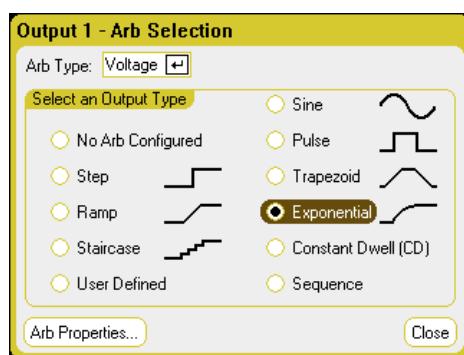
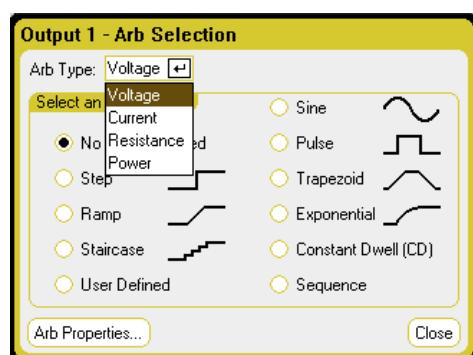
ARB:VOLT:TRAP:TOP:TIM 1.5,(@1)

ARB:VOLT:TRAP:END:TIM 0.25,(@1)

Configuring Exponential Arbs

Step 1. Select the Arb Type and Shape. Power and resistance types apply to N679xA:

Press the **Arb** key twice or press the **Arb** key and then **Properties** to access the Arb Selection window. In the Arb Type dropdown, select the Arb type. Then select Exponential.

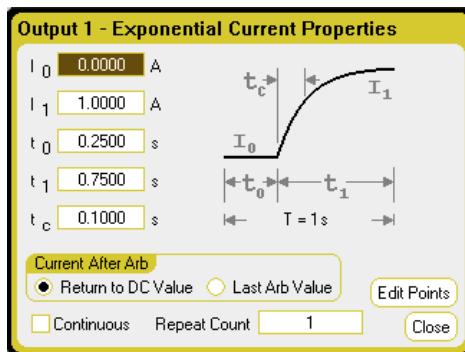


Step 2. Configure the Exponential Properties:

Press the **Properties** key or select the **Arb Properties...** button. Then program the following parameters:

The I_0 and I_1 parameters shown apply to the Current Arb type.

The V_0 , V_1 , P_0 , P_1 , R_0 , and R_1 parameters apply to the respective Voltage, Power and Resistance Arb types.



Parameter	Description
Start Setting (I_0 , V_0 , P_0 , or R_0)	The setting before the waveform.
End Setting (I_1 , V_1 , P_1 , or R_1)	The end setting of the waveform.
Delay (T_0)	The delay after the trigger is received but before the waveform starts.
Time (T_1)	Time for the amplitude to go from the start setting to the end setting.
Time Constant (T_c)	The time constant of the curve.

Step 3. Configure the final steps common to all Arbs.

Refer to [Configuring Parameters Common to all Arbs](#) at the end of this section.

From the remote interface:

Select the Arb Type and Shape:

```
ARB:FUNC:TYPE VOLT,(@1)
```

```
ARB:FUNC:SHAP EXP,(@1)
```

Enter the values for the level before and after a voltage exponential:

```
ARB:VOLT:EXP:STAR 0,(@1)
```

```
ARB:VOLT:EXP:END 5,(@1)
```

Enter the time before the exponential, the exponential time, and the time constant of the exponential:

```
ARB:VOLT:EXP:STAR:TIM 0.25,(@1)
```

```
ARB:VOLT:EXP:TIM 0.75,(@1)
```

```
ARB:VOLT:EXP:TCON 0.1,(@1)
```

Configuring Constant-Dwell Arbs

Constant-Dwell (CD) Arbs are a unique type that have some useful differences from other Arbs. CD Arbs are not limited to 511 points, they have up to 65,535 points. Unlike other Arbs, they do not have separate dwell values for each point - a single dwell value applies to ALL points. Also, the minimum dwell time of a CD Arb is 10 .24 microseconds, instead of the 1 microsecond resolution of other Arbs.

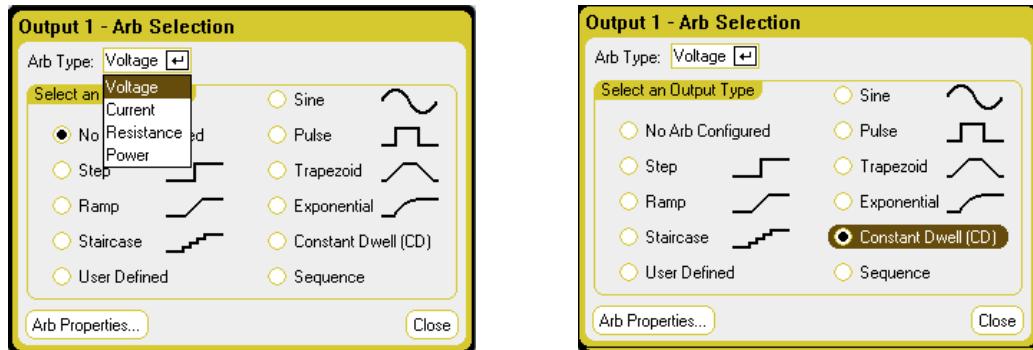
3 Using the Source/Load Functions

A CD Arb can run along with other Arbs on other outputs. If multiple outputs run a CD Arb, all CD Arbs must have the same dwell time. All CD Arbs must also have the same length and repeat count.

Because the CD Arbs can have such a large number of points, you cannot define individual values from the front panel. Instead, the data must be imported from a file. See [Importing and Exporting Arb Data](#).

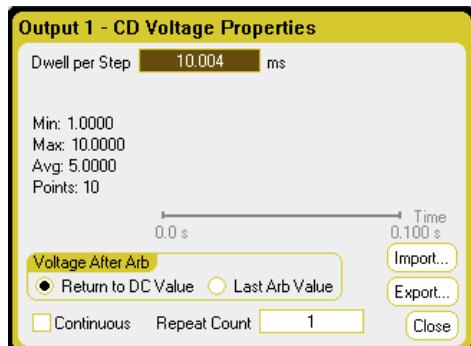
Step 1. Select the Arb Type and Shape. Power and resistance types apply to N679xA:

Press the **Arb** key twice or press the **Arb** key and then **Properties** to access the Arb Selection window. In the Arb Type dropdown, select the Arb type. Then select Constant-Dwell.



Step 2. Configure the Constant-Dwell Properties:

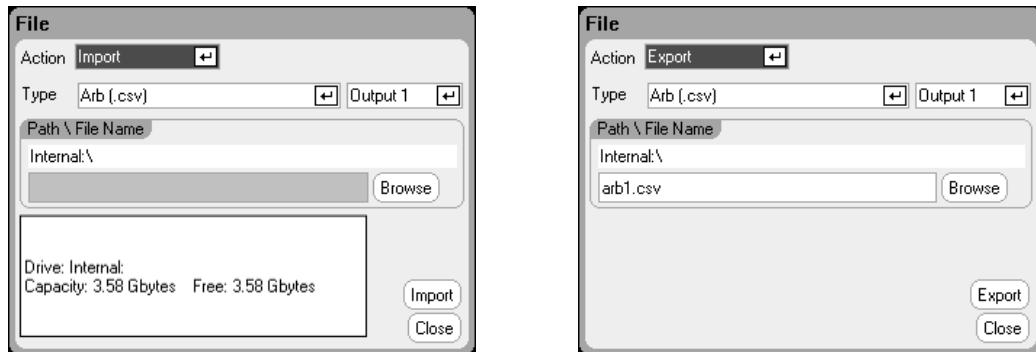
Press the **Properties** key or select the Arb Properties button. Then program the following parameters:



Parameter	Description
Dwell per Step	The dwell time for each step in seconds. Values range from 10.24 μ s to 0.30 s.
Min	The minimum value of the imported Arb.
Max	The maximum value of the imported Arb.
Avg	The average value of the imported Arb.
Points	The number of points in the imported Arb.
Time	The total time of the imported Arb.
Import (.csv format)	Imports a current or voltage CD Arb list (see below).
Export (.csv format)	Exports a current or voltage CD Arb list. (see below).

Step 3. Import or export Constant-Dwell Arb data:

Select the Import button to import the file. Select the Export button to export the file. Then provide the following information:



Parameter	Description
Action	The Import or Export action.
Type	The Arb file type is .csv
Output1	When importing, the output on which the Constant-dwell Arb will run. When exporting, the output from which the Arb is exported.
Path/Filename	The path and filename of the Arb. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel.
Browse	Specifies the location where the import file is located or where the export file will be placed.
Import	Imports the file.
Export	Exports the file.

Refer to under [Importing and Exporting Arb Data](#) later in this section for information on how to create .csv current or voltage data files.

Step 4. Configure the final steps common to all Arb.

Refer to [Configuring Parameters Common to all Arb](#)s at the end of this section.

From the remote interface:

Select the Arb Type and Shape:

```
ARB:FUNC:TYPE VOLT,(@1)
ARB:FUNC:SHAP CDW,(@1)
```

Program the dwell time and the number of points in a voltage CD Arb:

```
ARB:VOLT:CDW:DWEL 0.01,(@1)
ARB:VOLT:CDW 1,2,3,4,5,6,7,8,9,10,(@1)
```

3 Using the Source/Load Functions

The list of constant-dwell steps can be a list of comma-separated ASCII values (the default setting), or for better performance, it can be sent as a definite length binary block as described in IEEE 488.2.

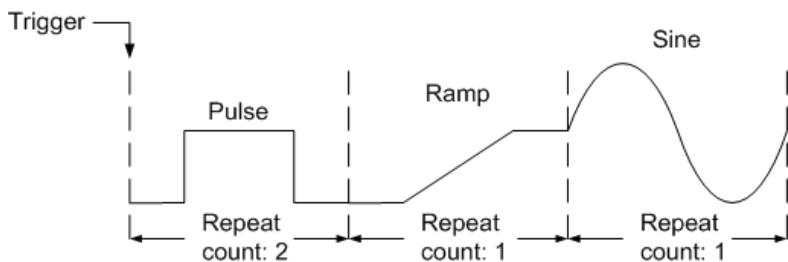
NOTE If you are sending data as a definite length binary block, the instrument will recognize the data format; however, you must specify the byte order. Refer to [Measurement Data Formats](#) for more information.

Configuring an Arb Sequence

The Arb Sequence allows multiple and different Arbs to run one after another in succession. Any of the standard Arb types, except for constant-dwell Arbs, can be included in the Arb sequence. All Arbs in the sequence must be of the same type; either voltage, current, resistance, or power.

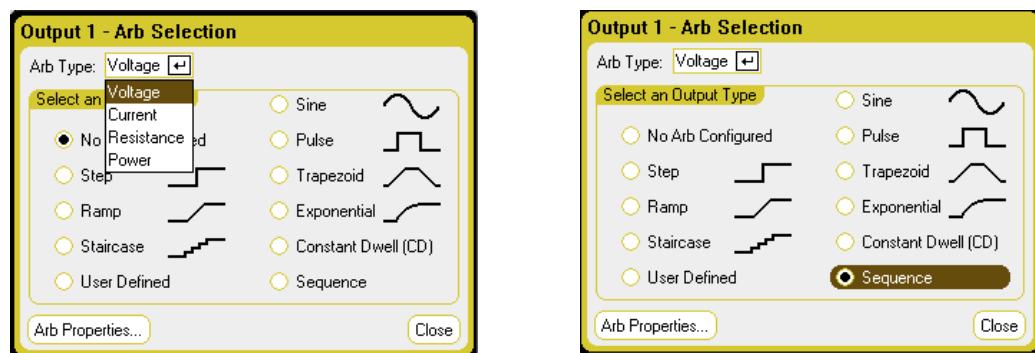
As with single Arbs, each Arb in the sequence has its own repeat count, can be set for dwell or trigger pacing, and can be set to repeat continuously. Note also that a repeat count can be set for the entire sequence, and it can also be set to repeat continuously.

The following figure illustrates a sequence comprised of a pulse Arb, a ramp Arb, and a sine Arb. The repeat count value indicates how many times each Arb repeats before moving to the next type.



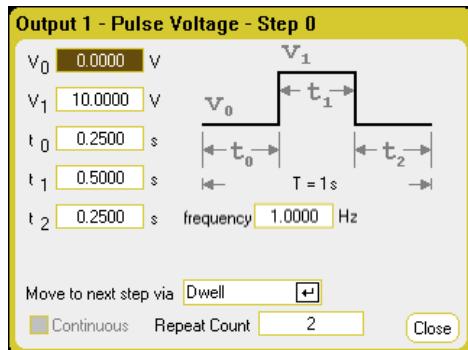
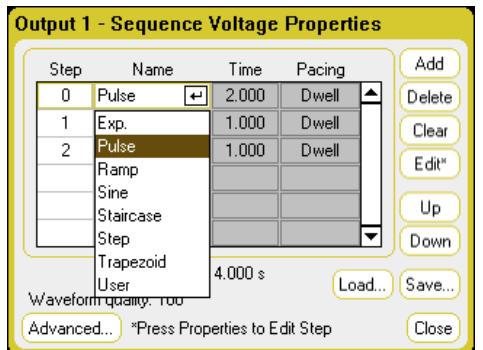
Step 1. Select the Arb Type and Shape. Power and resistance types apply to N679xA:

Press the **Arb** key twice or press the **Arb** key and then **Properties** to access the Arb Selection window. In the Arb Type dropdown, select the Arb type. Then select Sequence.



Step 2. Configure the Sequence Properties:

Press the **Properties** key or select the Arb Properties button. Then program the following parameters:



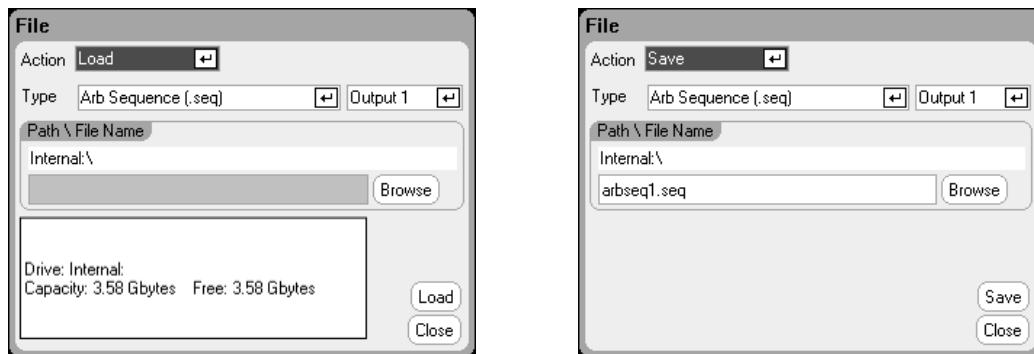
Parameter	Description
Step <n>	Each step of the sequence includes a step number, an arbitrary waveform, step time, and pacing option. The total number of steps determines the length. Use the ▲ ▼ navigation keys to scroll through the steps.
Name	The name of the Arb. Select an Arb from the dropdown list. Select Edit or Properties to edit the waveform. The Pulse waveform edit fields are shown above.
Time	Displays the total time that is allocated to the step in the Edit function. This time does not include the number of repeat counts
Pacing	Displays the pacing of the step. Dwell-paced transitions to the next step when the dwell time has elapsed. Trigger-paced transitions to the next step when an external trigger is received. If the step time completes before the trigger occurs, the step remains at the last Arb value while waiting for the trigger.
Add	Inserts a step below the selected step; values are copied from the previous step. Continue to Add steps until your sequence is complete.
Delete	Deletes the presently selected step.
Clear	Clears the presently selected step.
Edit	Edits the selected Arb. The Pulse waveform edit fields are shown above. Move to the next step specifies the step pacing, either dwell or trigger-paced. Repeat Count specifies how many times the Arb repeats. Continuous can only be selected if the Arb is trigger-paced.
Up	Move up through the steps.
Down	Move down through the steps.
Load (.seq format)	Loads a previously created sequence file (see below).
Save (.seq format)	Saves the present voltage or current sequence (see below).
Total time	Indicates the total run-time of the sequence.
Waveform Quality	Indicates the number of points allocated to the continuously changing portion of the following waveforms: sine, trapezoid, ramp, and exponential. Normally, each continuous section is approximated using 100 points, but in an Arb sequence this could result in exceeding the 511-point limit as more waveforms are added. The more of these waveforms that are added to the sequence, the fewer points will be allocated, down to a minimum of 16 points.
Advanced	Lets you edit the common properties that apply to the entire sequence. Refer to Configuring Parameters Common to all Arbs at the end of this section.

Step 3. Save or load Arb Sequences:

3 Using the Source/Load Functions

Arb sequences are saved and recalled in instrument state files, but you can also save and load them in files that are separate from other instrument settings.

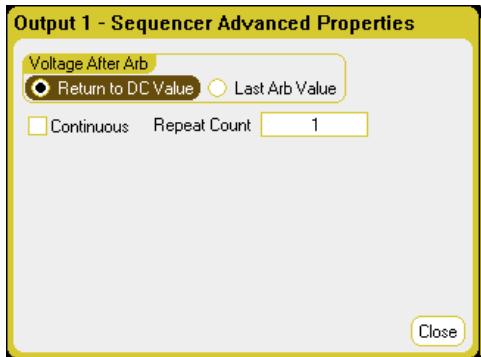
Select the Load button to load the file. Select the Save button to save the file. Then provide the following information:



Parameter	Description
Action	The Load or Save action.
Type	The Sequence file type is .seq
Output1	When loading, the output on which the sequence will run. When saving, the output from which the sequence is saved.
Path/Filename	The path and filename of the sequence. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel.
Browse	Specifies where the sequence file is located or where the sequence file will be placed.
Load	Loads the file.
Save	Saves the file.

Step 4. Configure the final steps common to all Arbss.

Press the Advanced button to specify what happens when the Arb sequence completes.



Refer to [Configuring Parameters Common to all Arbss](#) at the end of this section.

From the remote interface:

Observe the following when creating or editing an Arb sequence:

- The Arb function type must match the Arb type specified in each sequence step.
- Sequence steps must be specified sequentially. The last value in the parameter list is the sequence step number.
- When a step is added, all Arb parameters must be entered.

The following commands program a voltage sequence comprised of a pulse, a ramp, and a sine Arb with the pulse Arb repeated twice.

To set up output 1 to program a sequence of voltage waveforms:

```
ARB:FUNC:TYPE VOLT,(@1)
ARB:FUNC:SHAP SEQ,(@1)
ARB:SEQ:RESet (@1)
```

To program step 0 as a voltage pulse:

```
ARB:SEQ:STEP:FUNC:SHAP PULS,0,(@1)
ARB:SEQ:STEP:VOLT:PULS:STAR:TIM 0.25,0,(@1)
ARB:SEQ:STEP:VOLT:PULS:TOP 10.0,0,(@1)
ARB:SEQ:STEP:VOLT:PULS:TOP:TIM 0.5,0,(@1)
ARB:SEQ:STEP:VOLT:PULS:END:TIM 0.25,0,(@1)
```

To program step 1 as a voltage ramp:

```
ARB:SEQ:STEP:FUNC:SHAP RAMP,1,(@1)
ARB:SEQ:STEP:VOLT:RAMP:STAR:TIM 0.25,1,(@1)
ARB:SEQ:STEP:VOLT:RAMP:END 10.0,1,(@1)
ARB:SEQ:STEP:VOLT:RAMP:RTIM 0.5,1,(@1)
ARB:SEQ:STEP:VOLT:RAMP:END:TIM 0.25,1,(@1)
```

To program step 2 as a voltage sine wave:

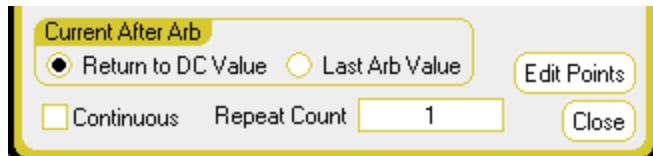
```
ARB:SEQ:STEP:FUNC:SHAP SIN,2,(@1)
ARB:SEQ:STEP:VOLT:SIN:FREQ 0.0167,2,(@1)
ARB:SEQ:STEP:VOLT:SIN:OFFS 10.0,2,(@1)
ARB:SEQ:STEP:VOLT:SIN:AMPL 20.0,2,(@1)
```

To repeat step 0 twice:

```
ARB:SEQ:STEP:COUN 2,0,(@1)
```

Configuring Parameters Common to all Arbs

From the front panel: The following properties are common to most Arb functions:



Parameter	Description
Return to DC Value	The parameter setting returns to the DC value that was in effect prior to the Arb.
Last Arb Value	The parameter setting remains at the last Arb value after the Arb completes.
Edit Points	Create a user-defined Arb from the present Arb property values. This lets you edit specific points in the standard arbitrary waveform. This function (button) is not available on User Defined, Constant-Dwell or Sequence Arbs.
Continuous	Check to repeat the Arb continuously.
Repeat Count	The number of times the Arb repeats. Except for CD Arbs, the maximum repeat count is about 16 million. The maximum repeat count for voltage and current CD Arbs is 256.
Close	Saves and closes the Properties window.

From the remote interface:

The parameter setting returns to the DC value that was in effect prior to the Arb.

ARB:TERM:LAST OFF,(@1)

The parameter setting remains at the last Arb value after the Arb completes.

ARB:TERM:LAST ON,(@1)

Create a user-defined Arb from the present Arb property values (same as Edit Points button):

ARB:CURR:CONV (@1)

ARB:VOLT:CONV (@1)

Specify the repeat count of the Arb, or specify continuous repetition (INF):

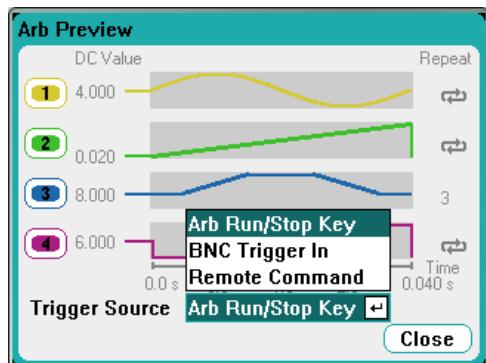
ARB:COUN 10,(@1)

ARB:COUN INF,(@1)

Running the Arbs

Step 1. Select the Arb trigger source:

From the front panel: Press the **Arb** key, then select the Trigger Source field. The same trigger source will be used to trigger all of the arbitrary waveforms. Note that the Arb Preview dialog provides a preview of the Arb waveform that will be run.



Trigger Source	Description
Arb Run/Stop Key	The front panel Run/Stop key will trigger the Arb when pressed.
BNC Trigger In	A signal on the rear panel BNC input connector will trigger the Arb
Remote Command	A remote interface command will trigger the Arb.

From the remote interface:

Select from one of the following SCPI trigger sources:

Trigger Source	Description
Bus	Selects a GPIB device trigger, *TRG, or <GET> (Group Execute Trigger).
IMMEDIATE	Selects the immediate trigger source. This triggers the Arb immediately when the INITiate command is sent.
EXTERNAL	Selects the trigger input BNC connector on the rear panel. You must provide a low-true signal to the connector.

Enable the specified Arb function to respond to output triggers:

CURR:MODE ARB,(@1)
 VOLT:MODE ARB,(@1)
 POW:MODE ARB,(@1)
 RES:MODE ARB,(@1)

Specify one of the following three trigger sources:

TRIG:ARB:SOUR BUS
 TRIG:ARB:SOUR IMM
 TRIG:ARB:SOUR EXT

Step 2. Initiate and Trigger the Arb:

NOTE	When the arbitrary waveform runs, front panel voltage and current controls as well as any remote voltage and current commands are ignored until after the Arb completes.
-------------	--

From the front panel: Press the Output **On** key to enable the output. Select **Meter View** or **Scope View** to display the Arb. Depending upon the selected trigger source, trigger the arbitrary waveforms as follows:

Trigger Source	Description
Arb Run/Stop Key	Press the Arb Run/Stop key to initiate and start the Arbs. All Arbs are triggered simultaneously. Press the Arb Run/Stop key again to stop the Arbs.
Rear Trigger Input	Provide a low-true signal to the Trigger In BNC connector. Refer to Supplemental Characteristics for minimum pulse width. All Arbs are triggered simultaneously.

Once configured, the instrument will wait indefinitely for the trigger signal. If the trigger does not occur, and you wish to cancel the arbitrary waveform, press the **Arb Run/Stop** key to stop the Arb.

From the remote interface:

To enable output 1:

OUTP ON,(@1)

To initiate the transient trigger system:

INIT:TRAN (@1)

It takes a few milliseconds for the instrument to be ready to receive a trigger signal after receiving the INITiate:TRANsient command. If a trigger occurs before the trigger system is ready for it, the trigger will be ignored. You can test the WTG_tran bit in the operation status register to know when the instrument is ready to receive a trigger after being initiated. Refer to Status Tutorial in the Operating and Service Guide document for more information.

To query the WTG_tran bit (bit 4):

STAT:OPER:COND? (@1)

If a bit value of 16 is returned in the query, the WTG_tran bit is true, and the instrument is ready to receive the trigger signal.

NOTE	Unless INITiate:CONTinuous:TRANsient is programmed, it will be necessary to initiate the transient trigger system each time a triggered action is desired.
-------------	--

To trigger the Arb if the trigger source is BUS:

*TRG

As previously discussed, a trigger can also be generated by a trigger signal applied to the rear panel BNC input connector. If this is configured as the trigger source, the instrument will wait indefinitely for the trigger signal. If the trigger does not occur, you must manually return the trigger system to the Idle state.

If the trigger does not occur, and you wish to cancel the arbitrary waveform, send

ABOR:TRAN,(@1)

When a trigger is received, the Arb runs. When the Arb completes, the trigger system returns to the Idle state. You can test the TRAN_active bit in the operation status register to know when the transient trigger system has returned to the Idle state.

To query the TRAN_active bit (bit 6):

STAT:OPER:COND? (@1)

If a bit value of 64 is returned in the query, the TRAN_active bit is true, and the Arb has NOT completed. When the TRAN_active bit is false, the Arb has completed.

Importing and Exporting Arb Data

NOTE

You can only import and export User-Defined and Constant-Dwell Arb data.

You can create an arbitrary waveform in a Microsoft Excel spreadsheet and import it into the instrument using the Import function as previously explained in this section under [Configuring User-Defined Arbs](#) and [Configuring Constant-Dwell Arbs](#). Likewise, you can also Export an arbitrary waveform from the instrument to a spreadsheet.

In the following spreadsheet examples, the file format for User-Defined Arbs and Constant-Dwell Arbs is shown. The format includes a notes section, tag header, and the appropriate number of data header and data row columns.

3 Using the Source/Load Functions

The image shows two Microsoft Excel windows side-by-side. The left window is titled "Microsoft Excel - arbUserDefinedExport.csv" and contains data for an "Arb User-Defined Waveform". It has a header row with columns A, B, C, D, E, and F. Row 1 is a note: "1 Arb User-Defined Waveform". Row 2 is a tag: "%arbtype=arbuservolt". Row 3 is a header: "3 VALUE TIME TRIGGER". Rows 4 through 10 contain data: (1, 1, 0), (2, 1, 0), (3, 1, 0), (4, 1, 0), (5, 1, 0), (6, 1, 0), (7, 1, 0). Rows 11 through 17 are empty. The right window is titled "Microsoft Excel - arbConstantDwellExport.csv" and contains data for an "Arb Constant-Dwell Waveform". It has a header row with columns A, B, C, D, E, and F. Row 1 is a note: "1 Arb Constant-Dwell Waveform". Row 2 is a tag: "%arbtype=arbcdrvolt". Row 3 is a header: "3 %constantdwell=0.1". Row 4 is a header: "4 VALUE". Rows 5 through 11 contain data: (1), (2), (3), (4), (5), (6), (7). Rows 12 through 17 are empty.

A	B	C	D	E	F
1	Arb User-Defined Waveform				
2	%arbtype=arbuservolt				
3	VALUE	TIME	TRIGGER		
4	1	1	0		
5	2	1	0		
6	3	1	0		
7	4	1	0		
8	5	1	0		
9	6	1	0		
10	7	1	0		
11					
12					
13					
14					
15					
16					
17					

A	B	C	D	E	F
1	Arb Constant-Dwell Waveform				
2	%arbtype=arbcdrvolt				
3	%constantdwell=0.1				
4	VALUE				
5	1				
6	2				
7	3				
8	4				
9	5				
10	6				
11	7				
12					
13					
14					
15					
16					
17					

Notes section - This section contains text to describe the file. It can also contain empty rows. Notes rows are generally one column wide.

Tag header - This row must contain one of the following tags:

%arbtype=arbuservolt
%arbtype=arbusercurr
%arbtype=arbuserpow
%arbtype=arbuserres
%arbtype=arbcdrvolt
%arbtype=arbcdcurr
%arbtype=arbcdpow
%arbtype=arbcdres

For constant-dwell Arbs, a second tag row must specify the dwell:

%constantdwell=<float>

Data header - For user-defined Arbs, the data header row must have 3 columns with the following headings: VALUE, TIME, and TRIGGER. For constant-dwell Arbs, the header row has one column with the heading: VALUE. All rows following the header are the data rows.

Data rows - For user-defined Arbs, the data in the VALUE column must match the Arb type; either voltage or current values. The TIME column specifies the dwell time of the step in seconds. The TRIGGER column requires a value of zero as the default. If you want the Arb to generate an external trigger signal at the start of the step, replace the zero with a one. For constant-dwell Arbs, the data in the VALUE column must match the Arb type; either voltage or current values.

