User's Guide

EDU33210 Series Trueform Arbitrary Waveform Generators

KEYSIGHT TECHNOLOGIES

Notices

Copyright Notice

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Warranty

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This product complies with the WEEE Directive marking 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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Declarations of Conformity for this product and for other Keysight products may be downloaded from the Web. Go to https://regulations.about.keysight.com/DoC/default.htm. You can then search by product number to find the latest Declaration of Conformity.

Safety Information

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.

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.

Safety and Regulatory Information

Safety Considerations

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

BEFORE APPLYING POWER

Verify that all safety precautions are taken. Make all connections to the unit before applying power.

GROUND THE INSTRUMENT

This product is provided with protective earth terminals. To minimize shock hazard, the instrument must be connected to the AC power 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 personal injury.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE OR WET ENVIRONMENTS

Do not operate the instrument around flammable gases or fumes, vapor, or wet environments.

DO NOT OPERATE DAMAGED OR DEFECTIVE INSTRUMENTS

Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Keysight Technologies Sales and Service Office for service and repair to ensure that safety features are maintained. To contact Keysight for sales and technical support, refer to the support links on the following Keysight website: www.keysight.com/find/assist (worldwide contact information for repair and service).

USE THE POWER CORD PROVIDED

Use the instrument with the power cord provided with the shipment.

DO NOT BLOCK VENTILATION HOLES

Do not block any of the ventilation holes of the instrument.

OBSERVE ALL INSTRUMENT MARKINGS BEFORE CONNECTING TO INSTRUMENT

Observe all markings on the instrument before connecting any wiring to the instrument.

ENSURE COVER IS SECURED IN PLACE

Do not operate the instrument with the cover removed or loosened. Only qualified, service-trained personnel should remove the cover from the instrument.

ENSURE THE INSTRUMENT IS WELL POSITIONED

Do not position the instrument in an area that will post difficulty during instrument disconnection.

AC POWER CORD

Removal of the AC power cord is the disconnect method to remove power from the instrument. Be sure to allow for adequate access to the power cord to permit disconnection from AC power. Use only the Keysight specified power cord for the country of use or one with equivalent ratings.

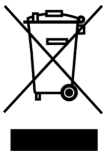
CAUTION CLEAN WITH SLIGHTLY DAMPENED CLOTH

Clean the outside of the instrument with a soft, lint-free, slightly dampened cloth. Do not use detergent, volatile liquids, or chemical solvents.

Safety Symbols

Symbol	Description
	Caution, risk of danger (refer to the manual for specific Warning or Caution information)
	Protective earth (ground) terminal
	Earth ground
	Alternating current (AC)

Regulatory Markings

Symbol	Description
	The CE mark is a registered trademark of the European Community. This CE mark shows that the product complies with all the relevant European Legal Directives. ICES/NMB-001 indicates that this ISM device complies with the Canadian ICES-001. Cet appareil ISM est conforme a la norme NMB-001 du Canada. ISM GRP.1 Class A indicates that this is an Industrial Scientific and Medical Group 1 Class A product.
	The CSA mark is a registered trademark of the Canadian Standards Association.
	The RCM mark is a registered trademark of the Australian Communications and Media Authority.
	This symbol indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of the product.
	This symbol is a South Korean Class A EMC Declaration. This is a Class A instrument suitable for professional use and in electromagnetic environment outside of the home.
	This instrument complies with the WEEE Directive marking requirement. This affixed product label indicates that you must not discard this electrical or electronic product in domestic household waste.

South Korean Class A EMC declaration:

Information to the user:

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 environment.

사 용 자 안 내 문
이 기기는 업무용 환경에서 사용할 목적으로 적합성평가를 받은 기기로서 가정용 환경에서 사용하는 경우 전파간섭의 우려가 있습니다.

– 사용자 안내문은 “업무용 방송통신기자재”에만 적용한다.

Safety and EMC Requirements

This power supply is designed to comply with the following safety and EMC (Electromagnetic Compatibility) requirements:

- Low Voltage Directive 2014/35/EU
- EMC Directive 2014/30/EU

Environmental Conditions

This instrument is designed for indoor use and in an area with low condensation. The table below shows the general environmental requirements for this instrument.

Environmental Condition	Requirement
Temperature	Operating condition: 0 °C to 55 °C Storage condition: –40 °C to 70 °C
Humidity	Operating/Storage condition: Up to 80% RH at temperatures up to 40 °C (non-condensing)
Altitude	Up to 3000 m
Pollution degree	2
Overvoltage Category	II
Power Supply and Line Frequency	100/120 V, 100/240 V 50/60 Hz
Power Consumption	<45 W
MAINS Supply Voltage Fluctuations	Mains supply voltage fluctuations are not to exceed 10% of the nominal supply voltage

1 Introduction to the Instrument

The Keysight EDU33210 Series Trueform Arbitrary Waveform Generator is a series of synthesized waveform generators with built-in arbitrary waveform and pulse capabilities.

Instrument at a Glance

The Keysight EDU33210 Series Trueform Arbitrary Waveform Generator is a series of synthesized waveform generators with built-in arbitrary waveform and pulse capabilities.

Two models are available:

- EDU33211A : 20 MHz, Single channel Trueform Arbitrary Waveform Generator
- EDU33212A : 20 MHz, Dual-channel Trueform Arbitrary Waveform Generator

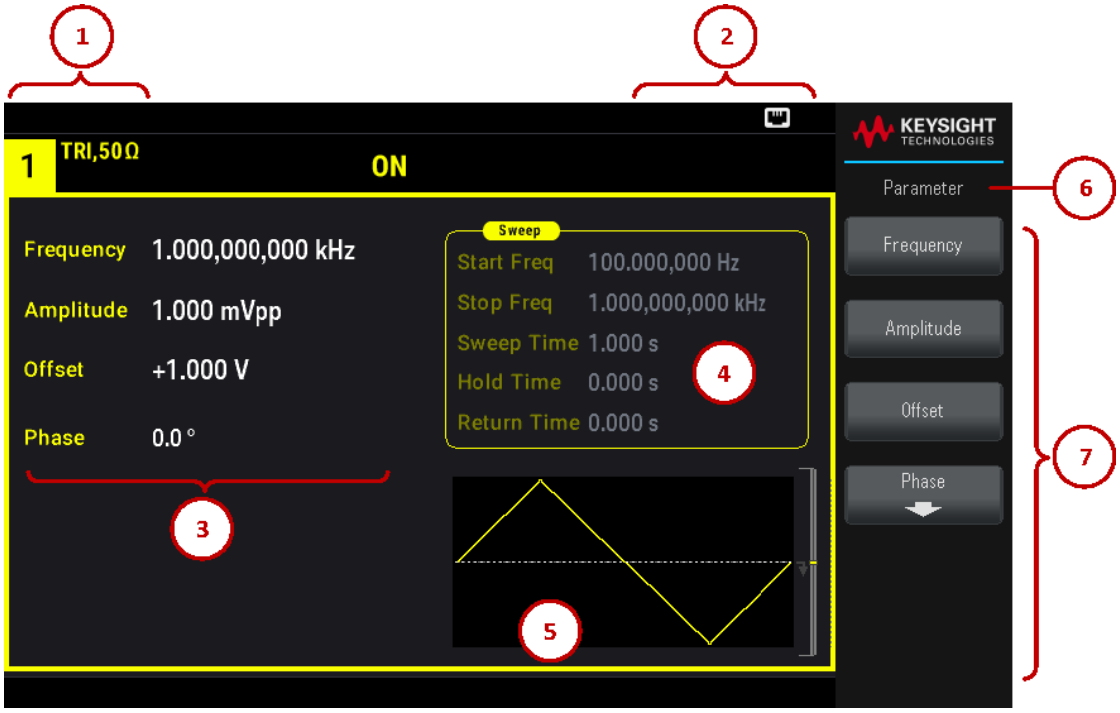
Key features:

- Built-in modulation and 17 popular waveforms
- 16-bit arbitrary waveform capability with memory up to 8 Msa/channel
- Two independent channels that can be coupled in amplitude and frequency (EDU33212A)
- Colorful, information-packed 7-inch WVGA display
- Excellent usability
- USB and LAN IO interface
- Web interface
- SCPI (Standard Commands for Programmable Instruments) compatibility
- PathWave BenchVue software included
- 3-year warranty standard

Front Panel at a Glance

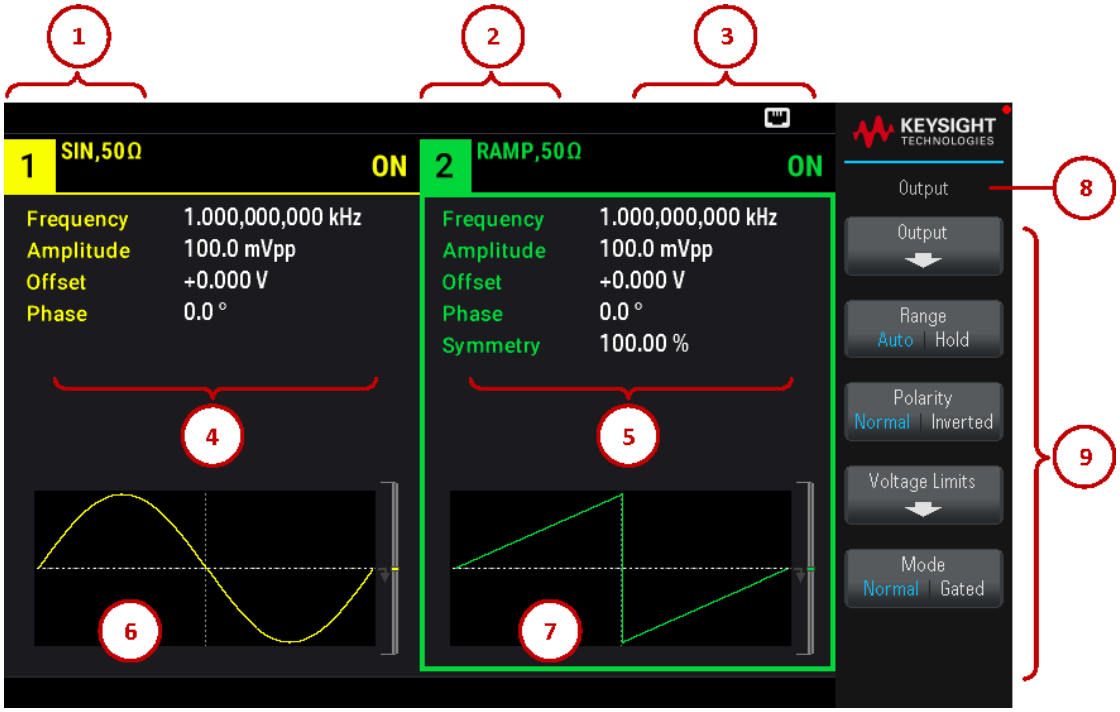
Legend	Description
1	7-inch WVGA display -Channel 1 display
2	Channel 2 display (EDU33212A only)
3	**[ON/OFF]** switch
4	USB port – allows an external USB flash drive to be connected to the instrument **NOTE** The EDU33210 Series supports USB flash drives with the following specification: USB 2.0, FAT32 format, up to 32 GB. We recommend using a SanDisk Cruzer Blade flash drive for the front panel USB port.
5	**[Back]** button **NOTE** Press and hold **[Back]** button for more than 3 seconds with an external USB flash drive connected to automatically capture the instrument screen. The captured image will be saved to the connected USB flash drive.
6	Menu softkeys
7	CAL connector
8	Ext Trig/Gate/FSK/Burst connector
9	Sync/Trigger Out connector
10	Fixed function buttons
11	Numeric keypad
12	Knob and cursor arrows
13	Channel 1 and Channel 2 (EDU33212A only) connectors and related buttons

Single Channel View



Legend	Description
1	Channel 1 information
2	Status indicators
3	Channel 1 waveform parameters
4	Sweep, modulation, or burst parameters
5	Channel 1 waveform display
6	Function name
7	Softkey labels

Dual Channel View (Applicable for EDU33212A Only)



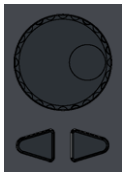
Legend	Description
1	Channel 1 information
2	Channel 2 information
3	Status indicators
4	Channel 1 waveform parameters
5	Channel 2 waveform parameters
6	Channel 1 waveform display
7	Channel 2 waveform display
8	Function name
9	Softkey labels

Instrument Status Indicators

Legend	Description
RMT	Shown when remote mode is enabled
RWL	Shown after SYSTem:RWL command is sent
	USB flash drive is connected
	LAN is connected
	Instrument error has occurred

Front Panel Number Entry

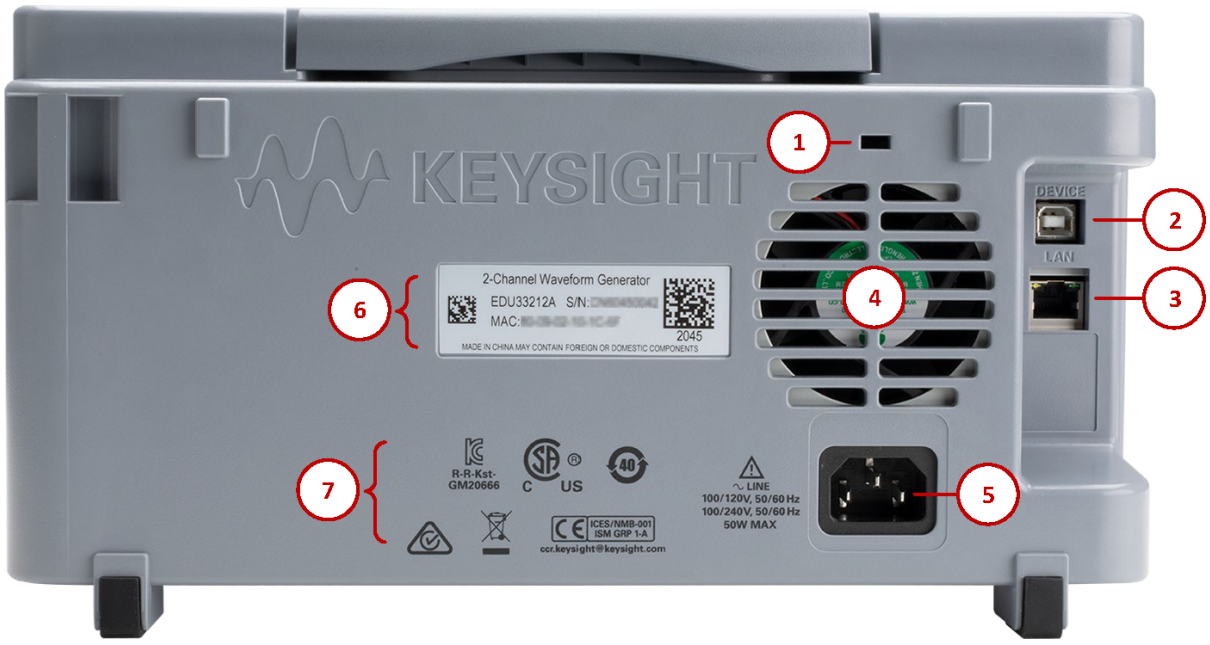
You can enter numbers from the front panel in two ways:



– Use the knob and cursor keys to modify the number. Rotate the knob to change a digit (clockwise increases). The arrows below the knob move the cursor.

– Use the keypad to enter numbers and the softkeys to select units. The [+/-] key changes the number's sign.

Rear Panel at a Glance

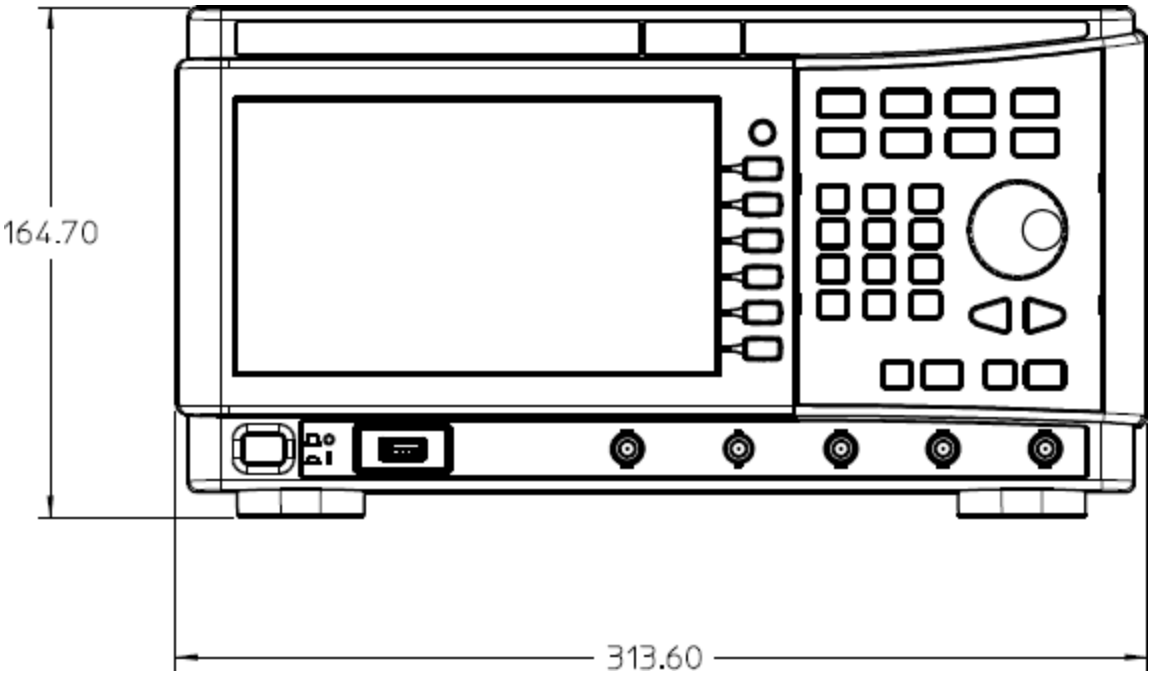


Legend	Description
1	Kensington lock
2	Universal Serial Bus (USB-B) interface connector
3	Local Area Network (LAN) interface connector
4	AC power connector
5	Ventilation fan
6	Instrument serial number and MAC address
7	Instrument safety and regulatory labels

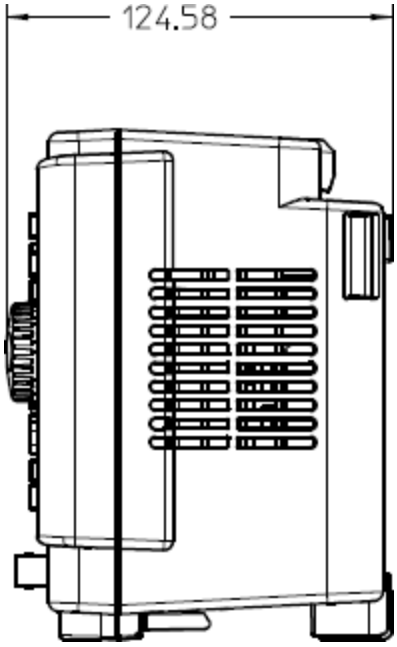
WARNING This is a Protection Class 1 equipment (chassis must be connected to a protective earth ground). The mains plug shall only be inserted in an outlet provided with a Protective Earth Terminal.

Instrument Dimensions

Height: 164.70 mm x Width: 313.60 mm



Length: 124.58 mm



2 Getting Started

This section describes basic procedures to help you get started quickly with the instrument.

Prepare the Instrument for Use

When you receive your instrument, 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 checked out the instrument, save the shipping carton and packing materials in case the unit has to be returned. Check the list below and verify that you have received these items with your instrument. If anything is missing, please contact your nearest Keysight Sales and Support Office.

- Quick Start Guide
- AC power cord (for country of destination)
- Certificate of Calibration and Shelf Life Notice
- Keysight Safety Leaflet (9320-6797)
- RoHS Addendum for Arbitrary Waveform Generators (China) (9320-6667)

Documentation and Firmware Revisions

The documentation listed below can be downloaded for free through our website at www.keysight.com/find/EDU33211A-manual.

- Keysight EDU33210 Series Trueform Arbitrary Waveform Generators Quick Start Guide.
- Keysight EDU33210 Series Trueform Arbitrary Waveform Generators User's Guide. This manual.
- Keysight EDU33210 Series Trueform Arbitrary Waveform Generators Programming Guide.
- Keysight EDU33210 Series Trueform Arbitrary Waveform Generators Service Guide.

For the latest firmware revision and firmware update instruction, go to www.keysight.com/find/EDU33211A-sw.

Recommended Calibration Interval

Keysight Technologies recommends a one-year calibration cycle for this instrument.

Set Up the Instrument

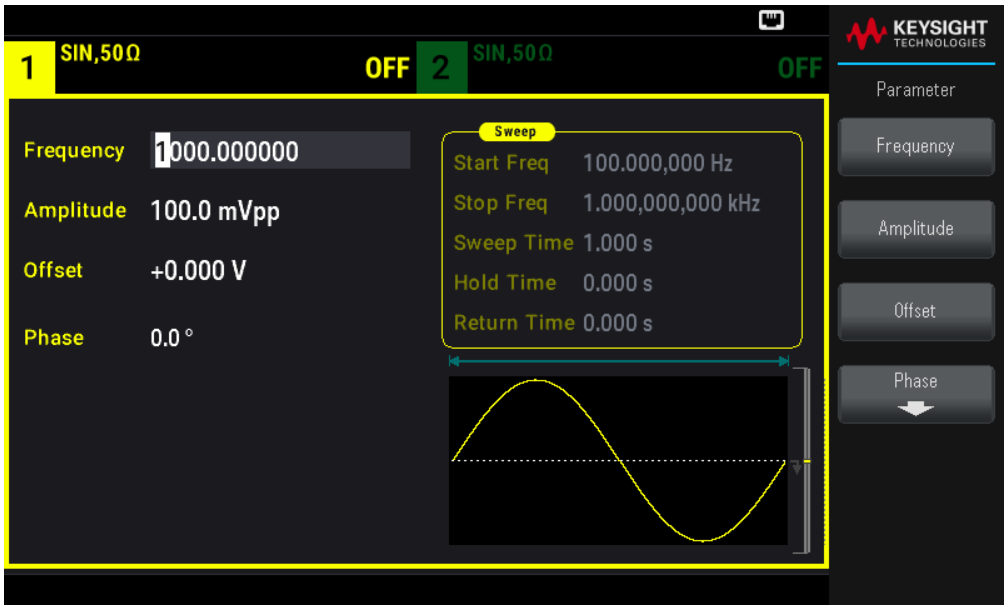
Place the instrument's feet on a flat, smooth horizontal surface. Attach the power cable to the rear panel, then plug it into main power. Connect the LAN or USB cables as desired, and you may also secure the instrument with a security lock cable. Finally, turn the instrument on using the front panel [On/Off] button.

The instrument runs a power-on self test and then displays a message about how to obtain help, along with the current IP address.

Set the Output Frequency

The default frequency is 1 kHz. You can change the frequency, and you can specify frequency in units of period instead of Hz.

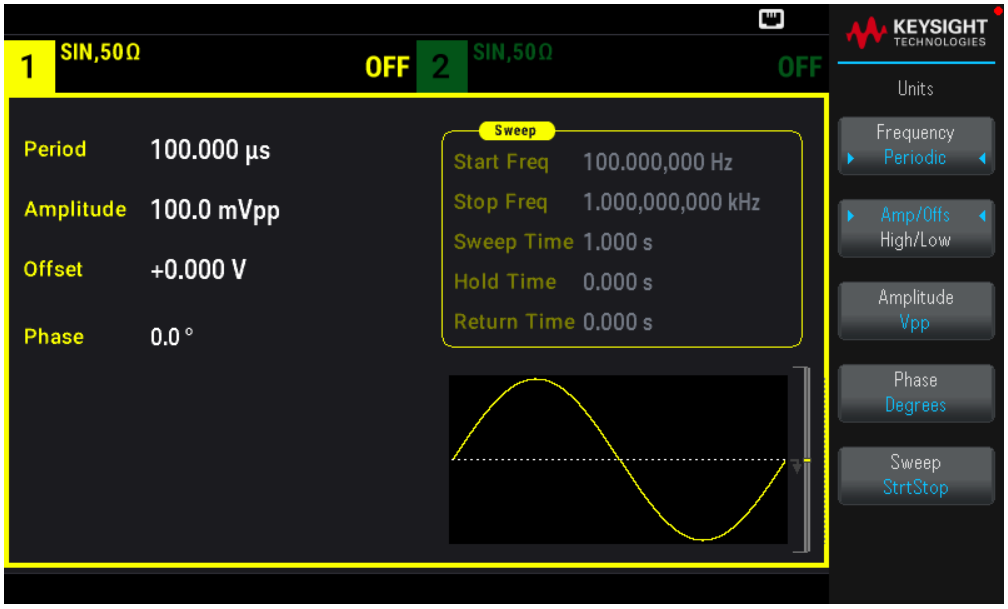
Press [Parameter] > Frequency.



– Use the knob to change the numeric value and/or use the cursor arrows to move the cursor to the next or previous digit, or

– Use the numeric keypad to set a numeric value. Select a prefix unit (µHz, mHz, Hz, kHz, or MHz) to confirm your changes.

Press [Units] > Frequency Periodic to change the units to period instead of frequency.



Set the Output Amplitude

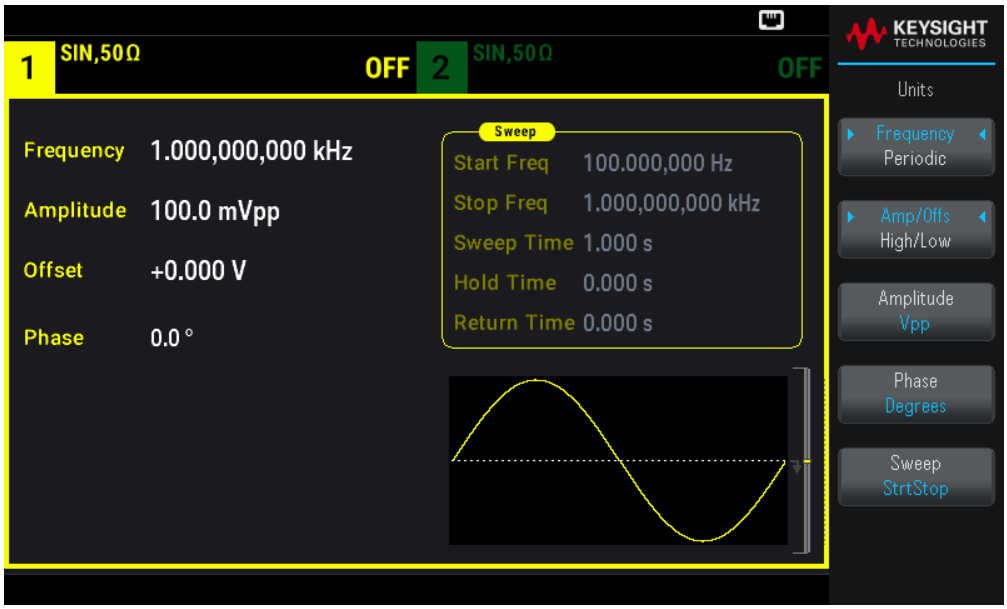
The instrument's default function is a 1 kHz, 100 mVpp sine wave (into a 50 Ω termination).

The following steps change the amplitude to 50 mVpp.

1. Press [Units] > Amp/Offs High/Low to specify voltage as amplitude and offset.

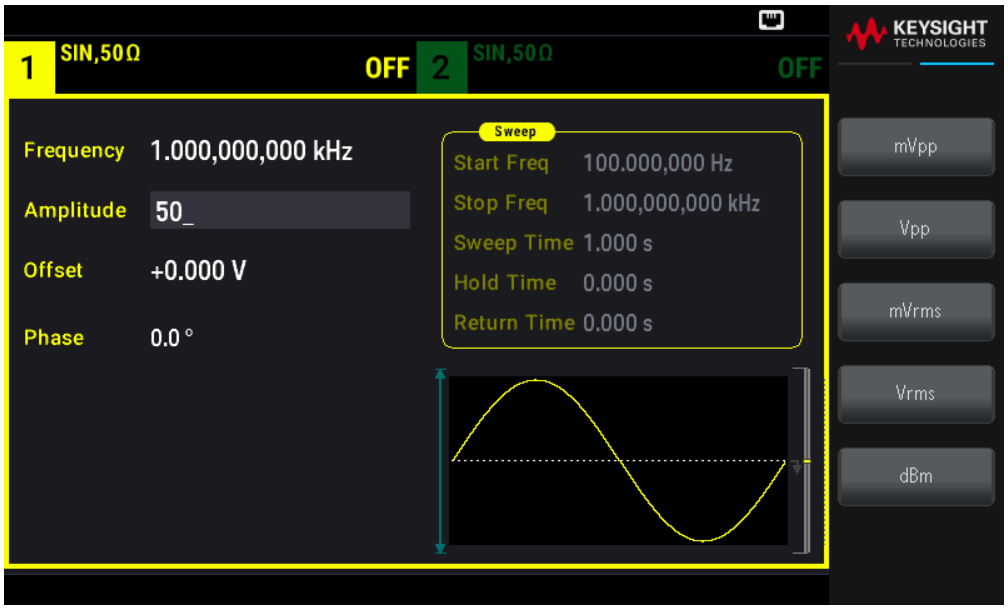
   The displayed amplitude is either the power-on value or the amplitude previously selected. When you change functions, the same amplitude is used if it is valid for the new function. To choose to specify voltage as high and low values instead, press Amp/Offs High/Low.

   In this example, we will highlight Amp/Offs High/Low.



2. Enter the magnitude of the desired amplitude.

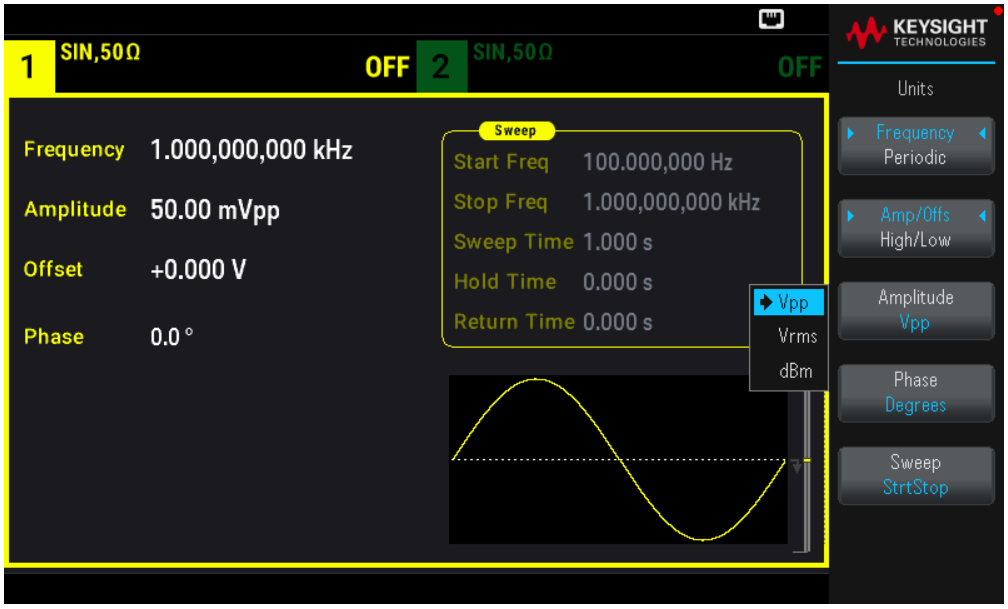
   Press [Parameters] > Amplitude. Using the numeric keypad, enter the number 50.



3. Select the desired units.

   Press the softkey that corresponds to the desired units. When you select the units, the instrument outputs the waveform with the displayed amplitude (if the output is enabled). For this example, press mVpp.

   You can also enter the desired value using the knob and arrows. If you do so, you do not need to use a units softkey. You can easily convert unit types. Simply press [Units] > Amplitude and select the desired units.

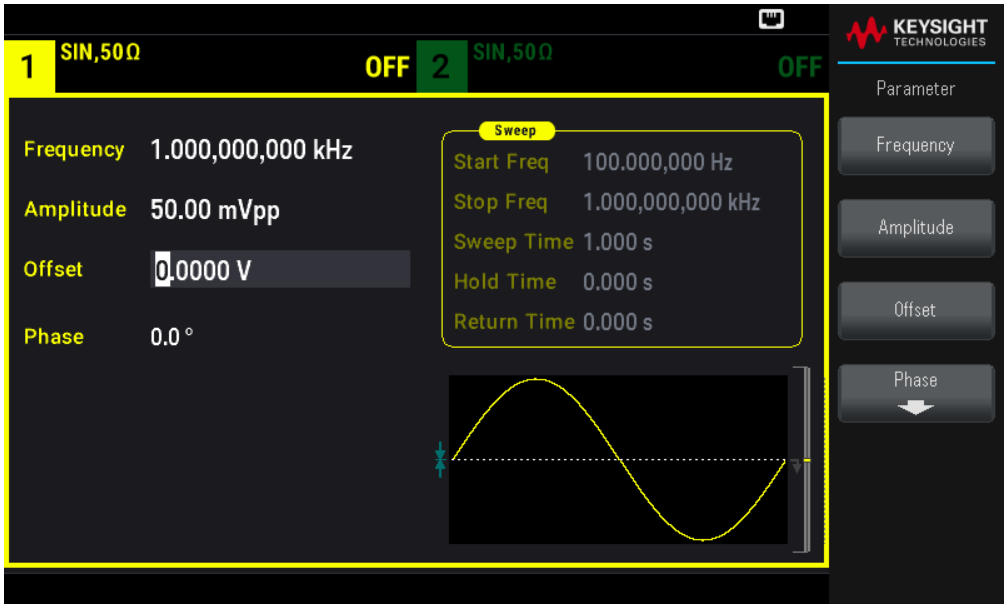


Set the DC Offset Voltage

At power-on, the DC offset is 0 V. The following steps change the offset to 1.5 VDC.

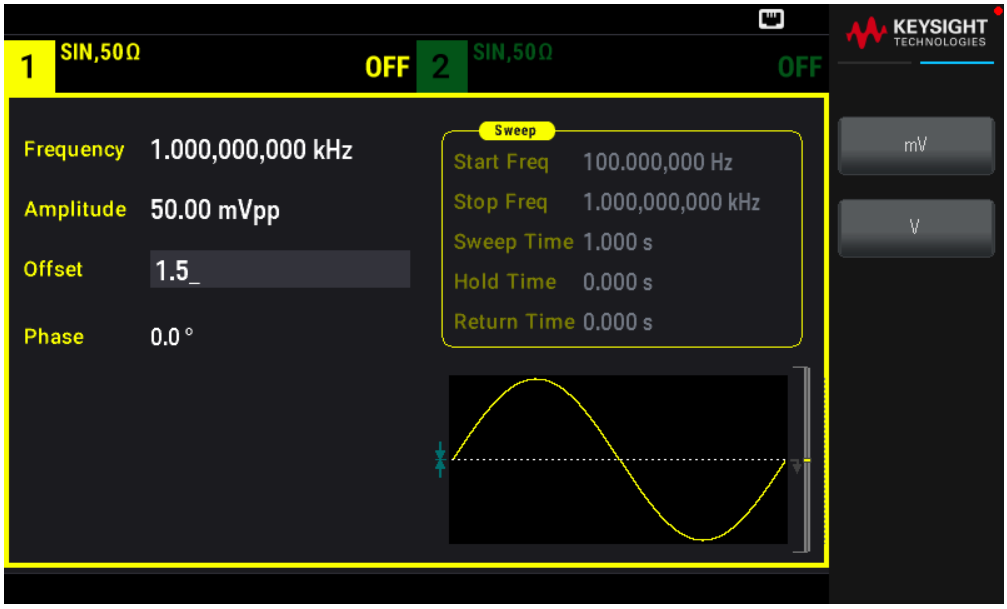
1. Press [Parameter] > Offset.

   The displayed offset voltage is either the power-on value or the offset previously selected. When you change functions, the same offset is used if the present value is valid for the new function.



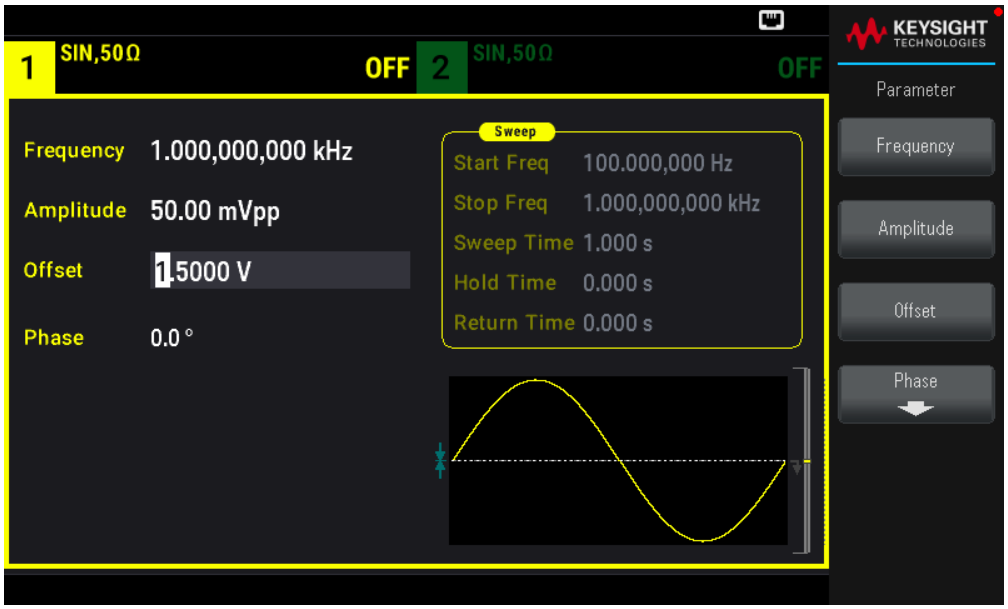
2. Enter the desired offset.

   In this case we will use the numeric keypad to enter 1.5.



3. Select the desired units.

   Press the softkey for the desired units. When you select the units, the instrument outputs the waveform with the displayed offset (if the output is enabled). For this example, press V. The voltage will be set as shown below.

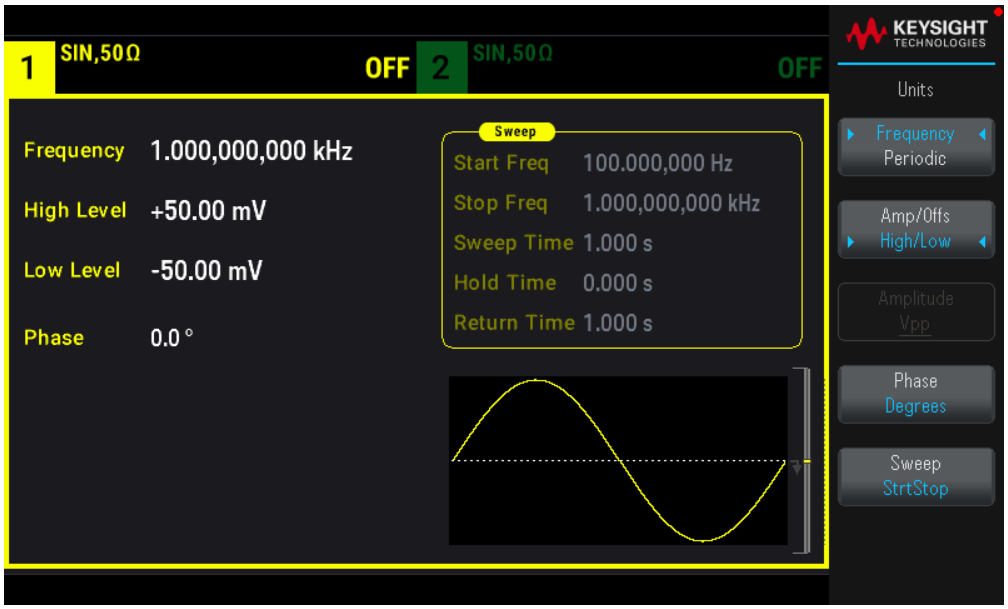


   You can also enter the desired value using the knob and arrows.

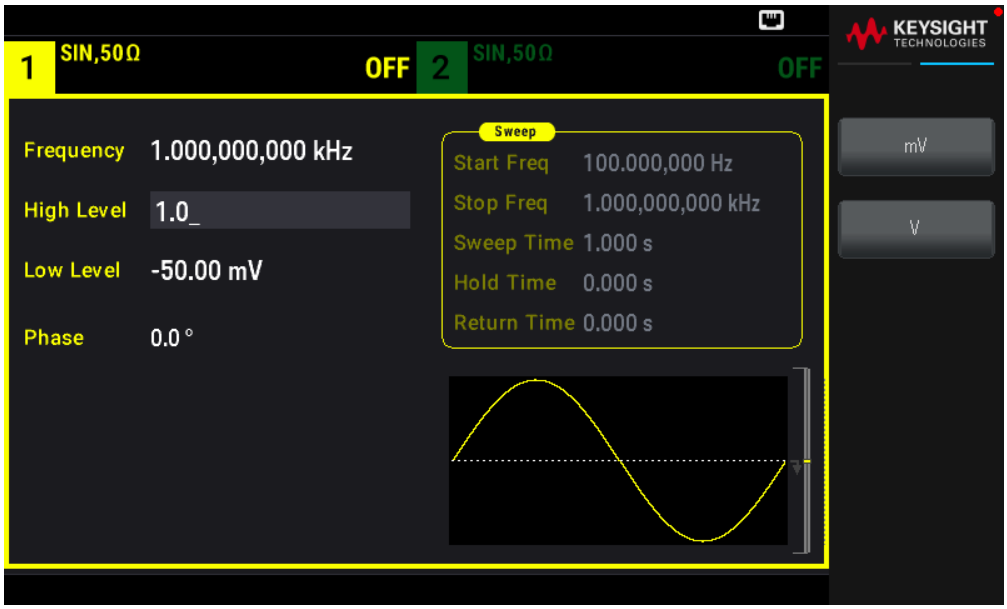
Set High-Level and Low-Level Values

You can specify a signal by setting its amplitude and DC offset, described above. You can also specify the signal as high (maximum) and low (minimum) values. This is typically convenient for digital applications. In the following example, we will set the high level to 1.0 V and the low level to 0.0 V.

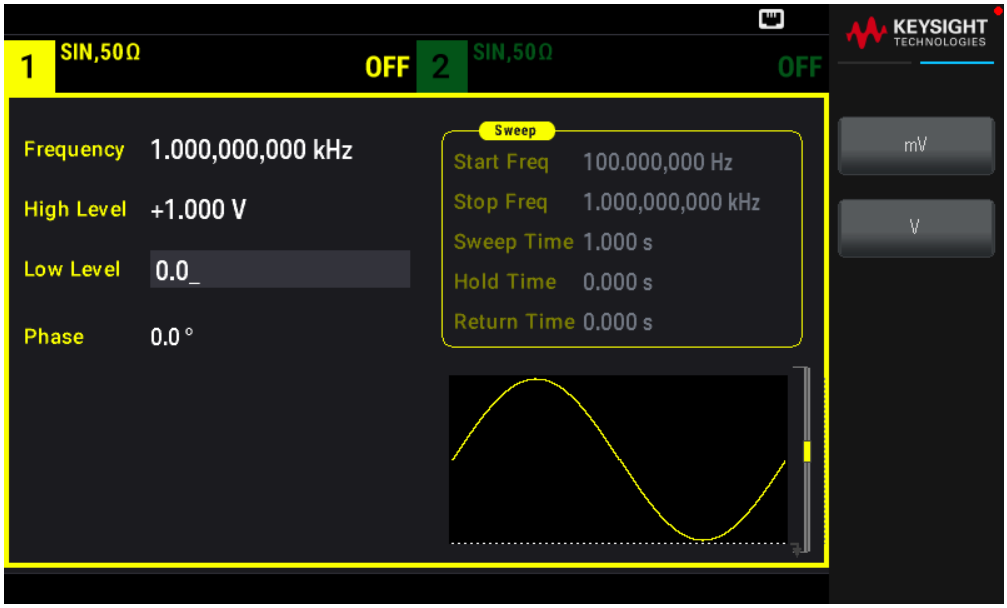
1. Press [Units] > Ampl/Offs High/Low. Toggle to High/Low as shown below.



2. Press [Parameter] > High Level. Using the numeric keypad or knob and arrows, select a value of 1.0 V. (If you are using the keypad, you will need to select the V unit softkey to enter the value.)



3. Press the Low Level softkey and set the value. Again, use the numeric keypad or the knob to enter a value of 0.0 V.

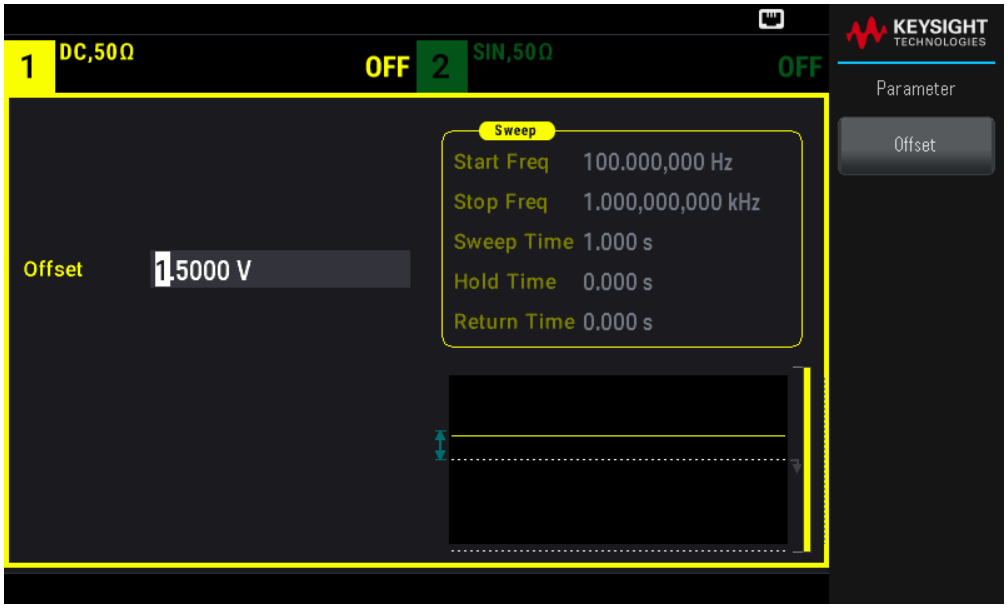


These settings (high-level = 1.0 V and low-level = 0.0 V) are equivalent to setting an amplitude of 1.0 Vpp and an offset of 500 mV.

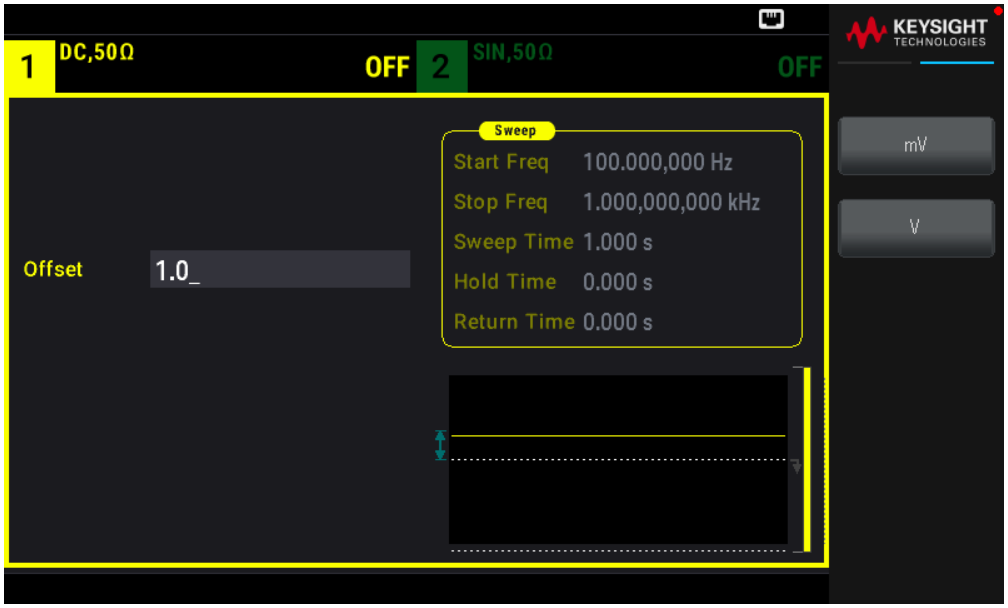
Output a DC Voltage

You can output a constant DC voltage, from -5 V to +5 V into 50 Ω, or -10 V to +10 V into a high impedance load.

1. Press [Waveform] > MORE 1 / 2 > DC > Offset. The Offset value becomes selected.



2. Enter the desired voltage offset. Enter 1.0 with the numeric keypad or knob, and press the V softkey if you used the keypad.

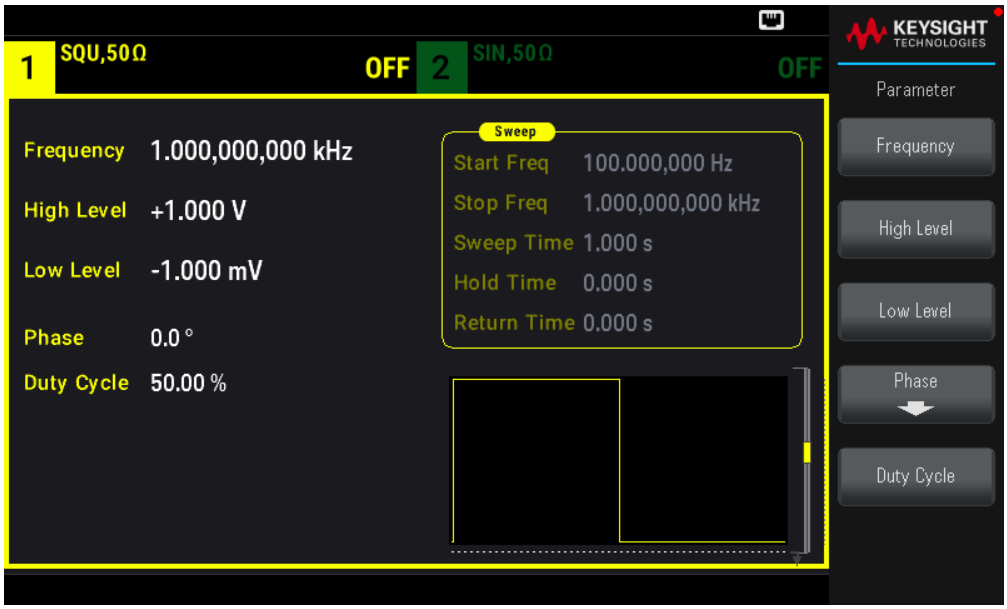


Set Duty Cycle of a Square Wave

The power-on default for square wave duty cycle is 50%. The duty cycle is limited by the minimum pulse width specification of 16 ns. The following procedure changes the duty cycle to 75%.

