Instruments.uni-trend.com

UTG4000X Series

Function/Arbitrary Waveform Generators

User Manual

This document applies to the following models:

UTG4000X Series

V1.0

December, 2025

Foreword

Thank you for choosing this UNI-T instrument. For safe and proper use of this instrument, please read this manual carefully, especially the safety instructions section.

After reading this manual, it is recommended to keep the manual in a convenient location, preferably near the device, for future reference.

Chapter 1 Instructions Manual

This chapter introduces the safety requirements and the basic operation of the UTG4000X series function/arbitrary waveform generator.

1.1 Inspecting Packaging and List

Upon receiving the instrument, please check the packaging and list as follows.

1. Check whether the shipping box and cushioning materials show any signs of compression or damage from external impact. Also, inspect the instrument's exterior for visible damage. If you have any concerns about the product or require assistance, please contact your distributor or local service office.
2. Carefully remove the instrument from the package and compare the items received against the packing list.

1.2 Safety Information

This chapter contains information and warnings that must be observed. Ensure that the instrument is operated under the safe conditions. In addition to the safety precautions indicated in this chapter, you must also follow accepted safety procedures.

Safety Precautions

Safety Precautions	
Warning	**Please follow these guidelines to avoid possible electric shock and risk to personal safety.**
	Users must adhere to standard safety precautions during the operation, servicing, and maintenance of this device. UNI-T will not be liable for any personal safety and property loss caused by the user's failure following the safety precautions. This device is designed for professional users and responsible organizations for measurement purposes. Do not use this device in any manner not specified by the manufacturer. This device is intended for indoor use only, unless otherwise stated in the product manual.
Safety Statements	
Warning	**"Warning" indicates the presence of a hazard. It warns users to pay attention to a certain operation process, operation method or similar. Personal injury or death may occur if the rules in the "Warning" statement are not properly executed or observed. Do**

	not proceed to the next step until you fully understand and meet the conditions stated in the "Warning" statement.
Caution	**"Caution" indicates the presence of a hazard. It warns users to pay attention to a certain operation process, operation method or similar. Product damage or loss of important data may occur if the rules in the "Caution" statement are not properly executed or observed. Do not proceed to the next step until you fully understand and meet the conditions stated in the "Caution" statement.**
Note	**"Note" indicates important information. It reminds users to pay attention to procedures, methods, and conditions, etc. The contents of "Note" should be highlighted if necessary.**

Safety Signs

	Danger	It indicates danger of electric shock, which may cause personal injury or death.
	Warning	It indicates that there are factors you should be cautious about to prevent personal injury or product damage.
	Caution	It indicates danger, which may cause damage to this device or other equipment if you fail to follow a certain procedure or condition. If the "Caution" sign is present, all conditions must be met before you proceed to the operation.
	Note	It indicates potential problems, which may cause failure of this device if you fail to follow a certain procedure or condition. If the "Note" sign is present, all conditions must be met before this device will function properly.
	AC	Alternate current of the device. Please check the region's voltage range.
	DC	Direct current device. Please check the region's voltage range.
	Grounding	Frame and chassis grounding terminal
	Grounding	Protective grounding terminal
	Grounding	Measurement grounding terminal
	OFF	Main power off
	ON	Main power on
	Power	Standby power supply: When the power switch is turned off, this device is not completely disconnected from the AC power supply.
CAT I	Secondary electrical circuit connected to wall sockets through	

		transformers or similar equipment, such as electronic instruments and electronic equipment; electronic equipment with protective measures, and any high-voltage and low-voltage circuits, such as the copier in the office.
CAT II		Primary electrical circuit of the electrical equipment connected to the indoor socket via the power cord, such as mobile tools, home appliances, etc. Household appliances, portable tools (e.g., electric drill), household sockets, sockets more than 10 meters away from CAT III circuit or sockets more than 20 meters away from CAT IV circuit.
CAT III		Primary circuit of large equipment directly connected to the distribution board and circuit between the distribution board and the socket (three-phase distributor circuit includes a single commercial lighting circuit). Fixed equipment, such as multi-phase motor and multi-phase fuse box; lighting equipment and lines inside large buildings; machine tools and power distribution boards at industrial sites (workshops).
CAT IV		Three-phase public power unit and outdoor power supply line equipment. Equipment designed to “initial connection,” such as power distribution system of power station, power instrument, front-end overload protection, and any outdoor transmission line.
CE	**Certification**	CE indicates a registered trademark of EU.
UK CA	**Certification**	UKCA indicates a registered trademark of United Kingdom.
Intertek 4007682	**Certification**	Conforms to UL STD 61010-1 and 61010-2-030. Certified to CSA STD C22.2 No.61010-1 and 61010-2-030.
	Waste	Do not place equipment and accessories in the trash. Items must be properly disposed of in accordance with local regulations.
40	**EEUP**	This environment-friendly use period (EFUP) indicates that dangerous or toxic substances will not leak or cause damage within this indicated time period. The environmentally friendly use period of this product is 40 years, during which it can be used safely. Upon expiration of this period, it should enter the recycling system.
Safety Requirements		
Warning		
Preparation before use		Please connect this device to the AC power supply with the power cable provided. The AC input voltage of the line reaches the rated value of this device. See the product manual for a specific rated value. The line voltage switch of this device matches the line voltage. The line voltage of the line fuse of this device is correct.

	This device is not intended for measuring the main circuit.
Check all terminal rated values	Please check all rated values and marking instructions on the product to avoid fire and the impact of excessive current. Please consult the product manual for detailed rated values before connection.
Use the power cord properly	Users can only use the special power cord for the instrument approved by the local and state standards. Please check whether the insulation layer of the cord is damaged, or if the cord is exposed, and test whether the cord is conductive. If the cord is damaged, please replace it before using the instrument.
Instrument Grounding	To avoid electric shock, the grounding conductor must be connected to the ground. This product is grounded through the grounding conductor of the power supply. Please be sure to ground this product before it is powered on.
AC power supply	Please use the AC power supply specified for this device. Please use the power cord approved by your country and confirm that the insulation layer is not damaged.
Electrostatic prevention	This device may be damaged by static electricity, so it should be tested in the anti-static area if possible. Before the power cable is connected to this device, the internal and external conductors should be grounded briefly to release static electricity. The protection grade of this device is 4 kV for contact discharge and 8 kV for air discharge.
Measurement accessories	Measurement of accessories designated as lower-grade, which are not applicable to main power supply measurement, CAT II, CAT III, or CAT IV circuit measurement. Probe subassemblies and accessories within the range of IEC 61010-031 and current sensors within the range of IEC 61010-2-032 can meet its requirements.
Use the input / output port of this device properly	Please use the input / output ports provided by this device in a proper manner. Do not load any input signals at the output port of this device. Do not load any signal that does not reach the rated value at the input port of this device. The probe or other connection accessories should be effectively grounded to avoid product damage or abnormal function. Please refer to the product manual for the rated value of the input/output port of this device.
Power fuse	Please use a power fuse for exact specification. If the fuse needs to be replaced, it must be replaced with another one that meets the specified specifications by the maintenance personnel authorized by UNI-T.
Disassembly and cleaning	There are no components available for operators inside. Do not remove the protective cover. Qualified personnel must conduct maintenance.

Service environment	This device should be used indoors in a clean and dry environment with ambient temperature from 0 °C to +40 °C. Do not use this device in explosive, dusty, or high humidity conditions.
Do not operate in humid environment	Do not use this device in a humid environment to avoid the risk of internal short circuits or electric shock.
Do not operate in flammable and explosive environment	Do not use this device in a flammable and explosive environment to avoid product damage or personal injury.
Caution	
Abnormality	If this device may be faulty, please contact the authorized maintenance personnel of UNI-T for testing. Any maintenance, adjustment or parts of replacement must be done by the relevant personnel of UNI-T.
Cooling	Do not block the ventilation holes at the side and back of this device. Do not allow any external objects to enter this device via ventilation holes. Please ensure adequate ventilation and leave a gap of at least 15 cm on both sides, front and back of this device.
Safe transportation	Please transport this device safely to prevent it from sliding, which may damage the buttons, knobs, or interfaces on the instrument panel.
Proper ventilation	Insufficient ventilation will cause the device temperature to rise, thus causing damage to this device. Please keep proper ventilation during use, and regularly check the vents and fans.
Keep clean and dry	Please take precautions to prevent dust or moisture in the air affecting this device's performance. Please keep the product's surface clean and dry.
Note	
Calibration	The recommended calibration period is one year. Calibration should only be conducted by qualified personnel.

1.3 Environmental Requirements

This instrument is designed for use under the following conditions.

- Indoor use only
- Pollution degree 2
- Overvoltage Category II: Connect this product only to a power supply that complies with Overvoltage Category II. This typically applies to equipment connected to the mains via power cords and plugs.
- Operating altitude: up to 2000 meters (about 1.24 mi); non-operating altitude: up to 15,000

meters (about 9.32 mi)

- Unless otherwise specified, the operating temperature range is +10 °C to +40 °C; storage temperature range is −20 °C to +60 °C.
- Operating relative humidity: ≤90% RH at temperatures up to +35 °C; non-operating relative humidity: ≤60% RH at +35 °C to +40 °C

Ventilation openings are on the instrument's rear and side panels. Ensure that airflow through these vents remains unobstructed. To prevent excessive dust accumulation, clean the instrument housing regularly. The housing is not waterproof, always disconnect the power supply before cleaning. Use a dry cloth or a soft cloth slightly moistened with water.

1.4 Connecting Power Supply

The AC power supply specifications are shown in the following table.

Voltage Range	Frequency
100 V-240 V AC (Fluctuations ±10%)	50/60 Hz
100-120 V AC (Fluctuations ±10%)	400

Notes:

- The maximum power consumption of the instrument does not exceed 75 W.
- Use only the supplied power cord to connect to the power inlet.

Connecting the Power Cable

This instrument is a Class I safety product. The supplied power cables have reliable performance in terms of case grounding. This instrument is equipped with a three-prong power cable that meets international safety standards. It provides good grounding performance for the specifications of your country or region.

To install the AC power cable:

- Ensure the power cable is in good condition.
- Leave enough space to connect to the power cord.
- Plug the attached three-prong power cable into a well-grounded power socket.

1.5 Electrostatic Discharge Protection

Electrostatic discharge (ESD) can cause permanent damage to components. Such damage may not be immediately visible and can occur during transportation, storage, or operation.

To minimize the risk of ESD damage:

- Perform testing in an ESD-protected area whenever possible.
- Before connecting the power cord to the instrument, briefly ground both the inner and outer conductors to discharge any static electricity.
- Ensure all instruments are properly grounded to prevent the buildup of static charges.

1.6 Preparation Work

1. Connect the power cord. Insert the plug into a properly grounded AC outlet, then adjust the alignment jig as required.
2. Press the software switch on the front panel to turn on the instrument.

1.7 Firmware Upgrade

After downloading the firmware upgrade package from the official UNI-T website, follow these steps to perform the upgrade:

1. Extract the upgrade package to the root directory of a USB flash drive. The package should contain two files: “update.md5” and “update.usa.”
2. Insert the USB flash drive to the USB port on the front panel. The system will automatically detect the upgrade file. When detected, a prompt will appear: “The upgrade file is detected, upgrade now?”, as shown in the figure below.

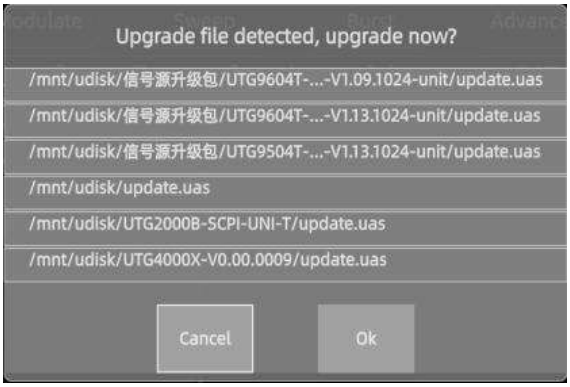


Figure 1-1 Upgrade Interface

3. Select the corresponding UTG4000X upgrade file “/mnt/udisk/UTG4000X-V0.00.0009/update.uas” in the dialog. Press the OK key to start the upgrade process.
4. Once the installation is complete, the instrument will restart again.

Note

- Use a USB drive formatted in FAT32.
- Do not power off or remove the USB flash drive during the upgrade process.

- Avoid performing other operations during the upgrade to prevent failure, which may cause the device to malfunction.

1.8 Remote Control

The UTG4000X series function/arbitrary waveform generator supports communication with a computer via USB and LAN interfaces. Users can send SCPI (Standard Commands for Programmable Instruments) commands over USB or LAN, using programming languages or NI-VISA, to remotely control the instrument as well as other SCPI-compliant instruments.
For detailed information about installation, remote control modes, and programming, please refer to the *UTG4000X Series Function/Arbitrary Waveform Generator-Programming Manual* on the official website: http://www.uni-trend.com.

1.9 Help Information

The UTG4000X series has a built-in help system for each function key and menu control key. From the main interface, press the Help icon to open the help system and navigate to the relevant page for detailed information.

Chapter 2 UTG4000X Series Overview

The UTG4000X series function/arbitrary waveform generators use Direct Digital Synthesis (DDS) technology to generate high-precision, stable, low-distortion output signals. The instruments also support high-frequency square-wave output with fast rise and fall times.

With high-performance, multi-function four-channel function/arbitrary waveform generators, the UTG4000X series provides standard AM, FM, and PM (Phase Modulation) analog modulation, as well as a variety of digital modulation modes. Additional functions include frequency sweep, burst, multi-pulse, multi-tone, sequence, pattern generation, and frequency counter operation.

With intuitive operation, strong technical performance, and a graphical user interface, the UTG4000X series are versatile instruments suitable for both educational and test applications, helping improve overall work efficiency.

Parameter configurations and available ranges vary by model. For detailed specifications and settings, refer to the corresponding datasheet for each model.

2.1 Key Features

- Four-channel standard configuration, with all channels offering equal performance and supporting independent channel output
- Maximum output amplitude: 20 Vpp
- Maximum sampling rate: 2.5 GSa/s; vertical resolution: 16-bit
- Waveform types: Sine, square, ramp, pulse, harmonic, noise, PRBS (Pseudo-Random Bit Sequence), DC, and arbitrary waveforms
- Sine wave phase noise: -130 dbc/Hz @10 kHz (Typ.)
- Adjustable noise bandwidth
- Sine wave output: Up to 250 MHz, 160 MHz, 100 MHz, with 1 μHz frequency resolution across the full range
- Square wave output: Up to 100 MHz, 80 MHz, 50 MHz, with minimum edge time < 2 ns and adjustable duty cycle
- Pulse output: Up to 100 MHz, 80 MHz, 50 MHz, featuring wide dynamic range, high-precision adjustable rise/fall times, and adjustable duty cycle
- Harmonic output: 2nd to 16th harmonics with independently adjustable phase and amplitude
- Arbitrary waveform output: 8 pts to 128 Mpts; supports point-by-point output and storage of over 200 sets of non-volatile digital arbitrary waveforms
- Storage capacity: 16 GB for arbitrary waveform files (.bsv/.csv)
- USB compatibility: Supports reading arbitrary waveform and state files (.bsv/.csv) from USB

flash drives

- Various modulation types: AM, FM, PM, DSB-AM, QAM, ASK, FSK, 3FSK, 4FSK, PSK, BPSK, QPSK, OSK, PWM, SUM
- Supports sweep and burst functions
- Digital protocol output: SPI, IIC, UART
- Supports multi-pulse, multi-tone, sequence, I/Q, expression, and pattern output
- One-key SNR output
- Each channel supports independent or simultaneous internal/external modulation and internal/external/manual triggering
- Hardware frequency counter: 800 MHz, AC or DC coupling
- Powerful PC software and arbitrary waveform editor
- 10.1-inch capacitive touch screen, 1280 × 800 resolution
- Standard interfaces: USB Host, USB Device, LAN, and independent 10 MHz clock input/output
- Compatible with NeptuneLab laboratory system management software

2.2 Panel Overview

2.2.1 Front Panel

The product has a front panel of simple, intuitive, and easy to use, as shown in the following figure.

UTG4000X Front Panel

1. Display Screen

   The 10.1-inch capacitive touch screen clearly distinguishes function menus, control statuses, and other important information using distinct color tones. Parameter adjustments and output controls are accessible through the touch screen, and the user-friendly system interface enhances human-computer interaction, improving work efficiency.

2. Function Button

   The function buttons are Default, Utility, CW, Mod, Sweep, and Burst. The CW key opens the continuous wave setting menu. The Mod key enables modulation functions and related parameter settings. The Sweep key activates the sweep function. The Burst key opens the burst mode and its parameter settings. The Default key restores the instrument to factory settings. The Utility key provides access to auxiliary system settings.

3. Waveform Types (Quick Selection)

   Quickly select the desired waveform type using the dedicated waveform keys to generate commonly used waveforms as needed.

4. Multifunction Rotary Knob / Arrow Keys

   The multifunction rotary knob is used to change values (rotate clockwise to increase the number) or function as an arrow key. Press the knob to select a function or confirm a setting. When using the multifunction rotary knob and arrow key to set parameters, they can be used to switch between digit positions, clear the previous digit, or move the cursor left or right.

5. Numeric keypad

   The numeric keypad includes digit keys 0–9, a decimal point (“.”), a sign key (+/–), and unit keys for parameter input. The left arrow key functions as a backspace to delete the previous digit in the current entry.

6. Output Interface

   CH1, CH2, CH3, and CH4 output interfaces.

7. USB Port

   This port is used to connect to an external USB storage device. It allows the instrument to read or import arbitrary waveform data files stored on the USB flash drive. It can also be used to upgrade the instrument system, ensuring that the firmware and function/arbitrary waveform generator software are kept up to date.

8. Power Supply Switch

   Press the power switch to turn on the instrument; press it again to turn it off.

9. Channel Output Control Button

   Method 1: Quick toggle via current channel selection

Identify the currently active channel displayed on the screen (for example, if the CH1 label at the bottom of the screen is highlighted, CH1 is active). The parameter list shows settings relevant to this active channel, allowing waveform configuration. To quickly enable or disable the output, press the corresponding channel key (e.g., CH1) when it is active.

Method 2: Enable via Utility menu

Press the Utility key→ Channel Settings to set the output to On.

Method 3: Direct touchscreen operation

On touchscreen models, locate the Channel Settings menu on the right side of the screen and tap to set the output to On.

Output status indicators: When Enabled: The backlight of the corresponding channel key (e.g., CH1) illuminates. The channel information label at the bottom of the screen displays the current output mode (such as Continuous or AM), and the channel output port transmits the configured signal.

When Disabled: The backlight of the channel key (e.g., CH1) turns off. The channel information label is greyed out, and the signal from the channel output port stops.

Note

The channel output interface includes an overvoltage protection function, which is triggered when any of the following conditions are met.

- When the output amplitude exceeds 4 Vpp, the protection will activate if the input voltage is greater than ±12.5 V and the frequency is below 10 kHz.
- When the output amplitude is 4 Vpp or lower, the protection will activate if the input voltage is greater than ±3 V and the frequency is below 10 kHz.

When the overvoltage protection function is triggered, the channel automatically disables the output.

2.2.2 Rear Panel

UTG4000X Rear Panel

1. External Analog Modulation Input

   When performing amplitude modulation (AM), frequency modulation (FM), or phase modulation (PM) , and the modulation source is set to External or Internal + External, the modulation signal must be applied through the external analog modulation input.

   The corresponding modulation depth, frequency deviation, phase deviation, or duty cycle deviation is determined by a 4 Vpp high-impedance signal applied to the external analog modulation input.

2. External Analog Modulation and Trigger Input

   When performing modulation for Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), or Oscillation Shift Keying (OSK) signals, selecting an external modulation source allows the modulation signal (TTL level) to be input via the external digital modulation interface. The corresponding output amplitude, frequency, and phase are determined by the signal level of this interface.

   When an external trigger source is selected for frequency sweep, a TTL pulse with the specified polarity can be received through the external digital modulation interface to initiate the sweep. When the pulse train mode is set to gate mode, or when the trigger source for N-cycle or infinite-cycle pulse trains is set to external, a gating signal can be input via the external digital modulation interface. This signal triggers the output of a pulse train with the specified number

of cycles.

3. HDMI Port

   Connect to an HDMI port for video signal output.

4. USB Port

   Connect the waveform generator to a PC, allowing instrument control via PC software.

5. Local Area Network (LAN)

   Connect to a local area network via this port for remote control.

6. Main Power Switch

   When the power switch is set to **I**, the instrument is powered on. When the power switch is set to **O**, the instrument is powered off.

   Note: The power switch on the front panel is non-functional.

7. AC Power Input Port

   For the AC power specifications, refer to the *Connecting Power Supply* section.

8. Safety Lock

   The safety lock (sold separately) is used to secure the instrument in a fixed position.

9. External 10 MHz Input Port

   Establish synchronization between multiple generators or with an external 10 MHz clock signal. If the instrument detects an external 10 MHz clock signal at the 10 MHz IN connector (input requirements: frequency of 10 MHz, amplitude ≥ 0 dBm/50 Ω), it will automatically switch to this signal as the external clock source, indicated by the first icon Ext Ref in the status bar. In Auto mode, when the external clock source is lost, exceeds limits, or disconnected, the instrument clock source will automatically switch to the internal clock, and the icon Ext Ref will update to Int Ref.

10. Internal 10 MHz Output Port

    Establish synchronization between multiple waveform generators or the output of a 10 MHz reference clock signal to an external source.

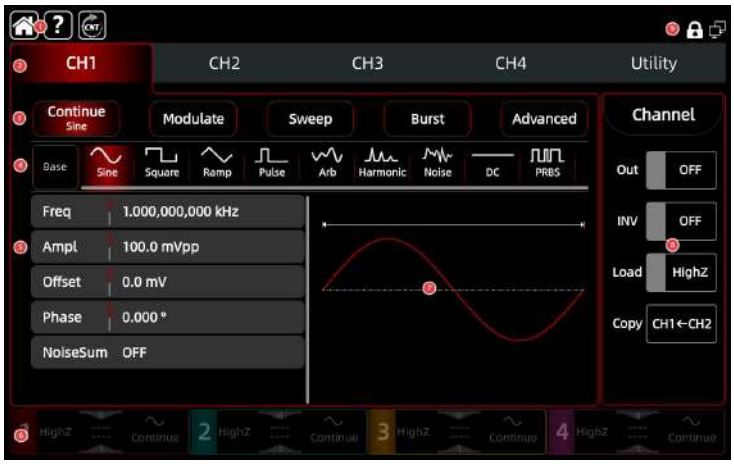
11. Frequency Counter Interface

    In frequency counter mode, this interface is used to input the signal.

12. Cooling Hole

    Ensure proper heat dissipation by keeping these openings unobstructed.

2.2.3 Function Interface



1. Function Setting: Screenshot, file system, setup system, and help system.

   Hom page : Tap this key to return to the home page.

   Frequency counter : Indicates the frequency counter. Tap this icon to activate the frequency counter function and view measurement results.

   Help system : Open the help navigation.

2. Menu Bar

   Tap CH1, CH2, CH3, CH4, or Utility to configure parameters for each channel and auxiliary functions.

3. Output Mode

   Continue, modulate, sweep, burst, and advanced waveforms.

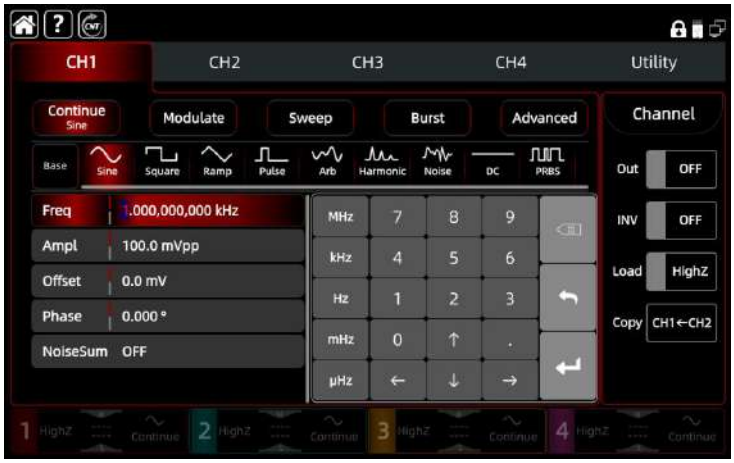
4. Fundamental Wave

   9 wave types: Sine, square, ramp, pulse, arbitrary, harmonic, noise, DC, and PRBS.

5. Waveform List

   Displays waveform parameters in list mode. Tap a parameter field to set its value.

   For example, tap the Ampl or Freq field to open the virtual keyboard for entry, as shown in the figure below.



6. Channel Info Bar: When a channel is enabled, its label is highlighted.

   HighZ: Indicates that the load is set to high impedance; the load can also be configured to 50 Ω.

   ∿: Indicates that the output fundamental wave is a sine wave.

   Continue: Indicates that the output waveform is continuous (i.e., only the fundamental wave is output). Depending on the operating mode, this label may also display Continue, AM, Line, NCycle, etc.

7. Waveform Display Area: This area shows the waveform shape currently configured for the channel. The waveform of a specific channel can be distinguished by its color or by the highlight on the channel info label. The parameter list on the left displays the waveform parameters.

   Note: The waveform display area is unavailable when the menu bar is set to Utility.

8. Current Channel Setting Status: Provides quick access to common settings for the current channel.

   Tap the corresponding box to toggle each setting:

   Out: Tap the Out On/Off box to enable or disable the output of the corresponding channel.

   INV: Tap the INV On/Off box to invert the output waveform.

   Load: Tap HighZ or 50 Ω to set the output impedance.

   Copy: Tap the icon CH1→CH2 to copy the settings from CH2 to CH1.

9. System Setting Status: This area displays the connection status of USB flash drive, LAN indicators, external clock status, and other system-related information.

2.2.4 Touch Operation

The waveform generator is equipped with a 10.1-inch capacitive touch screen that supports the following gesture operations.

- Tap: Tap on on-screen parameters or menus to edit settings.
- Swipe left/right: Switch between menus.
- Swipe up/down: Scroll through menu items.

Note: Scrolling is available only when a scroll bar appears on the right side of the screen after tapping. If no scroll bar is displayed, only the current page is available.

Chapter 3 Quick Start Guide

3.1 Fundamental Wave Output

3.1.1 Output Frequency

Default waveform configuration: A sine wave with a frequency of 1 kHz and an amplitude of 100 mVpp (high resistance).

To change the frequency to 2.5 MHz, follow these steps:

1. Press the Sine key to enter the sine wave setting menu.
2. On the screen, tap the Freq key and use the numeric keypad to enter 2.5.
3. Select MHz as the unit.

3.1.2 Output Amplitude

Default waveform configuration: A sine wave with an amplitude of 100 mVpp (high resistance).

To change the amplitude to 300 mVpp, follow these steps:

1. Press the Sine key to enter the sine wave setting menu.
2. On the screen, tap the Ampl key and use the numeric keypad to enter 300.
3. Select mVpp as the unit.

3.1.3 DC Offset Voltage

Default waveform configuration: A sine wave (high resistance) with DC offset voltage of 0 V.

To change the DC offset voltage to -150 mV, follow these steps:

1. Press the Sine key to enter the sine wave setting menu.
2. On the screen, tap the Offset key and use the numeric keypad to enter -150.
3. Select mVpp as the unit.

Note: The multifunction knob and arrow keys can also be used together to set this parameter.

3.1.4 Phase Setting

Default waveform configuration: The phase is set to 0°.

To change the phase offset to 90°, follow these steps:

1. Press the Sine key to enter the sine wave setting menu.
2. On the screen, tap the Phase key and use the numeric keypad to enter 90.
3. Select deg as the unit.

3.1.5 Duty Cycle of Square Wave

Default square waveform configuration: The frequency is set to 1 kHz with the duty cycle 25%.

To change the duty cycle to 25%, follow these steps:

1. Press the Square key to enter the square wave setting menu.
2. On the screen, tap the Duty and use the numeric keypad to enter 25.
3. Select % as the unit.

3.1.6 Symmetry of Ramp Wave

Default ramp waveform configuration: The frequency is set to 1 kHz with the symmetry 50%.

To change the symmetry to 75%, follow these steps:

1. Press the Ramp key to enter the ramp wave setting menu.
2. On the screen, tap the Symmetry key and use the numeric keypad to enter 75.
3. Select % as the unit.

3.1.7 Arbitrary Wave Setting

Default arbitrary waveform configuration: The frequency is set to 1 kHz. The arbitrary waveform file is “ACos.bsv.”

To change the arbitrary waveform file to “SineH.bsv,” follow these steps:

1. Press the Arb key to enter the arbitrary wave setting menu.
2. On the screen, tap the WaveFile key to access the file window and single-click the Trigonome folder, then select the “SineH.bsv” file.
3. Tap the Load key to load the arbitrary waveform.

3.1.8 DC Voltage

Default: The DC voltage is set to 0 V.

To change the symmetry to 3 V, follow these steps:

1. Press the DC key to enter the DC setting menu.
2. On the screen, tap the Offset key and use the numeric keypad to enter 3.
3. Select V as the unit.

3.1.9 Noise Setting

Default: Gaussian noise with an amplitude of 100 mVpp and a DC offset of 0 V.

To set the amplitude to 300 mVpp and the DC offset to 1 V, follow these steps:

1. Press the Noise key to enter the noise setting menu.

2. On the screen, tap the Ampl key and use the numeric keypad to enter 300.
3. Select mVpp as the unit.
4. Tap the Offset key and use the numeric keypad to enter 1.
5. Select V as the unit.

3.1.10 Harmonic Wave

Default harmonic waveform configuration: The frequency is set to 1 kHz.

To change the total harmonic order to 10, follow these steps:

1. Press the Harmonic key to enter the harmonic wave setting menu.
2. On the screen, tap the Order key and use the numeric keypad to enter 10.
3. Tap the Type key to select All.

3.1.11 PRBS Setting

Default: The frequency is set to 1 kbps.

To set symbol to PN7 and the edge time to 20 ns as an example, follow these steps:

1. Press the PRBS key to enter the PRBS setting menu.
2. On the screen, tap the PN Code key to select PN7.
3. Tap the EdgeTime key and use the numeric keypad to enter 20.
4. Select ns as the unit.

3.1.12 Noise Superposition

The UTG4000X series supports noise superposition function, allowing the signal-to-noise ratio (SNR) to be adjusted as needed.