Using the Protection Functions

Protection Functions

Configuring Protection

Advanced Protection

Protection Functions

Each output has independent protection functions. A front panel status indicator will turn on when a protection function has been set. Protection functions are latching, which means that they must be cleared once they have been set.

Additionally, as explained under [Output Coupling](#), you can configure the instrument so that when a protection fault occurs on one output, ALL outputs will be turned off.

Of the following protection functions, only OV, OV-, OC, OSC, PROT, and INH are user-programmable.

OV - Over-voltage protection is a hardware protection whose trip level is a programmable value. The OV protection is always enabled.

OV- - Negative voltage protection is a hardware OVP. Only applies to Keysight N6784A and N6783A.

OC - Over-current protection is a programmable function that can be enabled or disabled. When enabled, the output will be disabled when the output current reaches the current limit setting.

OT - Over-temperature protection monitors the temperature of each output and shuts down the output if any temperature exceeds the maximum factory-defined limits (see OUTPut:PROTection:TEMPerature:MARGIN? in the Operating and Service Guide document).

OSC - Oscillation protection shuts down the output if an oscillation is detected on the output. Only applies to Keysight N678xA SMU.

PF - PF indicates that a power fail condition on the AC mains has disabled the output.

CP+ - CP+ indicates that a positive power limit condition has disabled the output. This protection function does not apply to all power modules. Refer to [Power Limit Operation](#) for further information.

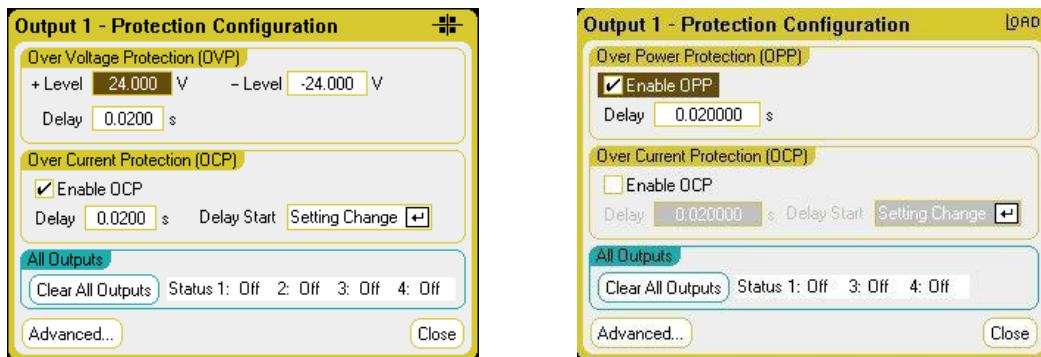
CP- - CP- indicates that a negative power limit condition has disabled the output. This protection function does not apply to all power modules. Refer to [Power Limit Operation](#) for further information.

PROT - Prot indicates that the output is disabled, either because of a coupled protection signal from another output, or because the programmed watchdog time has expired.

INH - The Inhibit input (pin 3) on the rear panel digital connector can be programmed to act as an external shutdown signal. Refer to [Inhibit Input](#) for further information.

Configuring Protection

Protection functions are configured in the Protection Configuration window. Press the Settings key to access the Source Settings window. Navigate to and select Protection. Then press Enter.



Over-Voltage Protection - Over-voltage protection disables the output if the output voltage reaches the OVP level. The OVP circuit monitors the voltage at the + and – output terminals. To set the over-voltage protection, enter an over-voltage value in the **+Level** field.

For models N678xA SMU **N678xA SMU**, the OVP circuit senses at the 4-wire sense terminals rather than at the output terminals. This allows for more precise over-voltage monitoring directly at the load. Refer to **Over-Voltage Protection Considerations** for details. These models also have a back-up local OVP function. Refer to **Local OVP** for a description of the feature. Additionally, for model N6784A, you can program a negative over-voltage value. Enter the value in the **-Level** field.

For models N678xA SMU and N6783A **N678xA SMU** **N6783A**, you can specify a delay to prevent momentary voltage excursions from tripping the over-voltage protection. Enter the value in the over-voltage **Delay** field. These models also have negative voltage protection, which disables the output if negative voltages are detected. Negative voltage protection is indicated by the OV- annunciator.

For models N679xA **N679xA** the over-voltage protection level is not programmable and is fixed at 110% of the rated input voltage.

Over-Current Protection - With over-current protection enabled, the power analyzer disables the output if the output current reaches the current limit setting, which causes a transition from CV to CC mode. To enable over-current protection, check the **Enable OCP** box.

Note that you can also specify a Delay to prevent momentary CV-to-CC status changes from tripping the over-current protection. The delay can be programmed from 0 to 0.255 seconds. You can specify if the Start of the delay is initiated by any transition into CC mode, or only at the end of a settings change in voltage, current, or output state. Refer to **CC Mode Delay** for more information.

Models N679xA **N679xA** have an additional fixed over-current protection that is always enabled. This protection will turn the output off whenever the input current exceeds 105% of the high ranges and approximately 110% of the low current ranges.

Over-Power Protection - For models N679xA **N679xA** only, the over-power protection will turn the output off if the input power exceeds 110% of the module's power rating. You can program an

over-power protection delay to prevent the over-power protection function from being triggered during the delay time. This prevents momentary input power spikes from triggering the over-power protection. A status bit (CP+) indicates that the output has been turned off by a power limit condition.

All Outputs Status – The Status field shows the status of all outputs. This indicator also appears in the lower left corner of each output in Meter View. When a protection function trips the power analyzer disables the affected output and the status indicator shows which protection function was activated.

Clear All Outputs – To clear the protection function, first remove that condition that caused the protection fault. Then select Clear All Outputs. This clears the protection function and returns the output to its previous operating state.

Advanced button – Advanced protection properties are configured in the Advanced Protection window. Navigate to and select Advanced.

From the remote interface:

To program the OVP level for outputs 1 and 2 to 10 V:

VOLT:PROT 10,(@1,2)

To enable OCP for outputs 1 and 2 and specify a 10 millisecond delay for the OCP:

CURR:PROT:STAT 1,(@1,2)

CURR:PROT:DEL.01,(@1,2)

To start the delay timer by ANY output transition into CC mode:

CURR:PROT:DEL:STAR CCTR, (@1,2)

To start the timer by a settings change in voltage current or output:

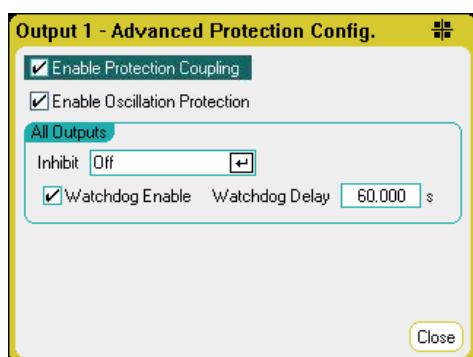
CURR:PROT:DEL:STAR SCH, (@1,2)

To clear an output protection fault on output 1:

OUTP:PROT:CLE (@1)

Advanced Protection

Press the Settings key to access the Source Settings window. Navigate to and select Protection. Navigate to and select Advanced.



Enable Protection Coupling – Checking this box lets you couple the outputs so that when a protection fault occurs on one output, ALL outputs will be turned off.

Enable Oscillation Protection - This is only available on models N678xA SMU N678xA SMU. If open sense leads or capacitive loads outside the allowable range cause the output to oscillate, the oscillation protection function detects the oscillation and latches the output off. The condition is annunciated on the front panel by the Osc status.

All Outputs – For all outputs you can program the Inhibit input (digital pin 3) on the rear panel to act as an external protection shutdown signal. The behavior of this signal can be set to either Latched or Live (non-latched). Off disables the remote inhibit. Refer to [Inhibit Input](#) for further information.

Watchdog – For all outputs you can program a watchdog timer function. The output watchdog timer causes all outputs to go into protection mode if there is no SCPI I/O activity on the remote interfaces (USB, LAN, GPIB) within the user-specified time period. Note that the watchdog timer function is NOT reset by activity on the front panel or when using the Web server – the outputs will still shut down after the time period has elapsed.

After the time period has expired, the outputs will be disabled, but the programmed output state is not changed. This condition is annunciated on the front panel by the Prot status. The delay is programmable from 1 to 3600 seconds in 1 second increments.

From the remote interface:

To program the INH signal to act as an external shutdown:

DIG:PIN3:FUNC INH

To configure the pin polarity for pin 3:

DIG:PIN3:POL POS

To enable output protection coupling:

OUTP:PROT:COUP ON

To enable output oscillation protection:

OUTP:PROT:OSC ON, (@1)

To enable the watchdog timer function and set the delay to 15 minutes (900 seconds):

OUTP:PROT:WDOG ON

OUTP:PROT:WDOG:DEL 900

4

Using the Measurement Functions

Using the Meter Functions

Using the Scope Functions

Using the Data Logger Functions

External Data Logging

Equivalent SCPI commands to program a specific function are included at the end of each topic. However some functions such as the front panel Scope View, Data Logger View, and some Administrative functions do not have equivalent SCPI commands

Using the Meter Functions

Meter View

Meter Ranges and Measurement Times

Seamless Measurements

N678xA SMU Meter-Only Modes

N679xA Load Measurements

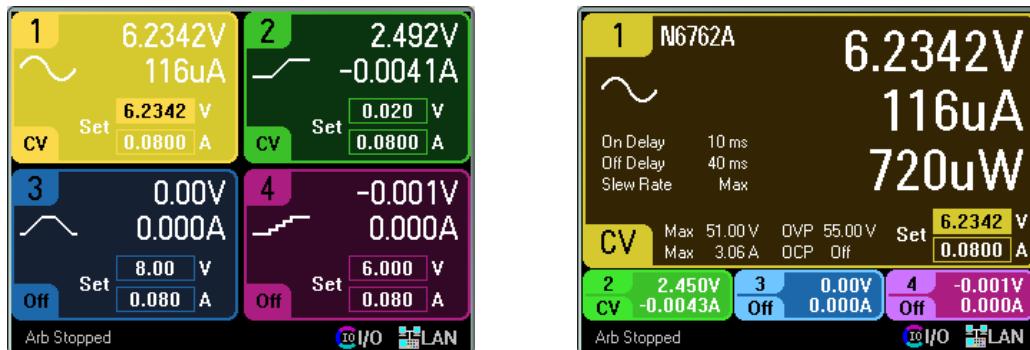
Auxiliary Voltage Measurements

Each power module has a fully integrated voltmeter and ammeter to measure the actual voltage and current being sourced from the output to the device under test. The accuracy of the voltage and current measurements is based on the type of power modules that are installed, as documented in the [Keysight N6700 Modular Power System Family Specifications Guide](#).

Meter View

Each output has its own measurement capability. When the Meter view is displayed, the measurement system continuously measures the output voltage and current. The measurement system acquires as many points as needed based on the number of power line cycles (NPLC) and the time interval, and averages the samples.

As shown below, the default view on the left displays all four outputs. The single-output view on the right displays more information about the selected output. Press the **Meter View** key to toggle between the two views.



From the remote interface:

To trigger and return DC current or voltage measurements:

```
MEAS:CURR? (@1)
MEAS:VOLT? (@1)
```

To return a previously triggered DC current or voltage:

```
FETC:CURR? (@1)
FETC:VOLT? (@1)
```

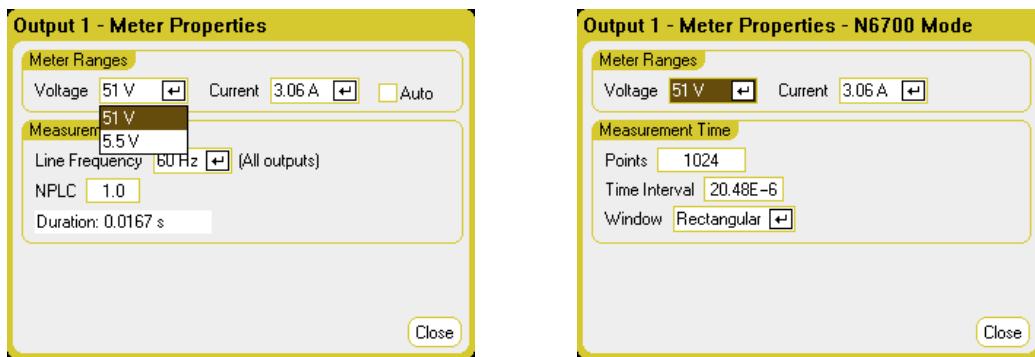
Meter Ranges and Measurement Times

Some power modules have multiple voltage and current meter ranges (see [Model Differences](#)). Selecting a lower measurement range provides greater measurement accuracy, provided that the measurement does not exceed the range. If the measurement exceeds the range, an “Overload” error will occur.

Measurement Time parameters can be configured for all power modules.

From the front panel:

To specify a measurement range, press the **Meter View** key, then press **Properties**.



NOTE How the Meter View measurement system behaves depends on whether the standard controls, or the N6700 Mode controls are selected. N6700 mode controls are selected in the Front Panel Preferences dialog, located in the Utilities menu.

The standard measurement controls are shown in the Meter Properties dialog on the left. These controls are completely independent from the measurement controls for Scope View, Data Logger View, Elog, Histogram, and the SCPI commands.

The N6700 Mode controls are shown in the Meter Properties dialog on the right. In N6700 mode, the Meter View measurement system uses the same measurement control settings as set by their corresponding SCPI commands.

Meter Ranges – In the Voltage or Current dropdown menu, select the desired lower measurement range. Check the **Auto** box to enable measurement autoranging. The instrument automatically selects the best measurement range for the amplitude of the measurement. Note that this functionality is not the same as seamless measurements.

Line Frequency – Specify the ac mains frequency (50 Hz or 60 Hz).

NPLC – Specify the number of power line cycles (NPLC) that the measurement will span. Increase the NPLC for improved accuracy and noise reduction on low current and voltage measurements.

Duration – Indicates the duration of the measurement based on the Frequency and NPLC settings.

N6700 Mode

Meter Ranges – These selections match the SCPI range commands. The Auto selection is not available, as SCPI commands do not support automatic measurement range selection based on amplitude.

Points – Specify the number of sample points in each measurement.

Time Interval – Indicates the integration time of each measurement.

Window – Specify a Hanning or Rectangular measurement window.

From the remote interface:

In N6700 mode, the Meter View measurement system uses the same measurement settings as the following SCPI commands. To specify a voltage or current measurement range:

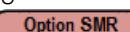
```
SENS:CURR:RANG <current>,(@1)
SENS:VOLT:RANG <voltage>,(@1)
```

The range value that you send should be the maximum value that you expect to measure. The instrument selects the range with the best resolution for the value entered.

You can also specify the points, time interval, and window function:

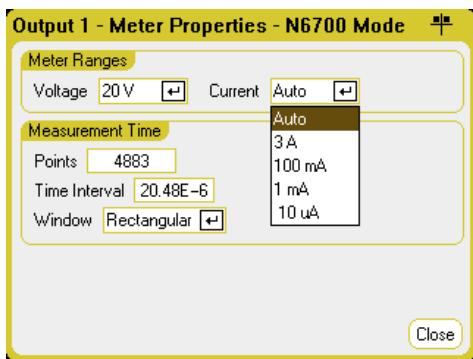
```
SENS:SWE:POIN <points>,(@1)
SENS:SWE:TINT <interval>,(@1)
SENS:WIND RECT|HANN,(@1)
```

Seamless Measurements

Seamless measurement autoranging for both voltage and current is available on models N678xA SMU and with Option SMR.   This enables a wide dynamic measurement range with no data lost across ranges.

NOTE Seamless autoranging does not include the 10 µA range, which must be selected manually. Seamless autoranging is only available in Meter View when N6700 Mode is selected in the Front Panel Preferences dialog, located in the Utilities menu.

To enable seamless voltage or current autoranging, press the **Meter View** key, then press **Properties**. In the Voltage or Current dropdown menu, select Auto.



From the remote interface:

Use the following SCPI commands to enable seamless measurements:

```
SENS:CURR:RANG:AUTO ON,(@1)
SENS:VOLT:RANG:AUTO ON,(@1)
```

N678xA SMU Meter-Only Modes N678xA SMU

Models N678xA SMU can measure voltage or current at the output terminals without involving the source function of the instrument.

Make all measurement connections before selecting the Measure Only functions. This is necessary because when the Measure Only functions are selected, the instrument goes through an initialization sequence that minimizes the amount of disturbances imposed on the DUT.

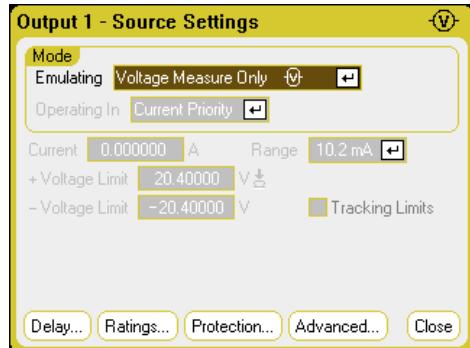
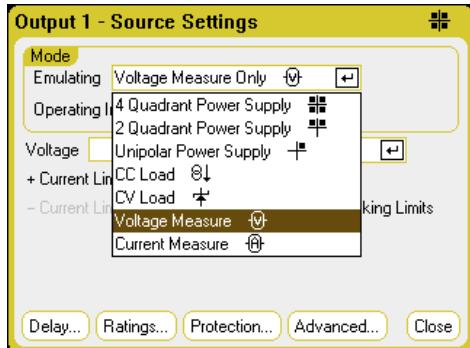
When the Measure Only modes are selected, the output is enabled to allow the meters to measure correctly. The voltage or current measurement is continuously displayed on the Meter View. Both voltage and current meters are active in either mode.



From the front panel:

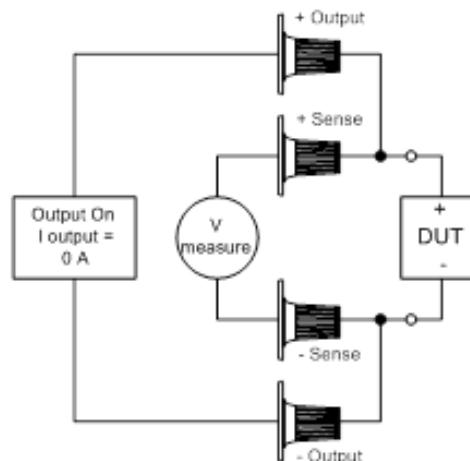
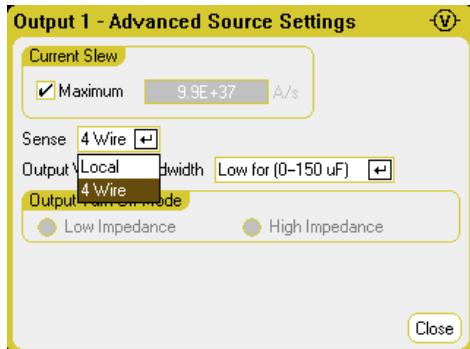
In the Source Settings window, the Voltage Measure selection emulates a voltmeter. Current priority mode is set by default. The +/- Voltage Limits are set to their maximum values. The voltage measurement cannot exceed the voltage ratings of the unit as indicated in the +/- Voltage Limit fields.

4 Using the Measurement Functions

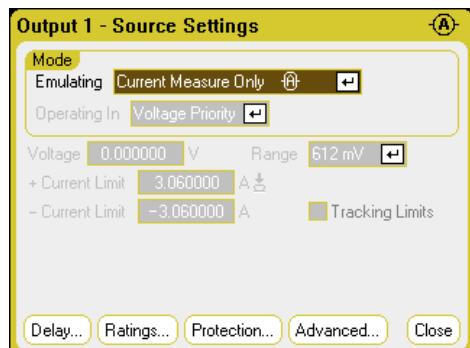
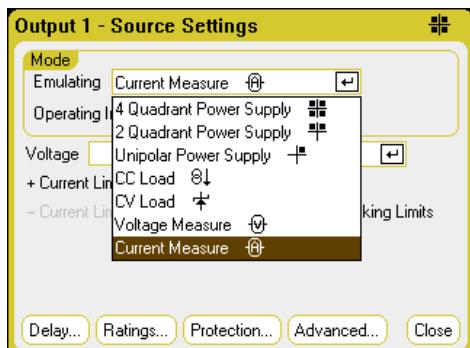


Voltage Measure – the Voltage Measure mode works best when the sense terminals are connected to the output terminals. You can use 4 Wire sensing and connect the sense and output leads directly to the DUT as shown below, or you can use Local sensing and connect only the output leads to the DUT.

NOTE The input impedance in Voltage Measure mode will be somewhere around 2000 pF depending on the grounding of the DUT. This may draw up to a few microamperes of current from the nodes that are being measured.

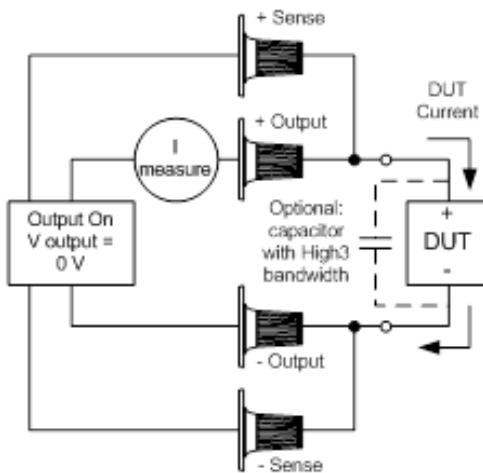
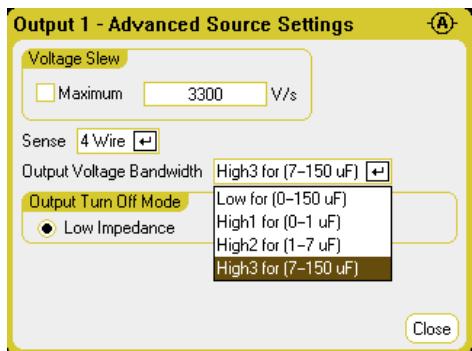


Current Measure – the Current Measure selection emulates a zero-burden ammeter. Voltage priority mode is set by default. The +/- Current Limits are set to their maximum values. The current measurement cannot exceed the current ratings of the unit as indicated in the +/- Current Limit fields.



The following additional settings are also required. Remote sensing (4 Wire) is always required. For applications with transient voltage drops, use the High3 setting with a compensation capacitor across

the DUT. Capacitors can be film or ceramic with values from 7 μF to 150 μF . Refer to [Keysight N678xA SMU Wiring](#) for additional wiring information.



From the remote interface:

To specify current measure and measure the current:

```
EMUL AMET,(@1)
MEAS:CURR?(@1)
```

To specify voltage measure and measure the voltage:

```
EMUL VMET,(@1)
MEAS:VOLT?(@1)
```

N679xA Load Measurements

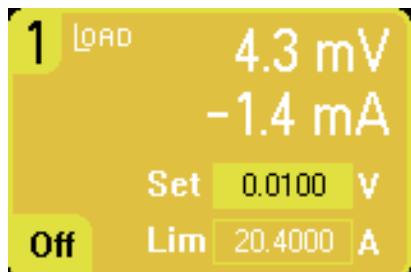
NOTE

This information only applies to Models N679xA.

N679xA

No matter which priority mode you are operating in, the front panel display returns the Voltage and Current measurements from either the output or sense terminals. Power measurements are displayed along with voltage and current in single-channel view.

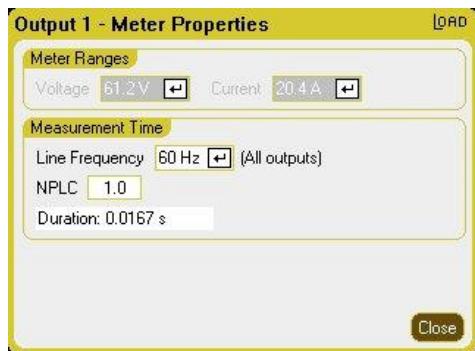
The following meter view applies to Voltage priority mode. Current, power, and resistance views are similar. All measurements have an over-range capability of 20% above the maximum range limit. If the measurement exceeds this limit, an “Overload” error will occur.



From the front panel:

To view the meter properties, press the **Meter View** key, then press **Properties**.

Note that the Meter Properties dialog only displays the voltage or current ranges that have been set in the **Source Settings** dialogs. Also, Load modules have a High and a Low current meter ranges; however, these cannot be selected in the Meter properties window. The reason for this is because measurement ranges are coupled with the priority mode range settings.



The voltage measurement range is set to 61.2 V for all priority modes.

For the Voltage priority mode, the current measurement range is set to High.

For the Power priority low range, the current measurement range is set to Low.

For the Power priority high range, the current measurement range is set to High.

For the Resistance priority high range, the current range is set to Low.

For the Resistance priority medium and low ranges, the current range is set to High.

When changing priority modes, all ranges will be reset to the default (*RST) settings. Measurement ranges are not auto-ranging.

Line Frequency – Specify the ac mains frequency (50 Hz or 60 Hz).

NPLC – Specify the number of power line cycles (NPLC) that the measurement will span. Increase the NPLC for improved accuracy and noise reduction on low current and voltage measurements.

Duration – Indicates the duration of the measurement based on the Frequency and NPLC settings.

From the remote interface:

To trigger and return a measurement:

```
MEAS:CURR? (@1)
MEAS:VOLT? (@1)
```

To return a previous measurement:

```
FETC:CURR? (@1)
FETC:VOLT? (@1)
```

Auxiliary Voltage Measurements

NOTE This information only applies to Models N6781A and N6785A. **N6781A, N6785A**

Models N6781A and N6785A have an auxiliary voltage measurement input, whose primary use is for battery voltage rundown measurements. It may also be suitable for other applications including general purpose DC voltage measurements between +/-20 VDC.

Auxiliary voltage measurements cannot be made along with output voltage measurements. When the auxiliary voltage measurement input is selected, all voltage measurement functions receive their input from this source instead of the normal + and – sense terminals. These functions include the front panel, SCPI measurements, Scope View, Data Logger View, Elog, and histogram measurements.

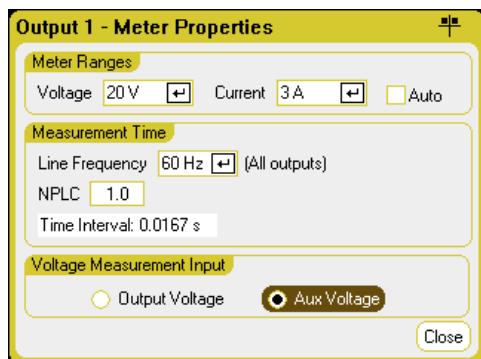
The instrument will continuously display the auxiliary voltage measurement on the Meter View.



NOTE When the auxiliary voltage measurement terminals are left unconnected, the front panel meter will indicate a voltage reading of approximately 1.6V. This is a normal indication which does not affect the external voltage measurement once the measurement terminals are connected.

From the front panel:

To enable auxiliary voltage measurements, select **Meter View**, then **Properties**, then select Aux Voltage.



From the remote interface:

To specify the auxiliary voltage measurement input:

SENS:FUNC:VOLT:INP AUX,(@1)

Using the Scope Functions

Making a Measurement

Scope View

Scope Properties

Scope Ranges

Scope Markers

Horizontal Properties

Scope Presets

The power analyzer's scope function is similar to a bench oscilloscope, displaying output voltage and current signals as a function of time. It has controls that select which outputs and functions to display, front panel knobs that adjust gain and offset, and configurable triggers and markers.

You can configure the Scope View to display voltage or current waveforms for all outputs. Power waveforms can only be displayed on Keysight Models N676xA and N678xA SMU, as these have simultaneous voltage and current measurement capability (see [Model Differences](#)). As explained under [Horizontal Properties](#), the maximum sampling rate of the scope varies, depending on the number of waveforms that are displayed. Note that in the Scope View there is only one time-base and trigger configuration for all outputs.

Making a Measurement

In the following measurement example, an output turn-on sequence is displayed using the oscilloscope. The oscilloscope measures the actual voltages as the outputs turn on.

Step 1 – Program the output voltage and current values:

In Meter View, set the output voltage and currents of all four outputs of the power analyzer to 10 volts and 1 ampere. This is described under [Turning the Unit On](#).

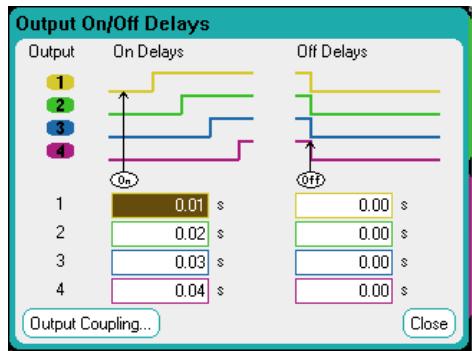


Step 2 – Configure the output turn-on sequence:

Configure the output turn-on sequence as described under [Configuring a Turn-On/Turn-Off Sequence](#).

Note that you will only need to configure the Turn-on delays, not the turn off delays. The turn on delays for the output channels are as follows:

- Output 1: 10 ms
- Output 2: 20 ms
- Output 3: 30 ms
- Output 4: 40 ms



Step 3 – Configure the Scope View traces:

- Check V1 through V4
- Uncheck I1 through I4
- Use the **Vertical Volts/Div.** knob to set V1 through V4 to 10 V/Div.
- Use the **Offset** knob to move the four traces so that they are separated by at least one space on the vertical grid.
- Use the **Horizontal Time/Div.** knob to set the timebase to 20 ms.