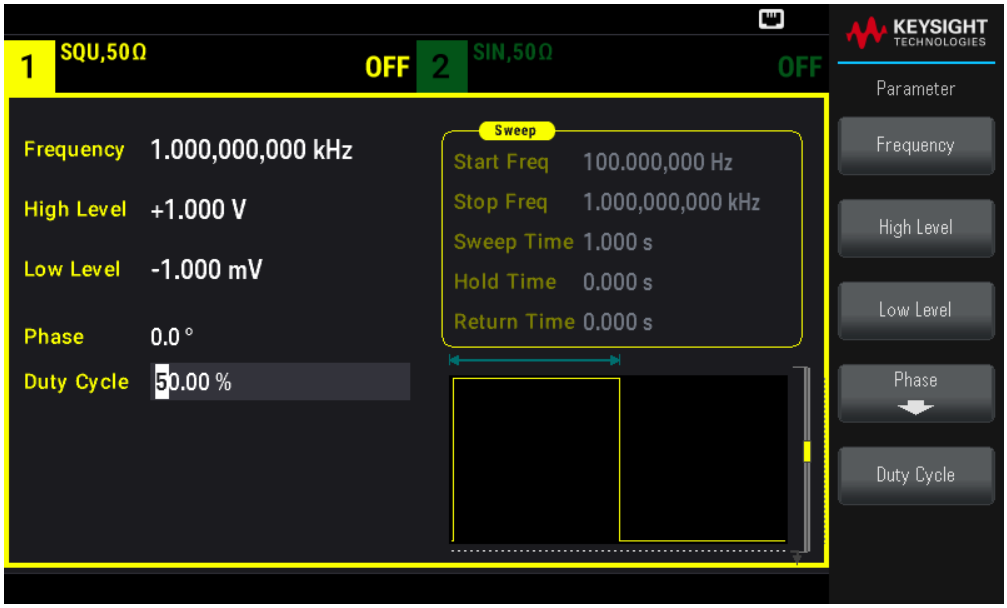
1. Select the square wave function.

   Press [Waveform] > Square.



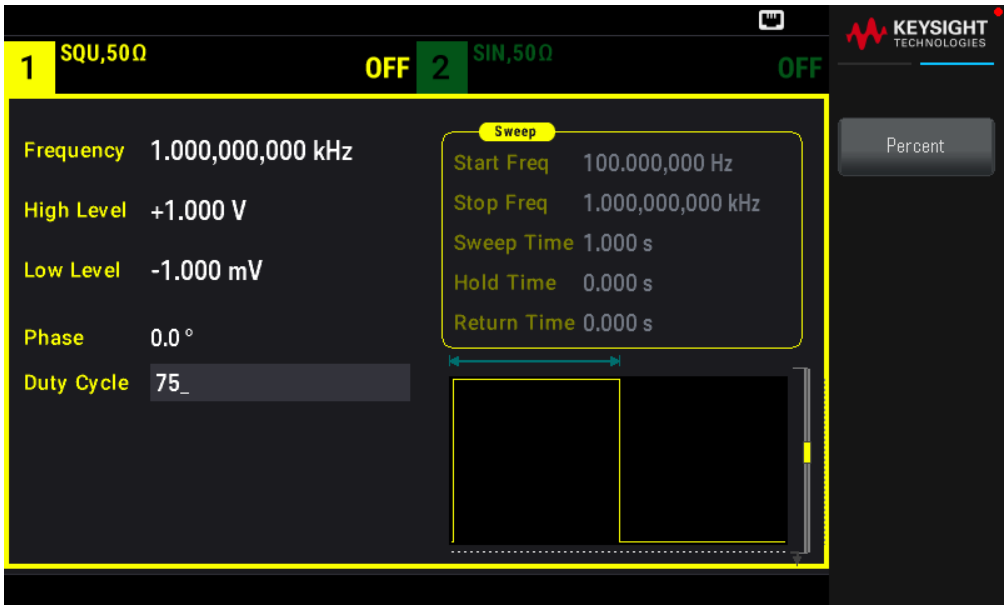
2. Press the Duty Cycle softkey.

   The displayed duty cycle is either the power-on value or the percentage previously selected. The duty cycle represents the amount of time per cycle that the square wave is at a high level.



3. Enter the desired duty cycle.

   Using the numeric keypad or the knob and arrows, select a duty cycle value of 75. If you are using the numeric keypad, press Percent to finish the entry. The instrument adjusts the duty cycle immediately and outputs a square wave with the specified value (if the output is enabled).

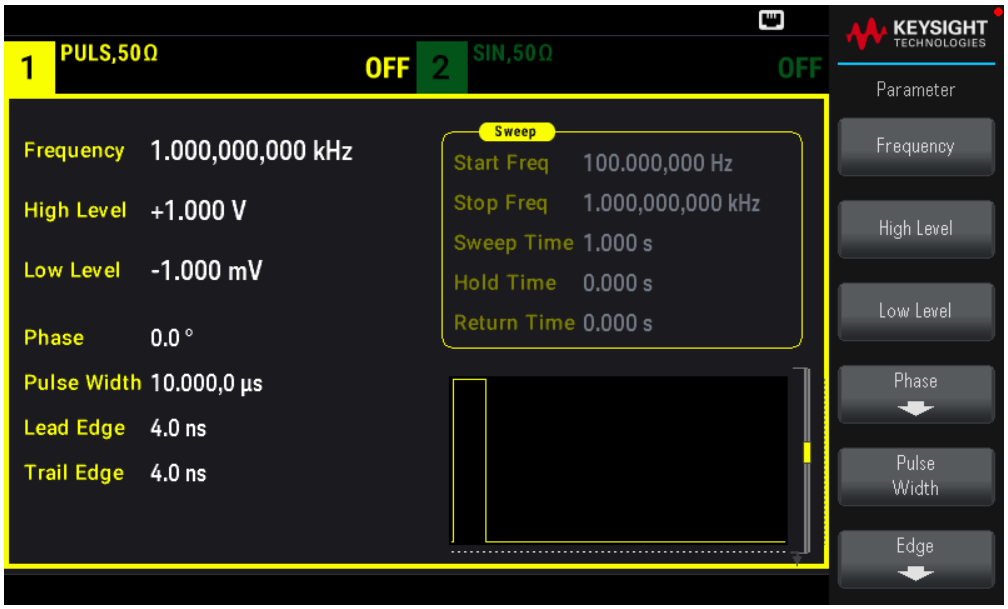


Configure a Pulse Waveform

You can configure the instrument to output a pulse waveform with variable pulse width and edge time. The following steps configure a 500 ms periodic pulse waveform with a pulse width of 10 ms and edge times of 50 ns.

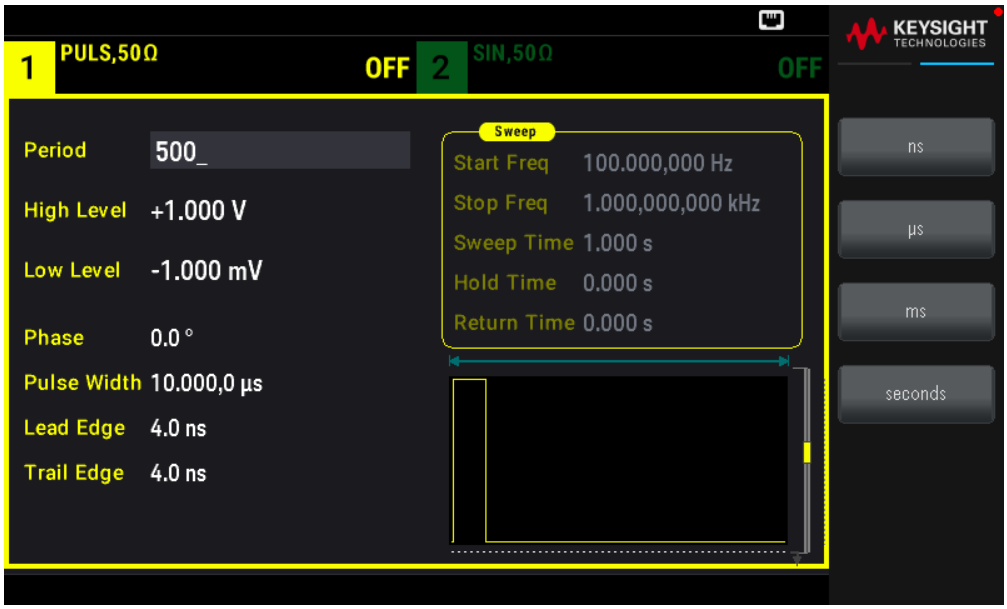
1. Select the pulse function.

   Press [Waveform] > Pulse to select the pulse function.



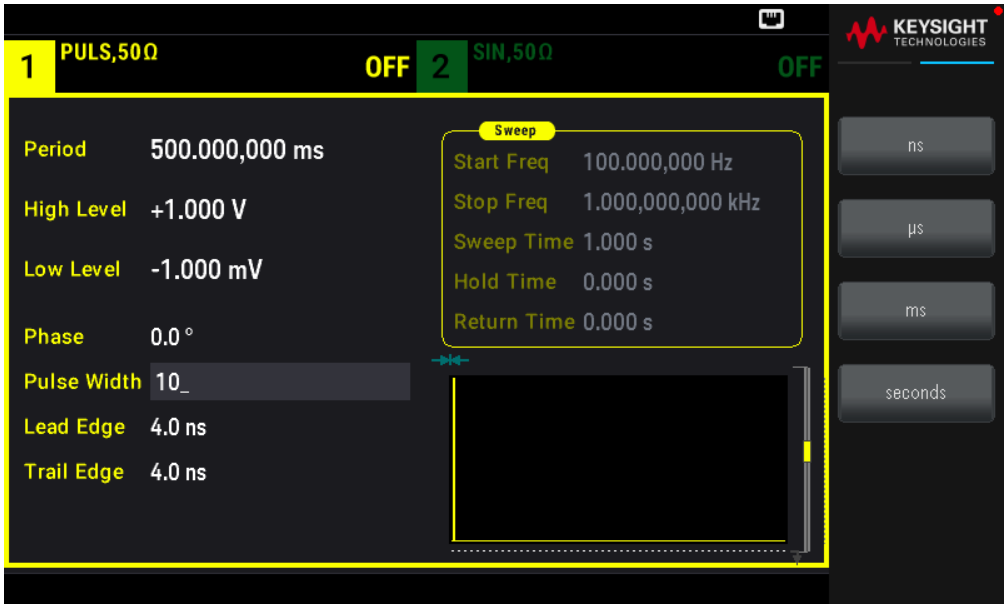
2. Set the pulse period.

   Press the [Units] key and then press Frequency Periodic. Then press [Parameter] > Period. Set the period to 500 ms.



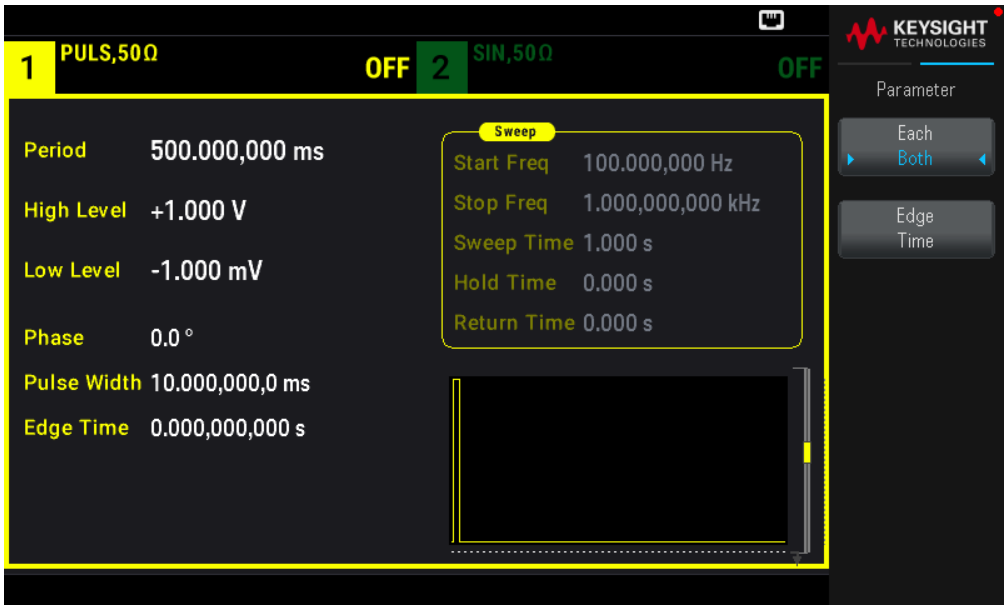
3. Set the pulse width.

   Press [Parameter] > Pulse Width. Then set the pulse width to 10 ms. The pulse width represents the time from the 50% threshold of the rising edge to the 50% threshold of the next falling edge.

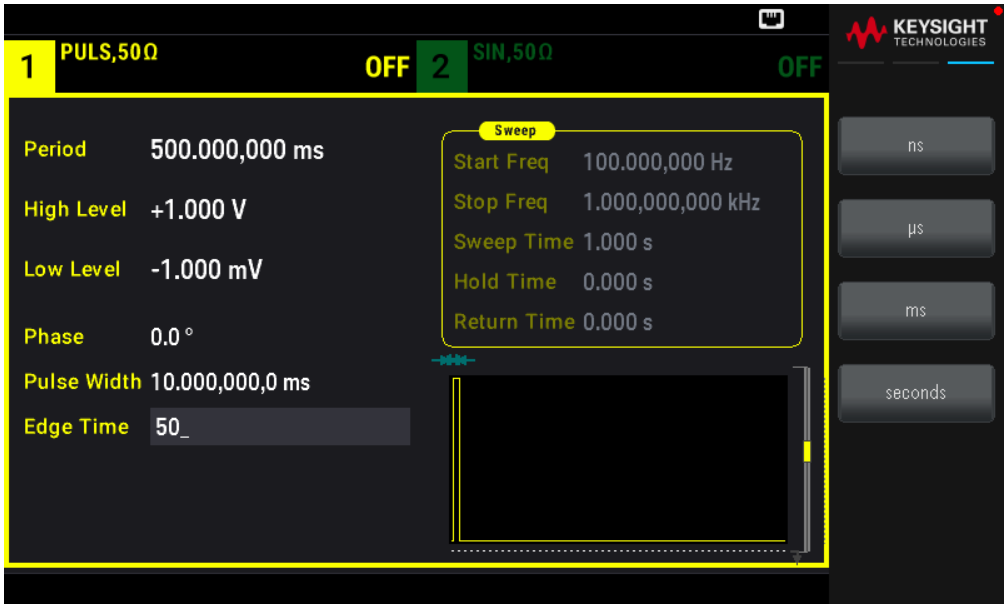


4. Set the edge time for both edges.

   Press the Edge softkey and then Each Both.



Press Edge Time to set the edge time for both the leading and trailing edges to 50 ns. The edge time represents the time from the 10% threshold to the 90% threshold of each edge.

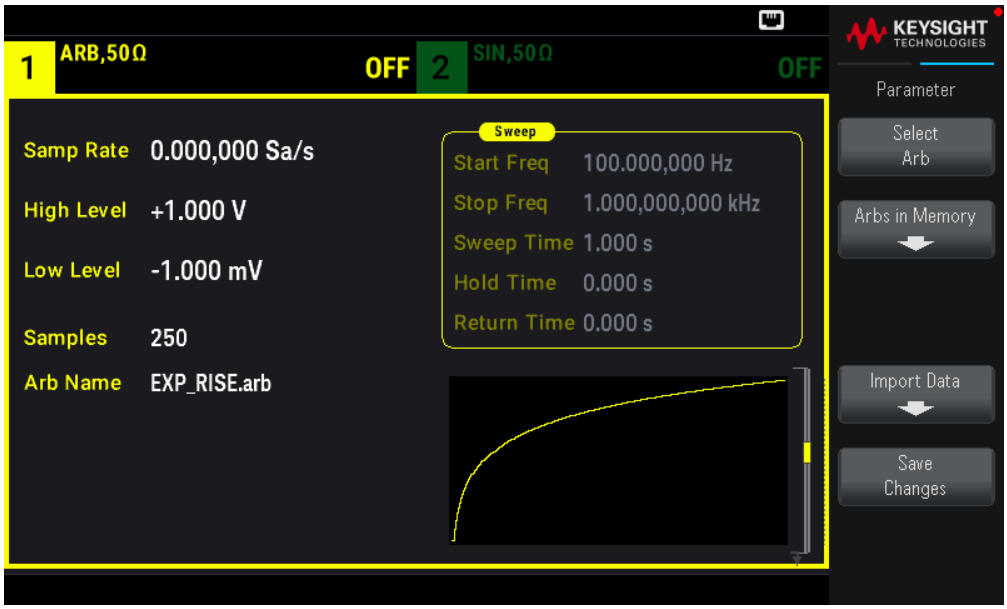


Select a Stored Arbitrary Waveform

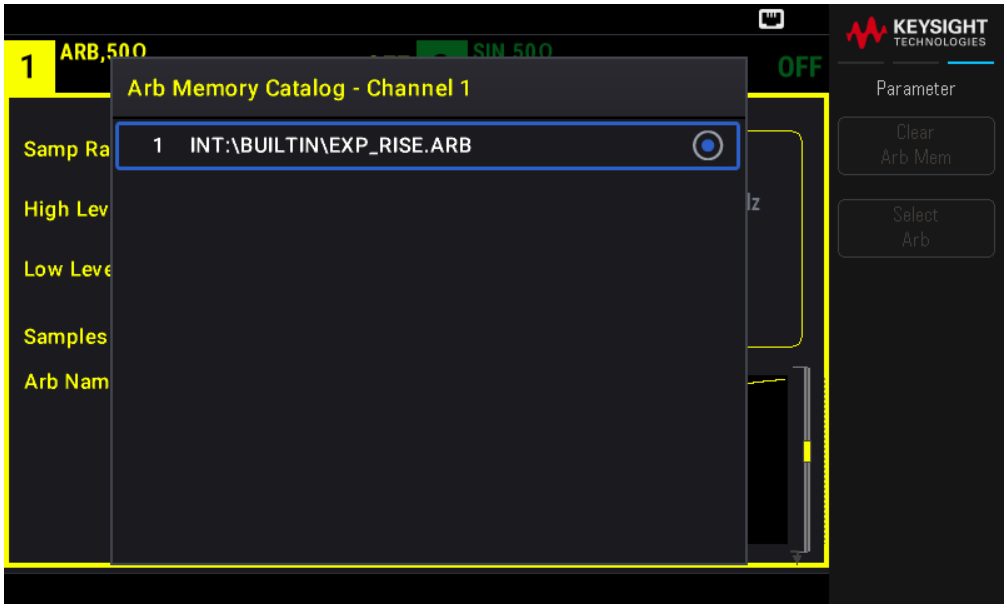
There are nine built-in arbitrary waveforms stored in non-volatile memory. They are Cardiac, D-Lorentz, Exponential Fall, Exponential Rise, Gaussian, Haversine, Lorentz, Negative Ramp, and Sinc.

This procedure selects the built-in "exponential rise" waveform from the front panel.

1. Press [Waveform] > Arb > Arbs.



2. Choose Arbs in Memory and use the knob to select EXP_RISE. Press Select Arb.

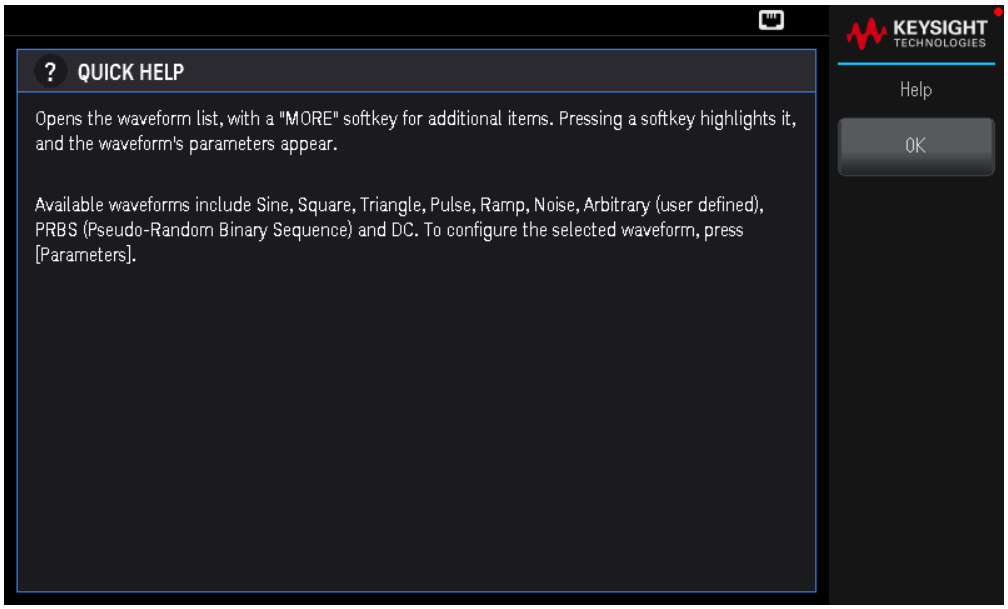


Use the Built-in Help System

The built-in help system provides context-sensitive help on any front panel key or menu softkey. A list of help topics is also available to assist you with several front panel operations.

View the Help Information for a Button or Softkey

Press and hold any softkey or front panel button, such as [Waveform].



If the message contains more information than will fit on the display, press the down arrow softkey to view the remaining information.

Press OK to exit Help.

NOTE **Local Language Help**

All messages, context-sensitive help, and help topics are available in English, French, German, Spanish, Simplified Chinese, Traditional Chinese, Japanese, Korean, and Russian. Softkey labels and status line messages are not translated (i.e. always in English). To select the language, press **[System]** > **User Settings** > **Language**. Then select the desired language.

Update the Firmware

NOTE **Do not turn off the instrument during the update.**

Press [System] > Help > About to determine the version number of the instrument's firmware currently installed.

Go to www.keysight.com/find/EDU33211A-sw to find the latest firmware version. If this matches the version installed on your instrument, there is no need to continue with this procedure. Otherwise, download the firmware update utility and a ZIP file of the firmware. Detailed firmware update instructions are located on the download page.

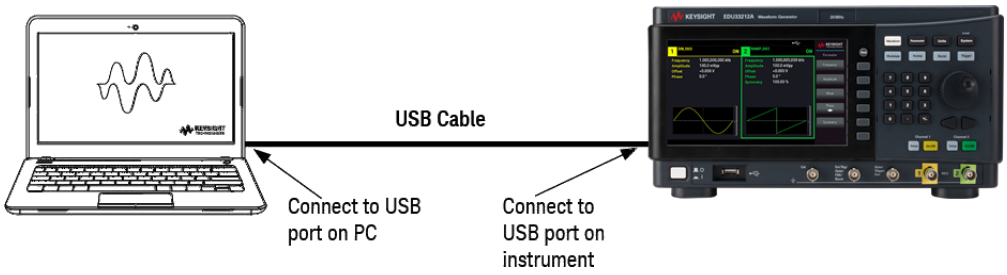
Remote Interface Connections

This section describes how to connect to the various communication interfaces to your instrument. 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.

Connect to the Instrument via USB

The following figure illustrates a typical USB interface system.



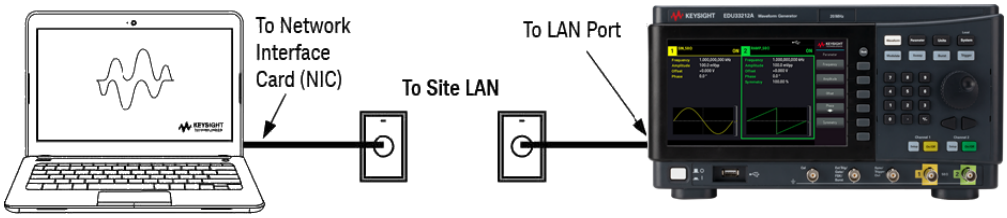
1. Connect your instrument to the USB port on your computer using a USB cable.
2. With the Connection Expert Utility of the Keysight IO Libraries Suite running, the computer will automatically recognize the instrument. This may take several seconds. When the instrument is recognized, your computer will display the VISA alias, IDN string, and VISA address. 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.

NOTE The USB cable is not recommended to be longer than 3 meters.

Connect to the Instrument via LAN (Site and Private)

Site LAN

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 ON by default). 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.

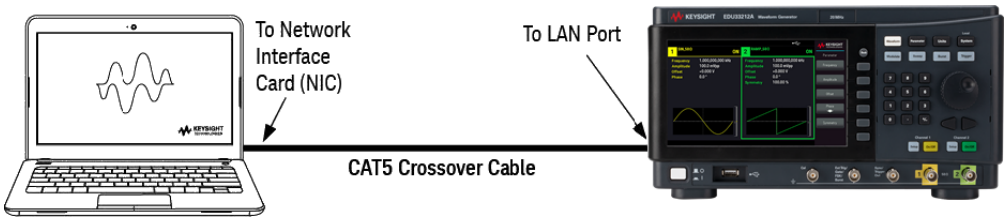
2. Use the Connection Expert utility of the Keysight IO Libraries Suite to add the instrument and verify a connection. To add the instrument, you can request the Connection Expert to discover the instrument. If the instrument cannot be found, add the instrument using its hostname or IP address.

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.

Private LAN

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 supply 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.

3. Use the Connection Expert utility of the Keysight IO Libraries Suite to add the power supply 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.

Remote Interface Configuration

The instrument supports remote interface communication over two interfaces: USB and LAN. Both are "live" at power up.

– USB Interface: Use the rear panel USB port to communicate with your PC. There is no configuration required for the USB interface. Simply connect the instrument to your PC with a USB cable.

– LAN Interface: Use the rear panel LAN port to communicate with your PC. By default, DHCP is on, which may enable communication over LAN. The acronym DHCP stands for Dynamic Host Configuration Protocol, a protocol for assigning dynamic IP addresses to networked devices. With dynamic addressing, a device can have a different IP address every time it connects to the network.

Keysight IO Libraries Suite

NOTE Ensure that the Keysight IO Libraries Suite is installed before you proceed for the remote interface configuration.

Keysight IO Libraries Suite is a collection of free instrument control software that automatically discovers instruments and allows you to control instruments over LAN, USB, GPIB, RS-232, and other interfaces. For more information, or to download IO Libraries, go to www.keysight.com/find/iosuite.

LAN Configuration

The following sections describe the LAN configuration functions on the front panel menu.

When shipped, DHCP is on, which may enable communication over LAN. The acronym 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.

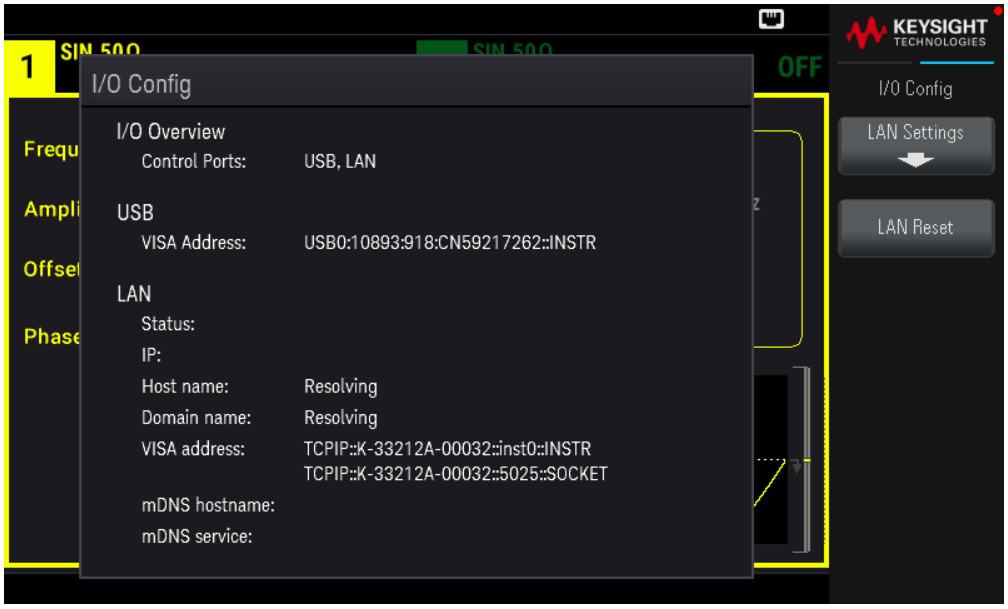
Some LAN settings require you to cycle instrument power to activate them. The instrument briefly displays a message when this is the case, so watch the screen closely as you change LAN settings.

NOTE After changing the LAN settings, you must save the changes. Press **Apply** to save the setting. If you do not save the setting, exiting the I/O Config menu will also prompt you to press **Yes** to save the LAN setting or **No** to exit without saving. Selecting **Yes** cycles power to the instrument and activates the settings. LAN settings are non-volatile; they will not be changed by power cycling or *RST. If you do not want to save your changes, press **No** to cancel all changes.

View the LAN Settings

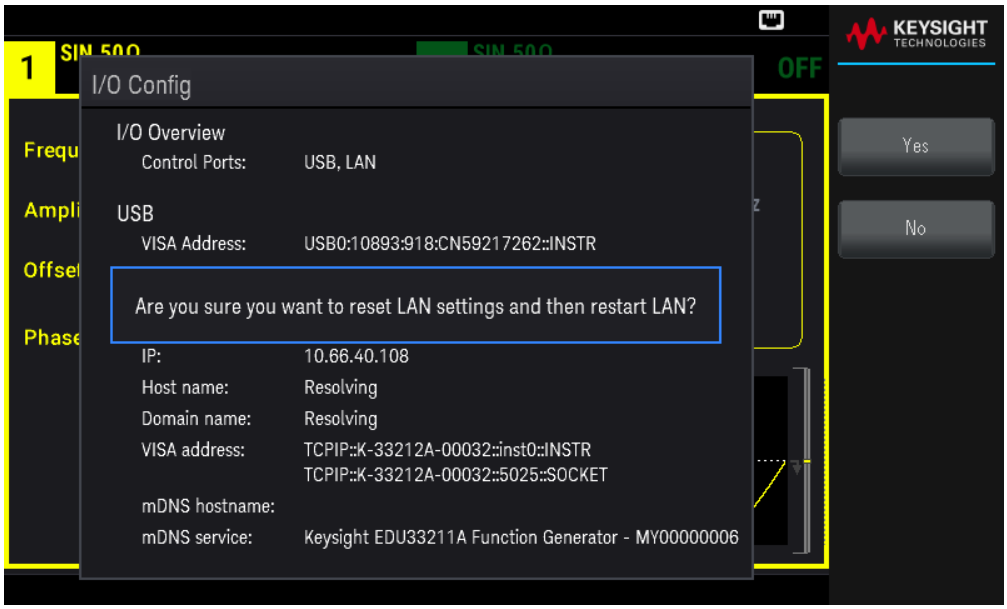
Press [System] > I/O Config to view the LAN Settings.

The LAN status 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.



Press LAN Settings to access the LAN Settings Menu. See Modify the LAN Settings for more details.

Press LAN Reset restore the LAN settings to default values.

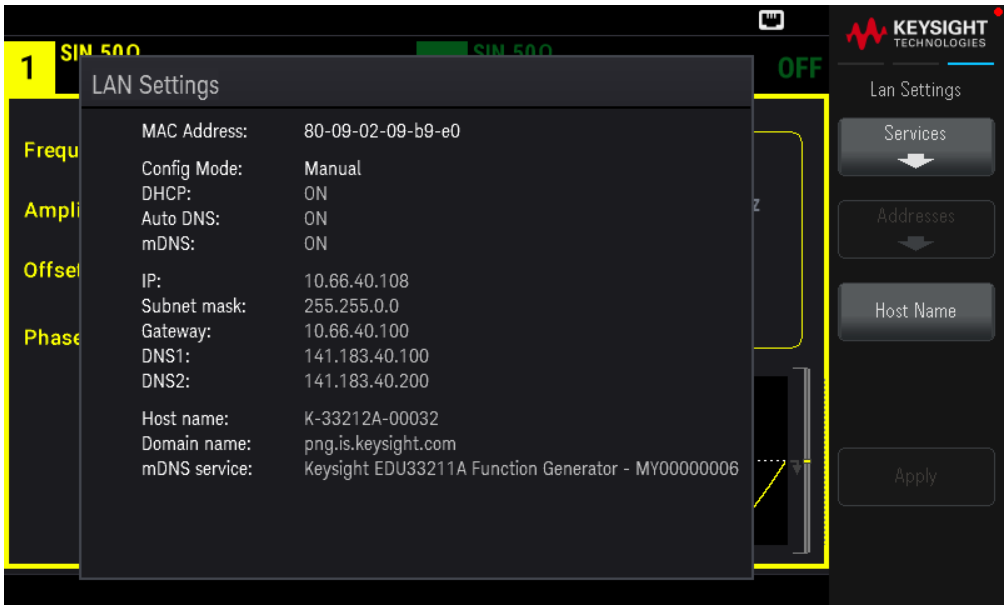


Modify the LAN Settings

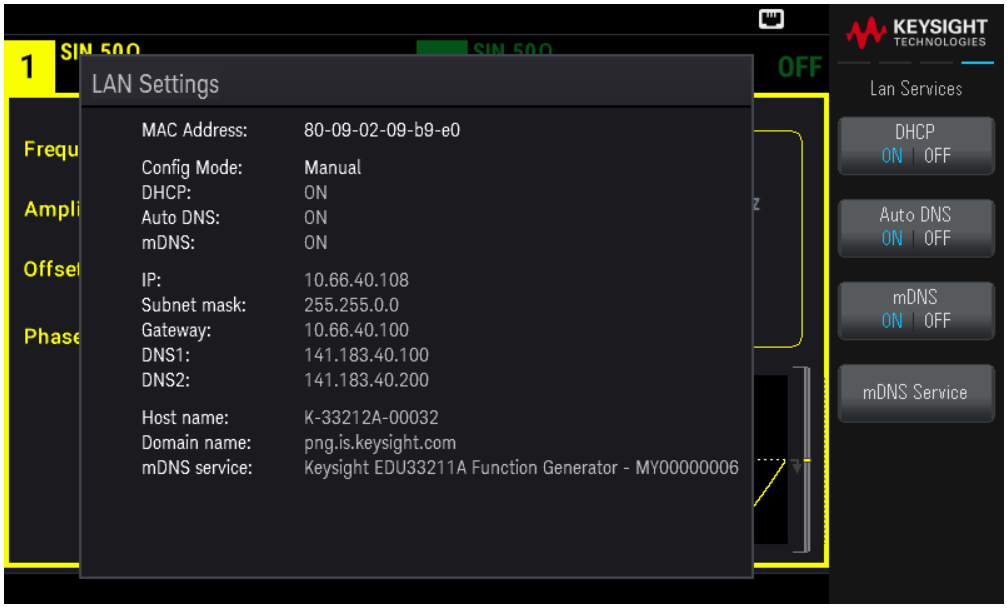
As shipped from the factory, the instrument pre-configured settings should work in most LAN environments. Refer to the "Non-Volatile Settings" in the *Programming Guide* for information on the factory-shipped LAN settings.

1. Access the LAN Settings menu.

   Press the **LAN Settings** softkey.



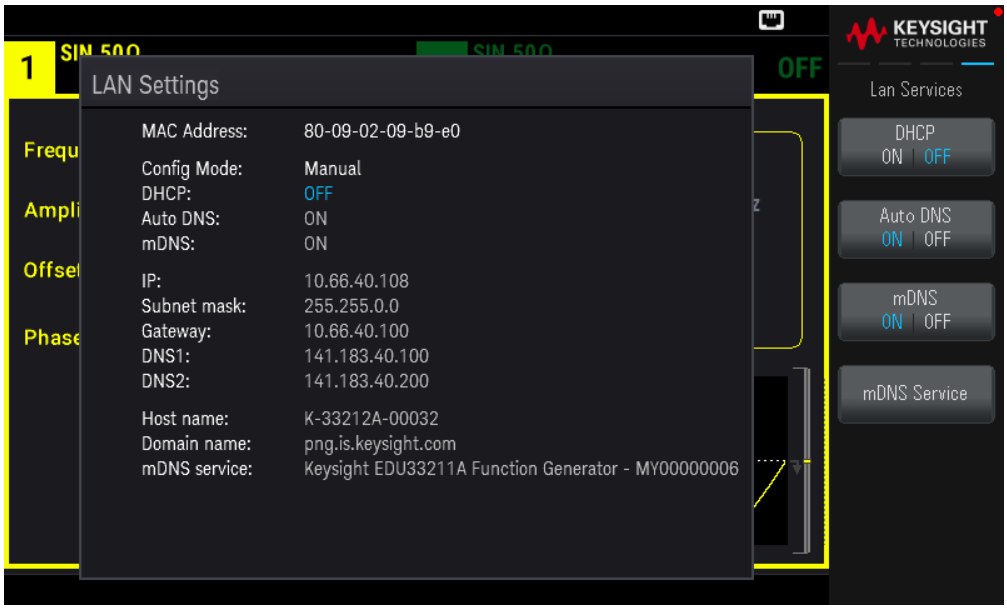
   Select **Services** to turn the various LAN services on or off.



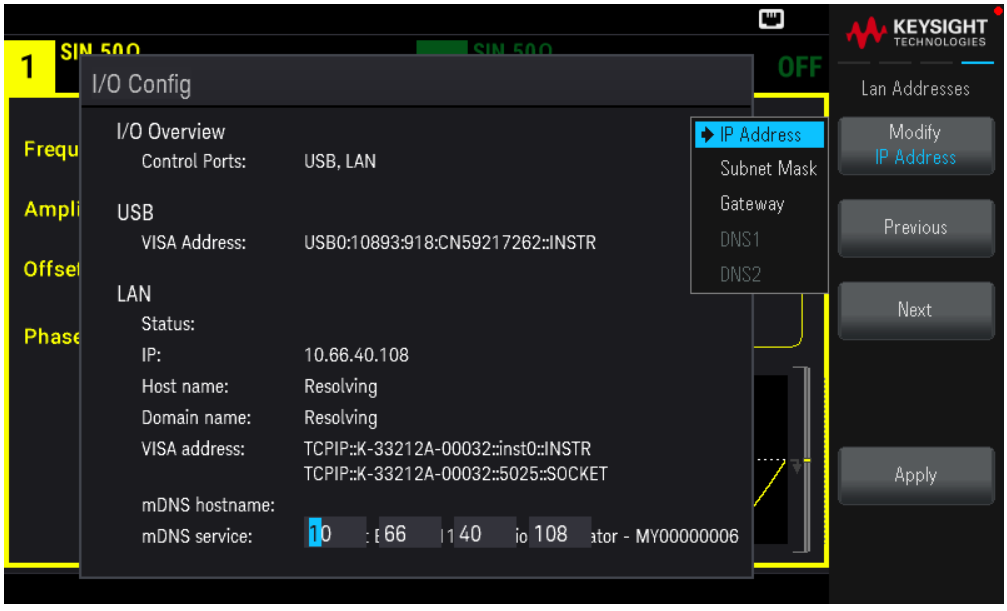
   With DHCP on, an IP address will automatically be set by the DHCP (Dynamic Host Configuration Protocol) when you connect the instrument to the network, provided the DHCP server is found and is able to do so. DHCP also automatically deals with the subnet mask and gateway address, if required. This is typically the easiest way to establish LAN communication for your instrument. All you need to do is leave DHCP on. Contact your LAN administrator for details.

2. Establish an "IP Setup."

   If you are not using DHCP (use the **Services** softkey to set **DHCP** to OFF), you must establish an IP setup, including an IP address, and possibly a subnet mask and gateway address.



Press **[Back]** > **Addresses** > **Modify** to configure the IP address, subnet mask, and gateway address.



Contact your network administrator for the IP address, subnet mask, and gateway to use.

IP Address: All IP addresses take the dot-notation form "nnn.nnn.nnn.nnn" where "nnn" in each case is a byte value in the range 0 through 255. You can enter a new IP address using the numeric keypad (not the knob). Type in the numbers using the keypad and the cursor keys. Press **Previous** or **Next** to move the cursor to the next field or previous field. Do not enter leading zeros.

Subnet Mask: Subnetting allows the LAN administrator to subdivide a network to simplify administration and minimize network traffic. The subnet mask indicates the portion of the host address used to indicate the subnet. Type in the numbers using the keypad and the cursor keys. Press Previous or Next to move the cursor to the next field or previous field.

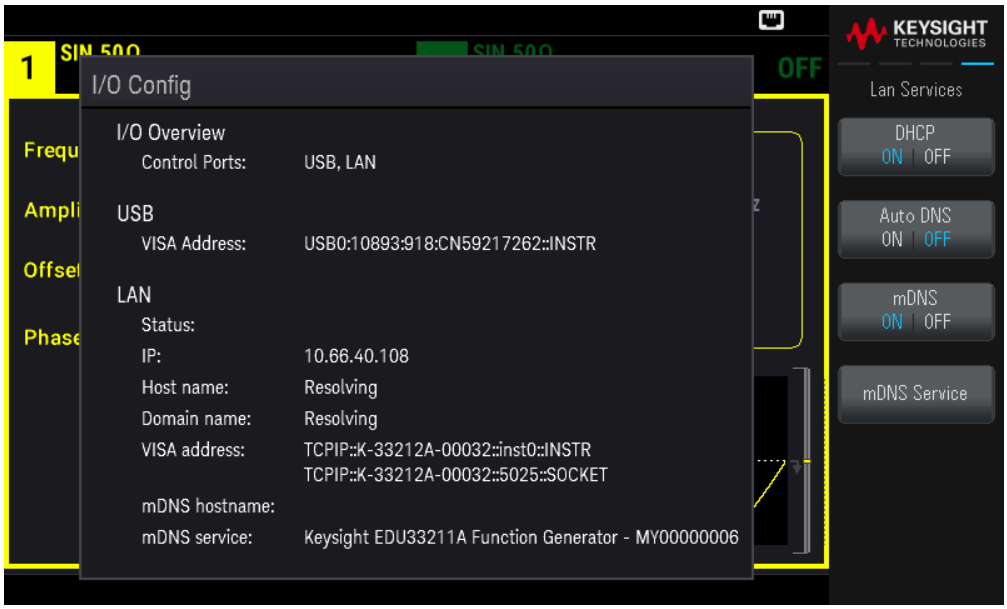
Gateway: A gateway is a network device that connects networks. The default gateway setting is the IP address of such a device. Type in the numbers using the keypad and the cursor keys. Press Previous or Next to move the cursor to the next field or previous field.

Press Apply to save your changes.

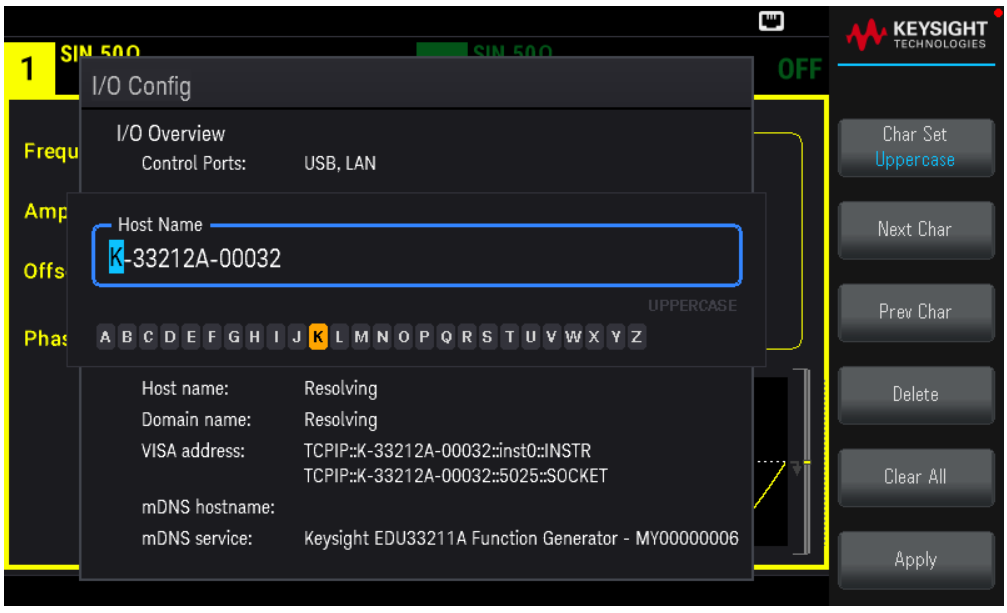
3. Configure the "DNS Setup" (optional)

DNS (Domain Name Service) is an Internet service that translates domain names into IP addresses. Ask your network administrator whether DNS is in use, and if it is, for the host name, domain name, and DNS server address to use.

Normally, DHCP discovers DNS address information; you only need to change this if DHCP is unused or not functional. To manually configure the addressing of the instrument, use the Services softkey to set Auto DNS to OFF.



a. Set the "hostname." Press [Back] > Host Name and enter the hostname. A hostname is the host portion of the domain name, which is translated into an IP address. The hostname is entered as a string using the softkeys provided. The hostname may include letters, numbers, and dashes ("-").

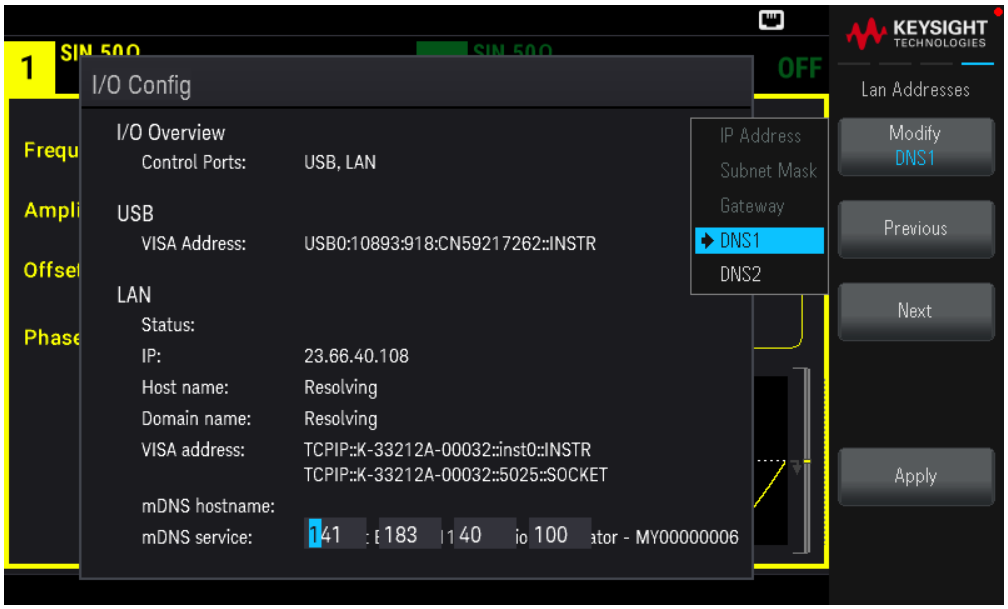


The instrument is shipped with a default hostname with the following format: K-{modelnumber}-{serialnumber},

where {modelnumber} is the instrument's 6-character model number (e.g. 33212A) and {serialnumber} is the last five characters of the instrument's serial number (e.g. 45678 if the serial number is MY12345678).

b. Set the "DNS Server" addresses. Press [Back]. Press Addresses > Modify to configure the DNS server addresses.

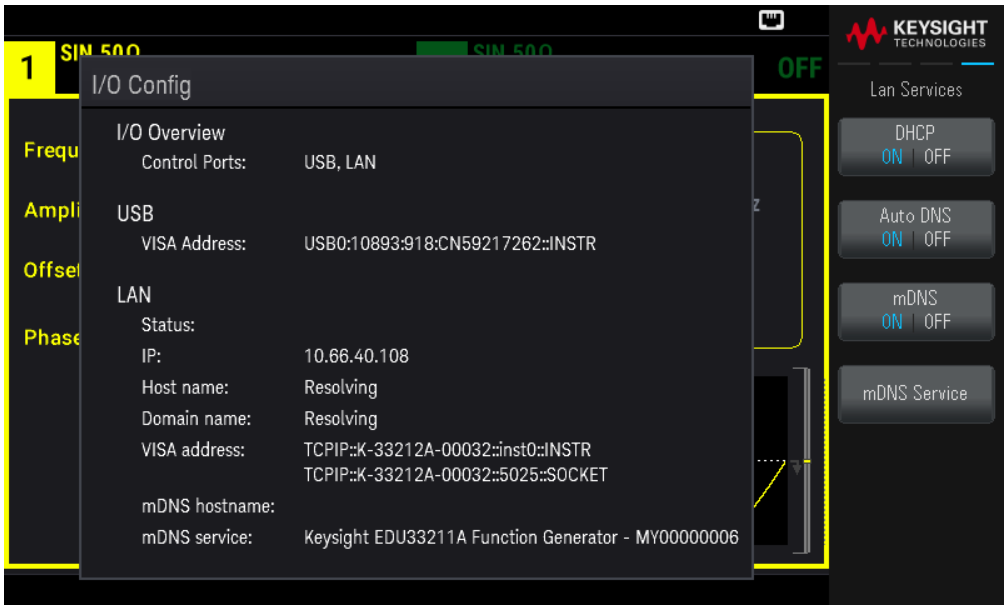
Enter the Primary DNS (DNS1) and Second DNS (DNS2). Type in the numbers using the keypad and the cursor keys. Press Previous or Next to move the cursor to the next field or previous field. See your network administrator for details.



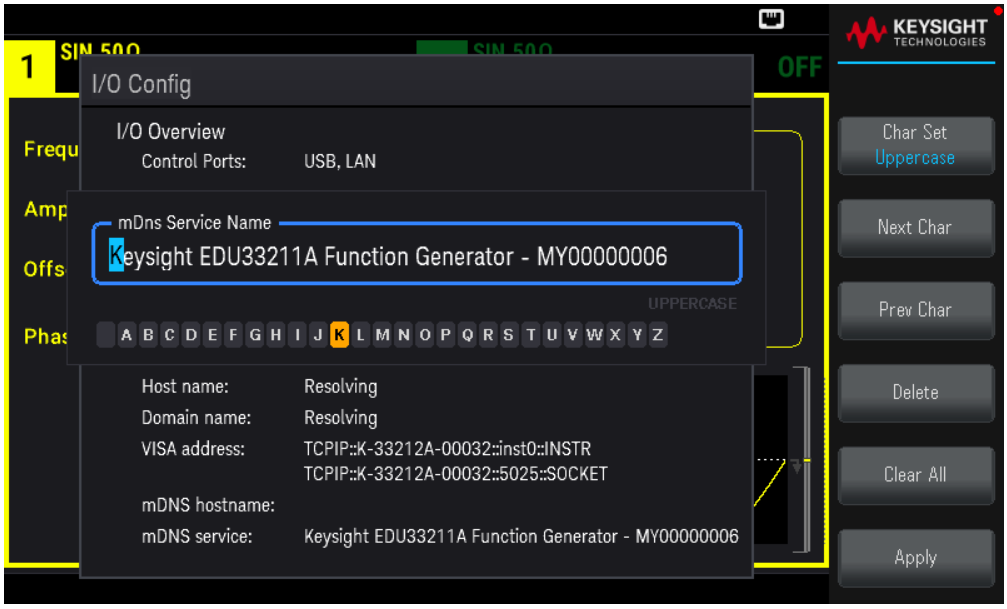
4. Configure the mDNS Service (optional).

   Your instrument receives a unique mDNS service name at the factory, but you may change it. The mDNS service name must be unique on the LAN.

   To manually configure the service name of the instrument, use the **Services** softkey to set **mDNS** to ON.



   Press **mDNS Service**.



   Use the softkeys provided to set a desired service name. The name must start with letter; other characters can be an upper or lower case letters, numeric digits, or dashes ("-"). Press **Apply** to save your changes.

SCPI Socket Services

This instrument allow any combination of up to two 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 system 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.

More About IP Addresses and Dot Notation

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.