Set the output frequency to 10 kHz, amplitude to 2 Vpp, 0 V DC offset, and SNR to 0 dB, follow these steps:

1. On the screen, tap the Continue→Sine→Freq keys to open the virtual keyboard and enter 10 kHz.
2. Tap the Ampl parameter field to open the virtual keyboard and enter 2 Vpp.
3. Tap the NoiseSum key to set it to ON.
4. Tap SNR (dB) field to open the virtual keyboard and enter 0 dB.

3.2 Auxiliary Function

The Utility (auxiliary) functions include channel settings, channel coupling, frequency counter, digital protocols, system settings, network configuration, and Assist. The specific functions are listed in the

table below.

3.2.1 Channel Settings

Table 3-1 CH1/2 Setting

Function Menu	Sub-Menu	Setting	Description
CH1/2 Setting	Channel output	OFF, ON	
	Channel invert	OFF, ON	
	Load	50Ω, high resistance	Range: 1 Ω to 1000 kΩ
	Amplitude limit	OFF, ON	
	Upper limit of amplitude		Set the upper limit for the channel amplitude output.
	Lower limit of amplitude		Set the lower limit for the channel amplitude output.
	Sync output	OFF, ON	
	Sync invert	OFF, ON	

Table 3-2 CH3/4 Setting

Function Menu	Sub-Menu	Setting	Description
CH3/4 Setting	Channel output	OFF, ON	
	Channel invert	OFF, ON	
	Load	High resistance (Default)	Range: 1 Ω to 1000 kΩ
	Amplitude limit	OFF, ON	
	Upper limit of amplitude		Set the upper limit for the channel amplitude output.
	Lower limit of amplitude		Set the lower limit for the channel amplitude output.

Tap or press Utility→Channel, or tap the corresponding field to configure the channel settings.

1. Channel Output

   Select Out, then tap OFF or ON.

   Note: Press the CH1, CH2, CH3, CH4 buttons can also quickly activate channel output.

2. Channel Invert

   Select INV, then tap OFF or ON.

3. Load

   Select Load, then tap to switch between HighZ and 50Ω, or tap the numeric field to set a value

in the range of 1 Ω to 1000 kΩ.

4. Amplitude Limit

   Supports amplitude limit output function to protect load.

   Select Amp Limit, then tap OFF or ON.

5. Upper Limit of Amplitude

   Select Upper to set the upper limit of amplitude. The setting method is consistent with the Amplitude.

6. Lower Limit of Amplitude

   Select Lower to set the lower limit of amplitude. The setting method is consistent with the Amplitude.

7. Sync Output

   Select Sync, then tap OFF or ON.

   The synchronous output of CH1 is mapped to CH3, and the synchronous output of CH2 is mapped to CH4.

   When the sync output of CH1 is enabled, the channel label of CH3 changes to .

   When the sync output of CH2 is enabled, the channel label of CH4 changes to .

8. Sync Invert

   Select SYNC-INV, then tap OFF or ON.

3.2.2 Channel Coupling

The channel coupling includes frequency coupling, amplitude coupling, and phase coupling. The specific functions are listed in the table below.

Table 3-3 Frequency Coupling Setting

Function Menu	Sub-Menu	Setting	Description
Frequency Coupling	Frequency coupling	OFF, ON	
	Channel coupling		
	Coupling mode	Ratio, offset	
	Ratio		Can only be set when the coupling mode is set to ratio.
	Offset		Can only be set when the coupling mode is set to offset.

Table 3-4 Amplitude Coupling Setting

Function Menu	Sub-Menu	Setting	Description
Amplitude Coupling	Amplitude coupling	OFF, ON	
	Channel coupling		
	Coupling mode	Ratio, offset	
	Ratio		Can only be set when the coupling mode is set to ratio.
	Offset		Can only be set when the coupling mode is set to offset.

Table 3-5 Phase Coupling Setting

Function Menu	Sub-Menu	Setting	Description
Phase Coupling	Phase coupling	OFF, ON	
	Channel coupling		
	Coupling mode	Ratio, offset	
	Ratio		Can only be set when the coupling mode is set to ratio.
	Offset		Can only be set when the coupling mode is set to offset.

Notes:

1. The settings in CH Coupling 1 are identical to those in CH Coupling 2.
2. When coupling is enabled, the channel merging and channel copying functions are unavailable.
3. When amplitude limiting is enabled, the channel coupling function becomes unavailable.

Tap or press Utility→Coupling, or tap the corresponding field to configure the channel coupling settings.

1. Frequency Coupling

   Set the frequency coupling mode to ratio or offset between channels.

   Multiple channel combinations are available for selection, including CH1&2, CH1&3, CH1&4, CH2&3, CH2&4, CH3&4, CH1&2&3, CH1&2&4, CH1&3&4, CH2&3&4, and CH1&2&3&4. The selected coupled channels serve as mutual reference sources. When the frequency of one of these channels (acting as the reference) is adjusted, the frequencies of the other coupled channels are automatically modified to maintain the specified ratio or offset relative to the reference channel.

Select Freq, then tap OFF or ON.

Select Type, then tap to switch between Ratio or Deviation.

When the coupling mode is set to ratio: Tap the ratio value to open the virtual keyboard, enter the desired ratio, and press Enter to confirm.

When the coupling mode is set to offset: Tap the offset value to open the virtual keyboard, enter the desired offset frequency, and press Enter to confirm.

2. Amplitude Coupling

Set the amplitude coupling mode to ratio or offset between channels.

Multiple channel combinations are available for selection, including CH1&2, CH1&3, CH1&4, CH2&3, CH2&4, CH3&4, CH1&2&3, CH1&2&4, CH1&3&4, CH2&3&4, and CH1&2&3&4. The selected coupled channels serve as mutual reference sources. When the amplitude of one of these channels (acting as the reference) is adjusted, the amplitudes of the other coupled channels are automatically modified to maintain the specified ratio or offset relative to the reference channel.

Select Ampl, then tap OFF or ON.

Select Type, then tap to switch between Ratio or Deviation.

When the coupling mode is set to ratio: Tap the ratio value to open the virtual keyboard, enter the desired ratio, and press Enter to confirm.

When the coupling mode is set to offset: Tap the offset value to open the virtual keyboard, enter the desired offset frequency, and press Enter to confirm.

3. Phase Coupling

Set the phase coupling mode to ratio or offset between channels.

Multiple channel combinations are available for selection, including CH1&2, CH1&3, CH1&4, CH2&3, CH2&4, CH3&4, CH1&2&3, CH1&2&4, CH1&3&4, CH2&3&4, and CH1&2&3&4. The selected coupled channels serve as mutual reference sources. When the phase of one of these channels (acting as the reference) is adjusted, the phases of the other coupled channels are automatically modified to maintain the specified ratio or offset relative to the reference channel.

Select Phase, then tap OFF or ON.

Select Type, then tap to switch between Ratio or Deviation.

When the coupling mode is set to ratio: Tap the ratio value to open the virtual keyboard, enter the desired ratio, and press Enter to confirm.

When the coupling mode is set to offset: Tap the offset value to open the virtual keyboard, enter the desired offset frequency, and press Enter to confirm.

4. Coupling Icon

After opening the coupling parameters for each channel, a coupling icon appears on the right side of the waveform parameter list on the home page, as shown in the figure below.

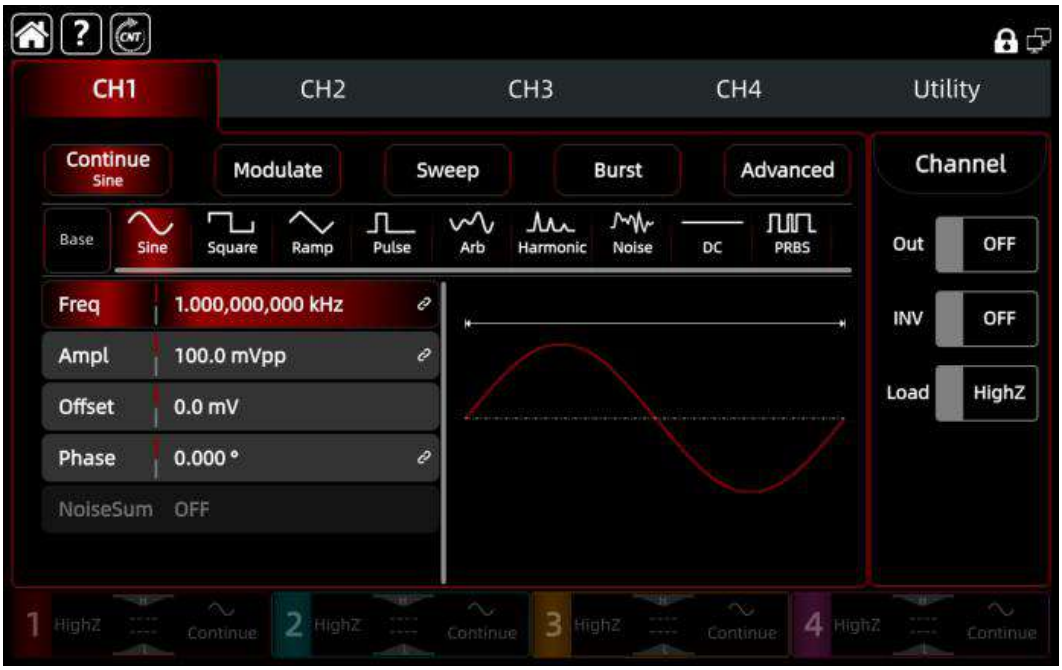


Figure 3-1 Channel Coupling

3.2.3 Channel Merge

Tap or press Utility→Merge, or tap the corresponding field to configure the channel merge settings. In normal mode, each channel output port of the signal source delivers its own independent waveform. When channel merging is enabled, the instrument outputs a combined waveform formed by multiple channels. Various channel merging combinations are available, including CH1+2, CH1+3, CH1+4, CH2+3, CH2+4, CH3+4, CH1+2+3, CH1+2+4, CH1+3+4, CH2+3+4, and CH1+2+3+4.

Select CH1 Merge, then tap OFF or CH1+2+3+4. The channel merge interface is shown in the figure below.

Figure 3-2 Channel Merge

When CH1 is set to the CH1+CH2 merging mode, a channel merging icon Merged:CH1+CH2+CH3+CH4 appears in the bottom-left corner of the waveform display on the home screen.

The merging configuration for CH2, CH3, and CH4 follows the same operation logic as CH1.

Note: When channel merging is enabled, the amplitude coupling function becomes unavailable.

3.2.4 Frequency Counter

This function/arbitrary waveform generator is equipped with an 8-digit/s frequency counter, featuring a measurement range of 100 mHz to 800 MHz and supporting wide-range signal voltage input.

It can measure parameters of externally applied signals, including frequency, period, duty cycle, positive pulse width, and negative pulse width, and provides statistical analysis of measurement results. The instrument automatically calculates the maximum, minimum, average, and standard deviation of the measured data. Additionally, the dual-channel output can operate simultaneously with the frequency of counter measurement.

Table 3-6 Frequency Counter Setting

Function Menu	Sub-Menu	Setting	Description
Frequency Counter	Switch	OFF, ON	
	Coupling mode	AC, DC	To ensure accurate measurements, select AC coupling for high-frequency input signals and DC coupling for low-frequency signals.
	Trigger level	-2.5 V to 2.5 V	
	Sensitivity	0% to 100%	
	High-frequency reject	OFF, ON	

Tap or press Utility→Counter, or tap the corresponding field to configure the frequency counter settings.

Figure 3-3 Frequency Counter

1. Switch

Select Switch, then tap OFF or ON.

2. Coupling Mode

   Select Coupling, then tap to switch between AC or DC. The default setting is AC.

3. Trigger Level

   Select TrigLevel, then tap the trigger level field to open the virtual keyboard, enter the desired level, and press Enter to confirm. The default value is 0 V.

4. Sensitivity

   Select Sensitivity, then tap the sensitivity field to open the virtual keyboard, enter the desired level, and press Enter to confirm. The default value is 100%.

5. High-Frequency Reject

   Select HFReject, then tap OFF or ON. The default setting is OFF.

6. Zero

   Tap Zero to clear the statistical measurement results and restart statistical processing. The default setting is OFF.

3.2.5 System Setting

Tap or press Utility→System, or tap the corresponding field to configure and view the system settings.

1. Basic Information

   Product name, manufacturer, model, serial number, software version, logic version, hardware version, Web username, and password.

2. Basic Setting

   Language: Simplified Chinese, English

   Note: The setting takes effect only after the device restarts.

   Separator: Sets the delimiter used between channel parameter values. Available options: Comma, space, or none.

   Sound: Sets whether a buzzer sounds when keys are pressed. Options: Off or On.

   Backlight brightness: Sets the screen brightness to 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100%.

   Screen saver: When no operation is performed for the preset duration, the instrument enters screen-saver mode while maintaining the current keypad state. Press any key to restore the display. Options: Off, 5 minutes, 15 minutes, 30 minutes, 60 minutes.

   Clock source: Set the system clock source to internal or external.

   Internal: Provides a 10 MHz clock source.

External: Receives an external 10 MHz clock via the [10 MHz In] connector on the rear panel (input requirements: frequency 10 MHz, TTL level).

If no valid external clock is detected, the message “Invalid external 10 MHz clock” appears, and an icon is displayed in the upper-right corner of the screen. When a valid clock is detected, the corresponding status icon is shown.

Clock output: Enables or disables the 10 MHz clock output. When enabled, the [10 MHz Out] connector on the rear panel outputs a 10 MHz TTL-level clock signal for synchronization with other devices.

Synchronization Between Instruments:

Connect the [10 MHz Out] connector of the first instrument (with clock output enabled) to the [10 MHz In] connector of the second instrument (set to External clock source). Then configure both instruments to output the same frequency to achieve synchronization between them.

To synchronize more than two instruments, repeat this connection method in sequence to form a multi-instrument configuration.

Image format: Sets the file format for saved screenshots. Available options: BMP, JPEG, and PNG.

Start phase: Two configuration modes are available. Independent: The initial phases of the four output channels are not correlated. Synchronization: The start phases of the four output channels are linked.

Power-on State: Sets the instrument’s configuration state at power-on. Available options: Default, Last Time, Preset 1, Preset 2, Preset 3, Preset 4, and Preset 5.

Manual trigger: When the instrument operates in sweep frequency or burst mode, the trigger source is set to Manual. When independent trigger is selected, a manual trigger applies only to the current channel. When synchronized trigger is selected, a manual trigger activates all channels set to Manual.

Switch Mode: Independent, CH1&2, CH3&4, CH1&2&3, CH2&3&4, CH1&2&3&4.

In independent mode, each channel’s on/off state is independent; switching one channel does not affect the others (except in cases involving channel synchronization).

In CH1&2 mode, the on/off states of Channels 1 and 2 are linked. Turning Channel 1 on or off automatically performs the same action on Channel 2, and vice versa. The same logic applies to the other combined-channel modes.

Channel tracking: When channel tracking is enabled, CH1, CH2, CH3, and CH4 serve as reference sources for one another. Changing a parameter on any channel (the reference source) automatically copies that parameter to the other three channels.

Save as Preset: Saves the instrument's current configuration to a preset slot. The user can save to Preset 1, Preset 2, Preset 3, Preset 4, or Preset 5.

Restore Factory Settings: Restores all system settings to their factory defaults.

3. Network Setting

Auto acquisition: When enabled, the instrument automatically obtains network configurations. When disabled, network parameters must be configured manually.

IP address: The format of the IP address is nnn.nnn.nnn.nnn. The range of the first nnn is from 1 to 223. The range of the other three nnn is from 0 to 255. It is recommended to consult your network administrator for an available IP address.

Subnet mask: The format of the subnet mask is nnn.nnn.nnn.nnn. The range of nnn is from 0 to 255. It is recommended to consult your network administrator for a subnet mask address.

Gateway address: The format of the gateway address is nnn.nnn.nnn.nnn. The range of the first nnn is from 1 to 255. The range of the other three nnn is from 0 to 255. It is recommended to consult your network administrator for an available gateway address.

MAC address: The physical address used to identify the location of the network device, also known as the hardware address. It is 48 bits (6 bytes) in length, composed of hexadecimal numbers, and divided into two parts: the first 24 bits and the last 24 bits. The format is xx-xx-xx-xx-xx-xx. The first 24 bits are called the Organizationally Unique Identifier (OUI), while the last 24 bits are allocated by the manufacturer and called the Extended Identifier.

4. Interface Setting

Web login username: Sets the username for browser-based login. The default username is admin and cannot be changed.

Web access address: The access address uses the format http://IP, where IP is the IPv4 address configured in the network settings (e.g., http://192.168.20.117).

Web login password: Sets the password for browser-based login. The default password is 123 and cannot be changed.

Once the web login username and password have been configured, the user can use a web browser on a PC or mobile device to remotely control the instrument. This remote-control feature simulates the touchscreen and mouse operation of the physical device, allowing the instrument to function identically to local operation.

(1) LAN Access

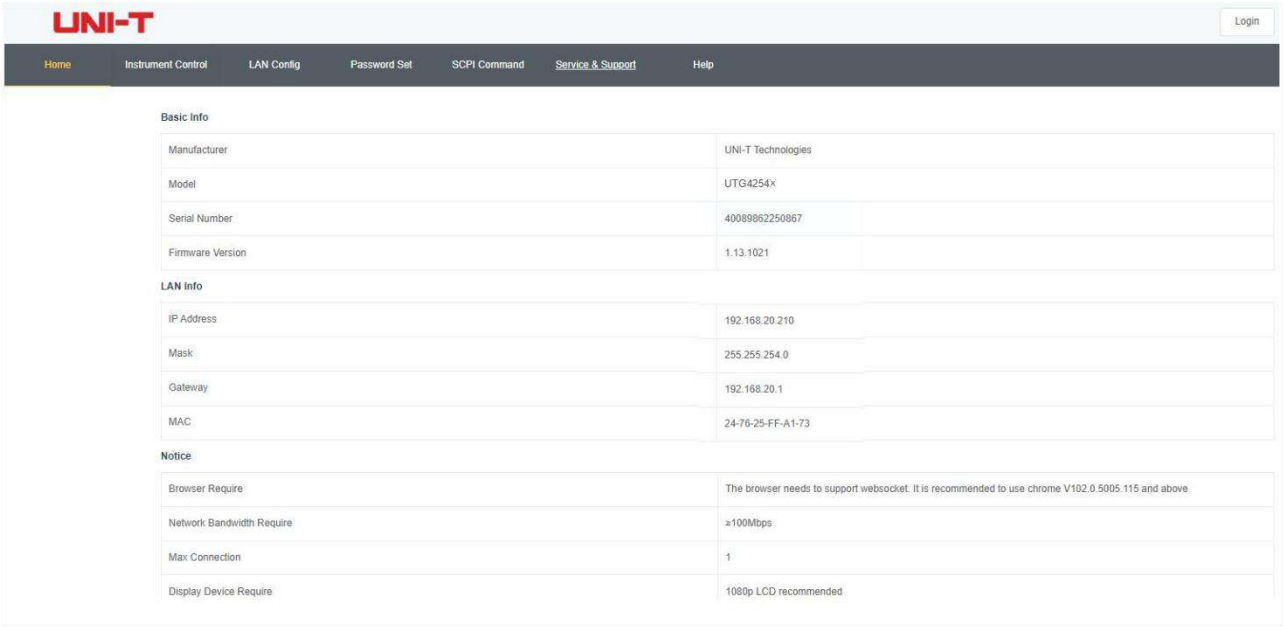
The computer and the waveform generators are required to be in the same LAN and can ping each other. View the waveform generator's local IP via the Utility menu and then access the waveform generators by accessing the http://ip: port in a browser.

Example:

Computer IP: 192.168.21.131

Waveform generator IP: 192.168.20.117

Use 192.168.20.117 to access the waveform generator in the computer browser, view the basic information, and perform operations such as instrument control, network settings, password settings, and SCPI command control, as shown in the following figure.

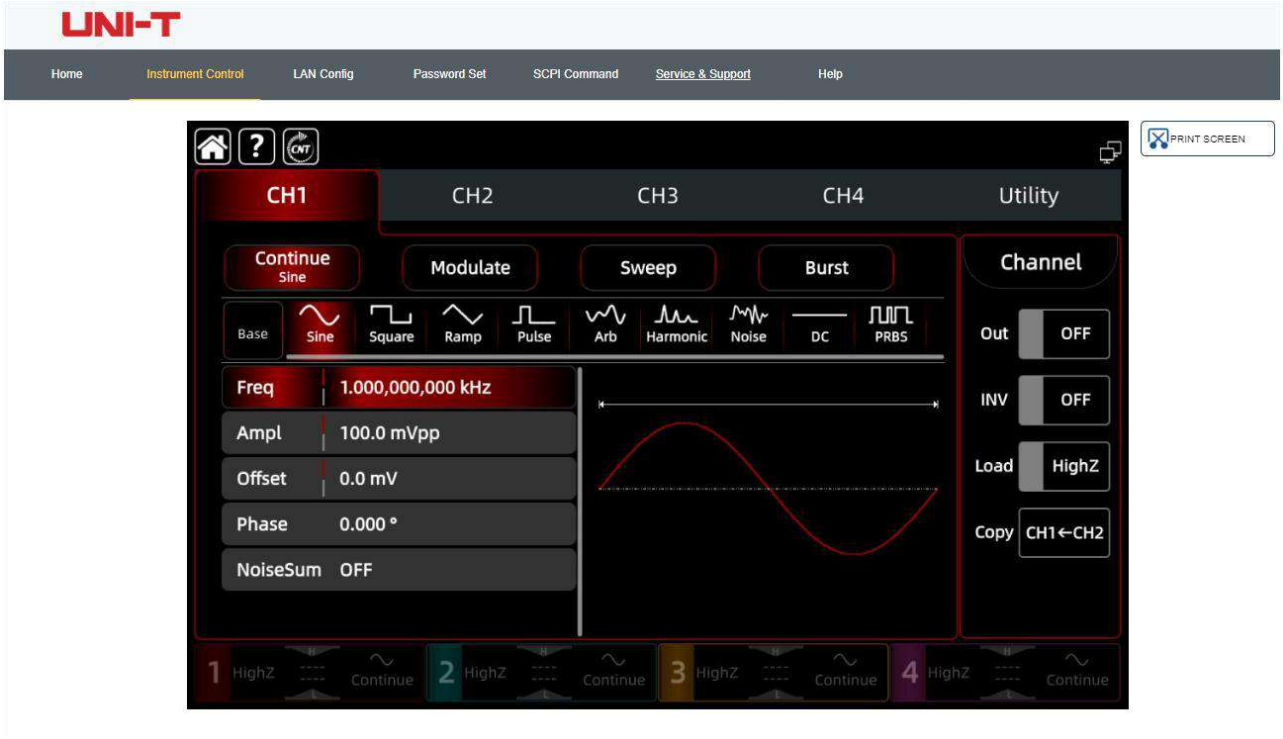


Web Basic Information

When accessing instrument control, network settings, password settings, or SCPI command control, login authentication is required.

For the username and password, refer to Web Login Username and Web Login Password in the interface setting.

After successful login, the user can view and control the waveform generator, as shown in the figure below.



Web Instrument Control

Operations that can be performed on the touch screen of a physical instrument, such as selecting a menu panel, clicking function keys, entering numbers and characters, dragging a mark, etc., can also be operated on this web page, and the screen can also be printed.

(2) External Access Network

a. Connect the waveform generator to a network cable and ensure the network has Internet access.

b. Enable the frp proxy service on the server.

c. Configure the frp proxy IP address and port number on the waveform generator.

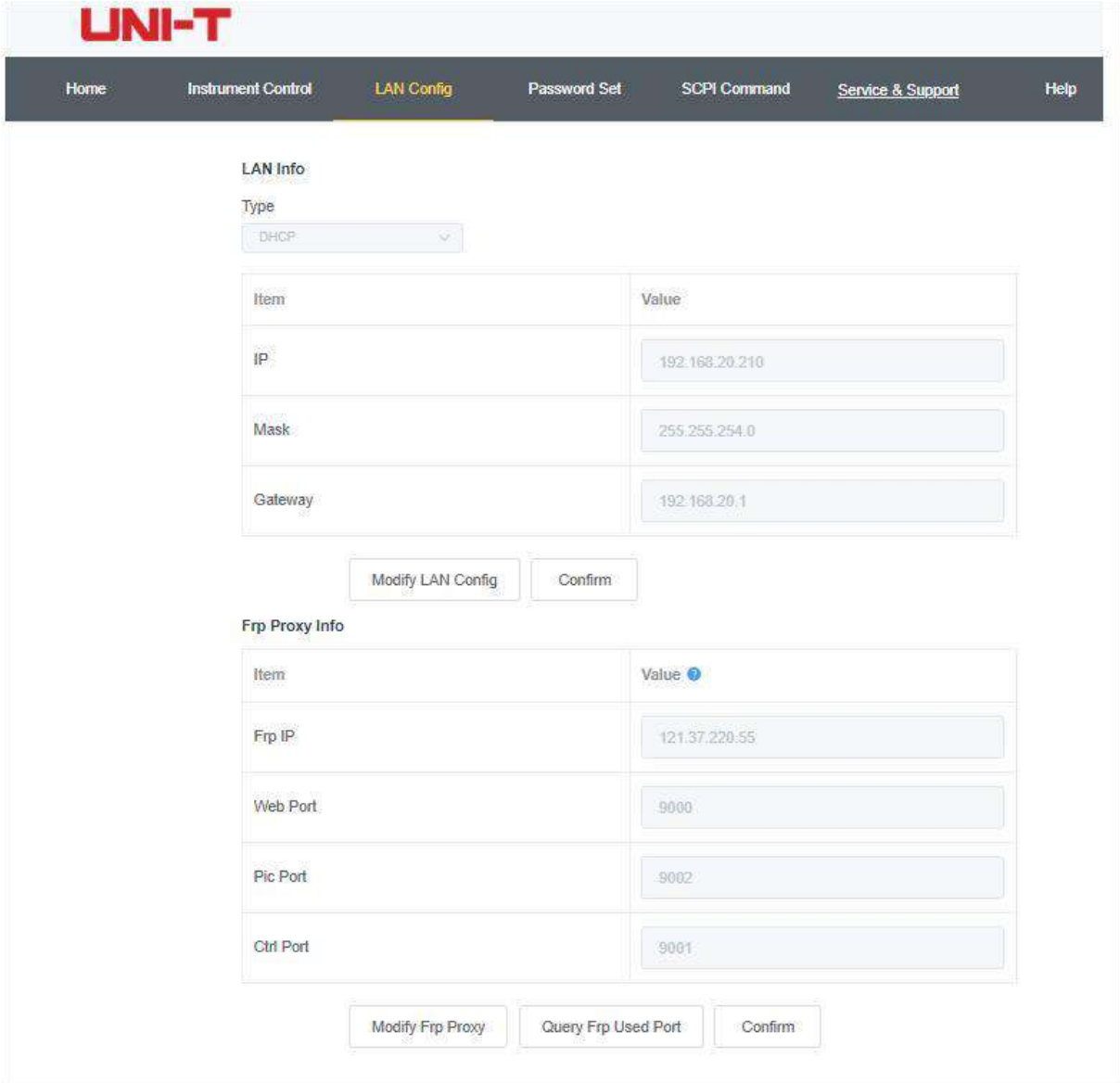
d. In the browser, enter the proxy address in the format http://IP:web_port to access the waveform generator. The access interface is identical to that of the intranet connection.

Note: The instrument uses the frp intranet penetration mode to enable external network access. The frp version is 0.34.0.

The instrument includes the frp-0.34.0 client, which must be used in conjunction with an FRP server. The server must have the FRP service enabled, and the client connects to the server through port 7000. Therefore, the server configuration must include the parameter bind_port = 7000.

(3) Network Setting

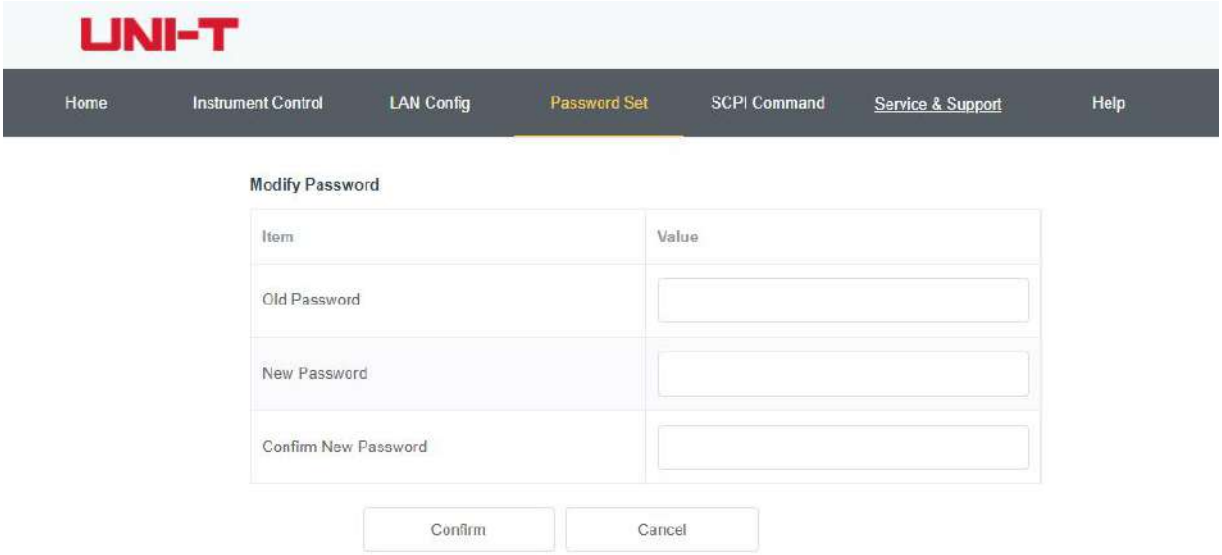
Set and modify the network information of the waveform generator and the frp agent, as shown in the following figure.