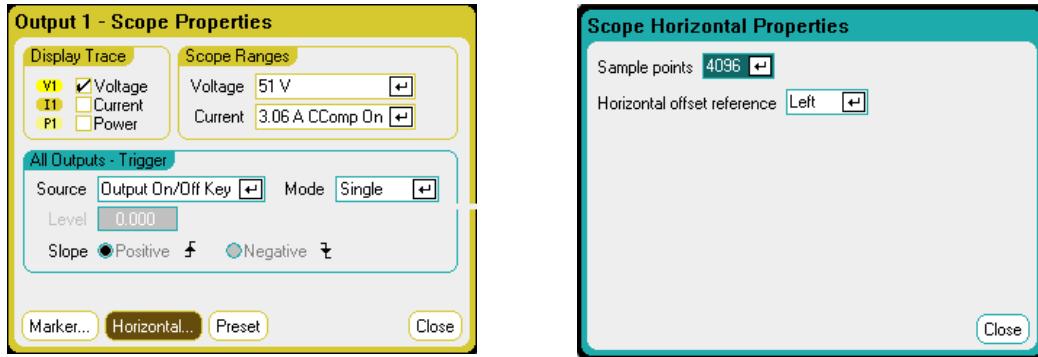


Step 4 – Configure the Scope properties:

Press the **Properties** key to configure the scope properties as follows:

- In the Trigger Source dropdown list, select Output On/Off Key.
- In the Mode dropdown list, select Single.
- Select the Horizontal button and make sure that the Horizontal Offset Reference is set to Left.

4 Using the Measurement Functions

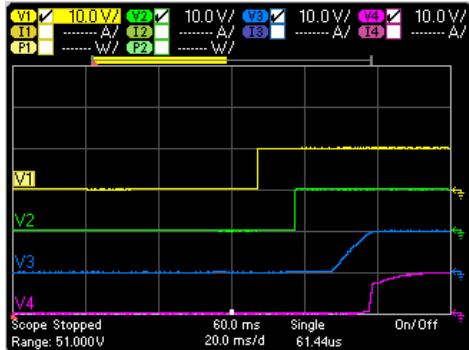


Step 5 – Turn on the outputs and measure the voltage:

Press the **Scope View** key to return the display the scope view:

- Press the **Run/Stop** key to run the scope. When this key is lit, it indicates that the scope is running.
- Press the **All Outputs On** key to start the output sequence and trigger the scope.

You should see the output waveforms displayed as follows:



Note that the delay for output 1 does not start until 57 milliseconds have elapsed. This is because the internal delay for the mainframe used in this example is 57 milliseconds. This built in delay precedes any user-defined delays that have been programmed.

Also note that outputs 3 and 4 start at the specified delay time but do not ramp up as fast as outputs 1 and 2. This is because Outputs 1 and 2 are “Precision” and “High Performance” modules, while outputs 3 and 4 are “DC Power” modules, which have a slower turn-on ramp. Refer to [Model Differences](#).

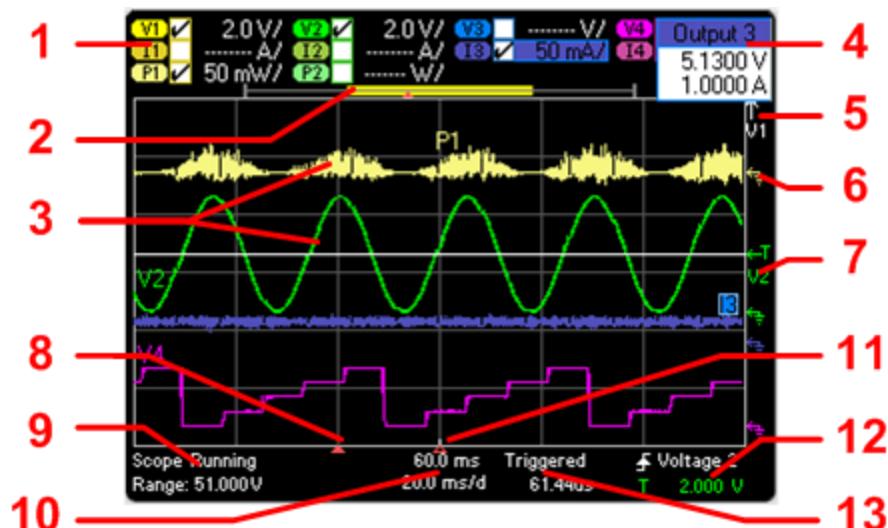
From the remote interface:

You cannot program the scope from the remote interface.

Scope View

Press the **Scope View** key to view the scope. This key toggles between the Standard view shown below, and Marker view, which enables markers and marker calculations.

Standard View

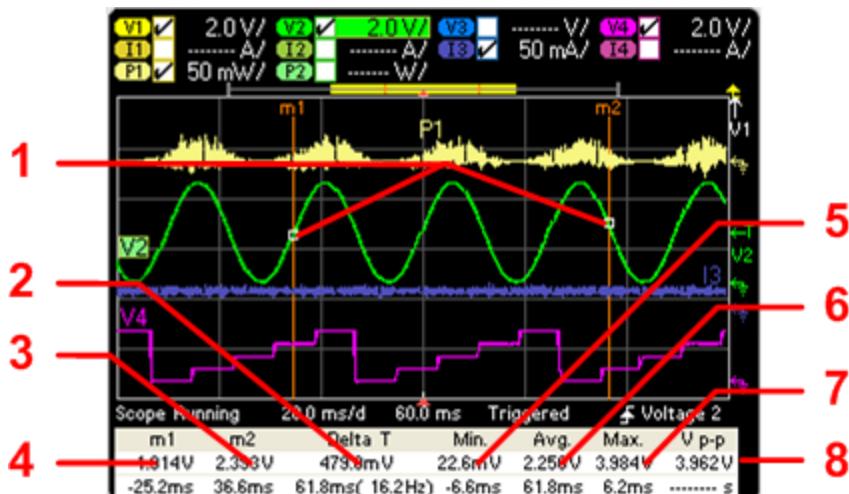


Symbol/Field	Description
1 Trace Controls	Identifies the volt/div. or curr/div. setting. ✓ indicates the trace is on. Dashes (----) indicate the trace is off. Select the trace and press Enter to turn it on or off.
2 Data Bar	The data bar represents all of the waveform data that has been collected. The yellow part indicates the portion of the data that is visible on the display. The black part represents the data that is not visible.
3 Scope Traces	Voltage trace labels appear on the left side of the grid (V1 V2, V3, V4). Current trace labels appear on the right side of the grid (I1, I2, I3, I4). Power trace labels appear on the center of the grid (P1, P2, P3, P4). If a portion of a trace is red, it means that portion of the trace is out of range. Push the Trigger Level knob to autoscale the traces. This will trigger a new measurement. Only Models N676xA and N678xA SMU can display power traces.
4 Output Pop-ups	Turning the voltage and current knobs displays a pop-up dialog showing the present output settings. Pushing the voltage and current knobs displays a pop-up dialog allowing the following actions: <ul style="list-style-type: none"> • Lock/Unlock the voltage or current knobs. • On Models N678xA, select a limit parameter to control or select limit tracking.
5 Out of View Arrows	Indicate that the trace, V1 in the figure, is out of view. Use the Vertical Volt/Div knob or the Vertical Offset knob to bring the trace into view. Push the Trigger Level knob to autoscale the traces. This will trigger a new measurement.
6 Ground Reference	The ground reference of the trace. Ground references are offset so that they do not overlap. The ground reference offset value is referenced to the horizontal center line of the grid.

4 Using the Measurement Functions

Symbol/Field	Description
7 Trigger Level	Shows the location of the voltage or current trigger level and output. In this example, the voltage trigger level of output 2 is shown. The trigger source and amplitude are shown at the bottom right of the display.
8 Trigger Indicator	Shows the position of the trigger with respect to the waveform. In the figure, the trigger is offset to the left of the original point. The trigger point corresponds to the offset reference when the offset is zero.
9 Scope Status	Indicates whether the scope is Running, Stopped, or Waiting for a trigger.
Range	Range indicates the measurement range setting of the selected trace. If the range field is red, it means that portions of the selected trace are out of range.
10 Time	Indicates the time from the trigger point indicator to the vertical center line of the grid. Negative values indicate the center line is to the left of the trigger point. Positive values indicate the center line is to the right of the trigger point. Use the front panel Horizontal Offset knob to adjust the trigger point.
Time/Div.	Time/Div. identifies the horizontal time-base setting. This can be adjusted using the front panel Horizontal Time/Div knob.
11 Horizontal Reference	Indicates the horizontal reference. In the figure, the reference is centered. Change the reference justification in the Scope Horizontal Properties window.
12 Trigger Source	In the figure, the trigger source is a voltage level on output 2.
	 Up trigger indicates the measurement will be triggered on the up-slope (positive).
	 Down trigger indicates the measurement will be triggered on the down-slope (negative).
Amplitude	If the trigger source is set to a voltage or current level, the amplitude of the trigger level is indicated below the trigger source. In the figure, the voltage trigger level is set to 4.5 V.
13 Trigger Mode	Indicates the trigger mode (Auto, Single, or Triggered).
Sample Rate	The indicated scope sample rate is based on the horizontal time/div. setting. When the time/div. setting is less than 20 ms/division, the scope will sample at its fastest rate, depending on the number of traces selected: 1 trace (Model N678xA SMU only): 5.12 microseconds 1 to 2 traces (all modules): 10.24 microseconds 3 to 4 traces (all modules): 20.48 microseconds

Marker View



Symbol/Field	Description
1 m1/m2 points	Shows where the measurement markers intersect the selected waveform. Data values at the bottom of the display are referenced to the intersect locations of the markers. Calculations are based on the data points in between the intersect locations.
2 Delta	Indicates the delta or absolute difference between the markers in units (volts, amps, or watts) and in time (seconds). The value in parenthesis is the frequency, which is the reciprocal of the time (1/time).
3 m2	Indicates the m2 marker value in volts, amps, or watts at the intersection point. Also indicates the distance in time that the m2 marker is in relation to the present trigger position.
4 m1	Indicates the m1 marker value in volts, amps, or watts at the intersection point. Also indicates the distance in time of the m1 marker in relation to the present trigger position.
5 Min	Indicates the minimum data value (in volts, amps, or watts) between the marker locations of the selected waveform. Also indicates the distance in time of the minimum value in relation to the present trigger position.
6 Avg	Calculates the average data value (in volts, amps, or watts) between the marker locations of the selected waveform. Time indicates the time between markers over which the average value is calculated.
7 Vp-p	Indicates the maximum data value (in volts, amps, or watts) between the marker locations of the selected waveform. Also indicates the distance in time of the maximum value in relation to the present trigger position.
8 Trigger Mode	Calculates the difference between the maximum and minimum values. Time information is not valid for calculated p-p values.
RMS (if selected)	Calculates the rms value between the marker locations. To view the rms values, you may need to unselect one of the other measurements in the Scope Marker Properties window. Only 5 measurements may be displayed at a time.

Using the Waveform Display Knobs



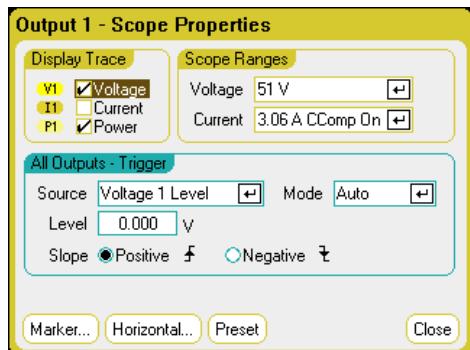
Symbol/Field	Description
1 Vertical Volts/Div.	Makes the waveform bigger or smaller vertically in relation to its ground reference. Specified in volts/division or amps/division on the y axis. On outputs with multiple ranges, when Knob Control is selected in the Scope Range Property window, adjusting the vertical gain will automatically select lower measurement ranges for better resolution. If the vertical gain causes the trace to be out of view, arrow symbols will indicate the direction of the trace.
2 Vertical Offset	Moves the ground reference of the trace up or down in relation to the horizontal center line of the grid. The offset popup that appears in the upper right corner of the display shows how far the ground reference of the selected trace is above or below the horizontal center line of the grid.
3 Trigger Level	Moves the trigger level up and down when a voltage or current level is the trigger source. The trigger level is identified by the symbol. If the trigger level is out of view, an arrow indicates the direction of the trigger level. Push the Trigger Level knob to auto-scale the traces on the display. This will trigger a new measurement.
4 Horizontal Time/Div	Stretches or shrinks the waveform horizontally around the horizontal offset reference. Specified in time/division on the x axis. Applies to ALL traces.
5 Horizontal Offset	Moves the waveform to the right or left of the horizontal offset reference. The trigger point is indicated by the solid arrow.

Symbol/Field	Description
6 Marker 1/Marker 2	Moves the measurement markers right or left. Press Scope View to display the markers. Markers are displayed on the selected trace. Values at the bottom of the display are referenced to the intersection of the markers. If a marker is out of view, an arrow indicates the direction of the marker m2 > .
	Push the Marker 1 or Marker 2 knobs to reset the markers. When pushed, the following menu appears. 
	Push the Enter key to Reset the marker. Push Enter again to undo the reset action. Scroll down and select Marker options to access the Scope Marker Properties window. Scroll down and select Jump to peak to move the marker to the peak measurement point of the trace.

Scope Properties

NOTE There are no remote interface commands that correspond directly to the front panel Scope functions. Refer to [Digitizing Measurements](#) for information on programming digitized measurements from the remote interface.

With the Scope View displayed, press the **Properties** key to access the Scope Properties window.



Display Trace lets you select which traces to display for the output. If no box is checked, no traces will be displayed for that output. Voltage, current, and power traces can be displayed simultaneously only on Models N676xA and N678xA SMU, as these models have simultaneous voltage and current measurement capability (see [Model Differences](#)). All other power modules can display either voltage or current traces, but not simultaneously.

Source dropdown lets you select a trigger source. This trigger source will trigger the scope measurements on all output channels. Depending upon the selected trigger source, you can trigger the scope as follows:

4 Using the Measurement Functions

Trigger Source	Description
Voltage <1-4> level Current <1-4> level	Triggers the measurement when the voltage or current of the corresponding output passes through the specified level.
Arb Run/Stop key	Triggers the measurement when the Arb Run/Stop key is pressed.
Output On/Off key	Triggers the measurement when any of the Output On/Off keys are pressed. Also applies to the All Outputs On/Off key.
BNC Trigger In	Provide a low-true signal to the BNC trigger input connector. Refer to Supplemental Characteristics for minimum pulse width. Selecting BNC Trigger In also enables any digital I/O pins configured as Trigger Outputs .
Remote Command	Send a trigger command over one of the three interfaces (i.e. *TRG).

If a trigger source is grayed out, it is unavailable. This can happen on power modules that cannot simultaneously display voltage and current. For these power modules, if one of the traces has been turned on, you cannot use the other trace as the trigger source. Also, current levels are not available as trigger sources on outputs that have been grouped (paralleled).

Level lets you specify a trigger level if you selected a Voltage level or Current level as the trigger source.

Slope specifies if the measurement will be triggered on the positive (up-slope) or negative (down-slope) portion of the waveform.

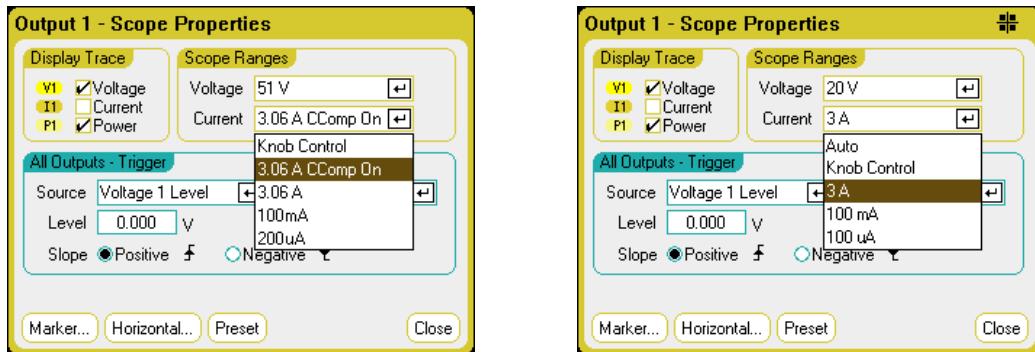
Mode dropdown lets you select a trigger mode.

Trigger Mode	Description
Auto	Configures the scope to display a single-sweep measurement when a trigger is received, or automatically if a trigger is not received. The scope continues running and waits for another trigger when the measurement completes.
Single	Configures the scope to display a single-sweep measurement when a trigger is received. The scope stops running when the measurement completes.
Triggered	Configures the scope to display a single-sweep measurement when a trigger is received. The scope continues running and waits for the next trigger when the measurement completes.

Scope Ranges

For outputs that have multiple measurement ranges, you can select a lower range for better measurement resolution. Scope range settings are independent of the Meter View and Data Logger range settings.

In the Scope Ranges area, select the desired lower measurement range from the Voltage or Current dropdown menus.



Selecting Knob Control allows the Vertical Volts/Div knob on the front panel to automatically select lower measurement ranges at higher measurement resolutions. For lower measurement resolution a higher range is automatically selected. The present range is displayed on the lower left corner of the Scope View window.

Some models have a high measurement range labeled CComp On, which is selected by default. The CComp On range compensates output current measurements during voltage transients. For more information, see [Dynamic Current Measurement Control](#).

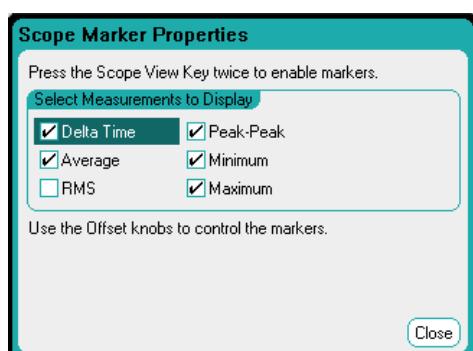
NOTE On Keysight N679xA Load modules [N679xA](#), the source and measurement ranges are coupled. Therefore the scope measurement ranges are not settable (grayed out) in the Scope Properties window.

Seamless Measurements

For Models N6781A, N6782A, N6785A, and N6786A, you can select seamless voltage and current measurements, which results in a wide dynamic range with no data being lost across ranges. Select Auto to enable seamless measurement ranging. Seamless ranging does not include the 10 μ A range, which must be selected manually.

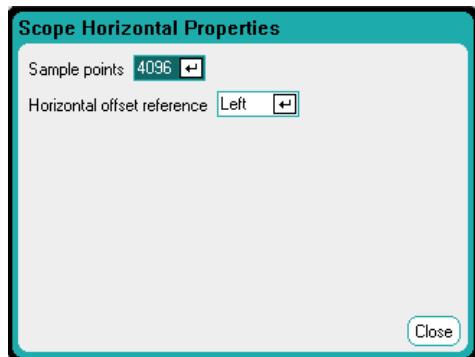
Scope Markers

Select the Markers button to configure the measurements that appear on the bottom of the display in Marker view. Measurements apply to the portion of the waveform between the two markers. You can only select a maximum of five measurements to be displayed.



Horizontal Properties

Select the Horizontal button to configure the horizontal properties.



Sample Points - lets you specify the number of points in a scope trace. The maximum number of points that can be specified depends on the number of scope traces that have been enabled. The minimum number of points that can be specified is 1024.

1 trace enabled: 256 K points

2 traces enabled: 128 K points

4 traces enabled: 64 K points

8 traces enabled: 32 K points (maximum points = 256 K/# of traces)

The Power trace counts as 2 traces, since voltage and current must be measured to calculate power. If the voltage and current traces have already been selected, the Power trace is not counted

Horizontal Offset Reference - places the reference point on the left, right, or center of the display. This is the position of the trigger if no offset has been set. Left lets you see the waveform after the trigger event. Center lets you see the waveform before and after the trigger event. Right lets you see the waveform up to the trigger event.

Scope Presets

Select the Preset button to return the Scope View to the power-on display settings. The vertical offset of each trace will be set to a different value. This is to prevent the traces from overlapping. The offset is referenced to the horizontal center line of the grid.

Using the Data Logger Functions

Logging Data

Data Logger View

Data Logger Properties

Data Logger Ranges

Data Logger Trigger

Data Logger Filename

Data Logger Markers

Data Logger Presets

Data Logger Sampling Modes

Data Logger and Scope Display Differences

NOTE

The Data Logger function is not available if Option 055 has been ordered.

The Data Logger is similar to the Scope View function except that it lets you view and log output voltage and current data for up to 99,999 hours.

As in Scope View, you can configure the Data Logger View to display voltage or current waveforms for all outputs. Power waveforms can be displayed for all outputs because of the interleaved data logging capability. Refer to [Data Logger Sampling Modes](#) for more information.

The display functions like a strip chart recorder. Use the Waveform Display knobs to scroll through the data. Unless specified otherwise, data is automatically stored to a file named *default.dlog*.

Logging Data

In the following data log example, a user-defined arbitrary waveform is captured on the data logger. The data logger records the actual output voltage of the arbitrary waveform.

Step 1 – Program the arbitrary waveform:

Configure the user-defined arbitrary waveform as described under [Configuring User-Defined Arbs](#). Program the voltage and time values as follows:

Step 0: 10 V; 1 s

Step 1: 20 V; 1 s

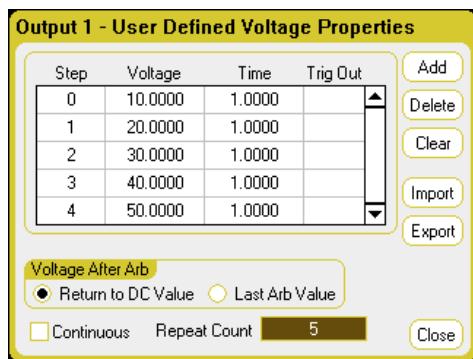
Step 2: 30 V; 1 s

Step 3: 40 V; 1 s

Step 4: 50 V; 1 s

Repeat Count: 5

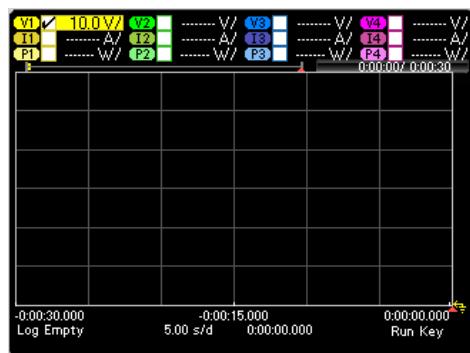
4 Using the Measurement Functions



Step 2 – Configure the data logger traces:

- Check V1
- Uncheck V2 through V4 as well as the current and power traces
- Use the Vertical Volts/Div. knob to set V1 10 V/Div.
- Use the Offset knob to move the V1 trace to the bottom of the grid.

Traces are color coded according to output. The ground symbol on the right side of the display indicates the ground reference of the trace.



Step 3 – Configure the data logger properties:

Press the **Properties** key to configure the data logger properties.

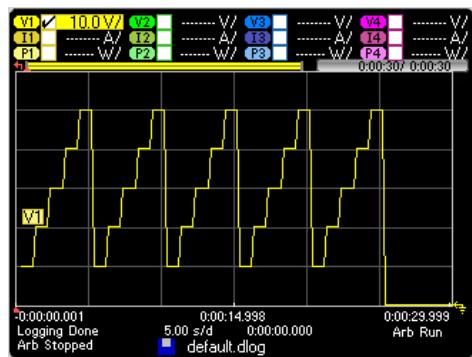
- Leave the default Duration and Sample Period at 30 seconds and 100 milliseconds respectively.
- Select the Trigger button and set the trigger source to Arb Run/Stop Key.

Step 4 – Turn on output 1, start the Arb, and log the data:

Press the **Data Logger** key to return the display to the data logger view:

- Press the **Output 1 On** key to turn on output 1.
- Press the **Run/Stop** key to run the data logger. When this key is lit, the data logger is initiated and the output 1 trace is displayed on the screen.
- Press the **Arb Run/Stop** key to start the user-defined Arb and trigger the data logger.

The data logger will run for 30 seconds and log the voltage data from output 1. When the data log completes, you should see the output waveform displayed as follows:

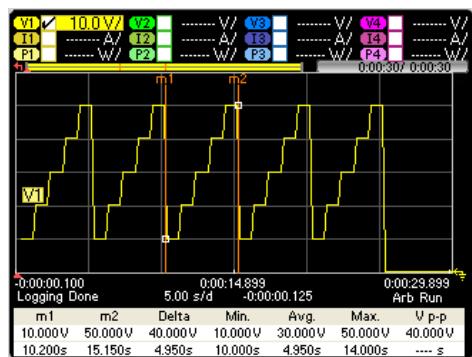


A message will indicate that the logged data has been saved in a file named default.dlog. If you wish to save the data under a different filename, you must specify the filename before the data logger runs. Select the **Filename** button located in the Datalogger Properties dialog to specify a filename.

Step 5 – Use the marker controls to measure the logged data:

Press the **Data Logger** key to display the marker controls.

- Use the **Marker 1** and **Marker 2** knobs to move the markers along the voltage trace. Measurements between the markers are displayed on the bottom of the display.
- You can also use the **Vertical Volts/Div** knob and the **Horizontal Time/Div** knob to zoom in on any portion of the logged data.



From the remote interface:

To program a User-defined voltage waveform of five steps on output 1:

4 Using the Measurement Functions

```
ARB:FUNC:TYPE VOLT,(@1)
ARB:FUNC:SHAP UDEF,(@1)
ARB:VOLT:UDEF:LEV 10,20,30,40,50,(@1)
ARB:VOLT:UDEF:DWEL 1,(@1)
ARB:VOLT:UDEF:BOST 0,(@1)
ARB:TERM:LAST OFF,(@1)
```

To initiate the transient trigger system:

```
VOLT:MODE ARB,(@1)
TRIG:ARB:SOUR BUS
INIT:TRAN (@1)
```

To set up the data log for output 1:

```
SENS:DLOG:FUNC:VOLT ON,(@1)
SENS:DLOG:TIME 30
SENS:DLOG:PER .1
```

To initiate that data logger and specify the filename in which to save the data:

```
TRIG:DLOG:SOUR BUS,(@1)
INIT:DLOG "internal:\data1.dlog"
```

To turn on output 1 and trigger the Arb and the data logger:

```
OUTP ON, (@1)
*TRG
```

Once the data log completes, you can position the data log markers and return data from between the marker locations. To position the two data log markers at 10 seconds and at 15 seconds from the start trigger of the data log:

```
SENS:DLOG:MARK1:POIN 10
SENS:DLOG:MARK2:POIN 15
```

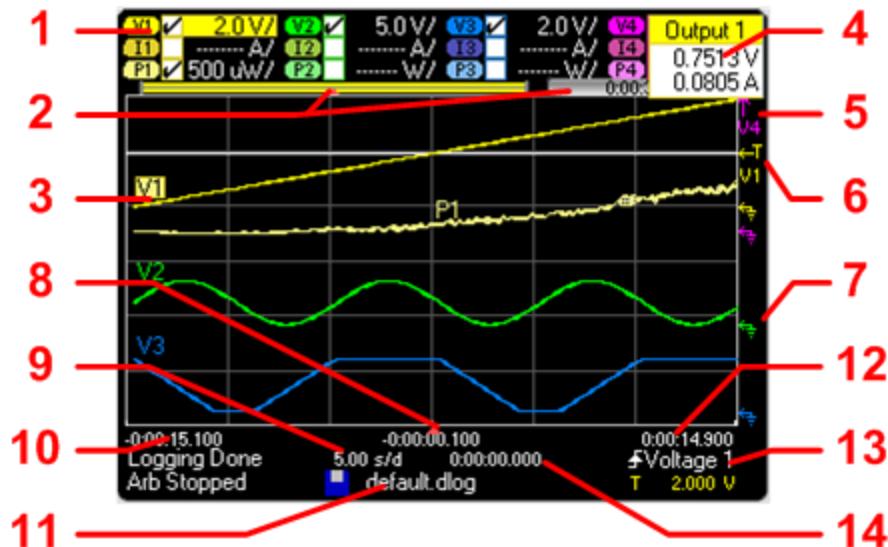
The following commands return either the average, minimum, or maximum values between the marker positions:

```
FETC:DLOG:VOLT? (@1)
FETC:DLOG:VOLT:MIN? (@1)
FETC:DLOG:VOLT:MAX? (@1)
```

Data Logger View

Press the **Data Logger** key to access the data logger. This key toggles between the Standard view shown below, and Marker view, which enables markers and marker calculations.