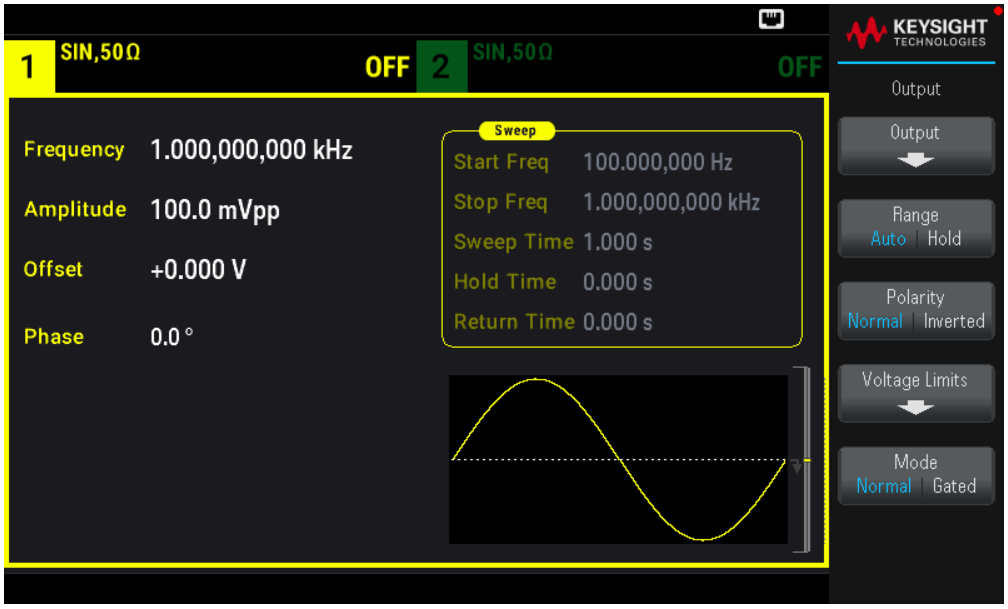
3 Front Panel Menu Operations

This section introduces front panel keys and menus. See Features and Functions for additional front panel operation information.

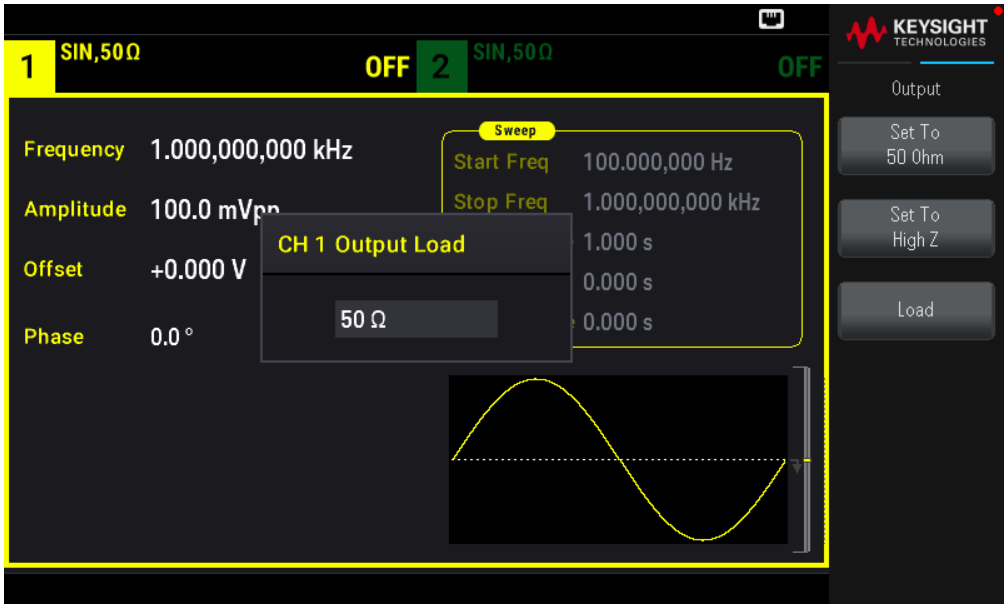
Select an Output Termination

The instrument has a fixed series output impedance of 50 Ω to the front panel channel connectors. If the actual load impedance differs from the value specified, the displayed amplitude and offset levels will be incorrect. The load impedance setting is simply a convenience to ensure that the displayed voltage matches the expected load.

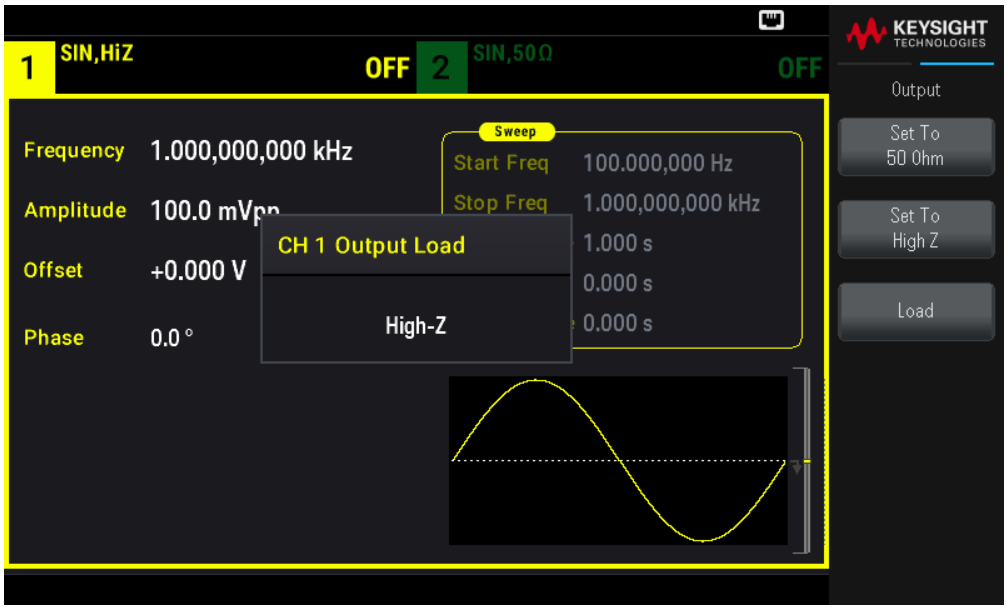
1. Press a channel [Setup] key to open the channel configuration screen. Note that the current output termination values (both 50 Ω in this case) appear on the tabs at the top of the screen.



2. Begin specifying the output termination by pressing Output.

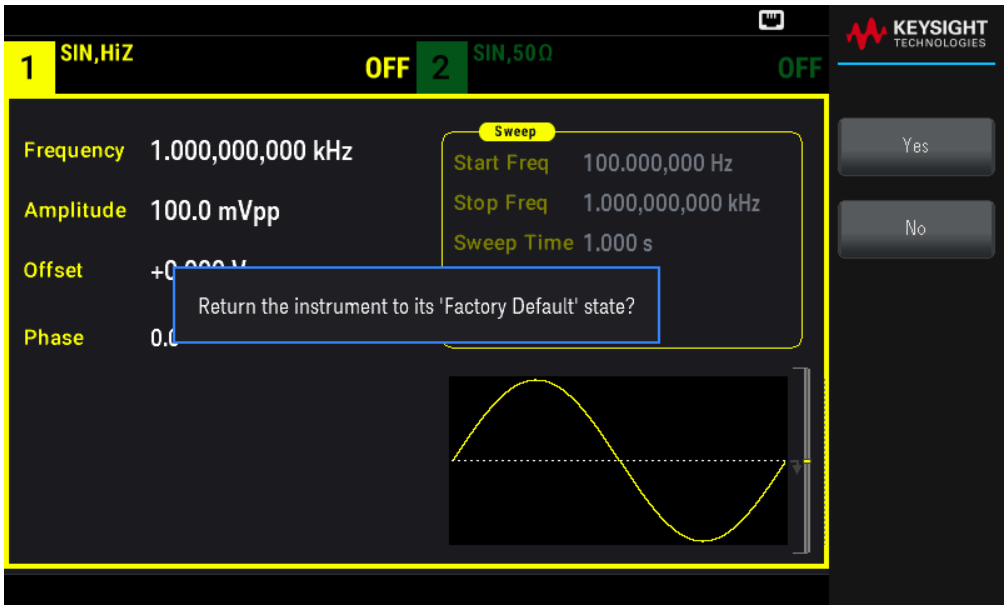


3. Select the desired output termination either by using the knob or numeric keypad to select the desired load impedance or by pressing **Set to 50 Ω** or **Set to High Z**. You can also set a specific value by pressing **Load**.



Reset the Instrument

To reset the instrument to its factory default state, press **[System]** > **Store/Recall** > **Set to Defaults** > **Yes**. See "Factory Reset State" in the *EDU33210 Series Programming Guide* for more details.



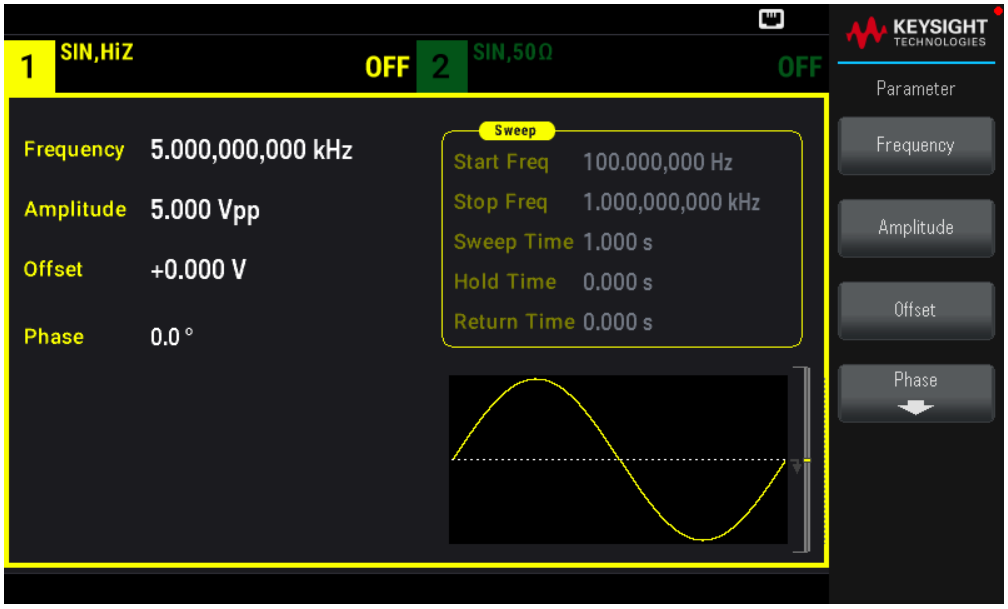
Output a Modulated Waveform

A modulated waveform consists of a carrier waveform and a modulating waveform. In AM (amplitude modulation), the carrier amplitude is varied by the modulating waveform. For this example, you will output an AM waveform with

80% modulation depth. The carrier will be a 5 kHz sinewave and the modulating waveform will be a 200 Hz sine wave.

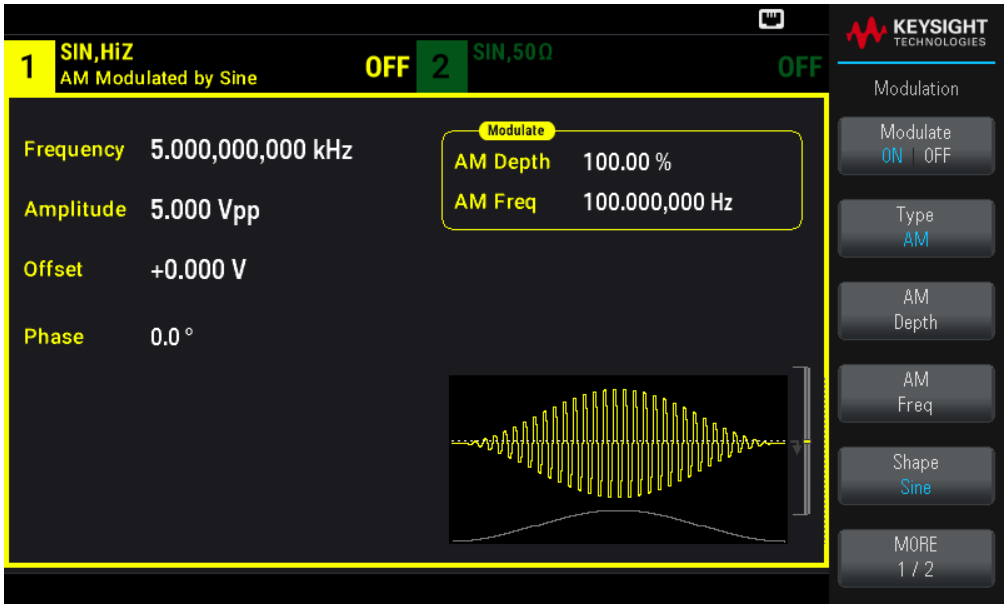
1. Select the function, frequency, and carrier amplitude.

   Press [Waveform] > Sine. Press the Frequency, Amplitude, and Offset softkeys to configure the carrier waveform. For this example, select a 5 kHz sine wave with an amplitude of 5 Vpp, with 0 V offset. Note that you may specify amplitude in Vpp, Vrms, or dBm.

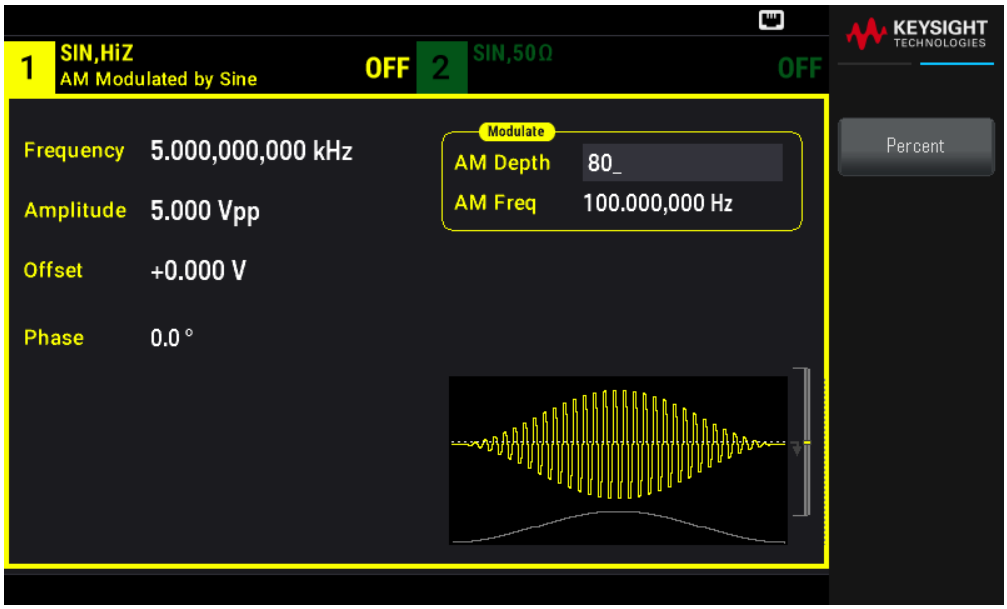


2. Select AM.

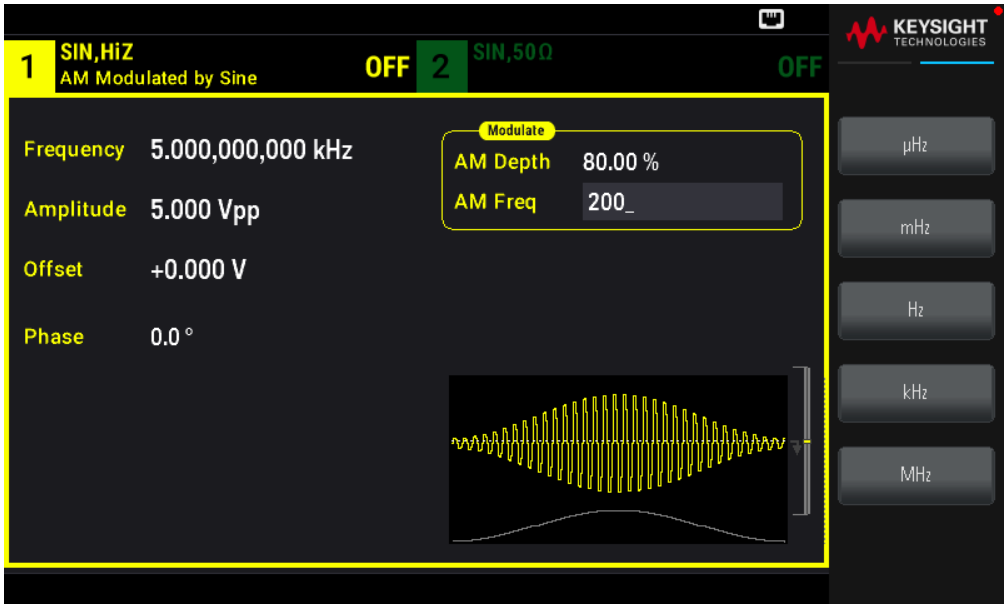
   Press [Modulate] and then select AM using the Type softkey. Then press the Modulate soft key to turn modulation ON.



3. Set the modulation depth. Press the AM Depth softkey and then set the value to 80% using the numeric keypad or the knob and arrows.



4. Select the modulating waveform shape. Press Shape to select the modulating waveform's shape. For this example, select a Sine wave.
5. Press AM Freq. Set the value to 200 Hz using the numeric keypad or the knob and arrows. Press Hz to finish entering the number if you are using the numeric keypad.



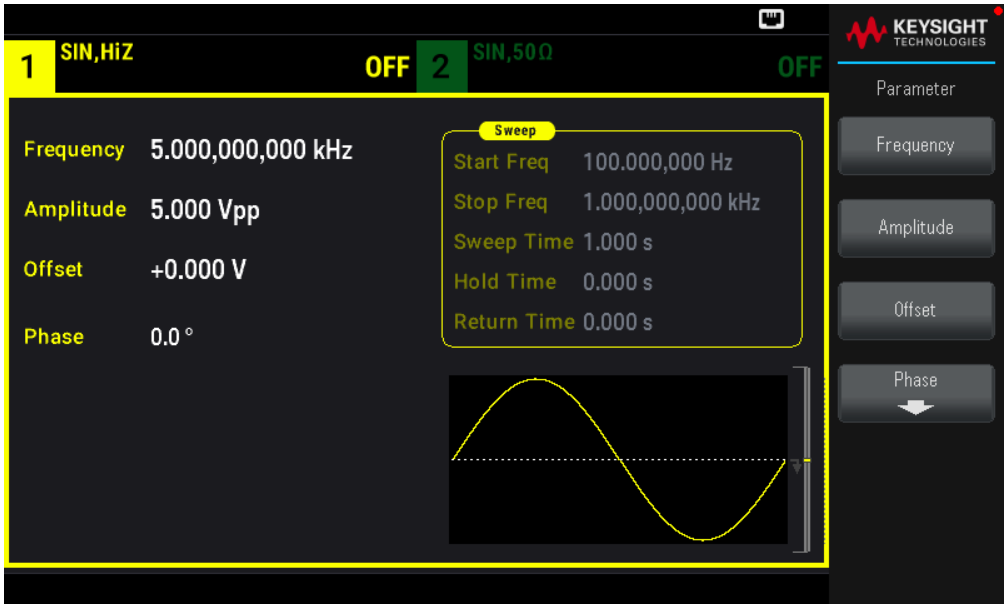
Output an FSK Waveform

You can configure the instrument to "shift" its output frequency between two preset values (called the "carrier frequency" and the "hop frequency") using FSK modulation. The rate at which the output shifts between these two frequencies is determined by the internal rate generator or the signal level on the front panel Ext Trig connector. For

this example, you will set the "carrier" frequency to 5 kHz and the "hop" frequency to 500 Hz, with an FSK rate of 100 Hz.

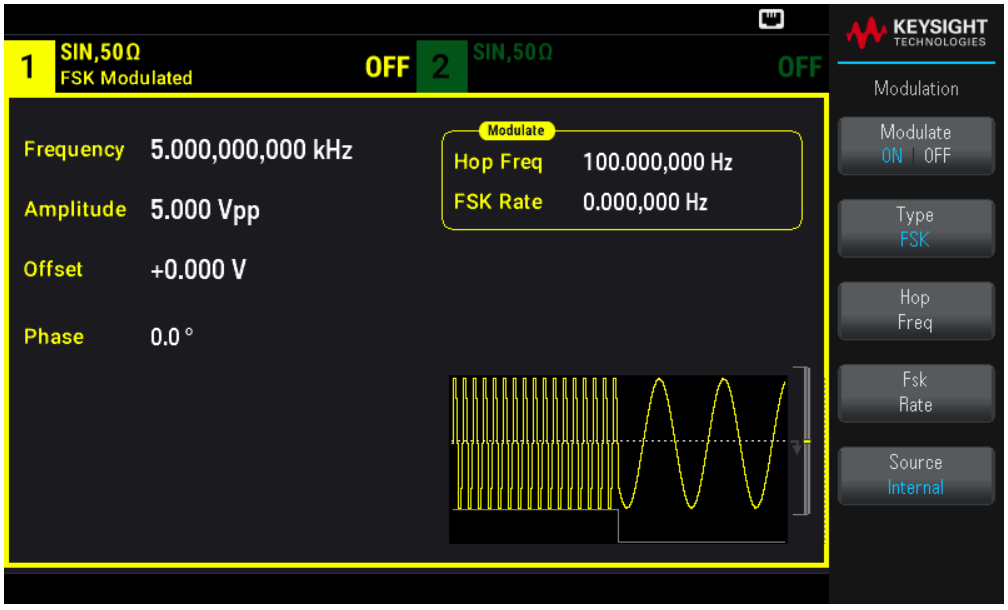
1. Select the function, frequency, and carrier amplitude.

   Press [Waveform] > Sine. Press the Frequency, Amplitude, and Offset softkeys to configure the carrier waveform. For this example, select a 5 kHz sine wave with an amplitude of 5 Vpp, with 0 V offset.



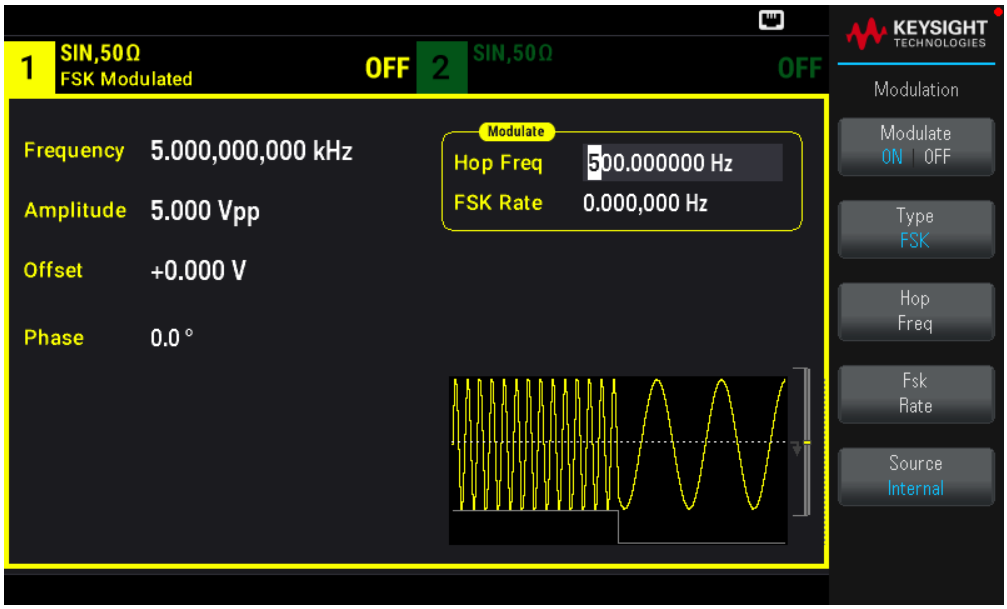
2. Select FSK.

   Press [Modulate] and then select FSK using the Type softkey. Then press the Modulate softkey to turn modulation ON.



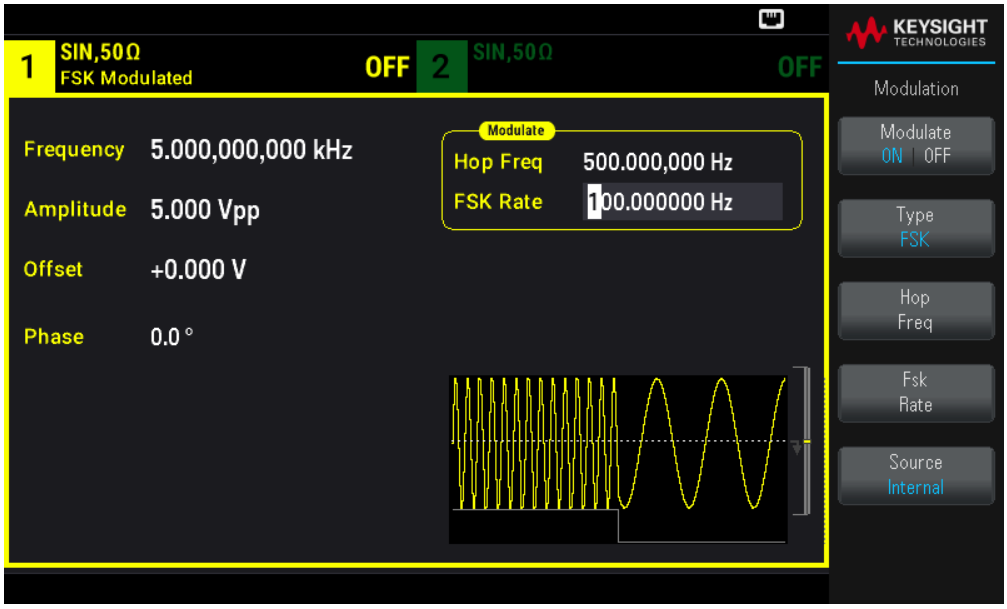
3. Set the "hop" frequency.

   Press the **Hop Freq** softkey and then set the value to 500 Hz using the numeric keypad or the knob and arrows. If you use the numeric keypad, be sure to finish the entry by pressing **Hz**.



4. Set the FSK "shift" rate.

   Press the **Fsk Rate** softkey and then set the value to 100 Hz using the numeric keypad or the knob and arrows.



   At this point, the instrument outputs an FSK waveform if the channel output is enabled.

Output a PWM Waveform

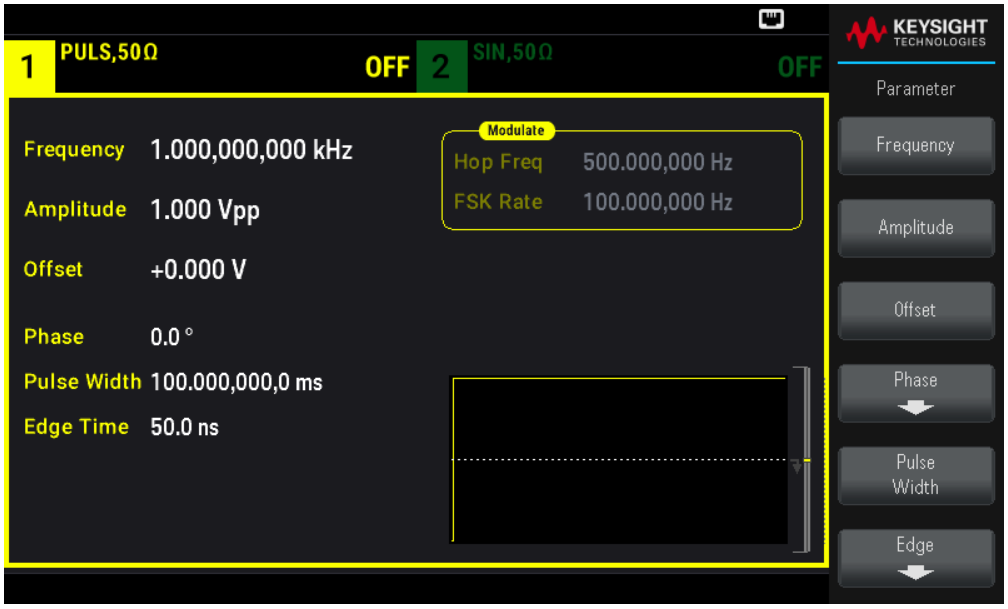
You can configure the instrument to output a pulse width modulated (PWM) waveform. PWM is only available for the Pulse waveform, and the pulse width varies according to the modulating signal. The amount by which the pulse width varies is called the width deviation, and it can be specified as a percentage of the waveform period (that is, duty cycle) or in units of time. For example, if you specify a pulse with 20% duty cycle and then enable PWM with a 5% deviation, the duty cycle varies from 15% to 25% under control of the modulating signal.

To change from pulse width to pulse duty cycle, press [Units].

For this example, you will specify a pulse width and pulse width deviation for a 1 kHz pulse waveform with a 5-Hz sine wave modulating waveform.

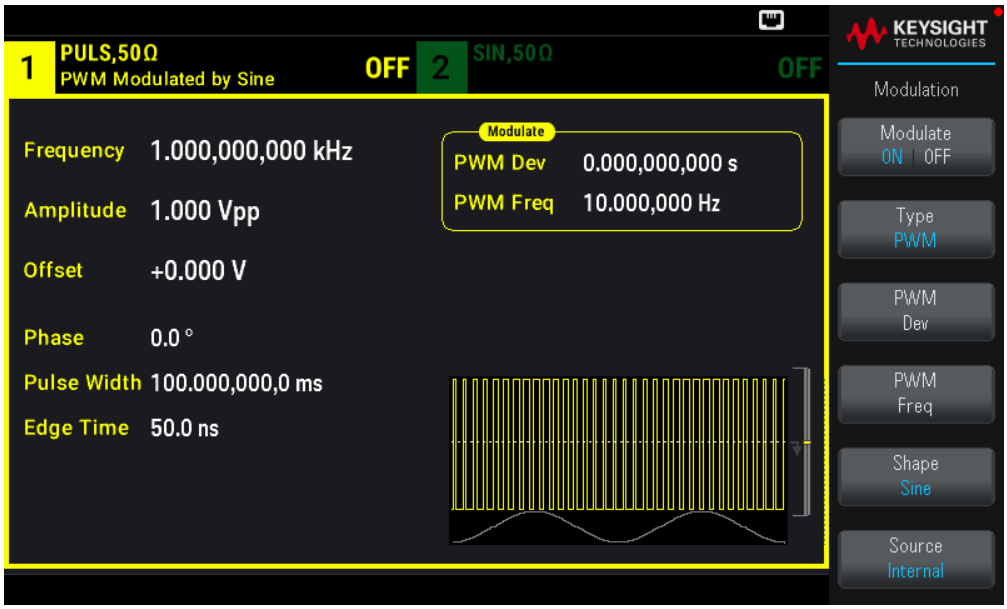
1. Select the carrier waveform parameters.

   Press [Waveform] > Pulse. Use the Frequency, Amplitude, Offset, Pulse Width, and Edge Times soft keys to configure the carrier waveform. For this example, select a 1 kHz pulse waveform with an amplitude of 1 Vpp, zero offset, a pulse width of 100 ms, and an edge time of 50 ns (both leading and trailing).



2. Select PWM.

   Press [Modulate] > Type PWM. Then press the Modulate softkey to turn modulation ON.



3. Set the width deviation.

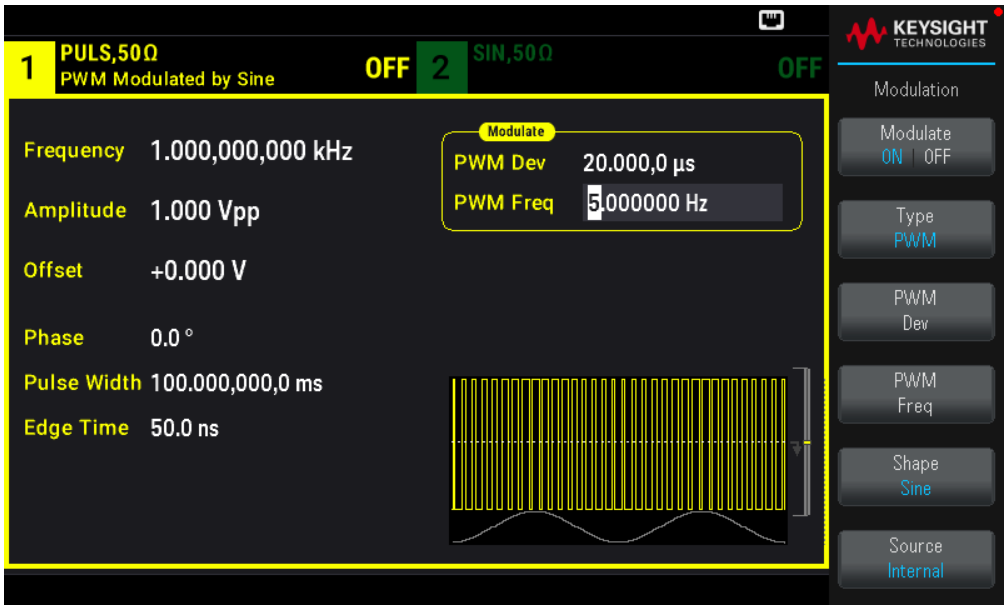
   Press the PWM Dev softkey and set the value to 20 µs using the numeric keypad or the knob and arrows.

4. Set the modulating frequency.

   Press the PWM Freq softkey and then set the value to 5 Hz using the numeric keypad or the knob and arrows.

5. Select the modulating waveform shape.

   Press Shape to select the modulating waveform's shape. For this example, select a sinewave.



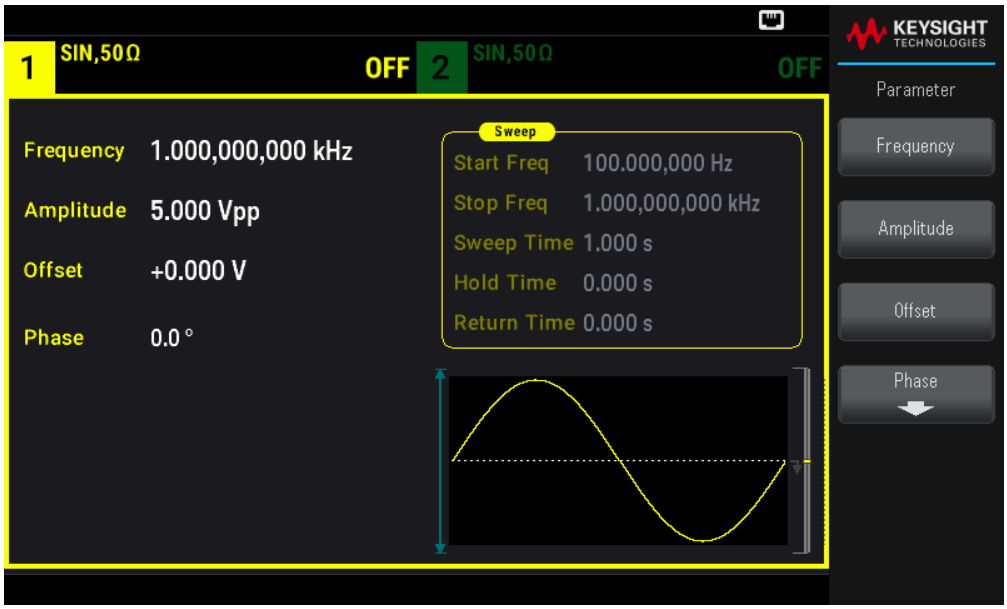
To view the actual PWM waveform, you would need to output it to an oscilloscope. If you do this, you will see how the pulse width varies, in this case, from 80 to 120 µs. At a modulation frequency of 5 Hz, the deviation is easily visible.

Output a Frequency Sweep

In the frequency sweep mode, the instrument moves from the start frequency to the stop frequency at a sweep rate, which you specify. You can sweep up or down in frequency, and with either linear or logarithmic spacing, or using a list of frequencies. For this example, you will output a swept sinewave from 50 Hz to 5 kHz.

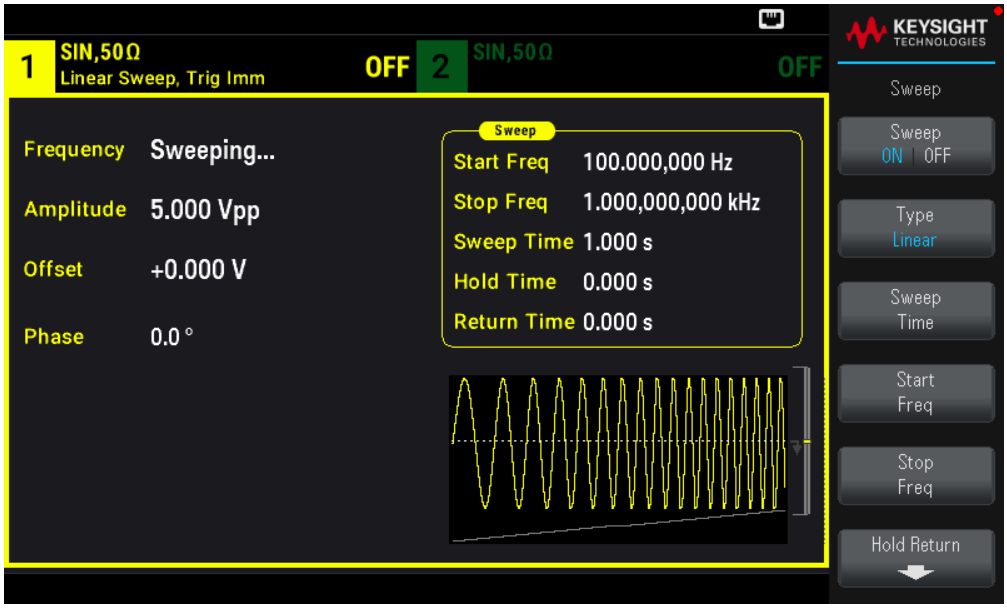
1. Select the function and amplitude for the sweep.

   For sweeps, you can select sine, square, ramp, pulse, triangle, PRBS waveforms, or arbitrary waveforms (noise and DC are not allowed). For this example, select a sine wave with an amplitude of 5 Vpp.



2. Select the sweep mode.

   Press [Sweep] and verify that the Linear sweep mode is currently selected on the second softkey. Press the Sweep softkey to turn sweep ON. Notice the Linear Sweep status message at the top of the tab for the current channel. The button is also illuminated.

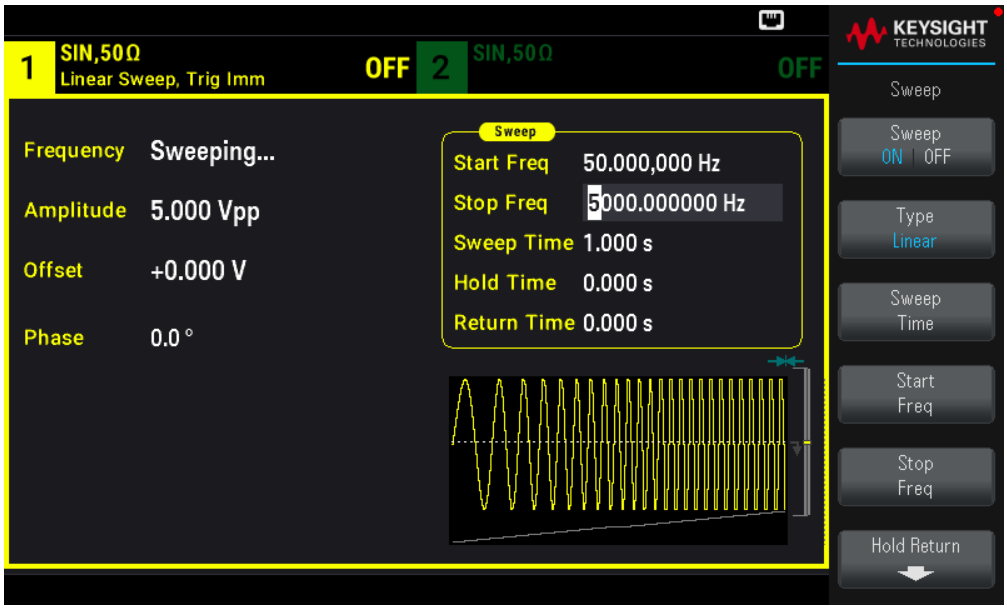


3. Set the start frequency.

   Press **Start Freq** and then set the value to 50 Hz using the numeric keypad or the knob and arrows.

4. Set the stop frequency.

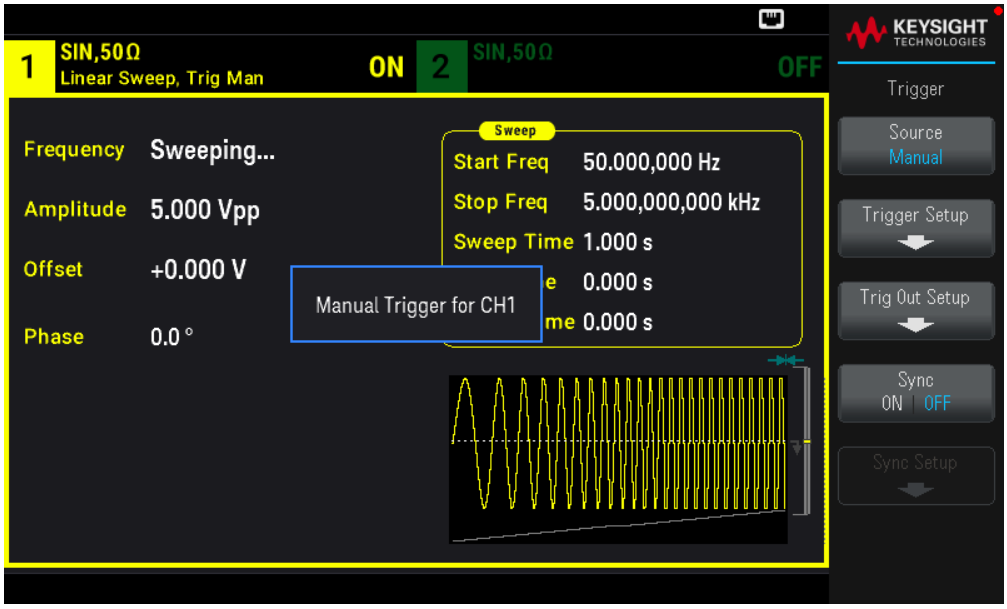
   Press Stop Freq and set the value to 5 kHz using the numeric keypad or the knob and arrows.



   At this point, the instrument outputs a continuous sweep from 50 Hz to 5 kHz if output is enabled.

   You can also set the sweep frequency boundaries of the sweep using a center frequency and frequency span. These parameters are similar to the start frequency and stop frequency (above) and they provide added flexibility. To achieve the same results, set the center frequency to 2.525 kHz and the frequency span to 4.950 kHz.

   To generate a frequency sweep, press [Trigger] > Source Manual to put the trigger in manual mode. Press [Trigger] to send a trigger. For more information, see Trigger a Sweep or Burst.

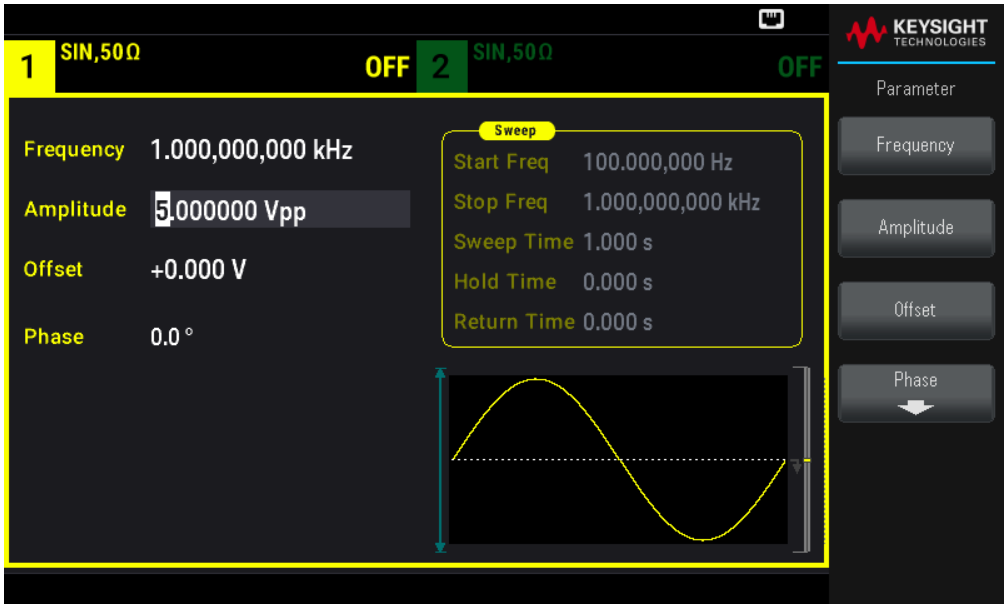


Output a Burst Waveform

You can configure the instrument to output a waveform with for a specified number of cycles, called a burst. You can control the amount of time that elapses between bursts with the internal timer or the signal level on the front panel Ext Trig connector. For this example, you will output a three-cycle sine wave with a 20 ms burst period.

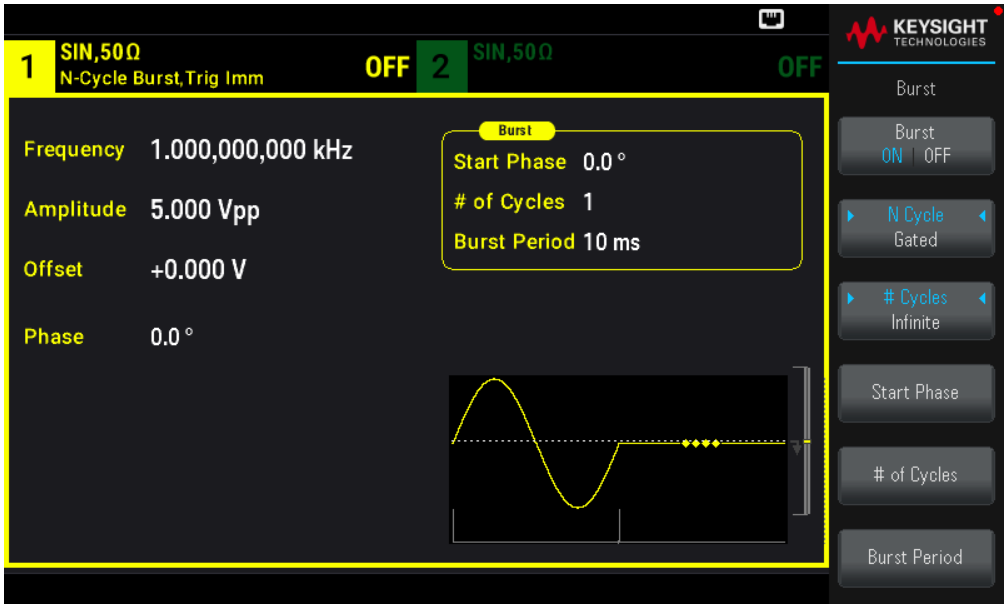
1. Select the function and amplitude for the burst.

   For burst waveforms, you can select sine, square, ramp, pulse, arbitrary waveforms, triangle, or PRBS. Noise is allowed only in the "gated" burst mode and DC is not allowed. For this example, select a sine wave with an amplitude of 5 Vpp.



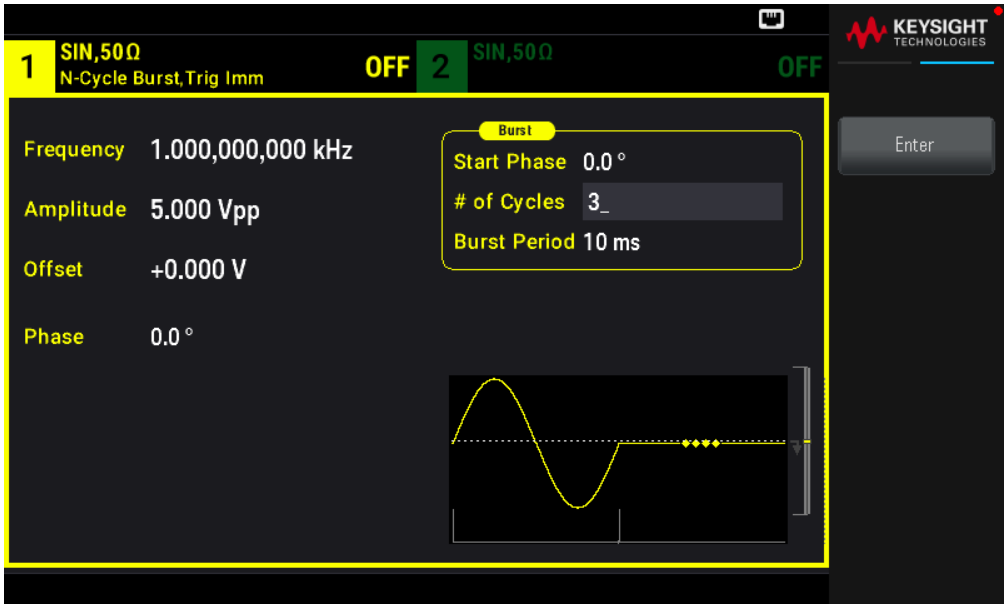
2. Select the burst mode.

   Press [Burst] > Burst ON | OFF.



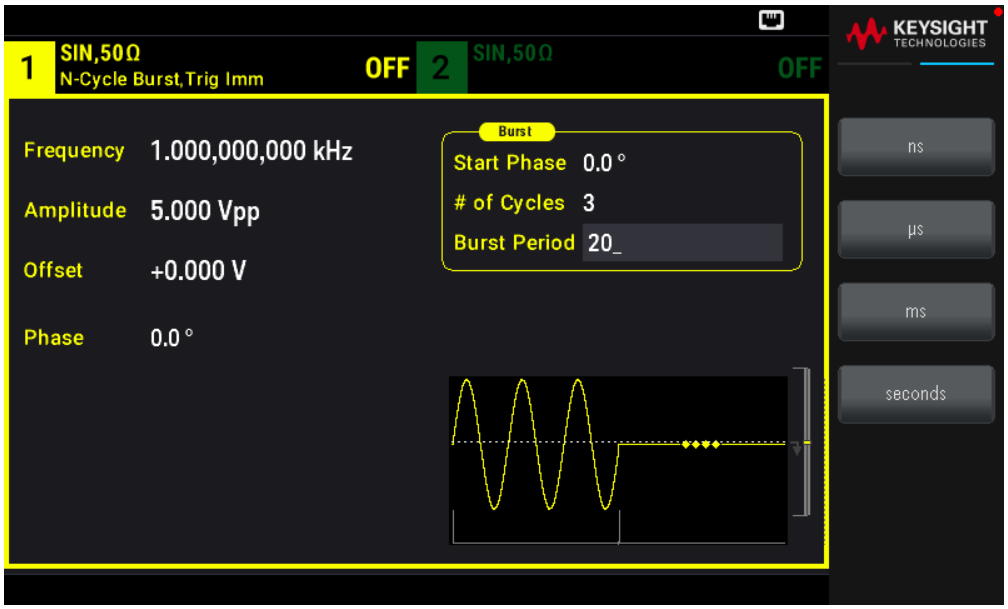
3. Set the burst count.

   Press # of Cycles and set the count to "3" using the numeric keypad or knob. Press Enter to finish data entry if you are using the numeric keypad.