Web Network Setting

(4) Password Setting

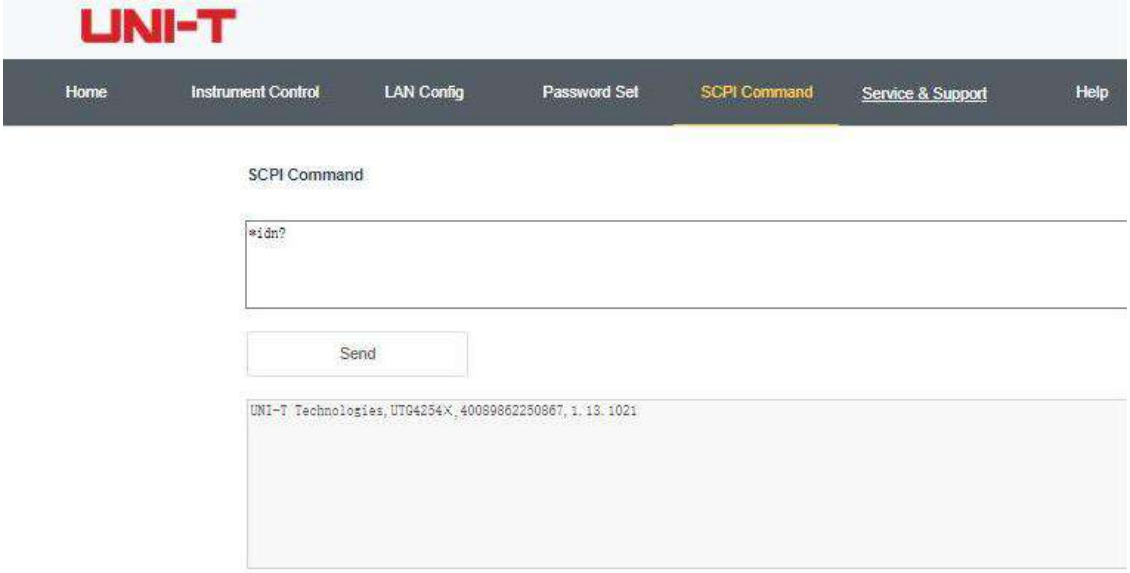
Set and modify the web login password of the waveform generator, as shown in the following figure. The original password can be viewed under the Physical Instrument ->System->Setting-> Interface Setting.



Web Password Setting

(5) SCPI Command

Execute the SCPI command, as shown in the following figure. Enter the command in the SCPI command to edit box, click the Send Command key, and print the execution result to the report column below.



SCPI Command Control

Chapter 4 Advanced Application

This chapter describes 15 modulation modes, including AM, FM, PM, DSB-AM, QAM, ASK, FSK, 3FSK, 4FSK, PSK, BPSK, QPSK, OOK, PWM, and SUM, as well as frequency sweep waveforms, pulse waveforms, and other advanced waveform functions.

Press the MOD On/Off key to enter modulation mode; the backlight of the MOD On/Off key will illuminate. Press the key again to exit modulation mode; the backlight will turn off.

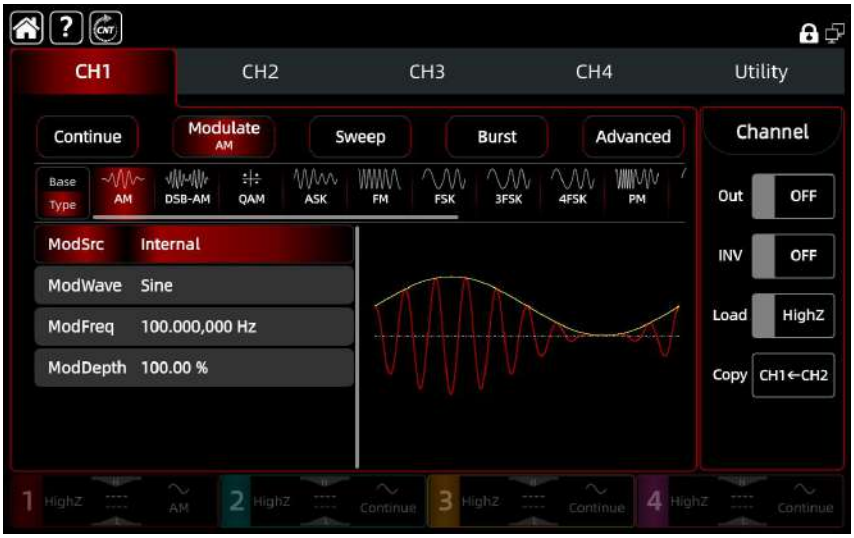
4.1 Modulation Wave Output

4.1.1 Amplitude Modulation (AM)

In AM mode, the modulated wave consists of the carrier wave and the modulation wave. The amplitude of the carrier wave changes with the amplitude of the modulation wave.

AM Setting

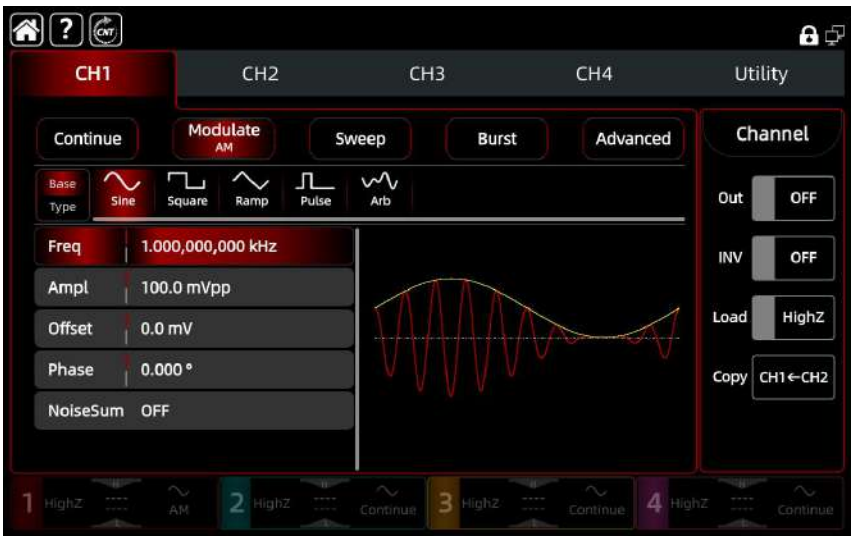
Press the CH1 button, then tap Modulate→AM key to enable AM mode. The instrument will output the modulated waveform according to the current modulation wave and the carrier wave.



Carrier Wave Setting

The carrier signal can be selected from the following waveform types: sine, square, ramp, pulse, or arbitrary, with sine set as the default.

After selecting AM modulation, press Base/Type on the modulation function interface to display the list of available carrier waveforms.



Carrier Wave Frequency

Each carrier wave has a different frequency, with a default frequency of 1 kHz. The frequencies of each carrier wave are shown in the following table.

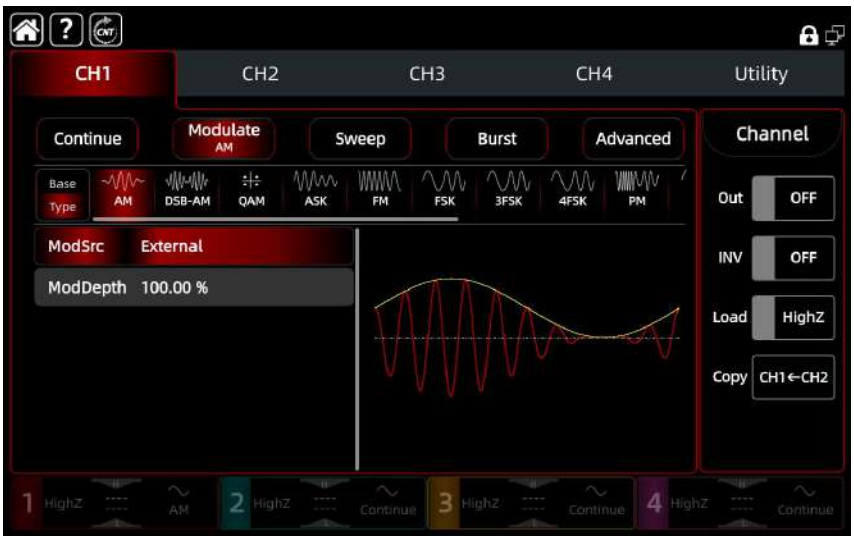
Carrier Frequency	Frequency					
	UTG4254X		UTG4164X		UTG4104X	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Sine Wave	1μHz	250MHz	1μHz	160MHz	1μHz	100MHz
Square Wave	1μHz	100MHz	1μHz	80MHz	1μHz	50MHz
Ramp Wave	1μHz	20MHz	1μHz	20MHz	1μHz	20MHz
Pulse Wave	1μHz	100MHz	1μHz	80MHz	1μHz	50MHz
Arbitrary Wave	1μHz	50MHz	1μHz	50MHz	1μHz	50MHz

To set the carrier frequency, first select the desired carrier waveform, then use the multifunction knob to adjust the value. Alternatively, tap the frequency field in the parameter area, enter the target value using the numeric keypad, and press the appropriate unit key to confirm.

Modulation Source Setting

This series provides two modulation source options: internal and external.

After AM mode is enabled, the default modulation source (Internal) is displayed. The modulation source can be switched using the multi-function rotary knob in the AM interface, or by pressing ModSrc→Internal, then selecting External.



1) Internal Source

When the modulation source is set to internal, the modulation waveform can be sine, square, rising ramp, falling ramp, arbitrary, or noise. The default waveform is sine.

After AM modulation is enabled, the modulation waveform defaults to Sine. Rotate the multi-function rotary knob or tap Modulate→Sine to select a different waveform on the AM setting interface.

- Square wave: duty cycle 50%
- Rising ramp wave: symmetry 100%
- Falling ramp wave: symmetry 0%
- Arbitrary wave: waveform length limited to 2 kpts when using the Auto Point Select method
- Noise wave: white Gaussian noise

2) External Source

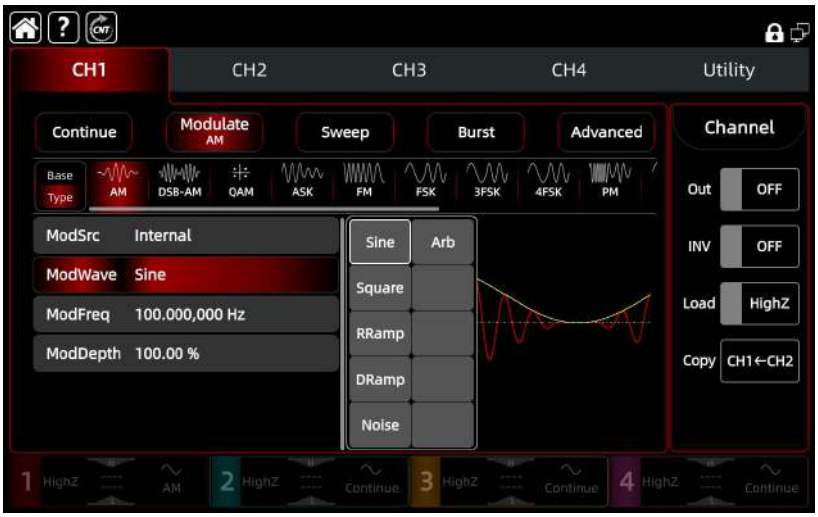
When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform. The AM modulation depth is controlled by the ±5 V signal level applied to the external analog modulation input (Modulation In connector) on the rear panel. For example, when the modulation depth is set to 100%, the AM output amplitude reaches its maximum at an external modulation input of +5 V and its minimum at −5 V.

Modulation Wave Setting

When the modulation source is set to internal, the internal modulation waveform can be sine, square, ramp, or arbitrary. The default waveform is sine.

After AM modulation is enabled, the modulation waveform defaults to Sine. Rotate the multi-function rotary knob or tap Modulate to select a different waveform on the AM setting interface.

- Square wave: duty cycle 50%
- Rising ramp wave: symmetry 100%
- Falling ramp wave: symmetry 0%
- Arbitrary wave: waveform length limited to 2 kpts when using the Auto Point Select method
- Noise wave: white Gaussian noise



Modulation Wave Frequency Setting

After the AM function is enabled, when the modulation source is set to internal, the modulation wave frequency can be configured. The frequency range is 1 μHz to 2 MHz, with a default value of 100 Hz.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation frequency. Alternatively, tap ModFreq on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface. When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform.

Modulation Depth Setting

The modulation depth indicates the percentage change in amplitude. The AM modulation depth can be set from 0% to 120%, with a default value of 50%.

- When the modulation depth is 0%, the output amplitude remains constant at half of the carrier amplitude.
- When the modulation depth is 100%, the output amplitude varies in accordance with the modulation waveform.
- When the modulation depth exceeds 100%, the output amplitude of the instrument does not exceed 10 Vpp (50 Ω load).

Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation

depth. Alternatively, tap ModDepth on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface. When the modulation source is set to external, the output amplitude is controlled by the ±5 V signal level applied to the external analog modulation input (Modulation In connector) on the rear panel. For example, when the modulation depth is set to 100%,

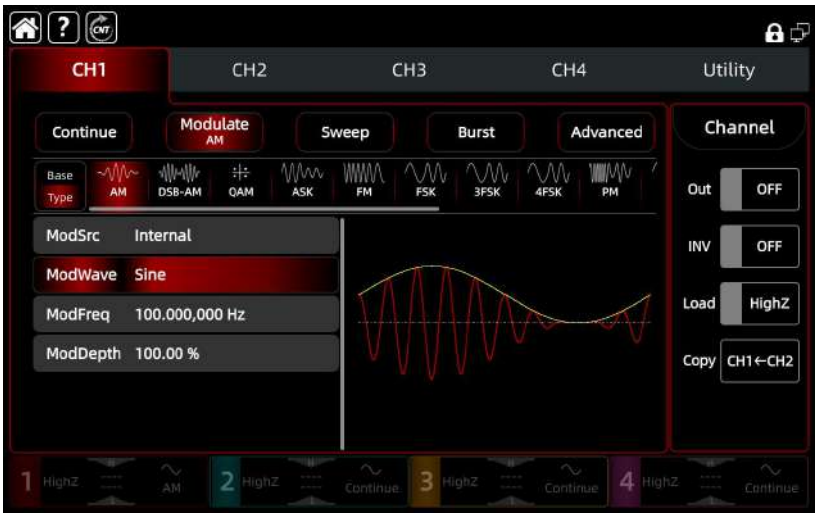
the AM output amplitude reaches its maximum at an external modulation input of +5 V and its minimum at −5 V.

Comprehensive Example

In AM mode, set an internal 200 Hz sine wave as the modulating signal, and set a 10 kHz square wave with an amplitude of 200 mVpp and a duty cycle of 45% as the carrier. Finally, set the modulation depth to 80%. The setting steps are as follows.

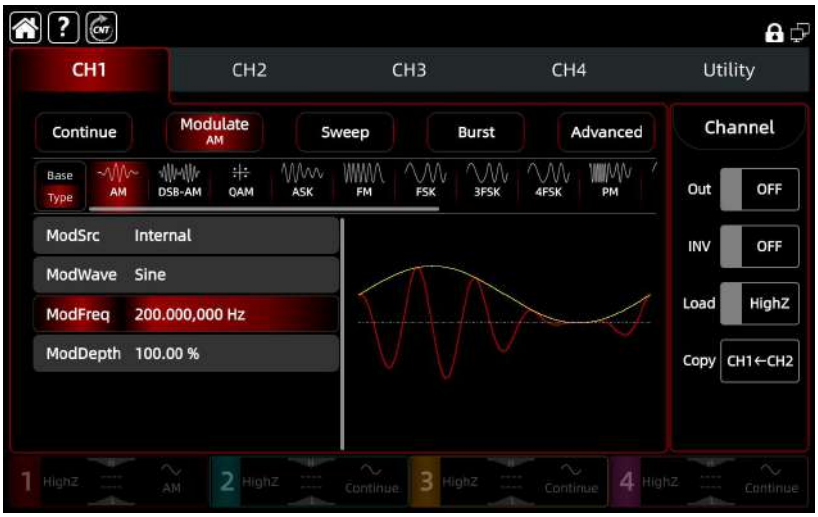
1) Enable AM mode

Press the CH1 button, then tap Modulate→AM on the screen to enable AM mode.



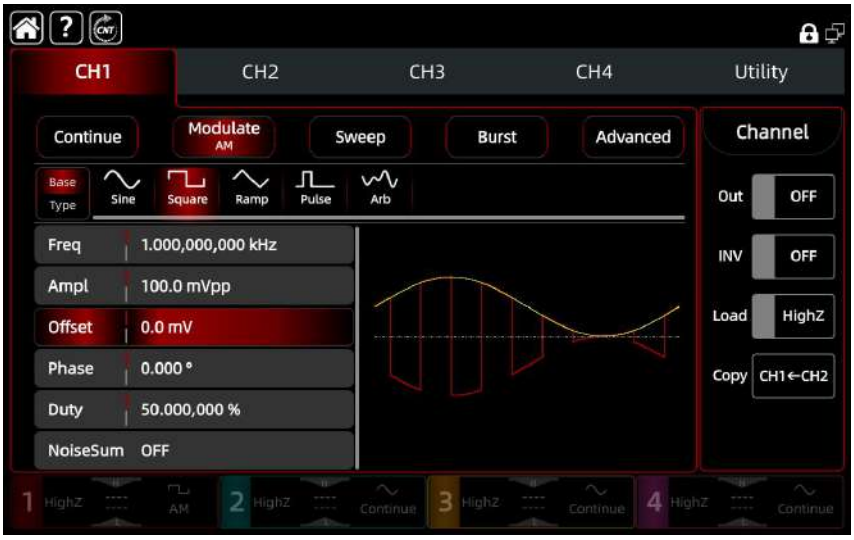
2) Set Modulation Signal

Based on Step 1, tap ModFreq, use the numeric keypad to enter 200, and select Hz as the unit.



3) Set Carrier Wave and Parameters

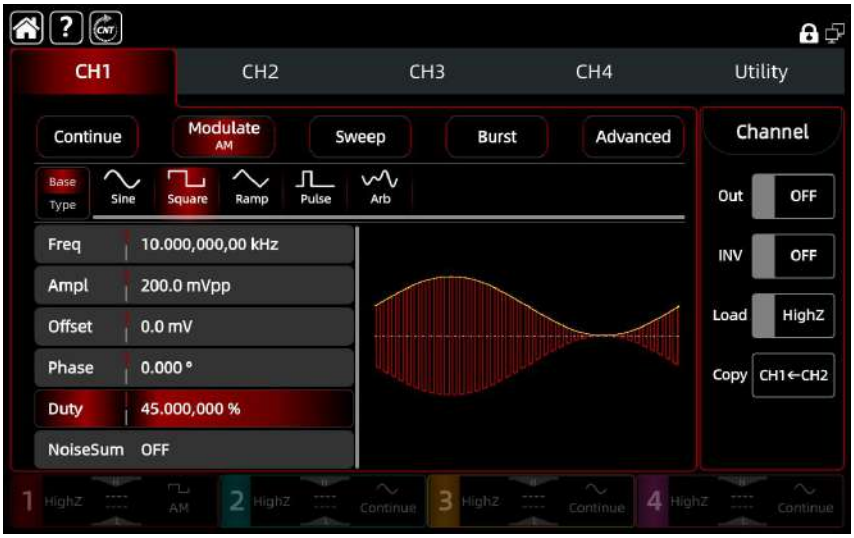
Tap Base/Type to select the square wave as the carrier wave. The default is sine wave.



Tap Freq, use the numeric keypad to enter 10, and select kHz as the unit.

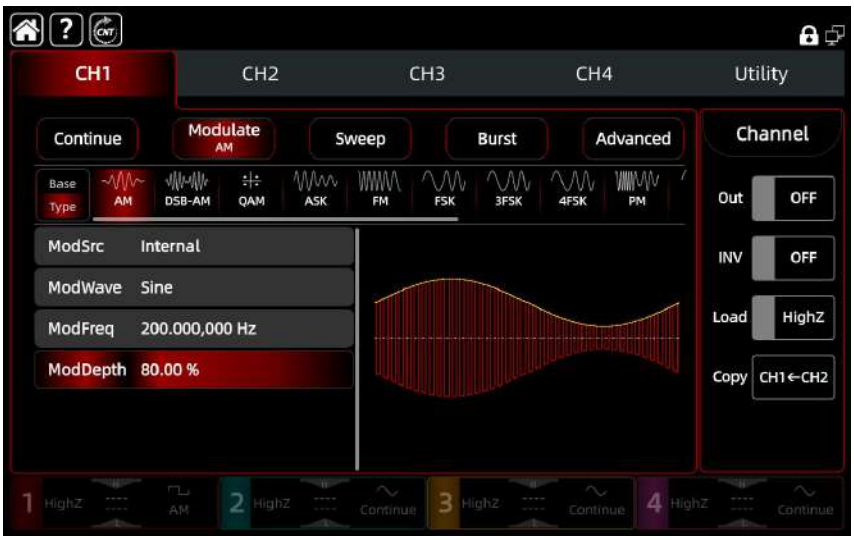
Tap Ampl, use the numeric keypad to enter 200, and select mVpp as the unit.

Tap Duty, use the numeric keypad to enter 45, and select % as the unit.



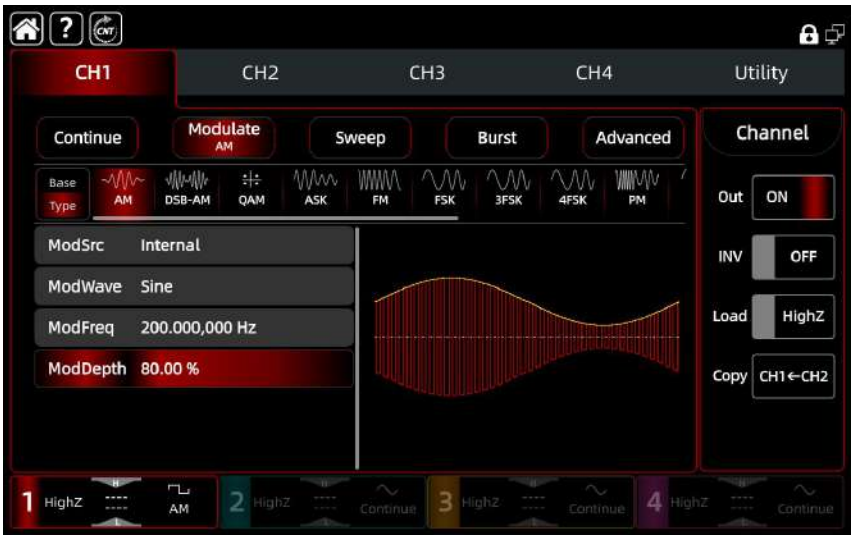
4) Set Modulation Depth

After configuring the carrier wave parameters, tap Base/Type to enter the AM setting, tap ModDepth, use the numeric keypad to enter 80, and select % as the unit.

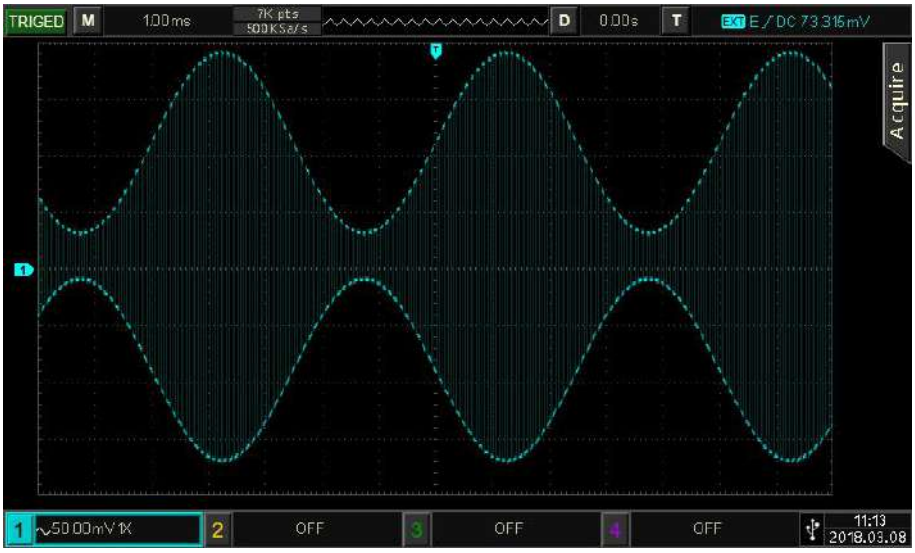


5) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the AM waveform through an oscilloscope as shown in the following figure.

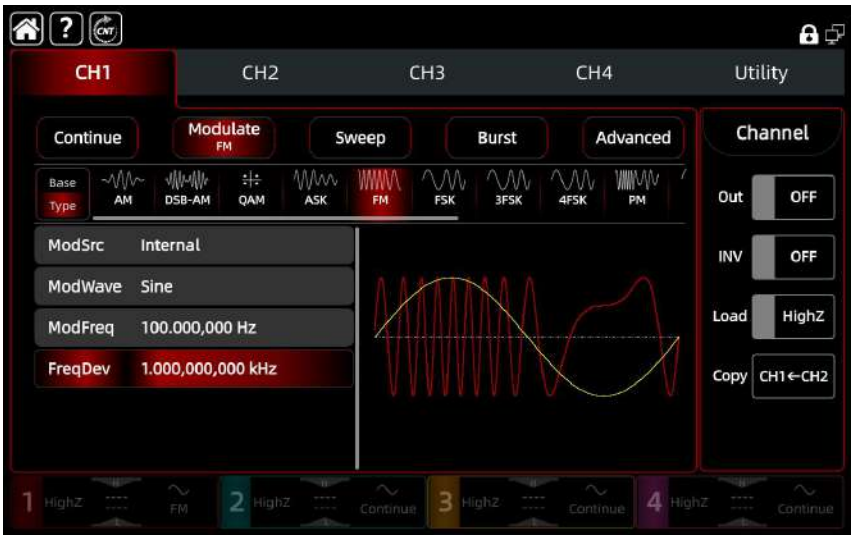


4.1.2 Frequency Modulation (FM)

In FM mode, the modulated wave consists of the carrier wave and the modulation wave. The frequency of the carrier wave changes with the frequency of the modulation wave.

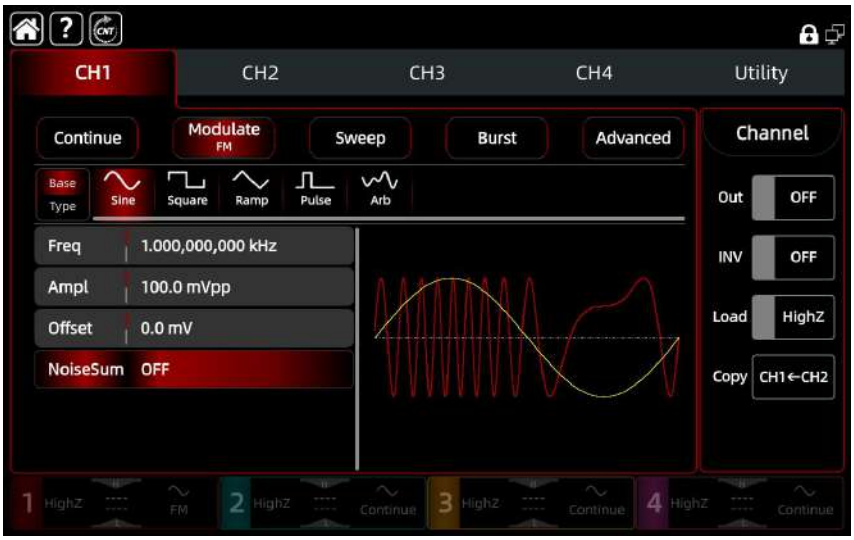
FM Setting

Press the CH1 button, then tap Modulate→FM key to enable FM mode. The instrument will output the modulated waveform according to the current modulation wave and the carrier wave.



Carrier Wave Setting

The carrier waveform can be set to sine, square, ramp, pulse, or arbitrary. The default is sine wave. After selecting FM mode, tap Base/Type to choose a different carrier waveform.



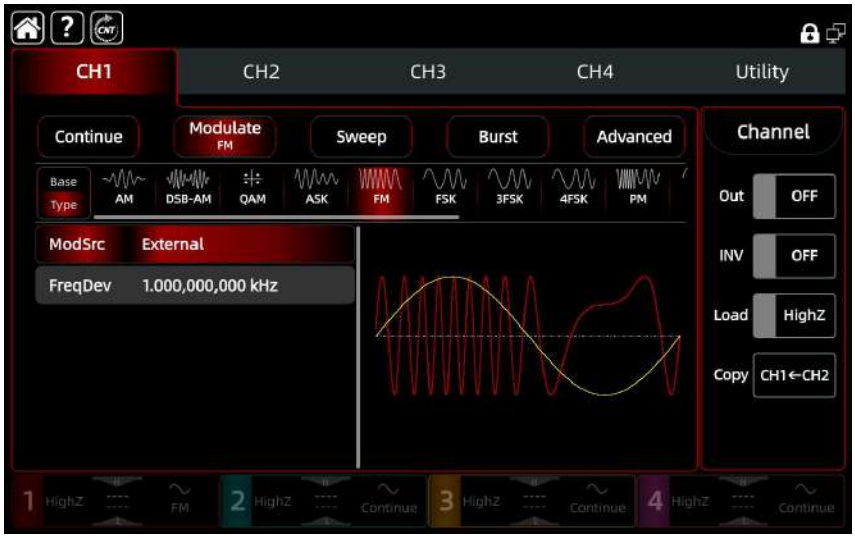
Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Modulation Source Setting

This series provides two modulation source options: internal and external.

After FM mode is enabled, the default modulation source (Internal) is displayed. The modulation source can be switched using the multi-function rotary knob in the FM interface, or by pressing ModSrc→Internal, then selecting External.



1) Internal Source

When the modulation source is set to internal, the modulation waveform can be sine, square, rising ramp, fall ing ramp, arbitrary, or noise. The default waveform is sine.

After FM modulation is enabled, the modulation waveform defaults to Sine. Rotate the multi-function rotary knob or tap Modulate→Sine to select a different waveform on the FM setting interface.

- Square wave: duty cycle 50%
- Rising ramp wave: symmetry 100%
- Falling ramp wave: symmetry 0%
- Arbitrary wave: waveform length limited to 2 kpts when using the Auto Point Select method
- Noise wave: white Gaussian noise

2) External Source

When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform. The FM deviation is controlled by the ±5 V signal applied to the external analog modulation input (Modulation In connector) on the rear panel. A positive input voltage increases the FM output frequency above the carrier frequency, while a negative input voltage decreases it. Lower input voltages produce smaller frequency deviations.