Standard View

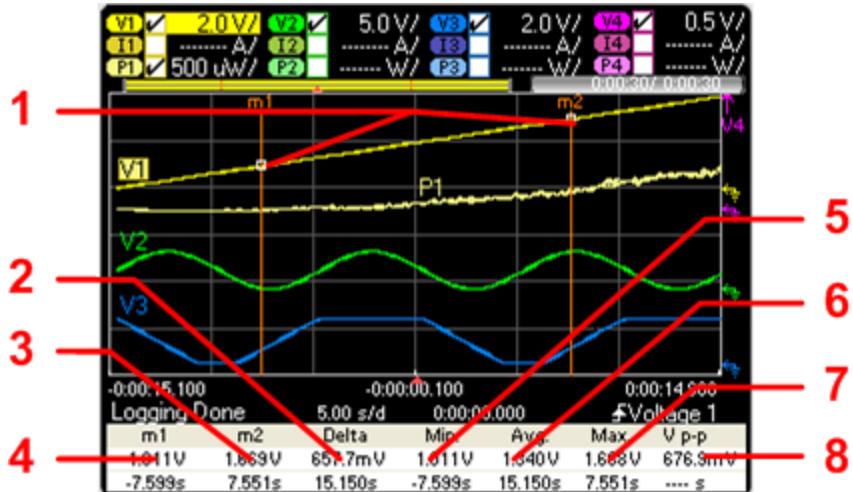


Symbol/Field	Description
1 Trace Controls	Identifies the volt/div. or curr/div. setting. ✓ indicates the trace is on. Dashes (----) indicate the trace is off. Select the trace and press Enter to turn it on or off.
2 Data Bar	The data bar represents all of the logged data. The yellow part indicates the portion of the data that is visible on the display. The black part represents the data that is not visible.
Time Elapsed	Indicates the time elapsed during the data log and the total duration. The values match when data logging finishes.
3 Data Traces	Voltage trace labels appear on the left side of the grid (V1 V2, V3, V4). Current trace labels appear on the right side of the grid (I1, I2, I3, I4). Power trace labels appear on the center of the grid (P1, P2, P3, P4). If a portion of a trace is red, it means that portion of the trace is out of range. Push the Trigger Level knob to auto-scale the data traces.
4 Output Pop-ups	Turning the voltage and current knobs displays a pop-up dialog showing the present output settings. Pushing the voltage and current knobs displays a pop-up dialog allowing the following actions: <ul style="list-style-type: none"> • Lock/Unlock the voltage or current knobs. • On Models N678xA, select a limit parameter to control or select limit tracking.
5 Out of View Arrows	Indicate that the trace, V4 in the figure, is out of view. Use the Vertical Volt/Div knob or the Vertical Offset knob to bring the trace into view. Push the Trigger Level knob to autoscale the data traces.
7 Trigger Level	Shows the location of the voltage or current trigger level and output. In this example, the voltage trigger level of output 1 is shown. The trigger source and amplitude are shown at the bottom right of the display.

4 Using the Measurement Functions

Symbol/Field	Description
6 Ground Reference	The ground reference of the trace. Ground references are offset so that they do not overlap. The ground reference offset value is referenced to the horizontal center line of the grid.
8 Trigger Point Indicator	Indicates the trigger position in the data log. In this example the trigger point was offset by 50%, and the pre trigger data and the post trigger data was logged. The time at the trigger point is always zero. Change the trigger offset in the Datalogger Trigger Properties window.
9 Time/Div.	Identifies the horizontal time-base setting. This can be adjusted using the front panel Horizontal Time/Div knob.
10 Left-Grid Time	Identifies the time at the left gridline in relation to the trigger point. If the trigger is at the left of the grid, the time will be zero.
11 Filename	Indicates the filename of the data that is being displayed.
12 Right-Grid Time	Identifies the time at the right gridline in relation to the trigger point. If the trigger point is at the start of the data log, the time will equal the total duration of the data log.
13 Trigger Source	In the figure, the trigger source is a voltage level on output 1. The Data Logger starts logging data when the indicated level is reached.
	 Up trigger indicates the data logger will be triggered on the up-slope (positive).  Down trigger indicates the data logger will be triggered on the down-slope (negative).
Amplitude	If the trigger source is set to a voltage or current level, the amplitude of the trigger level is indicated below the trigger source. In the figure, the voltage trigger level is set to 2 V.
14 Offset Time	Indicates the time that the right gridline is offset or away from the end of the data log. When this value is zero, it means that the right gridline is positioned at the end of the data log. Turning the offset knob will move the grid away from the end of the data log, as indicated by the Offset Time. The yellow part of the bar represents the data that is visible on the display. The black part represents the offset time.

Marker View

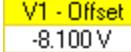


Symbol/Field	Description
1 m1/m2 points	Shows where the measurement markers intersect the selected waveform. Data values at the bottom of the display are referenced to the intersect locations of the markers. Calculations are based on the data points in between the intersect locations.
2 Delta	Indicates the delta or absolute difference between the markers in units (volts, amps, or watts) and in time (seconds).
3 m2	Indicates the m2 marker value in volts, amps, or watts at the intersection point. Also indicates the distance in time that the m2 marker is in relation to the present trigger position.
4 m1	Indicates the m1 marker value in volts, amps, or watts at the intersection point. Also indicates the distance in time of the m1 marker in relation to the present trigger position.
5 Min	Indicates the minimum data value (in volts, amps, or watts) between the marker locations of the selected waveform. Also indicates the distance in time of the minimum value in relation to the present trigger position.
6 Avg	Calculates the average data value (in volts, amps, or watts) between the marker locations of the selected waveform. Time indicates the time between markers over which the average value is calculated.
7 V p-p	Indicates the maximum data value (in volts, amps, or watts) between the marker locations of the selected waveform. Also indicates the distance in time of the maximum value in relation to the present trigger position.
8 Trigger Mode	Calculates the difference between the maximum and minimum values. Time information is not valid for calculated p-p values.
Ah (if selected)	Calculates the Amp-hours between the marker locations. To view the Amp hours, you may need to unselect one of the other measurements in the Datalogger Marker Properties window. Only 5 measurements may be displayed at a time.
Wh (if selected)	Calculates the Watt-hours between the marker locations. To view the Watt hours, you may need to unselect one of the other measurements in the Datalogger Marker Properties window. Only 5 measurements may be displayed at a time.

Using the Waveform Display Knobs



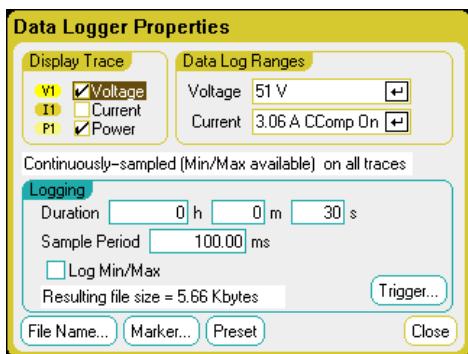
4 Using the Measurement Functions

Symbol/Field	Description
1 Vertical Volts/Div.	Makes the waveform bigger or smaller vertically in relation to its ground reference. Specified in volts/division or amps/division on the y axis. On outputs with multiple ranges, when Knob Control is selected in the Scope Range Property window, adjusting the vertical gain will automatically select lower measurement ranges for better resolution. If the vertical gain causes the trace to be out of view, arrow symbols will indicate the direction of the trace . 
2 Vertical Offset	Moves the ground reference of the trace up or down in relation to the horizontal center line of the grid. The offset popup that appears in the upper right corner of the display shows how far the ground reference of the selected trace is above or below the horizontal center line of the grid. 
	Positive values indicate that the center line is above the ground reference. Negative values indicate that the center line is below the ground reference.
3 Trigger Level	Moves the trigger level up and down when a voltage or current level is the trigger source. The trigger level is identified by the  symbol. If the trigger level is out of view, an arrow  indicates the direction of the trigger level. Push the Trigger Level knob to auto-scale the traces on the display.
4 Horizontal Time/Div	Zooms in or out of the data so that you can view waveform details. The numbers on the bottom of the display indicate the location of the data that is being viewed relative to the entire data log.
5 Horizontal Offset	Moves the grid area to the right or left along the logged data.
6 Marker 1/Marker 2	Moves the measurement markers right or left. Press Data Logger to display the markers. Markers are displayed on the selected trace. Values at the bottom of the display are referenced to the intersection of the markers. If a marker is out of view, an arrow indicates the direction of the marker  .
	Push the Marker 1 or Marker 2 knobs to reset the markers. When pushed, the following menu appears. 
	Push the Enter key to Reset the marker. Push Enter again to undo the reset action. Scroll down and select Marker options to access the Datalogger Marker Properties window. Scroll down and select Jump to peak to move the marker to the peak measurement point of the trace.

Data Logger Properties

From the front panel:

With the Data Logger View displayed, press the **Properties** key to access the Scope Properties window.



Display Trace – lets you select which traces to display for the output. If no box is checked, no data logging will occur on the output.

The text line under the traces identifies the data logging mode. Continuously-sampled mode continuously samples the voltage or current data and stores one averaged value per sample period. Selecting Log Min/Max also stores the minimum and maximum values per sample period. Standard (interleaved) mode alternates voltage and current measurements. One voltage and one current value is returned per sample period.

NOTE Depending on which traces are enabled on specific power modules, the Data Logger selects between Continuously-sampled mode and Normal (interleaved) mode. Refer to [Data Logger Sampling Modes](#) for more information.

Duration lets you specify the duration of the data log in hours, minutes, and seconds. The maximum duration is 99,999 hours. The logging information applies to data logger measurements on all output channels.

Sample Period specifies the interval between data samples in milliseconds, which can be set from 20 microseconds to 60 seconds.

Log Min/Max when checked, lets you log the minimum and maximum values to the data log file when in Continuously-sampled mode. With Log Min/Max checked, the resulting file size will triple.

Resulting file size text box indicates the file size when the data log completes. The maximum file size is 2E9 bytes (1.87 Gbytes in Microsoft Windows units). If settings exceed this limit, the logging interval will automatically increase to keep the size within the limit. If the file size exceeds the available space on the drive to which it will be written, an error is generated and the Data Logger will not run.

From the remote interface:

To enable current or voltage data logging on outputs 1 and 2:

```
SENS:DLOG:FUNC:CURR ON,(@1,2)
SENS:DLOG:FUNC:VOLT ON,(@1,2)
```

You cannot data log output power from the remote interface. To obtain power data, you need to data log both voltage and current and then calculate the power from the resulting voltage and current data.

To log the minimum and maximum values to the data log file for all enabled outputs:

4 Using the Measurement Functions

SENS:DLOG:FUNC:MINM ON

To specify a data log of 1000 seconds on all enabled outputs:

SENS:DLOG:TIME 1000

To specify a sample period of 50 milliseconds between data samples on all enabled outputs:

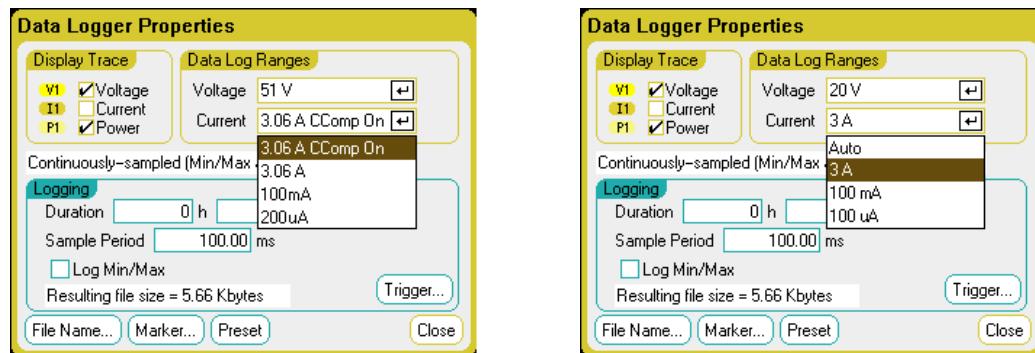
SENS:DLOG:PER .05

Data Logger Ranges

For outputs that have multiple measurement ranges, you can select a lower range for better measurement resolution. Data Logger range settings are independent of the Meter View and Scope range settings.

From the front panel:

In the Data Log Ranges area, select the desired lower measurement range from the Voltage or Current dropdown menus.



Some models have a high measurement range labeled CComp On, which is selected by default. The CComp On range compensates output current measurements during voltage transients. For more information, see [Dynamic Current Measurement Control](#).

NOTE On Keysight N679xA Load modules **N679xA**, the source and measurement ranges are coupled. Therefore the data logger measurement ranges are not settable (grayed out) in the Data Logger Properties window.

Seamless Measurements

Seamless measurement autoranging for both voltage and current is available on models N678xA SMU and with Option SMR. **N678xA SMU** **Option SMR** This enables a wide dynamic measurement range with no data lost across ranges.

Seamless ranging does not include the 10 μ A range, which must be selected manually. Select Auto to enable seamless measurement ranging.

From the remote interface:

To enable seamless measurement autoranging:

```
SENS:DLOG:CURR:RANG:AUTO ON,(@1)
SENS:DLOG:VOLT:RANG:AUTO ON,(@1)
```

To select a lower current or voltage measurement range:

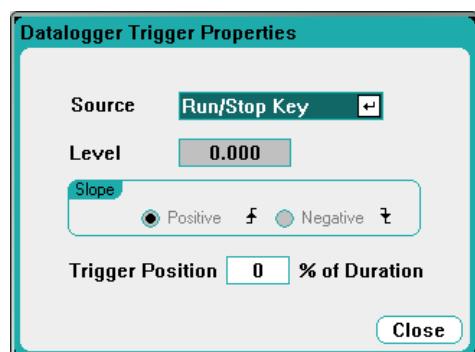
```
SENS:DLOG:CURR:RANG 0.1, (@1)
SENS:DLOG:VOLT:RANG 5, (@1)
```

Data Logger Trigger

NOTE Once the Data Logger has been triggered, do not change the display to Scope View or Meter View; otherwise Data Logger will stop.

From the front panel:

Select the **Trigger** button to configure the trigger properties. The Data Logger uses triggers to synchronize itself with an external event.



The Source dropdown list lets you select a trigger source. The same trigger source will be used to trigger all of the outputs that have been configured for data logging. Depending upon the selected trigger source, you can trigger the Data Logger as follows:

Trigger Source	Description
Voltage <1-4> level Current <1-4> level	Triggers the Data Logger when the voltage or current of the corresponding output passes through the specified level.
Run/Stop key	Triggers the Data Logger when the Run/Stop key is pressed. This is the default trigger source.
Arb Run/Stop key	Triggers the Data Logger when the Arb Run/Stop key is pressed.
Output On/Off key	Triggers the Data Logger when any of the Output On/Off keys are pressed. Also applies to the All Outputs On/Off key.

Trigger Source	Description
BNC Trigger In	Provide a low-true signal to the BNC trigger input connector. Refer to Supplemental Characteristics for minimum pulse width. Selecting BNC Trigger In also enables any digital I/O pins configured as Trigger Outputs .
Remote Command	Send a trigger command over one of the three interfaces (i.e. *TRG).

If a trigger source is grayed out, it is unavailable. For example, current levels are not available as trigger sources on outputs that have been grouped (paralleled). Note also that a trace must be turned on for it to be used as a trigger source.

Level - specifies a trigger level if you selected a Voltage level or Current level as the trigger source. Along with the level, you must also specify a slope.

Slope - specifies if the measurement will be triggered on the positive (up-slope) or negative (down-slope) portion of the waveform.

Trigger Position % of Duration - specifies a trigger offset. This allows the specified percent of pre-trigger data to be logged to the file. The trigger position is expressed as a percentage of the data log duration. For example, if you specified a data log duration of 30 minutes and a trigger position of 50%, the Data Logger will log 15 minutes of pre-trigger data to the file before the trigger occurs. Subsequently, 15 minutes of post-trigger data will then be logged to the data file.

From the remote interface:

To select the immediate trigger source (triggers the Data Logger immediately when initiated):

TRIG:DLOG:SOUR IMM

To select the rear panel trigger input BNC connector:

TRIG:DLOG:SOUR EXT

To select a BUS trigger source:

TRIG:DLOG:SOUR BUS

To select a voltage level of another output as the trigger (output 3 will generate the voltage level trigger):

TRIG:DLOG:SOUR VOLT3

To select a current level of another output as the trigger (output 4 will generate the current level trigger):

TRIG:DLOG:SOUR CURR4

To select the Arb Run/Stop key as the trigger source:

TRIG:DLOG:SOUR ARSK

To select the Output On/Off key as the trigger source for output 1:

TRIG:DLOG:SOUR OOK

To select a voltage trigger level and slope on output 3 for the datalog:

```
TRIG:DLOG:VOLT 10,(@3)
TRIG:DLOG:VOLT:SLOP POS,(@3)
```

To select a current trigger level and slope on output 4 for the datalog:

```
TRIG:DLOG:CURR 1,(@4)
TRIG:DLOG:CURR:SLOP POS,(@4)
```

To specify a trigger offset at 25 percent of the duration of the datalog:

```
SENS:DLOG:OFFS 25
```

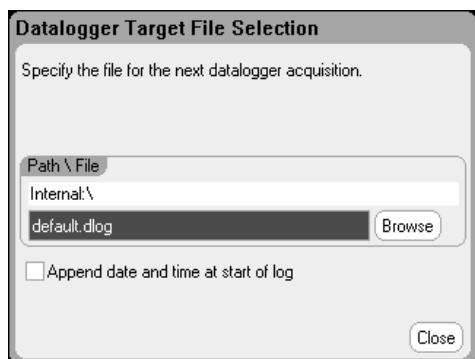
To trigger the datalog measurement: (If the trigger source is BUS, you can also send *TRG or <GET>.)

```
TRIG:DLOG (@1)
```

Data Logger Filename

From the front panel:

Select the Filename button to specify a filename in which to save the datalog. Data will be logged to this filename the *next* time the Data Logger runs. If you do not specify a filename, the data will be logged to default.dlog, which is overwritten each time the Data Logger runs.



Enter the filename in the Path\File field. Check Append date and time at start of log to include timestamp information in the file.

From the remote interface:

To specify the internal filename in which to save the datalog:

```
INIT:DLOG "datalog1.dlog"
```

You can also export the datalog that is presently displayed in the data logger view. To export the datalog to the specified filename, send:

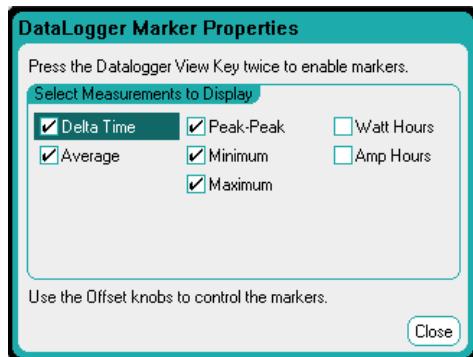
```
MMEM:EXP:DLOG "datalog1.csv"
```

NOTE To export a datalog that has been saved in the instrument, you must first load the saved file into the data logger view.

Data Logger Markers

From the front panel:

Select the Markers button to configure the measurements that appear on the bottom of the display in Marker view. Measurements apply to the portion of the trace between the two markers. You can only select a maximum of five measurements to be displayed.



From the remote interface:

The following commands position the markers. To position the two data log markers at 100 seconds and at 200 seconds from the start trigger on the data log:

```
SENS:DLOG:MARK1:POIN 100  
SENS:DLOG:MARK2:POIN 200
```

The following commands return data between the two markers. To return the average current or voltage between the markers:

```
FETC:DLOG:CURR? (@1)  
FETC:DLOG:VOLT? (@1)
```

To return the minimum current or voltage between the markers:

```
FETC:DLOG:CURR:MIN? (@1)  
FETC:DLOG:VOLT:MIN? (@1)
```

To return the maximum current or voltage between the markers:

```
FETC:DLOG:CURR:MAX? (@1)  
FETC:DLOG:VOLT:MAX? (@1)
```

To return the peak-to-peak current or voltage between the markers:

```
FETC:DLOG:CURR:PTP? (@1)  
FETC:DLOG:VOLT:PTP? (@1)
```

Data Logger Presets

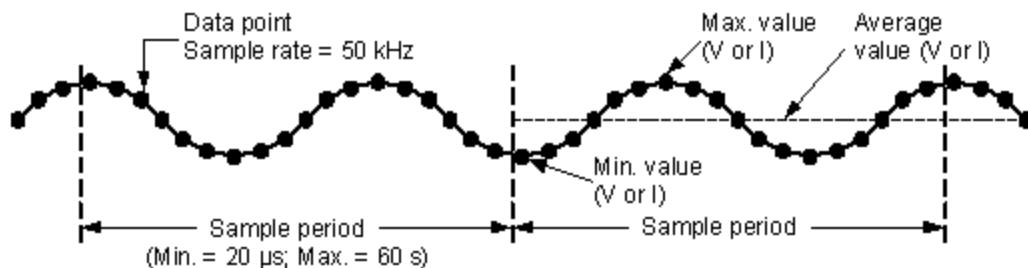
Select the Preset button to return the Data Logger View to the power-on display settings. The vertical offset of each trace will be set to a different value. This is to prevent the traces from overlapping. The offset is referenced to the horizontal center line of the grid.

Data Logger Sampling Modes

The power analyzer provides two modes of data logging: Continuously-sampled mode (the default), and Standard (or interleaved) mode. The mode is automatically selected based on the installed power module types and the selected measurements, and applies to all outputs. A text message in the Display Trace area of the Data Logger Properties window indicates which mode is in effect.

Continuously-sampled mode

Continuously-sampled mode continuously samples the voltage or current data at 200 kHz for Models N678xA SMU, and at 50 kHz for all other power modules. Both voltage and current can be sampled continuously on Models N676xA and N678xA SMU. Power is calculated from the instantaneous voltage and current values. Either voltage or current can be sampled continuously on all other power modules. Only the averaged value (and optionally, a minimum and maximum value) is returned for each sample period.



Continuous data sampling is available for the following power modules with the indicated display trace selections:

Power Module	Display Trace selection
N676xA, N678xA	Voltage, Current, & Power (24 parameters maximum)
N673xB, N674xB	Voltage or Current only (12 parameters maximum)
N675xA, N677xA	Voltage or Current only (12 parameters maximum)
N6783A-BAT/MFG	Voltage or Current only (12 parameters maximum)
Available capabilities for ALL outputs	
<ul style="list-style-type: none"> • Sample period: 20.48 microseconds to 60 seconds • Trigger source: all trigger sources available • Trigger offset: 0 to 100% • Values logged: average, minimum, maximum (minimum/maximum values must be selected) 	

4 Using the Measurement Functions

The fastest sample period that can be programmed for continuously-sampled measurements is 20.48 microseconds. However, this speed is only possible if one parameter is being measured. Note that you can measure up to 24 parameters (average voltage+min+max X 4 outputs, and average current+min+max X 4 outputs) with a corresponding decrease in measurement sample rate. The following typical sample periods are based on the number of parameters selected:

1 parameter (voltage or current)	20 microseconds (rounded)
3 parameters (voltage+min+max)	60 microseconds (rounded)
6 parameters (voltage+min+max X 2 outputs)	120 microseconds (rounded)
12 parameters (voltage+min+max X 4 outputs)	240 microseconds (rounded)
24 parameters (voltage+min+max X 4 outputs & current+min+max X 4 outputs)	480 microseconds (rounded)

NOTE When the Power trace is selected, it counts as 2 parameters, since voltage and current must be measured to calculate power. If voltage and current traces have already been selected, the Power trace is not counted as a parameter

Standard mode (interleaved)

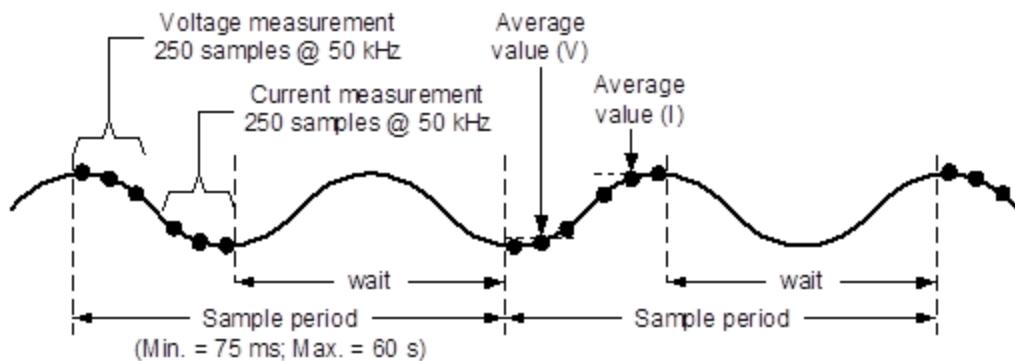
Standard (interleaved) mode only applies when both voltage and current measurement traces are selected on power modules other than Models N676xA and N678xA SMU. These other power modules cannot measure voltage and current simultaneously; hence, the voltage and current measurements must be interleaved for all power modules in the mainframe. Each measurement is sampled for about 5 milliseconds at the beginning of every sample period. Power is calculated from the interleaved measurements.

Standard data sampling is used with the following Power Module and Display Trace selections:

Power Module	Display Trace selection
N673xB, N674xB	Voltage, Current, and Power
N675xA, N677xA	Voltage, Current, and Power
N6783A-BAT/MFG	Voltage, Current, and Power

Available capabilities for ALL outputs

- Sample period: 20.48 microseconds to 60 seconds
- Trigger source: all trigger sources available
- Trigger offset: 0 to 100%
- Values logged: average, minimum, maximum (minimum/maximum values must be selected)



Data Logger and Scope Display Differences

The Scope View and Data Logger displays are similar in many respects, such as the way traces are displayed, how traces are selected, and the marker controls – to name a few. This similarity makes it easier to program each function.

However, there are important differences in the Scope and Data Logger displays that may not be obvious at first glance. To help eliminate confusion when using both Scope and Data Logger, the following table lists the major differences in the display functions.

Function	Scope View	Data Logger
Graph	Waveform capture	Strip chart
Trace selection	Voltage, current, and power traces - for N676xA and N678xA SMU power modules Voltage or current trace - for all other power modules	<i>Continuous mode</i> Voltage, current, and power traces - for N676xA and N678xA SMU power modules Voltage or current trace - for all other power modules <i>Interleaved mode</i> Voltage and current, or power
Trigger level selection	Note that current levels cannot be selected as triggers on outputs that have been grouped.	<i>Continuous mode</i> Voltage or current level of selected trace - for all power modules <i>Interleaved mode</i> Run Stop key only - for all power modules Note that current levels cannot be selected as triggers on outputs that have been grouped.
Trigger mode	Auto, single, or triggered	Does not apply
Trigger position	Turn the horizontal offset knob	Press Properties, select Trigger. Trigger position is specified as a % of the data log duration.
Horizontal trigger offset reference	Left, center, or right	Does not apply to strip chart
Trace save	Press File, select Save.	Automatically saved to default.dlog file. A different file name can be specified prior to running the datalog.

External Data Logging

Data Logging Functions

Select the Measurement Function and Range

Specify the Integration Period

Select the Elog Trigger Source

Initiate and Trigger the Elog

Periodically Retrieve the Data

Terminate the Elog

Data Logging Functions

NOTE

The external Data Logger function is not available if Option 055 has been ordered.

In addition to the built-in data logger, the power analyzer has an external data logger (Elog) function that lets you log voltage and current measurements from all four outputs directly to an internal FIFO (first-in, first-out) buffer. Note that this buffer is only large enough to hold about 20 seconds of accumulated measurements. The following table lists the major differences between the built-in and external data loggers.

The following table details the various data logging functions.

Function	Built-in Data Logger	External Data Logger
Data viewing	Optimized for viewing the measurements on the power analyzer's display.	No front panel view or front panel control.
Data Storage	Stores the measurements to an internal file. Can be left unattended for an extended time and results can be viewed afterward.	Buffers measurements for about 20 seconds and requires that the computer periodically reads measurements to prevent the power analyzer's buffer from overflowing. The computer needs to provide the data storage function.
Measurement Resources	Allocates all the measurement resources of ALL outputs, even if data logging is only enabled on some of the outputs.	Runs independently on each output. Some outputs can be running an external data log, while the remaining outputs can be used in front panel control or used for other SCPI functions.
Interleaved Mode	Interleaved mode allows the data logger to log both voltage and current on power modules that have only one measurement converter.	Interleaved mode is not available. If a power module has only one measurement converter, then either voltage or current can be logged, but not both.
Logging Rate	Can log data at up to 20.48 microseconds for one parameter.	Can log data at up to 102.4 microseconds for one parameter with data format = real.

Programming the external data logger consists of:

- Selecting the measurement functions and ranges.
- Specifying the measurement integration period.
- Selecting the trigger source.
- Triggering the data logger.
- Retrieving the data log measurement.

The external data logger function cannot be programmed from the front panel. When an external data log measurement is initiated on an output channel, the front panel changes to Meter View. Any channel that is performing an external data log measurement displays a message to this effect. Switching to Scope or Data Logger view will terminate the external data log measurement

Select the Measurement Function and Range

The following commands select a measurement function. To enable voltage measurements and min/max measurements on channel 1:

```
SENS:ELOG:FUNC:VOLT ON,(@1)
SENS:ELOG:FUNC:VOLT:MINM ON,(@1)
```

To enable current measurements and min/max measurements on channel 1:

```
SENS:ELOG:FUNC:CURR ON,(@1)
SENS:ELOG:FUNC:CURR:MINM ON,(@1)
```

The following commands select the range. To select the 5 V voltage range on channel 1:

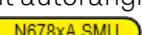
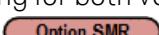
```
SENS:ELOG:VOLT:RANG 5,(@1)
```

To set the 1 A current range on channel 1:

```
SENS:ELOG:CURR:RANG 1,(@1)
```

In order to log both voltage and current on an output channel, that channel must have simultaneous measurement capability (see **Model Differences**). Models that do not have simultaneous measurement capability cannot externally log both voltage and current. There is no interleaved voltage/current mode as there is with the instrument's internal data logger

Seamless Measurements

Seamless measurement autoranging for both voltage and current is available on models N678xA SMU and with Option SMR.   This enables a wide dynamic measurement range with no data lost across ranges

Seamless ranging does not include the 10 µA range, which must be selected manually. To enable seamless elog autoranging on channel 1:

```
SENS:ELOG:VOLT:RANG:AUTO ON,(@1)
SENS:ELOG:CURR:RANG:AUTO ON,(@1)
```

Specify the Integration Period

The integration period can be set from a minimum of 102.4 microseconds to a maximum of 60 seconds. The following specifies an integration period of 600 microseconds:

SENS:ELOG:PER 0.0006, (@1)

During the integration period, Elog samples are averaged, and the minimum and maximum values are tracked. At the end of each integration period the average, minimum, and maximum values are added to the internal FIFO buffer. You can specify up to six measurement parameters per channel: Voltage+Vmax+Vmin, and Current+I_{max}+I_{min}.