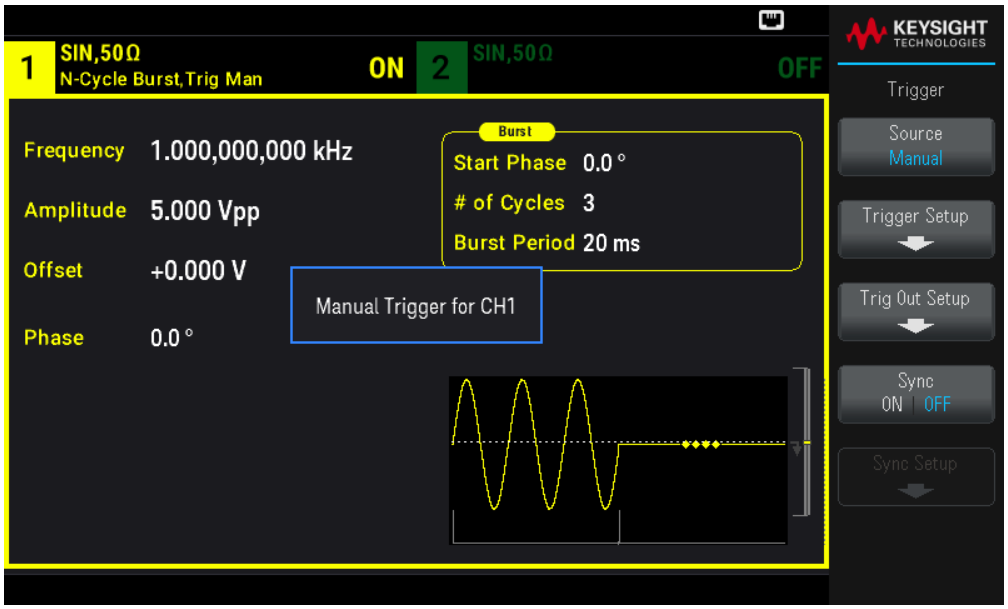


4. Set the burst period.

   Press Burst Period and set the period to 20 ms using the numeric keypad or the knob and arrows. The burst period sets the time from the start of one burst to the start of the next burst. At this point, the instrument outputs a continuous three-cycle burst at 20 ms intervals.



You can generate a single burst (with the specified count) by pressing the [Trigger] key. For more information, see Trigger a Sweep or Burst.



You can also use the external gate signal to create gated bursts, where a burst is produced while a gate signal is present on the input.

Trigger a Sweep or Burst

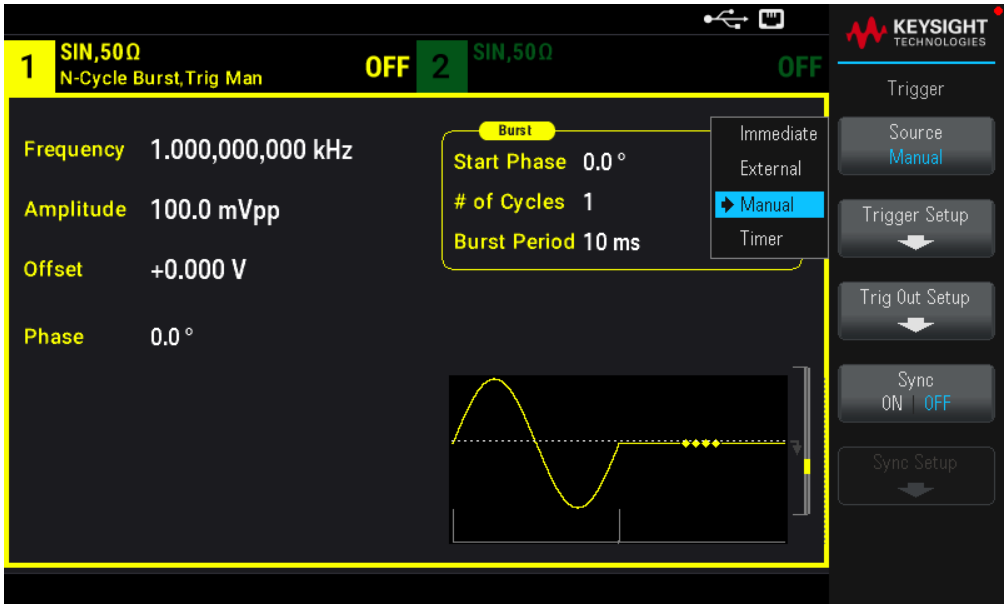
You can select one of four different types of triggers from the front panel for sweeps and bursts:

– **Immediate** or "automatic" (default): Instrument outputs continuously when sweep or burst mode is selected.

– **External**: Triggering controlled by front panel **Ext Trig** connector.

– **Manual**: Initiates one sweep or burst each time you press **[Trigger]**. Continue pressing **[Trigger]** to re-trigger instrument.

– **Timer**: Issues one or more triggers a fixed time amount apart.



If sweep or burst is on, pressing **[Trigger]** displays the trigger menu. An illuminated **[Trigger]** key (solid or blinking) indicates that one or both channels are awaiting a manual trigger. Solid illumination occurs when the trigger menu is selected, and flashing illumination occurs when the trigger menu is not selected. The **[Trigger]** key is disabled when the instrument is in remote.

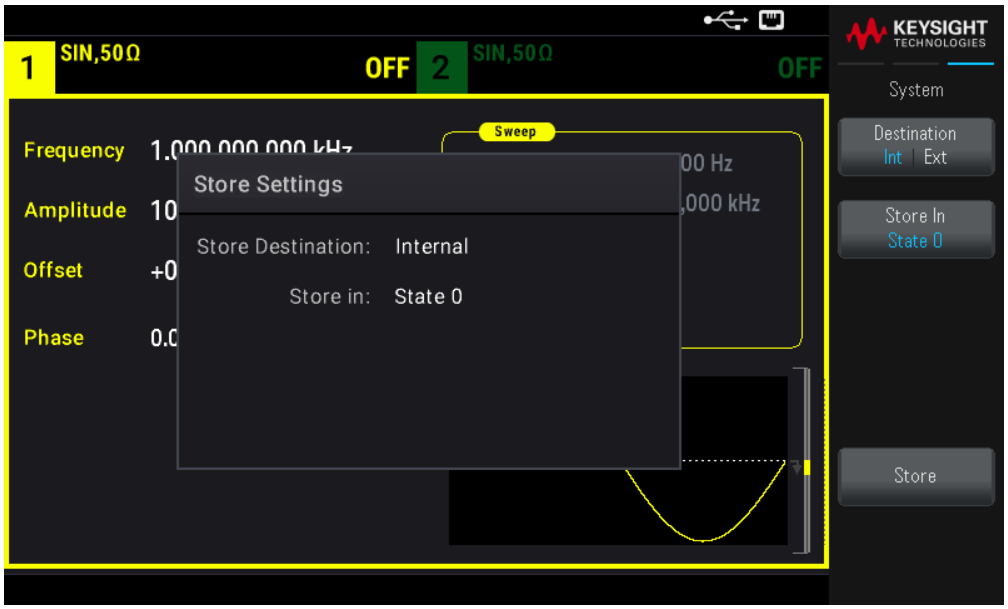
Pressing **[Trigger]** when it is solidly illuminated causes a manual trigger. Pressing **[Trigger]** when it is flashing selects the trigger menu; a second press causes a manual trigger.

Store or Retrieve the Instrument State

You can store instrument states in any number of state files, (extension .sta). You can do this for backup purposes, or you can save your state to a external USB flash drive and load it on another instrument to have instruments with matching configurations. A stored state contains the selected function, frequency, amplitude, DC offset, duty cycle, symmetry, and any modulation or burst parameters in use. The instrument does not store volatile arbitrary waveforms.

Store Settings

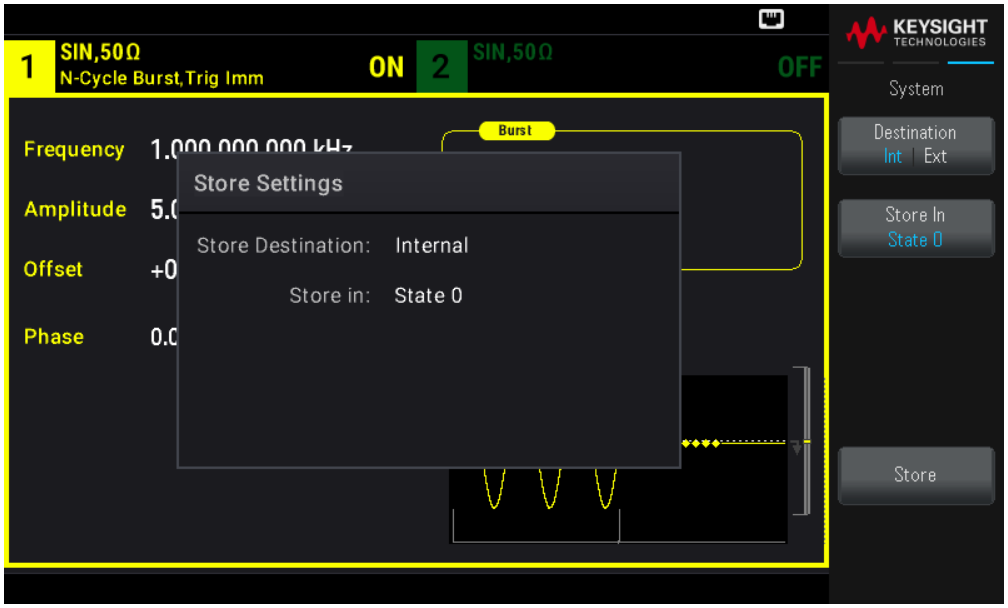
Store Settings allows you to browse to a directory and specify a file name, and to choose whether you want to store a state file internally or to an external USB flash drive.



To store (save) the current instrument state:

1. Select the desired storage destination.

   Press [System] > Store/Recall > Store Settings > Destination.



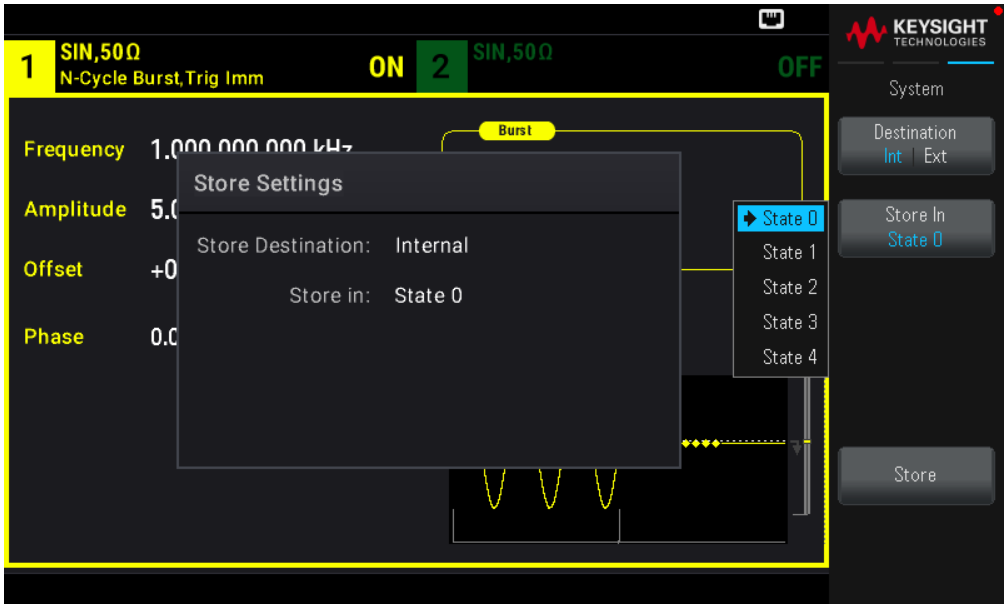
   If choose to store the instrument state in the instrument's non-volatile internal memory, select Int. Proceed to step 2.

   If you choose to store the state file (.sta) in a connected external USB flash drive, select Ext. Skip to step 3.

   NOTE Make sure to connect a USB flash drive before proceed. If a USB flash drive is not connected, the menus under Destination Int | Ext will be grayed out.

2. Select the desired internal storage location to save the instrument state to.

   Press **Store In**, and select between State 0, State 1, State 2, State 3, or State 4. Skip to step 5.



3. Select the desired external storage location to save the state file (.sta) to.

   Press **Select** File | Path > **Browse** to browse for existing state files (.sta) in the connected external USB flash drive. Use the front panel knob to highlight an existing state file (.sta). Press **Select** to select the highlighted file and return to the previous menu.

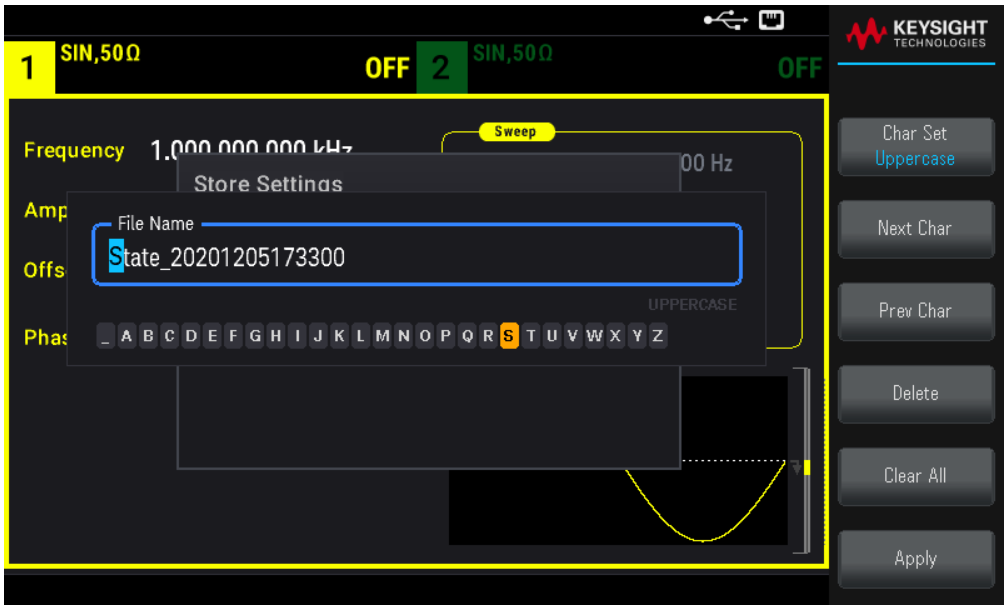
   You can also press **Rename** to rename the highlighted file or press **Delete** to delete the highlighted file.

   Press **Select File** | Path > **Browse** to browse for folders in the external USB flash drive to store the state file (.sta) to. Use the front panel knob to highlight a folder. Press **Select** to browse the highlighted folder. Press **Select Folder** to select the highlighted folder and return to the previous menu.

   You can also press **Rename** to rename the highlighted folder or press **Delete** to delete the highlighted folder.

4. Optional: If you have not done so in the previous step, you can change the state file name.

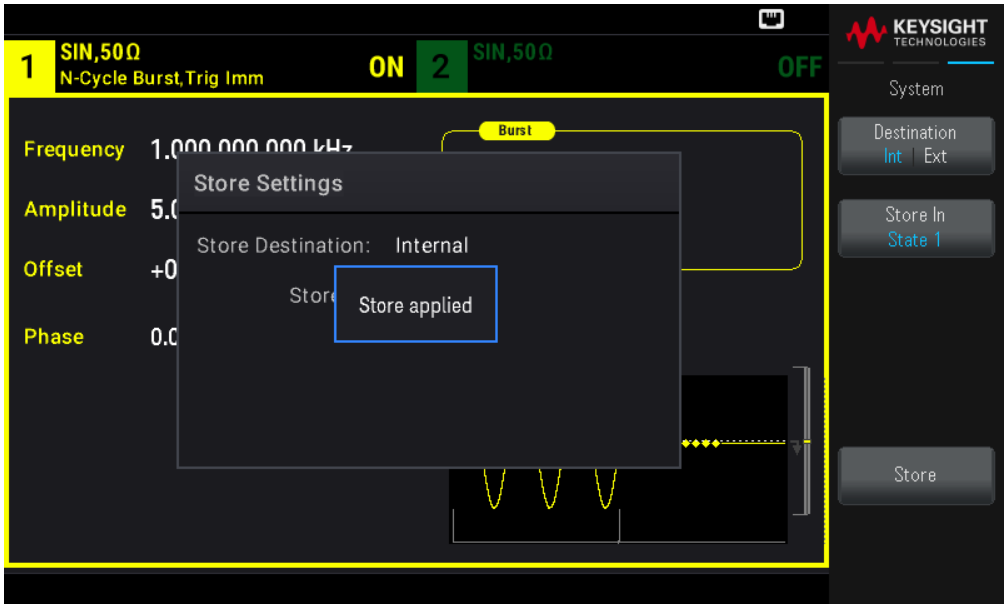
   Press File Name to specify the name of the state file (.sta). Use the provided softkeys to set a desired file name.



   Press Apply when you have finished entering the name.

5. Store the instrument state.

   Press Store.



Recall Settings

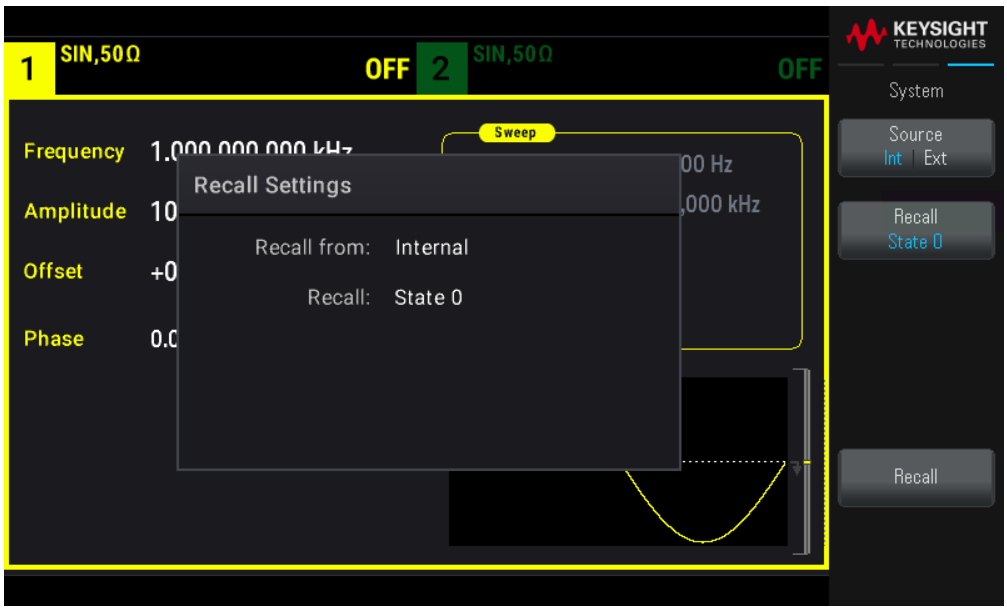
Recall Settings allows you to browse to the state in the internal memory or browse to the instrument state file (.sta format) in the external USB flash drive to be recalled.

NOTE The state file you recall must be from same instrument model.

To restore (retrieve) a stored instrument state:

1. Select the desired recall source.

   Press [System] > Store/Recall > Recall Settings > Source.



   If choose to recall an instrument state file from the instrument's non-volatile internal memory, select Int. Proceed to step 2.

   If you choose to recall a state file (.sta) from a connected external USB flash drive, select Ext. Skip to step 3.

2. Select the internal storage location to recall from.

   Press Recall, and select between State 0, State 1, State 2, State 3, or State 4. Skip to step 4.

3. Select the desired external storage location to recall from.

   Press Browse and use the front panel knob and arrow keys to navigate to the desired state file (*sta) that you would like to recall. Press Select when done.

4. Recall the selected instrument state.

   Press Recall.

Front Panel Menu Reference

This section begins with an overview of the front panel menus. The remainder of this section contains examples of using the front panel menus.

– **[Waveform]** Button

– **[Parameter]** Button

– **[Units]** Button

– **[Modulate]** Button

– **[Sweep]** Button

– **[Burst]** Button

– **[Trigger]** Button

– **[System]** Button

– Channel **[Setup]** and **[On/Off]** Button

[Waveform] Button

Selects waveform:

– Sine

– Square

– Ramp

– Pulse

– Arbitrary

– Triangle

– Noise

– PRBS

– DC

[Parameter] Button

Configures waveform-specific parameters:

– Period / Frequency

– Amplitude or High and Low Voltage

– Offset

– Phase

– Duty Cycle

– Symmetry

– Pulse Width

– Edge Times

– Arbitrary Waveform

– Sample Rate

– Filter

– Arb Phase

– Bandwidth

– PRBS Data

– Bit Rate

– Lead Edge

– Trail Edge

[Units] Button

Specifies unit and parameter preferences:

– Arb Rate: Sa/s, Freq or Period

– Voltage as Amplitude/Offset or High/Low

– Voltage units as Vpp, Vrms, or dBm

– Pulse Width or Duty Cycle

– Burst Phase as Degrees, Radians, or Seconds

– Arb Phase as Degrees, Radians, Seconds, or Samples

– Frequency sweep as Center/Span or Start/Stop

[Modulate] Button

Configures modulation parameters:

– Modulation on or off

– Modulation type: AM, FM, PM, PWM, BPSK, FSK, or Sum

– Modulation source

– Modulation parameters (vary by modulation type)

[Sweep] Button

Configures frequency sweep parameters:

– Sweep on or off

– Sweep type: Linear, logarithmic, or frequency list

– Sweep time

– Start/stop frequencies or center/span frequencies

– Dwell, hold, and return times

[Burst] Button

– Burst on or off

– Burst mode: triggered (N Cycle) or externally-gated

– Cycles per burst (1 to 100,000,000 or infinite)

– Starting phase angle of burst (-360° to +360°)

– Burst period

[Trigger] Button

Configures trigger settings and sync output signal:

– Perform a manual trigger, when illuminated

– Specify the trigger source for sweep, burst or arbitrary waveform advance

– Specify the trigger voltage level, count, and delay

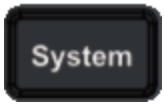
– Specify the slope (rising or falling edge) for an external trigger source

– Specify the slope (rising or falling edge) of the trigger output signal

– Enable / disable the signal output from the "Sync" connector

– Specify the Sync source, polarity, mode, marker point, and so on

[System] Button



Store/Recall Softkey

Stores and recalls instrument states:

– Manage files and folders

– Store instrument states in non-volatile memory.

– Recall stored instrument states.

– Select the instrument's power-on configuration (last power-down or factory default).

– Return the instrument to its factory default state.

I/O Config Softkey

Configures instrument I/O interfaces:

– Turn LAN services on and off

– Configure LAN (addresses and host name)

– Reset the LAN

Instr. Setup Softkey

Performs system administration tasks:

– Perform self-test

User Settings Softkey

Configures system-related parameters:

– Select local language for front panel messages and help text

– Enable or disable error beeper

– Enable disable keypad click

– Turn display on and off

– Adjust display dimming behavior

– Set date and time

Help Softkey

Shows list of Help topics:

– View "about" data - serial number, IP address, firmware version, and so on

– View remote command error queue

Channel [Setup] and [On / Off] Button

Enables and configures channels:

[On / Off] button

Turn channel on and off

[Setup] button

– Specify which channel is the focus of the menus

– Select output termination (50 Ω, High Z, or Manual)

– Enable/disable amplitude autoranging

– Select waveform polarity (normal or inverted)

– Specify voltage limits

– Specify whether output is normal or gated

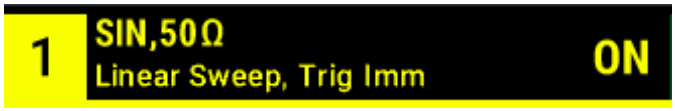
4 Features and Functions

This chapter contains details on instrument features, including front panel and remote interface operation. You may want to read Front Panel Menu Operation first. See the *EDU33210 Series Programming Guide* for details on SCPI commands and queries.

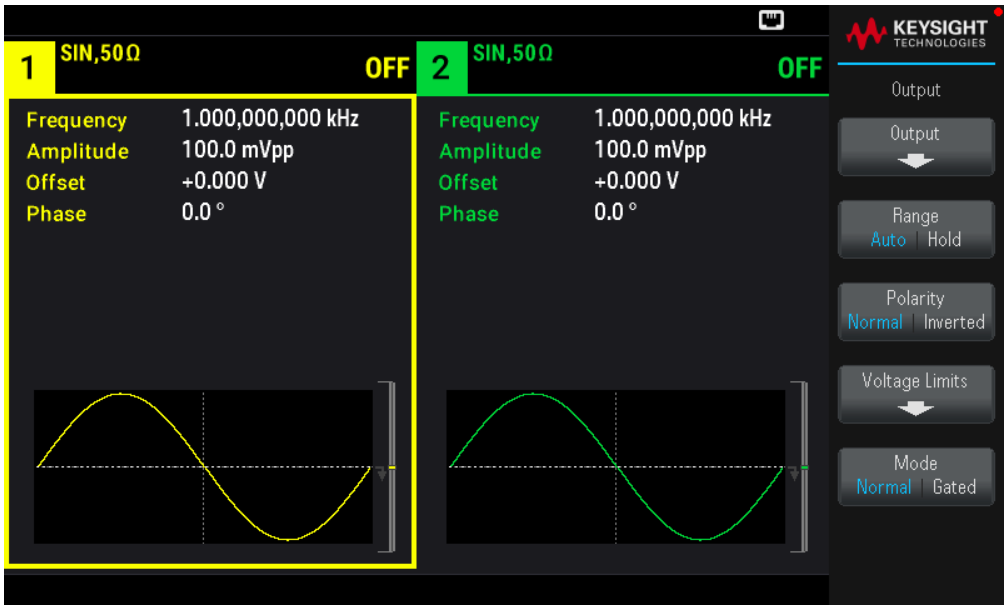
Output Configuration

This section describes the output channel configuration. Many commands associated with the output configuration starts with SOURce1: or SOURce2: to indicate a certain channel. If omitted, the default is channel 1. For example, VOLT 2.5 sets the output on channel 1 to 2.5 V, and SOUR2:VOLT2.5 does the same for channel 2.

The instrument's display includes a "tab" for each channel that summarizes various aspects of each channel's output configuration:



On a dual-channel instrument, the tab for channel 1 is in yellow, and the tab for channel 2 is in green.



Output Function

The instrument includes eight standard waveforms: sine, square, ramp, pulse, triangle, noise, PRBS (pseudorandom binary sequence), and DC. There are also nine built-in arbitrary waveforms.

The table below shows which functions are allowed (●) with modulation, sweep, and burst. Selecting a function that is not allowed with a modulation or mode disables the modulation or mode.

Carrier	AM	FM	PM	FSK	BPSK	PWM	Sum	Burst	Sweep
Sine and Square	●	●	●	●	●		●	●	●
Pulse	●	●	●	●	●	●	●	●	●
Triangle and Ramp	●	●	●	●	●		●	●	●
Gaussian Noise	●						●	●[1]	
PRBS	●	●	●				●	●	
Arbitrary Waveform	●	●	●[2]		●[2]		●	●	●

1 Gated burst only

2 Applies to sample clock, not whole waveform

– Frequency Limitations: Changing functions may change the frequency to meet the new function's frequency limits.

– Amplitude Limitations: When the output units are Vrms or dBm, changing functions may lower the amplitude to the maximum for the new function due to variation in waveform shapes. For example, a 5 Vrms square wave (into 50 Ω) changed to a sine will decrease to 3.536 Vrms (sine's upper limit).

– Amplitude and offset cannot combine to exceed the instrument's capability. The one you set last may be changed to stay within limits.

– You may protect a device-under-test (DUT) by specifying upper and lower output voltage limits.

Front Panel Operations

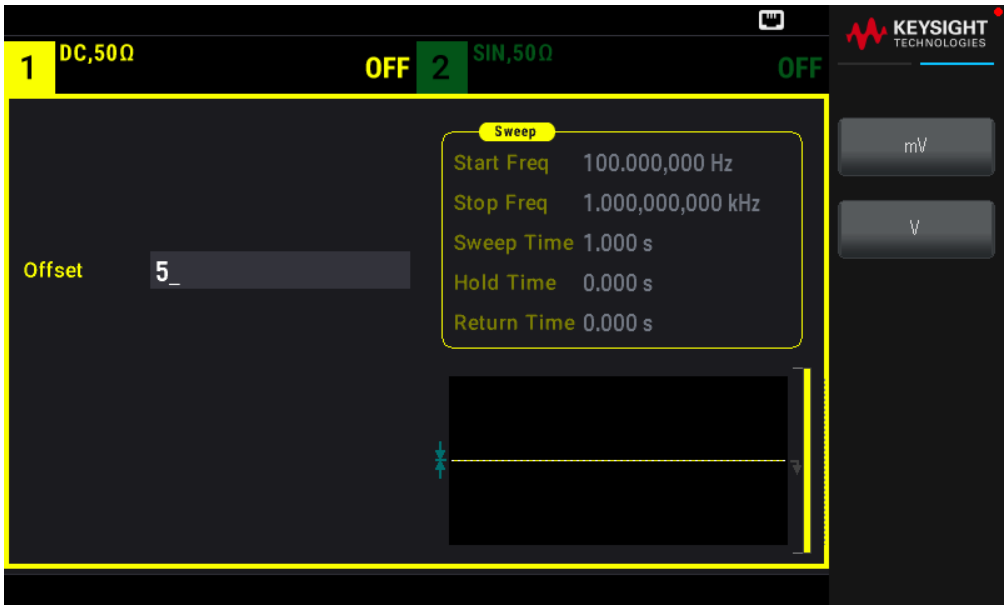
– To turn on an output: Press Channel [On/Off] for your desired channel.

– To select another waveform: Press [Waveform].

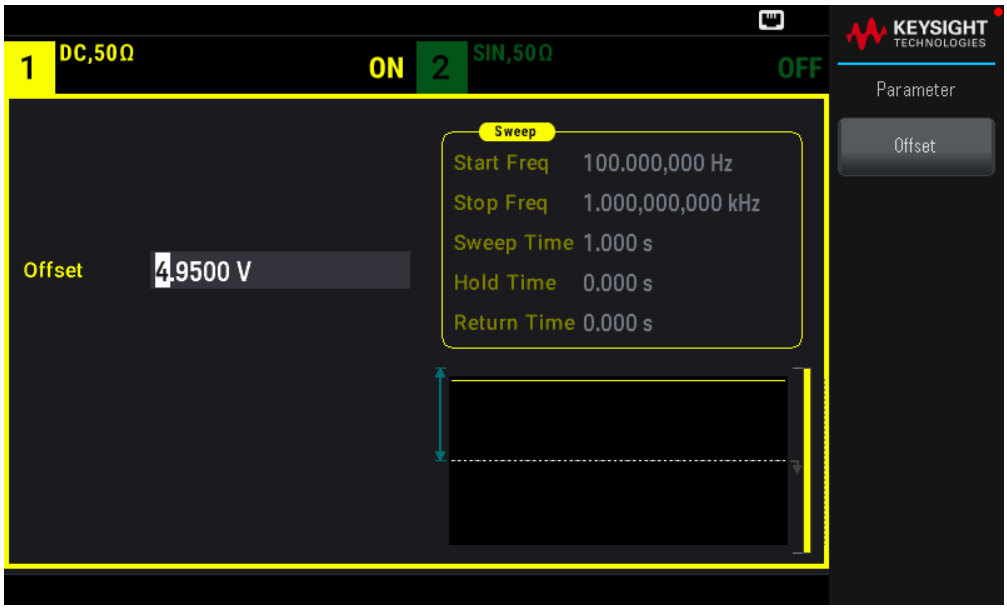
For example, to specify a DC signal:

1. Press [Waveform] > MORE 1 / 2 > DC > Offset.

Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a unit prefix to finish.



2. Press Channel [On/Off] to produce the DC output.



SCPI Command

```
[SOURce[1|2]:]FUNCtion <function>
```

The APPLy command configures a waveform with one command.

Output Frequency

The output frequency range depends on the function, model, and output voltage, as shown here. The default frequency is 1 kHz for all functions, and the minimum frequencies are shown in the table below.

Function	Minimum Frequency
Sine	1 µHz
Square	1 µHz
Ramp/Triangle	1 µHz
Pulse	1 µHz
PRBS	1 mbps
Arbitrary	1 µSa/s

– Frequency limitations: Changing functions may change the frequency to meet the new function's frequency limits. Arbitrary waveforms retain their last frequency setting.

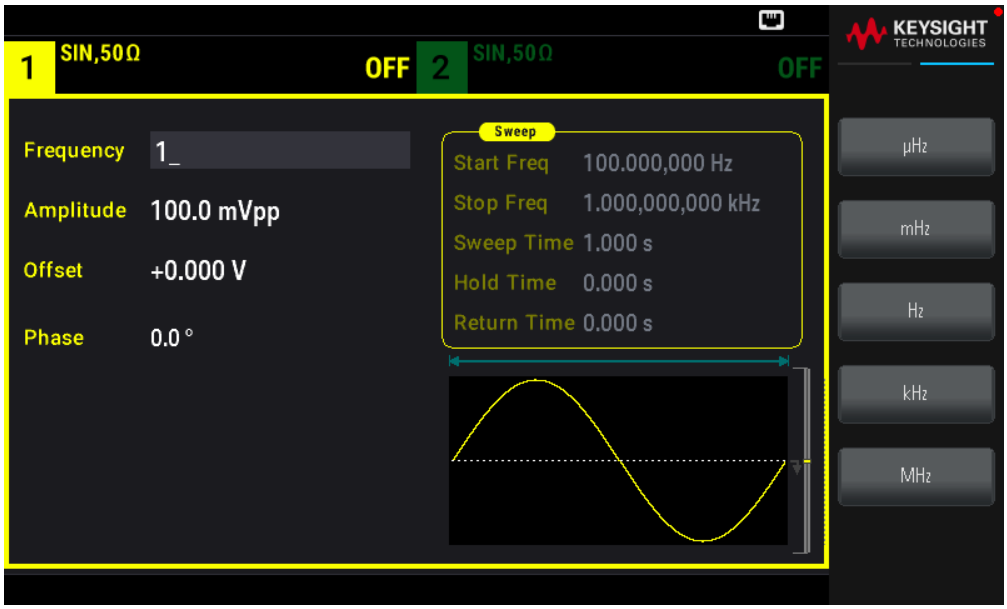
– Burst limitation: For internally-triggered bursts, the minimum frequency is 126 µHz.

– Duty cycle limitations: For Square and Pulse, the Duty Cycle is limited by the 16-ns minimum pulse width specification. For example, at 1 kHz, Duty Cycle may be set as low as 0.01%, because that would result in a pulse width of 100 ns. At 1 MHz, the minimum Duty Cycle is 1.6%, and at 10 MHz it is 16%. Changing to a frequency that cannot produce the current duty cycle will adjust the duty cycle to meet the minimum pulse width specification.

The minimum pulse width is 16 ns.

Front Panel Operations

Press [Parameter] > Frequency. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a unit prefix to finish.



SCPI Command

```
[SOURce[1|2]:]FREQuency {<frequency>|MINimum|MAXimum|DEFault}
```

The APPLy command configures a waveform with one command.

Output Amplitude

The default amplitude is 100 mVpp (into 50 Ω) for all functions.

– Offset voltage limitations: The relationship between amplitude and offset is shown below. Vmax is ±5 V for a 50 Ω load or ±10 V for a high-impedance load.

$$Vpp < 2(Vmax - |Voffset|)$$

– Limits due to output termination: If the amplitude is 10 Vpp and you change the output termination setting from 50 Ω to "high impedance" (OUTPut[1|2]:LOAD INF), the displayed amplitude doubles to 20 Vpp. Changing from "high impedance" to 50 Ω halves the displayed amplitude. The output termination setting does not affect the actual output voltage; it only changes the values displayed and queried from the remote interface. Actual output voltage depends on the connected load.

– Limits due to units selection: Amplitude limits are sometimes determined by the output units selected. This may occur when the units are Vrms or dBm due to the differences in various functions' crest factors. For example, if you change a 5 Vrms square wave (into 50 Ω) to a sine wave, the instrument will adjust the amplitude to 3.536 Vrms (the upper limit for sine in Vrms). The remote interface will also generate a "Settings conflict" error.

– You can set the output amplitude in Vpp, Vrms, or dBm. You cannot specify output amplitude in dBm if output termination is set to high impedance. See Output Units for details.

– Arbitrary waveform limitations: For arbitrary waveforms, amplitude is limited if the waveform data points do not span the full range of the output DAC (Digital-to-Analog Converter). For example, the built-in "Sinc" waveform does not use the full range of values, so its maximum amplitude is limited to 6.087 Vpp (into 50 Ω).

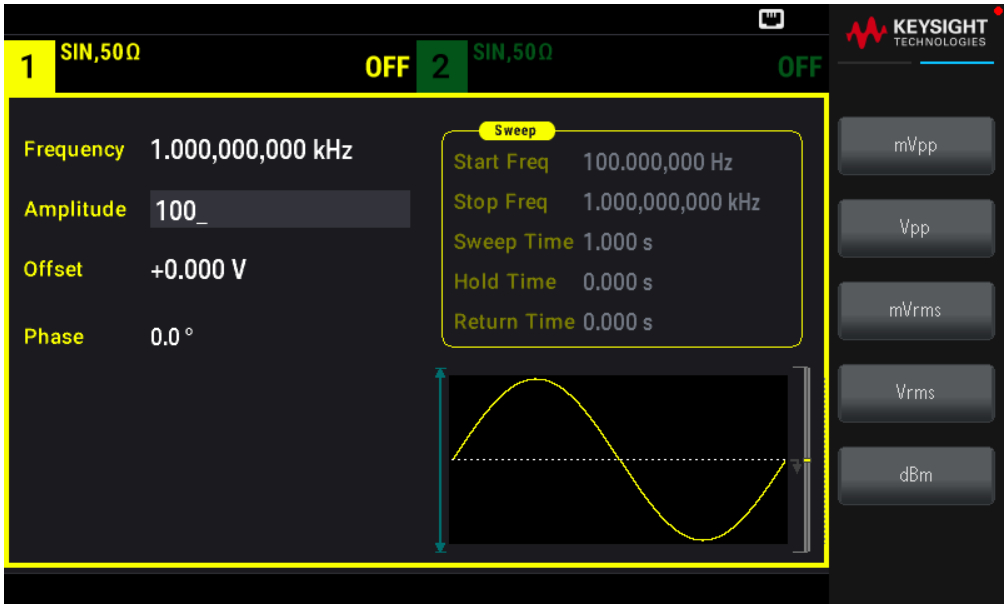
– Changing amplitude may briefly disrupt output at certain voltages due to output attenuator switching. The amplitude is controlled, however, so the output voltage will never exceed the current setting while switching ranges. To prevent this disruption, disable voltage autoranging using VOLTage:RANGe:AUTOOFF. The APPLy command automatically enables autoranging.

– Setting the high and low levels also sets the waveform amplitude and offset. For example, if you set the high level to +2 V and the low level to -3 V, the resulting amplitude is 5 Vpp, with a -500 mV offset.

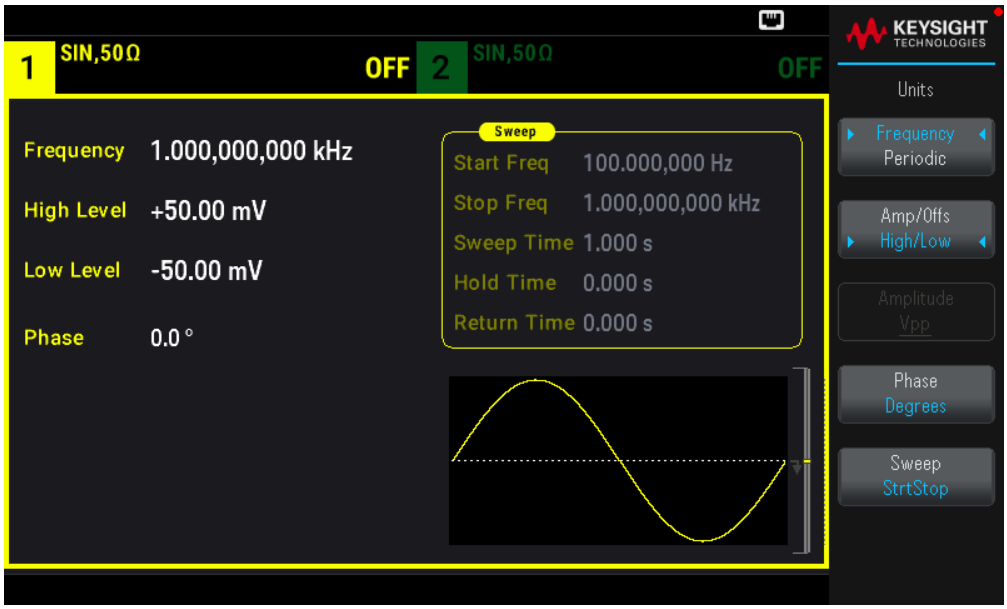
– ADC signal's output level is controlled by the offset voltage (DC Offset Voltage). The DC level may be between ±5 V into a 50 Ω load or ±10 V with a high-impedance load.

Front Panel Operations

Press [Parameter] > Amplitude. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a unit prefix to finish.



To use a high level and low level instead: Press [Units] > Ampl/Offs | High/Low.



SCPI Command

```
[SOURce[1|2]:]VOLTage {<amplitude>|MINimum|MAXimum|DEFault}

[SOURce[1|2]:]VOLTage:HIGH {<voltage>|MINimum|MAXimum|DEFault}

[SOURce[1|2]:]VOLTage:LOW {<voltage>|MINimum|MAXimum|DEFault}
```

The APPLy command configures a waveform with one command.

DC Offset Voltage

The default offset is 0 V for all functions.

– Limits Due to Amplitude: The relationship between offset voltage and output amplitude is shown below. The peak output voltage (DC plus AC) cannot exceed the instrument output rating (±5 V into 50 Ω load, or ±10 V into an open circuit).

– The relationship between offset voltage and output amplitude is shown below. Vmax is the maximum peak voltage for the selected output termination (5 V for a 50 Ω load or 10 V for a high-impedance load).

$$|Voffset| < Vmax - Vpp/2$$

If the specified offset voltage is not valid, the instrument will adjust it to the maximum DC voltage allowed with the specified amplitude. From the remote interface, a "Data out of range" error will also be generated.

– Limits Due to Output Termination: The offset range depends on the output termination setting. For example, if you set offset to 100 mVDC and then change output termination from 50 Ω to "high impedance," the offset voltage displayed on the front panel doubles to 200 mVDC (no error is generated). If you change from "high impedance" to 50 Ω, the displayed offset voltage will be halved. Changing the output termination setting does not change the voltage present at the output terminals of the instrument. This only changes the displayed values on the front panel and the values queried from the remote interface. The voltage present at the instrument's output depends on the load connected to the instrument. See "OUTPut[1|2]:LOAD" in the *EDU33210 Series Programming Guide* for details.

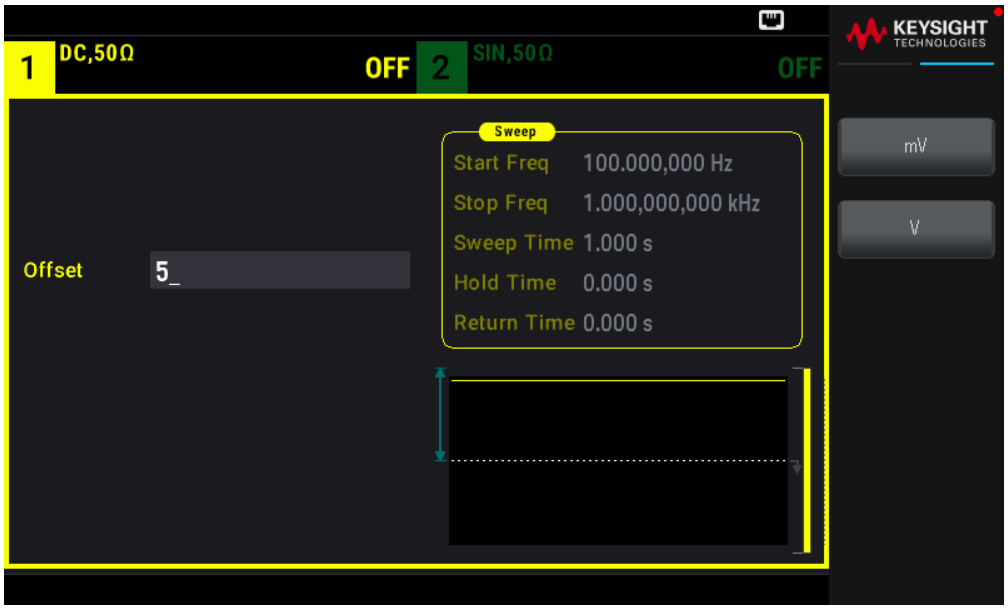
– Arbitrary waveform limitations: For arbitrary waveforms, amplitude is limited if the waveform data points do not span the full range of the output DAC (Digital-to-Analog Converter). For example, the built-in "Sinc" waveform does not use the full range of values, so its maximum amplitude is limited to 6.087 Vpp (into 50 Ω).

– Setting the high and low levels also sets the waveform amplitude and offset. For example, if you set the high level to +2 V and the low level to -3 V, the resulting amplitude is 5 Vpp, with a -500 mV offset.

– To output a DC voltage level, select the DC voltage function (FUNCtion DC) and then set the offset voltage (VOLTage:OFFSet). Valid values are between ±5 VDC into 50 Ω or ±10 VDC into an open circuit. While the instrument is in DC mode, setting amplitude has no effect.

Front Panel Operations

Press [Waveform] > MORE 1/2 > DC > Offset. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a unit prefix to finish.



SCPI Command

```
[SOURce[1|2]:]VOLTage:OFFSet {<offset>|MINimum|MAXimum|DEFault}
[SOURce[1|2]:]VOLTage:HIGH {<voltage>|MINimum|MAXimum|DEFault}
[SOURce[1|2]:]VOLTage:LOW {<voltage>|MINimum|MAXimum|DEFault}
```

The APPLy command configures a waveform with one command.

Output Units

Applies to output amplitude only.

– Output units: Vpp (default), Vrms, or dBm.

– Setting is volatile.

– Units selection applies to front panel and remote interface operations. For example, if you select "VRMS" remotely, the units are displayed as "VRMS" on the front panel.

– Amplitude units cannot be dBm if output termination set to high impedance. Calculating dBm requires finite load impedance. In this case, units are converted to Vpp.

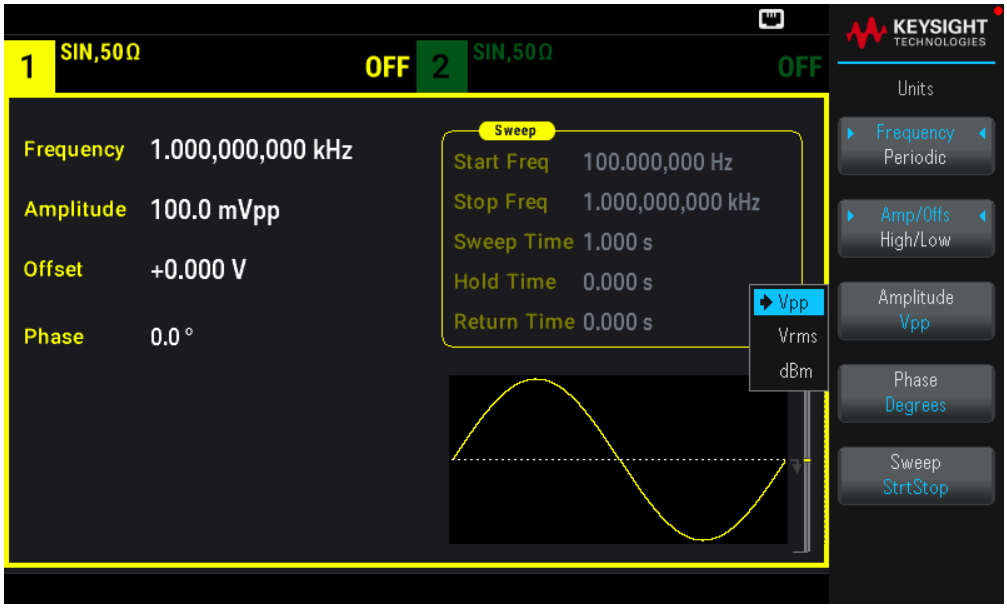
– You can convert between units. For example, to convert 2 Vpp to Vrms equivalent:

Press [Units] > Amplitude Vpp > Amplitude Vrms.

The converted value is 707.1 mVrms for a sinewave.

Front Panel Operations

Press [Units] > Amplitude.



SCPI Command

```
[SOURce[1|2]:]VOLTage:UNIT {VPP|VRMS|DBM}
```

Output Termination

The instrument has a fixed series output impedance of 50 Ω to the front panel channel connectors. If the actual load impedance differs from the value specified, the displayed amplitude and offset levels will be incorrect. The load impedance setting is simply a convenience to ensure that the displayed voltage matches the expected load.

– Output termination: 1 Ω to 10 kΩ, or infinite. The default is 50 Ω.

– If you specify a 50 Ω termination but actually terminate into an open circuit, the output will be twice the value specified. For example, if you set the DC offset to 100 mVDC(and specify a 50 Ω load) but terminate into an open circuit, the actual offset will be 200 mVDC.

– Changing output termination setting, adjusts displayed output amplitude and offset (no error is generated). If the amplitude is 10 Vpp and you change the output termination setting from 50 Ω to "high impedance" (OUTPut

[1|2]:LOAD INF), the displayed amplitude doubles to 20 Vpp. Changing from "high impedance" to 50 Ω halves the displayed amplitude. The output termination setting does not affect the actual output voltage; it only changes the values displayed and queried from the remote interface. Actual output voltage depends on the connected load.

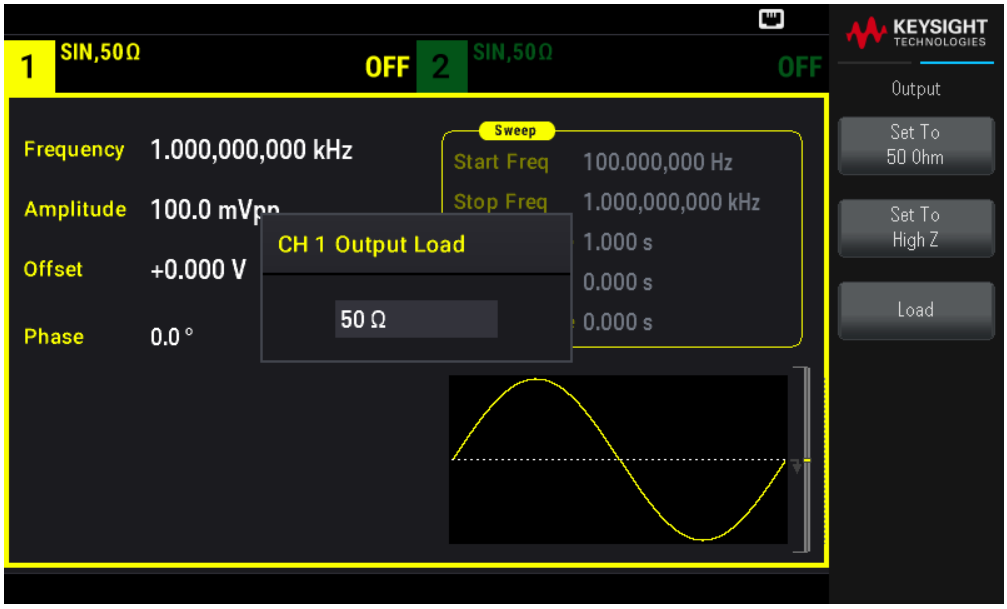
NOTE **The output load can affect signal quality for pulse or other functions with high-speed transitions. High load resistance can produce reflections.**

– Units are converted to Vpp if output termination is high impedance.

– You cannot change output termination with voltage limits enabled, because instrument cannot know which termination setting the limits apply to. Instead, disable voltage limits, set the new termination value, adjust voltage limits, and re-enable voltage limits.

Front Panel Operations

Press Channel [Setup] > Output > Load.