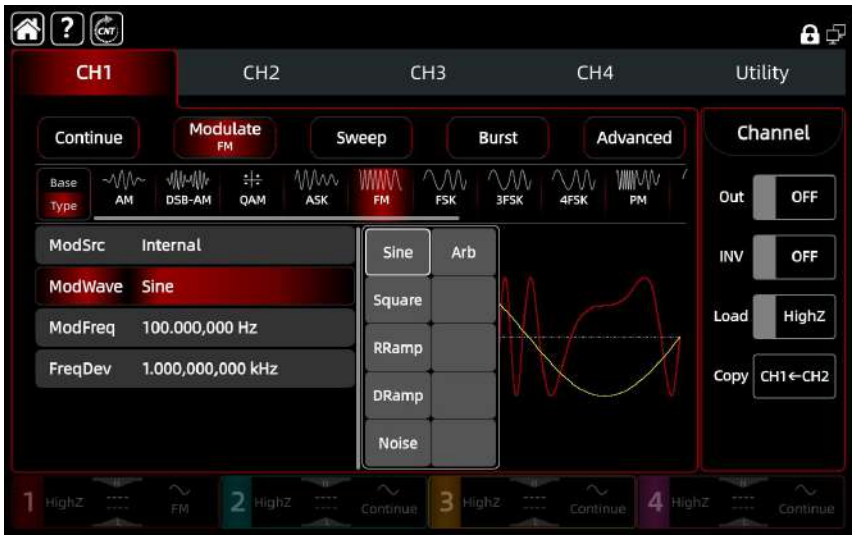
For example, if the frequency deviation is set to 1 kHz, the FM output frequency increases by 1 kHz from the carrier frequency when the external modulation signal is +5 V, and decreases by 1 kHz when the signal is −5 V.

Modulation Wave Setting

When the modulation source is set to internal, the internal modulation waveform can be sine, square, ramp, or arbitrary. The default waveform is sine.

After FM modulation is enabled, the modulation waveform defaults to Sine. Rotate the multi-function rotary knob or tap Modulate to select a different waveform on the FM setting interface.

- Square wave: duty cycle 50%
- Rising ramp wave: symmetry 100%
- Falling ramp wave: symmetry 0%
- Arbitrary wave: waveform length limited to 2 kpts when using the Auto Point Select method
- Noise wave: white Gaussian noise



Modulation Wave Frequency Setting

After the FM function is enabled, when the modulation source is set to internal, the modulation wave frequency can be configured. The frequency range is 1 μHz to 2 MHz, with a default value of 100 Hz. Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation frequency. Alternatively, tap ModFreq on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface. When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform.

Frequency Deviation Setting

Frequency deviation refers to the difference between the frequency of an FM-modulated waveform and the carrier (fundamental) frequency. The configurable FM frequency deviation range is from DC to half of the current fundamental bandwidth, with a system default of 10 kHz.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the frequency

deviation. Alternatively, tap FreqDev on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

- Frequency deviation ≤ Carrier frequency

  If the set frequency deviation exceeds the carrier frequency, the instrument automatically limits it to the maximum allowed by the current carrier frequency.

- Carrier frequency + Frequency deviation ≤ Maximum allowable frequency

  If an invalid deviation is set, the instrument automatically limits it to the maximum permitted by the current carrier frequency.

- When the carrier waveform is a pulse wave: Carrier frequency − Frequency deviation > Modulation frequency

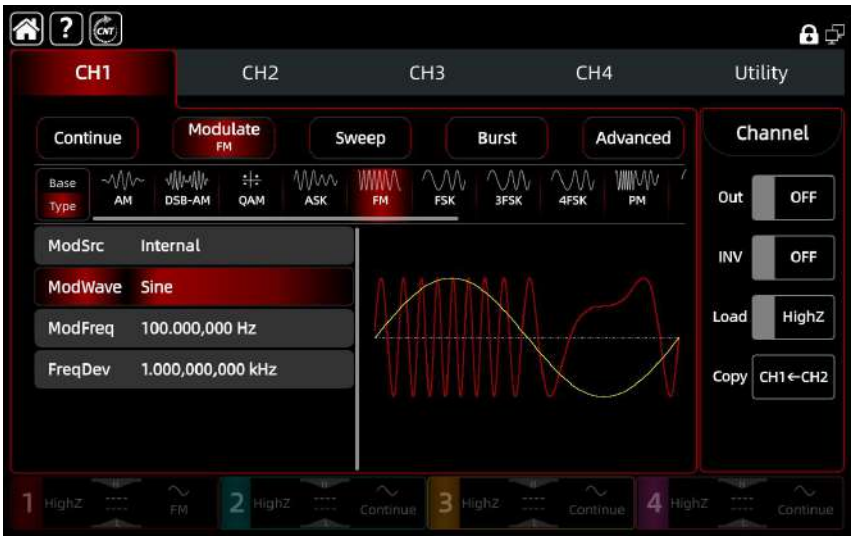
  If an invalid deviation is set, the instrument automatically limits it to the maximum permitted by the current carrier frequency.

Comprehensive Example

In FM modulation mode, set an internal 2 kHz square wave as the modulating signal, and set a 10 kHz sine wave with an amplitude of 100 mVpp as the carrier signal. Then, set the frequency deviation to 5 kHz. The setting steps are as follows.

1) Enable FM Mode

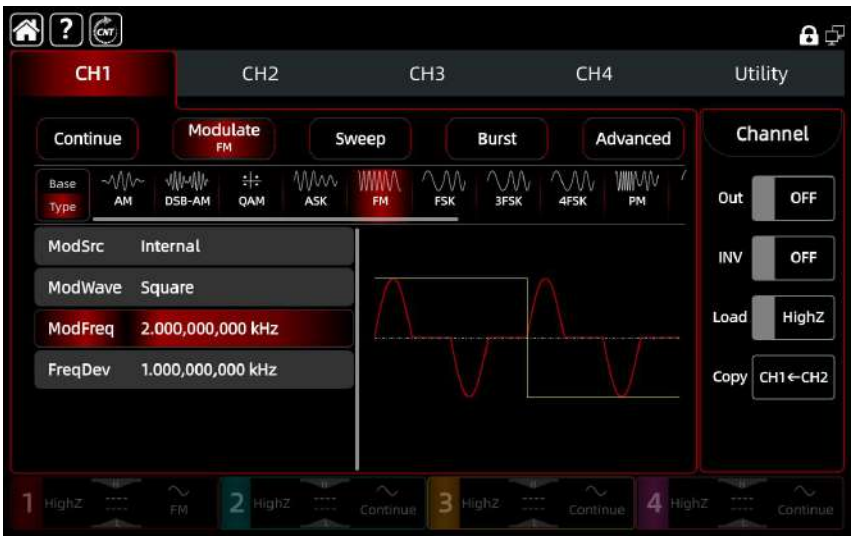
   Press the CH1 button, then tap Modulate→FM on the screen to enable FM mode.



2) Set Modulation Signal and Parameters

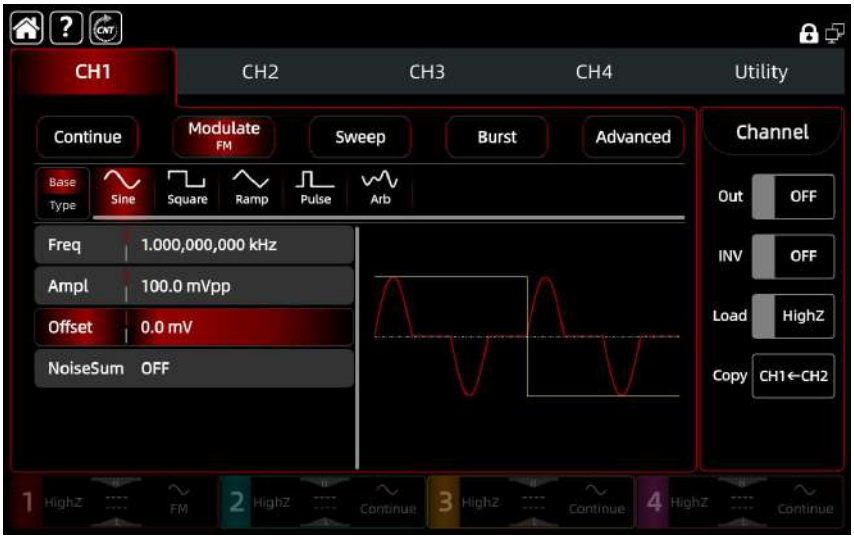
   Based on Step 1, tap Modulate to select the square as the modulation wave.

   Tap ModFreq, use the numeric keypad to enter 2, and select kHz as the unit.



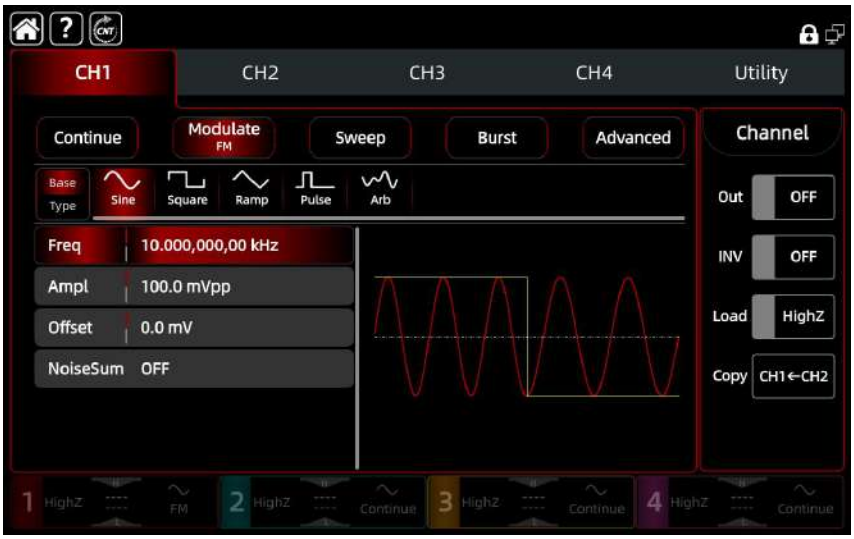
3) Set Carrier Wave and Parameters

Tap Base/Type to select the sine wave as the carrier wave. The default is sine wave.



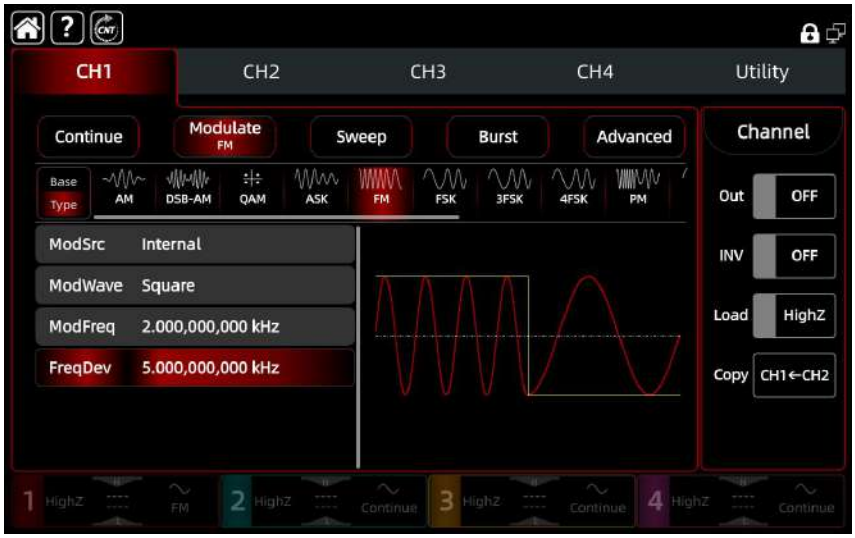
Tap Freq, use the numeric keypad to enter 10, and select kHz as the unit.

Tap Ampl, use the numeric keypad to enter 100, and select mVpp as the unit.



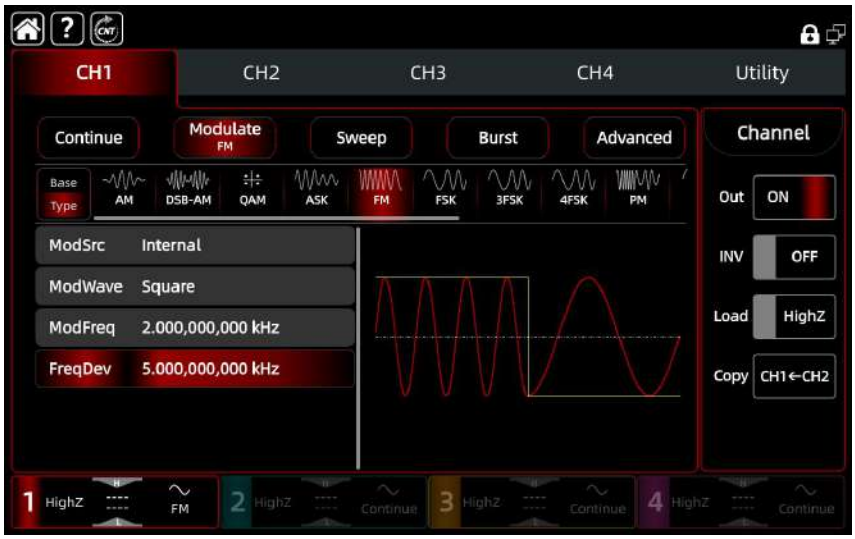
4) Set Frequency Deviation

After configuring the carrier wave parameters, tap Base/Type to enter the FM setting, tap FreqDev, use the numeric keypad to enter 5, and select kHz as the unit.

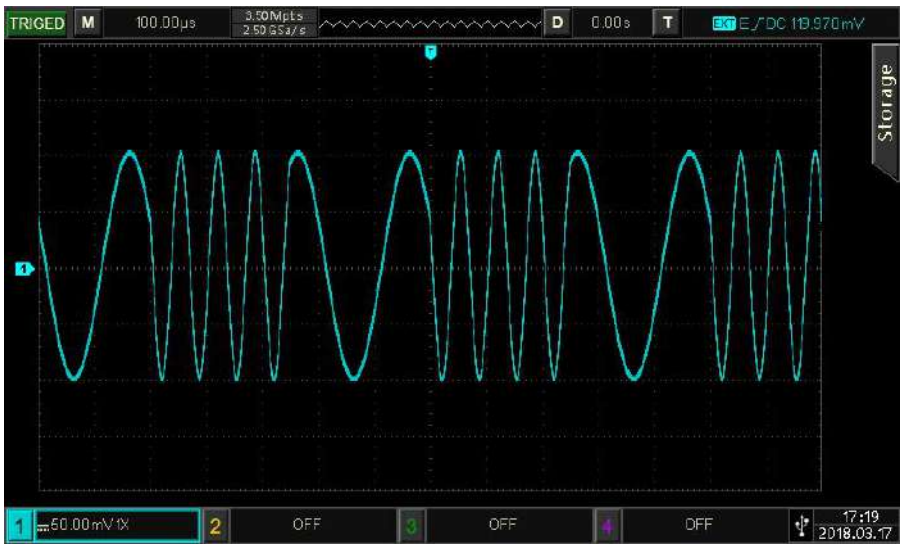


5) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the FM waveform through an oscilloscope as shown in the following figure.

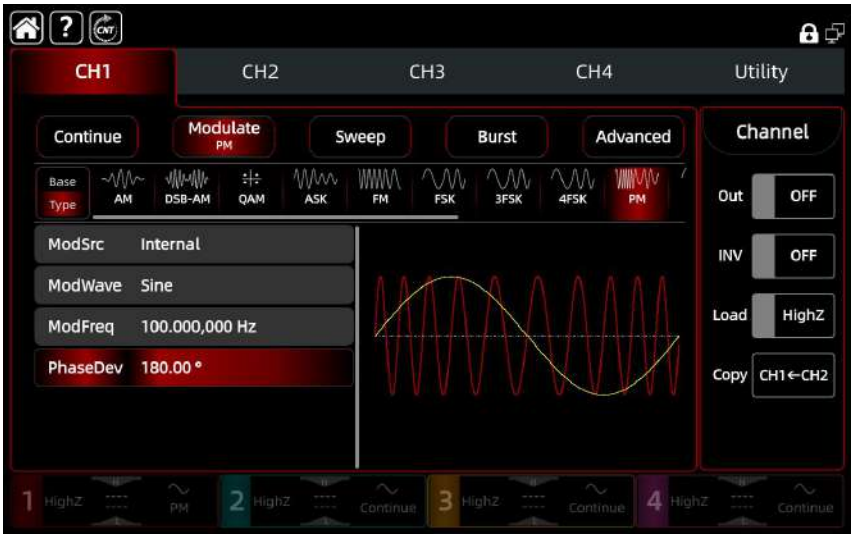


4.1.3 Phase Modulation (PM)

In PM mode, the modulated wave consists of the carrier wave and the modulation wave. The phase of the carrier wave changes with the amplitude of the modulation wave.

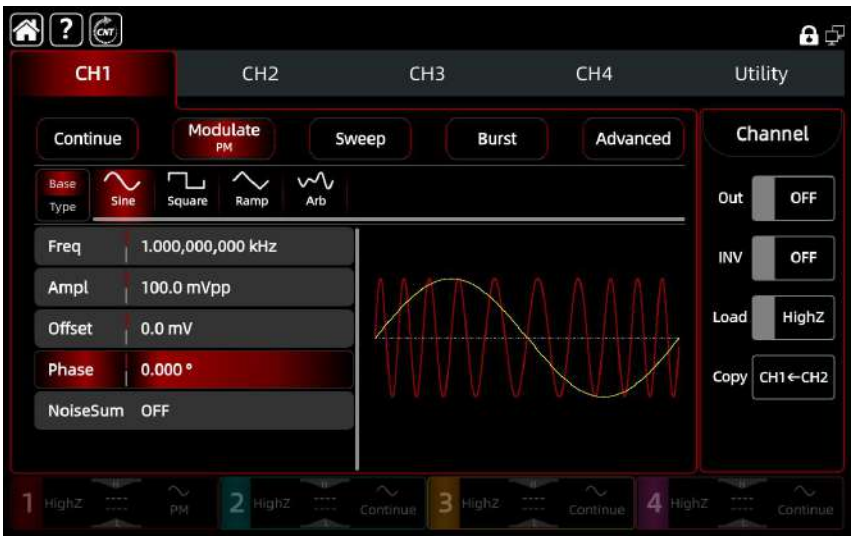
Enable PM Mode

Press the CH1 button, then tap Modulate→PM key to enable PM mode. The instrument will output the modulated waveform according to the current modulation wave and the carrier wave.



Carrier Wave Setting

The carrier waveform can be set to sine, square, ramp, or arbitrary. The default is sine wave. After selecting PM mode, tap Base/Type to choose a different carrier waveform.



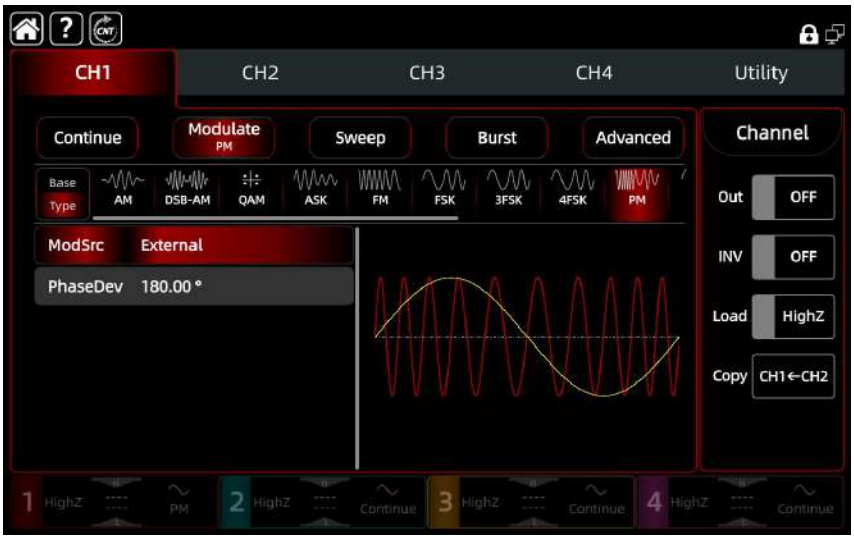
Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Modulation Source Setting

This series provides two modulation source options: internal and external.

After PM mode is enabled, the default modulation source (Internal) is displayed. The modulation source can be switched using the multi-function rotary knob in the PM interface, or by pressing ModSrc→Internal, then selecting External.



1) Internal Source

When the modulation source is set to internal, the modulation waveform can be sine, square, rising ramp, falling ramp, arbitrary, or noise. The default waveform is sine.

After PM modulation is enabled, the modulation waveform defaults to Sine. Rotate the multi-function rotary knob or tap Modulate→Sine to select a different waveform on the PM setting interface.

- Square wave: duty cycle 50%

- Rising ramp wave: symmetry 100%
- Falling ramp wave: symmetry 0%
- Arbitrary wave: waveform length limited to 2 kpts when using the Auto Point Select method
- Noise wave: white Gaussian noise

2) External Source

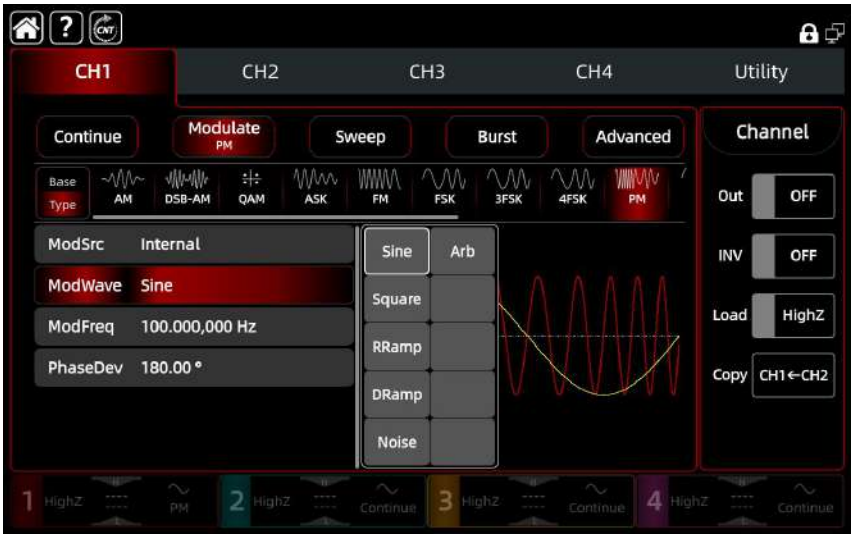
When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform. The PM deviation is controlled by the ±5 V signal applied to the external analog modulation input (Modulation In connector) on the rear panel. For example, when the phase deviation is set to 180°, an external modulation input of +5 V produces a phase deviation of 180°. Lower input voltages result in smaller phase deviations.

Modulation Wave Setting

When the modulation source is set to internal, the internal modulation waveform can be sine, square, ramp, or arbitrary. The default waveform is sine.

After PM modulation is enabled, the modulation waveform defaults to Sine. Rotate the multi-function rotary knob or tap Modulate to select a different waveform on the PM setting interface.

- Square wave: duty cycle 50%
- Rising ramp wave: symmetry 100%
- Falling ramp wave: symmetry 0%
- Arbitrary wave: waveform length limited to 2 kpts when using the Auto Point Select method
- Noise wave: white Gaussian noise



Modulation Wave Frequency Setting

After the PM function is enabled, when the modulation source is set to internal, the modulation wave

frequency can be configured. The frequency range is 1 μHz to 2 MHz, with a default value of 100 Hz. Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation frequency. Alternatively, tap ModFreq on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface. When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform.

Phase Deviation Setting

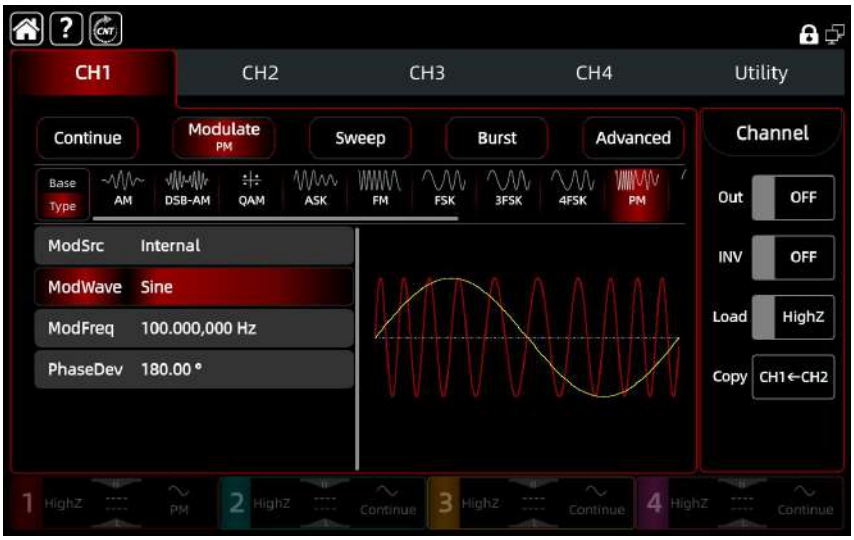
Phase deviation indicates the difference between the phase of a PM-modulated waveform and the carrier phase. The configurable phase deviation range is 0° to 360°, with a default value of 0°. Rotate the multi-function rotary knob, in combination with the arrow keys to set the phase deviation. Alternatively, tap PhaseDev on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Comprehensive Example

In PM (PM) modulation mode, set an internal 200 Hz sine wave as the modulating signal, and set a 900 Hz sine wave with an amplitude of 100 mVpp as the carrier signal. Then set the phase deviation to 200°. The setting steps are as follows.

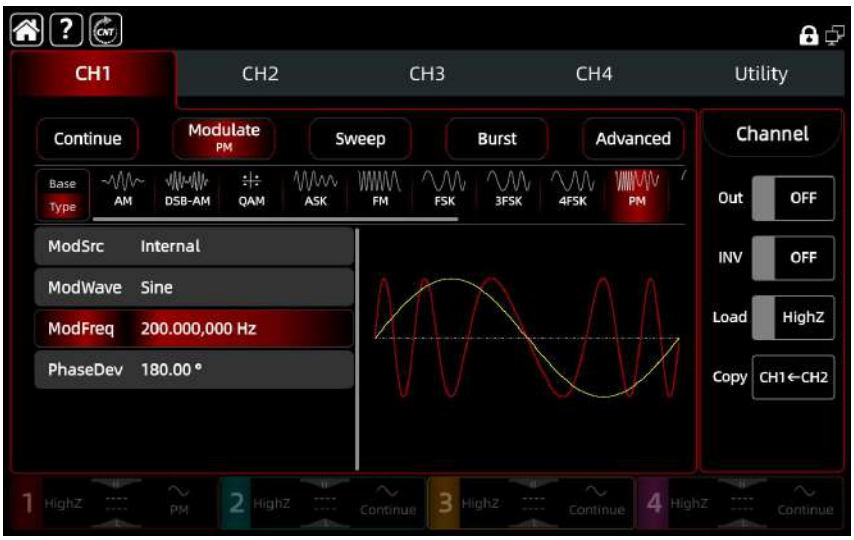
1) Enable PM Mode

Press the CH1 button, then tap Modulate→PM on the screen to enable PM mode.



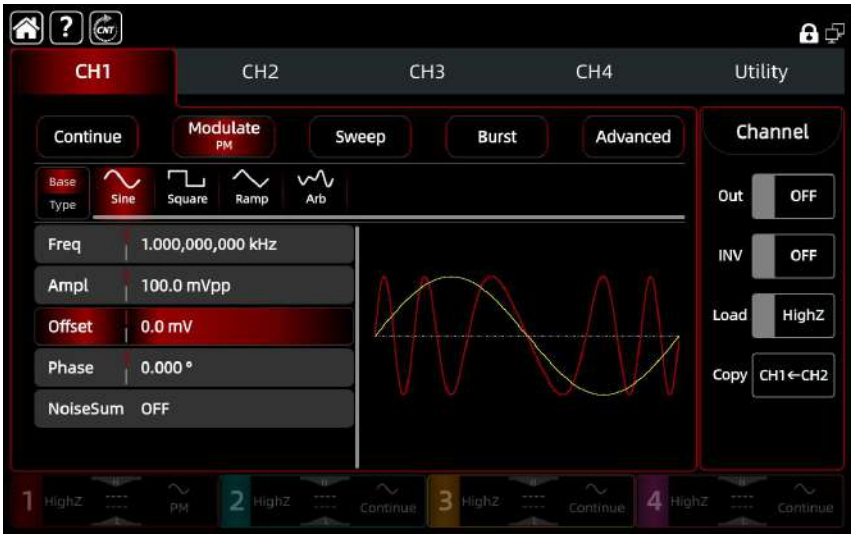
2) Set Modulation Signal

Based on Step 1, tap ModFreq, use the numeric keypad to enter 200, and select Hz as the unit.



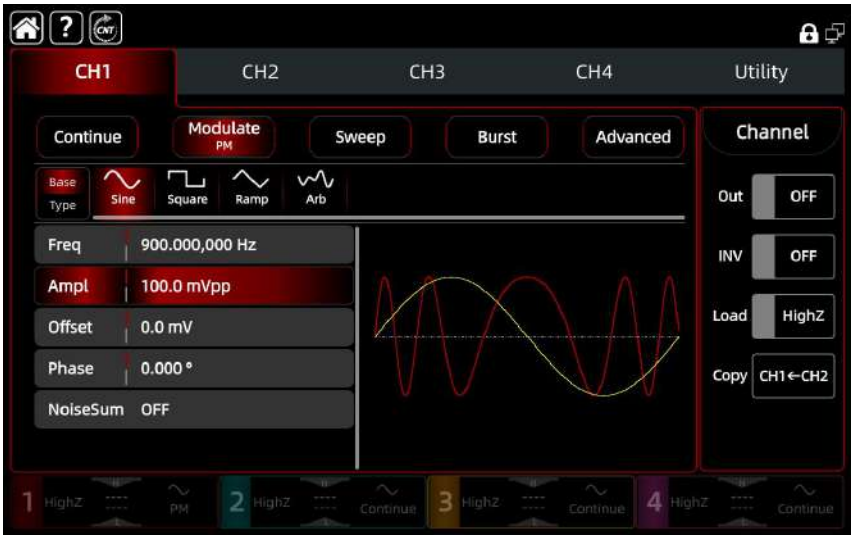
3) Set Carrier Wave and Parameters

Tap Base/Type to select the square wave as the carrier wave. The default is sine wave.