Although the absolute minimum integration period is 102.4 microseconds, the actual minimum depends on the number of measurement parameters that are being logged. The actual minimum is 102.4 microseconds times the number of parameters being logged at each interval. Note that you can measure up to 4 parameters with the time interval resolution set to 20 microseconds, and up to 24 parameters with the resolution set to 40 microseconds. When the instrument sets an integration period, the value sent is rounded to the nearest integer multiple of the chosen resolution, either 20.48 microseconds or 40.96 microseconds.

1 parameter (Voltage or Current), with 20 μ s resolution	102.4 μ s
2 parameters (Voltage and Current), with 20 μ s resolution	204.8 μ s
4 parameters (Voltage+Vmin+Vmax+Current), with 20 μ s resolution	409.6 μ s
8 parameters with 40 μ s resolution	819.2 μ s
16 parameters with 40 μ s resolution	1638.4 μ s
24 parameters with 40 μ s resolution	2457.6 μ s

You can change the time interval resolution as follows:

SENS:SWE:TINT:RES RES20|RES40

If the specified integration period is at or near the minimum logging intervals, the data format must be specified as binary. If the REAL format is not specified, the data will be in ASCII format and the minimum logging intervals will typically be up to five times longer than what can be achieved with binary format. Refer to [Measurement Data Formats](#) for more information. To set the data format to REAL, use:

FORM REAL

Select the Elog Trigger Source

The TRIGger:ELOG command generates an immediate trigger regardless of the trigger source. Unless you are using this command, select a trigger source from the following:

BUS	Selects GPIB device trigger, *TRG, or <GET> (Group Execute Trigger)
EXTernal	Selects ANY pin that has been configured as a Trigger Input on the digital port.
IMMEDIATE	Selects the immediate trigger source. This triggers the data logger immediately when initiated.

PIN<1-7>	Selects a specific pin that is configured as a Trigger Input on the digital port. The selected pin must be configured as a Trigger Input in order to be used as a trigger source (see Using the Digital Port).
----------	---

Use the following commands to select a trigger source. To select Bus triggers:

TRIG:TRAN:SOUR BUS, (@1)

To select any digital pin as the trigger source:

TRIG:TRAN:SOUR EXT,(@1)

To select the immediate trigger source:

TRIG:TRAN:SOUR IMM,(@1)

To select digital pin 5 as the trigger source:

TRIG:ACQ:SOUR PIN5,(@1)

Initiate and Trigger the Elog

When the power analyzer is turned on, the trigger system is in the Idle state. In this state, the trigger system is disabled, ignoring all triggers. The INITiate command enables the measurement system to receive triggers. To initiate and trigger the Elog, use:

INIT:ELOG, (@1)

TRIG:ELOG, (@1)

Alternatively, if the trigger source is BUS, you can program a *TRG or an IEEE-488 <get> command.

When triggered, the Elog starts placing data in the internal measurement buffer. Because the buffer is only large enough to hold 20 seconds of accumulated measurement your PC application must periodically retrieve (or fetch) the data from this buffer.

Periodically Retrieve the Data

Each FETCh command returns number of requested records of the data in the buffer and removes them, making room available for more data. The Elog continues until it is aborted. To retrieve a maximum of 1000 records:

FETC:ELOG? 1000, (@1)

ASCII data (the default) is returned as comma-separated ASCII numeric data sets of average, min, or max values terminated by a newline. ASCII queries can only fetch data from one channel at a time.

Binary data is returned as a comma-separated list of data for each channel requested. The data is a definite length binary block, with the byte order specified by the FORMat:BORDer command.

Terminate the Elog

ABOR:ELOG, (@1)

5

Using the System Functions

Using the File Functions

Specifying User Preferences

Using the Administrative Tools

Configuring the Remote Interfaces

NOTE

Most of the system functions can only be programmed using the front panel menus.

Using the File Functions

Save

Load

Export

Import

Screen Capture

File Management

Reset/Recall/Power-On State

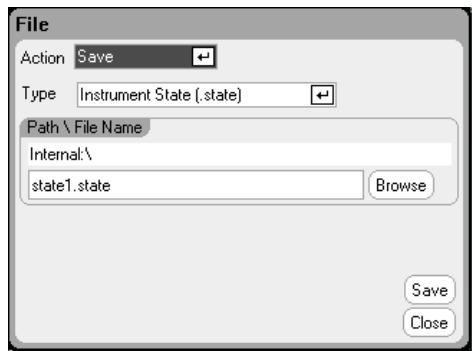
Using an External USB Memory Device

Press the **File** key to access the file functions, then scroll to and select from the following:



Save Function

To save the instrument state, scope data, or an Arb sequence, press the **File** key, then scroll to and select Save.



Parameter	Description
Type	Specifies the data type: instrument state or scope data or Arb sequence.
Path\file Name	Specifies a file name in which to save the data. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel. Enter a name in the text field. See Enter the File Name .
Browse	Lets you browse another directory or USB memory device.
Save	Saves the data to the file name in binary format.

Enter the File Name

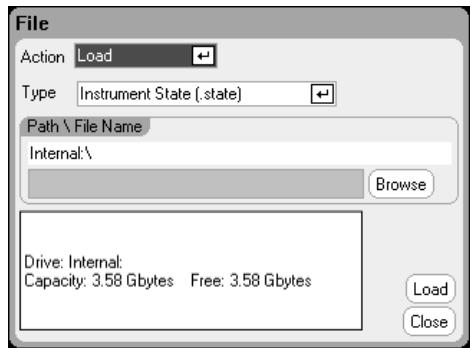
Use the navigation keys to scroll to and select the File Name field. Use the alpha/numeric keys to enter a file name. Alpha keys automatically become active on data entry fields that allow alpha as well as numeric characters. Repeatedly pressing a key cycles through the choices. This is similar to the way cell phones work. For example, repeatedly pressing 2 ABC cycles as follows:

a, b, c, A, B, C, 2

After a brief pause, the cursor will accept the displayed character and move one position to the right. Use Backspace to back up and delete an entry. Use ► to enter a space. Press Enter when finished.

Load Function

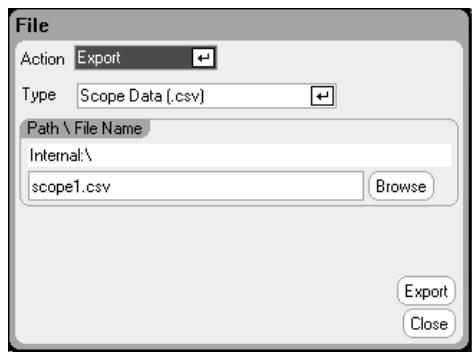
To load an instrument state, scope data, logged data, or an Arb sequence, press the **File** key, then scroll to and select Load. You can only load binary files. You cannot load data files in .csv format.



Parameter	Description
Type	Data type: instrument state, scope data, or logged data, or Arb sequence.
Path\file Name	Displays the file where the data is located. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel.
Browse	Lets you browse another directory or USB memory device.
Save	Loads the data from the binary file into the instrument.

Export Function

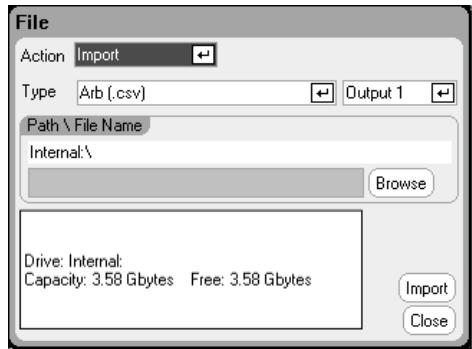
To export (and convert) scope data, logged data, or Arb data (user-defined or CD), press the **File** key, then scroll to and select Export.



Parameter	Description
Type	Data type: scope data, logged data, or Arb (User or CD). All data is exported in .csv format (comma separated values).
Path\File Name	Specifies a file name in which to export the data. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel. Enter a name in the text field. See Enter the File Name .
Browse	Lets you browse another directory or USB memory device.
Export	Exports the data to the file name in .csv format.

Import Function

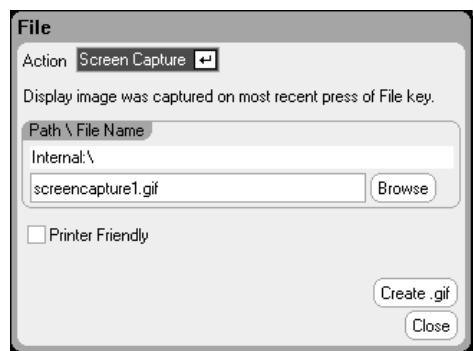
To import (and convert) Arb data (user-defined or CD), press the **File** key, then scroll to and select Import.



Parameter	Description
Type	Data type: Arb data (user-defined or CD). Data is converted from .csv format to an internal file format.
Output <1-4>	Specifies the output that will receive the Arb data.
Path\File Name	Specifies a file where the data is located. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel.
Browse	Lets you browse another directory or USB memory device.
Export	Imports the .csv data to the file name in .csv format.

Screen Capture

To capture a screen, press the **File** key, then scroll and select Screen Capture. This saves the screen that was active when you pressed File



A copy of the current screen is saved whenever the **File** key is pressed.

Parameter	Description
Path\File Name	Specifies a file name in which to save the image. Screens are saved in .gif format (graphics interchange format). Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel. Enter a name in the text field. See Enter the File Name .
Browse	Lets you browse another directory or USB memory device.
Print Friendly	Check this box to save Scope View and Data Logger screens with a white instead of a dark background.
Create .gif	Saves the image to the specified .gif file.

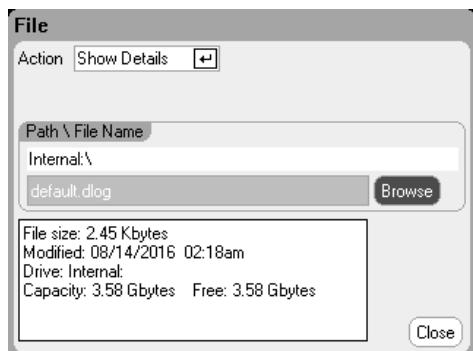
NOTE

The time of step 0 is the sum of the Start Time, Top Time and End Time. The default pacing for sequence steps is Dwell-pacing.

File Management

Show Details

To view the details of a specific file, press the **File** key, then scroll to and select File Management. In the Action dropdown box, select Show Details.



Parameter	Description
Path\File Name	Specifies the file. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel.
Browse	Lets you browse another directory or USB memory device.
Details	File details are displayed in the text box.

Delete Function

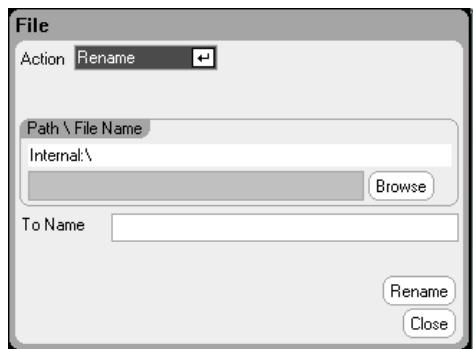
To delete a file, press the **File** key, then scroll to and select File Management. In the Action dropdown box, select Delete.



Parameter	Description
Path\File Name	Specifies a file or directory to be deleted. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel.
Browse	Lets you browse another directory or USB memory device.
Delete	Deletes the selected file.

Rename Function

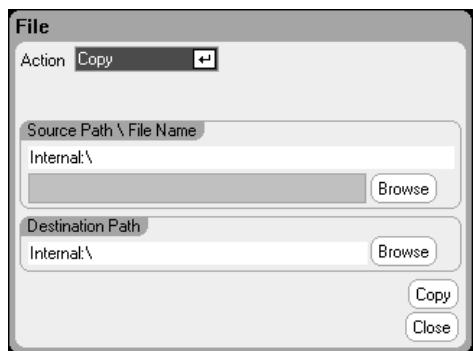
To rename a file, press the **File** key, then scroll to and select File Management. In the Action dropdown box, select Rename.



Parameter	Description
Path\File Name	Specifies a file or directory to be renamed. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel.
Browse	Lets you browse another directory or USB memory device.
To Name	Enter the name that you wish to rename the file to in this text field. See Enter the File Name .
Rename	Renames the selected file.

Copy Function

To copy the selected file to another directory or an external USB memory device, press the **File** key, then scroll to and select File Management. In the Action dropdown box, select Copy.

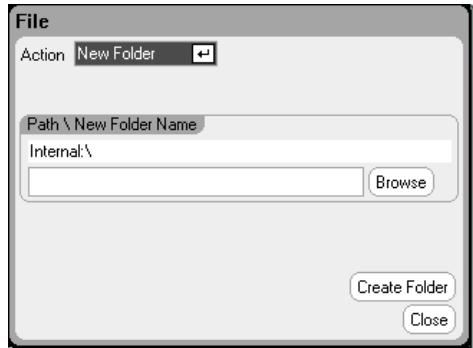


Parameter	Description
Path\File Name	Specifies the file to be copied. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel.

5 Using the System Functions

Parameter	Description
Destination Path	Specifies a destination directory. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel.
Browse	Lets you browse another directory or USB memory device.
Copy	Copies the selected file to the specified destination.

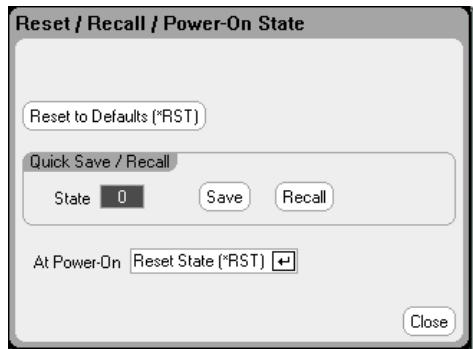
New Folder



Parameter	Description
Path\New Folder Name	Specifies a name for the folder. Internal:\ specifies the instrument's internal memory. External:\ specifies the Memory port on the front panel. Enter the name in the text field. See Enter the File Name .
Browse	Lets you browse another directory or USB memory device.
Create Folder	Creates the new folder in the specified location.

Reset/Recall/Power-On State

As shipped, the power analyzer is configured to automatically recall the Reset State (*RST) settings at power-on. However, you can configure the reset, recall, and power-on state of the instrument. Press the **File** key, then scroll and select Reset/Recall/Power-On State.



Selecting Reset to Defaults lets you immediately return the instrument to its factory default settings as described under Reset State in the Operating and Service Guide document.

Quick Save/Recall - lets you save and subsequently recall an instrument state in memory locations 0 through 9. This is the same as saving an instrument state to a file name, but quicker. These functions can also be accessed using the SCPI *SAV and *RCL commands.

At Power-On - lets you recall the Reset State (*RST), or recall the instrument state in location 0.

From the remote interface:

To save a state in location 1:

*SAV 1

To recall a state in location 1:

*RCL 1

To recall the settings you have stored in memory location 0 (RCL0) at power-on:

OUTP:PON:STAT RCL0

Using an External USB Memory Device

You can use an external USB memory device (commonly referred to as a flash drive) to transfer files to and from the power analyzer. Connect the memory device to the front panel Memory port, which is specifically designed for this purpose. The rear panel USB connector should only be used for connecting to a PC.

When using an external USB memory device, be aware of the following cautions:

- While the power analyzer supports the majority of USB memory devices, there may be differences in manufacturing standards of some devices that will prevent them from working in the power analyzer.
- It is recommended that you test your USB device by importing and exporting a file before you actually use it to save data directly from the test you will be running. If the USB memory device does not work in the power analyzer, try a device from a different manufacturer.

Exporting Data to a Spreadsheet

You can export scope data and logged data to a spreadsheet such as Microsoft Excel on your PC as follows:

1. Collect the scope or logged data using the power analyzer.
2. Insert a USB memory device into the Memory port on the front of the power analyzer.

3. Export the scope data or logged data to the memory device using the Export file function as previously discussed. Note that the export file format is .csv (comma separated values).
4. Insert the memory device into the USB port on your computer.
5. Run Microsoft Excel and select File, then Open. Navigate to the USB memory device. Under Files of type:, select Text Files (*.csv). Open the scope data or data log file.

Logging Data Directly to the Memory Device

You can save logged data directly to the USB memory device rather than to the instrument's internal memory as follows:

1. Insert a USB memory device into the Memory port on the front of the power analyzer.
2. In the Datalogger Target File Selection window (located under Datalogger Properties/File Name), use the Browse button and select External:\. Enter a filename in the text field. The data will now be placed on the USB memory device.

NOTE

Data is saved in binary format. To export in .csv format you must Load the data from the USB memory device back into the instrument and Export the data in .csv format as previously described under "Exporting Data to a Spreadsheet".

Specifying User Preferences

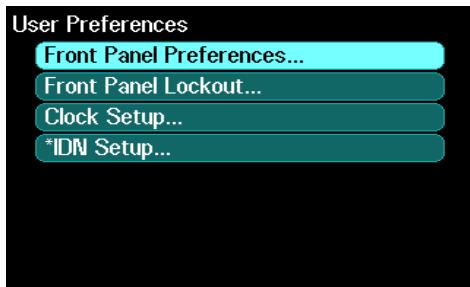
Front Panel Preferences

Front Panel Lockout

Clock Setup

*IDN Setup

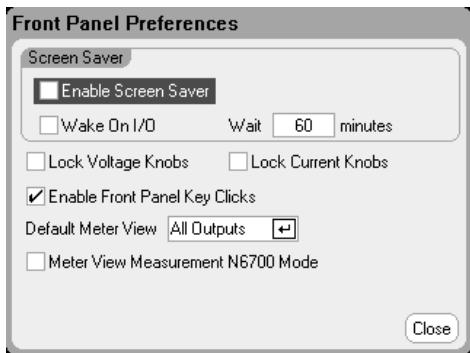
To configure the User Preferences, press the Menu key, scroll down and select the Utilities item, then select User Preferences. Then scroll to and select one of the following User Preferences:



Front Panel Preferences

The power analyzer has a front panel screen saver that increases the life of the LCD display by turning it off during periods of inactivity. As shipped from the factory, the screen saver comes on one hour after activity on the front panel or interface has ceased.

When the screen saver is active, the front panel display turns off, and the LED next to the Line switch changes from green to amber. To restore the front panel display, simply press one of the front panel keys.



Enable Screen Saver - check to enable the screen saver. Uncheck to disable the screen saver.

Wait - when Screen saver is enabled, enter a value in minutes in this field to specify the time when the screen saver will activate. The wait can be set from 30 to 999 minutes in 1 minute increments.

5 Using the System Functions

Wake on I/O - check to activate the display with I/O bus activity. If Wake on I/O is enabled, the display is restored whenever there is activity on the remote interface. This also resets the Wait timer.

Lock Voltage Knobs / Lock Current Knobs - check these to disable the front panel voltage or current knobs. This is useful if you wish to prevent someone from changing the voltage or current settings if a test is in progress. Uncheck to enable the voltage or current knobs.

Enable Front Panel Key Clicks check to enable key clicks. Uncheck to disable key clicks.

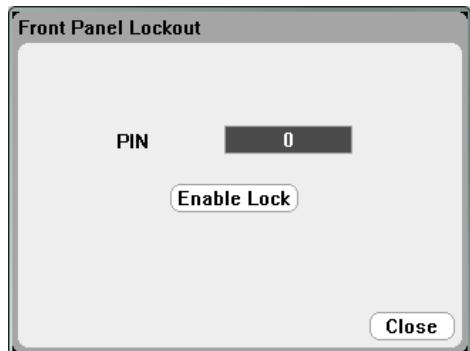
Default Meter View - in the dropdown, specify if the instrument turns on in single-output view or all-outputs view.

Meter View Measurement N6700 Mode - check to synchronize the corresponding SCPI SENSe measurement settings to the Meter View properties and vice versa. Refer to **Meter Ranges and Measurement Times** for details.

Front Panel Lockout

You can password-protect the front panel keys to prevent unwanted control of the instrument from the front panel. The lock setting and password is saved in non-volatile memory so that the front panel remains locked even when AC power is cycled.

To access the front panel lockout function press the **Menu** key, scroll down and select Utilities, then User Preferences, then Front Panel Lockout.



In the PIN text box, enter the numeric password that you wish to use to unlock the front panel. Then click Enable Lock to lock the front panel keys. A dialog prompting the user to unlock the front panel appears every time a key is pressed. Enter the password to unlock the front panel.

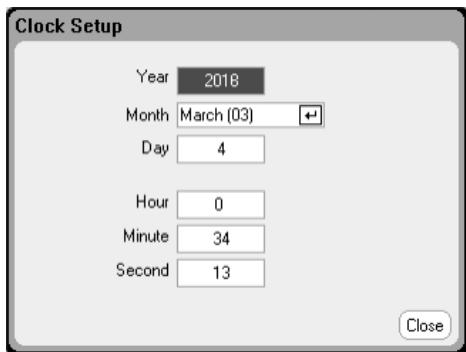
NOTE

If the password is lost, the SYSTem:PASSWORD:FPANEL:RESET command can reset the front panel lockout password.

Clock Setup

When shipped from the factory, the power analyzer's clock is set to Greenwich mean time.

To access the clock function press the **Menu** key, scroll down and select Utilities, then User Preferences, then Clock Setup.



Select a Month from the dropdown list. Enter the Day, then Year.

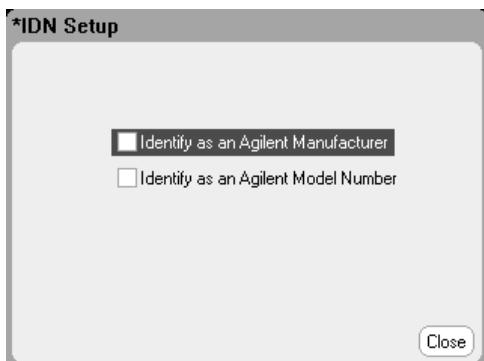
Enter the Hour (0 - 23), Minute, and Second. The time becomes active when the values are entered.

*IDN Setup

You have the ability to change the identity of the mainframe, as reported in the *IDN? query. This functionality is only intended for compatibility with previous "A" and "B" version mainframes.

To access the *IDN function press the **Menu** key, scroll down and select Utilities, then User Preferences, then *IDN Setup.

Check the appropriate box to identify the instrument as an Agilent product.



From the remote interface, program:

```
SYST:PERS:MAN "<manufacturer>"  
SYST:PERS:MOD "<model number>"
```

The *IDN setup change and PERSona commands affects the following identification items:

- *IDN? command for vendor and model
- VISA programmatic access APIs for vendor and model
- LXI instrument web pages
- LXI XML
- LXI mDNS announcements

Using the Administrative Tools

Administrator Login/Logout

Calibration

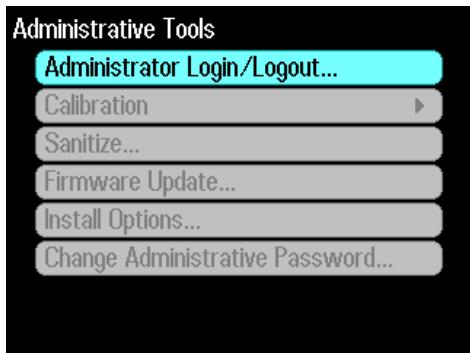
Sanitize

Firmware Update

Install Options

Change Administrative Password

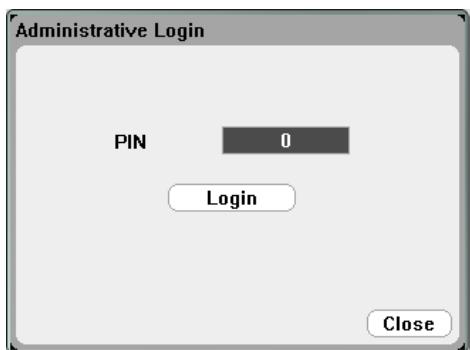
To enter the Administrative Utilities menu, press the **Menu** key, scroll down and select Utilities, then select Administrative Tools. Access to the Administrative Tools menu is password protected. Select Administrator Logout/Login to enter the password:



Administrator Login/Logout

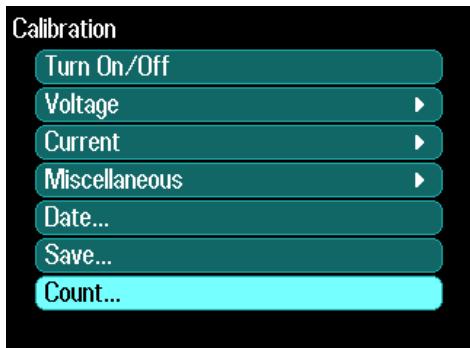
If a password is required, enter it in to the PIN field, select the Login button and press [Enter].

As shipped from the factory, the password is 0 (zero). If the PIN field shows 0; simply select the Login button and press [Enter].



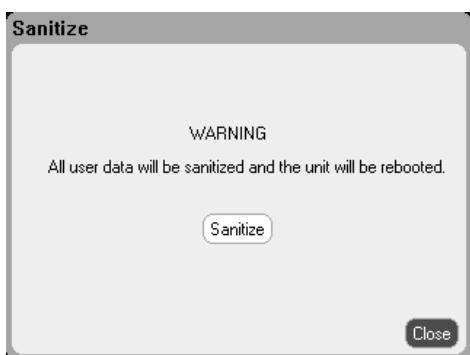
Calibration

The calibration functions are located in the Administration Tools menu and are password-protected from unauthorized use. For complete information about calibrating the instrument, refer to the calibration section in the Operating and Service Guide document.



Sanitize

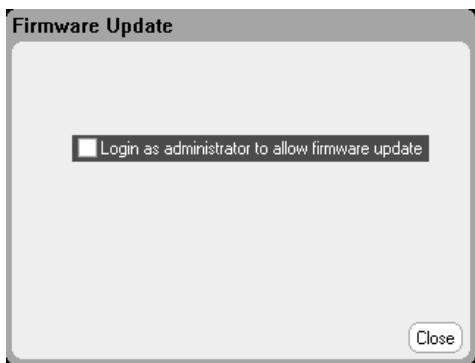
- NOTE** This procedure is not recommended for use in routine applications because of the possibility of unintended loss of data.
-
- To erase all user-data from the instrument and restore the factory-shipped settings, log into the Administrative Tools menu. Then select Sanitize and press the Sanitize button. Refer to Instrument Sanitize in the Operating and Service Guide document for more information.



Firmware Update

You must use the Firmware Update Utility to update the firmware in your instrument. Refer to Firmware Update in the Operating and Service Guide document for more information.

You can restrict access to the instrument by the Firmware Update Utility. This prevents unauthorized users from updating the firmware. Check Login as administrator to allow firmware update.



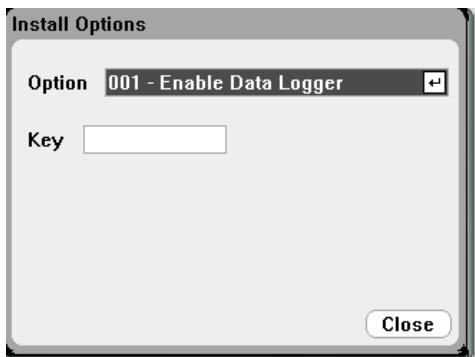
Install Options

The Install Options function lets you install firmware options into the power analyzer.

Option 001 Data Logger Software This option is only available on instruments that have been purchased with Option 055 – Delete Data Logger.

Option 056 Keysight 14585A Control and Analysis Software

To access the disk management utilities, log into the Administrative Tools menu. Select Install Options. From the dropdown menu, select the option you wish to install. Enter the Access Key number from your software license documentation.



Obtaining the License

To obtain the license, you must first purchase the option. After you have purchased the option, you will receive a Software Entitlement Certificate. When this is received, you can obtain the license.

To get the license key, log onto the website <https://software.business.keysight.com/asm> and follow the on-screen directions. These include:

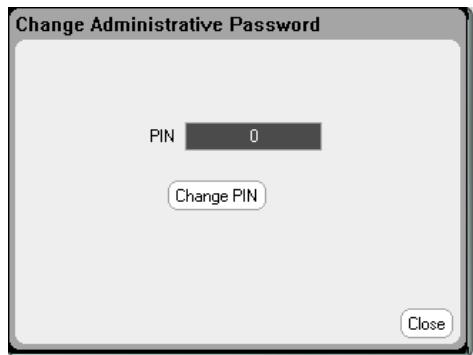
1. Creating a user account (if not already set up).
2. Entering your Order and Certificate number (these appear in your Software Entitlement Certificate).
3. Entering the Host instrument's 10-character serial number (this is located on the rear panel of the instrument).
4. Selecting the software license for the instrument.

When you have completed the license request, a license key will be sent to your email. Enter the Access Key into the Key field of the Install Options window shown above.

Change Password

To password-protect or change the password for the Administrative Tools menu, log into the Administrative Tools menu as previously described. Select Change Password. Select a password that is numeric and up to 15 digits long. Enter it into the PIN field and then select Change Pin.

When done, select Administrator Login/Logout to log out of the Administrative Tools menu and activate the password. You can now only enter the Administrative Tools menu by providing the new password.



If the password is lost or forgotten, access to the Administrative Tools menu can be restored by setting an internal switch to reset the password to 0. If the message “Locked out by internal switch setting” or “Calibration is inhibited by switch setting” appears, the internal switch is set to prevent the password from being changed (refer to the calibration switches section in the Operating and Service Guide document).

Configuring the Remote Interfaces

[GPIB Configuration](#)

[USB Configuration](#)

[LAN Configuration](#)

[Modifying the LAN Settings](#)

[Using the Web Interface](#)

[Using Sockets](#)

[Using Telnet](#)

[Securing the LAN](#)

This Keysight N6705C DC Power Analyzer supports remote interface communication over three interfaces: GPIB, USB, and LAN. All three interfaces are live at power on. For information on connecting the interfaces, refer to [Interface Connections](#).