SCPI Command

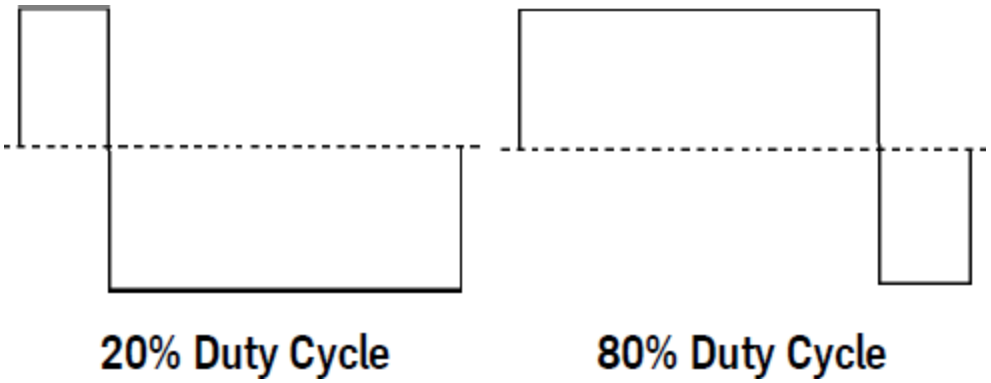
```
OUTPut[1|2]:LOAD {<ohms>|INFinity|MINimum|MAXimum|DEFault}
```

Duty Cycle (Square Waves)

A square wave's duty cycle is the fraction of time per cycle that the waveform is at a high level (assuming the waveform is not inverted). (See Pulse Waveforms for pulse duty cycle details.)

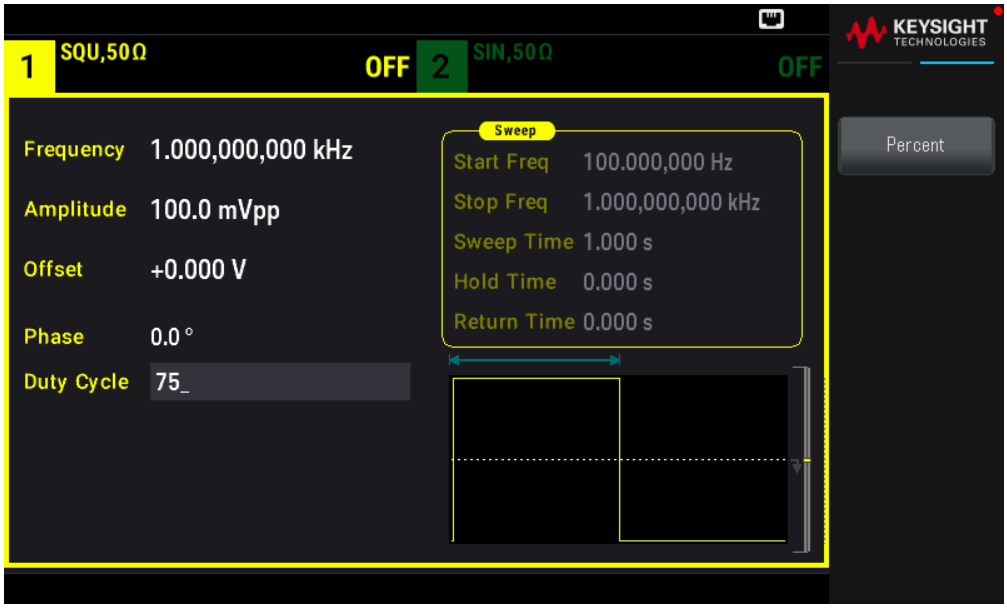
– Duty Cycle: 0.01% to 99.99% at low frequencies; range reduced at higher frequency. Stored in volatile memory; default 50%.

– This setting is remembered when you change to another function. A 50% duty cycle is always used for a modulating square waveform; the duty cycle setting applies only to a square wave carrier.



Front Panel Operations

Press [Waveform] > Square > Duty Cycle. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, press Percent to confirm your changes.



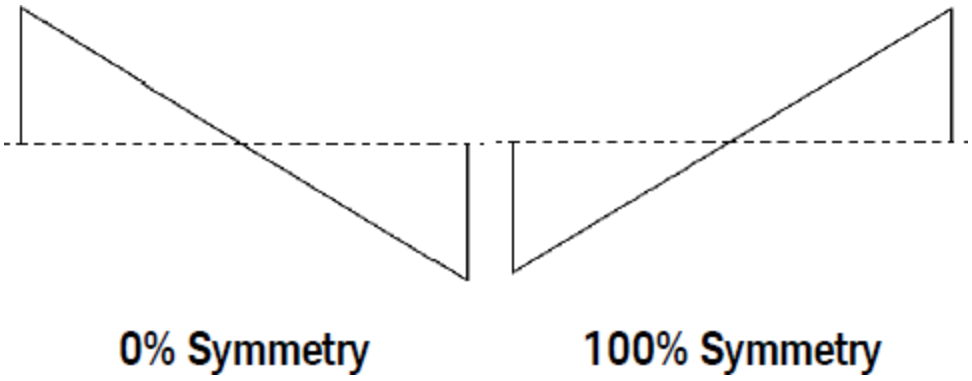
SCPI Command

```
[SOURce[1|2]:]FUNCtion:SQUare:DCYCle {<percent>|MINimum|MAXimum}
```

The APPLy command sets the duty cycle to 50%.

Symmetry (Ramp Waves)

Applies to ramp waves only. Symmetry represents the fraction of each cycle that the ramp wave is rising (assuming waveform is not inverted).

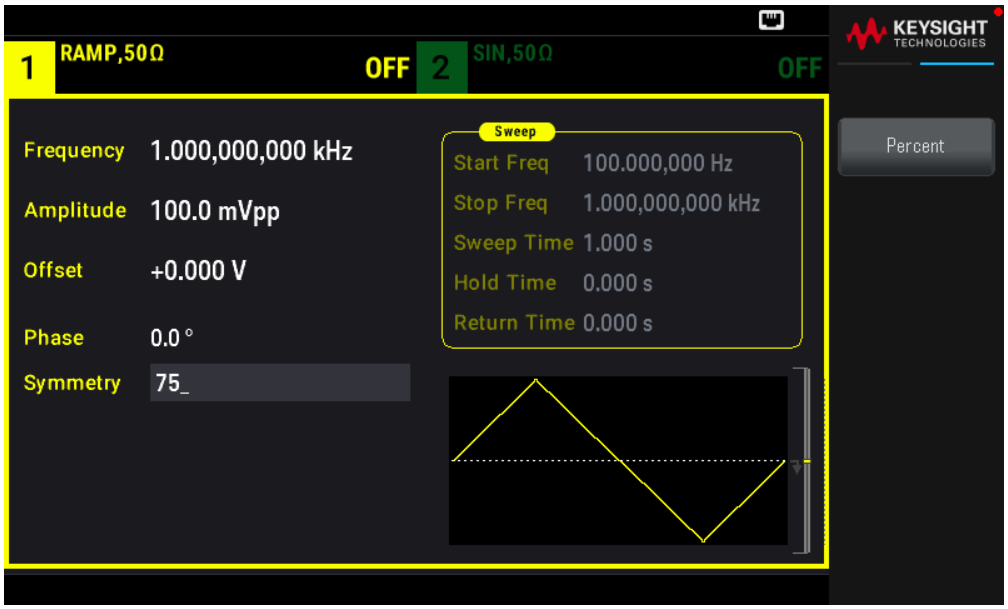


– The symmetry (default) is stored in volatile memory; and is remembered when you change to and from other waveforms.

– When ramp is the modulating waveform for AM, FM, PM, or PWM, the symmetry setting does not apply.

Front Panel Operations

Press [Waveform] > Ramp > Symmetry. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, press Percent to confirm your changes.



SCPI Command

`[SOURce[1|2]:]FUNCtion:RAMP:SYMMetry {<percent>|MINimum|MAXimum|DEFault}`

The APPLy command sets the symmetry to 100%.

Voltage Autoranging

Autoranging is enabled by default and the instrument selects optimal attenuator settings. With autoranging disabled, the instrument uses the current attenuator settings and does not switch attenuator relays.

– You can disable autoranging to eliminate momentary disruptions caused by attenuator switching while changing amplitude. However:

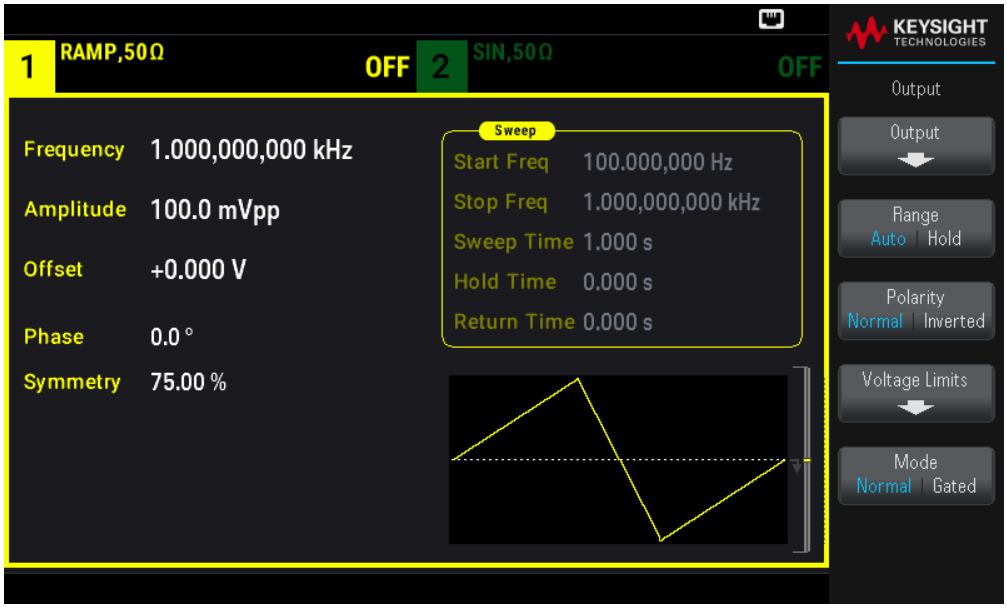
– The amplitude and offset accuracy and resolution (and waveform fidelity)may be adversely affected when reducing the amplitude below a range change that would occur with autoranging on.

– You may not achieve minimum amplitude with autoranging on.

– Some instrument specifications do not apply with autoranging off.

Front Panel Operations

Press Channel [Setup] > Range Auto | Hold or Range Auto | Hold.



SCPI Command

```
[SOURce[1|2]:]VOLTage:RANGe:AUTO {OFF|0|ON|1|ONCE}
```

The APPLy command always enables autoranging.

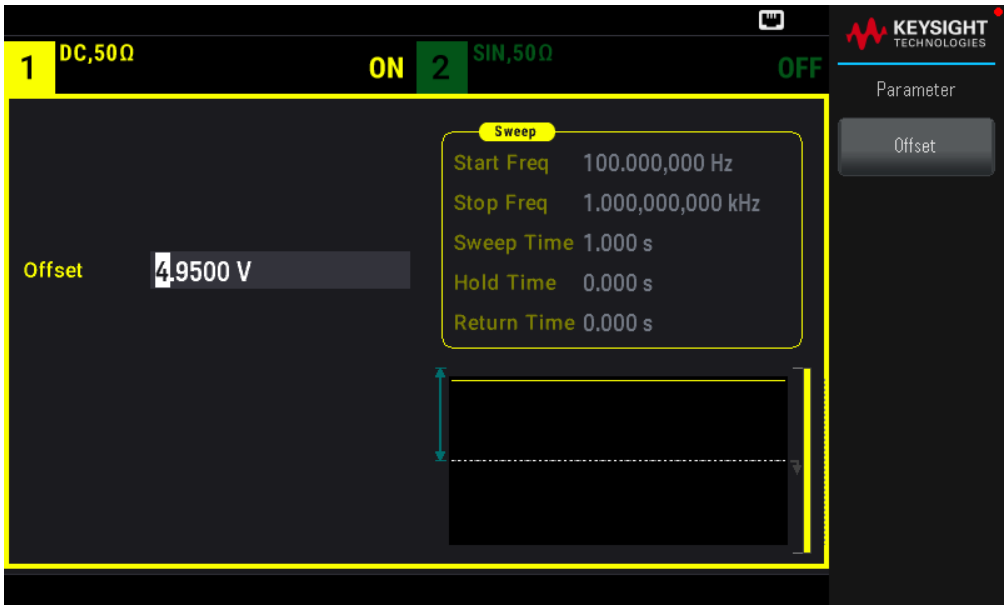
Output Control

By default, channel output is disabled at power on to protect other equipment. To enable a channel's output, see below. When channel output is enabled, the corresponding channel button is lit.

If an external circuit applies excessive voltage to a channel output connector, the instrument generates an error message and disables the output. To re-enable output, remove the overload and turn the channel on again.

Front Panel Operations

Press Channel [On/Off].



SCPI Command

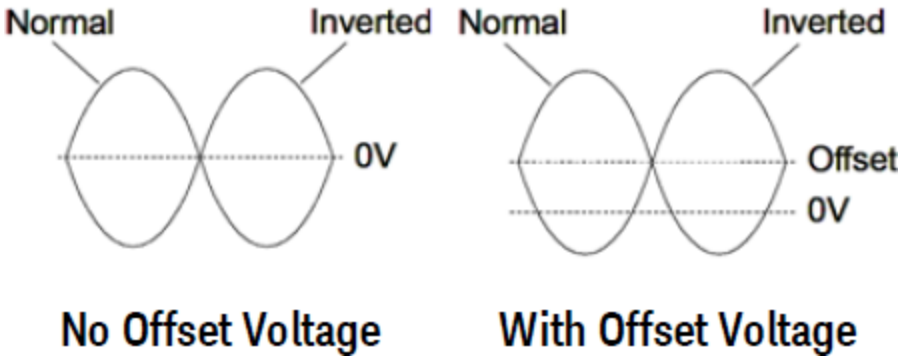
```
OUTPut[1|2] {ON|1|OFF|0}
```

The APPLy command always enables the channel output connector.

Waveform Polarity

In normal mode (default), the waveform goes positive at the beginning of the cycle. Inverted mode does the opposite.

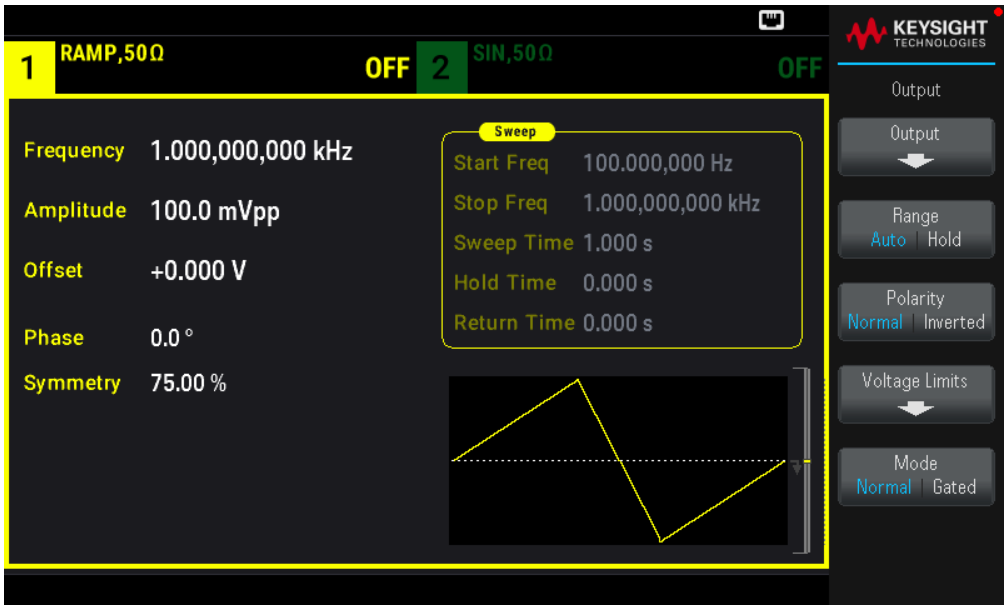
– As shown below, the waveform is inverted relative to the offset voltage. The offset voltage remains unchanged when the waveform is inverted.



– The Sync signal associated with an inverted waveform is not inverted.

Front Panel Operations

Press [Setup] > Polarity Normal | Inverted or Polarity Normal | Inverted.



SCPI Command

```
OUTPut[1|2]:POLarity {NORMal|INVerted}
```

Sync Output Signal

A sync output is provided on the front panel Sync connector. All of the standard output functions (except DC and noise) have an associated Sync signal. For applications where you may not want to output the Sync signal, you can disable the Sync connector. The Sync signal may be derived from either output channel in a two-channel instrument.

General Behavior

– By default, the Sync signal is derived from channel 1 and is routed to the Sync connector (enabled).

– When the Sync signal is disabled, the output level on the Sync connector is at a logic "low."

– The polarity of the Sync signal is specified by OUTPut:SYNC:POLarity {INVerted|NORMal}.

– Inverting a waveform (see Waveform Polarity), does not invert the associated Sync signal .

– For sine, pulse, ramp, square, and triangle waves, the Sync signal is a square wave that is "high" in the first half of the cycle and "low" in the last half. The Sync signal's voltages are TTL-compatible when its load impedance exceeds 1 kΩ.

– For arbitrary waveforms, the Sync signal rises at the beginning of the waveform and falls at the middle of the arbitrary waveform. You can override this default behavior by using MARKer:POINt to specify the point within the arbitrary waveform at which the Sync signal transitions to "low."

Modulation

– For internally-modulated AM, FM, PM, and PWM, the Sync signal is normally referenced to the modulating waveform (not the carrier) and is a square waveform with a 50% duty cycle. The Sync signal is a TTL "high" during the

first half of the modulating waveform. You can set up the Sync signal to follow the carrier waveform by using the command OUTPut:SYNC:MODE {CARRier|NORMal|MARKer} when modulating with internal modulation.

– You can override normal sync behavior to force Sync to always follow the carrier waveform (OUTPut [1|2]:SYNC:MODE CARRier).

– For FSK, the Sync signal is referenced to the FSK rate. The Sync signal is a TTL "high" on the transition to the "hop" frequency.

Sweep

– The Sync signal is a TTL "high" at the beginning of the sweep and goes "low" at the sweep's midpoint. The Sync signal is synchronized with the sweep, but is not equal to the sweep time because its timing includes the re-arm time.

– For frequency sweeps with Marker On, the Sync signal is a TTL "high" at the beginning of the sweep and a "low" at the marker frequency. You can change this with OUTPut[1|2]:SYNC:MODE MARKER.

Burst

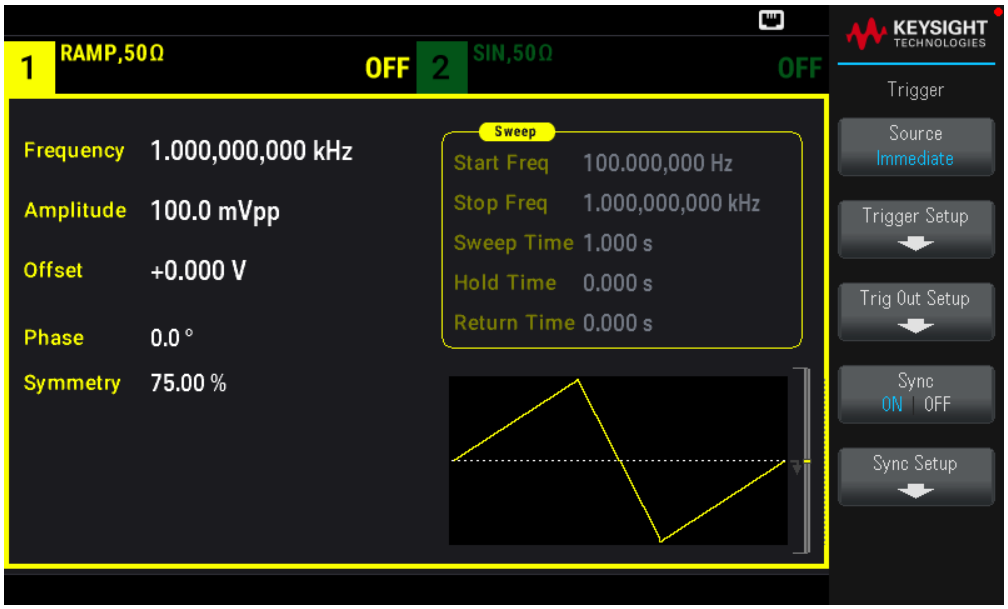
– For a triggered burst, the Sync signal is a TTL "high" when the burst begins. The Sync signal is a TTL "low" at the end of the specified number of cycles (may not be the zero-crossing point if the waveform has an associated start phase). For an infinite count burst, the Sync signal is the same as for a continuous waveform.

– For an externally-gated burst, the Sync signal follows the external gate signal. However, the signal will not go "low" until the end of the last cycle (may not be a zero-crossing if the waveform has an associated start phase).

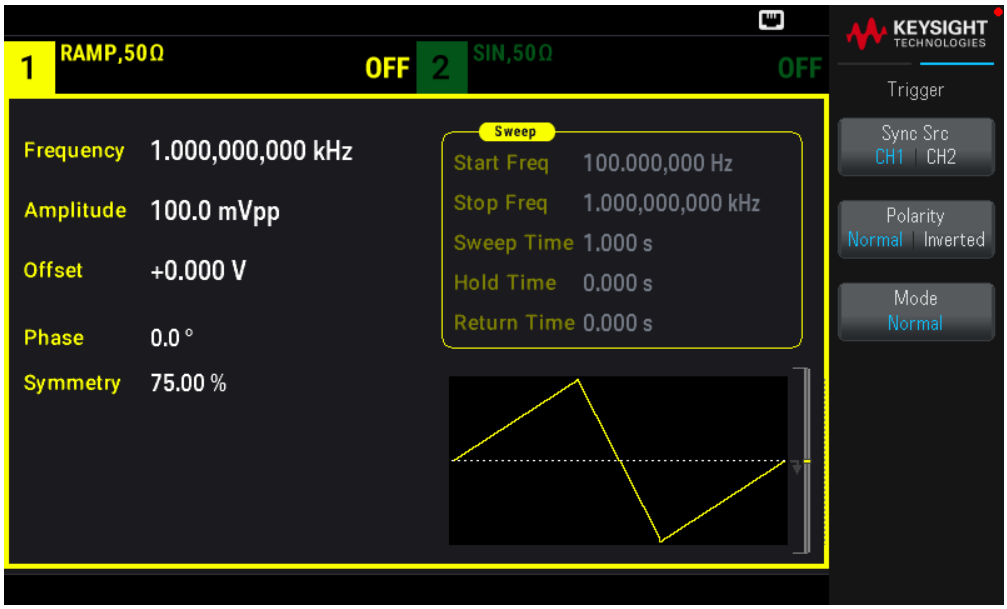
Configuring Sync Output

Front Panel Operations

To toggle Sync off and on: Press [Trigger] > Sync ON | OFF or Sync ON | OFF.



To configure Sync: Press [Trigger] > Sync Setup.

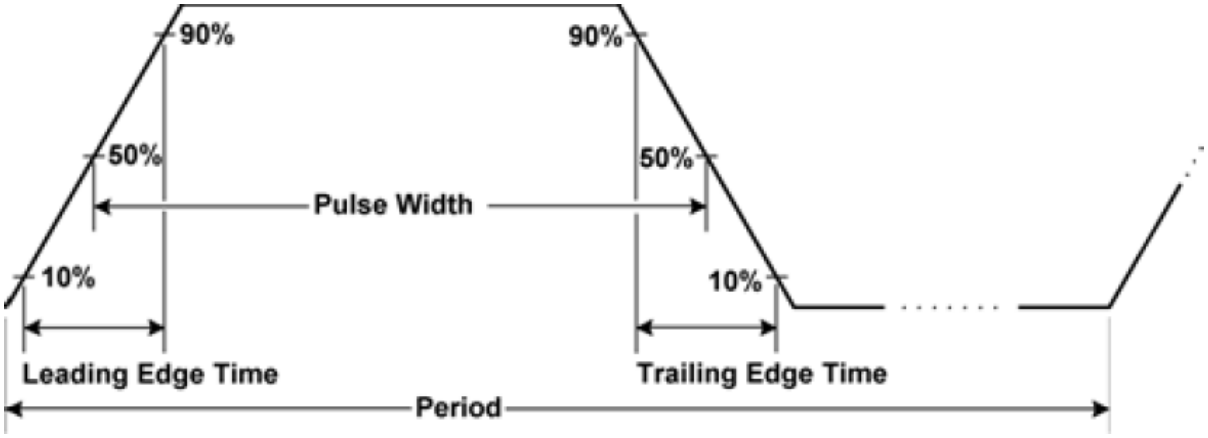


SCPI Command

```
OUTPut:SYNC {ON|1|OFF|0}

OUTPut[1|2]:SYNC:MODE {NORMal|CARRier|MARKer}

OUTPut[1|2]:SYNC:POLarity {NORMal|INVerted}

OUTPut:SYNC:SOURce {CH1|CH2}
```

Pulse Waveforms

As shown below, a pulse or square wave consists of a period, a pulse width, a rising edge, and a falling edge.



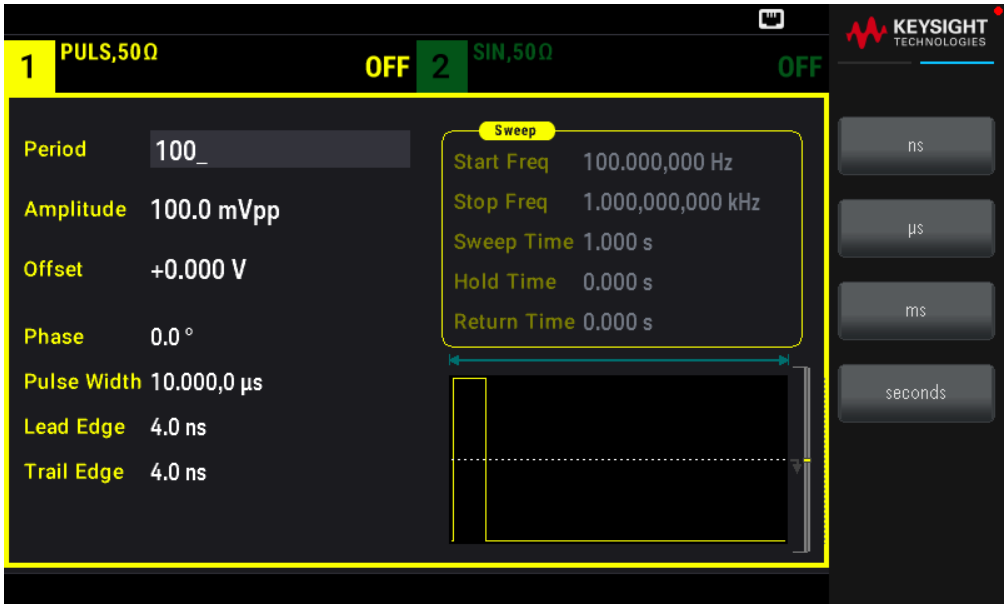
Period

– Period: reciprocal of maximum frequency to 1,000,000 s. The default is 1 ms.

– The instrument adjusts the pulse width and edge time as needed to accommodate the specified period.

Front Panel Operations

1. Select Pulse waveform: Press [Waveform] > Pulse.
2. Select period instead of frequency: Press [Units] > Frequency Periodic > Frequency Periodic.
3. Set the period: Press [Parameter] > Period. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a unit prefix to finish.



SCPI Command

```
[SOURce[1|2]:]FUNCtion:PULSe:PERiod {<seconds>|MINimum|MAXimum|DEFault}
```

Pulse Width

Pulse width is the time from the 50% threshold of a pulse's rising edge to the 50% threshold of the next falling edge.

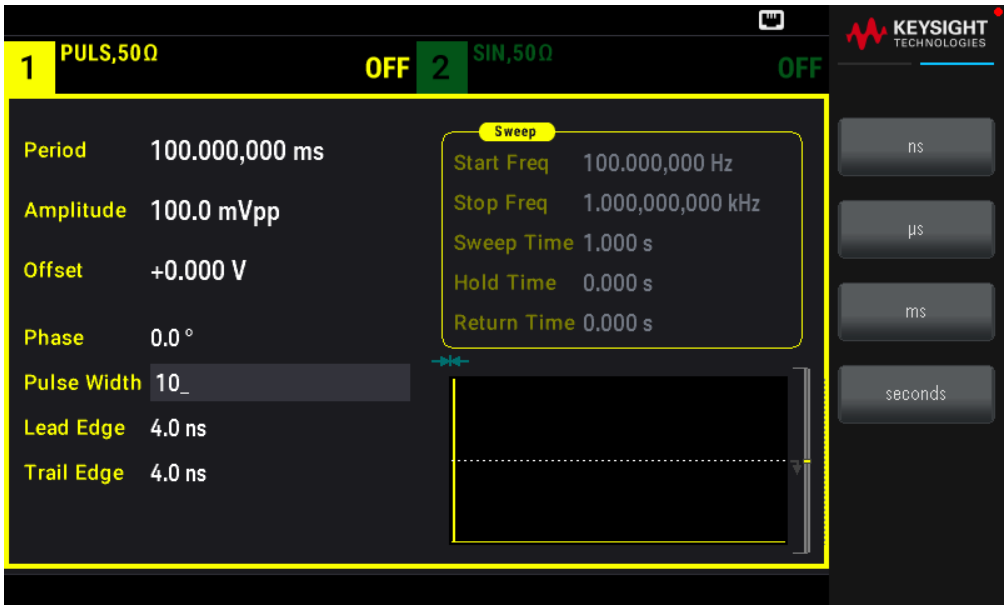
– Pulse width: up to 1,000,000 s (see restrictions below). The default pulse width is 100 µs. The minimum pulse width is 16 ns.

– The specified pulse width must also be less than the difference between the period and the minimum pulse width.

– The instrument will adjust the pulse width to accommodate the specified period.

Front Panel Operations

Press [Waveform] > Pulse > Pulse Width. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a unit prefix to finish.



SCPI Command

```
[SOURce[1|2]:]FUNCtion:PULSe:WIDTh {<seconds>|MINimum|MAXimum|DEFault}
```

Pulse Duty Cycle

The pulse duty cycle is defined as follows:

Duty Cycle = 100 (Pulse Width)/Period

Pulse width is the time from the 50% threshold of a pulse's rising edge to the 50% threshold of the next falling edge.

– Pulse duty cycle: 0.01% to 99.99%(see restrictions below). The default is 10%.

– The pulse duty cycle must conform to the following restrictions determined by the minimum pulse width (Wmin).

The instrument will adjust the pulse duty cycle to accommodate the specified period.

Duty Cycle > 100 (Minimum Pulse Width) / Period

and

Duty Cycle < 100 (1 – (Minimum Pulse Width/ Period))

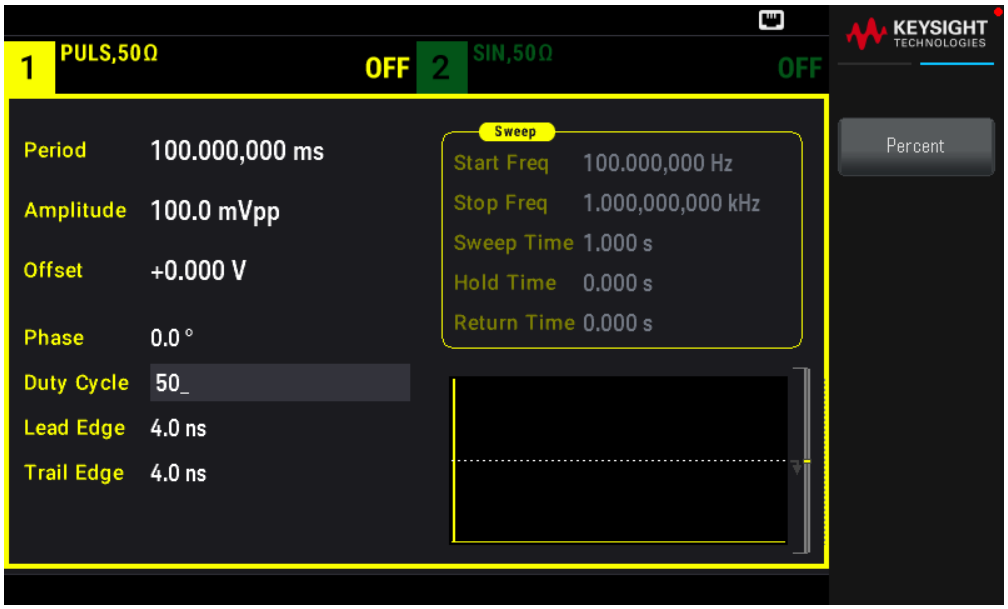
The minimum pulse width is 16 ns.

– The longer the edges, the greater the minimum pulse width. Longer edges will therefore restrict duty cycle more than shorter edges.

Front Panel Operations

1. Select Pulse function: Press [Waveform] > Pulse.
2. Toggle to Duty Cycle: Press [Units] > Width Duty Cyc > Width Duty Cyc.

3. Enter the Duty Cycle: Press [Parameter] > Duty Cycle. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, press Percent to finish.



SCPI Command

```
[SOURce[1|2]:]FUNCtion:PULSe:DCYCle {<percent>|MINimum|MAXimum|DEFault}
```

Edge Times

The edge times set the transition times for the leading and trailing edges of the pulse, either independently or together. The edge time represents the time between the 10% and 90% thresholds.

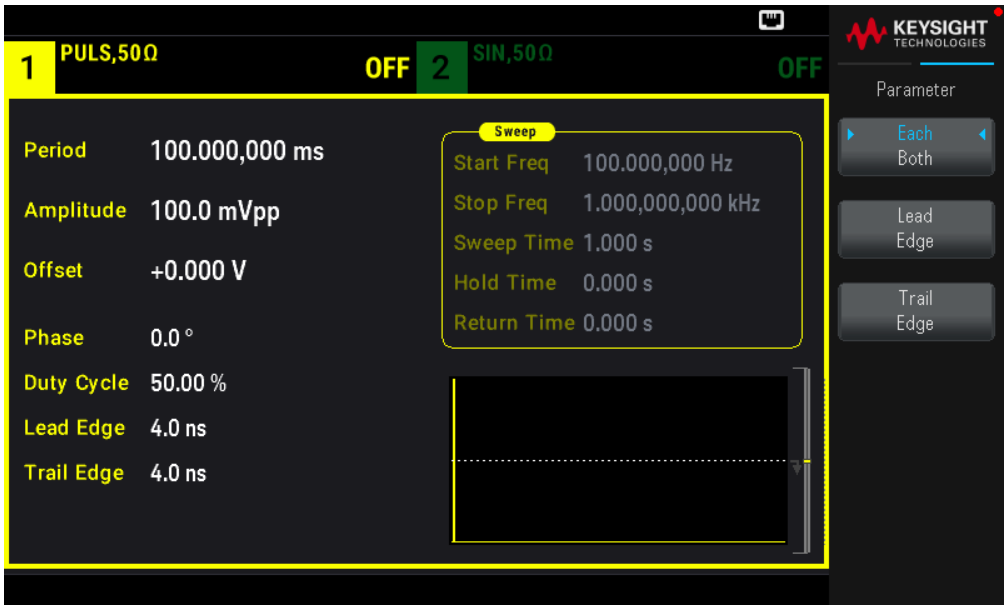
– Edge time: Minimum of 8.4 ns. Maximum of 1 µs and default 10 ns.

– The specified edge time must fit within the specified pulse width as shown above. The instrument will adjust the edge time to accommodate the specified pulse width.

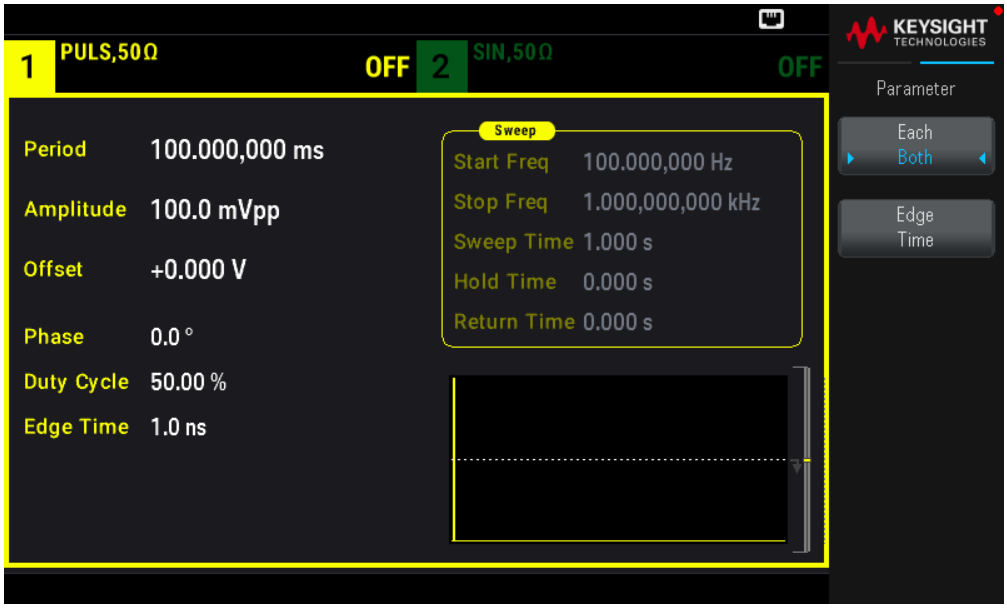
Front Panel Operations

1. To set the transition times for the edges of the pulse independently: Press [Waveform] > Pulse > Edge > Each Both.
2. Press Lead Edge to set the transition time for the leading edge of the pulse. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a unit prefix to finish.

3. Press Trail Edge to set the transition time for the trailing edge of the pulse. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a unit prefix to finish.



1. To set the transition times for the edges of the pulse together: Press [Waveform] > Pulse > Edge > Each Both.
2. Press Edge Time to set the transition times for both the leading and trailing edge of the pulse. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a unit prefix to finish.



SCPI Command

```
[SOURce[1|2]:]FUNCtion:PULSe:TRANsition:LEADing
{<seconds>|MINimum|MAXimum|DEFault}
```

```
[SOURce[1|2]:]FUNCtion:PULSe:TRANsition:TRAiling
{<seconds>|MINimum|MAXimum|DEFault}

[SOURce[1|2]:]FUNCtion:PULSe:TRANsition[:BOTH]
{<seconds>|MINimum|MAXimum|DEFault}
```

Amplitude Modulation (AM) and Frequency Modulation (FM)

A modulated waveform consists of a carrier waveform and a modulating waveform. In AM, the carrier amplitude is varied by the voltage level of the modulating waveform. In FM, the carrier frequency is varied by the voltage level of the modulating waveform. On a two-channel instrument, one channel can modulate the other.

Select AM or FM before setting up any other modulation parameter. For more information on modulation, see Modulation.

To Select AM or FM

– The instrument allows only one modulation mode to be enabled on a channel. When you enable AM or FM, all other modulations are off. On two-channel models, the two channels' modulations are independent from one another, and the instrument can add modulated waveforms from two channels. See PHASe:SYNChronize and COMBine:FEED in the *EDU33210 Series Programming Guide* for details.

– The instrument will not allow AM or FM to be enabled with sweep or burst. Enabling AM or FM, turns off sweep and burst.

– To avoid multiple waveform changes, enable modulation after configuring the other modulation parameters.

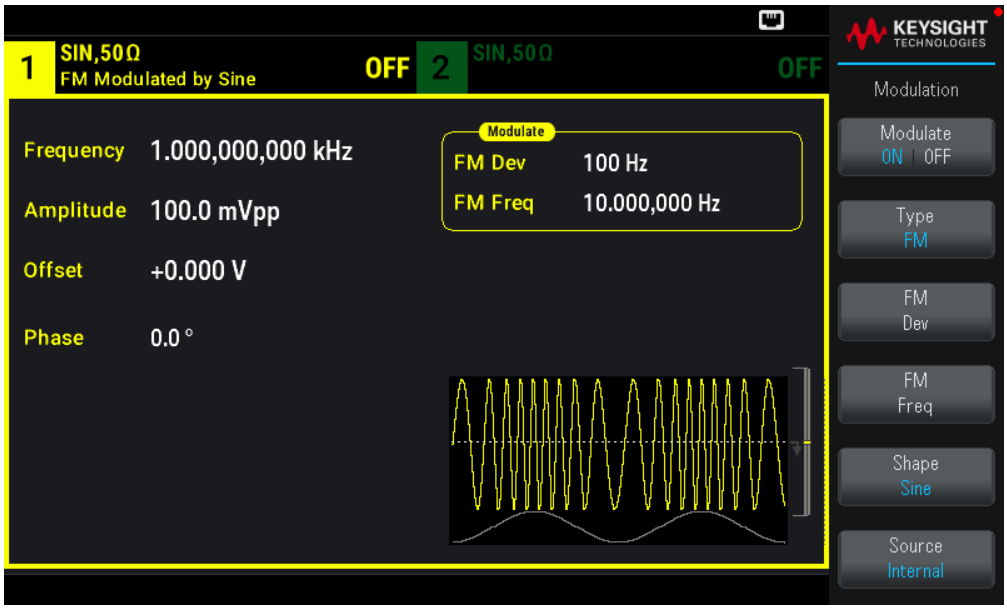
Front Panel Operations

Press [Modulate] > Type AM.

or

Press [Modulate] > Type AM > Type FM.

Then turn modulation on: Press [Modulate] > Modulate ON | OFF > Modulate ON | OFF.



The waveform is output using the present carrier and modulating waveform settings.

SCPI Command

```
[SOURce[1|2]:]AM:STATe{ON|1|OFF|0}
```

```
[SOURce[1|2]:]FM:STATe {ON|1|OFF|0}
```

Carrier Waveform Shape

– AM or FM carrier shape: Sine (default), Square, Ramp, Pulse, Triangle, Noise (AM only), PRBS, or Arbitrary waveform. You cannot use DC as the carrier waveform.

– For FM, the carrier frequency must always be greater than or equal to the frequency deviation. Attempting to set a deviation greater than the carrier frequency will cause the instrument to set the deviation equal to the carrier frequency.

– The carrier frequency plus the deviation cannot exceed the selected function's maximum frequency plus 100 kHz. If you attempt to set the deviation to an invalid value, the instrument adjusts it to the maximum value allowed with the present carrier frequency. The remote interface also generates a "Data out of range" error.

Front Panel Operations

Press [Waveform]. Then select a waveform shape.

SCPI Command

```
[SOURce[1|2]:]FUNCtion <function>
```

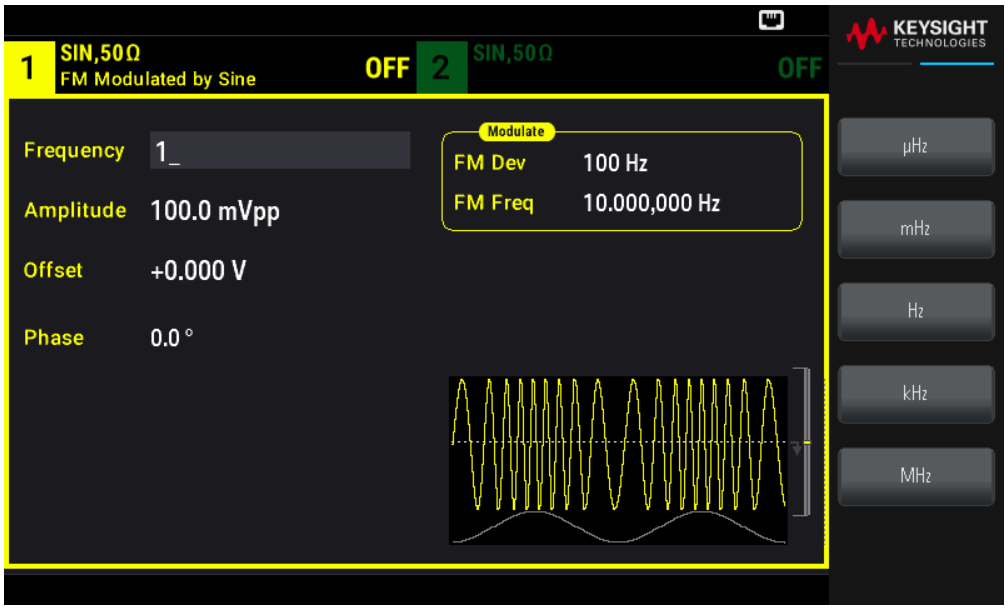
The APPLy command configures a waveform with one command.

Carrier Frequency

The maximum carrier frequency varies by function, model, and output voltage, as shown here. The default is 1 kHz for all functions other than arbitrary waveforms. Arbitrary waveform "frequency" is also set using the FUNCtion:ARBitrary:SRATe command.

Front Panel Operations

Press [Parameter] > Frequency. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a unit prefix to finish.



SCPI Command

```
[SOURce[1|2]:]FREQuency {<frequency>|MINimum|MAXimum|DEFault}
```

The APPLy command configures a waveform with one command.

Modulating Waveform Shape

On a two-channel instrument you can modulate one channel with the other.

You cannot modulate noise with noise, PRBS with PRBS, or an arbitrary waveform with an arbitrary waveform.

The modulating waveform shape (internal source) may be:

– Sine wave

– Square with 50% duty cycle

– Triangle with 50% symmetry

– UpRamp with 100% symmetry

– DnRamp with 0% symmetry

– Noise: White Gaussian noise

– PRBS: Pseudo Random Bit Sequence (polynomial PN7)

– Arb: Arbitrary waveform

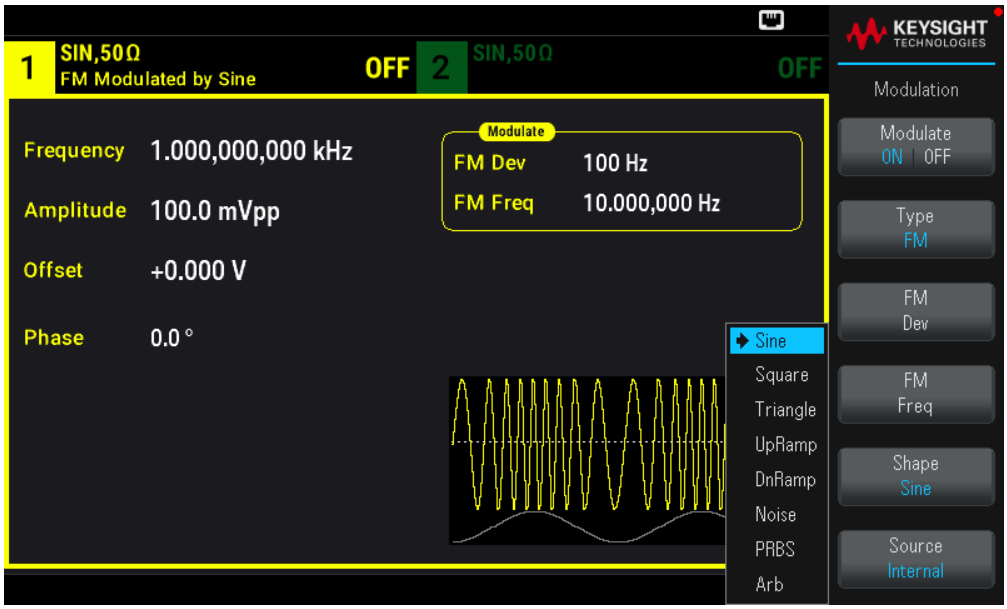
Front Panel Operations

Press [Modulate] > Type AM.

or

Press [Modulate] > Type AM > Type FM.

Then choose the modulating shape: Press Shape.



SCPI Command

```
[SOURce[1|2]:]AM:INTernal:FUNCtion <function>
[SOURce[1|2]:]FM:INTernal:FUNCtion <function>
```

Modulating Waveform Frequency

Modulating frequency (internal source): minimum is 1 µHz, and the maximum values vary by function.

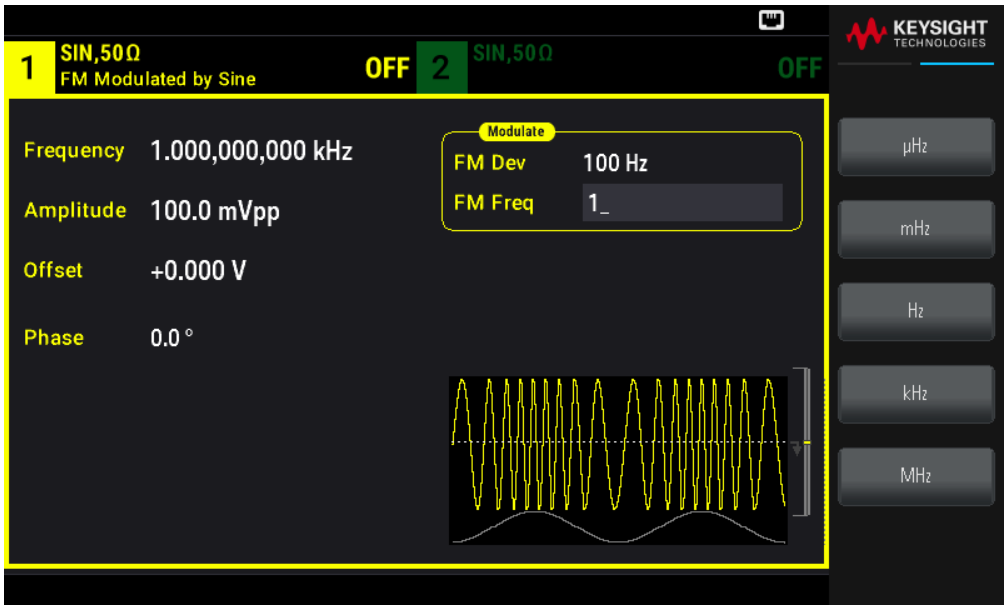
Front Panel Operations

Press [Modulate] > Type AM > AM Freq.

or

Press [Modulate] > Type AM > Type FM > FM Freq.

Then enter the AM or FM frequency with the knob and keypad. If you use the keypad, select a unit prefix to finish.



SCPI Command

```
[SOURce[1|2]:]AM:INTernal:FREQuency {<frequency>|MINimum|MAXimum|DEFault}
[SOURce[1|2]:]FM:INTernal:FREQuency {<frequency>|MINimum|MAXimum|DEFault}
```

Modulation Depth (AM)

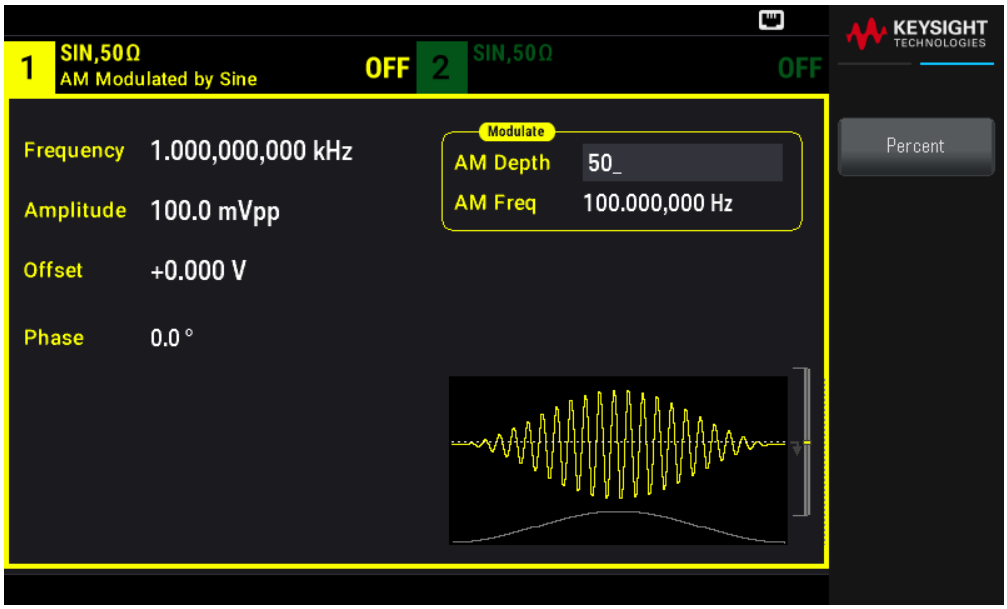
The modulation depth is a percentage that represents the amplitude variation. At 0% depth, the amplitude is one half of the carrier's amplitude setting. At 100% depth, the amplitude varies according to the modulating waveform, from 0% to 100% of the carrier's amplitude.