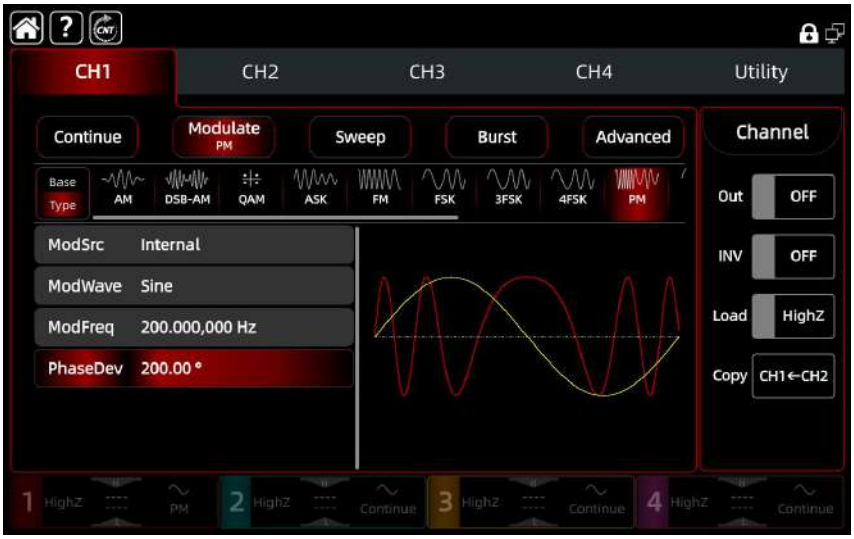
Tap Freq, use the numeric keypad to enter 900, and select Hz as the unit.

Tap Ampl, use the numeric keypad to enter 100, and select mVpp as the unit.



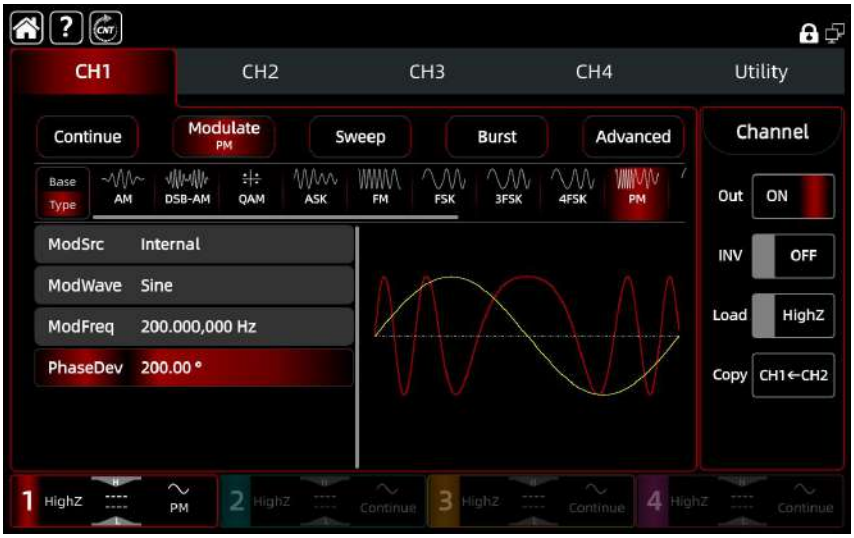
4) Set Frequency Deviation

After configuring the carrier wave parameters, tap Base/Type to enter the PM setting, tap PhaseDev, use the numeric keypad to enter 200, and select ° as the unit.

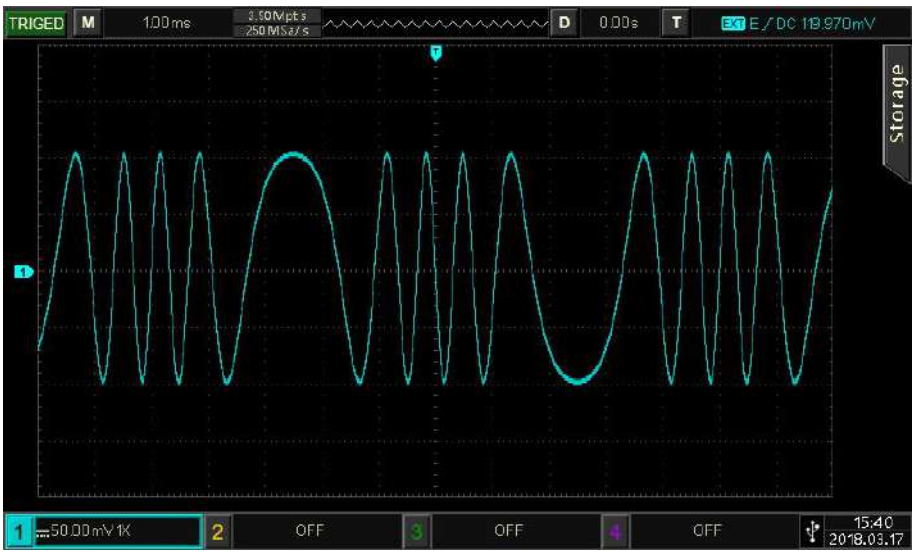


5) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the PM waveform through an oscilloscope as shown in the following figure.

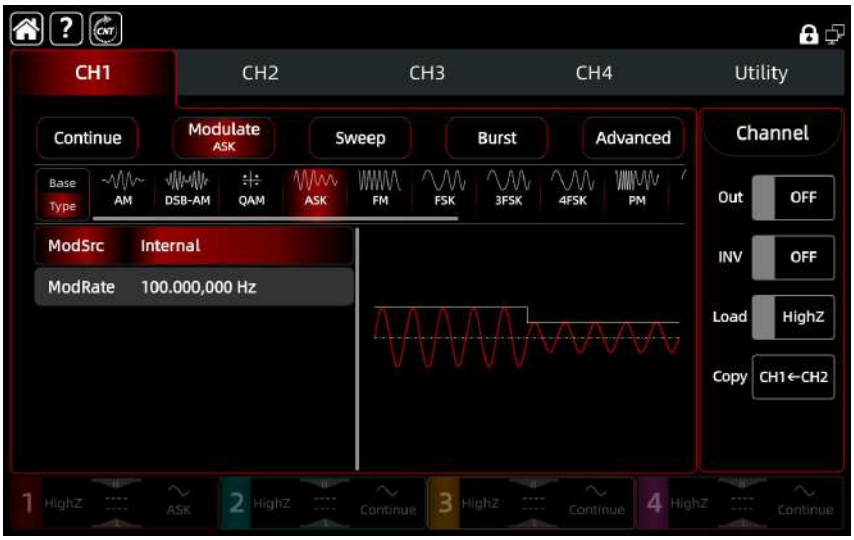


4.1.4 Amplitude Shift Keying (ASK)

In ASK mode, the amplitude of the carrier signal changes to represent the digital signal as “0” or “1.” The output carrier signal varies in amplitude based on the logic level of the modulation signal.

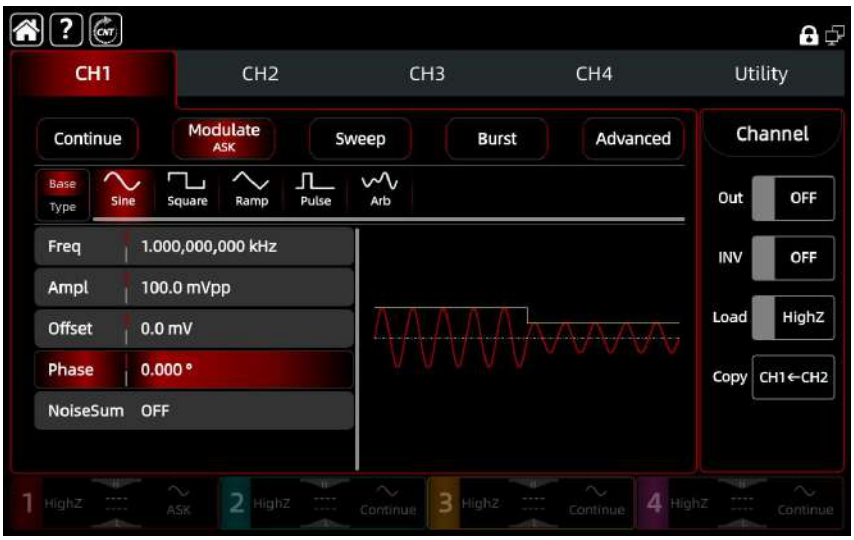
Enable ASK Mode

Press the CH1 button, then tap Modulate→ASK key to enable ASK mode. The instrument will output the modulated waveform according to the ASK rate setting and the carrier wave.



Carrier Wave Setting

The ASK carrier wave can be set to sine, square, ramp, pulse, or arbitrary. The default is sine wave. After selecting ASK mode, tap Base/Type to choose a different carrier waveform.



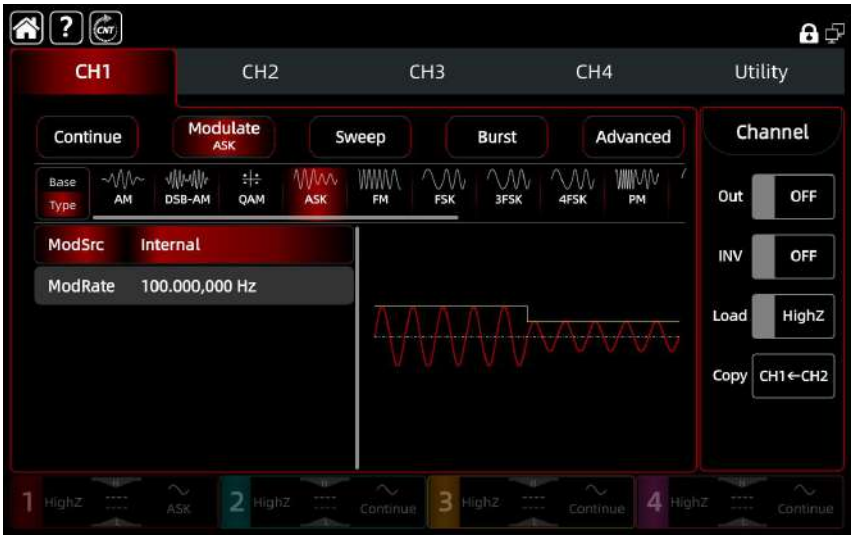
Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Modulation Source Setting

This series provides two modulation source options: internal and external.

After ASK mode is enabled, the default modulation source (Internal) is displayed. The modulation source can be switched using the multi-function rotary knob in the ASK interface, or by pressing ModSrc→Internal, then selecting External.



1) Internal Source

When the modulation source is set to internal, the internal modulation waveform is a built-in square wave with a fixed 50% duty cycle and is not adjustable. The amplitude switching frequency of the modulated waveform is determined by the modulation frequency setting.

2) External Source

When the modulation source is set to external, the rate parameter is hidden in the parameter list. The carrier is modulated by an external waveform.

The ASK output amplitude is controlled by the logic level applied to the external digital modulation input (FSK Trig connector). For example, when the external input is at logic Low, the output amplitude equals the current carrier amplitude; when the external input is at logic High, the output amplitude is reduced relative to the carrier amplitude.

Modulation Rate Setting

After the ASK function is enabled, when the modulation source is set to internal, the ASK rate range can be configured. The ASK rate range is 1 μHz to 2 MHz, with a default value of 100 Hz.

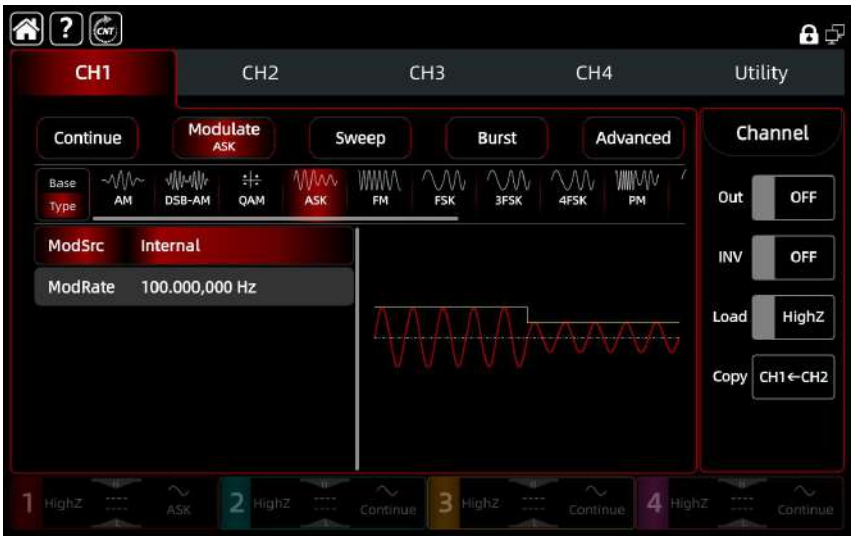
Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation rate. Alternatively, tap ModRate on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Comprehensive Example

In ASK modulation mode, set an internal 300 Hz logic signal as the modulating signal and a sine wave with a frequency of 15 kHz and an amplitude of 2 Vpp as the carrier signal. The setting steps are as follows.

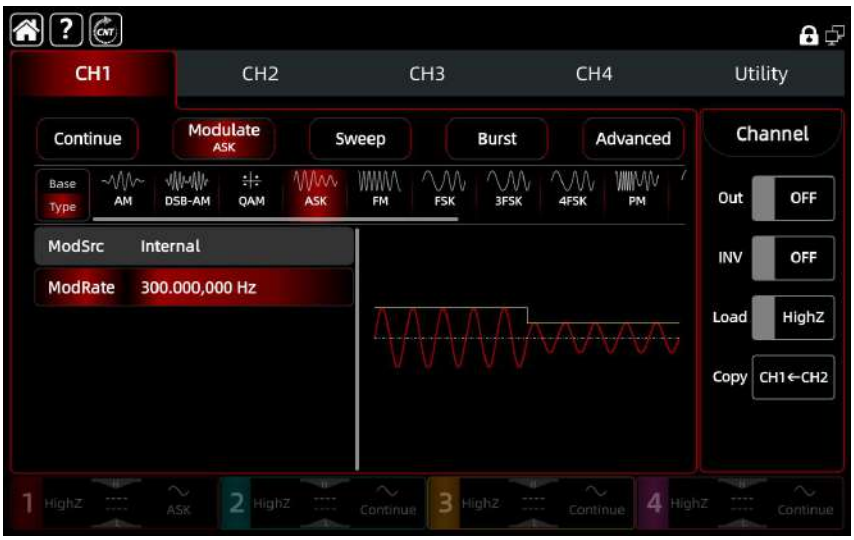
1) Enable ASK Mode

Press the CH1 button, then tap Modulate→ASK on the screen to enable ASK mode.



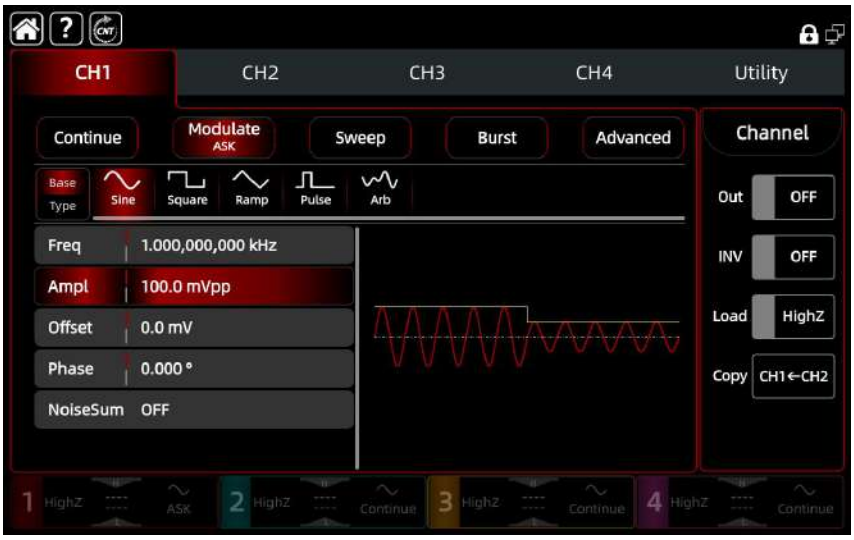
2) Set Modulation Rate

Tap ModRate, use the numeric keypad to enter 300, and select Hz as the unit.



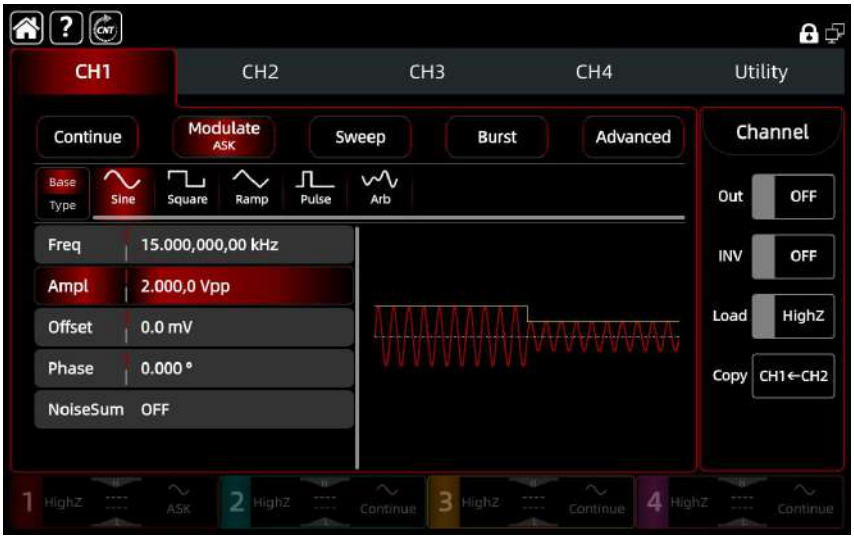
3) Set Carrier Wave and Parameters

Tap Base/Type to select the sine wave as the carrier wave. The default is sine wave.



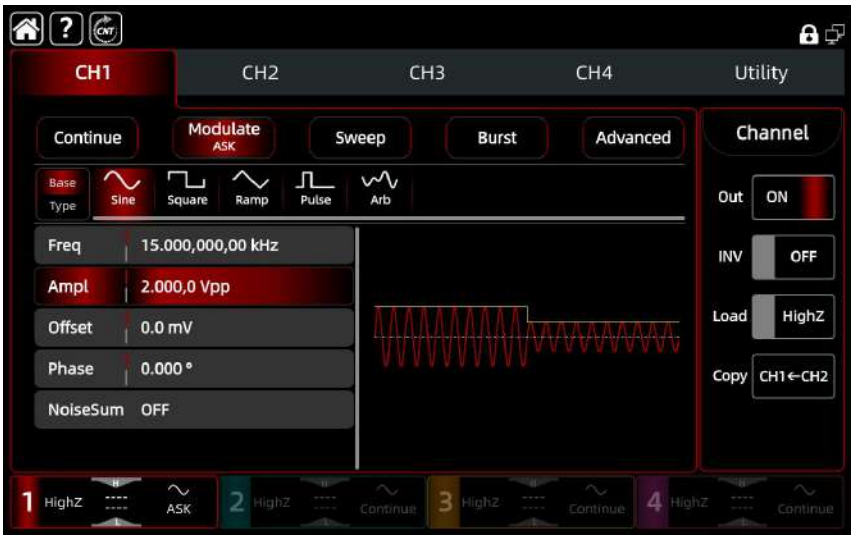
Tap Freq, use the numeric keypad to enter 15, and select kHz as the unit.

Tap Ampl, use the numeric keypad to enter 2, and select Vpp as the unit.

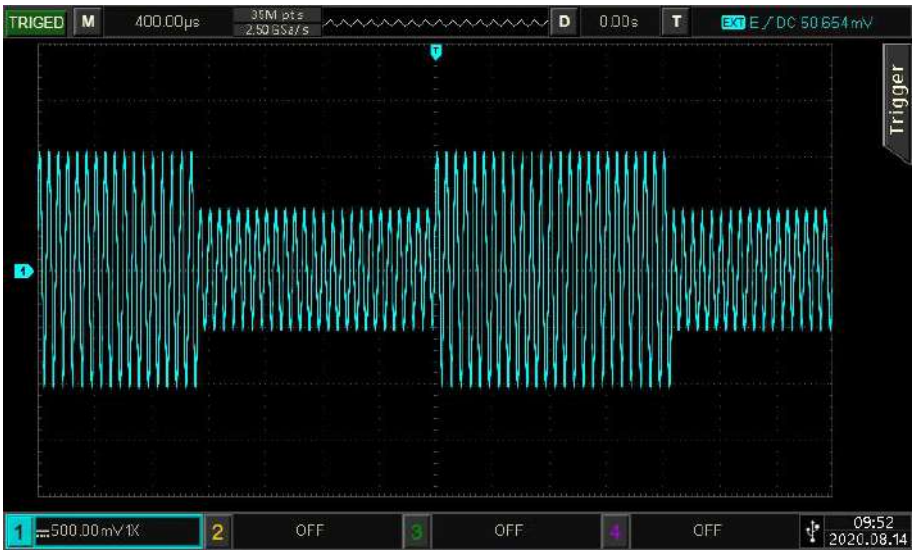


4) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the ASK waveform through an oscilloscope as shown in the following figure.

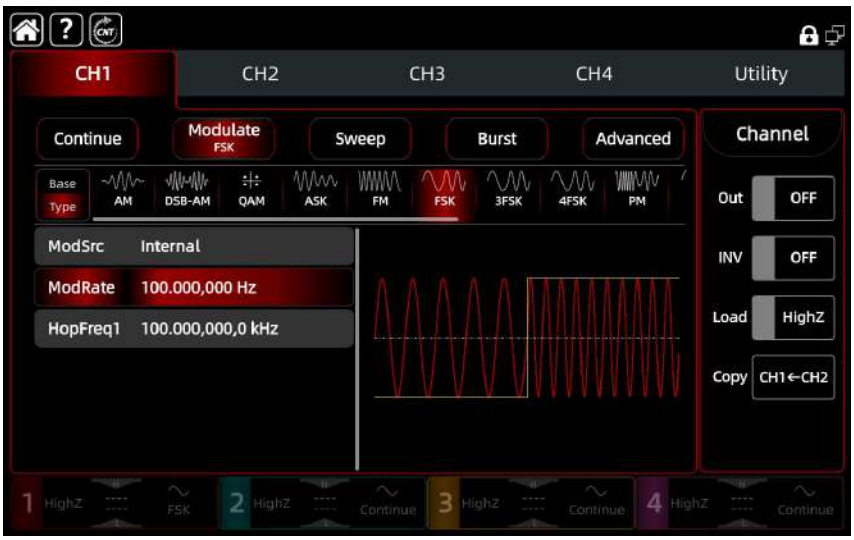


4.1.5 Frequency Shift Keying (FSK)

In FSK mode, the instrument switching rate between the carrier frequency and the hopping frequency can be configured.

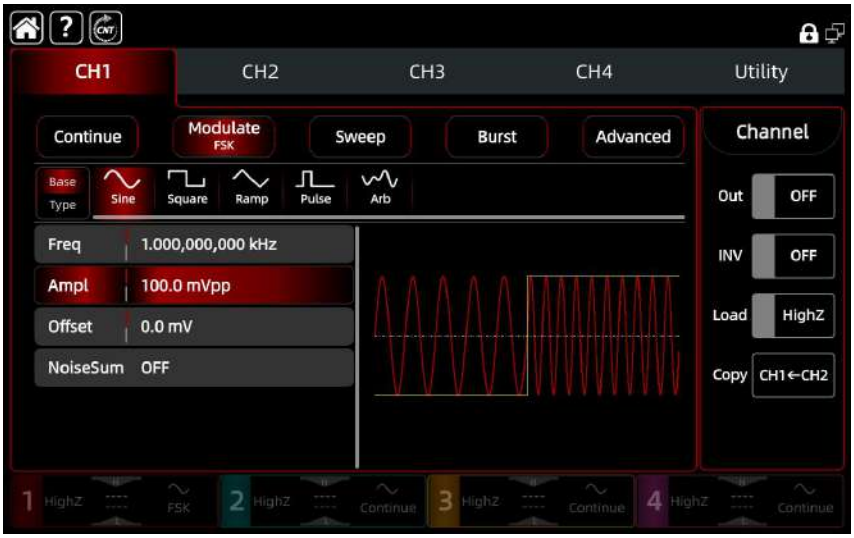
Enable FSK Mode

Press the CH1 button, then tap Modulate→FSK key to enable FSK mode. The instrument will output the modulated waveform according to the FSK rate setting and the carrier wave.



Carrier Wave Setting

The carrier wave can be set to sine, square, ramp, pulse, or arbitrary. The default is sine wave. After selecting FSK mode, tap Base/Type to choose a different carrier waveform.



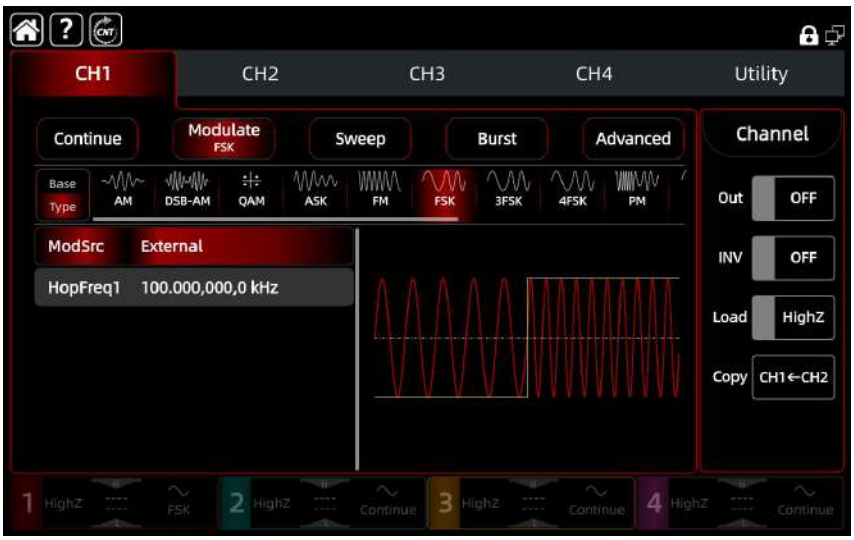
Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Modulation Source Setting

This series provides two modulation source options: internal and external.

After FSK mode is enabled, the default modulation source (Internal) is displayed. The modulation source can be switched using the multi-function rotary knob in the FSK interface, or by pressing ModSrc→Internal, then selecting External.



1) Internal Source

When the modulation source is set to internal, the internal modulation waveform is a built-in square wave with a fixed 50% duty cycle and is not adjustable. The switching frequency between the carrier frequency and the hopping frequency is determined by the modulation frequency setting.

2) External Source

When the modulation source is set to external, the frequency modulation frequency parameter is hidden in the parameter list. The carrier is modulated by an external waveform.

The FSK output frequency is controlled by the logic level applied to the external digital modulation input (FSK Trig connector) on the rear panel. For example, when the external input is Low, the output equals the carrier frequency; when the external input is High, the output equals the hopping frequency.

Hopping Frequency

After FSK mode is enabled, the default hopping frequency of 100 kHz is displayed.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the hopping frequency 1. Alternatively, tap HopFreq1 on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

The hopping frequency range depends on the carrier wave; the frequency setting of the carrier wave can refer to *Carrier Frequency* in AM mode.

Modulation Rate Setting

Switching frequency between the carrier frequency and the hopping frequency. When the modulation source is set to internal, the FSK rate range can be configured. The ASK rate range is 1

μHz to 2 MHz, with a default value of 100 Hz.

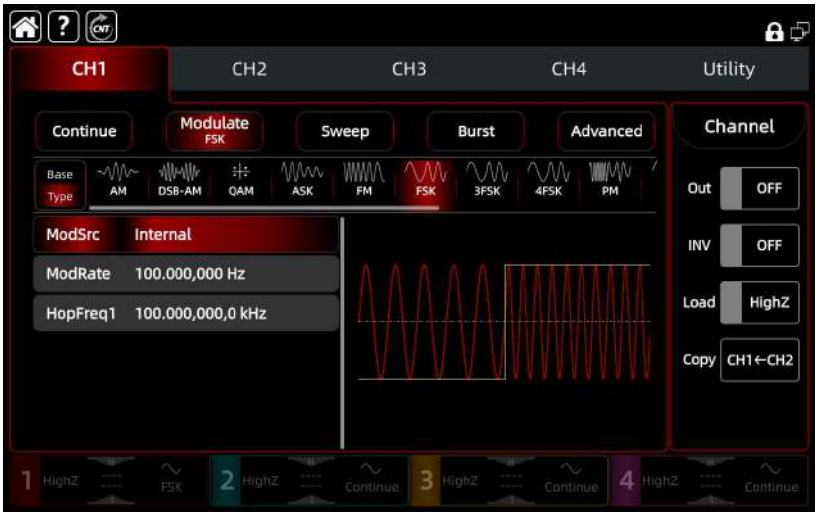
Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation rate. Alternatively, tap ModRate on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Comprehensive Example

In FSK modulation mode, set an internal 2 kHz, 1 Vpp sine wave as the carrier signal, and set the hopping frequency to 800 Hz, with the carrier and hopping frequencies alternating within a 200 Hz range. The setting steps are as follows.

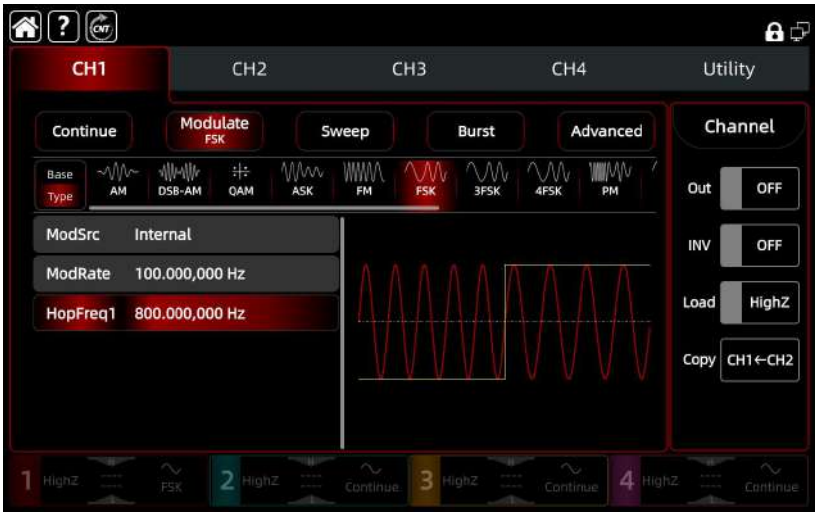
1) Enable FSK Mode

Press the CH1 button, then tap Modulate→FSK on the screen to enable FSK mode.