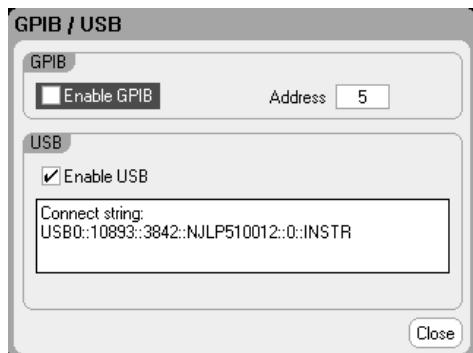
The front panel **IO** indicator comes on whenever there is activity on the remote interfaces. The front panel **Lan** indicator comes on when the LAN port is connected and configured.

Ethernet connection monitoring is also provided. With Ethernet connection monitoring, the instrument's LAN port is continually monitored, and automatically reconfigured when the instrument is unplugged for a minimum of 20 seconds and then reconnected to a network.

GPIB Configuration

Each device on the GPIB (IEEE-488) interface must have a unique whole number address between 0 and 30. The instrument ships with the address set to 5. Your computer's GPIB interface card address must not conflict with any instrument on the interface bus. This setting is non-volatile; it will not be changed by power cycling or *RST.

To access the GPIB parameters from the front panel, press the **Menu** key, select **Utilities**, then **I/O Configuration**, then **GPIB/USB**. Check or uncheck Enable GPIB to enable or disable the GPIB. Use the numeric keys to enter a value in the Address field. Press **Enter** to enter the value.



USB Configuration

Use the front panel menu to access the GPIB/USB window as described above. You can view the USB connect string in the GPIB/USB dialog. Check or uncheck Enable USB to enable or disable the USB.

LAN Configuration

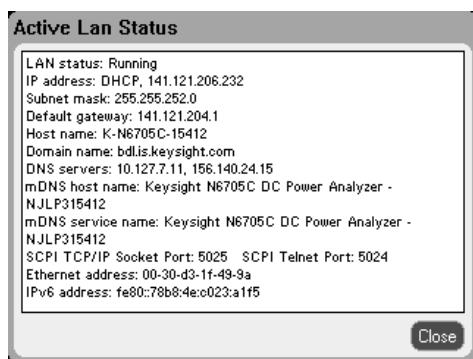
The following sections describe the primary LAN configuration functions on the front-panel menus. Note that there are no SCPI commands to configure the LAN parameters. All LAN configuration must be done from the front panel.

NOTE After changing the LAN settings, you must Save the changes. Select: **System\IO\LAN\Apply**. Selecting Apply cycles power to the instrument and activates the settings. LAN settings are nonvolatile, they will not be changed by power cycling or *RST. If you do not want to save your changes select: **System\IO\LAN\Cancel**. Selecting Cancel cancels all changes.

When shipped, DHCP is on, which may enable communication over LAN. The letters DHCP stands for Dynamic Host Configuration Protocol, a protocol for assigning dynamic IP addresses to devices on a network. With dynamic addressing, a device can have a different IP address every time it connects to the network.

Viewing Active Settings

To view the currently active LAN settings, press the **Menu** key, scroll down and select the **Utilities**, then select **I/O Configuration**, then **Active LAN Status**.



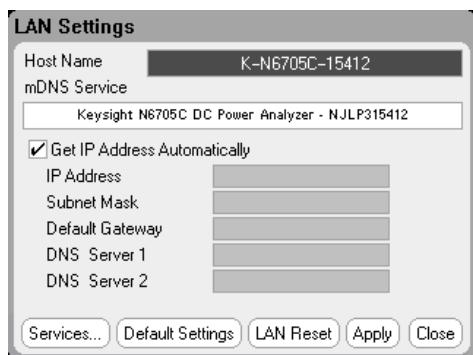
The currently active settings may be different from the front panel configuration menu settings - depending on the configuration of the network. If the settings are different, it is because the network has automatically assigned its own settings.

Modifying the LAN Settings

As shipped from the factory, the power analyzer's pre-configured settings should work in most LAN environments. If you need to manually configure these settings, press the **Menu** key, scroll down and select the **Utilities**, then select **I/O Configuration**, then **LAN Settings**.

5 Using the System Functions

Refer to Non-Volatile Settings in the Operating and Service Guide document for information on the factory-shipped LAN settings.



Host Name

A hostname is the host portion of the domain name, which is translated into an IP address. Use the numeric/alpha keys to enter letters or numbers. Repeatedly pressing a key cycles through the list of choices. After a short delay the cursor automatically moves to the right.

- **Host name** - This field registers the supplied name with the selected naming service. If the field is left blank, no name is registered. A hostname may contain upper and lower case letters, numbers and dashes(-). The maximum length is 15 characters.

Each power analyzer is shipped with a default hostname with the format: Keysight-modelnumber-serialnumber, where modelnumber is the mainframe's 6-character model number (e.g. N6705C), and serialnumber is the last five characters of the 10-character mainframe serial number located on the label on the top of the unit (e.g. 45678 if the serial number is MY12345678).

mDNS Service

The mDNS service name is registered with the selected naming service. Use the numeric/alpha keys to enter letters or numbers. Repeatedly pressing a key cycles through the list of choices. After a short delay the cursor automatically moves to the right.

- **mDNS Service Name** - This field registers the service name with the selected naming service. If the field is left blank, no name is registered. A service name may contain upper and lower case letters, numbers and dashes(-).

Each power analyzer is shipped with a default service name with the format: Keysight-mod- elnumber-serialnumber, where modelnumber is the mainframe's 6-character model number (e.g. N6705C), and serialnumber is the last five characters of the 10-character mainframe serial number located on the label on the top of the unit (e.g. 45678 if the serial number is MY12345678).

Get IP Address Automatically - checked

- Checking this box - automatically configures the addressing of the instrument. When selected, the instrument will first try to obtain an IP address from a DHCP server. If a DHCP server is found, the

DHCP server will assign an IP address, Subnet Mask, and Default Gateway to the instrument. If a DHCP server is unavailable, the instrument will try to obtain an IP address using AutoIP. AutoIP automatically assigns an IP address, Subnet Mask, and Default Gateway addresses on networks that do not have a DHCP server. (The letters DHCP stands for Dynamic Host Configuration Protocol, a protocol for assigning dynamic IP addresses to devices on a network. With dynamic addressing, a device can have a different IP address every time it connects to the network.)

Get IP Address Automatically - unchecked

- Unchecking this box - allows you to manually configure the addressing of the instrument by entering values in the following fields. These fields only appear when Manual is selected. Select **Apply** to apply the manually-entered settings.
- **IP Address** - This value is the Internet Protocol (IP) address of the instrument. An IP address is required for all IP and TCP/IP communications with the instrument. An IP Address consists of 4 decimal numbers separated by periods. Each decimal number ranges from 0 through 255 with no leading zeros. Note that the Internet Engineering Task Force reserved the IP address range of 169.254.1.0 to 169.254.254.255 for link-local addressing (auto-IP). Do not assign a manual IP address within this range.
- **Subnet Mask** - This value is used to enable the instrument to determine if a client IP address is on the same local subnet. The same numbering notation applies as for the IP Address. When a client IP address is on a different subnet, all packets must be sent to the Default Gateway.
- **Default Gateway** - This value is the IP Address of the default gateway that allows the instrument to communicate with systems that are not on the local subnet, as determined by the subnet mask setting. The same numbering notation applies as for the IP Address. A value of 0.0.0.0 indicates that no default gateway is defined.
- **DNS server 1** - This field enters the primary address of the DNS server. Contact your LAN administrator for server details. The same numbering notation applies as for the IP Address. A value of 0.0.0.0 indicates that no default server is defined.
- **DNS server 2** - This field enters the secondary address of the DNS server. Contact your LAN administrator for server details. The same numbering notation applies as for the IP Address. A value of 0.0.0.0 indicates that no default server is defined.

Dot-notation addresses ("nnn.nnn.nnn.nnn" where "nnn" is a byte value from 0 to 255) must be expressed with care, as most PC web software interprets byte values with leading zeros as octal (base 8) numbers. For example, "192.168.020.011" is actually equivalent to decimal "192.168.16.9" because ".020" is interpreted as "16" expressed in octal, and ".011" as "9". To avoid confusion, use only decimal values from 0 to 255, with no leading zeros.

Resetting the LAN

You can reset the LAN to the as-shipped settings by selecting **Default Settings**. This returns ALL LAN settings to the as-shipped values and restarts networking. All default LAN settings are listed under Non-volatile Settings in the Operating and Service Guide document.

5 Using the System Functions

You can also perform an LXI LCI reset by selecting **LAN Reset**. This resets the DHCP, DNS server address configuration, mDNS state, mDNS service name and the web password. These settings are optimized for connecting your instrument to a site network. They should also work well for other network configurations.

Using the Web Interface

Your power analyzer has a built-in Web interface that lets you control it directly from the Web browser on your computer. With the Web interface, you can access the front panel control functions including the LAN configuration parameters. Up to six simultaneous connections are allowed. With multiple connections, performance will be reduced.

NOTE

The built-in Web interface only operates over the LAN. It requires a web browser.

The Web interface is enabled when shipped. To launch the Web interface:

1. Open the Web browser on your computer.
2. Enter the instrument's hostname or IP address into the browser's address field. The following home page will appear.
3. Click on the Control Instrument tab on the top of the page to begin controlling your instrument.
4. For additional help about any of the pages, click on the ? icon.

The screenshot shows the web interface for the Keysight N6705C. At the top, it displays the Keysight logo and the model number N6705C, along with the serial number NJLP315412. There are links for 'Log in' and a gear icon. Below this is a navigation bar with 'Home', 'Control Instrument', 'Configure LAN', and a question mark icon. The main content area features a photograph of the instrument's front panel. To its right, text reads 'Connected to N6705C at IP address 141.121.202.165'. A checkbox labeled 'Enable front panel identification indicator' is present. On the right side of the page is the 'LXI' logo. Below the photograph is a 'Description' table with the following data:

Model number	N6705C
Serial number	NJLP315412
Firmware revision	E.00.01.2437
Description	Keysight N6705C DC Power Analyzer - NJLP315412

Underneath the table is a section titled 'VISA instrument addresses' containing a table of communication protocols and their corresponding addresses:

HISLIP LAN protocol	TCPPIP::K-N6705C-15412.local::hislip0::INSTR
VXI-11 LAN protocol	TCPPIP::K-N6705C-15412.local::inst0::INSTR
GPIB over LAN protocol	TCPPIP::K-N6705C-15412.local::gpb0,5::INSTR
TCP/IP SOCKET protocol	TCPPIP::K-N6705C-15412.local::5025::SOCKET
USB (USBTMC/488)	USB::10893::9223::NJLP315412::0::INSTR
GPIB	GPIB::5::INSTR

At the bottom left is a link 'More Information' with a downward arrow icon. The footer contains links for 'Support', 'Products', and 'Keysight'.

If desired, you can control access to the Web interface by enabling or disabling Web control under LAN Services (see [Securing the LAN](#)).

Using Sockets

NOTE

Power supplies allow any combination of up to six simultaneous data socket, control socket, and telnet connections to be made.

Keysight instruments have standardized on using port 5025 for SCPI socket services. A data socket on this port can be used to send and receive ASCII/SCPI commands, queries, and query responses. All commands must be terminated with a newline for the message to be parsed. All query responses will also be terminated with a newline.

The socket programming interface also allows a control socket connection. The control socket can be used by a client to send device clear and to receive service requests. Unlike the data socket, which uses a fixed port number, the port number for a control socket varies and must be obtained by sending the following SCPI query to the data socket: SYSTem:COMMunicate:TCPip:CONTrol?

After the port number is obtained, a control socket connection can be opened. As with the data socket, all commands to the control socket must be terminated with a newline, and all query responses returned on the control socket will be terminated with a newline.

To send a device clear, send the string "DCL" to the control socket. When the power analyzer has finished performing the device clear it echoes the string "DCL" back to the control socket.

Service requests are enabled for control sockets using the Service Request Enable register. Once service requests have been enabled, the client program listens on the control connection. When SRQ goes true the instrument will send the string "SRQ +nn" to the client. The "nn" is the status byte value, which the client can use to determine the source of the service request.

Using Telnet

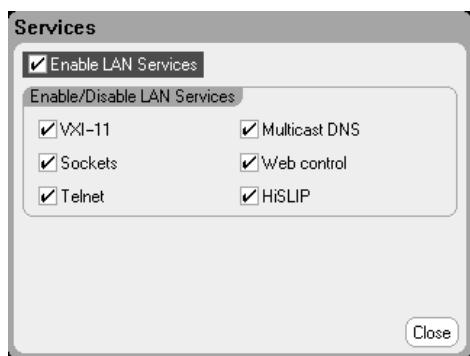
In an MS-DOS Command Prompt box type: telnet hostname 5024 where hostname is the instrument's hostname or IP address, and 5024 is the instrument's telnet port.

You should get a Telnet session box with a title indicating that you are connected to the power analyzer. Type the SCPI commands at the prompt.

Securing the LAN

You can enable or disable a number of LAN services. All LAN services are enabled when shipped. To enable or disable selected LAN services from the front panel, select **Utilities**, then select **I/O Configuration**, **LAN Settings**, then **Services...**

5 Using the System Functions



Check or uncheck Enable LAN Services.

Under Enable/Disable LAN services, configure the services that you wish to enable.

NOTE

LAN services must be enabled in order to enable the Web interface control.

6

Advanced Source, Measurement, and Control

Advanced Source Operation

Advanced Measurements

Using the Digital Control Port

This section discusses the difference between constant voltage and constant current operating modes, multiple output quadrant operation, and other advanced source functions.

Advanced measurement functions such as digitizing measurements, external data logging, histogram measurements, and other measurement functions are described.

A Digital Control Port consisting of seven I/O pins located on the rear panel, can be programmed to provide various external control functions.

Advanced Source Operation

Single-Quadrant Operation

Autoranging

CC Mode Delay

Power Limit Operation

Output Grouping

N678xA Multi-Quadrant Operation

N678xA Output Bandwidth

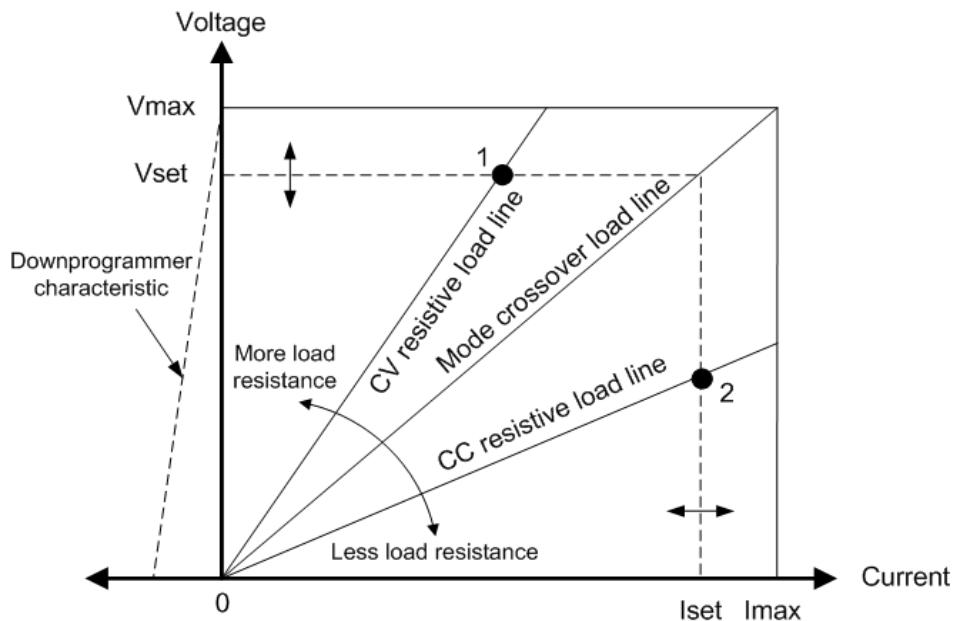
N679xA Load Module Operation

Single-Quadrant Operation

The Keysight N6705C DC Power Analyzer can operate in either constant voltage (CV) or constant current (CC) over the rated output voltage and current. Constant voltage mode is defined as an operating mode in which the dc source maintains its output voltage at the programmed voltage setting in spite of changes in load, line, or temperature. Thus, when the load resistance changes, the output voltage remains constant while the output current changes to accommodate the change in load.

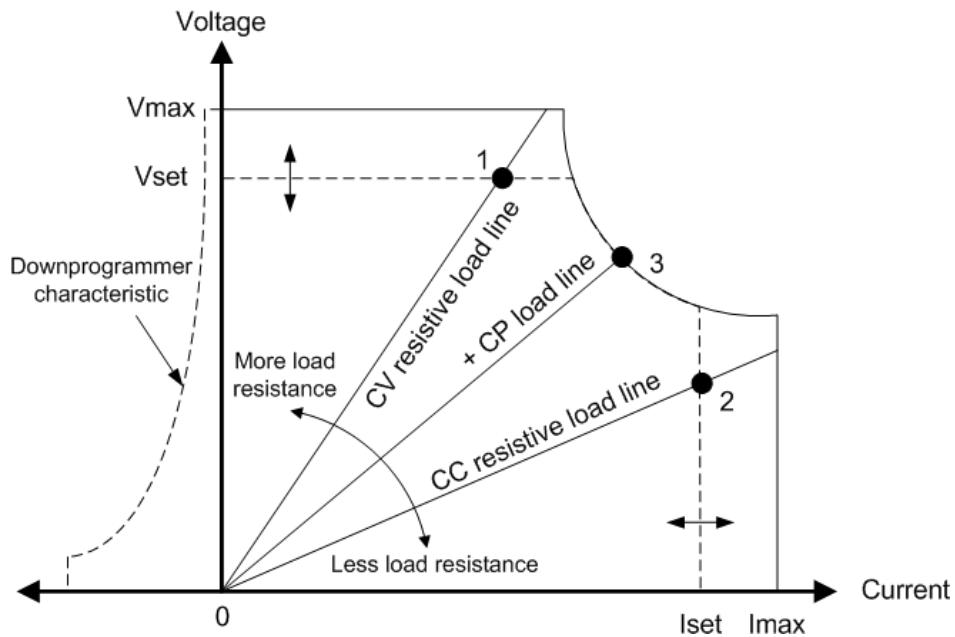
Constant current mode is defined as an operating mode in which the dc source maintains its output current at the programmed current limit in spite of changes in load, line, or temperature. Thus, when the load resistance changes, the output current remains constant while the output voltage changes to accommodate the change in load.

All DC power modules, except for Keysight Models N678xA SMU **not N678xA SMU**, are designed as constant voltage sources. This means that the specifications and operating characteristics are optimized for constant voltage mode operation. Note that these power modules cannot be programmed to operate in a specific mode. At turn-on, the operating mode will be determined by the voltage setting, current setting, and the load resistance. In the following figure, operating point 1 is defined by a fixed load line traversing the positive operating quadrant in the constant voltage region. Operating point 2 is defined by a fixed load line traversing the positive operating quadrant in the constant current region.



Autoranging

The following figure illustrates the autoranging output characteristic of the Keysight N675xA and N676xA power modules [N675xA, N676xA](#). Point 3 shows a situation in which the voltage and current settings are such that the operating locus is limited by the maximum output power boundary of the output. Depending on the power module, this may be greater than the output power rating of the module. In this situation, the output is not guaranteed to meet its operating specifications because it is operating in an area that is outside its specified power rating.



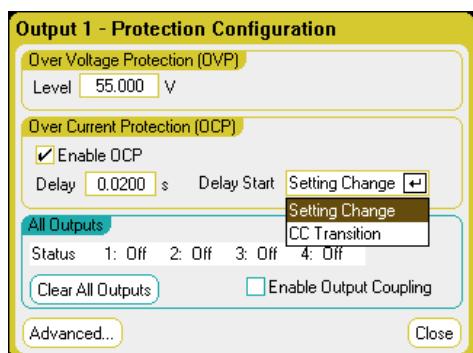
Downprogramming

As shown by the dashed line on the left in the figures, the power analyzer is capable of sinking current over the output voltage range from zero volts to the rated voltage. This negative current sinking capability provides fast downprogramming of the output. The negative current is not programmable.

CC Mode Delay

The power supply may momentarily cross into constant-current (CC) mode when it is turned on, when an output value is programmed, or when the output load is connected. In most cases these temporary conditions would not be considered an over-current protection fault, and having an OCP condition disable the output when the CC status bit is set would be a nuisance. Specifying an OCP delay will ignore the CC status bit during the specified delay period. For example, if the OCP delay is 100 ms, and the output goes into CC mode for 80 ms and then back to CV mode, the output will not shut down. If the CC mode persists for more than 100 ms, the output will shut down.

To program a delay time, press the **Settings** key to access the Source Settings. Navigate to and select Protection. Then press Enter.



You can specify if the delay timer is started by any transition of the output into CC mode (select CC Transition), or if the delay timer is started at the end of a settings change in voltage, current, or output state (select Settings Change).

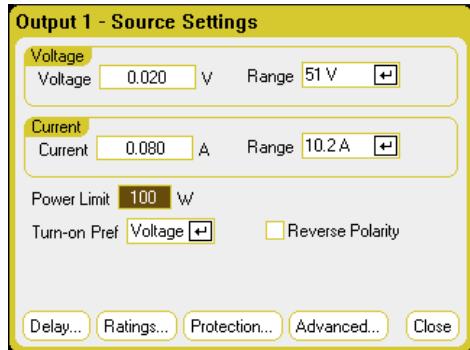
Factors that influence how long the settings or load change lasts may include: the difference between the old and new output value, the current limit setting, load capacitance in CV mode, load inductance in CC mode, the slew rate, and bandwidth setting. The delay required must be determined empirically; the power module programming-response time characteristics may be used as guidelines.

Note that the time it takes the output to go into CC mode varies – depending on the magnitude of the over-current condition compared to the current limit setting. For example, if the over-current is only slightly greater than the current limit setting, it may take several tens of milliseconds, depending on the power module type, for the output to set the CC status bit. If the over-current is significantly greater than the current limit setting, it may only take a few milliseconds or less, depending on power module type, for the output to set the CC status bit. To determine when the output will shut down, you must add the time it takes to set the CC status bit to the over-current protection delay time. If the over-current persists beyond the sum of these two time intervals, the output will shut down.

Power Limit Operation

For Keysight N6705 mainframes, the instrument will operate normally as long as the combined output power of the modules is within the power rating of the mainframe. If the combined power drawn from all of the outputs exceeds the mainframe's power rating of 600 W, a power fault protection event will occur. This causes ALL outputs to turn off and remain off until a protection clear command is given. A status bit (PF) will indicate that a power fault protection event has occurred.

To specify a module output power limit, press the **Settings** key to access the Source Settings window.



For Keysight N675xA, and N676xA power modules, the power limit function limits the output power at its programmed setting. A status bit (CP+) will indicate that the output is in power limit mode. When the power drawn by the load is reduced below the power limit setting, the output returns to normal operation. Note that these power modules contain an active down-programmer circuit, which is limited to about 7 W continuous power. A status bit (CP-) will indicate that the output has reached the negative limit.

For Keysight N673xB, N674xB, and N677xA power modules, the power limit function turns the output off after a power limit persists for about 1 millisecond. A status bit (CP+) will indicate that the output has been turned off by a power limit condition. To restore the output, you must first adjust the load so that it draws less power. Then clear the protection function as previously explained. For these power modules, it may be preferable to use the current or voltage setting to limit the output power so as to avoid turning the output off.

NOTE If the mainframe power limit is left at the maximum rating, the above power modules will not enable the power limit protection. The power limit protection will only activate when the power limit is set to a value less than the maximum rating of the power module and the output power subsequently exceeds this limit setting.

For Keysight N678xA SMU, N6783A-BAT/MFG, and N679xA loads, the mainframe power limit function does not affect the operation of the module. Note that Keysight N679xA load modules have a separate **over-power** protection function that limits the **input** power of the module.

Output Grouping

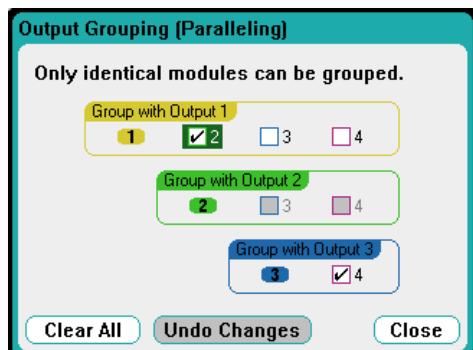
NOTE Output grouping does not apply to Keysight Models N678xA SMU .

Up to four identical outputs can be configured or “grouped” to create a single output with higher current and power capability. The following conditions apply for grouped outputs:

- Only identical outputs can be grouped. Outputs without identical model numbers and options will be unavailable for grouping.
- Grouped outputs must be connected in parallel as described under [Parallel Connections](#).
- On Keysight N676xA power modules, low current measurement ranges are unavailable. Low current output ranges, are available.
- Current-level triggering is unavailable for grouped outputs.
- Over-current protection delay has a slightly slower response time (~10 ms) and slightly less resolution than an ungrouped output.
- The power limit setting for Keysight N673xB, N674xB, N677xA, and N6783A power modules must be set to its maximum value.

From the front panel:

To group outputs, press the **Menu** key. Select Source Settings, then Output Grouping. Check the outputs that you wish to group.



Grouped outputs are controlled using the output number of the **lowest** output in the group. As shown in the following figure, output 1 is grouped with output 2 and output 3 is grouped with output 4.



To return grouped outputs back to an ungrouped state, turn the output off and remove the parallel connections between the outputs. Then uncheck the check boxes. Then cycle AC power to the unit for the grouping or ungrouping changes to take effect. Grouped settings are saved in non-volatile memory.

From the remote interface:

Send the following command to group channels 2 through 4. To address this group, use channel 2.

SYST:GRO:DEF 2,3,4

To ungroup all channels:

SYST:GRO:DEL:ALL

To reboot the instrument for the grouping changes to take effect either cycle AC power, or sent the following command:

SYST:REB

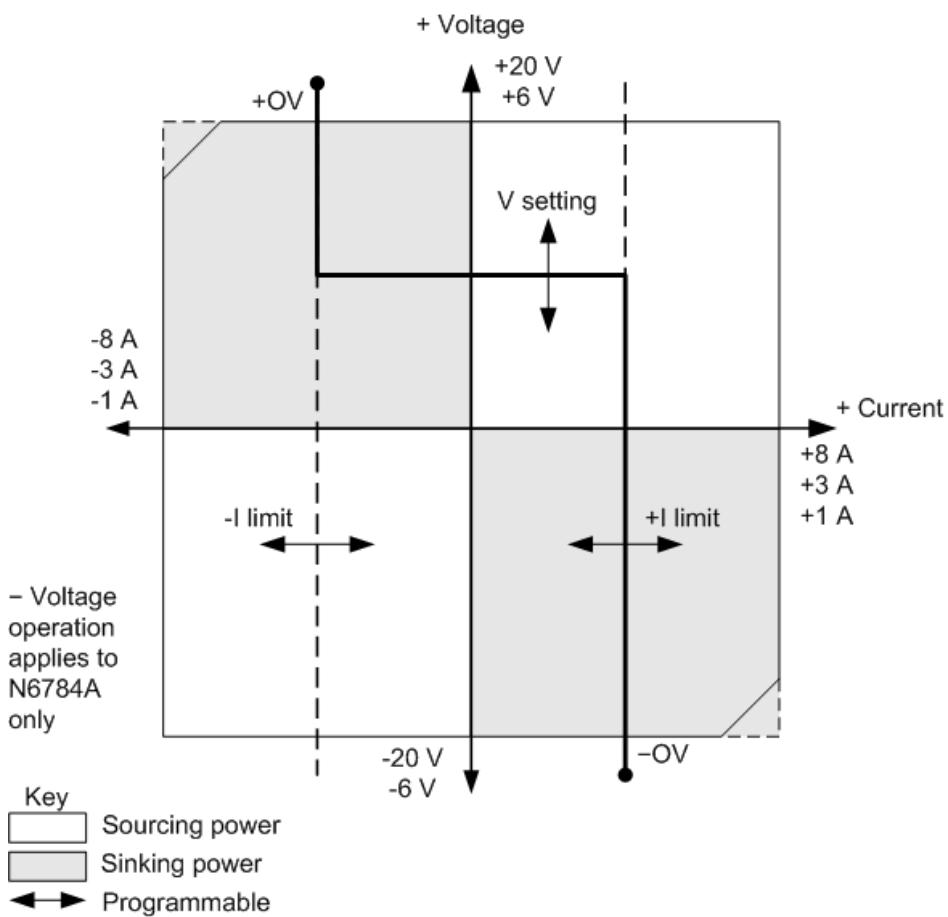
N678xA Multi-Quadrant Operation

Keysight Models N678xA SMU N678xA SMU can be operated in either voltage or current priority mode. They can source as well as sink output power. Note that Keysight Models N6781A, N6782A, N6785A, and N6786A operate only in the + Voltage quadrants.

Voltage Priority Mode

In voltage priority mode, the output voltage should be programmed to the desired positive or negative value. A positive current limit value should also be set. The current limit should always be set higher than the actual output current requirement of the external load. With tracking enabled, the negative current limit tracks the positive current limit setting. With tracking disabled, you can set different values for the positive and negative current limits.

The following figure shows the voltage priority operating locus of the power modules. The area in the white quadrants shows the output as a source (sourcing power). The area in the shaded quadrants shows the output as a load (sinking power).