– Modulation depth: 0% to 120%. The default is 100%.

– Even at greater than 100% depth, the instrument will not exceed ±5 Vpeak on the output (into a 50 Ω load). To achieve modulation depth greater than 100%, output carrier amplitude may be reduced.

Front Panel Operations

Press [Modulate] > Type AM > AM Depth. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, press Percent to finish.



SCPI Command

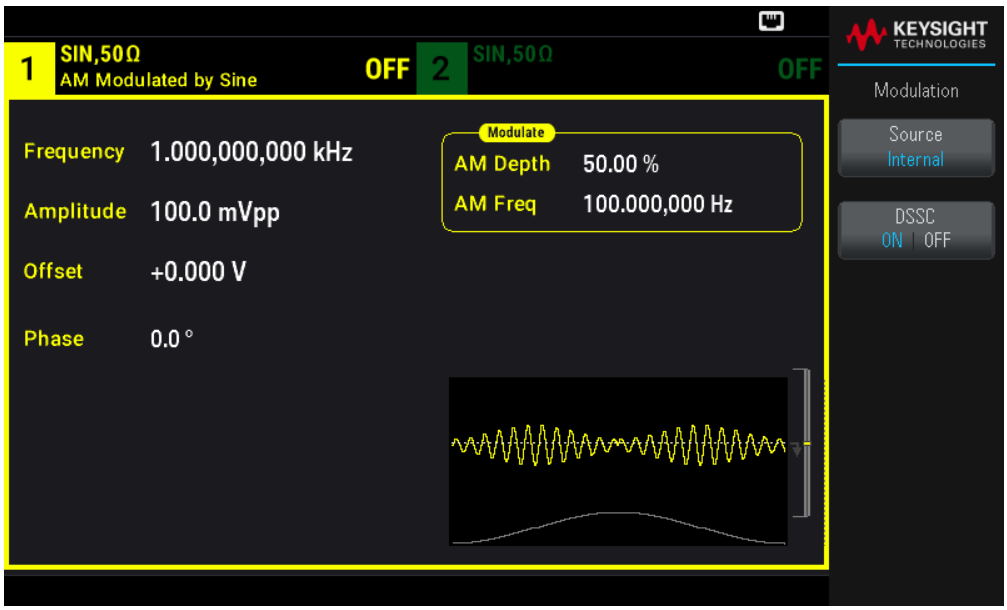
```
[SOURce[1|2]:]AM[:DEPTh] {<depth_in_percent>|MINimum|MAXimum}
```

Double Sideband Suppressed Carrier AM

The instrument supports two forms of amplitude modulation, "Normal" and Double Sideband Suppressed Carrier (DSSC). In DSSC, the carrier is not present unless the modulating signal has an amplitude greater than zero.

Front Panel Operations

Press [Modulate] > Type AM > MORE 1 / 2 > DSCC ON | OFF > DSCC ON | OFF.



SCPI Command

```
[SOURce[1|2]:]AM:DSSC{ON|1|OFF|0}
```

Frequency Deviation (FM)

The frequency deviation setting represents the peak variation in frequency of the modulated waveform from the carrier frequency.

When the carrier is PRBS, frequency deviation causes a change in the bit rate equal to one-half of the set frequency. For example, a 10 kHz deviation is equivalent to a 5 KBPS change in bit rate.

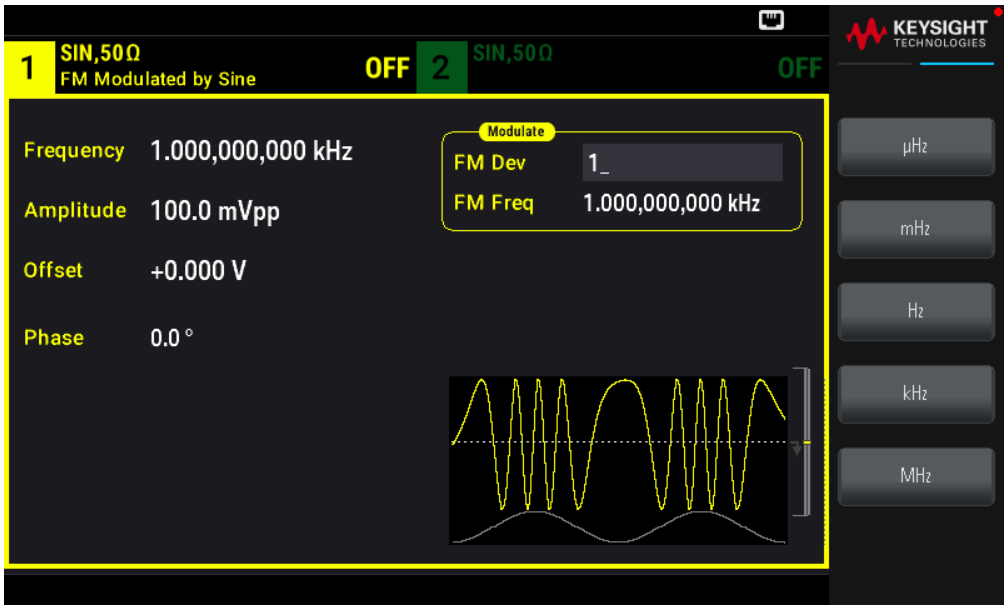
– Frequency deviation: 1 µHz to (carrier frequency) / 2, default 100 Hz.

– For FM, the carrier frequency must always be greater than or equal to the frequency deviation. Attempting to set a deviation greater than the carrier frequency will cause the instrument to set the deviation equal to the carrier frequency.

– The carrier frequency plus the deviation cannot exceed the selected function's maximum frequency plus 100 kHz. If you attempt to set the deviation to an invalid value, the instrument adjusts it to the maximum value allowed with the present carrier frequency. The remote interface also generates a "Data out of range" error.

Front Panel Operations

Press [Modulate] > Type AM > Type FM > Freq Dev. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.



SCPI Command

```
[SOURce[1|2]:]FM[:DEViation] {<peak_deviation_in_Hz>|MINimum|MAXimum|DEFault}
```

Modulating Source

On a two-channel instrument you can modulate one channel with the other.

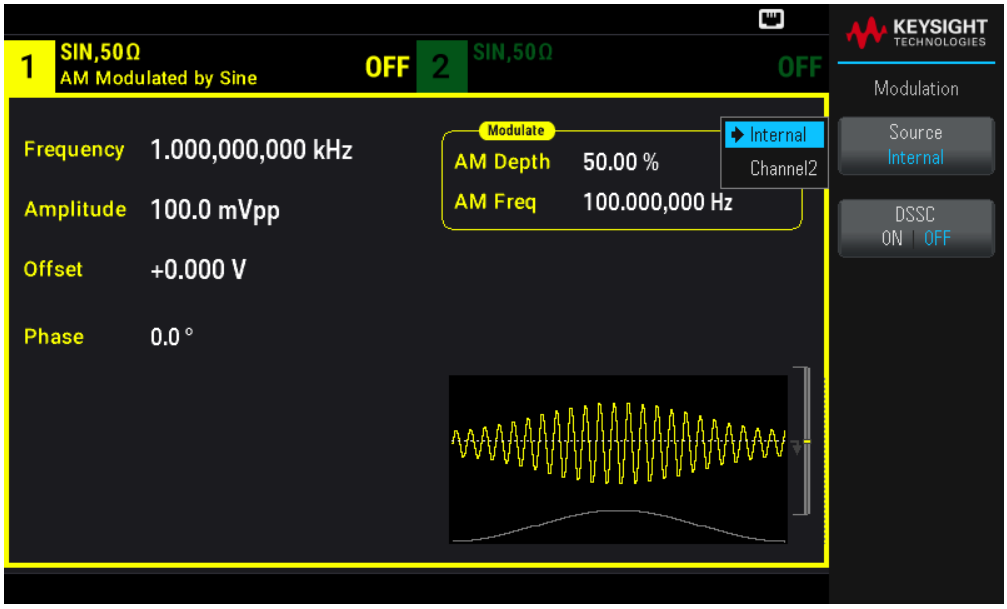
– Modulating source: Internal (default) or Channel#.

– AM example: With modulation depth 100%, when the modulating signal is at +5 V, the output will be at the maximum amplitude. When the modulating signal at -5 V, the output will be at minimum amplitude.

– FM example: With deviation of 10 kHz, then a +5 V signal level corresponds to a 10 kHz increase in frequency. Lower external signal levels produce less deviation and negative signal levels reduce the frequency below the carrier frequency.

Front Panel Operations

After enabling Type AM or Type FM, select the modulating source as shown: Press MORE 1 / 2 > Source.



SCPI Command

```
[SOURce[1|2]:]AM:SOURce {INTernal|CH1|CH2}
[SOURce[1|2]:]FM:SOURce {INTernal|CH1|CH2}
```

Phase Modulation (PM)

A modulated waveform consists of a carrier waveform and a modulating waveform. PM is very similar to FM, but in PM the phase of the modulated waveform is varied by the instantaneous voltage of the modulating waveform.

For more information on the fundamentals of Phase Modulation, see Modulation.

To Select Phase Modulation

– Only one modulation mode may be enabled at a time. Enabling PM disables the previous modulation mode.

– Enabling PM turns off sweep and burst.

Front Panel Operation

Press [Modulate] > Type AM > Type PM.

The waveform is output using the present carrier and modulating waveform settings.

To avoid multiple waveform changes, enable modulation after configuring the other modulation parameters.

SCPI Command

```
[SOURce[1|2]:]PM:STATe {ON|1|OFF|0}
```

Carrier Waveform Shape

PM carrier shape: Sine (default), Square, Ramp, Triangle, Pulse, PRBS, or Arbitrary. You cannot use Noise or DC as the carrier waveform.

Front Panel Operation

Press [Waveform]. Then select any waveform except Noise or DC.

SCPI Command

```
[SOURce[1|2]:]FUNCtion <function>
```

– The APPLy command configures a waveform with one command.

– When the carrier is an arbitrary waveform, modulation affects the sample "clock" instead of the full cycle defined by the arbitrary waveform sample set. Because of this, applying phase modulation to arbitrary waveforms is limited.

Carrier Frequency

The maximum carrier frequency varies by function, model, and output voltage, as shown here. The default is 1 kHz for all functions other than arbitrary waveforms. Carrier frequency must be greater than 20 times the peak modulation frequency.

Front Panel Operation

Press AM Freq or FM Freq or any other Frequency key. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.

SCPI Command

```
[SOURce[1|2]:]FREQuency {<frequency>|MINimum|MAXimum|DEFault}
```

The APPLy command configures a waveform with one command.

Modulating Waveform Shape

The modulating waveform shape may be:

– Sine wave

– Square with 50% duty cycle 

– Triangle with 50% symmetry 

– UpRamp with 100% symmetry 

– DnRamp with 0% symmetry

– Noise: White Gaussian noise

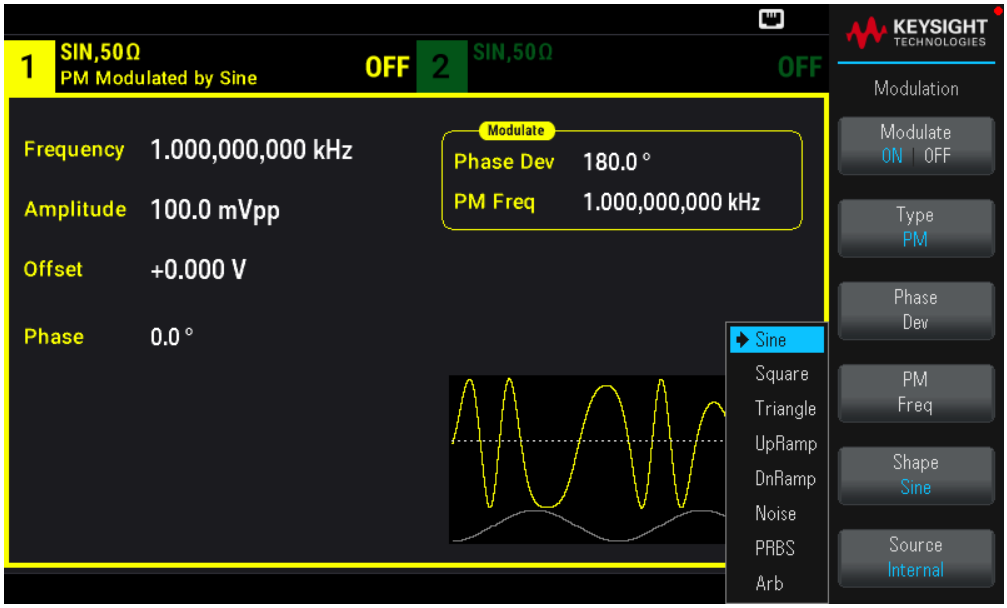
– PRBS: Pseudo Random Bit Sequence (polynomial PN7)

– Arb: Arbitrary waveform

You can use noise as the modulating wave shape, but you cannot use noise or DC as the carrier waveform.

Front Panel Operation

Press [Modulate] > Type AM > Type PM > Shape Sine.



SCPI Command

```
SCPI:[SOURce[1|2]:]PM:INTernal:FUNCtion <function>
```

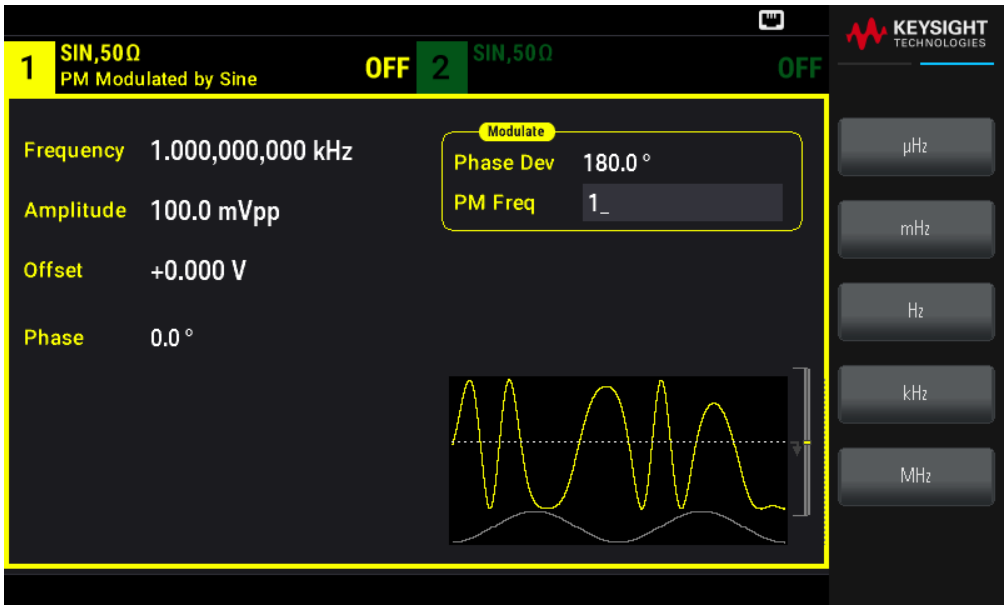
Modulating Waveform Frequency

Modulating frequency: default 10 Hz, minimum 1 µHz; maximum varies by model, function, and output voltage, as shown here.

Front Panel Operation

Press [Modulate] > Type AM > Type PM > PM Freq.

Then set the modulating waveform frequency with the knob and keypad. If you use the keypad, select a prefix unit to finish.



SCPI Command

```
SCPI: [SOURce[1|2]:]PM:INTernal:FREQuency
{<frequency>|MINimum|MAXimum|DEFault}
```

Phase Deviation

The phase deviation setting represents the peak variation in phase of the modulated waveform from the carrier waveform. The phase deviation can be set from 0 to 360 degrees (default 180).

Front Panel Operation

Press [Modulate] > Type AM > Type PM > Phase Dev.

Then set the phase deviation with the knob and keypad.

SCPI Command

```
[SOURce[1|2]:]PM:DEViation {<deviation in degrees>|MINimum|MAXimum|DEFault}
```

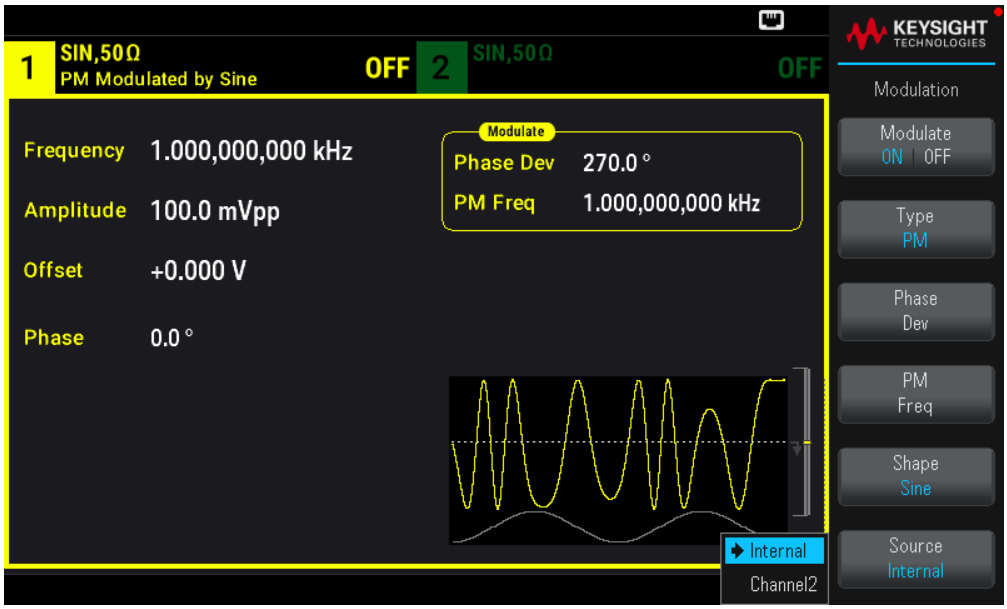
When the carrier is an arbitrary waveform, the deviation applies to the sample clock. Therefore, the effect on the full arbitrary waveform is much less than that seen with standard waveforms. The extent of the reduction depends on the number of points in the arbitrary waveform.

Modulating Source

Modulating source: Internal (default) or Channel#.

Front Panel Operation

Press [Modulate] > Type AM > Type PM > Source.



SCPI Command

```
[SOURce[1|2]:]PM:SOURce {INTernal|CH1|CH2}
```

Frequency-Shift Keying (FSK) Modulation

You can configure the instrument to "shift" its output frequency between two preset values (called the "carrier frequency" and the "hop frequency") using FSK modulation. The rate at which the output shifts between these two frequencies is determined by the internal rate generator or the signal level on the front panel Ext Trig connector.

See Front Panel Menu Operation - Output an FSK Waveform for details on FSK using the front panel.

To Select FSK Modulation

– Only one modulation mode may be enabled at a time. Enabling FSK turns off the previous modulation mode.

– You cannot enable FSK when sweep or burst is enabled. Enabling FSK turns off sweep and burst.

– To avoid multiple waveform changes, enable modulation after configuring the other modulation parameters.

SCPI Command

```
FSKey:STATe {OFF|ON}
```

FSK Carrier Frequency

The maximum carrier frequency varies by function, model, and output voltage, as shown here. The default is 1 kHz for all functions other than arbitrary waveforms.

When a logic low is present, the carrier frequency is output. With a logic high, the hop frequency is output.

SCPI Command

```
[SOURce[1|2]:]FREQuency {<frequency>|MINimum|MAXimum|DEFault}
```

FSK "Hop" Frequency

The maximum alternate ("hop") frequency depends on the function. The default is 100 Hz for all functions. The internal modulating waveform is a 50% duty cycle square wave.

Function	Minimum Hop Frequency	Maximum Hop Frequency
Sine	1 µHz	20 MHz
Square	1 µHz	10 MHz
Ramp/Triangle	1 µHz	200 kHz
Pulse	1 µHz	10 MHz

When the **External** source is selected, the output frequency is determined by the signal level on the front panel **Ext Trig** connector. When a logic low is present, the carrier frequency is output. With a logic high, the hop frequency is output.

SCPI Command

```
[SOURce[1|2]:]FSKey:FREQuency {<frequency>|MINimum|MAXimum|DEFault}
```

FSK Rate

The FSK rate is the rate at which the output frequency "shifts" between the carrier frequency and the hop frequency using the internal FSK source.

– FSK rate (internal source): 125 µHz up to 1 MHz, default 10 Hz.

– The FSK rate is ignored when the external FSK source is selected.

SCPI Command

```
[SOURce[1|2]:]FSKey:INTernal:RATE {<rate_in_Hz>|MINimum|MAXimum}
```

FSK Source

May be **Internal** (default) or **External**.

– When the **Internal** source is selected, the rate at which the output frequency "shifts" between the carrier frequency and hop frequency is determined by the FSK rate. The internal modulating waveform is a 50% duty cycle square wave.

– When the **External** source is selected, the output frequency is determined by the signal level on the front panel **Ext Trig** connector.When a logic low is present, the carrier frequency is output. With a logic high, the hop frequency is output.

– The connector used for externally-controlled FSK waveforms (Ext Trig) is not the same connector that is used for externally-modulated AM, FM, PM, and PWM waveforms (Modulation In). When used for FSK, the **Ext Trig** connector does not have adjustable edge polarity.

SCPI Command

```
[SOURce[1|2]:]FSKey:SOURce {INTernal|EXTernal}
```

Pulse Width Modulation (PWM)

This section discusses PWM, which stands for pulse-width modulation. PWM is only available for the Pulse waveform, and the pulse width varies according to the modulating signal. The amount by which the pulse width varies is called the width deviation, and it can be specified as a percentage of the waveform period (that is, duty cycle) or in units of time. For example, if you specify a pulse with 20% duty cycle and then enable PWM with a 5% deviation, the duty cycle varies from 15% to 25% under control of the modulating signal.

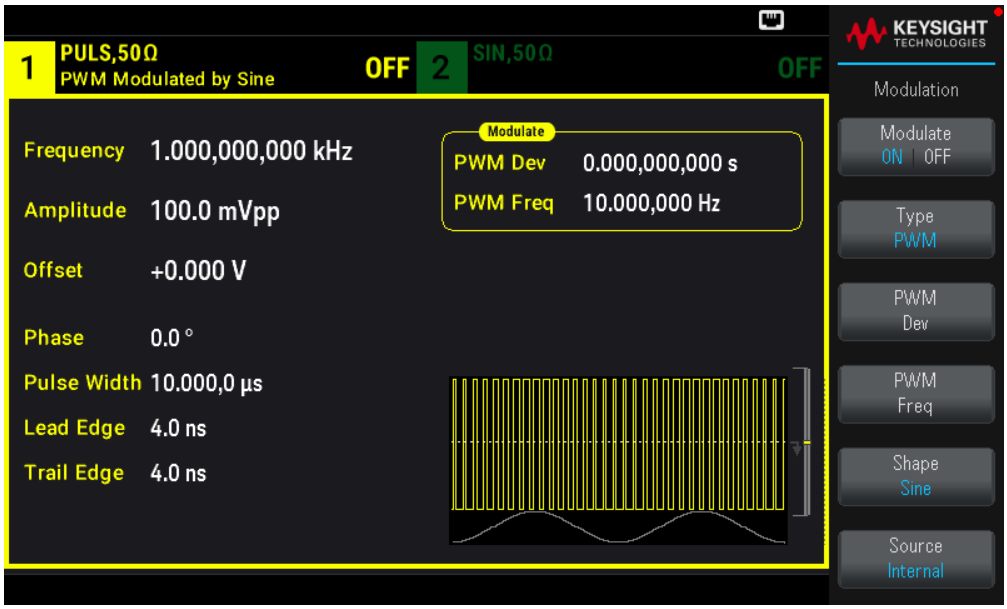
To Select PWM

You cannot enable PWM when sweep or burst is enabled.

To avoid multiple waveform changes, enable modulation after configuring the other modulation parameters.

Front Panel Operations

1. Press [Waveform] > Pulse.
2. Press [Modulate] > Type AM > Type PWM.
3. Press Modulate ON | OFF > Modulate ON | OFF.



The waveform is output using the present carrier and modulating waveform settings.

SCPI Command

```
[SOURce[1|2]:]PWM:STATe {ON|1|OFF|0}
```

Modulating Waveform Shape

The modulating waveform shape (internal source) may be:

– Sine wave

– **Square** with 50% duty cycle

– **Triangle** with 50% symmetry

– **UpRamp** with 100% symmetry

– **DnRamp** with 0% symmetry

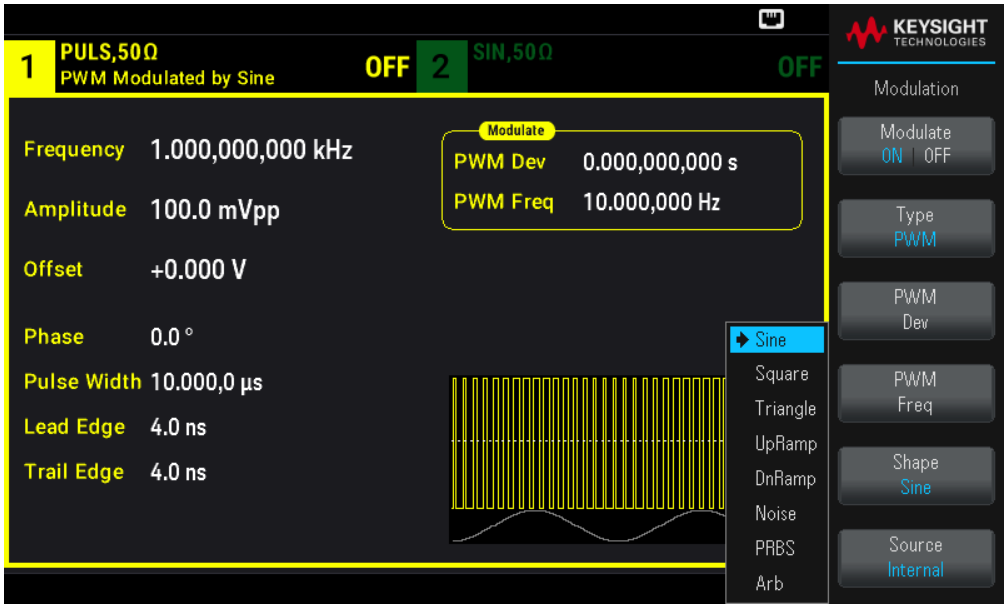
– **Noise**: White Gaussian noise

– **PRBS**: Pseudo Random Bit Sequence (polynomial PN7)

– **Arb**: Arbitrary waveform

Front Panel Operations

1. Press **[Waveform]** > **Pulse**.
2. Press **[Modulate]** > **Type** PWM > **Shape** Sine.



SCPI Command

```
[SOURce[1|2]:]PWM:INTernal:FUNCtion <function>
```

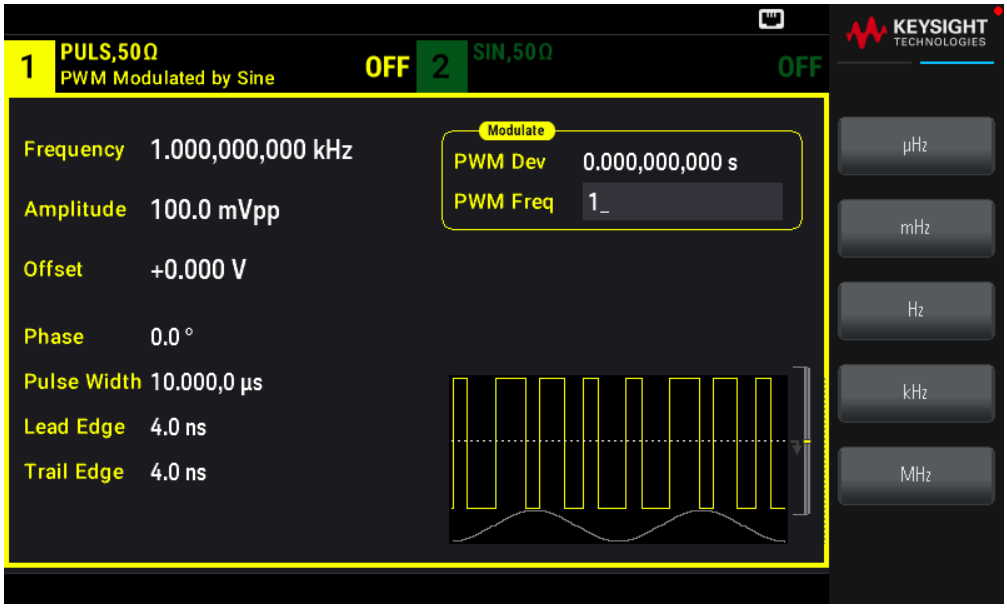
Modulating Waveform Frequency

Modulating frequency: The default is 10 Hz, and the minimum is 1 µHz. The maximum frequency varies by function, model, and output voltage, as shown here.

Front Panel Operations

1. Press [Waveform] > Pulse.
2. Press [Modulate] > Type PWM > PWM Freq.

Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.



SCPI Command

```
[SOURce[1|2]:]PWM:INTernal:FREQuency {<frequency>|MINimum|MAXimum|DEFault}
```

Width or Duty Cycle Deviation

The PWM deviation setting is the peak variation in width of the modulated pulse waveform. You can set it in units of time or duty cycle.

Front Panel Operations

1. Press [Waveform] > Pulse.
2. Press [Modulate] > Type PWM > PWM Dev. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.

To set deviation in terms of duty cycle:

1. Press [Units] >Width Duty Cyc > Width Duty Cyc.
2. Press [Modulate] > Duty Cycle. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, press Percent to finish.

SCPI Command

```
[SOURce[1|2]:]PWM:DEViation {<deviation>|MINimum|MAXimum|DEFault}
```

– The sum of the pulse width and deviation must satisfy the formula:

Pulse Width + Deviation < Period – 16 ns

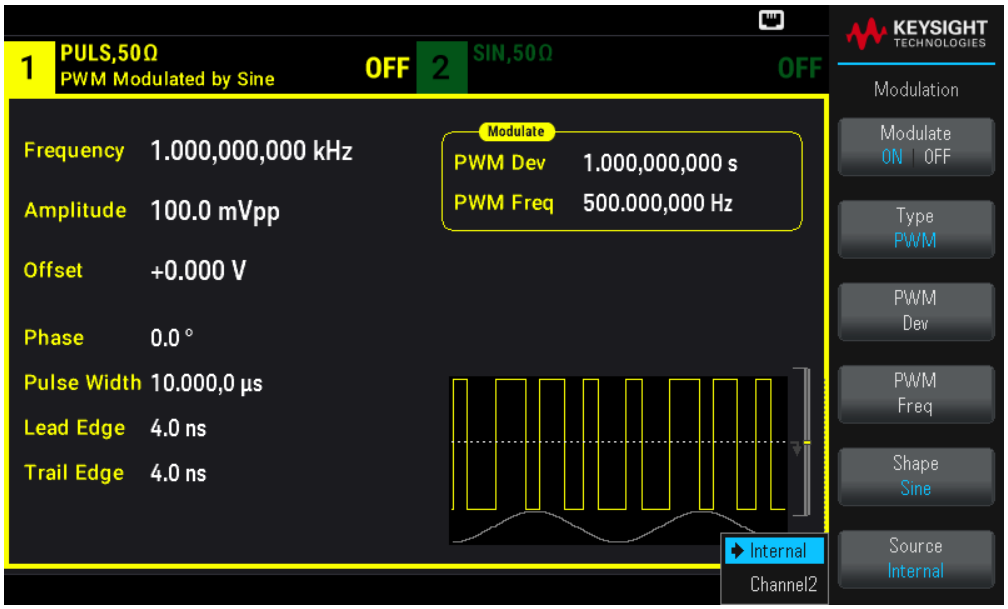
– If necessary, the instrument will adjust the deviation to accommodate the specified period.

Modulating Source

Modulating source: **Internal** (default) or **Channel#**.

Front Panel Operations

1. Press **[Waveform]** > **Pulse**.
2. Press **[Modulate]** > **Type** PWM > **Source**.



SCPI Command

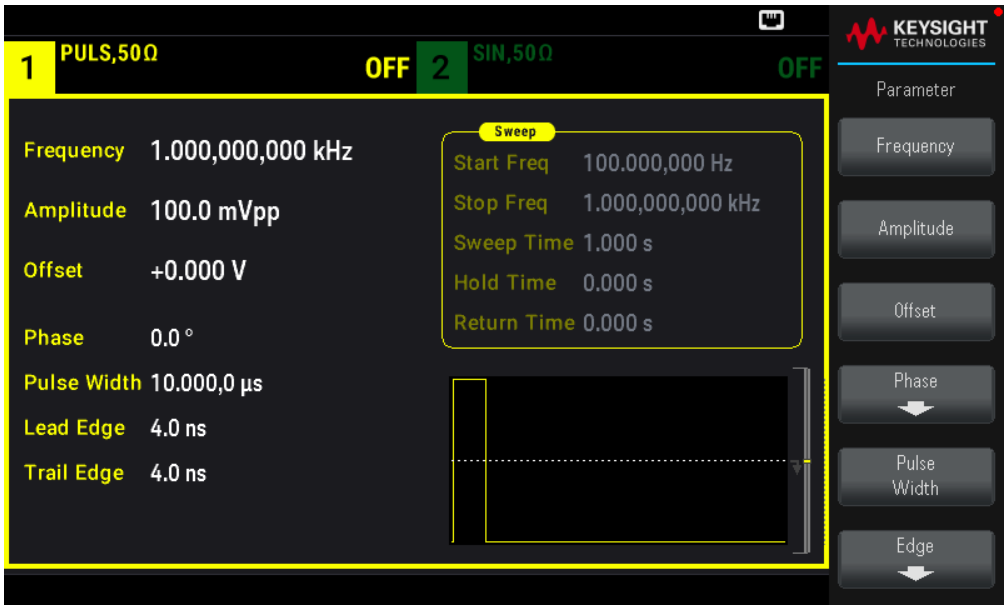
```
[SOURce[1|2]:]PWM:SOURce {INTernal|CH1|CH2}
```

Pulse Waveform

Pulse is the only waveform shape supported for PWM.

Front Panel Operations

Press **[Waveform]** > **Pulse**.



SCPI Command

```
FUNCtion PULSe
```

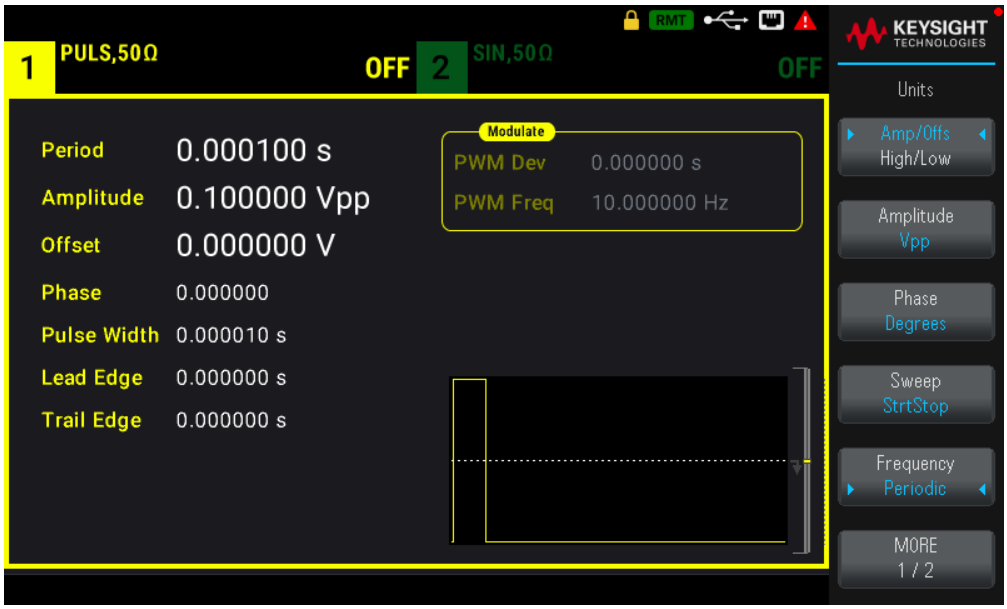
The APPLy command configures a waveform with one command.

Pulse Period

The range for the pulse period is from the reciprocal of the instrument's maximum frequency up to 1,000,000 s (default 100 µs). Note that the waveform period limits the maximum deviation.

Front Panel Operations

1. Press [Waveform] > Pulse.
2. Press [Units] > Frequency Periodic > Frequency Periodic.



SCPI Command

```
[SOURce[1|2]:]FUNCtion:PULSe:PERiod {<seconds>|MINimum|MAXimum|DEFault}
```

Sum Modulation

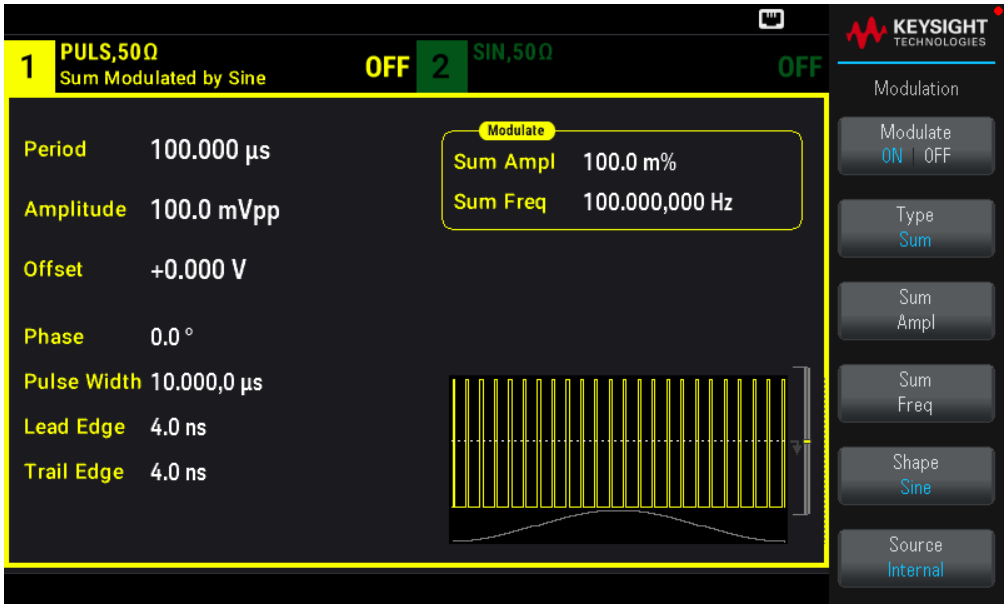
Sum modulation adds a modulating signal to any carrier waveform; it is typically used to add Gaussian noise to a carrier. The modulating signal is added to the carrier as a percentage of carrier waveform amplitude.

Enable Sum

To avoid multiple waveform changes, enable **Sum** after configuring other modulation parameters.

Front Panel Operations

1. Press [Modulate] > Type AM > Type Sum.
2. Press Modulate ON | OFF > Modulate ON | OFF.



SCPI Command

```
[SOURce[1|2]:]SUM:STATe {ON|1|OFF|0}
```

Modulating Waveform Shape

On a two-channel instrument you can modulate one channel with the other.

The modulating waveform shape may be:

– **Sine** wave

– **Square** with 50% duty cycle

– **Triangle** with 50% symmetry

– **UpRamp** with 100% symmetry

– **DnRamp** with 0% symmetry

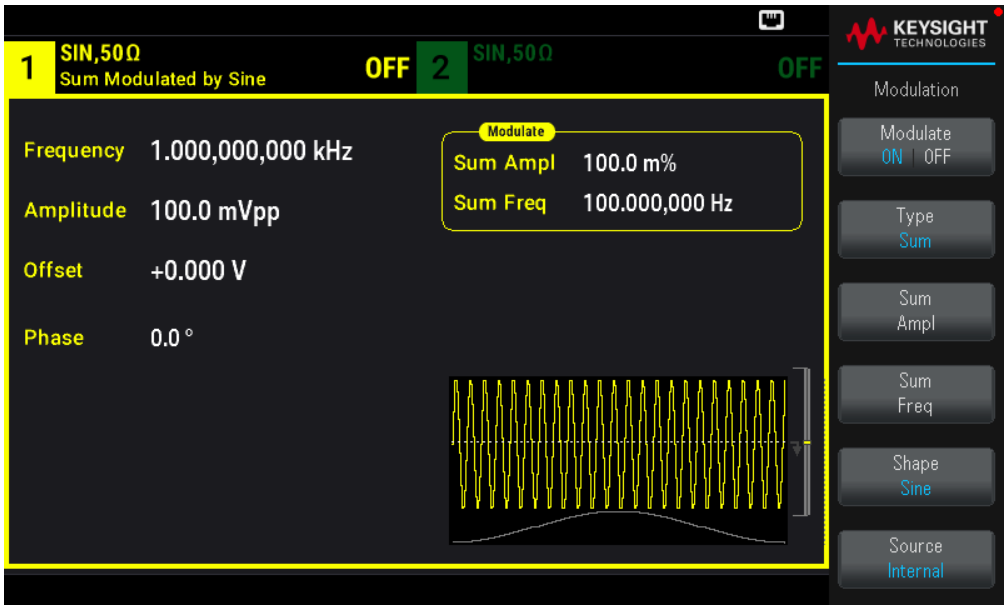
– **Noise**: White Gaussian noise

– **PRBS**: Pseudo Random Bit Sequence (polynomial PN7)

– **Arb**: Arbitrary waveform

Front Panel Operations

Press [Modulate] > Type Sum > Shape Sine.



SCPI Command

```
[SOURce[1|2]:]SUM:INTernal:FUNCtion <function>
```

Modulating Waveform Frequency

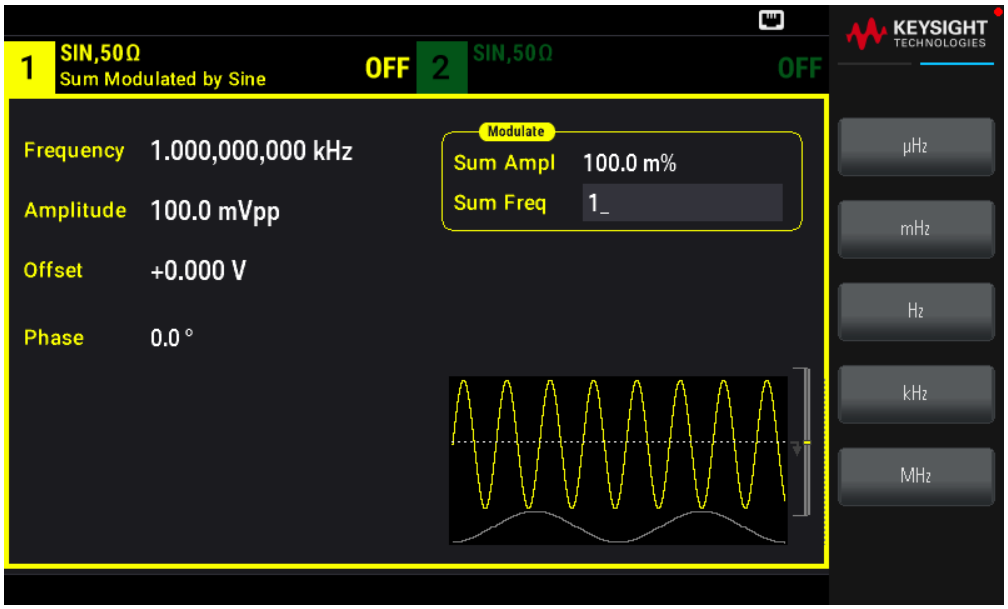
On a two-channel instrument you can modulate one channel with the other.

Modulating frequency: The default 100 Hz and the minimum is 1 µHz.

Front Panel Operations

Press [Modulate] > Type Sum > Sum Freq.

Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.



SCPI Command

```
[SOURce[1|2]:]SUM:INTernal:FREQuency {<frequency>|MINimum|MAXimum|DEFault}
```

Sum Amplitude

The Sum Amplitude represents the amplitude of the signal added to the carrier (in percent of carrier amplitude).

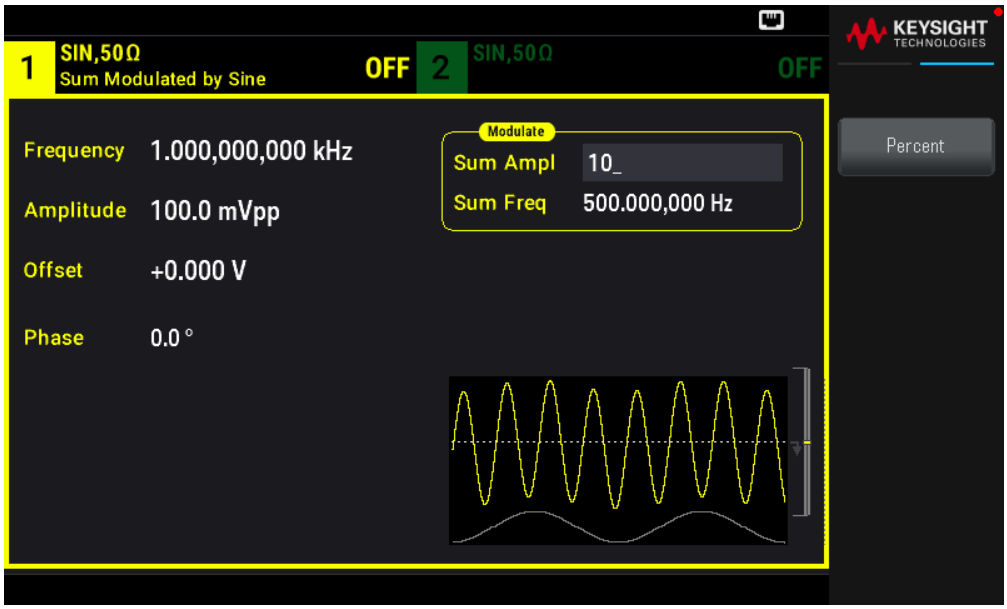
– Amplitude setting: 0 to 100% of carrier amplitude, 0.01% resolution.

– Sum Amplitude remains a constant fraction of carrier amplitude and tracks carrier amplitude changes.

Front Panel Operations

Press [Modulate] > Type Sum > Sum Ampl.

Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, press Percent to finish.



SCPI Command

```
[SOURce[1|2]:]SUM:AMPLitude {<amplitude>|MINimum|MAXimum|DEFault}
```

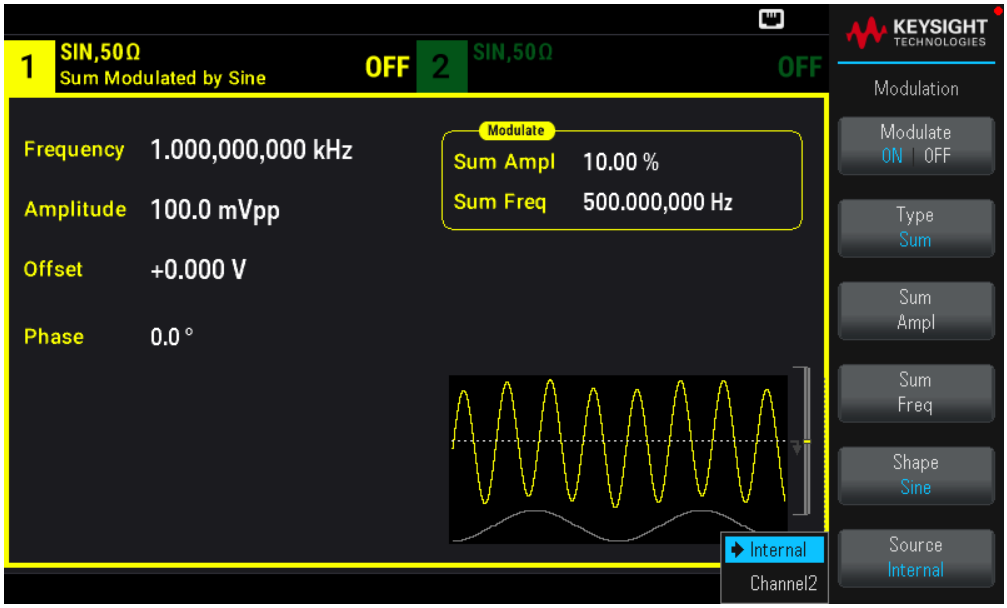
Modulating Source

On a two-channel instrument you can modulate one channel with the other.

Modulating source: Internal (default) or Channel#.

Front Panel Operations

Press [Modulate] > Type Sum > Source.



SCPI Command

```
[SOURce[1|2]:]SUM:SOURce {INTernal|CH1|CH2}
```

Frequency Sweep

In frequency sweep mode, the instrument moves from the start frequency to the stop frequency at a specified sweep rate. You can sweep up or down in frequency, with either linear or logarithmic spacing. You can also configure the instrument to output one sweep from start frequency to stop frequency by applying an external or manual trigger. The instrument can sweep sine, square, pulse, ramp, triangle, or arbitrary waveforms (PRBS, noise, and DC are not allowed).

You can specify a hold time, during which the sweep remains at the stop frequency, and a return time, during which the frequency changes linearly from the stop frequency to the start frequency.

For more information, see Frequency Sweep.

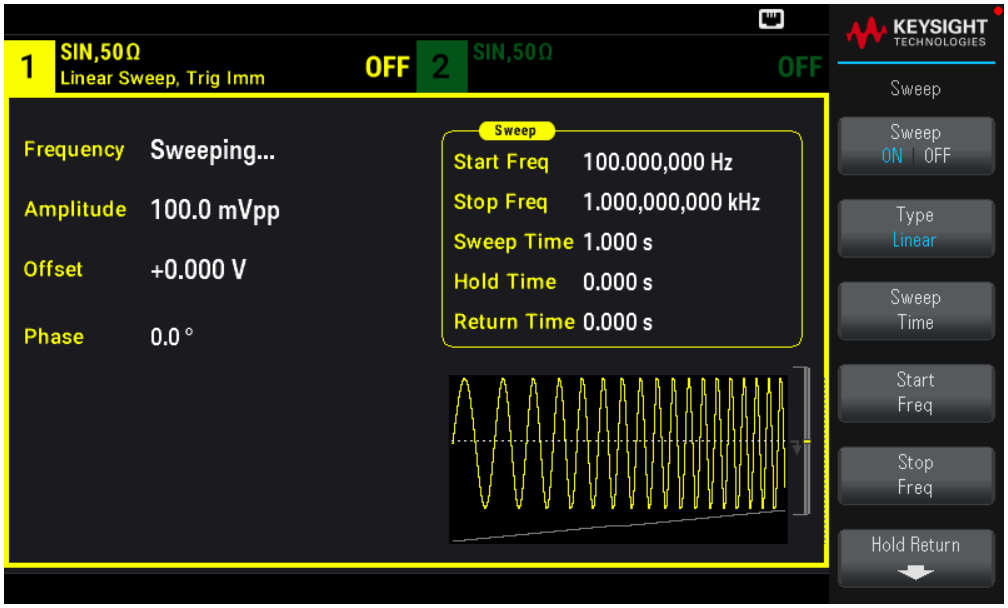
To Select Sweep

The instrument will not allow sweep or list mode to be enabled at the same time that burst or any modulation mode is enabled. When you enable sweep, the burst or modulation mode is turned off.

To avoid multiple waveform changes, enable the sweep mode after configuring the other parameters.

Front Panel Operations

Press [Sweep] > Sweep ON | OFF> Sweep ON | OFF.



SCPI Command

```
[SOURce[1|2]:]FREQuency:MODE SWEEP
[SOURce[1|2]:]SWEep:STATe {ON|1|OFF|0}
```

Start Frequency and Stop Frequency

The start frequency and stop frequency set the sweep's upper and lower frequency bounds. The sweep begins at the start frequency, sweeps to the stop frequency, and then resets back to the start frequency.