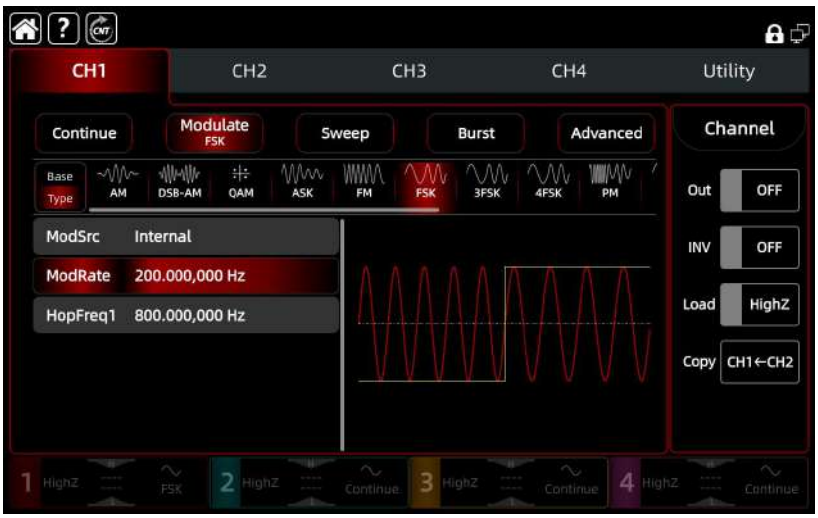
2) Set Hopping Frequency

Based on Step 1, tap HopFreq1, use the numeric keypad to enter 800, and select Hz as the unit.



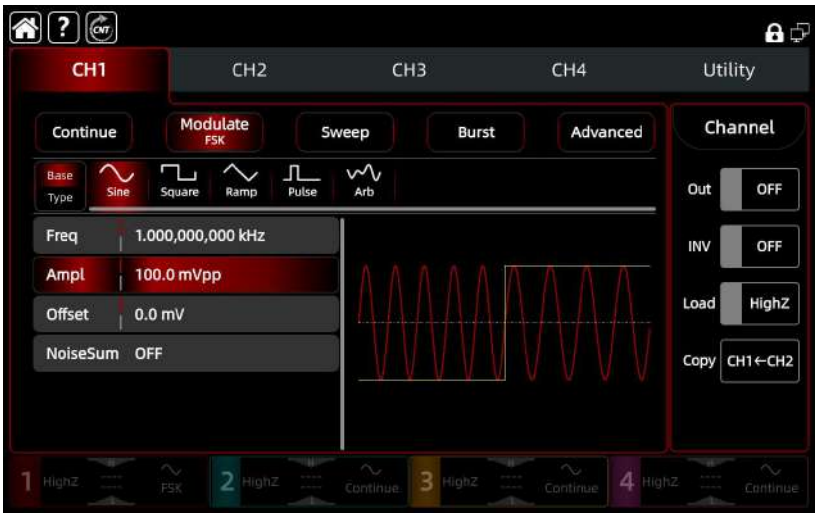
3) Set Modulation Rate

Tap ModRate, use the numeric keypad to enter 200, and select Hz as the unit.



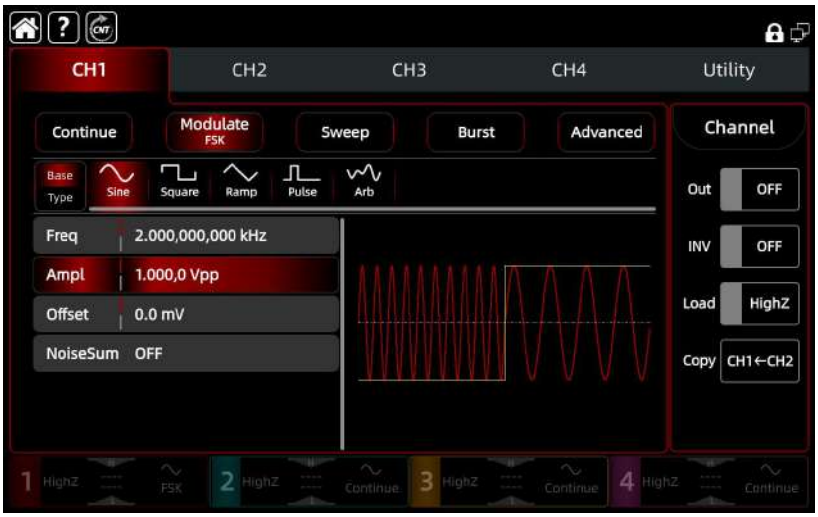
4） Set Carrier Wave and Parameters

Tap Base/Type to select the sine wave as the carrier wave. The default is sine wave.



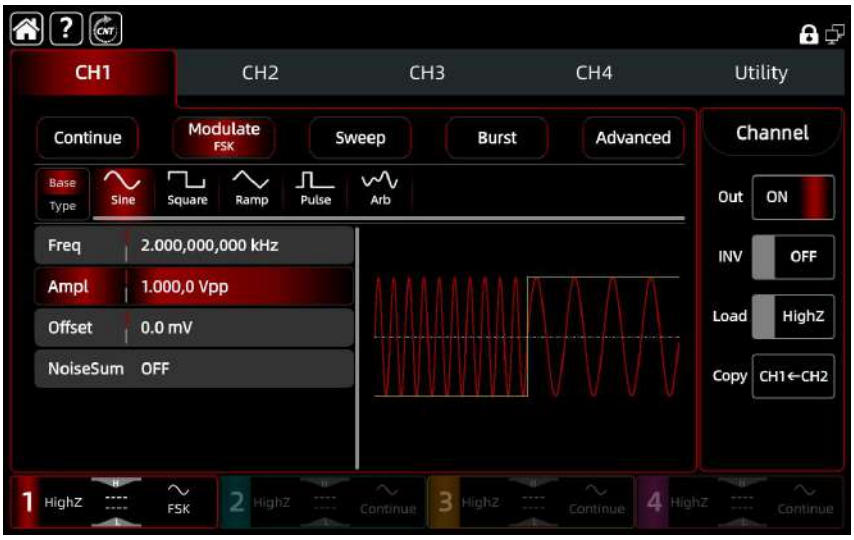
Tap Freq, use the numeric keypad to enter 2, and select kHz as the unit.

Tap Ampl, use the numeric keypad to enter 1, and select Vpp as the unit.

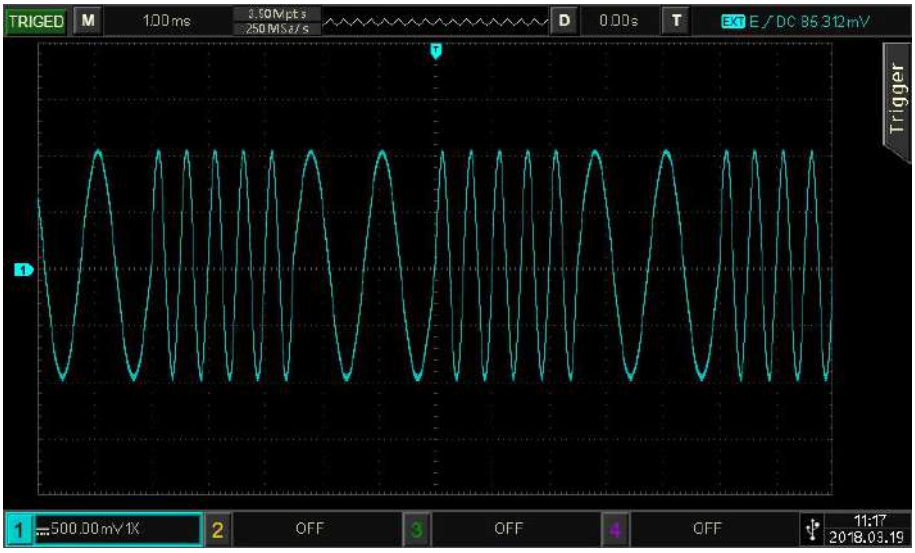


5） Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the FSK waveform through an oscilloscope as shown in the following figure.



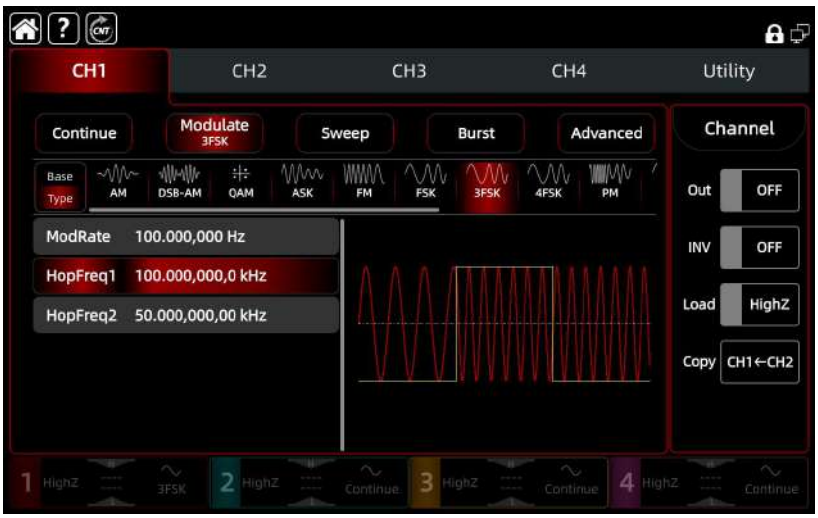
4.1.6 Three Frequency Shift Keying (3FSK)

In 3FSK mode, the function/arbitrary waveform generator switches among three preset frequencies (the carrier frequency and two hopping frequencies). The output frequency is selected according to the logic state of the modulation signal, and may be the carrier frequency or one of the hopping frequencies.

The modulation mode of each channel is independent, allowing the user to configure the same or different modulation modes for each channel.

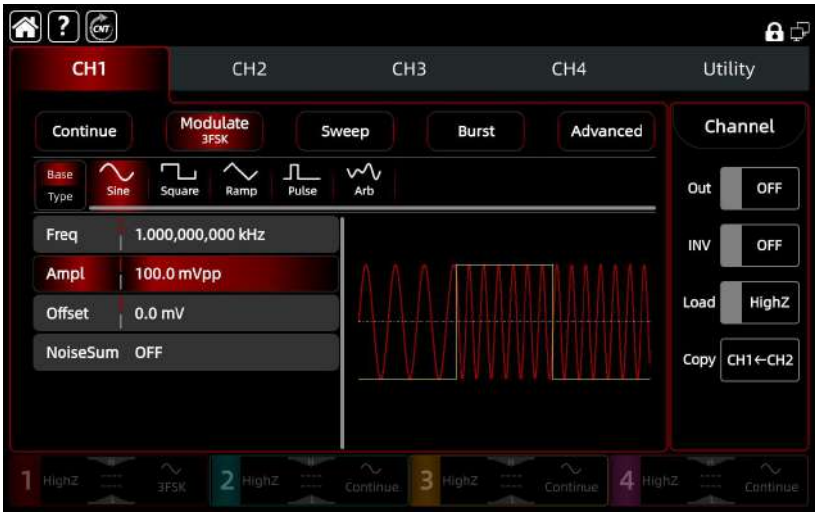
Select 3FSK Mode

Press the CH1 button, then tap Modulate→3FSK key to enable 3FSK mode. The instrument will output the modulated waveform according to the current setting and the carrier wave.



Carrier Wave Setting

The 3FSK carrier wave can be set to sine, square, ramp, pulse, or arbitrary (except DC). The default is sine wave. After selecting 3FSK mode, tap Base/Type to choose a different carrier waveform.



Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Hopping Frequency Setting

After 3FSK mode is enabled, rotate the multi-function rotary knob, in combination with the arrow keys to set the hopping frequency 1 or hopping frequency 2. Alternatively, tap HopFreq1 (or HopFreq2) on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

The hopping frequency range depends on the carrier wave; the frequency setting of the carrier wave can refer to *Carrier Frequency* in AM mode.

Modulation Rate Setting

When the modulation source is set to internal, switching frequency between the carrier frequency

and the hopping frequency. After 3FSK mode is enabled, the 3FSK rate can be configured within a range of 1 μHz to 2 MHz, with a default value of 100 Hz.

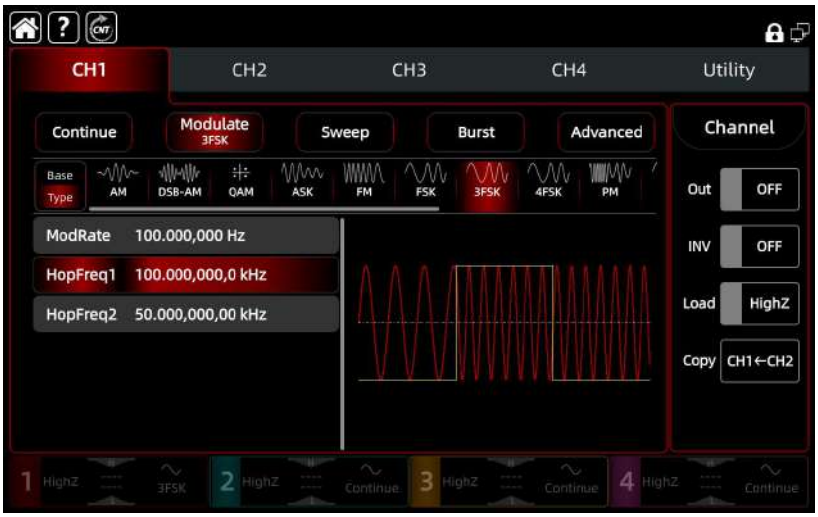
Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation rate. Alternatively, tap ModRate on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Comprehensive Example

In 3FSK mode, set a 2 kHz, 2 Vpp sine wave as the carrier signal, set hopping frequency 1 to 1 kHz and hopping frequency 2 to 5 kHz, and switch among the carrier and hopping frequencies at a rate of 100 Hz. The setting steps are as follows.

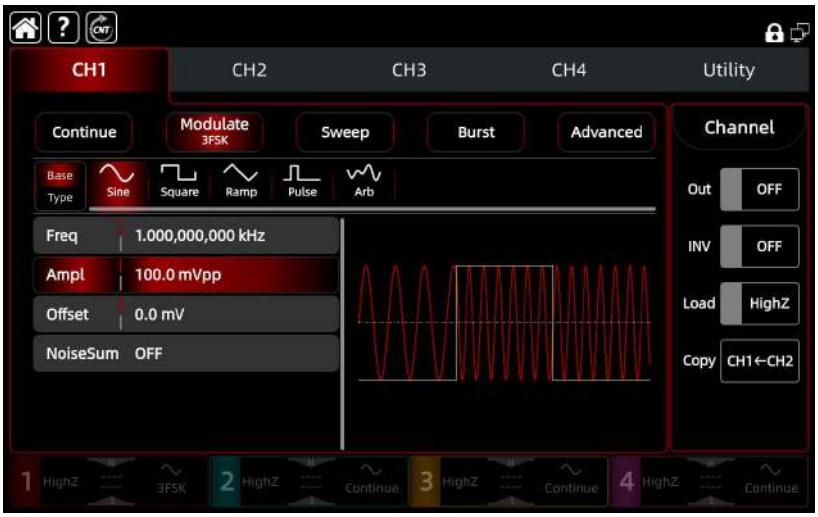
1) Enable 3FSK Mode

Press the CH1 button, then tap Modulate →3ASK on the screen to enable 3ASK mode.



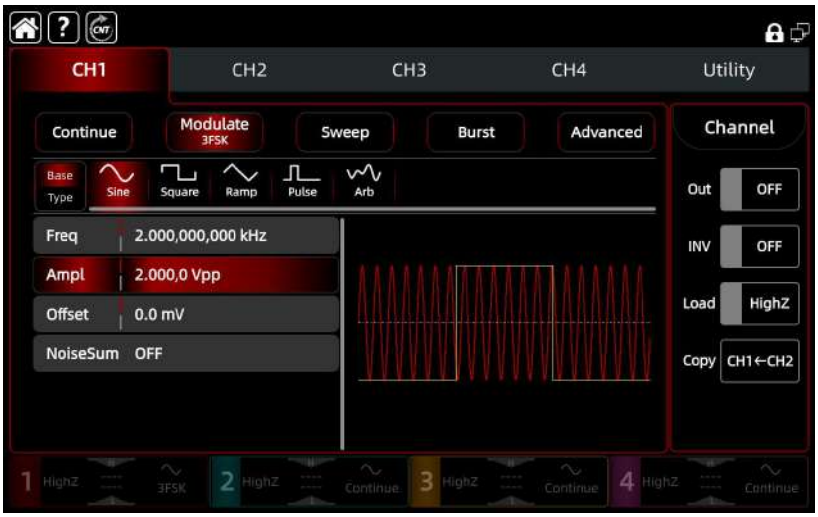
2) Set Carrier Wave and Parameters

Tap Base/Type to select the sine wave as the carrier wave. Since the default setting is sine, no changes are required in this case.



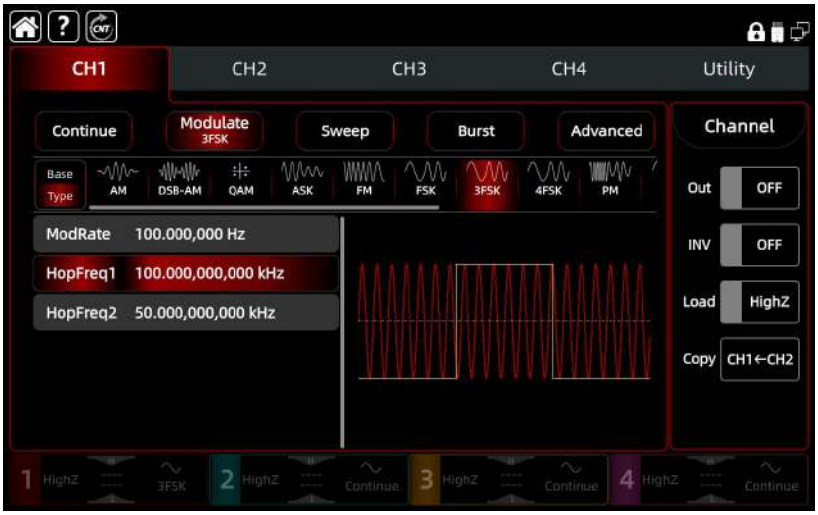
Tap Freq, use the numeric keypad to enter 2, and select kHz as the unit.

Tap Ampl, use the numeric keypad to enter 2, and select Vpp as the unit.



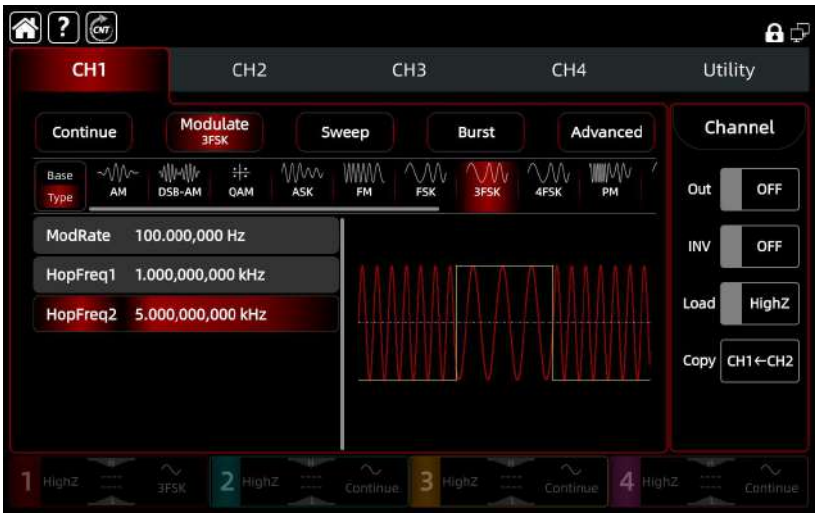
3) Set Hopping Frequency and ModRate

After configuring the carrier wave parameters, tap Base/Type to return to the modulation setting interface, as shown in the following figure.



Tap HopFreq1, use the numeric keypad to enter 1, and select kHz as the unit.

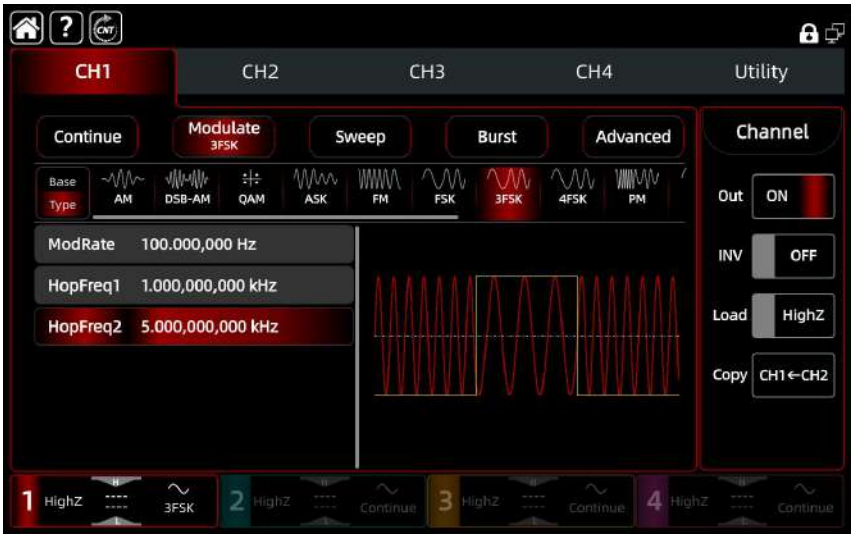
Tap HopFreq2, use the numeric keypad to enter 5, and select mVpp as the unit.



4) Enable Channel Output

Tap Out option to turn on the output, or press the CH1 button on the front panel to quickly enable the CH1 output. The output can also be enabled from the Utility interface by tap Utility→Channel Setting, and then tap CH1 to turn on the output. Alternatively, double-click the channel tab at the bottom of the screen to toggle between ON and OFF.

After the channel output is enabled, the CH1 button backlight turns on. At the same time, the CH1 status label changes from gray to the highlighted "3FSK," indicating that Channel 1 output is enabled.



View the 3FSK waveform through an oscilloscope as shown in the following figure.

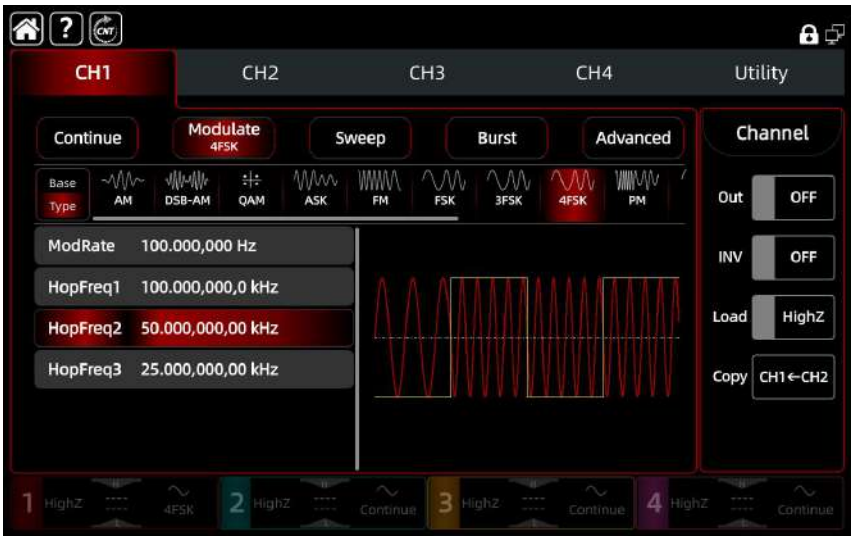
4.1.7 Four Frequency Shift Keying (4FSK)

In 4FSK mode, the function/arbitrary waveform generator switches among four preset frequencies (the carrier frequency and three hopping frequencies). The output frequency is selected according to the logic state of the modulation signal, and may be the carrier frequency or one of the hopping frequencies.

The modulation mode of each channel is independent, allowing the user to configure the same or different modulation modes for each channel.

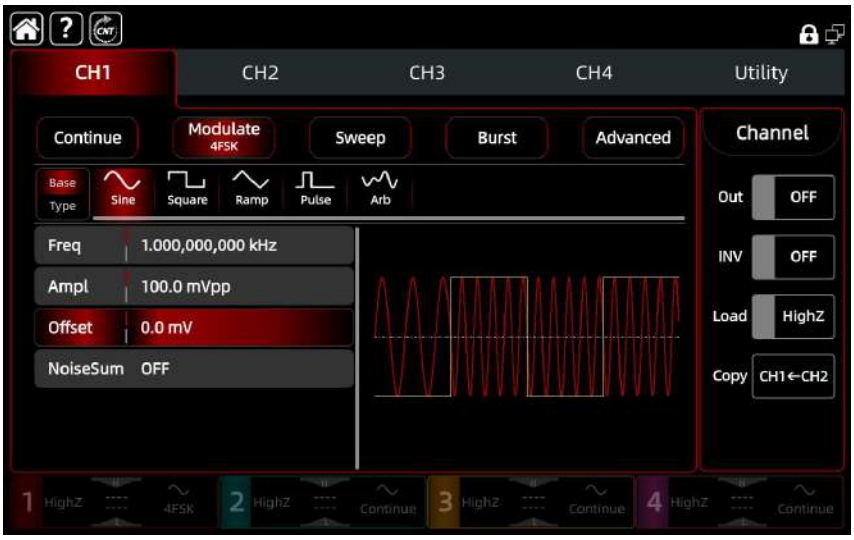
Select 4FSK Mode

Press the CH1 button, then tap Modulate→4FSK key to enable 4FSK mode. The instrument will output the modulated waveform according to the current setting and the carrier wave.



Carrier Wave Setting

The 4FSK carrier wave can be set to sine, square, ramp, pulse, or arbitrary (except DC). The default is sine wave. After selecting 4FSK mode, tap Base/Type to choose a different carrier waveform.



Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Hopping Frequency Setting

After 4FSK mode is enabled, rotate the multi-function rotary knob, in combination with the arrow keys to set the hopping frequency 1, hopping frequency 2, or hopping frequency 3. Alternatively, tap

HopFreq1 (or HopFreq2, HopFreq3) on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface. The hopping frequency range depends on the carrier wave; the frequency setting of the carrier wave can refer to *Carrier Frequency* in AM mode.

Modulation Rate Setting

When the modulation source is set to internal, switching frequency between the carrier frequency and the hopping frequency. After 4FSK mode is enabled, the 4FSK rate can be configured within a range of 1 μHz to 2 MHz, with a default value of 100 Hz.

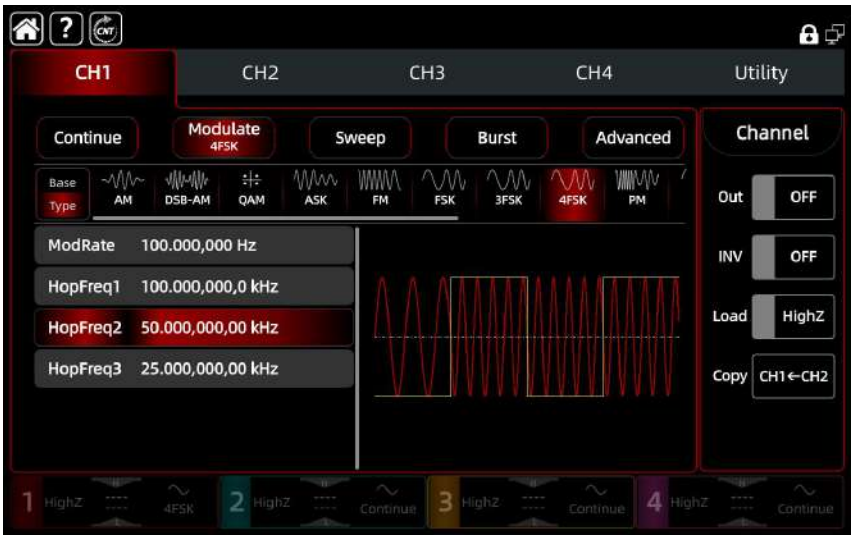
Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation rate. Alternatively, tap ModRate on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Comprehensive Example

In 4FSK mode, set a 500 Hz, 1 Vpp sine wave as the carrier signal, set hopping frequency 1 to 2 kHz, hopping frequency 2 to 5 kHz, and hopping frequency 3 to 10 kHz, and switch among the carrier and hopping frequencies at a rate of 100 Hz. The setting steps are as follows.

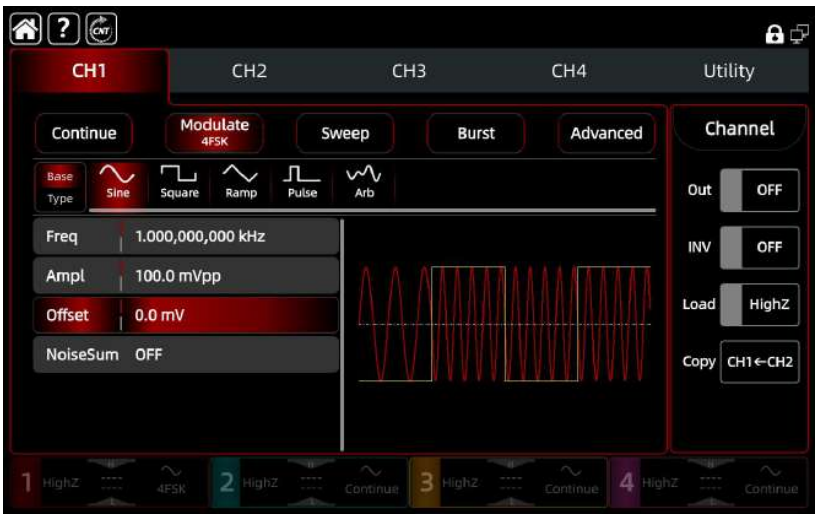
1) Enable 4FSK Mode

Press the CH1 button, then tap Modulate→4ASK on the screen to enable 4ASK mode.