The heavy solid line illustrates the locus of possible operating points as a function of the output load. As shown by the horizontal portion of the line, the output voltage remains regulated at its programmed setting as long as the load current remains within the positive or negative current limit setting. A CV (constant voltage) status flag indicates that the output current is within the limit settings.

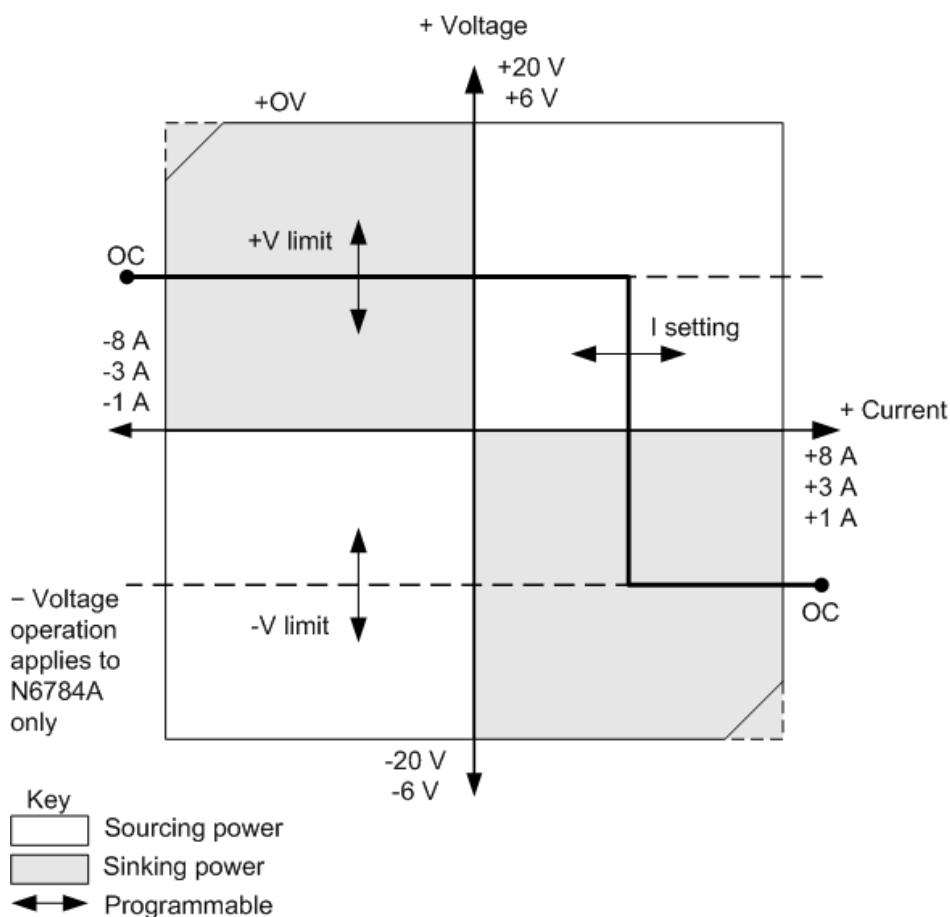
When the output current reaches either the positive or negative current limit, the unit no longer operates in constant voltage mode and the output voltage is no longer held constant. Instead, the power analyzer will now regulate the output current at its current limit setting. Either a LIM+ (positive current limit), or LIM- (negative current limit) status flag is set to indicate that a current limit has been reached.

As shown by the vertical portions of the load line, when the unit is sinking power, the output voltage may continue to increase in the positive or negative direction as more current is forced into the unit. When the output voltage exceeds either the positive or negative over-voltage setting, the output will shut down, the output relays will open, and either the OV or OV- and the PROT status bits will be set. Either the user-defined over-voltage setting or the local over-voltage function can trip the over-voltage protection.

Current Priority Mode

In current priority mode, the output current should be programmed to the desired positive or negative value. A positive voltage limit value should also be set. The voltage limit should always be set higher than the actual output voltage requirement of the external load. With tracking enabled, the negative voltage limit tracks the positive voltage limit setting. With tracking disabled, you can set different values for the positive and negative voltage limits.

The following figure shows the current priority operating locus of the power modules. The area in the white quadrants shows the output as a source (sourcing power). The area in the shaded quadrants shows the output as a load (sinking power).



The heavy solid line illustrates the locus of possible operating points as a function of the output load. As shown by the vertical portion of the line, the output current remains regulated at its programmed setting as long as the output voltage remains within the positive or negative voltage limit setting. A CC (constant current) status flag indicates when the output voltage is within the limit settings.

If the output voltage reaches either the positive or negative voltage limit, the unit no longer operates in constant current mode and the output current is no longer held constant. Instead, the power analyzer will now regulate the output voltage at its voltage limit setting. Either a LIM+ (positive

voltage limit) or LIM- (negative voltage limit) status flag is set to indicate that either the positive or negative voltage limit has been reached.

As shown by the horizontal portions of the load line, when the unit is sinking power, the output current may continue to increase in the positive or negative direction as more current is forced into the unit. Once the current is exceeds 112% of the rated current of the range, the output will shut down, the output relays will open, and the OC and PROT status bits will be set.

N678xA Output Bandwidth

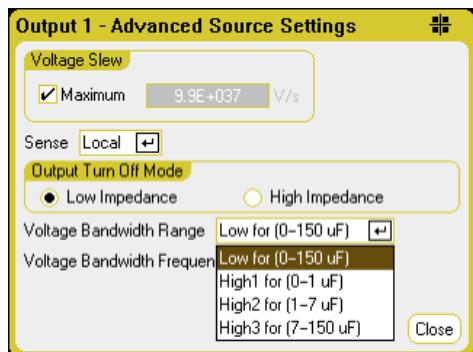
Keysight Models N678xA SMU **N678xA SMU** have several voltage bandwidth settings that let you optimize output response time with capacitive loads.

The Low bandwidth setting provides stability with a wide range of capacitive loads. Additional settings provide faster output response when the load capacitance is restricted to smaller values.

If capacitive loads cause the output to oscillate on the Low bandwidth or any other bandwidth setting, a protection function will detect the oscillation and latch the output off. This condition is annunciated by the OSC status bit. Oscillation usually occurs with load capacitances that fall outside the indicated ranges. At power-on the oscillation protection function is enabled.

From the front panel:

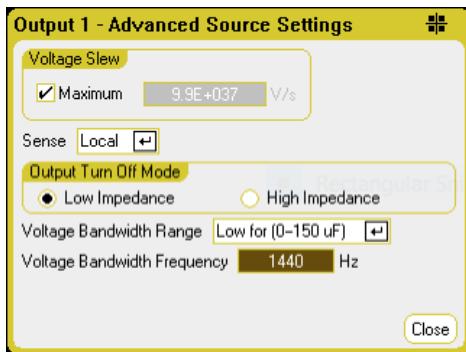
Press the **Settings** key to access the Source Settings window. Navigate to and select Advanced.



Select a bandwidth according to the following load capacitances and load lead lengths:

Setting	Load Capacitance	Sensing	Maximum distance from sense point to capacitor	ESR @100 kHz	Minimum frequency
Low	0-150 μF	Local or Remote	Full lead length ¹	50 to 200 m Ω	1440 Hz
High1	0-1 μF	Remote only	6 inches (155 mm)	50 to 200 m Ω	33,000 Hz
High2	0-7 μF	Remote only	6 inches (155 mm)	50 to 200 m Ω	20,500 Hz
High3	7-150 μF	Remote only	6 inches (155 mm)	50 to 200 m Ω	8300 Hz

Note 1 Refer to [Keysight N678xA SMU Wiring](#) for information on allowable full lead lengths.



The frequency parameter sets the pole frequency associated with a voltage bandwidth range. The power-on default for each range is the minimum frequency. This is optimized for no overshoot with the worst-case load capacitance for that range. If the load capacitance is not worst-case, or if some output overshoot is acceptable, the output voltage transition times can be reduced by increasing the frequency limit.

From the remote interface:

The bandwidth is selected using the following SCPI command:

VOLT:BWID <LOW|HIGH1|HIGH2|HIGH3>, (@1)

When queried, the bandwidth that was selected is returned.

To select a different frequency limit, use the following SCPI command:

VOLT:BWID:LEV <LOW|HIGH1|HIGH2|HIGH3>, <frequency>, (@1)

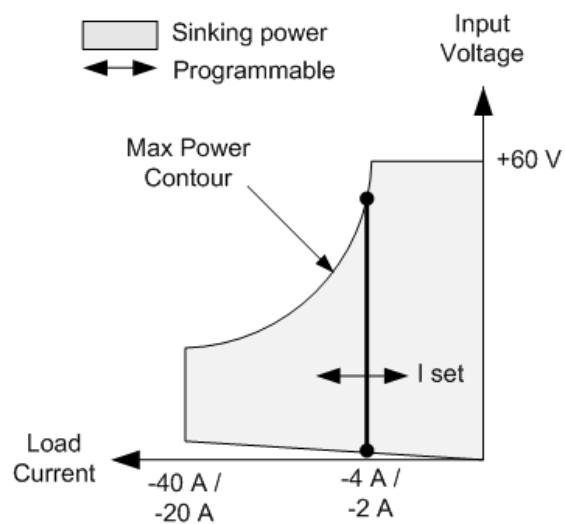
When queried, the selected frequency is returned.

Keysight N679xA Load Module Operation

The operating modes of operation for Keysight N679xA Load modules N679xA are: current priority, voltage priority, power priority, and resistance priority. When programmed to a mode, a module remains in that mode until the mode is changed or until a fault condition, such as an over-power or over-temperature occurs.

Current Priority Mode

In this mode, the load module will sink a current in accordance with the programmed value regardless of the input voltage.

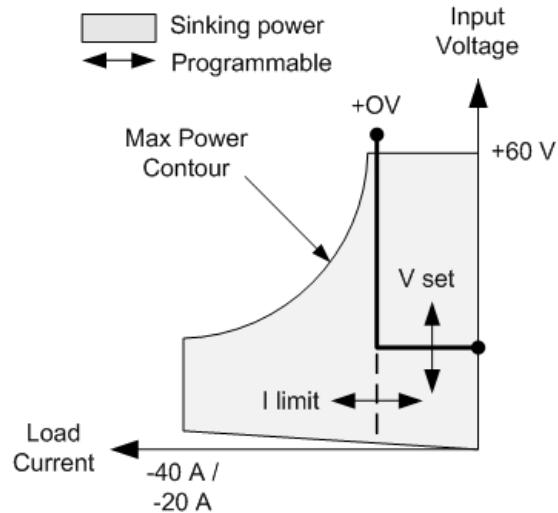


The heavy solid vertical line illustrates the locus of possible operating points as a function of the load current. A CC (constant current) status flag indicates that the load current is at the specified setting. A voltage limit is not programmable in current priority mode. Also, if the DUT imposes a voltage that is above 110% of the rated input voltage, the overvoltage protection will trip and the output will turn off.

Current may be programmed in one of two overlapping ranges, a Low range and a High range. The low range provides better programming and measurement resolution at low current settings.

Voltage Priority Mode

In this mode, the load module will attempt to sink enough current to maintain the input voltage at its programmed value.



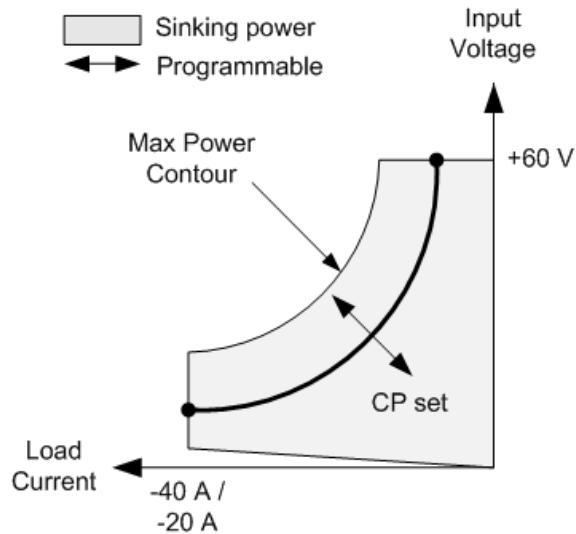
The heavy solid line illustrates the locus of possible operating points as a function of the load voltage.

Note that in voltage priority mode, a current limit can be imposed. As shown by the horizontal portion of the line, the input voltage remains regulated at its programmed setting as long as the input current remains within the current limit setting. A CV (constant voltage) status flag indicates that the input current is within the limit settings.

When the input current reaches the current limit, the unit is no longer in constant voltage operation and the input voltage is no longer held constant. Instead, the load module will now regulate the input current at its current limit setting. A CL (current limit) status flag is set to indicate that a current limit has been reached. If the input voltage increases until it exceeds 110% of the rated input voltage, the overvoltage protection will trip and the output will turn off.

Power Priority Mode

In this mode, the load module will regulate the power being drawn from the DUT according to the programmed constant-power value.



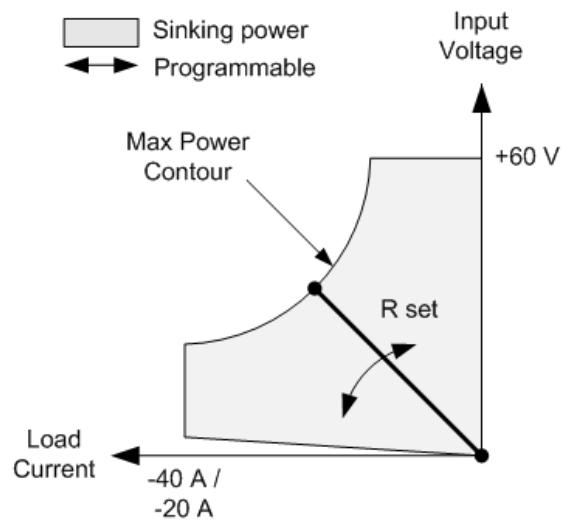
The load module regulates the input power by measuring the input voltage and current and adjusting the input power based on data streamed from the measurement ADCs.

Power may be programmed in one of two overlapping ranges, a Low range and a High range. The low range provides better programming and measurement resolution at low power settings.

The load modules have a built-in over-power protection function that will not let you exceed 110% of the power rating of the load module (the Max Power Contour).

Resistance Priority Mode

In this mode, the load module will sink current proportional to the input voltage in accordance with the programmed resistance.



The heavy solid line illustrates the locus of possible operating points as a function of the resistance.

Resistance may be programmed in one of three overlapping ranges - a Low, Medium, and a High resistance range. The lower ranges provide better programming and measurement resolution at lower resistance settings. The load module automatically selects the resistance range that best corresponds to the resistance value that you program. If the resistance value falls in a region where ranges overlap, the load selects the range with the highest resolution for the resistance value.

Advanced Measurements

Digitizing Measurements

Measurement System Bandwidth

Averaged Measurements

Current Histogram Measurements

Measurement Data Formats

Dynamic Current Measurement Control

Digitizing Measurements

The digitizing measurements discussed in this section allow you to perform most but not all of the scope measurement function available on the front panel. One example of functionality not available over the remote interface is the ability to program markers and make calculated measurements between markers.

With the digitizing measurement functions you can:

- Specify a measurement function and range.
- Adjust the measurement sample rate.
- Adjust the measurement to capture pre-trigger data.
- Select a measurement window that can attenuate AC noise.
- Select the measurement trigger source.
- Initiate the trigger system and generate a trigger.
- Retrieve the digitized measurements.

NOTE

When a measurement is in progress over the remote interface, the front panel display may indicate “-----”. Front panel measurements resume when the remote measurement completes.

Select a Measurement Function and Range

The following commands select a measurement function. To enable voltage measurements on channels 1–4, use:

SENS:FUNC:VOLT ON,(@1:4)

To enable voltage measurements on channels 1–4, use:

SENS:FUNC:CURR ON,(@2)

If a power module has simultaneous measurements (refer to [Model Differences](#)), you can enable BOTH voltage and current measurements on the same output channel.

Some power modules also have multiple measurement ranges. Selecting a lower measurement range provides greater measurement accuracy, provided that the measurement does not exceed the range. To select the low measurement range on channel 1, use:

```
SENS:VOLT:RANG 5,(@1)
```

To select the 1 A current range on channel 1:

```
SENS:CURR:RANG 1,(@1)
```

Seamless Measurements - For Keysight Models N678xA SMU and with Option SMR

N678xA SMU

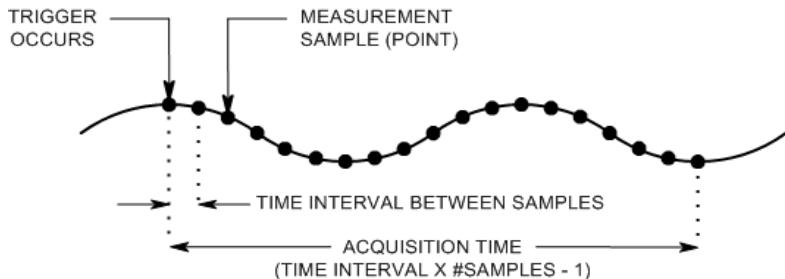
Option SMR, you can select seamless measurement autoranging, which enables a wide dynamic measurement range with no data lost when transitioning across ranges. Seamless autoranging does not include the 10 μ A range, which must be selected manually. To enable seamless voltage or current autoranging on channel 1:

```
SENS:VOLT:RANG:AUTO ON,(@1)
```

```
SENS:CURR:RANG:AUTO ON,(@1)
```

Adjust the Measurement Sample Rate

The following figure illustrates the relationship between measurement samples (or points), and the time interval between samples in a typical measurement.



You can vary the measurement data sampling rate using the following commands. For example, to set the time interval to 60 μ s with 4096 samples, use:

```
SENS:SWE:TINT 60E-6,(@1)
```

```
SENS:SWE:POIN 4096,(@1)
```

The maximum number of sample points that are available for all measurements is 512 K points (K = 1024). If you specify a voltage measurement with 500 K points on channel 1 for example, you will only have 12 K points available for all other measurements.

Time interval values can range from 5.12 microseconds (for one parameter on Models N678xA SMU) to 40,000 seconds. Note that the shortest time interval (fastest speed) that can be specified depends on the number of parameters that are being measured, the model that is doing the measuring, and the time interval resolution. You can only measure up to 4 parameters with the time interval resolution set to 20 microseconds.

1 parameter (models N678xA SMU only)	5.12 μ s
1 or 2 parameters (all models)	10.24 μ s
3 or 4 parameters (all models), with 20 μ s programmed resolution	20.48 μ s
5 to 8 parameters (all models), with 40 μ s programmed resolution	40.96 μ s

Time interval values from 10.24 up to 20.48 microseconds are rounded to the nearest 10.24-microsecond increment. Values above 20.48 microseconds are rounded to the nearest 20.48-microsecond increment when the resolution is set to RES20. Values above 40.96 microseconds are rounded to the nearest 40.96-microsecond increment when the resolution is set to RES40.

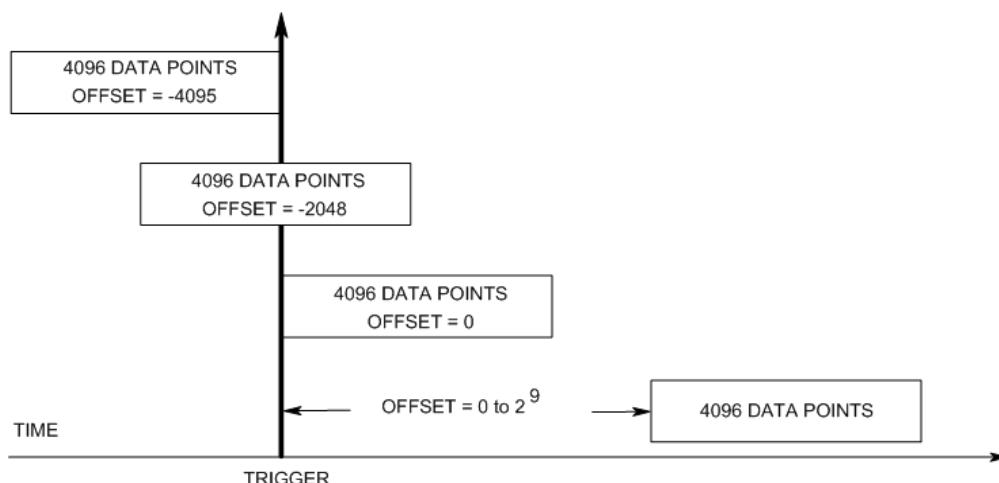
You can change the time interval resolution as follows:

SENS:SWE:TINT:RES RES20

SENS:SWE:TINT:RES RES40

Capture Pre-Trigger Data (optional)

The measurement system lets you capture data before, after, or at the trigger signal. As shown in the following figure, you can move the block of data being read into the acquisition buffer with reference to the trigger. This allows pre- or post-trigger data sampling.



The following command offsets the beginning of the acquisition buffer relative to the trigger by 100 points on channel 1:

SENS:SWE:OFFS:POIN 100,(@1)

When the value is 0, all measurement samples are taken after the trigger. Positive values represent the delay after the trigger occurs but before the samples are acquired. This can be used to exclude measurement samples that occur during the delay time. (Delay time = offset \times sample period).

Negative values represent data samples taken prior to the trigger. This lets you acquire measurement samples prior to the trigger.

NOTE If, during a pre-trigger data acquisition, a trigger occurs before the pre-trigger data count is completed, the measurement system ignores this trigger. This will prevent the completion of the measurement if another trigger is not generated.

Specify a Window Function

Windowing is a signal conditioning process that reduces the error in average measurements made in the presence of periodic signals and noise. Two window functions are available: Rectangular and Hanning. At power-on, the measurement window is Rectangular.

The Rectangular window calculates average measurements without any signal conditioning. However, in the presence of periodic signals such AC line ripple, a Rectangular window can introduce errors when calculating average measurements. This can occur when a non-integral number of cycles of data has been acquired due to the last partial cycle of acquired data.

One way of dealing with AC line ripple is to use a Hanning window. The Hanning window applies a cos⁴ weighting function to the data when calculating average measurements. This attenuates the AC noise in the measurement window. The best attenuation is achieved when at least three or more waveform cycles are in the measurement.

To select the Hanning window function, use:

`SENS:WIND HANN,(@1)`

Select the Measurement Trigger Source

NOTE

A TRIGger:ACQuire[:IMMEDIATE] command over the bus will always generate an immediate measurement trigger, regardless of the selected trigger source.

Unless you are using a TRIGger:ACQuire command to trigger the measurement, select a trigger source from the following:

BUS	Selects GPIB device trigger, *TRG, or <GET> (Group Execute Trigger)
CURRent<1-4>	Triggers the measurement when the current of the corresponding output passes through the specified level.
EXTernal	Selects the trigger input BNC connector. Requires a low-true trigger signal.
PIN<1-7>	Selects a specific pin that is configured as a Trigger Input on the digital port. The selected pin must be configured as a Trigger Input in order to be used as a trigger source (see Using the Digital Port).
TRANsient<1-4>	Selects the specified output channel's transient system as the trigger source.
VOLTage<1-4>	Triggers the measurement when the voltage of the corresponding output passes through the specified level.

Use the following commands to select a trigger source. To select Bus triggers for output 1:

`TRIG:ACQ:SOUR BUS,(@1)`

To select Digital pin triggers, where n is the pin number that will generate the trigger:

`TRIG:ACQ:SOUR PIN<n>,(@1)`

To select a Transient output as trigger, where n is the output channel that will generate the trigger signal:

`TRIG:ACQ:SOUR TRAN<n>,(@1)`

To enable trigger signals for output Steps or Lists: (Specify if the list trigger occurs at the Beginning Of the Step, or End Of the Step.)

```
STEP:TOUT ON,(@3)
LIST:TOUT:BOST 1, (@3)
LIST:TOUT:EOST 1, (@3)
```

To select a voltage or current level of another output as the trigger for output 1: (Output 3 will generate the voltage or current level to trigger output 1.)

```
TRIG:ACQ:SOUR VOLT3,(@1)
TRIG:ACQ:SOUR CURR3,(@1)
```

To specify the voltage or current trigger level and slope of output 3:

```
TRIG:ACQ:CURR 10,(@3)
TRIG:ACQ:CURR:SLOP POS,(@3)
TRIG:ACQ:VOLT 10,(@3)
TRIG:ACQ:VOLT:SLOP POS,(@3)
```

NOTE

A non-programmable hysteresis for level triggers reduces false triggering on slow signals. The hysteresis is set to 0.0005 X maximum range value. For example, on the 50 V range, the hysteresis is approximately 25 mV.

Initiate the Measurement

When the power analyzer is turned on, the trigger system is in the idle state. In this state, the trigger system is disabled, ignoring all triggers. The INITiate command enables the measurement system to receive triggers. To initiate the trigger system for all four outputs:

```
INIT:ACQ (@1:4)
```

It takes a few milliseconds for the instrument to be ready to receive a trigger signal after receiving the INITiate:ACQuire command, and it can take longer for Keysight Models N678xA SMU.

If a trigger occurs before the trigger system is ready for it, the trigger will be ignored. You can test the WTG_meas bit in the operation status register to know when the instrument is ready to receive a trigger after being initiated.

```
STAT:OPER:COND?(@1)
```

If a bit value of 8 is returned in the query, the WTG_meas bit is true, and the instrument is ready to receive the trigger signal. Refer to Status Tutorial in the Operating and Service Guide document for more information.

NOTE

It will be necessary to initiate the measurement trigger system each time a triggered measurement is desired.

Trigger the Measurement

The trigger system is waiting for a trigger signal in the initiated state. You can immediately trigger the measurement as follows:

TRIG:ACQ (@1)

Alternatively, if the trigger source is BUS, you can also program a *TRG or an IEEE-488 <get> command.

As previously discussed, a trigger can also be generated by another output channel or an input pin on the digital port connector. If any of these systems are configured as the trigger source, the instrument will wait indefinitely for the trigger signal. If the trigger does not occur, you must abort the measurement.

To abort the measurement and return the trigger system to the Idle state:

ABOR:ACQ (@1)

Retrieve the Measurement Data

After a trigger is received and the measurement completes, the trigger system will return to the idle state. When this occurs, you can use FETCh queries to return specific voltage or current data from a previously triggered measurement. FETCh queries do not alter the data in the measurement buffer.

To return average voltage & current:

FETC:VOLT?(@1)

FETC:CURR?(@1)

To return RMS voltage & current:

FETC:VOLT:ACDC?(@1)

FETC:CURR:ACDC?(@1)

To return the high level of a pulse:

FETC:VOLT:HIGH?(@1)

FETC:CURR:HIGH?(@1)

To return the low level of a pulse:

FETC:VOLT:LOW?(@1)

FETC:CURR:LOW?(@1)

To return the maximum value:

FETC:VOLT:MAX?(@1)

FETC:CURR:MAX?(@1)

To return the minimum value:

FETC:VOLT:MIN?(@1)

FETC:CURR:MIN?(@1)

To return power:

FETC:POW?(@1)

Power can only be measured on power modules with simultaneous measurement capability (refer to [Model Differences](#)).

If a FETCh query is sent before the measurement is finished, the response will be delayed until the measurement trigger occurs and the acquisition completes. You can test the MEAS_active bit in the operation status register to know when the measurement trigger system has returned to the idle state. To query the MEAS_active bit (bit 5):

```
STAT:OPER:COND?(@1)
```

If a bit value of 32 is returned in the query, the MEAS_active bit is true, and the measurement is NOT complete. When the MEAS_active bit is false, you can retrieve the measurement. Refer to Status Tutorial in the Operating and Service Guide document for more information.

Use Array queries to return all data from the measurement buffer.

```
FETC:ARR:CURR?(@1)
FETC:ARR:VOLT?(@1)
FETC:ARR:POW?(@1)
```

NOTE

You can specify the format of the array data. Refer to [Measurement Data Formats](#) for more information

ASCII data (the default format) is returned as comma-separated ASCII numeric voltage or current data terminated by a newline. An ASCII query can only fetch data from one channel at a time.

Binary data is returned as a comma-separated list of data for each channel requested. The data for each channel is a definite length binary block, with the byte order specified by the BORDer command.

Each FETCh command also has a corresponding MEASure command. Measure commands initiate, trigger, and return the data all in one step. Each measurement command overwrites previous data. Refer to Measure commands in the Operating and Service Guide document for more information.

Measurement System Bandwidth

NOTE

The following applies when making dynamic current measurements; not when making static (or DC) measurements. This information does not apply to models N678xA SMU. For N678xA bandwidth information, refer to the [Keysight N6700 Modular Power System Family Specifications Guide](#).

The measurement bandwidth of the power analyzer is dependent on the following factors:

- Whether voltage or current is being measured.
- Whether dynamic current correction has been turned on or off.
- The analog bandwidth of the power module.

The following table documents the bandwidth for the above-mentioned factors.

Power Module	Dynamic Current Correction	
	On	Off
Voltage measurements		
N6751A/52A, N6761A/62A	10 kHz BW (-3dB)	10 kHz BW (-3dB)
N6753A-56A, N6763A-66A	N/A	10 kHz BW (-3dB)
N673xB, N674xB, N677xA	10 kHz BW (-3dB)	25 kHz *
Current Measurements		
N6751A, N6752A	2 kHz BW (-3dB)	10 kHz BW (-3dB)
N6753A-N6756A	N/A	10 kHz BW (-3dB)
N6761A-N6762A	2 kHz BW (-3dB)	2 kHz BW (-3dB)
N6763A-N6766A	N/A	2 kHz BW (-3dB)
N673xB, N674xB, N677xA	2 kHz BW (-3dB)	25 kHz *

* Note Nyquist-limited to 25 kHz due to 50 kHz digitization rate.

Note that when dynamic current correction is turned off, you will see additional current in the output current measurement as the output capacitor charges and discharges when changing from one voltage value to another voltage value.