– Start and Stop frequencies: 1 µHz to maximum frequency for the waveform. The sweep is phase continuous over the full frequency range. The default start frequency is 100 Hz. The default stop frequency is 1 kHz.

– To sweep up in frequency, set the start frequency less than the stop frequency. To sweep down in frequency, set the opposite relationship.

– Sync setting Normal: Sync pulse is high throughout the sweep.

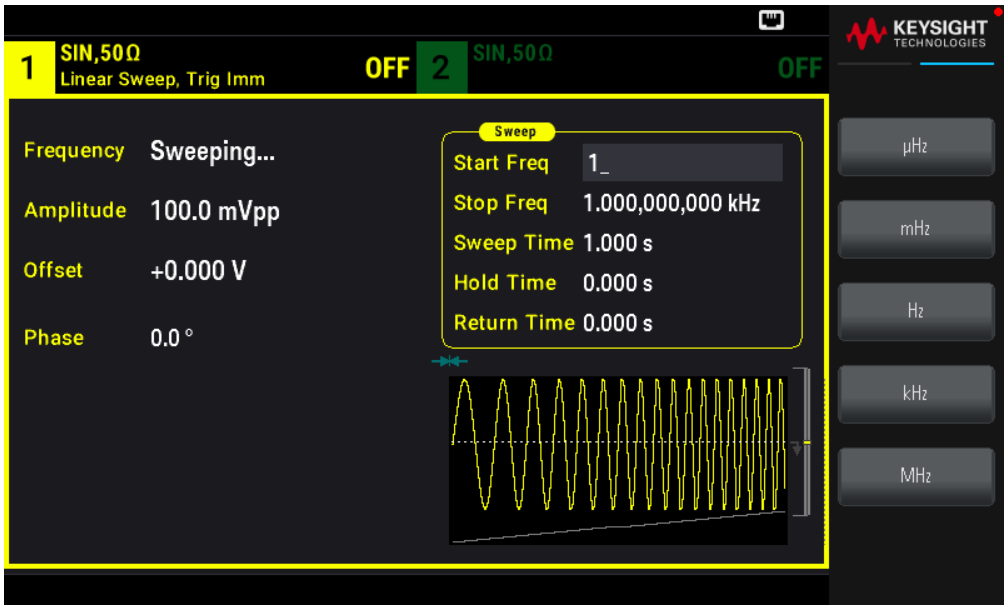
– Sync setting Carrier: Sync pulse has a 50% duty cycle for every waveform cycle.

– Sync setting Marker: Sync pulse goes high at the beginning and goes low at the marker frequency. You can change this with OUTPut[1|2]:SYNC:MODEMARKER.

Front Panel Operations

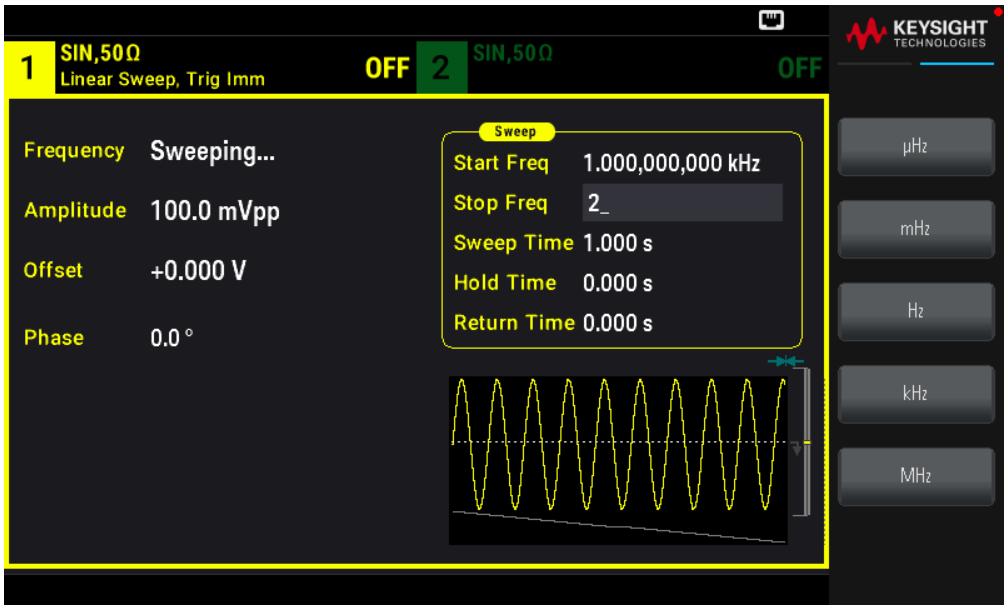
Press [Sweep] > Start Freq.

Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.



Press Stop Freq.

Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.



SCPI Command

```
[SOURce[1|2]:]FREQuency:STARt {<frequency>|MINimum|MAXimum|DEFault}
[SOURce[1|2]:]FREQuency:STOP {<frequency>|MINimum|MAXimum|DEFault}
```

Center Frequency and Frequency Span

You can also set the sweep frequency boundaries of the sweep using a center frequency and frequency span. These parameters are similar to the start frequency and stop frequency (above) and they provide added flexibility.

– Center frequency: 1 µHz to maximum frequency for the waveform. The default is 550 Hz.

– Frequency span: Any value between ±maximum frequency for the waveform. The default is 900 Hz.

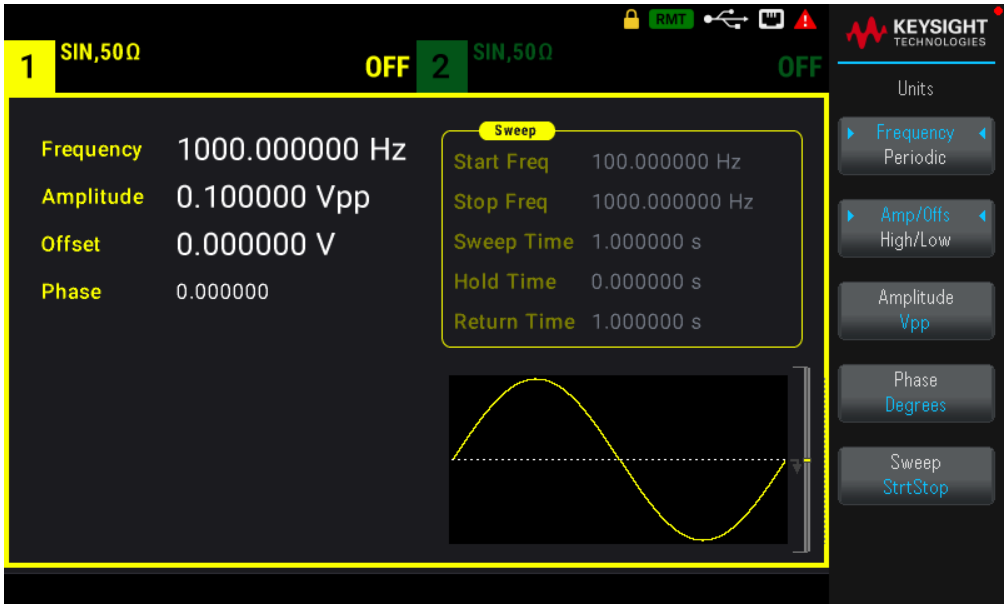
– To sweep up in frequency, set a positive frequency span; to sweep down, set a negative frequency span.

– Sync setting Normal: Sync pulse is high throughout the sweep.

– Sync setting Carrier: Sync pulse has a 50% duty cycle for every waveform cycle.

– Sync setting Marker: Sync pulse goes high at the beginning and goes low at the marker frequency. You can change this with OUTPut[1|2]:SYNC:MODEMARKER.

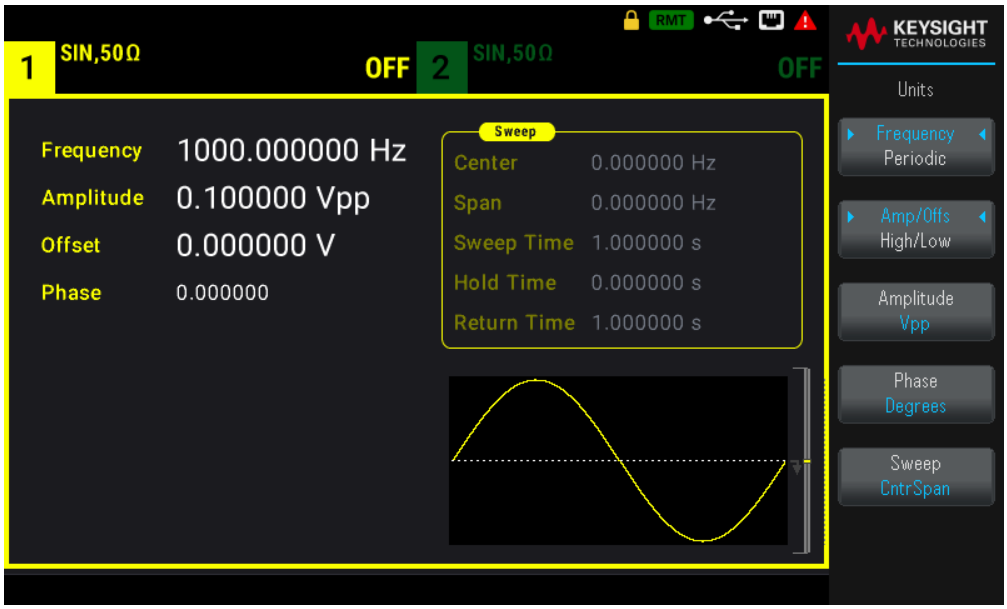
1. Press [Units] > Sweep StrtStop.



2. Press [Sweep] > Start Freq or Stop Freq. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.

   or

1. Press [Units] > Sweep CntrSpan.



2. Press [Sweep] > Center or Span. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.

SCPI Command

```
[SOURce[1|2]:]FREQuency:CENTer {<frequency>|MINimum|MAXimum|DEFault}
[SOURce[1|2]:]FREQuency:SPAN {<frequency>|MINimum|MAXimum|DEFault}
```

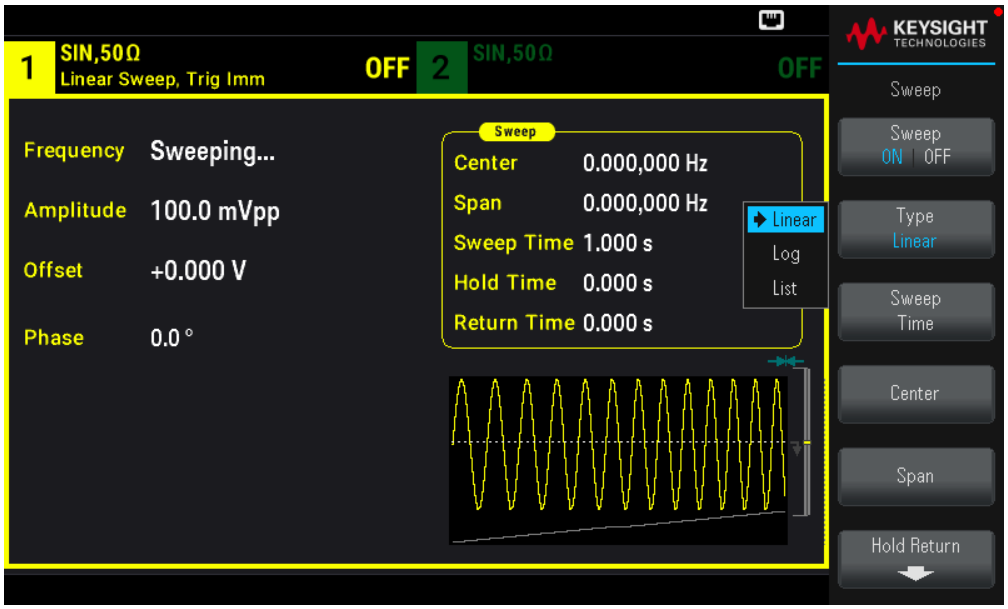
Sweep Mode

You can sweep with linear or logarithmic spacing, or with a list of sweep frequencies. For a linear sweep, the instrument varies the output frequency linearly during the sweep. A logarithmic sweep varies the output frequency logarithmically.

The selected mode does not affect the sweep return (from stop to start, if one is set).

Front Panel Operations

Press [Sweep] > Type Linear.



SCPI Command

```
[SOURce[1|2]:]SWEep:SPACing {LINear|LOGarithmic}
```

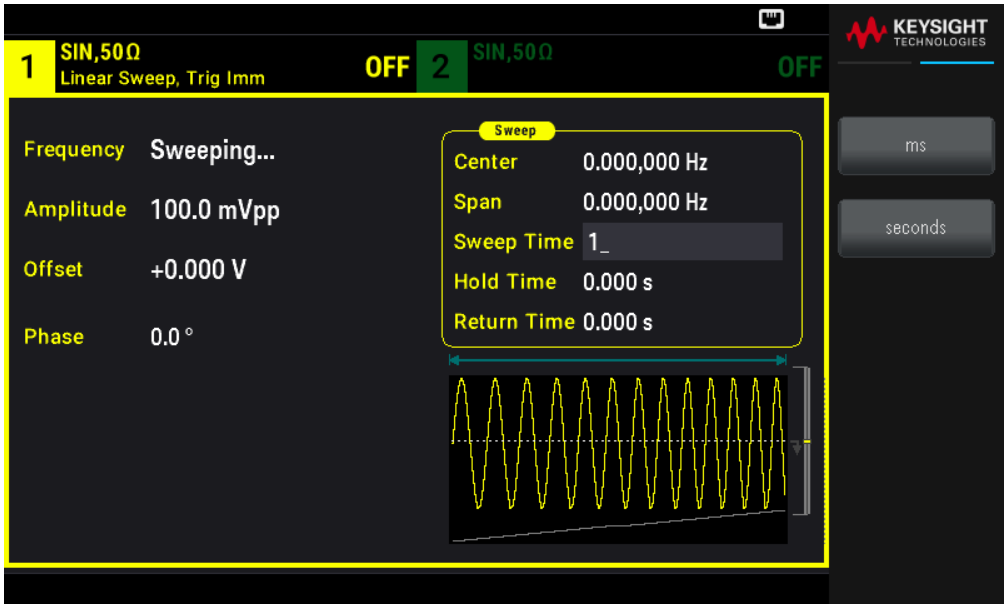
Sweep Time

Sweep time specifies the number of seconds required to sweep from the start frequency to the stop frequency. The instrument calculates the number of points in the sweep based on the sweep time.

Sweep time: 1 ms to 250,000 seconds, default 1 s. For a linear sweep in immediate trigger mode, the maximum total sweep time (including hold time and return time) is 8,000 s. The maximum total sweep time for linear sweeps using other trigger modes is 250,000 s; the maximum total sweep time for logarithmic sweeps is 500 s.

Front Panel Operations

Press [Sweep] > Sweep Time. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.



SCPI Command

```
[SOURce[1|2]:]SWEep:TIME {<seconds>|MINimum|MAXimum|DEFault}
```

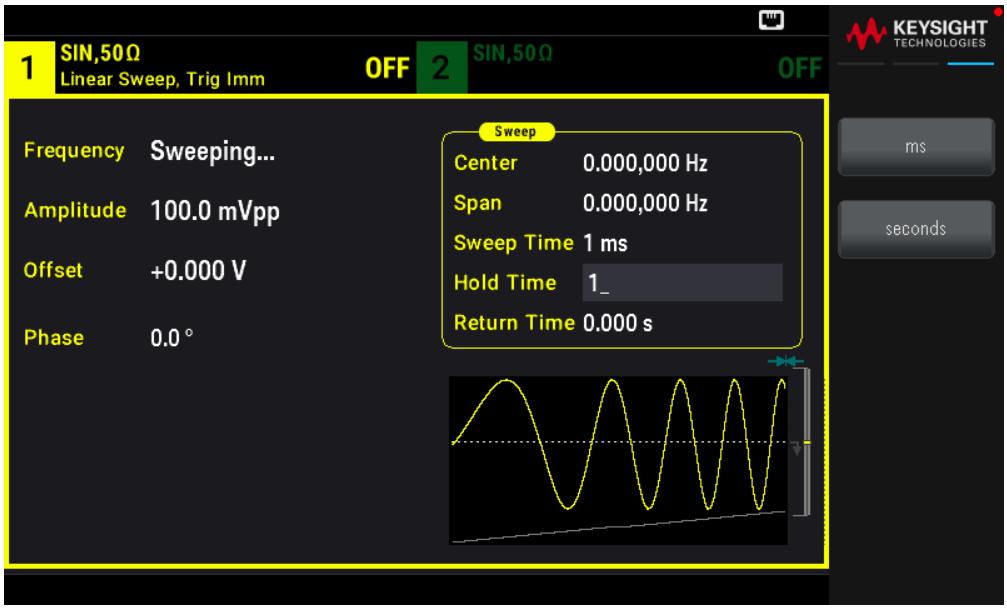
Hold/Return Time

Hold time specifies time (in seconds) to remain at the stop frequency, and return time specifies the number of seconds to return from the stop frequency to the start frequency.

Hold time and return time: 0 to 3600 seconds (default 0).

Front Panel Operations

Press [Sweep] > Hold Return > Hold Time or Return Time. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.



SCPI Command

```
[SOURce[1|2]:]SWEep:HTIMe {<hold_time>|MINimum|MAXimum|DEFault}
[SOURce[1|2]:]SWEep:RTIMe {<return_time>|MINimum|MAXimum|DEFault}
```

Marker Frequency

If desired, you can set the frequency at which the signal on the front panel Sync Out connector goes to a logic low during the sweep. The Sync signal always goes from low to high at the beginning of the sweep.

– Marker frequency: 1 µHz to maximum frequency for the waveform. The default is 500 Hz.

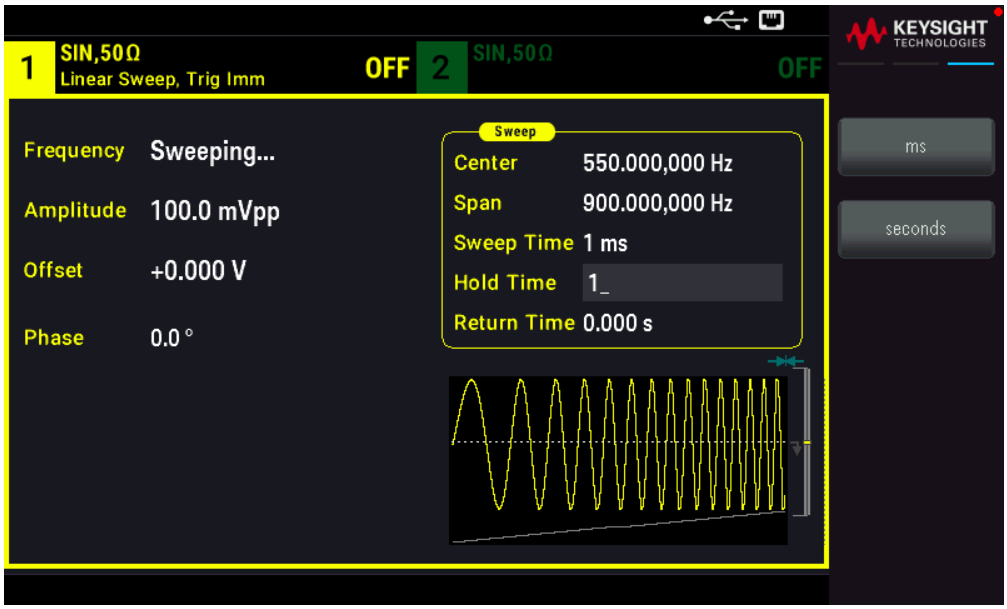
– When the sweep mode is enabled, the marker frequency must be between the specified start frequency and stop frequency. If you attempt to set the marker frequency to a frequency not in this range, the instrument will set the marker frequency equal to the start frequency or stop frequency (whichever is closer).

– You cannot configure the marker frequency with the front panel menus unless the Sync source is the sweeping channel.

Front Panel Operations

1. Press [Sweep] > Sweep ON | OFF > Sweep ON | OFF.
2. Press [Trigger] > Sync ON | OFF > Sync Setup.
3. Select Mode Marker.

4. Select Marker Freq. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.



SCPI Command

```
[SOURce[1|2]:]MARKer:FREQuency {<frequency>|MINimum|MAXimum|DEFault}
```

Sweep Trigger Source

In sweep mode, the instrument outputs a single sweep when a trigger signal is received. After one sweep from the start frequency to the stop frequency, the instrument waits for the next trigger while outputting the start frequency.

– Sweep trigger source: Immediate (default), External , Time, or Manual.

– With the Immediate (internal) source, the instrument outputs a continuous sweep at a rate determined by the total of the hold time, sweep time and return time. The sweep time for this source is limited to 8000 seconds.

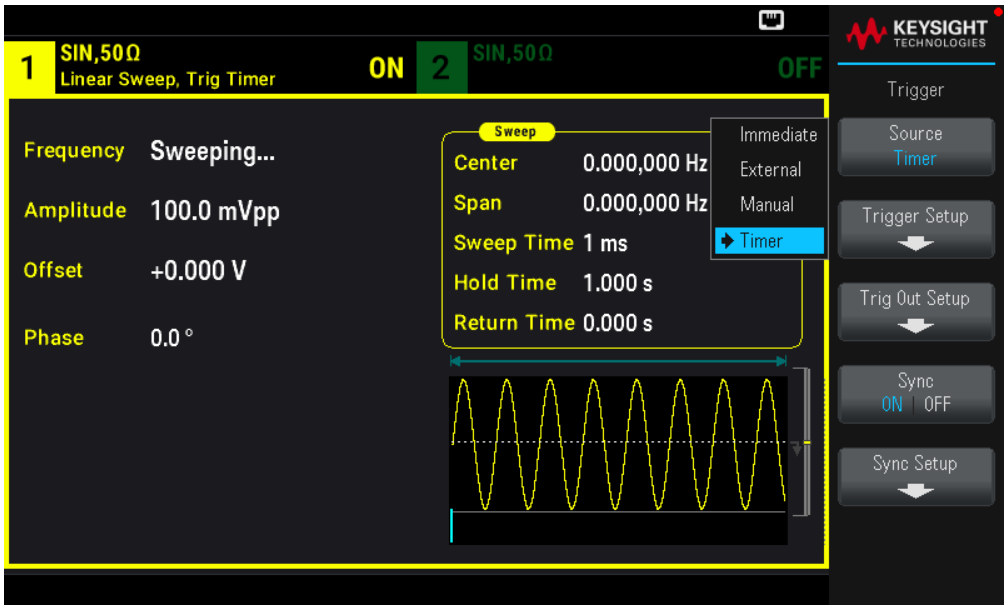
– With the External source, the instrument accepts a hardware trigger on the front panel Ext Trig connector and initiates one sweep each time Ext Trig receives a TTL pulse with the specified polarity.

– The trigger period must be greater than or equal to the specified sweep time.

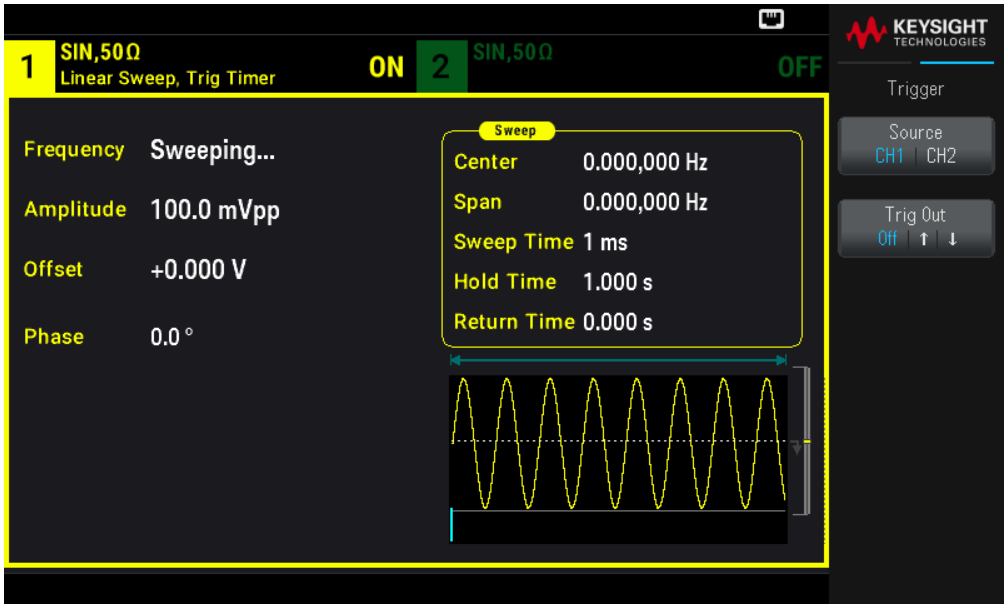
– With the Manual source, the instrument outputs one sweep each time the front panel [Trigger] key is pressed.

Front Panel Operations

Press [Trigger] > Source.



To specify the slope of the trigger signal edge: Press [Trigger] > Trig Out Setup > Trig Out Off | (Up) | (Down).



SCPI Command

```
TRIGger[1|2]:SOURce {IMMediate|EXTernal|TIMer|BUS}
TRIGger[1|2]:SLOPe {POSitive|NEGative}
```

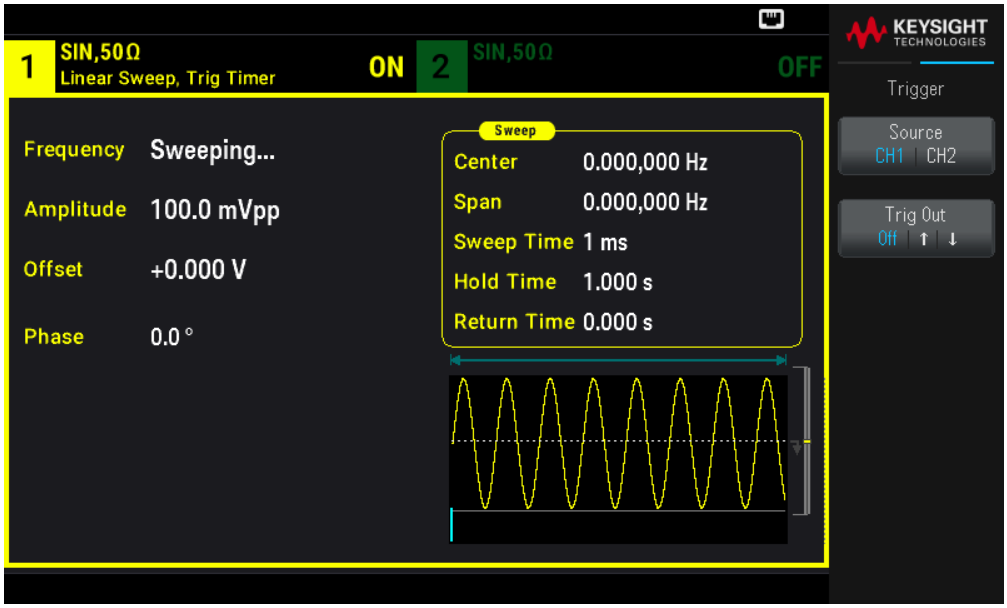
See Triggering for more information.

Trigger Out Signal

See Trigger Output Signal for more details.

Front Panel Operations

To specify whether the instrument triggers on the rising or falling edge on the Sync Out connector, press [Trigger] > Trig Out Setup. Then select the desired edge by pressing Trig Out.



SCPI Command

```
OUTPut:TRIGger:SLOPe {POSitive|NEGative}

OUTPut:TRIGger {ON|1|OFF|0}
```

Frequency List

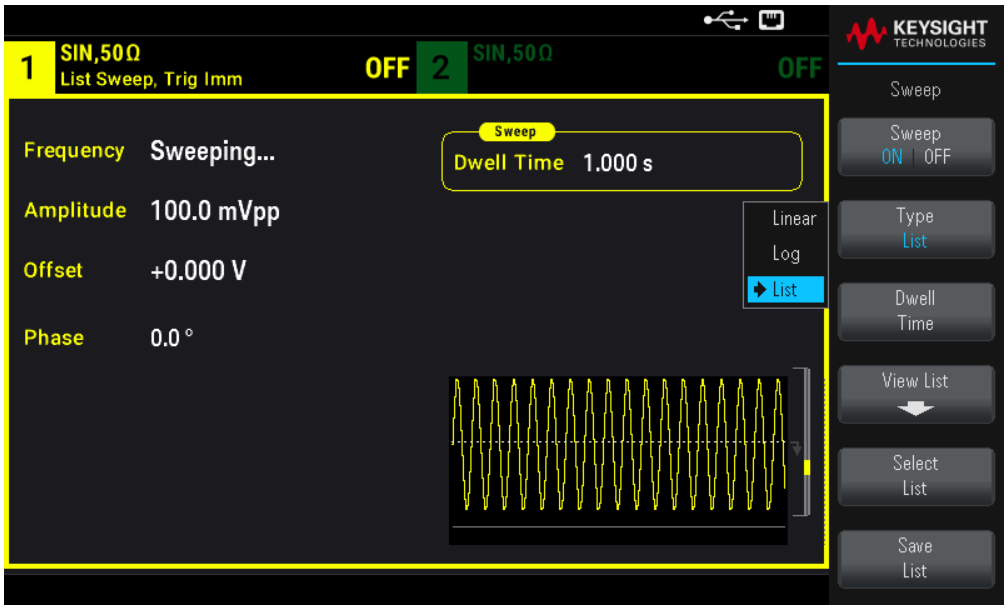
In frequency list mode, the instrument "steps" through a list of frequencies, dwelling on each frequency for a specified period. You may also control progress through the list with triggering.

– The instrument will not allow sweep or list mode to be enabled at the same time that burst or any modulation mode is enabled. When you enable sweep, the burst or modulation mode is turned off.

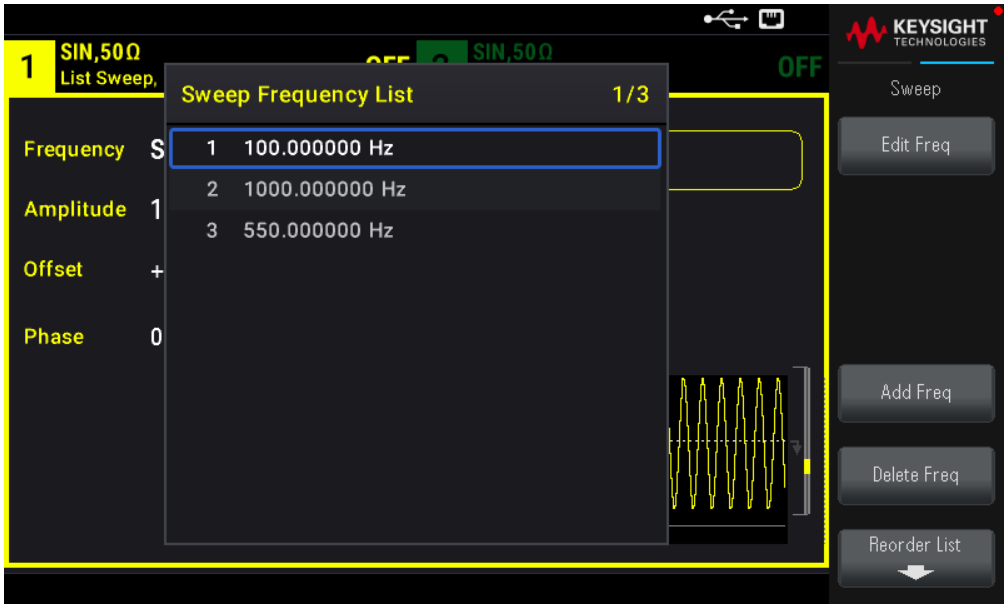
– To avoid multiple waveform changes, enable list mode after configuring its parameters.

Front Panel Operations

Enable list before setting any other list parameter. Press [Sweep] > Type Linear > Type List.



Select View List to view the list parameters. You can edit (Edit Freq) the frequency value in the sweep list, add (Add Freq) or delete (Delete Freq) a frequency value, and reorder the sweep list (Reorder List).



If you have a external USB flash drive connected, press Save List to save the sweep list to the external USB flash drive.

To retrieve a previously saved sweep list from the connected external USB flash drive, press Select List.

SCPI Command

```
[SOURcd[1|2]:]FREQuency:MODE LIST
[SOURce[1|2]:]LIST:FREQuency <freq1>[, <freq2>, etc.]
```

Progress through list is controlled by the trigger system. If trigger source is internal or immediate, the dwell time setting (LIST:DWELl) determines time spent at each frequency. For any other trigger source, dwell time is determined by trigger event spacing.

Burst Mode

The instrument can output a waveform for a specified number of cycles, called a burst. Burst is allowed with sine, square, triangle, ramp, pulse, PRBS, or arbitrary waveforms (noise is allowed only in gated burst mode; DC is not allowed).

For details, see Burst.

To Select Burst

Burst cannot be enabled when sweep or modulation is enabled. Enabling burst turns off sweep and modulation.

To avoid multiple waveform changes, enable burst mode after configuring other parameters.

Front Panel Operations

Press [Burst] > Burst ON | OFF > Burst ON | OFF.

SCPI Command

[SOURce[1|2]:]BURSt:STATe {ON|1|OFF|0}

Burst Mode

Burst has two modes, described below. Selected mode controls allowable trigger source, and which other burst parameters apply.

– Triggered Burst Mode (default): The instrument outputs a waveform for specified number of cycle (burst count) each time trigger is received. After outputting specified number of cycles, instrument stops and waits for next trigger. The instrument can use an internal trigger to initiate burst, or you can provide external trigger by pressing the front panel [Trigger] key, applying trigger signal to front panel Ext Trig connector, or sending software trigger command from remote interface.

– External Gated Burst Mode: Output waveform is on or off, based on level of external signal applied to front panel Ext Trig connector. When the gate signal is true, the instrument outputs a continuous waveform. When the gate signal goes false, the current waveform cycle is completed and the instrument stops while remaining at the voltage level corresponding to the starting burst phase of the selected waveform. The noise waveform output stops immediately when the gate signal goes false.

Parameter	Burst Mode (BURS:MODE)	Burst Count (BURS:NCYC)	Burst Period (BURS:INT:PER)	Burst Phase (BURS:PHAS)	TriggerSource (TRIG:SOUR)
Triggered Burst Mode: Internal Trigger	TRIGgered	Available	Available	Available	IMMediate
Triggered Burst Mode: External Trigger	TRIGgered	Available	Not Used	Available	EXTernal, BUS

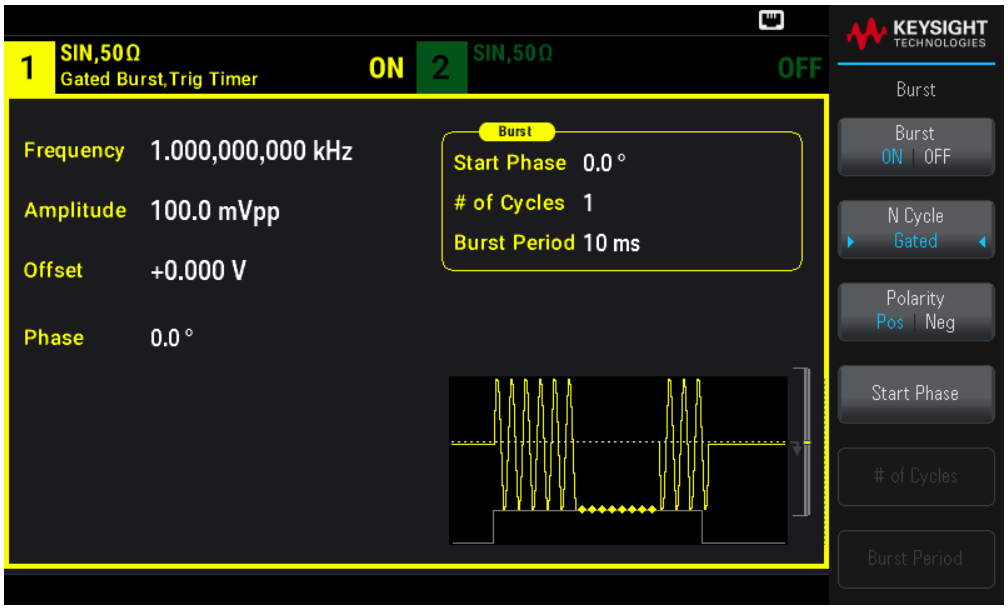
Parameter	Burst Mode (BURS:MODE)	Burst Count (BURS:NCYC)	Burst Period (BURS:INT:PER)	Burst Phase (BURS:PHAS)	TriggerSource (TRIG:SOUR)
Gated Burst Mode: External Trigger	GATed	Not Used	Not Used	Available	Not Used
Timer Burst Mode: Internal Trigger	TRIGgered	Available	Not Used	Available	TIMer

– In gated mode, burst count, burst period, and trigger source are ignored (used for triggered burst only). Manual triggers ignored; no error generated.

– In gated mode, you can specify polarity of signal on the front panel Ext Trig connector ([SOURce[1|2]:]BURSt:GATE:POLarity {NORMal|INVerted}). Default is NORMal (true-high).

Front Panel Operations

Press [Burst] > N Cycle Gated or N Cycle Gated.



SCPI Command

```
[SOURce[1|2]:]BURSt:MODE {TRIGgered|GATed}
```

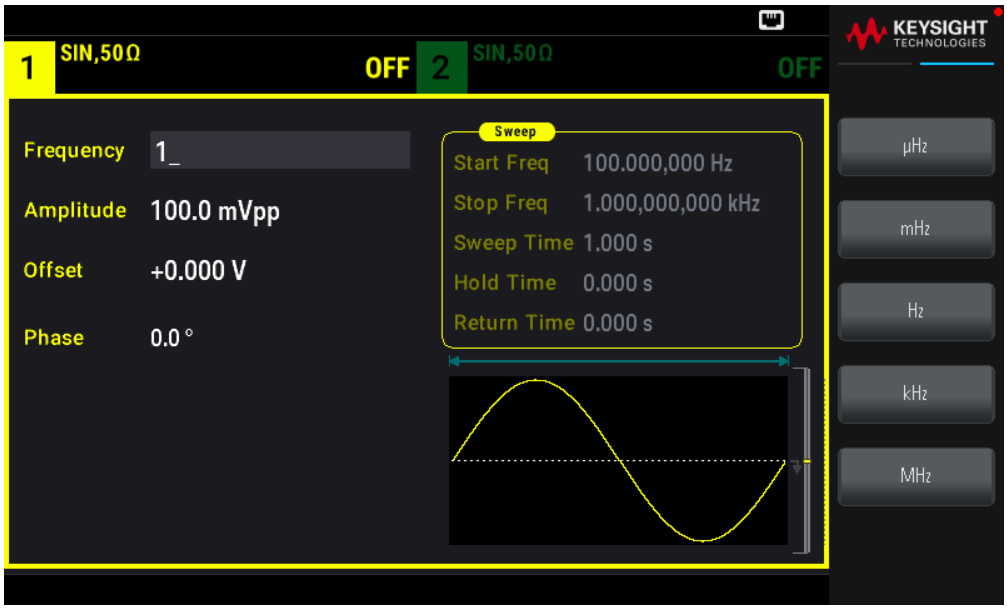
Waveform Frequency

You can specify the signal frequency during the burst in triggered and external gated modes. In the triggered mode, the number of cycles specified by the burst count is output at the waveform frequency. In the external gated mode, the waveform frequency is output when the external gate signal is true. This differs from the "burst period," which specifies interval between bursts (triggered mode only).

Waveform frequency: 1 µHz to maximum frequency of the waveform. The default value is 1 kHz. (For an internally triggered burst waveform, the minimum frequency is 126 µHz.)

Front Panel Operations

Press [Parameter] > Frequency. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.



SCPI Command

```
[SOURce[1|2]:]FREQuency {<frequency>|MINimum|MAXimum|DEFault}
```

The APPLy command configures awaveform with one command.

Burst Count

Number of cycles (1 to 100,000,000 or infinite) to be output per burst. Used in the triggered burst mode only (internal or external source).

– With the Immediate trigger source, the specified number of cycles are output continuously at a rate determined by the burst period. The burst period is the time between the starts of consecutive bursts. Also, the burst count must be less than the product of burst period and waveform frequency:

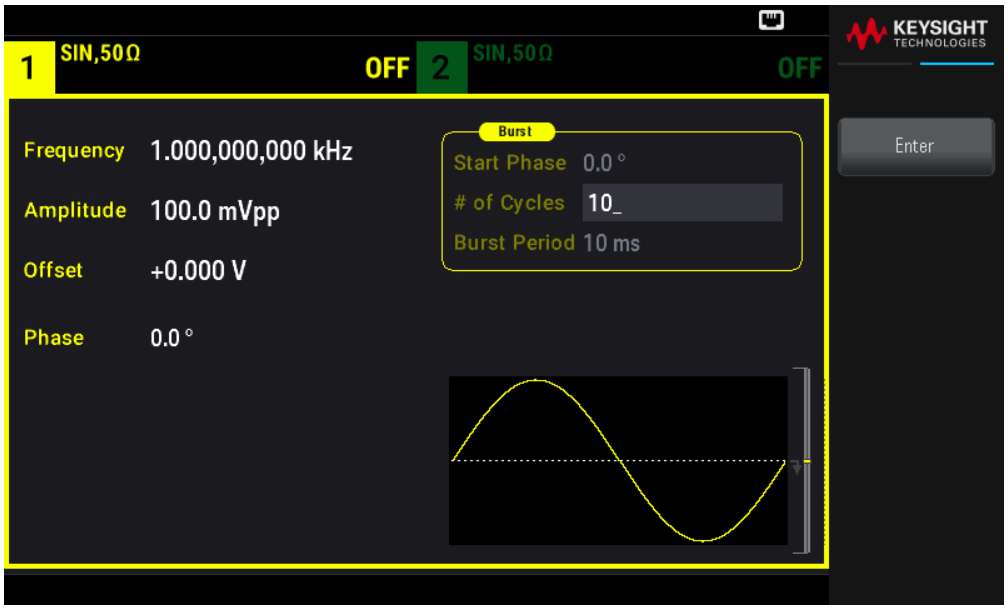
Burst Period > (Burst Count) / (Waveform Frequency) + 1 µsec

– The instrument will increase burst period to its maximum value to accommodate specified burst count (but waveform frequency will not be changed).

– In gated burst mode, burst count is ignored. However, if you change the burst count from the remote interface while in the gated mode, the instrument remembers the new count and will use it when the triggered mode is selected.

Front Panel Operations

Press [Burst] > # of Cycles. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, press Enter to finish.



SCPI Command

```
[SOURce[1|2]:]BURSt:NCYCles {<num_cycles>|INFinity|MINimum|MAXimum}
```

Burst Period

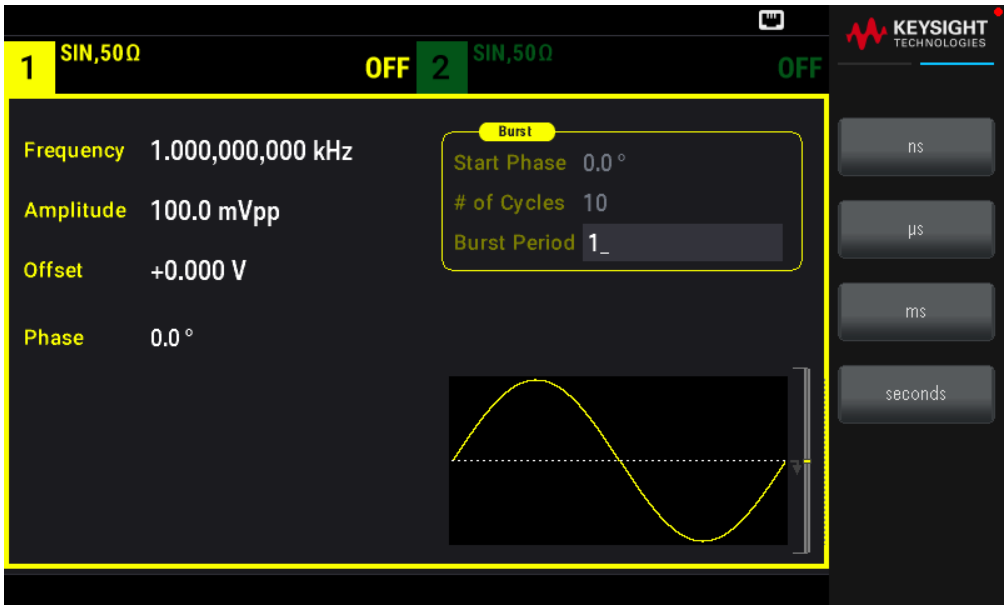
Burst period, which is used in internal triggered burst mode only, is the time from the start of one burst to the start of next burst (1 µs to 8000 s, default 10 ms). Burst period differs from "waveform frequency," which specifies the frequency of the bursted signal.

Burst period is used only when Immediate triggering is enabled. The burst period is ignored when manual or external triggering is enabled (or when the gated burst mode is selected).

You cannot specify a burst period that is too short for the instrument to output with the specified burst count and frequency. If the burst period is too short, the instrument will increase it as needed to continuously re-trigger the burst.

Front Panel Operations

Press [Burst] > Burst Period. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, select a prefix unit to finish.



SCPI Command

```
[SOURce[1|2]:]BURSt:INTernal:PERiod {<seconds>|MINimum|MAXimum}
```

Start Phase

Start phase of the burst, from -360 to +360 degrees (default 0).

– Specify the start phase units with UNIT:ANGLe.

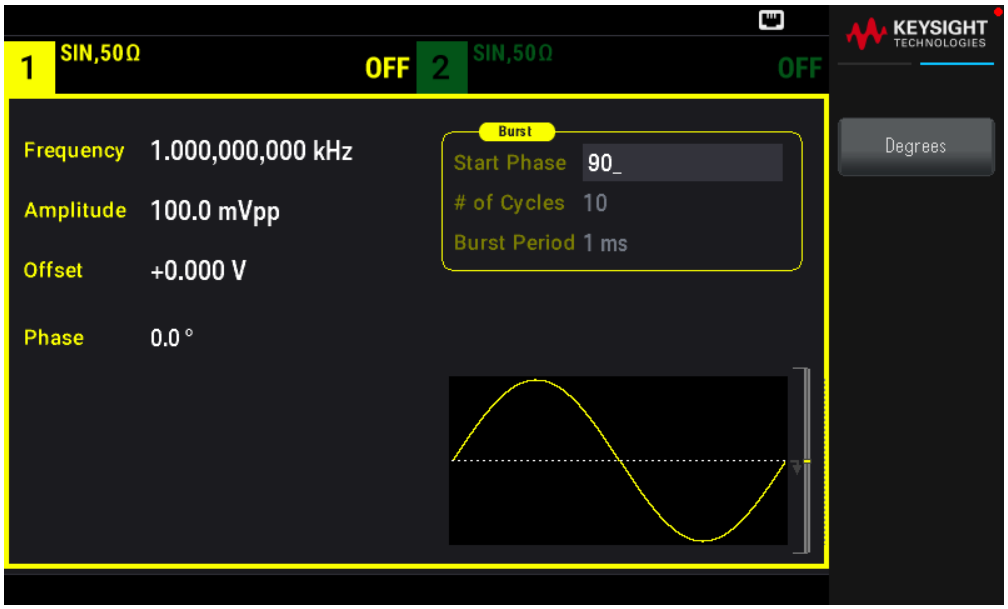
– Always displayed in degrees on front panel (never radians). If set in radians from remote interface, instrument converts value to degrees on the front panel.

– For sine, square, and ramp, 0 degrees is the point at which the waveform crosses 0 V(or DC offset) in a positive going direction. For arbitrary waveforms, 0 degrees is the first waveform point. Start phase has no effect on noise.

– Start phase also used in gated burst mode. When the gate signal goes false, the current waveform cycle finishes, and output remains at the voltage level of the starting burst phase.

Front Panel Operations

Press [Burst] > Start Phase. Use the numeric keypad or the knob and arrows to set a desired value. If you use the keypad, press Degrees to finish.



SCPI Command

```
[SOURce[1|2]:]BURSt:PHASe {<angle>|MINimum|MAXimum}
```

Burst Trigger Source

In triggered burst mode:

– The instrument outputs a waveform of the specified number of cycles (burst count) when a trigger is received. After the specified number of cycles have been output, the instrument stops and waits for next trigger.

– IMMediate (internal): the instrument outputs continuously when burst mode is enabled. The rate at which the burst is generated is determined by BURSt:INTernal:PERiod.

– EXTernal: the instrument accepts a hardware trigger at the front panel Ext Trig connector. The instrument outputs one burst of the specified number of cycles each time Ext Trig receives a level transition with the proper polarity (TRIGger[1|2]:SLOPe). External trigger signals during a burst are ignored.

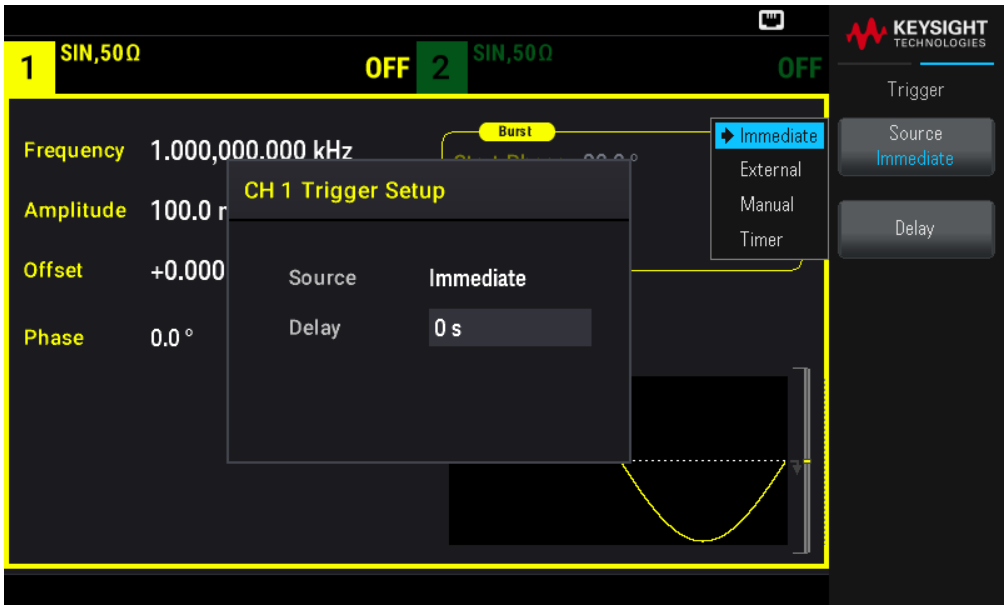
– BUS (software): the instrument initiates one burst each time a bus trigger (*TRG) is received. The front panel [Trigger] key is illuminated when the instrument is waiting for a bus trigger.

– EXTernal or BUS: burst count and burst phase remain in effect, but burst period is ignored.

– TIMer: trigger events are spaced by a timer, with the first trigger as soon as INIT occurs.

Front Panel Operations

Press [Trigger] > Trigger Setup > Source.



To specify whether the instrument triggers on a rising or falling edge of the signal at the Ext Trig connector, select the external trigger source before choosing Trigger Setup.

SCPI Command

```
TRIGger[1|2]:SOURce {IMMediate|EXTernal|TIMer|BUS}
TRIGger[1|2]:SLOPe {POSitive|NEGative}
```

See Triggering for more information.