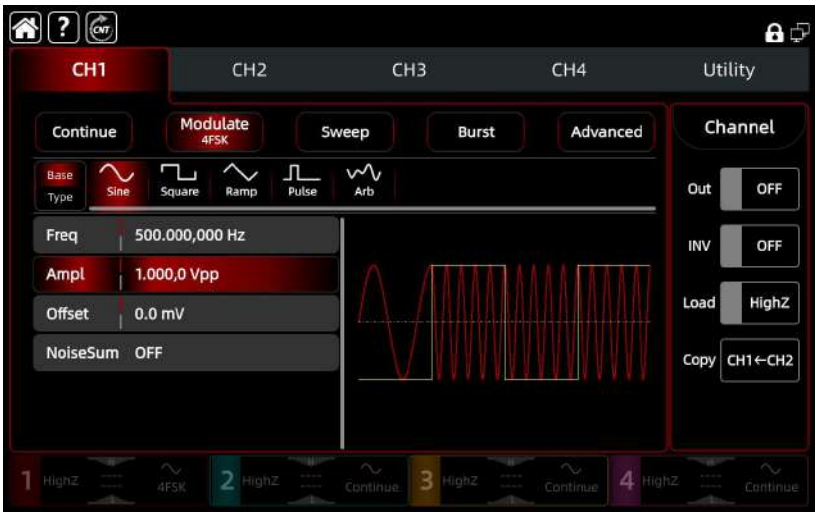
2) Set Carrier Wave and Parameters

Tap Base/Type to select the sine wave as the carrier wave. Since the default setting is sine, no changes are required in this case.



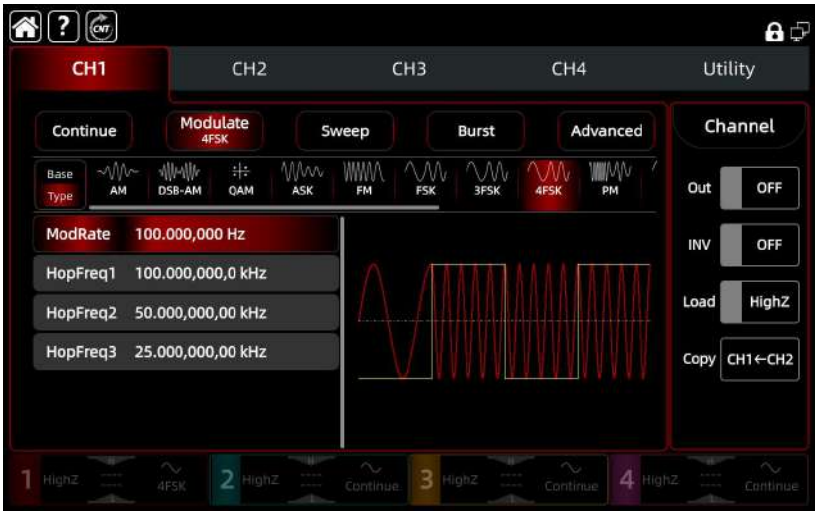
Tap Freq, use the numeric keypad to enter 500, and select Hz as the unit.

Tap Ampl, use the numeric keypad to enter 1, and select Vpp as the unit.



3) Set Hopping Frequency and ModRate

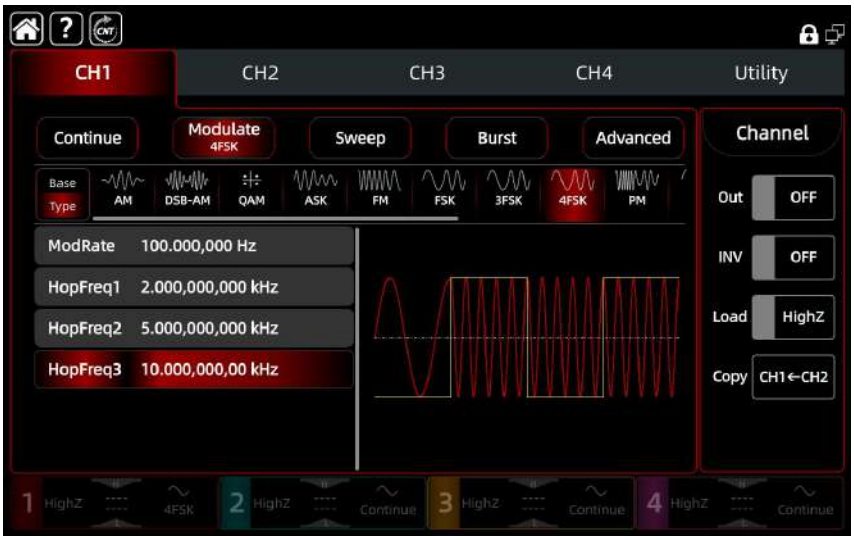
After configuring the carrier wave parameters, tap Base/Type to return to the modulation setting interface, as shown in the following figure.



Tap HopFreq1, use the numeric keypad to enter 2, and select kHz as the unit.

Tap HopFreq2, use the numeric keypad to enter 5, and select kHz as the unit.

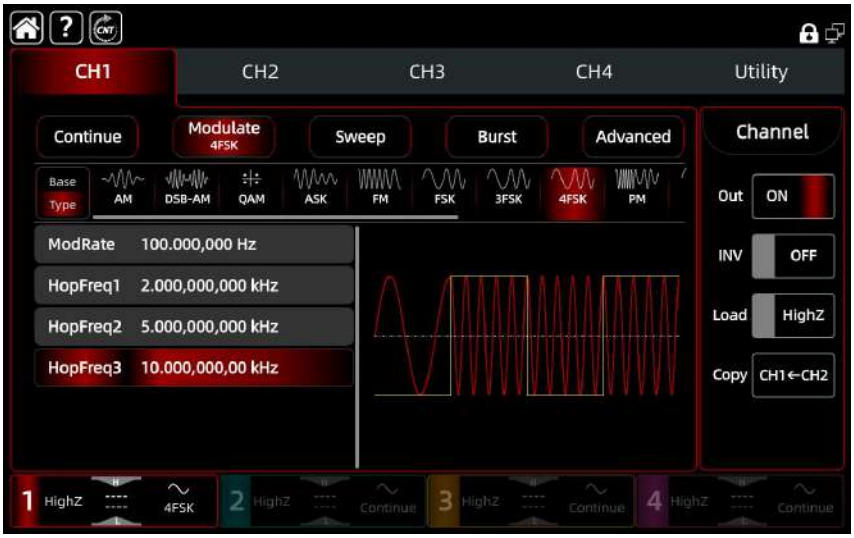
Tap HopFreq3, use the numeric keypad to enter 10, and select kHz as the unit.



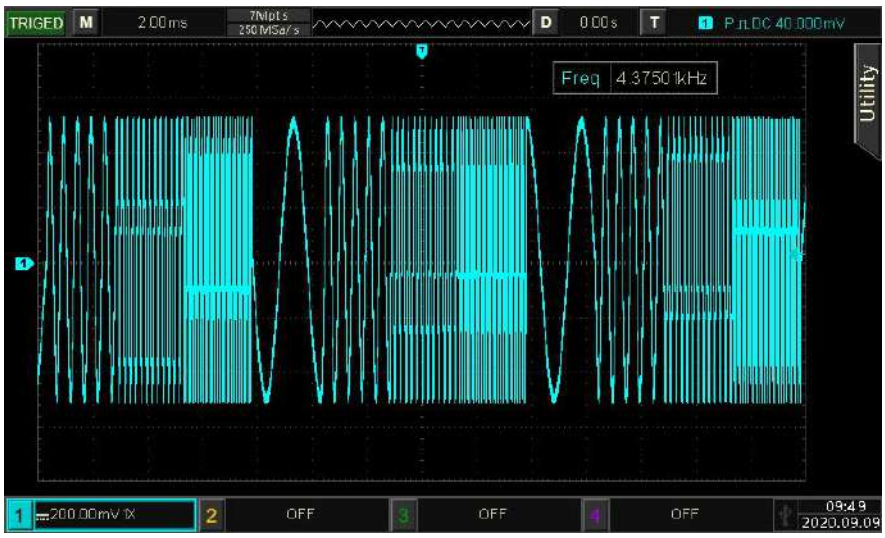
4) Enable Channel Output

Tap Out option to turn on the output, or press the CH1 button on the front panel to quickly enable the CH1 output. The output can also be enabled from the Utility interface by tap Utility→Channel Setting, and then tap CH1 to turn on the output. Alternatively, double-click the channel tab at the bottom of the screen to toggle between ON and OFF.

After the channel output is enabled, the CH1 button backlight turns on. At the same time, the CH1 status label changes from gray to the highlighted "4FSK," indicating that Channel 1 output is enabled.



View the 4FSK waveform through an oscilloscope as shown in the following figure.

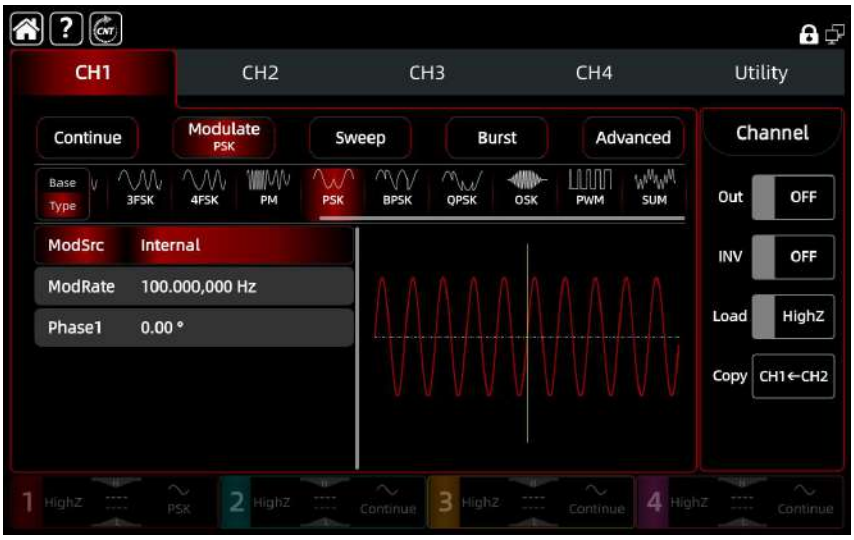


4.1.8 PSK (Phase Shift Keying)

In PSK modulation mode, the function/arbitrary waveform generator switches between two preset phases (the carrier phase and the hopping phase) according to the logic state of the modulation signal.

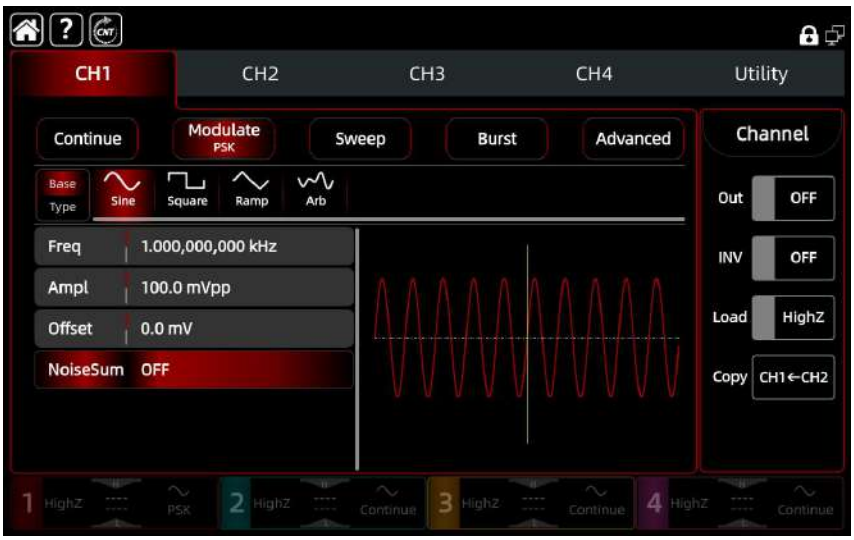
Select PSK Mode

Press the CH1 button, then tap Modulate→PSK key to enable PSK mode. The instrument will output the modulated waveform according to the current setting and the carrier wave.



Carrier Wave Setting

The carrier wave can be set to sine, square, ramp, or arbitrary. The default is sine wave. After selecting PSK mode, tap Base/Type to choose a different carrier waveform.



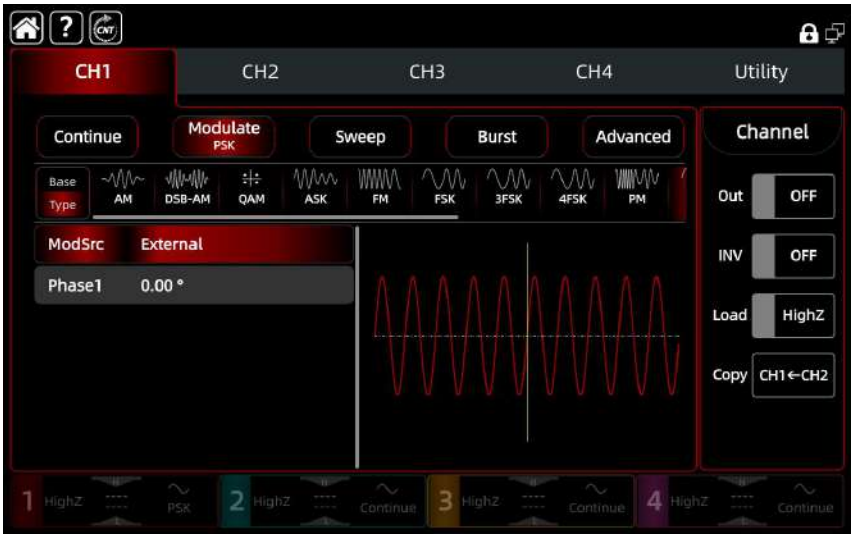
Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Modulation Source Setting

This series provides two modulation source options: internal and external.

After PSK mode is enabled, the default modulation source (Internal) is displayed. The modulation source can be switched using the multi-function rotary knob in the PSK interface, or by pressing ModSrc→Internal, then selecting External.



1) Internal Source

When the modulation source is set to internal, the internal modulation waveform is a built-in square wave with a fixed 50% duty cycle and is not adjustable. The switching rate between the carrier phase and the modulation phase is determined by the modulation frequency setting.

2) External Source

When the modulation source is set to external, the rate parameter is hidden in the parameter list. The carrier is modulated by an external waveform.

The PSK output phase is controlled by the logic level applied to the external digital modulation input (FSK Trig connector). For example, when the external input is at logic Low, the output is at the carrier phase; when the external input is at logic High, the output switches to the modulation phase.

Modulation Rate Setting

Switching frequency between the carrier phase and the hopping phase. After PSK mode is enabled, the PSK rate can be configured within a range of 1 μHz to 2 MHz, with a default value of 100 Hz. Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation rate. Alternatively, tap ModRate on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Modulation Phase Setting

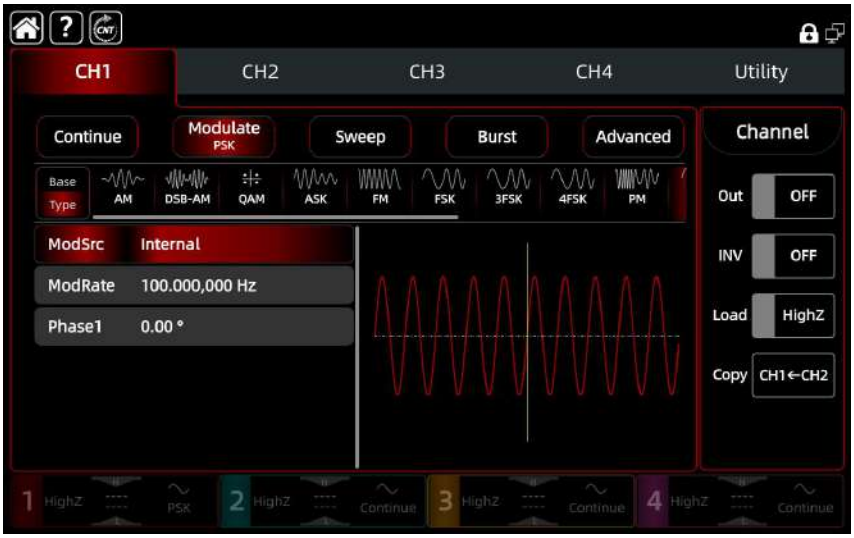
The modulation phase indicates the phase shift of a waveform under PSK modulation relative to the carrier phase. The modulation phase range is 0° to 360°, with a default value of 0° and 90°. Rotate the multi-function rotary knob, in combination with the arrow keys to set the phase 1. Alternatively, tap Phase1 on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Comprehensive Example

In PSK modulation mode, set an internal 2 kHz, 2 Vpp sine wave as the carrier waveform, and set a 1 kHz modulation frequency to switch the output between the carrier phase and a modulation phase of 180°. The setting steps are as follows.

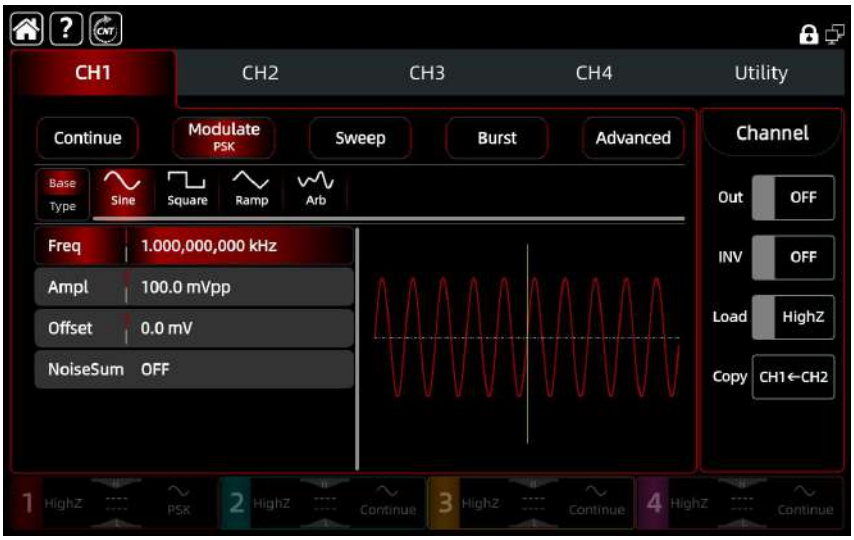
1) Enable PSK Mode

Press the CH1 button, then tap Modulate→PSK on the screen to enable PSK mode.



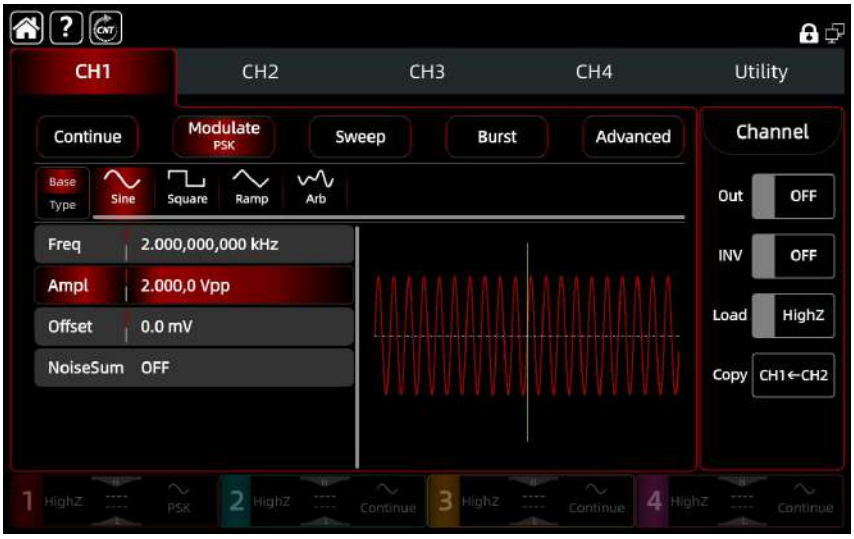
2) Set Carrier Wave and Parameters

Tap Base/Type to select the sine wave as the carrier wave. The default is sine wave.



Tap Freq, use the numeric keypad to enter 2, and select kHz as the unit.

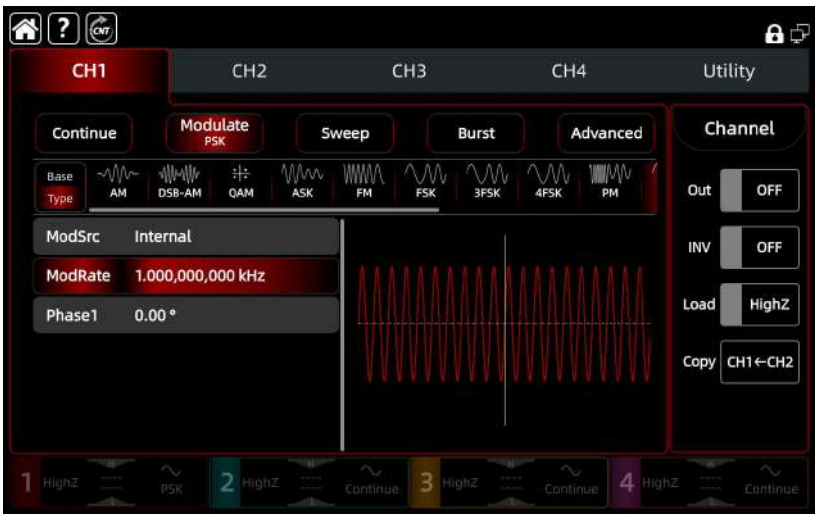
Tap Ampl, use the numeric keypad to enter 2, and select Vpp as the unit.



3) Set Modulation Rate

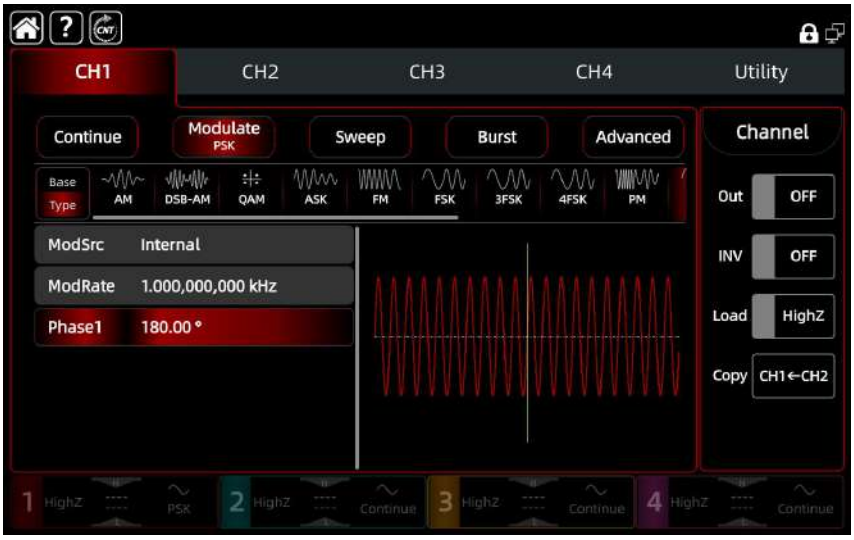
After configuring the carrier wave parameters, tap Base/Type to return to the modulation setting interface.

Tap ModRate, use the numeric keypad to enter 1, and select kHz as the unit.



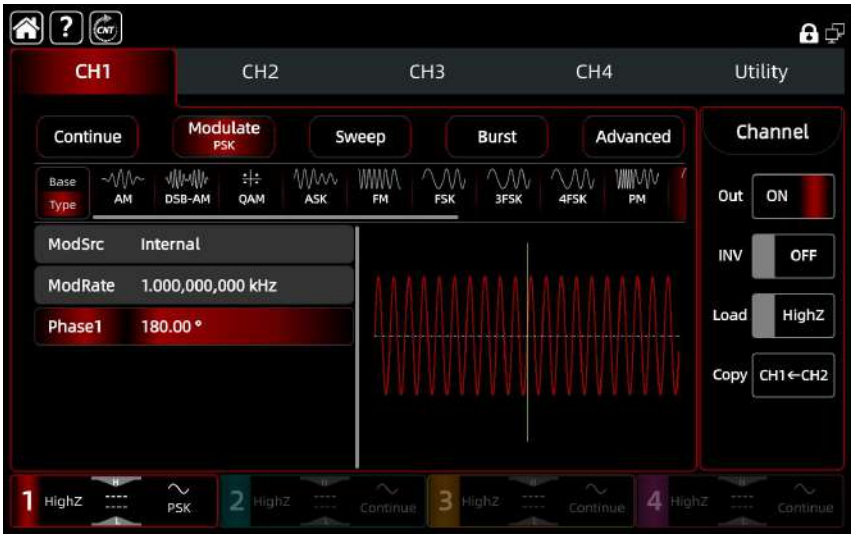
4) Set Phase

Tap Phase1 to set phase 1 to 180°.

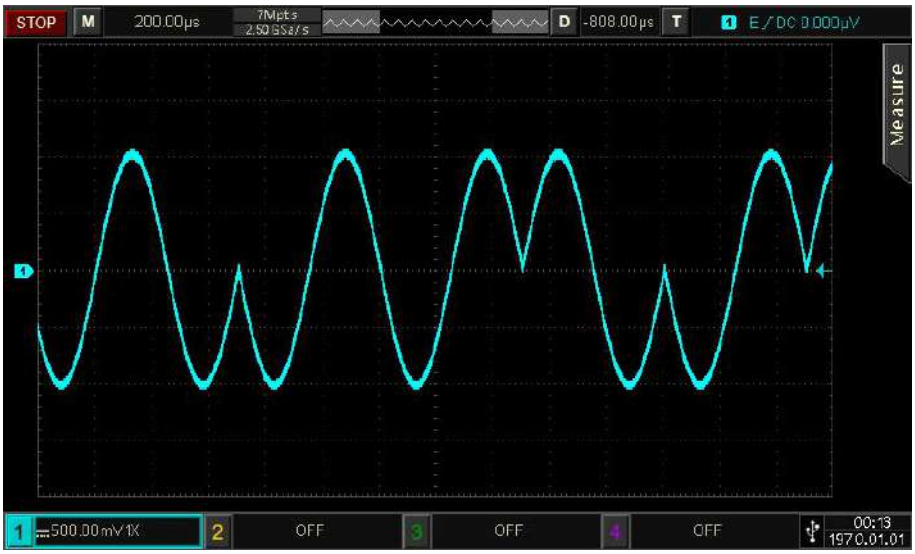


5) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the PSK waveform through an oscilloscope as shown in the following figure.

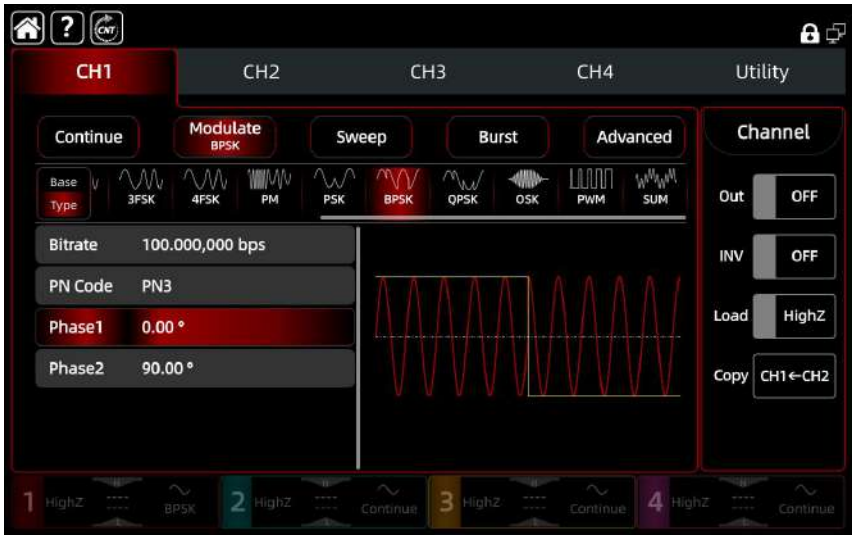


4.1.9 BPSK (Binary Phase Shift Keying)

In BPSK modulation mode, the function/arbitrary waveform generator shifts the carrier phase between two preset phase states to represent binary information (0 and 1). The modulation mode of each channel is independent, allowing the same or different modulation modes to be configured for each channel.

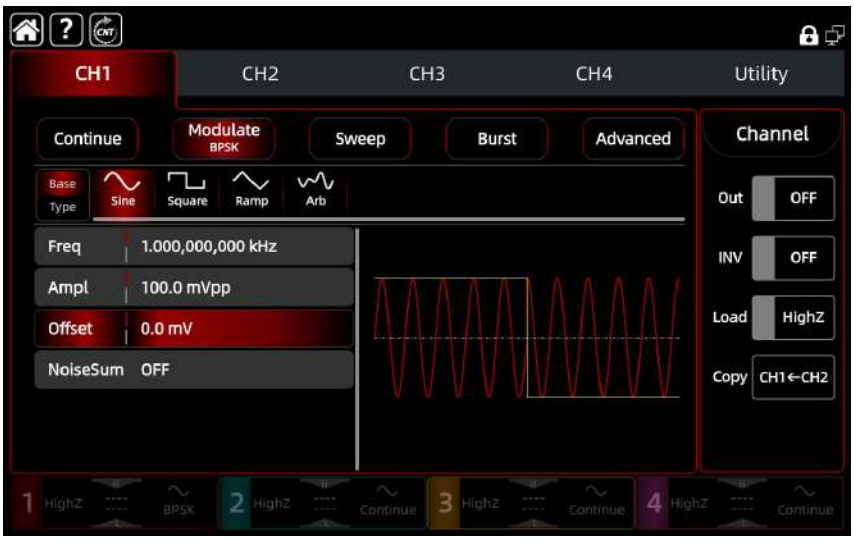
Select BPSK Mode

Press the CH1 button, then tap Modulate →BPSK key to enable BPSK mode. The instrument will output the modulated waveform according to the current setting and the carrier wave.



Carrier Wave Setting

The BPSK carrier wave can be set to sine, square, ramp, or arbitrary (except DC). The default is sine wave. After selecting BPSK mode, tap Base/Type to choose a different carrier waveform.



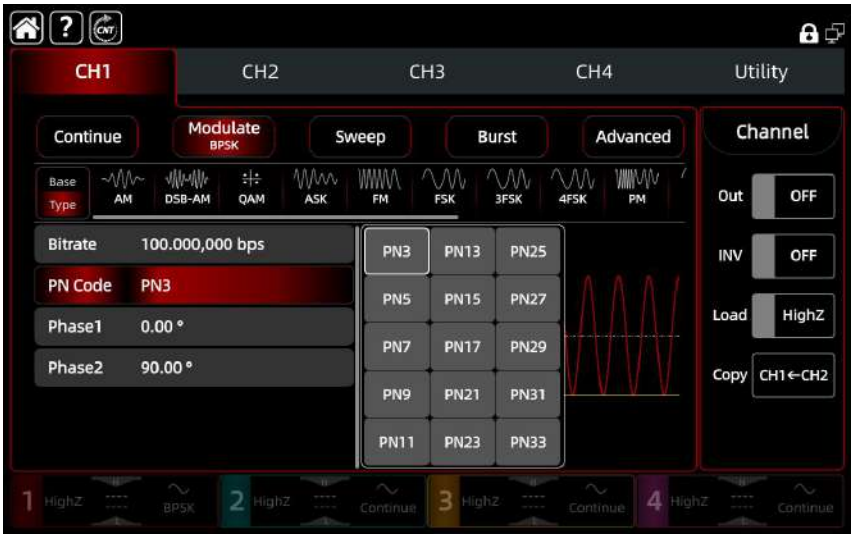
Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Symbol Setting

This series supports selection of an internal modulation source. After the BPSK function is enabled, the symbol is preset to PN3 by default.