The values in *italics* in the table will change based on the resistance of the output load. The values specified in the table only apply when the output load resistance is at or close to zero ohms. At larger resistance values, errors are introduced into the measurement due to the interaction of the output load and the power module's output capacitor. Use the following formula to calculate the largest frequency that can be measured without errors.

$$f = \frac{1}{2\pi C_o R_L}$$

f = maximum measurable frequency without measurement errors
 Co = the output capacitor value (from the following table)
 RL = the load resistance

Power Module	Co Value	Power Module	Co Value
N6751A, N6752A, N6761A, N6762A	25.4 µF	N6731B, N6741B	30 µF
N6753A, N6755A, N6763A, N6765A	4.7 µF	N6732B, N6742B	23.5 µF
N6754A, N6756A, N6764A, N6766A	2.2 µF	N6733B, N6743B	13.4 µF
N6773A	13.2 µF	N6734B, N6744B	9.8 µF
N6774A	11.2 µF	N6735B, N6745B	12.8 µF
N6775A	4.02 µF	N6736B, N6746B	3.52 µF
N6776A, N6777A	3.54 µF		

For example, if you are measuring the output current on a Keysight N6731B with a 10 ohm load connected to the output, and with dynamic current correction turned off, the largest frequency that can be measured without introducing measurement errors is 530 Hz. If a 1 ohm load were connected to the output, the largest frequency that could be measured without errors would be 5.3 kHz.

For frequencies above the maximum measurable frequency, the current flowing in the output capacitor causes the measured current to be greater than the actual output current by a factor of +20 dB per decade increase of frequency.

Averaged Measurements

Measurement values returned in Meter View, Scope View, and by the Data Logger are averaged. Each measurement value is an arithmetic average of all the data points in the specified sample period. The average is calculated as follows:

$$A = \frac{\sum_{i=1}^N x_i}{N}$$

A = the average
 N = the number of data points
 x_i = the i th data point

The Meter View sample period depends on the number of power line cycles (NPLC) specified for each measurement sample. The sample period of the Scope View can be adjusted indirectly by using the Horizontal Time/Div knob to adjust the horizontal time base. The Data Logger sample period can be adjusted by pressing **Data Logger**, then **Properties**, and entering a value in the Sample Period field.

Note that in the Scope Marker View, you can view the average value as well as the minimum and maximum value of the sample period that is located between the two markers.

Current Histogram Measurements

NOTE The following information only applies to Keysight Models N6781A, N6782A, N6785A, and N6786A. Histogram measurements are not available if option 055 (delete data logger) has been ordered.

A current histogram measurement provides a statistical measurement for profiling the measured current. The acquisition generates an array of frequency of occurrence vs. current amplitude data that can be analyzed using a CCDF function. The value of each element represents the number of times an amplitude within the range of that element has been detected.

There are two ranges of histogram bins, a low range and a high range for each model. Each range has 4096 bins with a minimum and maximum amplitude, and a bin size (see below).

Models N6781A/N6782A		Models N6785A/N6786A	
Low Range	High Range	Low Range	High Range
Amplitude	-7.8 mA to +7.8 mA	-8 A to +8 A	-15.6 mA to +15.6 mA
Bin size	3.8 μ A	3.9 mA	7.6 μ A

Both ranges are filled when the histogram runs. Measurement magnitudes that fall within the low range are automatically placed in the low-range histogram. The values for both histogram ranges can be queried as follows:

SENS:HIST:CURR:BIN:RANG? (@1)

This query returns the amplitudes of the high and low range. These amplitude limits are subsequently used by other SCPI commands when returning the histogram counts for the specified range.

Programming a current histogram measurement consists of:

- Selecting the histogram function and range.
- Specifying the trigger source.
- Initiating and triggering the histogram.
- Retrieving the histogram measurement.
- Querying the histogram bin and offset to calculate amperes.

Histograms cannot be programmed from the front panel and cannot run simultaneously with any other measurement. When a histogram measurement is initiated on an output channel, the front panel changes to Meter view. Any channel that is performing a histogram measurement displays a message to this effect. Switching to Scope or Data Logger view will terminate the histogram measurement.

Select the Histogram Function and Range

The following command selects a measurement function. To enable current histogram measurements on channel 1:

SENS:HIST:FUNC:CURR ON,(@1)

Each output channel uses its own current measurement range, which includes autoranging. To select the 3 A current range on channel 1:

SENS:HIST:CURR:RANG 3,(@1)

Seamless Measurements – For Keysight Models N6781A, N6782A, N6785A, and N6786A, you can select seamless current autoranging, which results in a wide dynamic range with no data lost across ranges. Seamless ranging does not include the 10 μ A range, which must be selected manually. To enable seamless current autoranging on channel 1:

SENS:HIST:CURR:RANG:AUTO ON,(@1)

Select the Histogram Trigger Source

The TRIGger:HISTogram command generates an immediate trigger regardless of the trigger source. Unless you are using this command, select a trigger source from the following:

BUS	Selects GPIB device trigger, *TRG, or <GET> (Group Execute Trigger).
EXternal	Selects the trigger input BNC connector. Requires a low-true trigger signal.
IMMEDIATE	Selects the immediate trigger source. This triggers the histogram immediately when initiated.
Pin<1-7>	Selects a specific pin that is configured as a Trigger Input on the digital port. The selected pin must be configured as a Trigger Input in order to be used as a trigger source (see Using the Digital Port).

Use the following commands to select a trigger source. To select Bus triggers for output 1:

TRIG:HIST:SOUR BUS,(@1)

To select the IMMEDIATE trigger source for output 1:

TRIG:HIST:SOUR IMM,(@1)

To select the EXTERNAL trigger source for output 1:

TRIG:HIST:SOUR EXT,(@1)

To select Digital pin triggers on pin 3 for output 1:

TRIG:HIST:SOUR PIN3,(@1)

Initiate and Trigger the Histogram

When the power analyzer is turned on, the trigger system is in the Idle state. In this state, the trigger system is disabled, ignoring all triggers. The INITiate command enables the measurement system to receive triggers. To initiate and then trigger histogram measurements on output 1:

INIT:HIST (@1)

TRIG:HIST (@1)

If the trigger source is BUS, you can also program *TRG or <GET> to trigger the histogram.

When a histogram measurement is initiated and triggered, the current is continuously sampled. Histograms sample at the rate of 20.48 microseconds per sample. Each sampled value is compared to the amplitude range of each bin of the histogram and the value of the bin that the sampled value falls within is incremented by 1. There is some overlap between the lowest bins of the high range and the highest bins of the low range; values that overlap both ranges are placed in the low range buckets. Each Fetch returns the latest cumulative histogram data. The measurement continues until it is aborted. The count bins are 64-bits wide, which eliminates any concern for overflow.

Terminate the Measurement

Measurements continue until the histogram is aborted. To abort the histogram measurement:

ABOR:HIST (@1)

Retrieve the Histogram Measurement

The following command returns the histogram counts for the 7.8 mA histogram range from output 1:

FETC:HIST:CURR? 0.0078,(@1)

The following command returns the histogram counts for the 8 A histogram range from output 1:

FETC:HIST:CURR? 8,(@1)

Histogram data is returned as 4096 comma-separated ASCII values terminated by a newline. A histogram query can only fetch data from one histogram range at a time.

Query the Histogram Bin and Offset to Calculate Amperes

The gain and offset are needed to convert a bin number to amperes. Therefore, the bin gain and offset can be queried for each histogram range. For example, to query the gain and offset value for the 3.9 mA histogram range, use:

```
SENS:HIST:CURR:BIN:GAIN? 0.0078,(@1)  
SENS:HIST:CURR:BIN:OFFS? 0.0078,(@1)
```

To query the gain and offset value for the 8 A histogram range, use:

```
SENS:HIST:CURR:BIN:GAIN? 8,(@1)  
SENS:HIST:CURR:BIN:OFFS? 8,(@1)
```

The median current in amperes of a bin can then be calculated using:

current = (bin number) x gain + offset

where (bin number) is an integer between 0 and 4095 corresponding to the 4096 counts returned by FETC:HIST:CURR? Because the current measurements can be positive or negative, bin 0 represents the most negative current, bin 2048 represents 0, and bin 4095 is the most positive current.

Measurement Data Formats

The default data format for measurement queries is ASCII. You can also specify Real data format when returning SCPI array and external datalog measurements as well as for setting and querying constant-dwell Arb levels.

ASCII - Numeric data is transferred as ASCII bytes in <NR1>, <NR2>, or <NR3> format as appropriate. The numbers are separated by commas.

Real - Data is returned in binary IEEE single precision floating point. In this case the four bytes of each value can be returned in either big-endian or little-endian byte order, determined by the FORMat:BORDer setting.

The following command specifies the data format:

```
FORM ASCII | REAL
```

You can also specify how binary data is transferred. This only applies when the FORMat:DATA is set to REAL

Normal - Binary data is transferred in normal order. The most significant byte is returned first, and the least significant byte is returned last (big-endian).

Swapped - Binary data is transferred in swapped-byte order. The least significant byte is returned first, and the most significant byte is returned last (little-endian).

The following command specifies the byte order of the data:

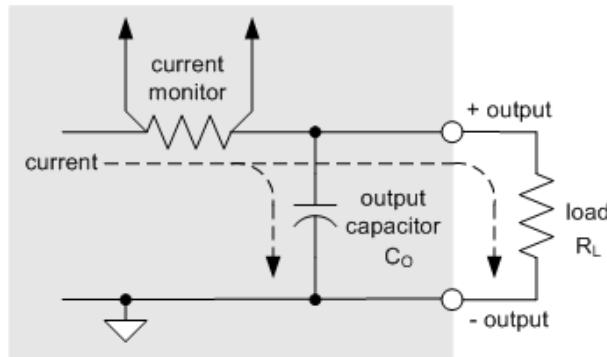
```
FORM:BORD NORM | SWAP
```

Use swapped format if you are using a little-endian data processor.

Dynamic Current Measurement Control

NOTE This control is used when making dynamic current measurements; it is not required for static (or dc) measurements. On Models N678xA SMU, N6753A - N6756A, and N6763A - N6766A, the designs are such that dynamic current correction is not needed and the control is therefore unavailable.

The power analyzer measures the output current across an internal current monitor. For most power modules this current monitor is located on the inboard side of the output capacitor.



For static (or dc) measurement applications this measurement method yields accurate measurements. However, due to the output capacitor C_0 , when there is a significant and rapid change in output voltage, the additional output current does not all flow into load R_L ; some of it flows through the output capacitor. In this momentary situation the measurement circuit is not only measuring the output current going into the load, but also the output current flowing through the output capacitor. Since the load never sees the additional current, this results in an inaccurate output current measurement.

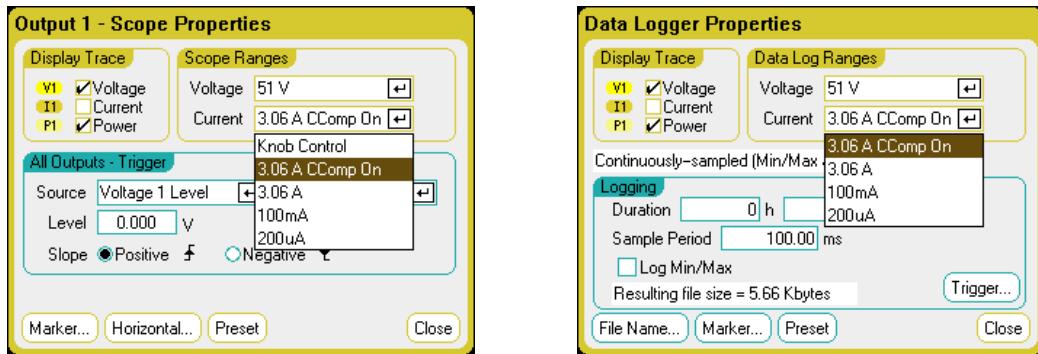
When the output current is measured and averaged over a number of samples as in the case of static measurements, the inaccuracy is insignificant. However, with the power analyzer's scope and data logging functions, which capture thousands of measurement samples per second, this inaccuracy becomes evident.

Dynamic current correction compensates for the current flowing into the output capacitor. The power analyzer calculates what the additional current is and subtracts it from the current measurement, thus providing accurate output current measurements. This feature is turned on by default and only applies to the high current range.

NOTE Dynamic current correction increases the peak to peak noise in current measurements on some power modules. It may also limit the measurement bandwidth as explained in the next section. If either condition is a significant factor in your application, you should turn dynamic current correction off.

To turn dynamic current correction on or off, press Scope View or Data Logger, then press Properties. In the current range dropdown box, select the range labeled "CComp On" to turn current correction on. Un-select the "CComp On" range to turn current correction off.

6 Advanced Source, Measurement, and Control



Using the Digital Control Port

Bi-directional Digital IO

Digital Input

Fault Output

Inhibit Input

Fault/Inhibit System Protection

Trigger Input

Trigger Output

Output Couple Controls

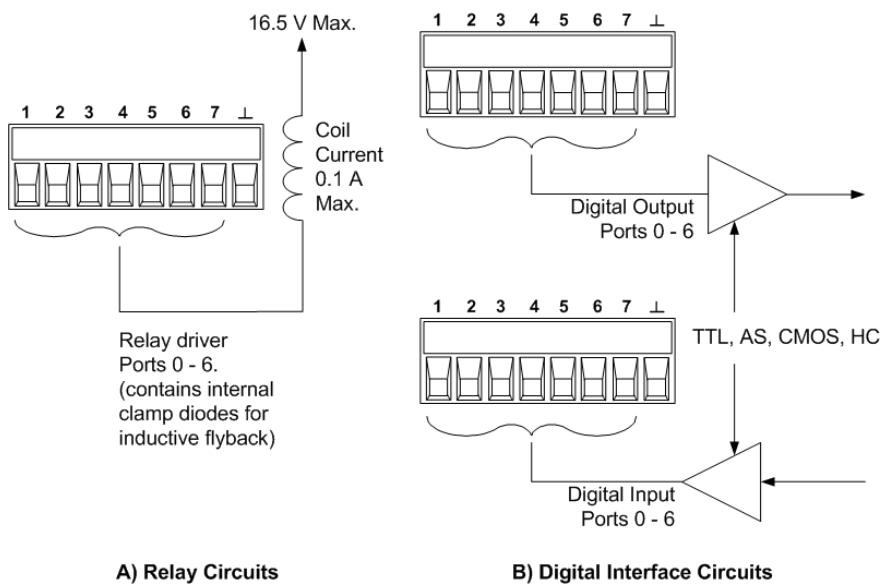
A Digital Control Port consisting of seven I/O pins is provided to access various control functions. Each pin is user-configurable. The following control functions are available for the I/O pins:

Bi-directional Digital IO

Each of the seven pins can be configured as general purpose bi-directional digital inputs and outputs. The polarity of the pins can also be configured. Pin 8 is the signal common for the digital I/O pins. Data is programmed according to the following bit assignments:

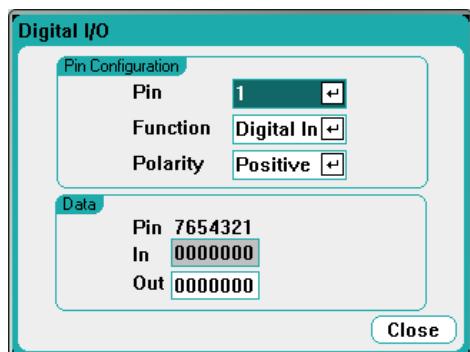
Pins	7	6	5	4	3	2	1
Bit weight	6 (msb)	5	4	3	2	1	0 (lsb)

The digital I/O pin can be used to control both relay circuits as well as digital interface circuits. The following figure illustrates typical relay circuits as well as digital interface circuit connections using the digital I/O functions.



From the front panel:

To configure the bi-directional digital I/O, press the **Menu** key, scroll down and select the Utilities item, then select Digital I/O. Then press Enter.



Select the pin you wish to configure from the Pin dropdown list.

Select the Digital I/O function from the Function dropdown list. Select and program the remaining pins in the same manner.

Configure the polarity for each pin by selecting the Polarity dropdown menu. Select either Positive or Negative. Select and program the remaining pins in the same manner.

The Data fields only apply to the Digital I/O and Digital In functions. Enter the binary word into the Out field of the Digital I/O window. The In field reflects the condition of the external signal that is applied to the pins.

From the remote interface:

To configure the digital I/O function for pins 1 through 4:

```
DIG:PIN1:FUNC POS
DIG:PIN2:FUNC POS
```

DIG:PIN3:FUNC POS
 DIG:PIN4:FUNC POS

To configure the pin polarity to positive for pins 1 through 4:

DIG:PIN1:POL POS
 DIG:PIN2:POL POS
 DIG:PIN3:POL POS
 DIG:PIN4:POL POS

To send a binary weighted value to configure pins 1 through 7 as “0000111”:

DIG:OUTP:DATA 7

Digital Input

Each of the seven pins can be configured as digital input only. The ground reference for the input pins is Signal Common on pin 8.

From the front panel;

To configure the digital input function, press the **Menu** key, scroll down and select the Utilities item, then select Digital I/O. Then press Enter. The Digital I/O window will appear as previously shown under **Bi-directional Digital I/O**.

Select the pin you wish to configure from the Pin dropdown list.

Select the Digital In function from the Function dropdown list. Select and program the remaining pins in the same manner.

Configure the polarity for each pin by selecting the Polarity dropdown menu. Select either Positive or Negative. Select and program the remaining pins in the same manner.

The Data fields only apply to the Digital I/O and Digital In functions. The In field reflects the condition of the external signal that is applied to the pins. The pin state is not affected by the value of the binary output word.

From the remote interface:

To configure the pin function:

DIG:PIN1:FUNC DINP

To select the pin polarity:

DIG:PIN1:POL POS
 DIG:PIN1:POL NEG

To read the pin data:

DIG:INP:DATA?

Fault Output

Pins 1 and 2 can be configured as a fault-output pair. The Fault Output function enables a fault condition on any channel to generate a protection fault signal on the digital port. Refer to [Protection Functions](#) for a list of protection signals that will generate a fault.

Both pins 1 and 2 are dedicated to this function. Pin 1 is the Fault output; pin 2 is the common for pin 1. This provides for an optically-isolated output. The polarity of pin 1 can also be configured. Note that the Fault output signal remains latched until the fault condition is removed and the protection circuit is cleared, as explained under [Clearing Protection Functions](#).

NOTE Pin 2's selected function is ignored. Pin 2 should be connected to the ground of the external circuit.

From the front panel:

To configure the digital input function, press the Menu key, scroll down and select the Utilities item, then select Digital I/O. Then press Enter. The Digital I/O window will appear as previously shown under [Bi-directional Digital I/O](#).

Select pin 1 from the Pin dropdown list.

Select the Fault Out function for the pin from the Function dropdown list.

Configure the polarity for the pin by selecting the Polarity dropdown menu. Select either Positive or Negative.

From the remote interface:

To configure the pin function:

DIG:PIN1:FUNC FAUL

To select the pin polarity:

DIG:PIN1:POL POS

DIG:PIN1:POL NEG

Inhibit Input

Pin 3 can be configured as a remote inhibit input. The Inhibit Input function lets an external input signal control the output state of all the output channels in the mainframe. The polarity of pin 3 can also be configured. The input is level triggered. The signal latency is 5 microseconds. Pin 8 is the common for pin 3.

The following non-volatile inhibit input modes can be programmed:

LATCHing - causes a logic-true transition on the Inhibit input to disable the output. The output will remain disabled after the inhibit signal is received.

LIVE - allows the enabled output to follow the state of the Inhibit input. When the Inhibit input is true, the output is disabled. When the Inhibit input is false, the output is re-enabled.

OFF - The Inhibit input is ignored.

From the front panel:

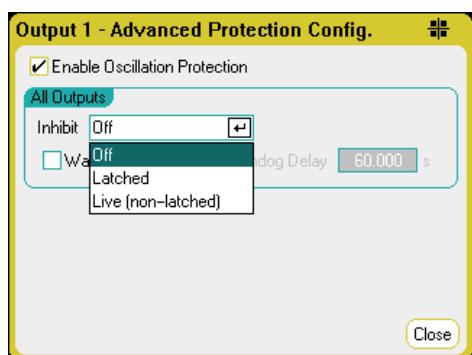
To configure the digital input function, press the Menu key, scroll down and select the Utilities item, then select Digital I/O. Then press Enter. The Digital I/O window will appear as previously shown under **Bi-directional Digital I/O**.

Select pin 3 from the Pin dropdown list.

Select the Inhibit In function for the pin from the Function dropdown list.

Configure the polarity for the pin by selecting the Polarity dropdown menu. Select either Positive or Negative

Next, you must configure the Inhibit Input mode. Press the **Settings** key to access the Source Settings window. Navigate to and select Protection, then Advanced. Then press Enter.



From the remote interface:

To select the Inhibit function:

DIG:PIN1:FUNC INH

To select the pin polarity:

DIG:PIN1:POL POS

DIG:PIN1:POL NEG

To set Inhibit mode to Latching:

OUTP:INH:MODE LATC

To set Inhibit mode to Live:

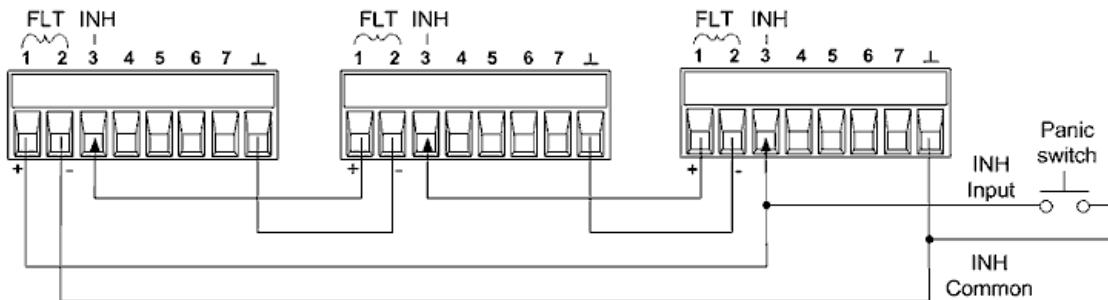
OUTP:INH:MODE LIVE

To disable the Inhibit signal:

OUTP:INH:MODE OFF

Fault/Inhibit System Protection

The following figure illustrates some ways that you can connect the Fault/Inhibit pins of the connector.



As shown in the figure, when the Fault outputs and Inhibit inputs of several instruments are daisy-chained, an internal fault condition in one of the units will disable all outputs without intervention by either the controller or external circuitry. Note that when using the Fault/Inhibit signals in this manner, both signals must be set to the same polarity.

You can also connect the Inhibit input to a manual switch or external control signal that will short the Inhibit pin to common whenever it is necessary to disable all outputs. **Negative** polarity must be programmed for all pins in this case. You can also use the Fault output to drive an external relay circuit or signal other devices whenever a user-definable fault occurs.

Clearing a System Protection Fault

To restore all instruments to a normal operating condition when a fault condition occurs in a daisy-chained system protection configuration, two fault conditions must be removed:

1. The initial protection fault or external Inhibit signal.
2. The subsequent daisy-chained fault signal (which is sourced by the Inhibit signal).

NOTE Even when the initial fault condition or external signal is removed, the fault signal is still active and will continue to shut down the outputs of all the units.

To clear the daisy-chained fault signal if the operating mode of the Inhibit input is Live, simply clear the output protection on any ONE unit as explained under [Clearing Protection Functions](#). If the operating mode of the Inhibit input is Latched, turn off the Inhibit input on ALL units individually. To re-enable the chain, re-program the Inhibit input on each unit to Latched mode.

Trigger Input

Any of the Digital Control pins can be programmed to function as a trigger input. All pins are referenced to the Signal Common pin.

To input an external trigger signal, you can apply either a negative-going or a positive-going pulse to the designated trigger input pin. The trigger latency is 5 microseconds. The minimum pulse width is 2

microseconds. The pin's polarity setting determines which edge generates a trigger-in event. Positive means a rising edge and Negative means a falling edge.

You can configure the scope, the data logger, and the arbitrary waveform generator to be triggered by external trigger signals. Simply select BNC Trigger In as the trigger source when configuring the scope, data logger, or arbitrary waveform generator. This will enable input trigger signals on the configured digital pins as well as on the BNC trigger input connector. A trigger is generated when an external signal that meets the signal criteria is applied to any configured trigger input pin or to the BNC connector.

From the front panel:

To configure the trigger input function, press the **Menu** key, scroll down and select the Utilities item, then select Digital I/O. Then press Enter. The Digital I/O window will appear as previously shown under **Bi-directional Digital I/O**.

Select the pin you wish to configure from the Pin dropdown list.

Select the Trigger In function for the pin from the Function dropdown list.

Configure the polarity for the pin by selecting the Polarity dropdown menu. Select either Positive or Negative.

From the remote interface:

To select the trigger input function:

DIG:PIN1:FUNC TOUT

To select the pin polarity:

DIG:PIN1:POL POS

DIG:PIN1:POL NEG

Trigger Output

Any of the Digital Control pins can be programmed to function as a trigger output. All pins are referenced to the Signal Common pin.

When configured as a trigger output, the designated trigger pin will generate a 10-microsecond trigger pulse in response to a trigger event. The polarity setting can be either positive-going (rising edge) or negative-going (falling edge) when referenced to common.

Trigger out signals can be generated when configuring User-defined voltage or current arbitrary waveforms. If you check the **Trigger box** when configuring the User-defined arbitrary waveform, an output trigger signal will be generated on the configured digital pin as well as on the BNC trigger output connector at the start of the voltage or current step.

From the remote interface:

To select the trigger input function:

DIG:PIN1:FUNC TINP

To select the pin polarity:

DIG:PIN1:POL POS

DIG:PIN1:POL NEG

Output Couple Controls

This function lets you connect multiple Keysight N6705 mainframes together and synchronize the output on/off sequence across mainframes. Each mainframe that will be synchronized must have at least one coupled output.

1. Configure the outputs on each mainframe as described under [Configuring an Output Turn-On/Turn-Off Sequence](#). Set the output coupling Mode to Manual.
2. Set the delay offset of each individual mainframe to match the longest delay offset of the mainframe group.
3. Connect and configure the digital connector pins of the synchronized mainframes as described in this section.

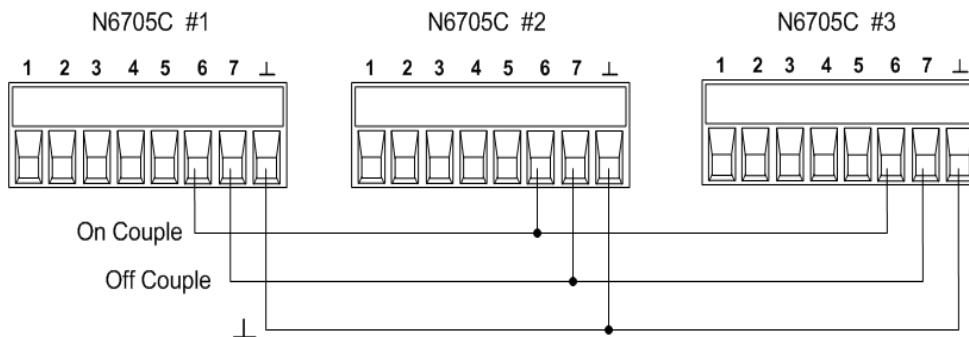
NOTE

All synchronized N6705 mainframes must have the same firmware revision. Only pins 4 through 7 can be configured as synchronization pins. You cannot configure more than one On Couple and one Off Couple pin per mainframe.

The polarity of the pins is not programmable; it is set to Negative

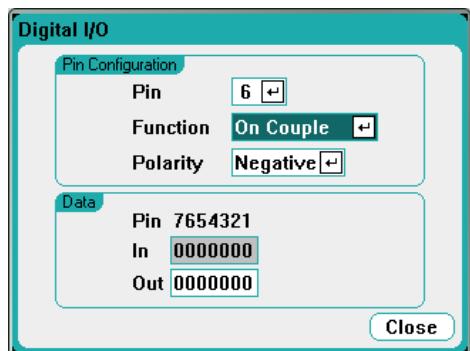
The digital connector pins of the synchronized mainframes that contain coupled outputs must be connected together as shown in the following figure. In this example, pin 6 will be configured as the output On control. Pin 7 will be configured as the output Off control. The ground or Common pins also need to be connected together.

Only two of the digital connector pins on each mainframe can be configured as “On Couple” and “Off Couple” on each synchronized mainframe. The designated pins will function as both an input and an output, with a negative transition on one pin providing the synchronization signal to the other pins.



From the front panel:

To configure the trigger input function, press the **Menu** key, scroll down and select the Utilities item, then select Digital I/O. Then press Enter.



Select pin 6 from the Pin dropdown list. Then select the On Couple function for the pin the from the Function dropdown list.

Select pin 7 from the Pin dropdown list. Then select the Off Couple function for the pin the from the Function dropdown list.

Repeat these steps for mainframes #2 and #3.

From the remote interface:

To configure pin 6 of mainframe #1 as the ON control:

DIG:PIN6:FUNC ONC

To configure pin 7 of mainframe #1 as the OFF control:

DIG:PIN7:FUNC OFFC

Repeat these commands for mainframes #2 and #3.

Operation

Once configured and enabled, turning the output on or off on any coupled output will cause all coupled outputs on all configured mainframes to turn on or off according to their user-programmed delays. This applies to the front panel On and Off keys, the Web server, and to SCPI commands.

Turning the outputs on or off using the front panel All Outputs **On** and **Off** keys will cause all coupled outputs as well as non-coupled outputs **on that mainframe** to turn on or off.

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