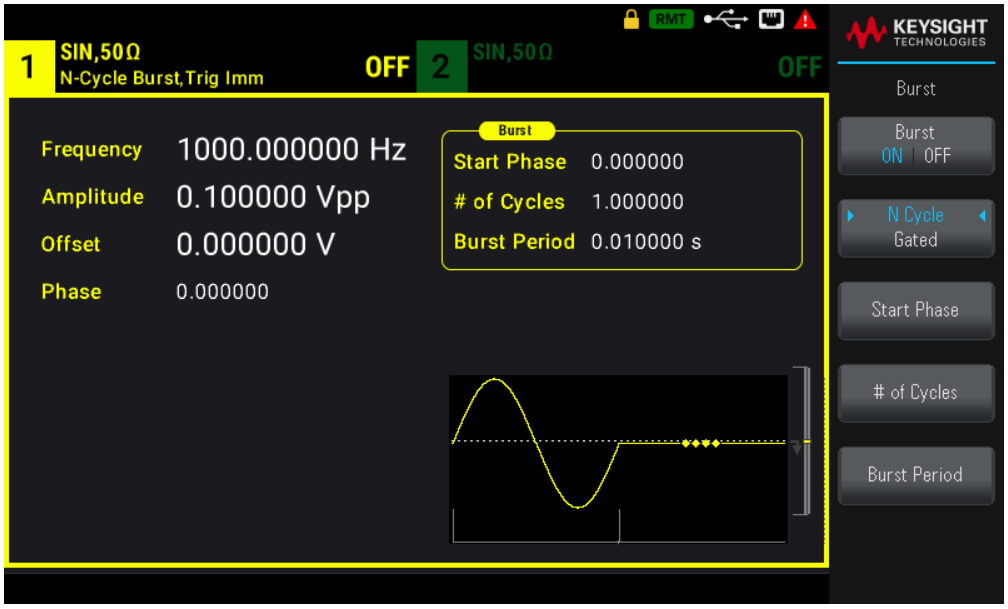
NOTE If the duty cycle is changed on a triggered bursted square wave with the trigger mode set to **Timer**, the current burst will finish and one more burst will be executed before the duty cycle of the burst changes.

Trigger Out Signal

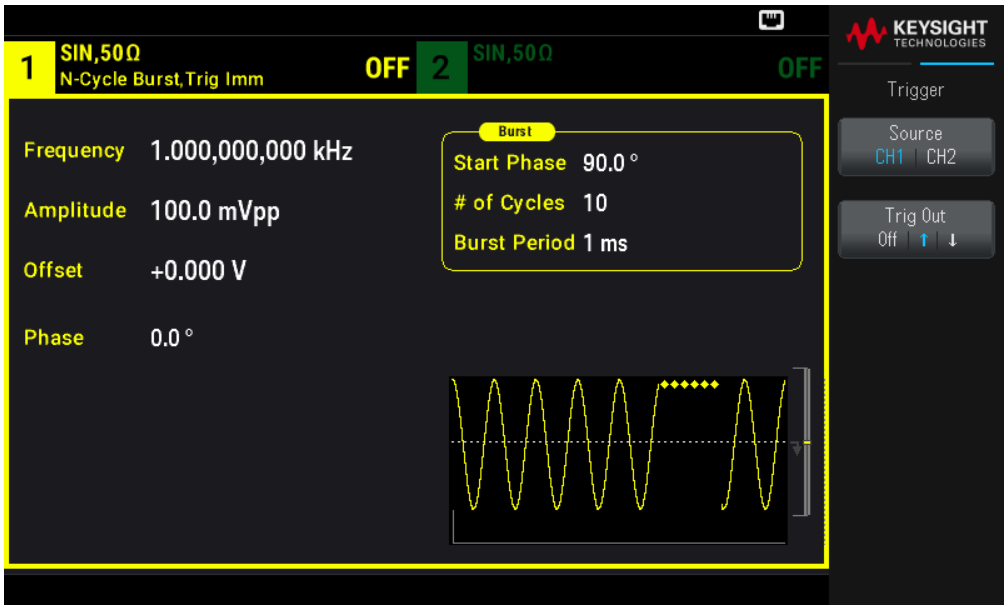
See Trigger Output Signal for more details.

Front Panel Operations

1. Press [Burst] > Burst ON | OFF > Burst ON | OFF.



2. Press [Trigger] > Trig Out Setup.
3. Then use this softkey to choose the desired edge direction: Press Trig Out Off | (Up) | (Down).



SCPI Command

```
OUTPut:TRIGger:SLOPe {POSitive|NEGative}

OUTPut:TRIGger {ON|1|OFF|0}
```

Triggering

This section describes the instrument's triggering system.

Trigger Overview

This triggering information applies to sweep and burst only. You can issue triggers for sweeps or bursts using internal triggering, external triggering, timer triggering, or manual triggering.

– Internal or "automatic" (default): Instrument outputs continuously when sweep or burst mode is selected.

– External: Uses front panel **Ext Trig** connector to control sweep or burst. The instrument initiates one sweep or outputs one burst each time **Ext Trig** receives a pulse. You can select whether instrument triggers on rising or falling edge.

– Manual: Triggering initiates one sweep or outputs one burst each time you press **[Trigger]** on the front panel.

– When you sweep a list, trigger moves the wave form to the next frequency in the list.

– The **[Trigger]** key is disabled when in remote and when a function other than burst or sweep is currently selected.

Trigger Sources

This triggering information applies to sweep and burst only. You must specify the source from which the instrument accepts a trigger.

– Sweep and Burst trigger source: **Immediate** (default), **External**, **Manual** or **Timer**.

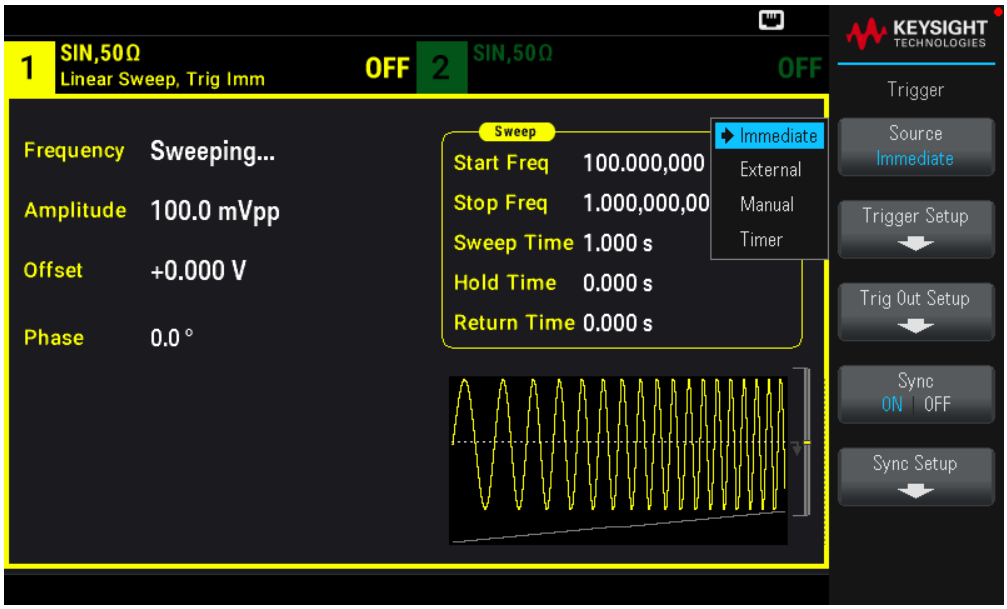
– The instrument will accept a manual trigger, a hardware trigger from the front panel **Ext Trig** connector, or continuously output sweeps or bursts using an internal trigger. You can also trigger bursts based on a timer. At power-on, immediate trigger is selected.

– Trigger source setting is volatile; set to internal trigger (front panel) or immediate (remote interface) by power cycle or *RST.

Front Panel Operations

Enable sweep or burst. Then:

Press **[Trigger]** > **Source**.



SCPI Command

```
TRIGger[1|2]:SOURce {IMMediate|EXTernal|TIMer|BUS}
```

The APPLy command automatically sets the source to Immediate.

Immediate Triggering

Internal trigger mode (default): Instrument continuously outputs sweep or burst (as specified by sweep time or burst period).

Front Panel Operations

Press [Trigger] > Source Immediate.

SCPI Command

```
TRIGger:SOURce IMMediate
```

Manual Triggering

Manual trigger mode (front panel only): You manually trigger the instrument by pressing [Trigger]. The instrument initiates one sweep or burst for each time you press [Trigger]. The button is lit when you are in the trigger menu and the instrument is waiting for a manual trigger. The button blinks when the instrument is waiting for a manual trigger, but you are not in the trigger menu. The key is disabled when the instrument is in remote.

Front Panel Operations

Press [Trigger] > Source Manual.

External Triggering

In external trigger mode, the instrument accepts a hardware trigger at the front panel **Ext Trig** connector. The instrument initiates one sweep or burst each time **Ext Trig** receives a TTL pulse with the specified edge. The external trigger mode is like the manual trigger mode except that you apply the trigger to the **Ext Trig** connector.

See Trigger Input Signal, below.

Front Panel Operations

Press **[Trigger]** > **Source** External.

To specify whether the instrument triggers on a rising or falling edge, press **Trigger Setup** and select the edge direction by pressing **Slope**.

SCPI Command

```
TRIGger:SOURce EXTernal
TRIGger[1|2]:SLOPe {POSitive|NEGative}
```

Software (Bus) Triggering

Available only from remote interface, this is similar to manual trigger mode from the front panel, but you trigger the instrument with a bus trigger command. The instrument initiates one sweep or outputs one burst each time a bus trigger command is received. The key blinks when a bus trigger command is received.

To select the bus trigger source, send TRIGger:SOURce BUS.

To trigger instrument from remote interface (USB, or LAN) when Bus source is selected, send TRIG or *TRG (trigger). The front panel **[Trigger]** key is illuminated when the instrument is waiting for a bus trigger.

Front Panel Operations

Press **[Trigger]** > **Source** Manual.

Timer Triggering

The timer trigger mode issues triggers a fixed period apart. To select the bus trigger source, send TRIGger:SOURce TIMer.

Front Panel Operations

Press **[Trigger]** > **Source** Timer.

Trigger Input Signal

This front panel connector is used in the following modes:

– Triggered Sweep Mode: Press [Trigger] > Trigger Setup > Source External, or execute TRIG:SOUR EXT (sweep must be enabled). When a level transition of the correct polarity is received on the Ext Trig connector, instrument outputs a single sweep.

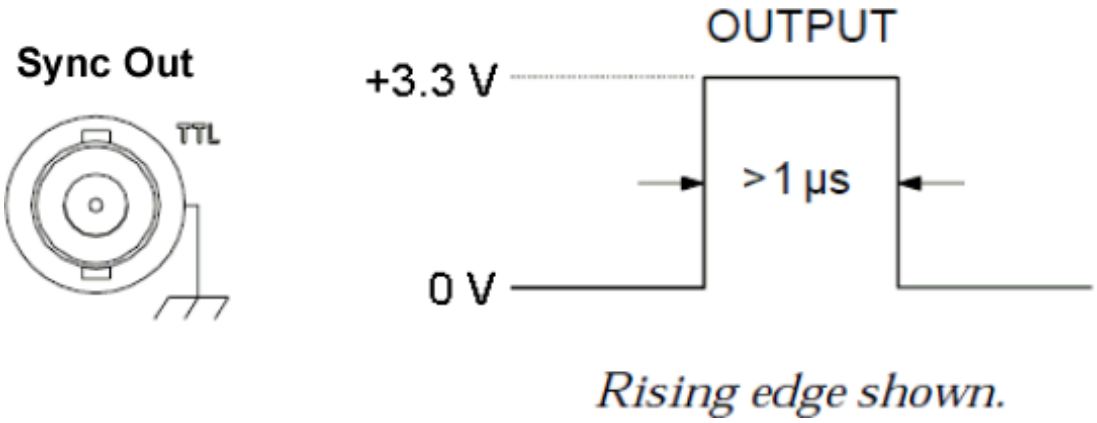
– Triggered Burst Mode: Press [Trigger] >Trigger Setup > Source External, or execute TRIG:SOUR EXT (burst must be enabled). The instrument outputs a waveform with specified number of cycles (burst count) each time a trigger is received from the specified trigger source.

– External Gated Burst Mode: Press the Gated softkey or execute BURS:MODE GAT with burst enabled. When external gate signal is true, instrument outputs a continuous waveform. When external gate signal goes false, the current waveform cycle completes and then instrument stops while remaining at voltage level corresponding to starting burst phase. For noise, output stops as soon as the gate signal goes false.

Trigger Output Signal

CAUTION **The trigger output signal is chassis referenced. Use appropriate care not to touch the two signals simultaneously as you are connecting or disconnecting these cables. De-energize connections to the instrument output before connecting or disconnecting these cables.**

– A "trigger out" signal is provided on the front panel Sync Out connector (used with burst and sweep only). When enabled, a pulse with either a rising edge (default) or falling edge is output from this connector at the beginning of the sweep or burst.



Rising edge shown.

– Internal (immediate) or Timer trigger source: Instrument outputs a square wave with a 50% duty cycle from the Sync Out connector at the beginning of the sweep or burst. Waveform period equals specified sweep time or burst period.

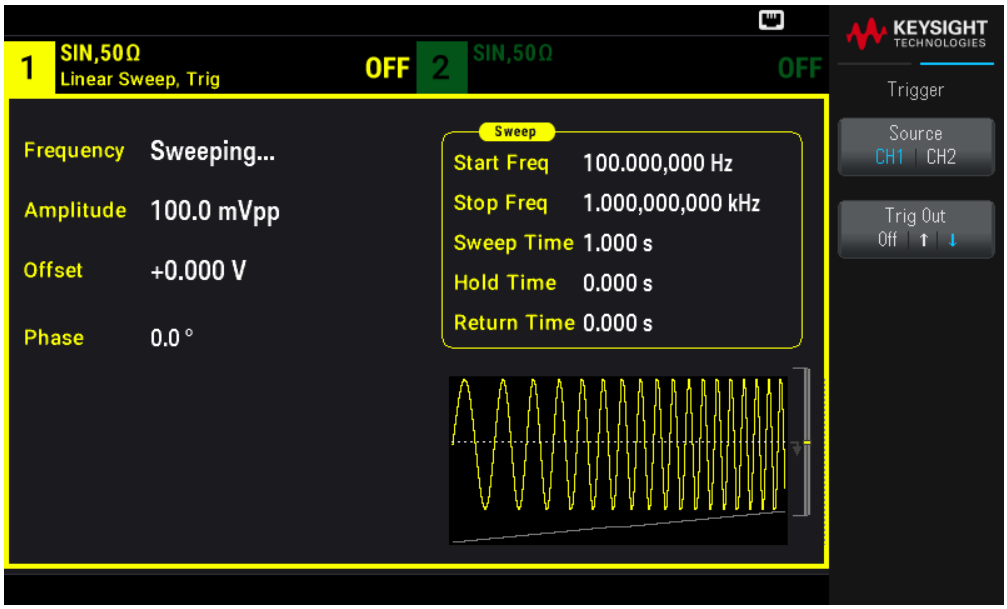
– External trigger source: Instrument disables "trigger out" signal.

– Bus (software) or manual trigger source: Instrument outputs a pulse (>1 µs pulse width) from Sync Out connector at beginning of each sweep or burst.

Front Panel Operations

1. Enable sweep or burst.
2. Then press [Trigger] > Trig Out Setup.

3. Then use this softkey to choose the desired edge direction: Trig Out Off | (Up) | (Down).



SCPI Command

```
OUTPut:TRIGger:SLOPe {POSitive|NEGative}
OUTPut:TRIGger {ON|1|OFF|0}
```

System-Related Operations

This section covers instrument state storage, power-down recall, error conditions, self test, and display control. Though unrelated to waveform generation, these operations are important for instrument operation.

Instrument State Storage

– There are two ways to store and retrieve instrument states:

  – Named state files, using the front panel or MMEMory:STORe:STATe and MMEMory:LOAD:STATe

  – Memory locations 0 through 4, using *SAV and *RCL

– Both state storage methods remember the selected function (including arbitrary waveforms), frequency, amplitude, DC offset, duty cycle, symmetry, and modulation parameters.

– Stored states are not affected by *RST; a stored state remains until overwritten or specifically deleted.

Front Panel Operations

See Store or Retrieve the Instrument State.

Instrument Power On State

You can configure instrument to power-down state from location 0 on power up. The factory default is to recall factory default state at power-on.

Front Panel Operations

Press [System] > Power On Setting > Power On Factory Default or Power On State 0.

SCPI Command

```
MEMory:STATe:RECall:AUTO {ON|1|OFF|0}
```

Error Conditions

Up to 20 command syntax or hardware errors can be stored in the error queue. See "SCPI Error Messages" in the *EDU33210 Series Programming Guide* for more information.

Front Panel Operations

Press [System] > Help > Error View.

SCPI Command

```
SYSTem:ERRor?
```

Beeper Control

The instrument normally beeps when an error is generated from the front panel or remote interface.

This setting is non-volatile; it will not be changed by power cycling or *RST.

Front Panel Operations

Press [System] > User Settings > Beeper ON | OFF.

SCPI Command

```
SYSTem:BEEPer:STATe {ON|1|OFF|0}
SYSTem:BEEPer
```

Key Click

The instrument emits a click when a front panel key or softkey is pressed.

This setting is non-volatile; it will not be changed by power cycling or *RST.

Front Panel Operations

Press [System] > User Settings > Key Click ON | OFF.

SCPI Command

```
SYSTem:CLICk:STATe {ON|1|OFF|0}
```

Turn off the Display

For security reasons, or to speed up the rate at which the instrument executes remote interface commands, you may want to turn off the display.

Front Panel Operations

Press [System] > User Settings > Display ON | OFF.

Press any key to turn the display back on.

SCPI Command

```
DISPlay {ON|1|OFF|0}
```

Display Brightness

You can set the display brightness to auto dim (100% to 10%) after 2 minutes of inactivity. You may set this feature from the front panel only.

This setting is non-volatile; it will not be changed by power cycling or *RST.

Front Panel Operations

Press [System] > User Settings > Auto Dimming ON | OFF.

Date and Time

You can set the instrument's date and time clock.

Front Panel Operations

Press [System] > User Settings > Date / Time.

SCPI Command

```
SYSTem:DATE <yyyy>, <mm>, <dd>
SYSTem:TIME <hh>, <mm>, <ss>
```

Manage Files

You can perform file management tasks, including copying, renaming, deleting, and creating new folders.

Front Panel Operations

Press [System] > Store/Recall > File Manager.

You can copy, rename, or delete files or folders. Deleting a folder removes all of the files within the folder, so be sure that you want to delete all of the files within the folder.

The most important softkey is Switch Pane, which allows you to specify the location of the action to perform. Once you have chosen the location of the action to perform, press Select to select the file to manage. Once you are completely prepared to execute the task, press Rename, Copy, or Delete.

SCPI Command

See "MEMory" and "MMEMory subsystems" in the *EDU33210 Series Programming Guide*.

Self-Test

A limited power-on self-test occurs when you turn on the instrument to assure you that the instrument is operational. You can also run a more complete self-test. For details, see "Self-Test Procedures" in the *EDU33210 Series Service Guide*.

Front Panel Operations

Press [System] > Instr. Setup > Self Test.

SCPI Command

```
*TST
```

Firmware Revision Query

Send *IDN? to determine which revision of firmware is currently installed. The query returns a string of the form:

Keysight Technologies,[Model Number],[10-char Serial Number],[Firmware Revision Number]

Firmware revision number example: K-01.00.04-01.00-01.00-01.00-01.00

Front Panel Operations

Press [System] > Help > About. Scan the QR code shown to view the documentation related to this instrument.

SCPI Command

```
*IDN?
```

SCPI Language Version Query

The instrument complies with the rules and conventions of the present version of SCPI (Standard Commands for Programmable Instruments). Use SYSTem:VERSion? to determine the SCPI version with which the instrument complies. The query returns a string in the form "YYYY.V", representing the year and version number for that year (for example, 1999.0).

I/O Config

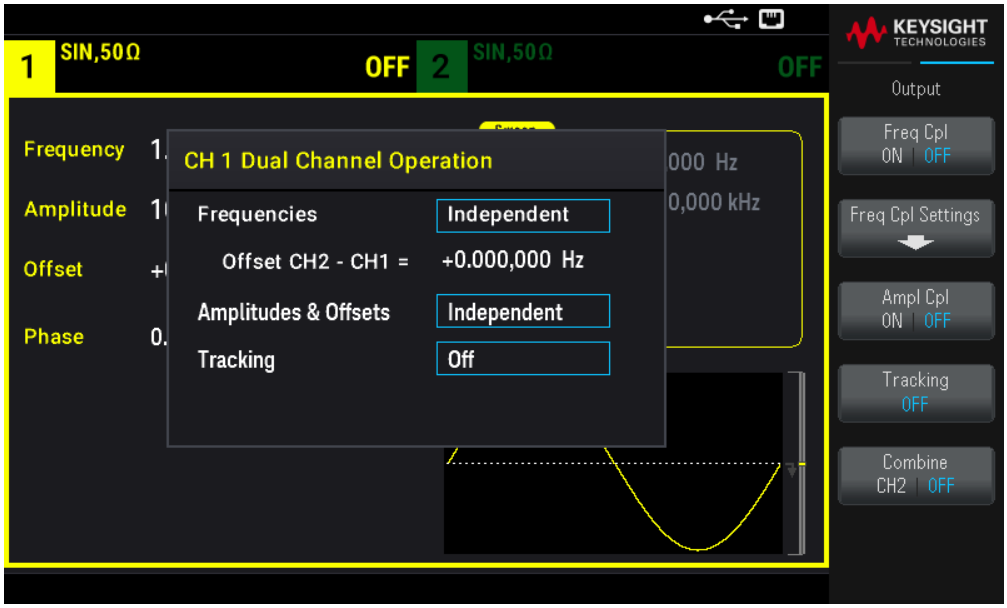
See Remote Interface Connections and Remote Interface Configuration for more details.

Dual Channel Operations

This section covers most topics related to dual channel operation.

Entering Dual Channel Operation

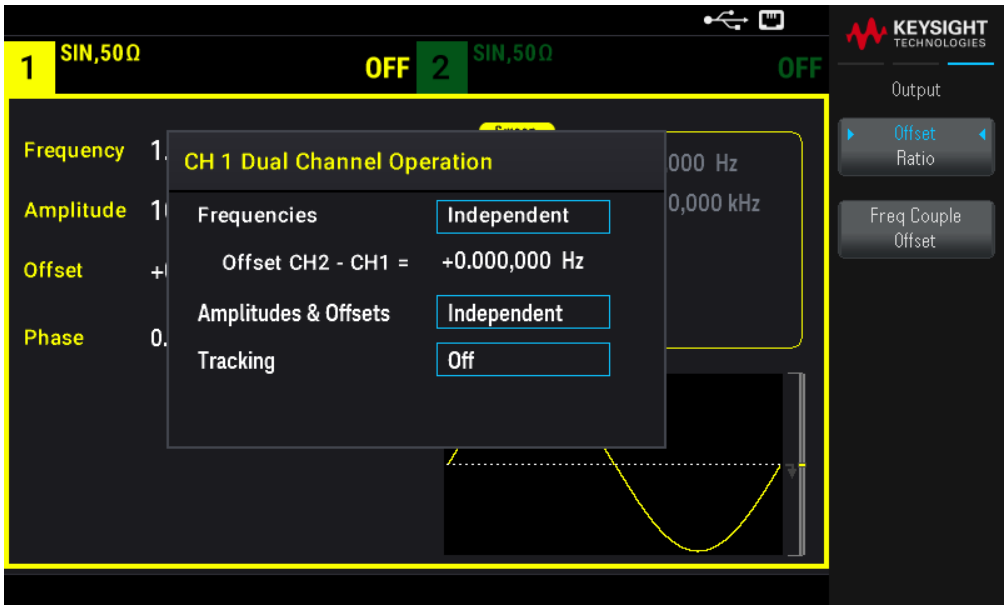
You enter dual channel configuration by pressing a channel output button, then **Dual Channel**.



Frequency Coupling

Frequency coupling allows you to couple frequencies or sample rates between channels, either by a constant ratio or offset between them. Press **Freq Cpl** ON | OFF to turn frequency coupling on or off, and press **Freq Cpl Settings** to configure frequency coupling.

The **Freq Cpl Settings** softkey opens the menu shown below. The first softkey allows you to specify whether you want to couple the frequencies with a ratio or an offset, and the second softkey allows you to specify the ratio or offset.



Amplitude Coupling

Amplitude coupling, enabled by the **Ampl Cpl** ON | OFF softkey, couples the amplitude and offset voltage between the channels so that changing the amplitude or offset on one channel affects both channels.

Tracking

Tracking, configured by the **Tracking** softkey, has three modes: **OFF**, **Identical**, and **Inverted**.

– When tracking is OFF, the two channels operate independently.

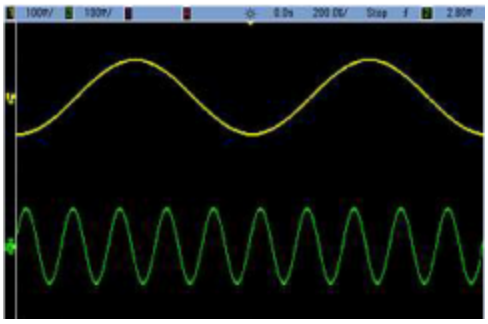
– When tracking is Identical, they behave as one channel.

– The third mode, Inverted, makes the channels' outputs inverses of each other, resulting in a differential channel using both outputs.

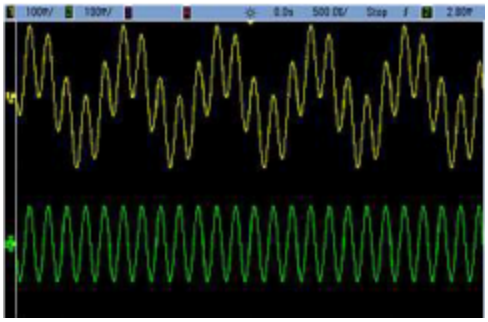
Combine

The **Combine** feature combines two outputs into one connector. If you choose CH2 from the Channel 1 menu, they are combined on channel 1; choosing CH1 from the Channel 2 menu combines them on channel 2.

In the image below, the top waveform is a 100 mVpp, 1 kHz sine wave on channel 1, and the bottom waveform is a 100 mVpp, 5 kHz sine wave on channel 2.

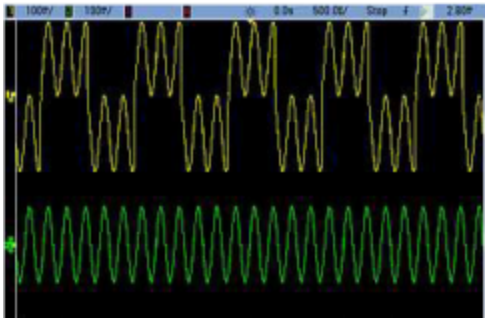


The image below shows the two outputs combined on channel 1. Note that the X-axis has been compressed (zoomed out) to show more cycles.

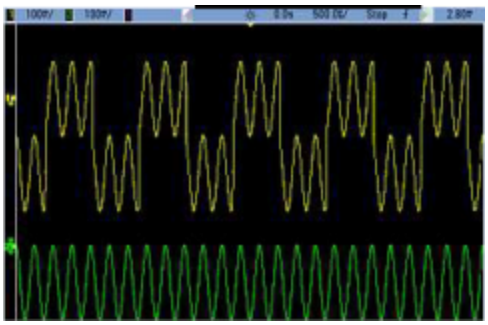


Operating Information

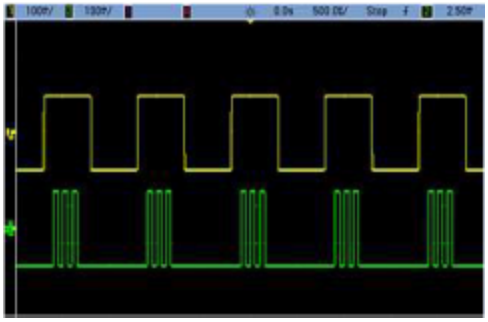
The signals being combined do not have to be of the same type; for example, this image shows the same 5 kHz channel on channel 2 combined with a 100 mVpp square wave on channel 1.



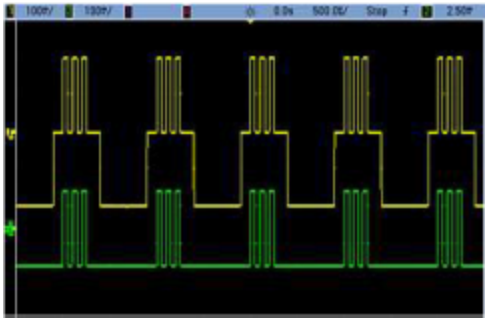
When signals are combined, the DC Offset values are not added together. Only the DC Offset from the receiving channel is used in the combined output. The figure below shows 50 a mV DC Offset added to Channel 1. The 50 mV offset added to Channel 2 is ignored.



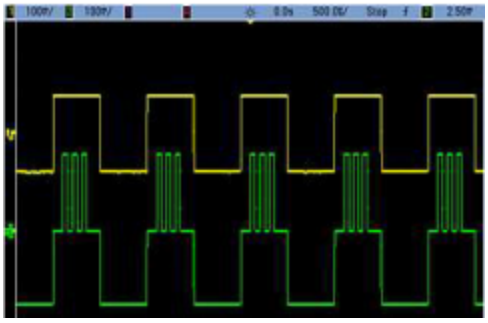
You may also use Combine with bursts. For example, consider the image below, which includes a 1 kHz sine wave on channel 1 and three-cycle bursts of a 5 kHz sine wave on channel 2.



When these signals are combined on channel 1, the result is a simple amplitude addition of the two signals, as shown below.



You also can combine the signals on channel 2, as shown below.



5 Characteristics and Specifications

For the characteristics and specifications of the EDU34450A 5½ Digit Digital Multimeter, refer to the data sheet at: https://www.keysight.com/us/en/assets/3120-1004/data-sheets/EDU33210-Series-20-MHz-Function-Arbitrary-Waveform-Generators.pdf.

6 Measurement Tutorial

This section describes theory of operation information for several waveform types and instrument operating modes. The last two topics include information that may help you improve signal quality.

Arbitrary Waveforms

Arbitrary waveforms can meet needs not met by the instrument's standard waveforms. For example, you might need a unique stimulus, or you might want to simulate signal imperfections such as overshoot, ringing, glitching, or noise. Arbitrary waveforms can be very complex, making them suitable for simulating signals in modern communications systems.

You can create arbitrary waveforms from a minimum of 8 points up to 1,000,000 points. The instrument stores these numeric data points, known as "samples," in memory and then converts them into voltages as the waveform is generated. The frequency at which points are read is the "sample rate," and the waveform frequency equals the sample rate divided by the number of points in the waveform. For example, suppose a waveform has 40 points and the sample rate is 10 MHz. The frequency would be (10 MHz)/40 = 250 kHz and its period would be 4 µs.

Waveform Filters

The instrument includes two filters to smooth transitions between points as arbitrary waveforms are generated.

- Normal filter: A wide, flat frequency response, but its step response exhibits overshoot and ringing
- Step filter: A nearly ideal step response, but with more roll-off in its frequency response than the Normal filter
- Off: Output changes abruptly between points, with a transition time of approximately 10 ns.

Each filter's cutoff frequency is a fixed fraction of the waveform's sample rate. The Normal filter's response is -3 dB at 27% of the sample rate and the Step filter's response is -3 dB at 13% of the sample rate. For example, for an arbitrary waveform at 100 MSa/s, the Normal filter's -3 dB frequency bandwidth is 27 MHz.

Turning the filter off may change the sample rate to a lower rate if the sample rate was greater than 250 MSa/s before the filter was turned off.

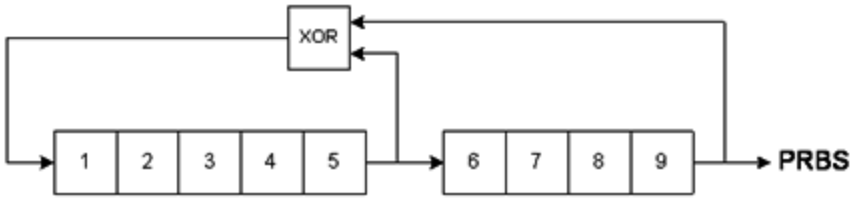
Quasi-Gaussian Noise

The Noise waveform is optimized for both quantitative and qualitative statistical properties. It does not repeat for more than 50 years of continuous operation. Unlike a true Gaussian distribution, there is zero probability of getting a voltage beyond the instrument's Vpp setting. The crest factor (peak voltage divided by RMS voltage) is approximately 4.6.

You can vary the Noise bandwidth from 1 mHz to the instrument's maximum bandwidth. The energy in the noise signal is concentrated in a band from DC to the selected bandwidth, so the signal has greater spectral density in the band of interest when the bandwidth setting is lower. In audio work, for example, you might set the bandwidth to 30 kHz, to make the audio band signal strength 30 dB higher than if the bandwidth were set to 30 MHz.

PRBS

A Pseudo-Random Bit Sequence (PRBS) has two levels (high and low), and it switches between them in a manner that is difficult to predict without knowing the sequence generation algorithm. A PRBS is generated by a linear-feedback shift register (LFSR), shown below.



An LFSR is specified by the number of stages it contains and which stages ("taps") feed the exclusive-or (XOR) gates in its feedback network. The PRBS output is taken from the last stage. With properly chosen taps, an L-stage LFSR produces a repetitive PRBS of length $2^L - 1$. The clocking frequency of the LFSR determines the "bit rate" of the PRBS.

You can set L to 7, 9, 11, 15, 20, or 23, resulting in sequences from 127 to 8,388,607 bits in length.

The default value for L is 7, resulting in a sequence of 127 bits in length.

Modulation

Amplitude Modulation (AM)

The instrument implements two forms of AM:

– Double-sideband full-carrier (DSB-FC), which has an ITU designation of A3E and is used in AM broadcasting.

The equation for DSB-FC is

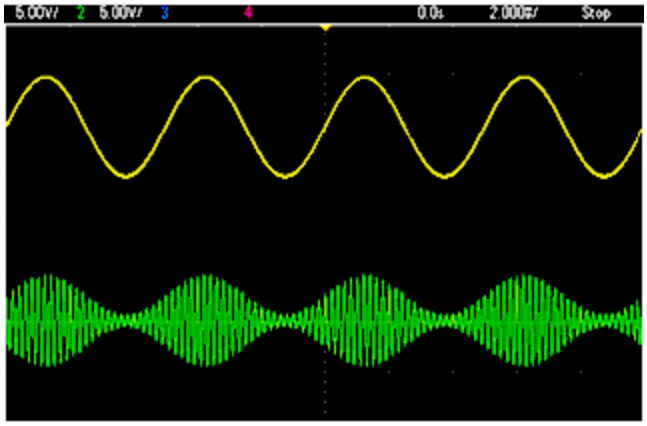
$$y(t) = [(½)+(½)\cdot d\cdot m(t)]\cdot A_C\cdot \sin(\omega_C t)$$

where

m(t) is the modulating signal
A_C is the carrier amplitude
ω_C is the carrier frequency of the carrier
d is the "modulation depth," or fraction of the amplitude range is used by the modulation

For example, a depth setting of 80% varies the amplitude from 10% to 90% of the amplitude setting (90% - 10% = 80%) with either an internal or a full-scale (±5 V) external modulating signal. You may set depth as high as 120%, as long as you do not exceed the instrument's maximum output voltage of (±5 V into 50 Ω, ±10 V into high impedance).

The top trace below represents the modulating signal; the bottom trace represents the modulated carrier.



– Double-sideband suppressed-carrier (DSSC). Many modern communications systems employ DSSC on each of two carriers that have the same frequency but a 90-degree phase difference. This is called quadrature amplitude modulation (QAM).

The equation for DSSC is

$$y(t)=d \cdot m(t) \cdot \sin(\omega_C t)$$

In DSB-SC, the carrier signal is inverted whenever $m(t) < 0$. For QAM, the second carrier signal would be $\cos(\omega_C t)$, making it 90 degrees out of phase from the first carrier.

Frequency Modulation (FM)

Frequency modulation varies a carrier signal's frequency according to the modulating signal:

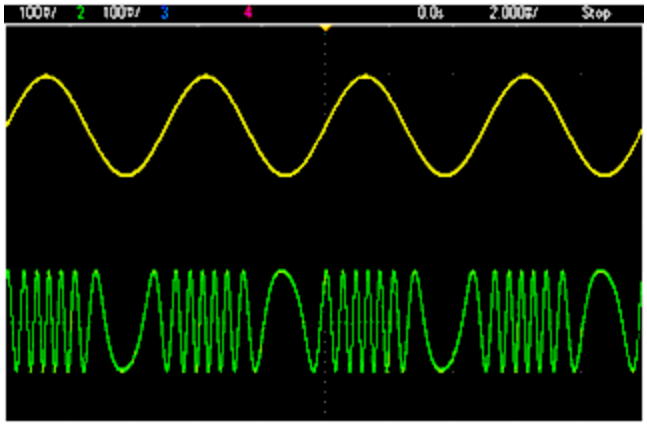
$$y(t)=A_C \cdot \sin[(\omega_C+d \cdot m(t)) \cdot t]$$

where m(t) is the modulating signal and d is the frequency deviation. FM is called narrowband if the deviation is less than 1% of the modulating signal's bandwidth, and wideband otherwise. You can approximate the modulated signal's bandwidth with the following equations.

$$BW \approx 2 \cdot (\text{Modulating Signal Bandwidth})$$ for narrowband FM

$$BW \approx 2 \cdot (\text{Deviation}+\text{Modulating Signal Bandwidth})$$ for wideband FM

The top trace below represents the modulating signal; the bottom trace represents the modulated carrier.



Phase Modulation (PM)

PM is similar to FM, but the phase of the carrier waveform is varied, rather than the frequency:

$$y(t)=\sin[\omega_c t+d\cdot m(t)]$$

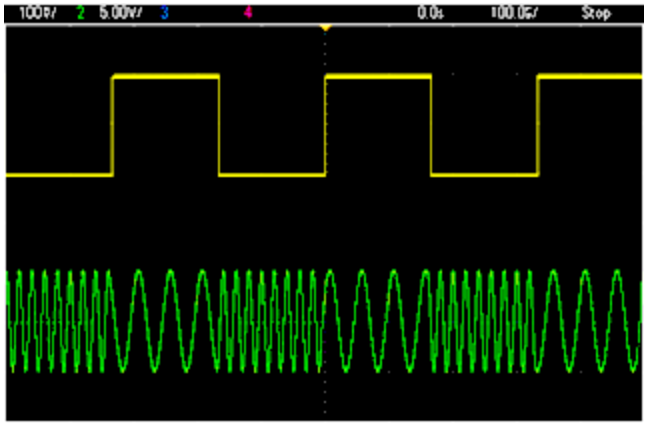
where m(t) is the modulating signal and d is the phase deviation.

Frequency-Shift Keying (FSK) Modulation

FSK is similar to FM, except the carrier frequency alternates between two preset values, the carrier frequency and the hop frequency. Sometimes the hop and carrier frequencies are called "Mark" and "Space," respectively. The rate at which the switching between these values occurs is determined by an internal timer or the signal on the front panel **Ext Trig** connector. Frequency changes are instantaneous and phase-continuous.

The internal modulating signal is a square wave with 50% duty cycle.

The top trace below represents the modulating signal; the bottom trace represents the modulated carrier.



Binary Phase Shift Keying (BPSK)

BPSK is similar to FSK, except it is the carrier's phase, rather than its frequency, that switches between two values. The rate at which the switching between these values occurs is determined by an internal timer or the signal on the front panel **Ext Trig** connector. Phase changes are instantaneous.

The internal modulating signal is a square wave with 50% duty cycle.

Pulse Width Modulation (PWM)

PWM is only available for the Pulse waveform, and the pulse width varies according to the modulating signal. The amount by which the pulse width varies is called the width deviation, and it can be specified as a percentage of the waveform period (that is, duty cycle) or in units of time. For example, if you specify a pulse with 20% duty cycle and then enable PWM with a 5% deviation, the duty cycle varies from 15% to 25% under control of the modulating signal.

Additive Modulation (Sum)

The "Sum" feature adds the modulating signal to the carrier. For example, you can add controlled amounts of variable-bandwidth noise to a signal or create two-tone signals. The instrument's internal modulation generator can produce the same continuous waveform as the main generator, so the Sum function lets you to create many signals that would have required two instruments before.

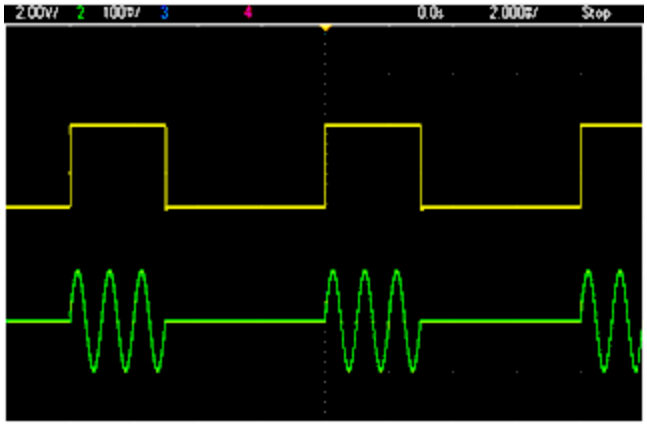
The Sum feature increases the amplitude of the output signal by the amplitude of the modulating signal. This might cause the instrument to switch to a higher output-voltage range, resulting in a momentary signal loss. If this is a problem in your application, turn on the Range Hold function. If the voltage increase could damage your device under test, apply Voltage Limits.

Burst

You can configure the instrument to output a waveform with for a specified number of cycles, called a burst. You can use burst in one of two modes: N-Cycle Burst (also called "triggered burst") or Gated Burst.

An N-Cycle burst consists of a specific number of waveform cycles (1 to 1,000,000) and is always initiated by a trigger event. You can also set the burst count to "Infinite," which results in a continuous waveform once the instrument is triggered.

In the image below, the top trace is the sync output, and the bottom one is the main output.



Three-Cycle Burst Waveform

For bursts, the trigger source can be an external signal, an internal timer, the key, or a command from the remote interface. The input for external trigger signals is the front panel **Ext Trig** connector. This connector is referenced to chassis ground (not floating ground). When not used as an input, the **Ext Trig** connector can be configured as an output to enable the instrument to trigger other instruments at the same time that its internal trigger occurs.

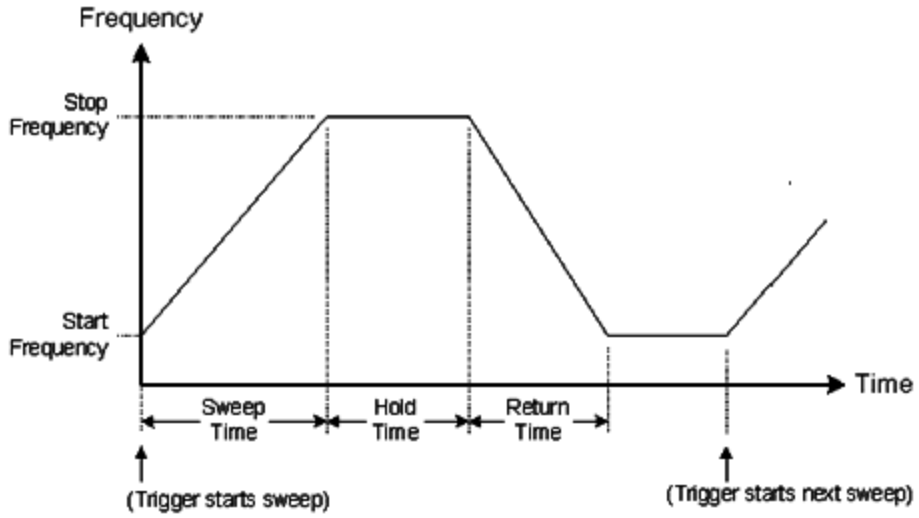
An N-Cycle burst always begins and ends at the same point in the waveform, called the start phase.

In GATed burst mode, the output waveform is on or off, based on the signal at the front panel **Ext Trig** connector. Select this signal's polarity using BURSt:GATE:POLarity. When the gate signal is true, the instrument outputs a continuous waveform. When the gate signal goes false, the current waveform cycle is completed and the instrument stops and remains at the voltage level corresponding to the waveform's starting burst phase. For a noise waveform, the output stops immediately when the gate signal goes false.

Frequency Sweep

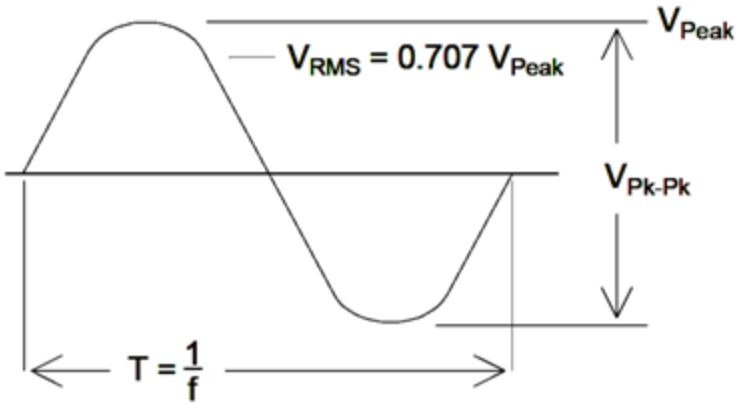
Frequency sweeping is similar to FM, but no modulating waveform is used. Instead, the instrument sets the output frequency based on either a linear or logarithmic function, or a list of up to 128 user-specified frequencies. A linear sweep changes the output frequency by a constant number of Hz per second, and a logarithmic sweep changes the frequency by a constant number of decades per second. Logarithmic sweeps let you cover wide frequency ranges where resolution at low frequencies could be lost with a linear sweep.

Frequency sweeps are characterized by a sweep time (during which the frequency changes smoothly from the start frequency to the stop frequency), a hold time (during which the frequency stays at the stop frequency), and a return time (during which the frequency returns smoothly and linearly to the start frequency). Trigger settings determine when the next sweep begins.



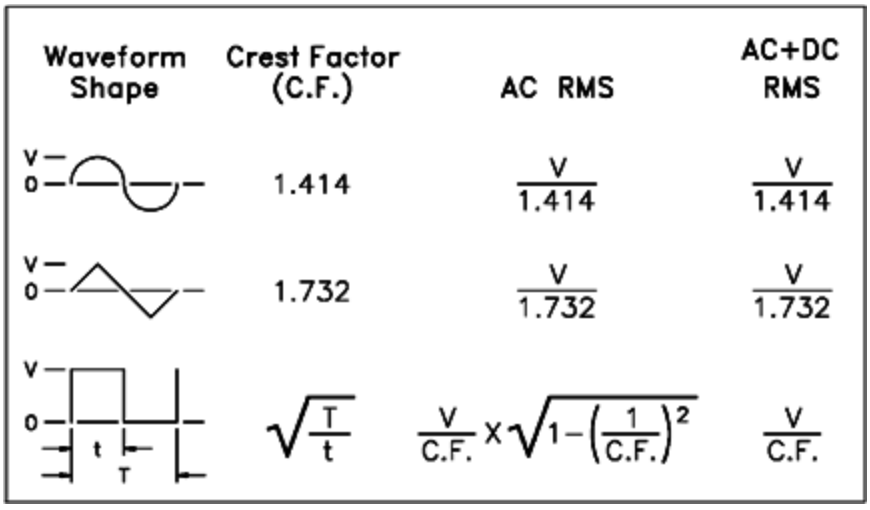
Attributes of AC Signals

The most common AC signal is a sine wave. In fact, any periodic signal can be represented as the sum of different sine waves. The magnitude of a sine wave is usually specified by its peak, peak-to-peak, or root mean-square (RMS) value. All of these measures assume that the waveform has zero offset voltage.



A waveform's peak voltage is the maximum absolute value of all of its points. The peak-to-peak voltage is the difference between the maximum and minimum. The RMS voltage equals the standard deviation of all waveform points; it also represents the one-cycle average power in the signal, minus the power in any DC component of the

signal. Crest factor is the ratio of a signal's peak value to its RMS value and varies according to waveshape. The table below shows several common waveforms with their respective crest factors and RMS values.



If an average-reading voltmeter is used to measure the "DC voltage" of a waveform, the reading may not agree with the DC Offset setting. This is because the waveform may have a non-zero average value that would be added to the DC Offset.

You may occasionally see AC levels specified in "decibels relative to 1 milliwatt" (dBm). Since dBm represents a power level, you need to know the signal's RMS voltage and the load resistance in order to make the calculation.

$dBm = 10 \times \log_{10} (P / 0.001)$ where $P = VRMS^2 / RL$

For a sine wave into a 50 Ω load, the following table relates dBm to voltage.

dBm	RMS Voltage	Peak-to-Peak Voltage
+23.98 dBm	3.54 Vrms	10.00 Vpp
+13.01 dBm	1.00 Vrms	2.828 Vpp
+10.00 dBm	707 mVrms	2.000 Vpp
+6.99 dBm	500 mVrms	1.414 Vpp
3.98 dBm	354 mVrms	1.000 Vpp
0.00 dBm	224 mVrms	6 32 mVpp
-6.99 dBm	100 mVrms	283 mVpp
-10.00 dBm	70.7 mVrms	200 mVpp
-16.02 dBm	35.4 mVrms	100 mVpp
-30.00 dBm	7.07 mVrms	20.0 mVp
-36.02 dBm	3.54 mVrms	10.0 mVpp
-50.00 dBm	0.707 mVrms	2.00 mVpp
-56.02 dBm	0.354 mVrms	1.00 mVpp

For 75 Ω or 600 Ω loads, use the following conversions:

dBm (75 Ω) = dBm (50 Ω) – 1.76

dBm (600 Ω) = dBm (50 Ω) – 10.79

Signal Imperfections

For sine waves, common signal imperfections are easiest to describe and observe in the frequency domain, using a spectrum analyzer. Any output signal component with a frequency different from the fundamental (or "carrier") is considered to be distortion. Those imperfections can be categorized as harmonic distortion, non-harmonic spurious, or phase noise, and they are specified in decibels relative to the carrier level, or "dBc."

Harmonic Distortion

Harmonic components occur at integer multiples of the fundamental frequency and are usually created by non-linear components in the signal path. At low signal amplitudes, another possible source of harmonic distortion is the Sync signal, which is a square wave with many strong harmonic components that can couple into the main signal. Although Sync is highly isolated from the instrument's main signal outputs, coupling can occur in external cabling. For best results, use high-quality coaxial cables with double or triple shields. If Sync is not required, leave it unconnected or off.

Non-Harmonic Spurious

One source of non-harmonic spurious components (called "spurs") is the digital-to-analog converter (DAC) that converts the digital waveform values into voltage. Non-linearity in this DAC gives rise to harmonics that can be higher than the Nyquist frequency and will therefore be aliased to a lower frequency. For example, the fifth harmonic of 30 MHz (150 MHz) could create a spur at 100 MHz.

Another source of non-harmonic spurs is the coupling of unrelated signal sources (such as the embedded controller's clocks) into the output signal. These spurs usually have constant amplitude and are most troublesome at signal amplitudes below 100 mVpp. For optimal signal purity at low amplitudes, keep the instrument's output level relatively high and use an external attenuator.

Phase Noise

Phase noise results from small, instantaneous changes in the output frequency ("jitter"). On a spectrum analyzer, it appears as a rise in the apparent noise floor near the frequency of the output signal. The phase noise specification represents the amplitudes of the noise in 1 Hz bands located 1 kHz, 10 kHz, and 100 kHz away from a 30-MHz sine wave. Be aware that spectrum analyzers also have phase noise, so the levels you read may include analyzer phase noise.

Quantization Noise

Finite resolution in the waveform DAC causes voltage quantization errors. Assuming the errors are uniformly distributed over a range of ±0.5 least-significant bit, the equivalent noise level for standard waveforms is approximately -95 dBc. At this level, other sources of noise in the instrument dominate. Quantization noise can be of concern, though, in arbitrary waveforms that do not use the whole range of DAC codes (-32767 to +32767). Scale arbitrary waveforms to use the entire range, if possible.

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