Rotate the multi-function rotary knob, or tap PN Code→PN3 to select one of the following: PN3, PN5, PN7, PN9, PN11, PN13, PN15, PN17, PN21, PN23, PN25, PN27, PN29, PN31, or PN33.



BPSK Rate Setting

In BPSK modulation mode, the switching rate between the two carrier phase states can be configured. The configurable BPSK bit rate ranges from 1 μbps to 2 Mbps, with a default value of 100 bps.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the bitrate. Alternatively, tap Bitrate on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Phase Setting

Phase 1 represents the carrier phase, with a default value of 0°.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation phase 1. Alternatively, tap Phase1 on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

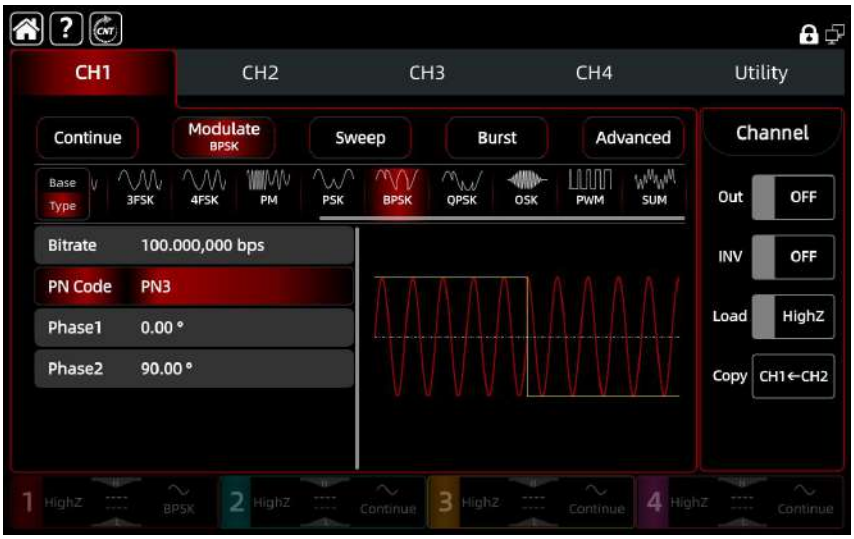
Phase 2 represents the modulation phase, that is, the phase difference between the BPSK-modulated waveform and the carrier phase. The Phase 2 range can be set from 0° to 360°, and the configuration procedure is the same as for Phase 1.

Comprehensive Example

In BPSK modulation mode, set an internal 2 kHz, 2 Vpp sine waveform as the carrier, set the initial phase to 90°, configure a shift rate of 1 kbps to switch between the carrier phase and the modulation phase, and set the PN code to PN15. The setting steps are as follows.

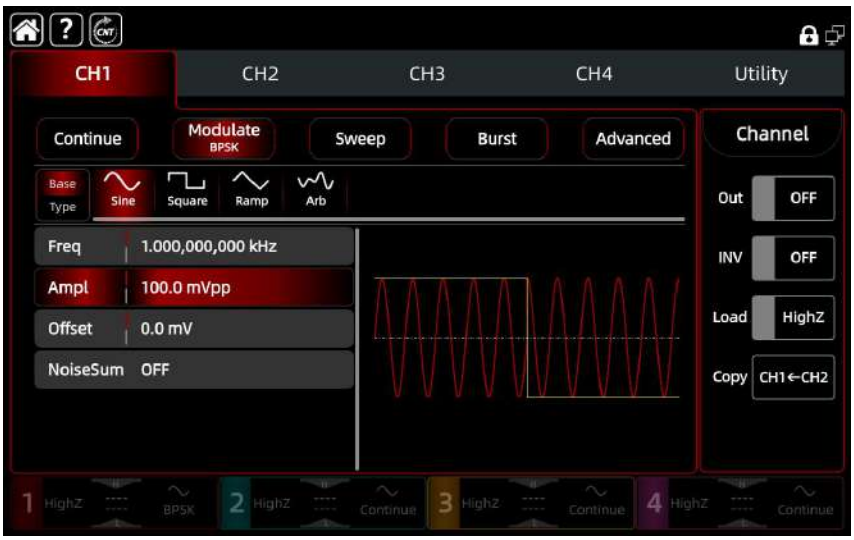
1) Enable BPSK Mode

Press the CH1 button, then tap Modulate→BPSK on the screen to enable BPSK mode.



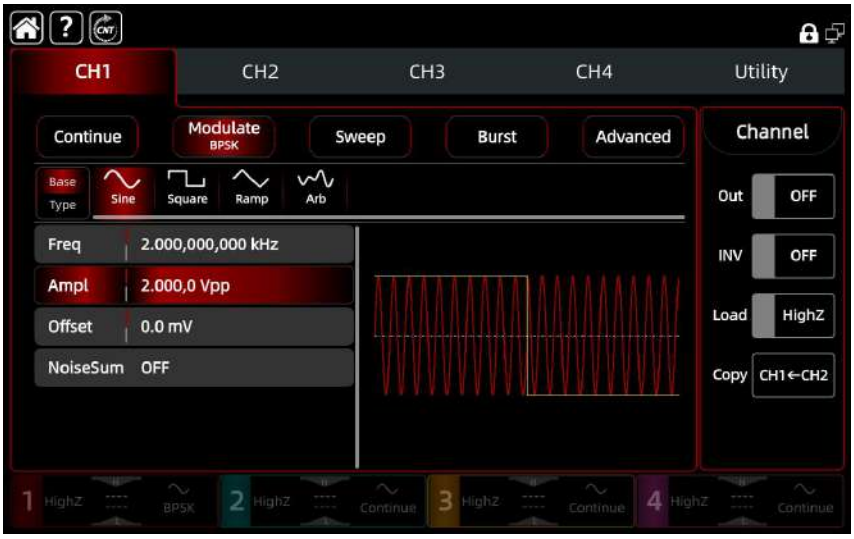
2) Set Carrier Wave and Parameters

Tap Base/Type to select the sine wave as the carrier wave. Since the default setting is sine, no changes are required in this case.



Tap Freq, use the numeric keypad to enter 2, and select kHz as the unit.

Tap Ampl, use the numeric keypad to enter 2, and select Vpp as the unit.



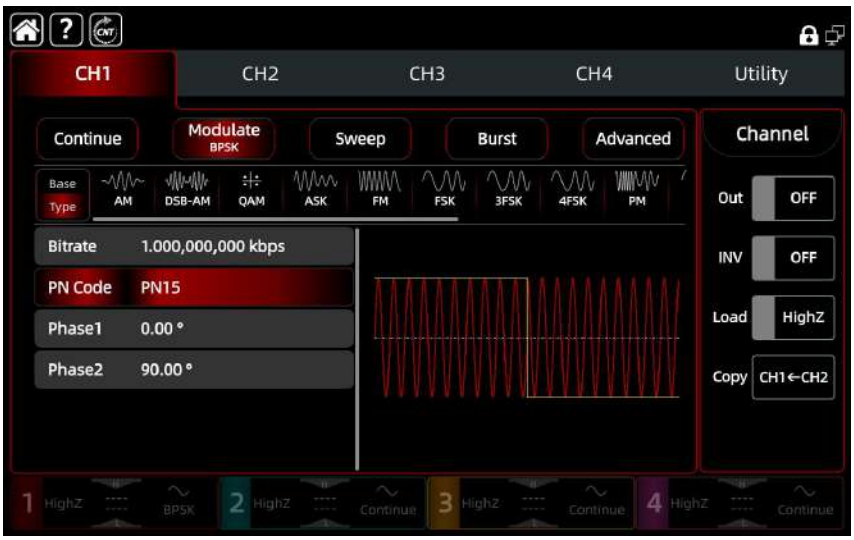
3) Set BPSK Rate and Phase

After configuring the carrier wave parameters, tap Base/Type to return to the modulation setting interface.

Tap Bitrate, use the numeric keypad to enter 1, and select kbps as the unit.

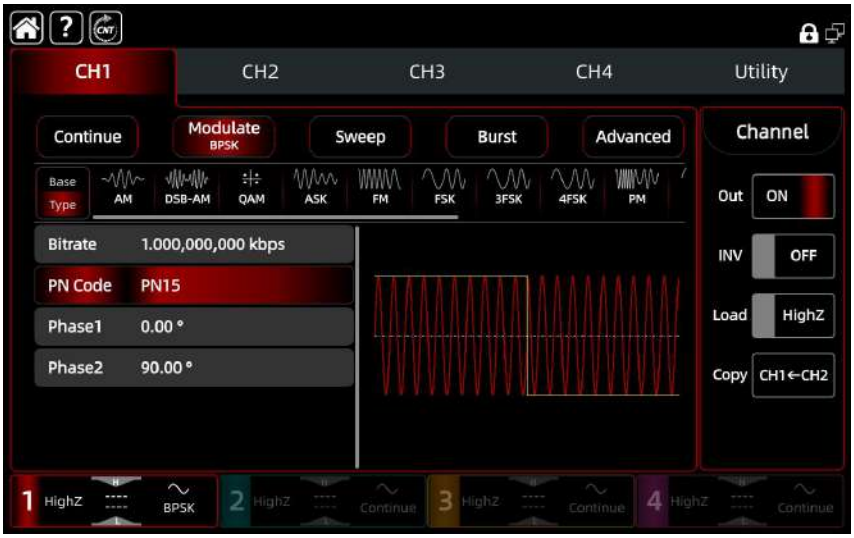
Use the default phase settings: Phase1 = 0° and Phase2 = 90°.

Tap PN Code to open the option list and select PN15.

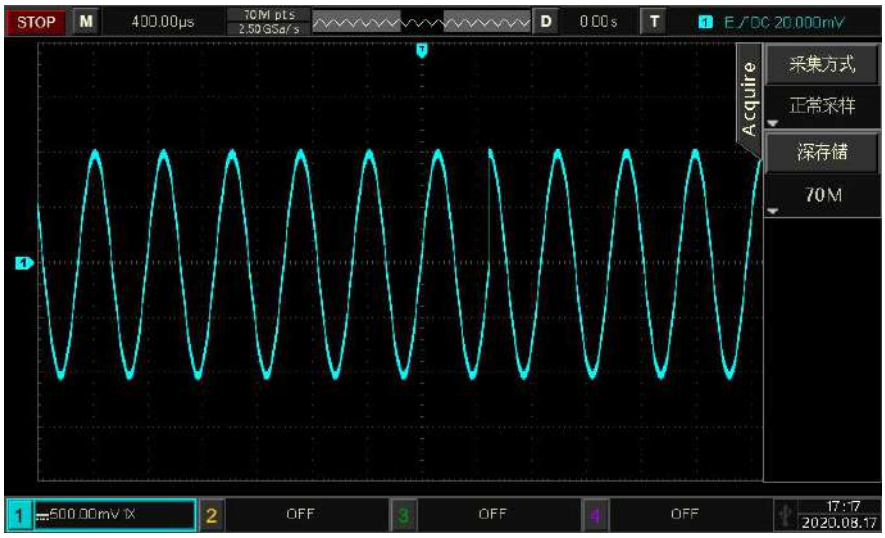


4) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the BPSK waveform through an oscilloscope as shown in the following figure.



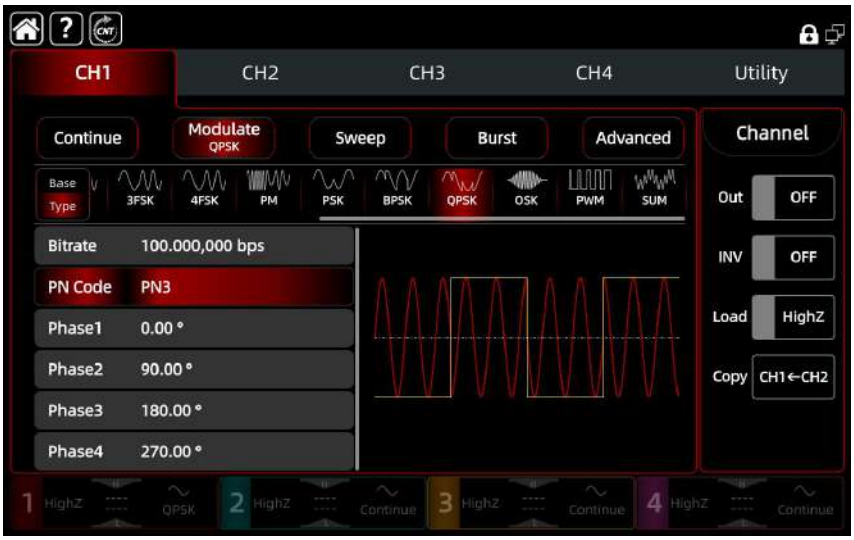
4.1.10 Quadrature Phase Shift Keying (QPSK)

In QPSK modulation mode, the function/arbitrary waveform generator switches among four preset phases (the carrier phase and three modulation phases) according to the logic state of the modulation signal. The output phase is selected from the carrier phase or one of the modulation phases.

The modulation mode of each channel is independent, allowing the same or different modulation modes to be configured for each channel.

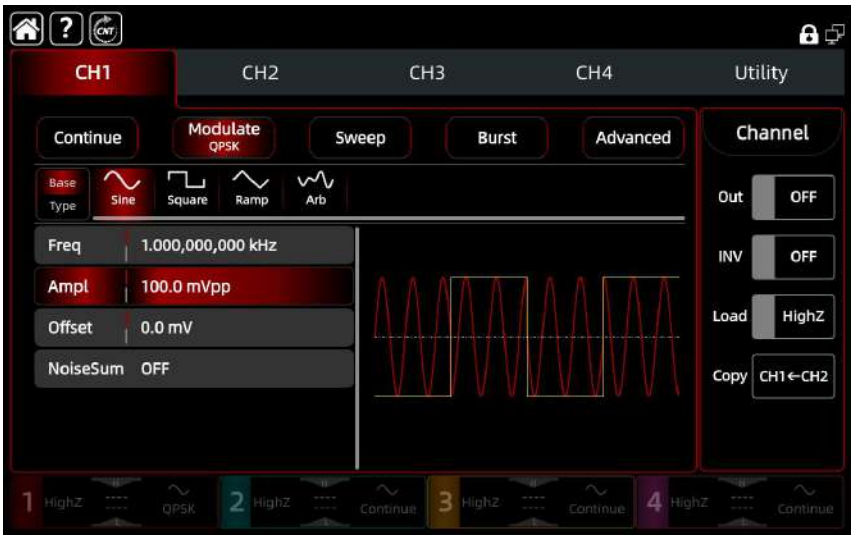
Select QPSK Mode

Press the CH1 button, then tap Modulate →QPSK key to enable QPSK mode. The instrument will output the modulated waveform according to the current setting and the carrier wave.



Carrier Wave Setting

The QPSK carrier wave can be set to sine, square, ramp, or arbitrary (except DC). The default is sine wave. After selecting QPSK mode, tap Base/Type to choose a different carrier waveform.



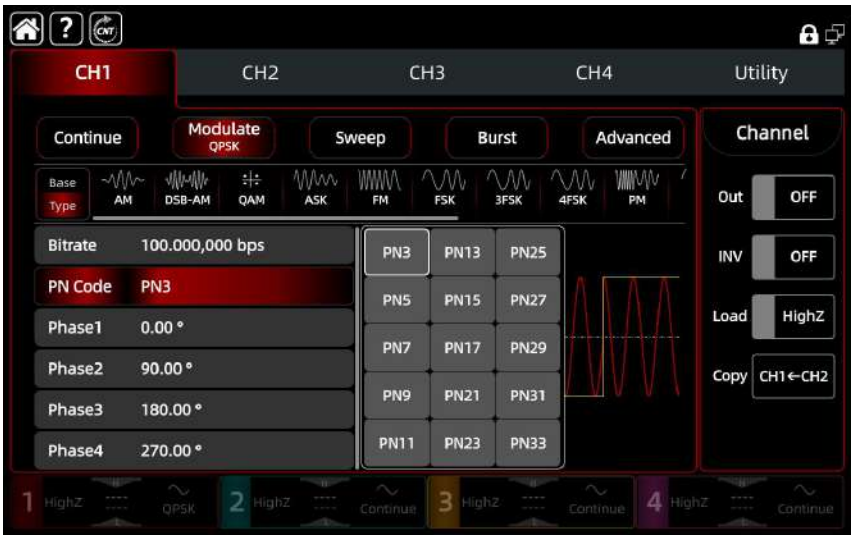
Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Symbol Setting

This series supports selection of an internal modulation source. After the QPSK function is enabled, the symbol is preset to PN3 by default.

Rotate the multi-function rotary knob, or tap PN Code→PN3 to select one of the following: PN3, PN5, PN7, PN9, PN11, PN13, PN15, PN17, PN21, PN23, PN25, PN27, PN29, PN31, or PN33.



QPSK Rate Setting

In QPSK modulation mode, the switching rate between the two carrier phase states can be configured. The configurable QPSK bit rate ranges from 1 μbps to 2 Mbps, with a default value of 100 bps.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the bitrate. Alternatively, tap Bitrate on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Phase Setting

Phase 1 represents the carrier phase, with a default value of 0°.

Phase 2, Phase 3, Phase 4 represents the modulation phase, that is, the phase difference between the QPSK-modulated waveform and the carrier phase. The QPSK modulation phase range can be set from 0° to 360°.

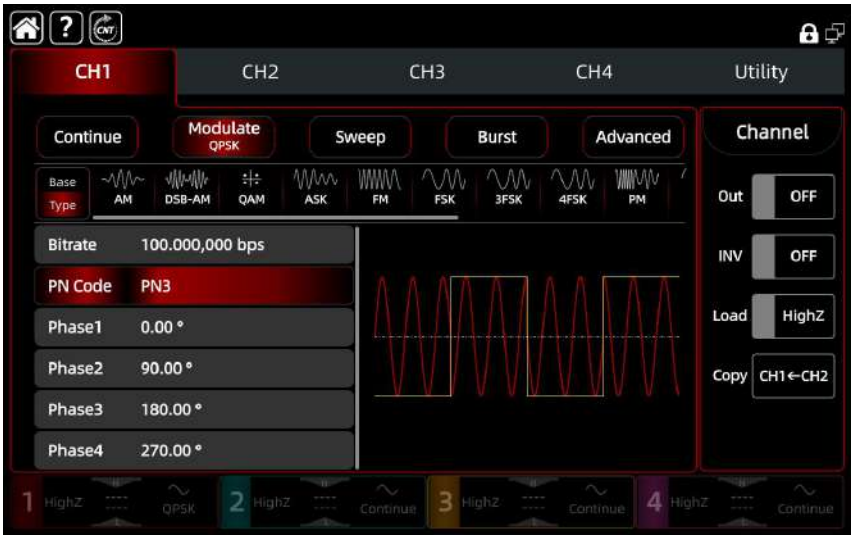
Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation phase 1, modulation phase 2, or modulation phase 3. Alternatively, tap Phase2, Phase3, Phase4 on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Comprehensive Example

In QPSK modulation mode, set an internal 2 kHz, 2 Vpp sine waveform as the carrier, set the phases of the three modulation states to 90°, 180°, and 270°, configure a hopping rate of 1 kbps between these phases, and select the PN code as PN15. The setting steps are as follows.

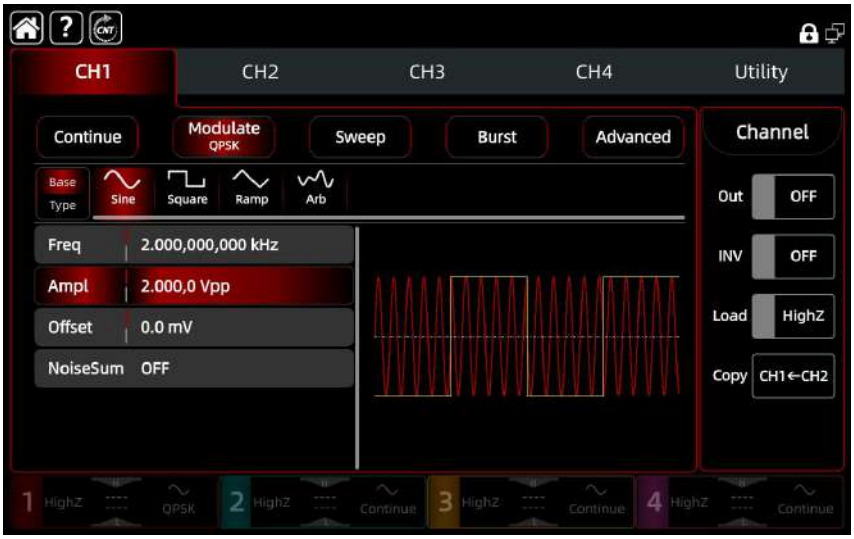
1) Enable QPSK Mode

Press the CH1 button, then tap Modulate→QPSK on the screen to enable QPSK mode.



2) Set Carrier Wave and Parameters

Tap Base/Type to select the sine wave as the carrier wave. Since the default setting is sine, no changes are required in this case.



Tap Freq, use the numeric keypad to enter 2, and select kHz as the unit.

Tap Ampl, use the numeric keypad to enter 2, and select Vpp as the unit.

3) Set QPSK Rate and Modulation Phase

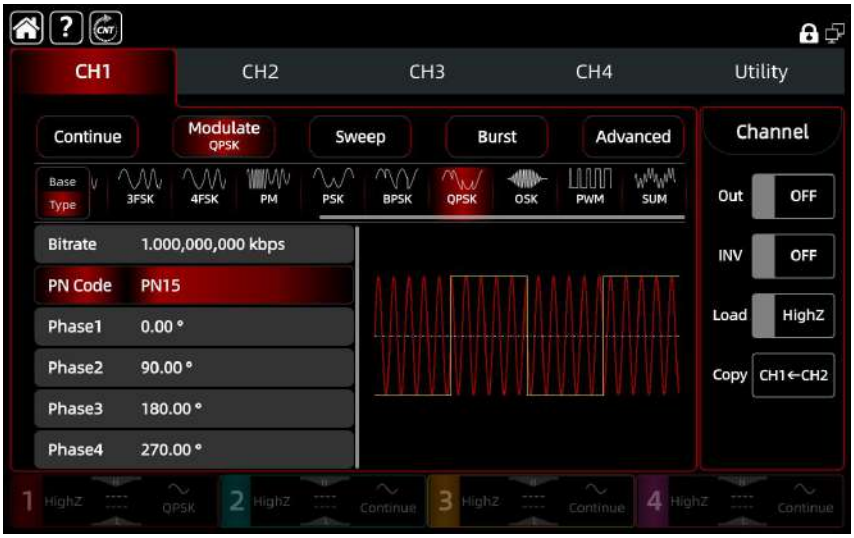
After configuring the carrier wave parameters, tap Base/Type to return to the modulation

setting interface.

Tap Bitrate, use the numeric keypad to enter 1, and select kbps as the unit.

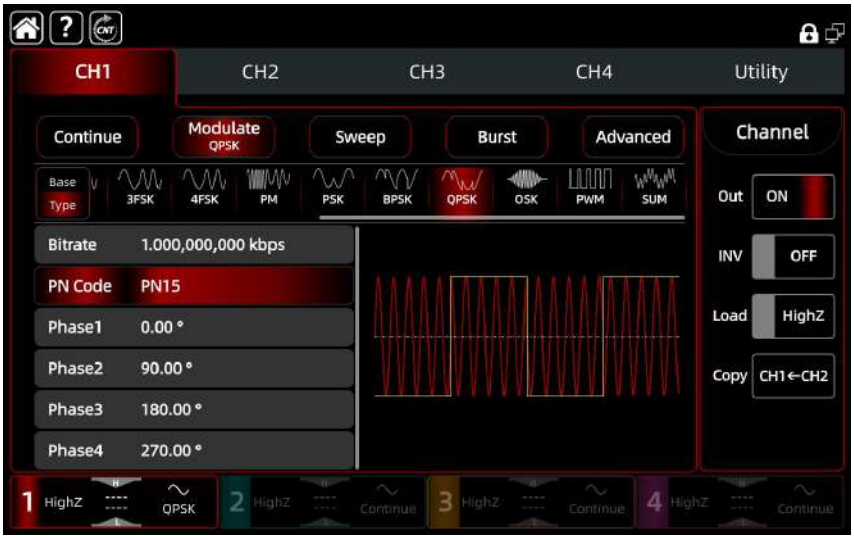
Use the default phase settings: Phase1 = 0°, Phase2 = 90°, Phase3 = 180°, and Phase4 = 270°.

Tap PN Code to open the option list and select PN15.

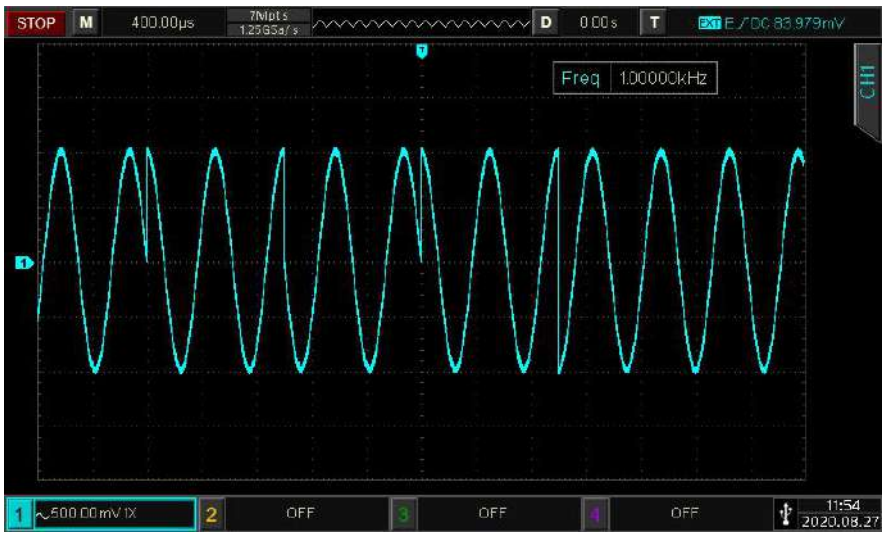


4) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the QPSK waveform through an oscilloscope as shown in the following figure.



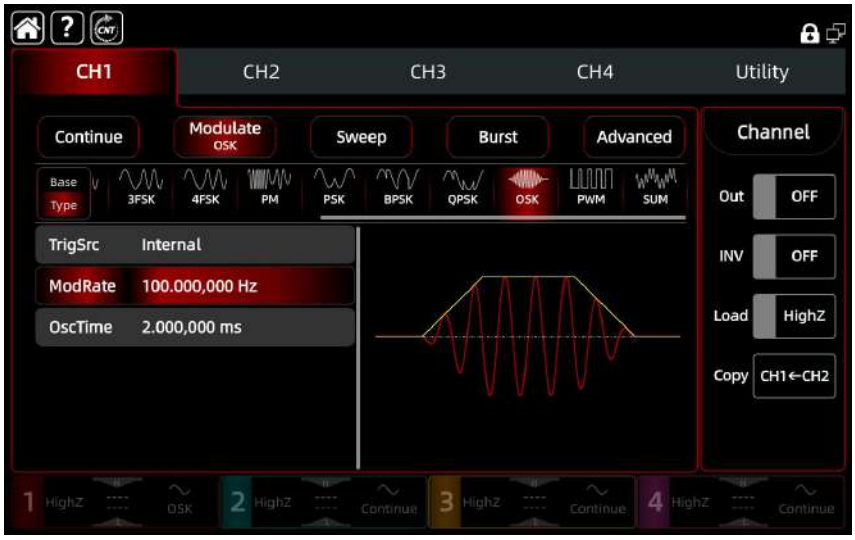
4.1.11 Oscillation Keying (OSK)

In OSK (Burst Keying) mode, the function/arbitrary waveform generator can output a sinusoidal signal with intermittent oscillation. The carrier waveform is output when the internal crystal oscillator is running, and output stops when the oscillator is stopped.

The modulation mode of each channel is independent, allowing the same or different modulation modes to be configured for each channel.

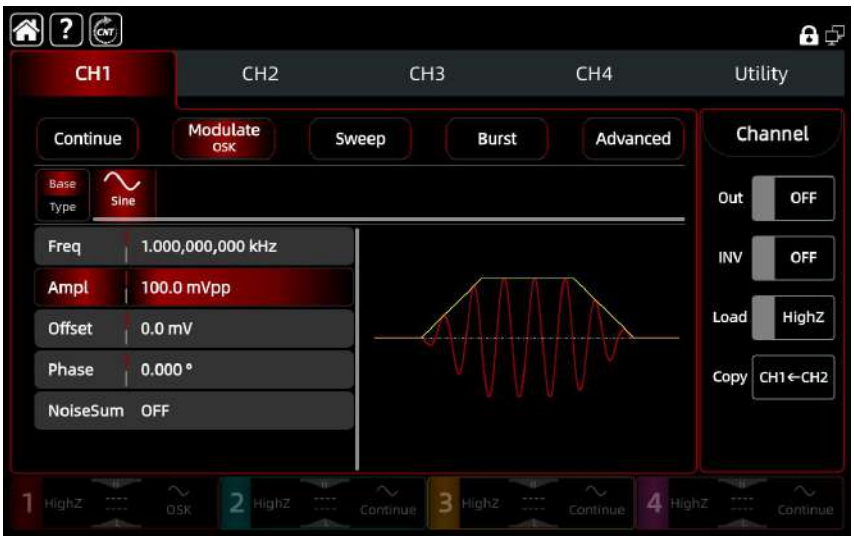
Select OSK Mode

Press the CH1 button, then tap Modulate →OSK key to enable OSK mode. The instrument will output the modulated waveform according to the current setting and the carrier wave.



Carrier Wave Setting

The carrier waveform in OSK mode is fixed as a sine wave. When OSK is selected, the waveform automatically switches to sine. On the modulation function interface, tap Base/Type displays only the sine waveform among the available base waveforms.



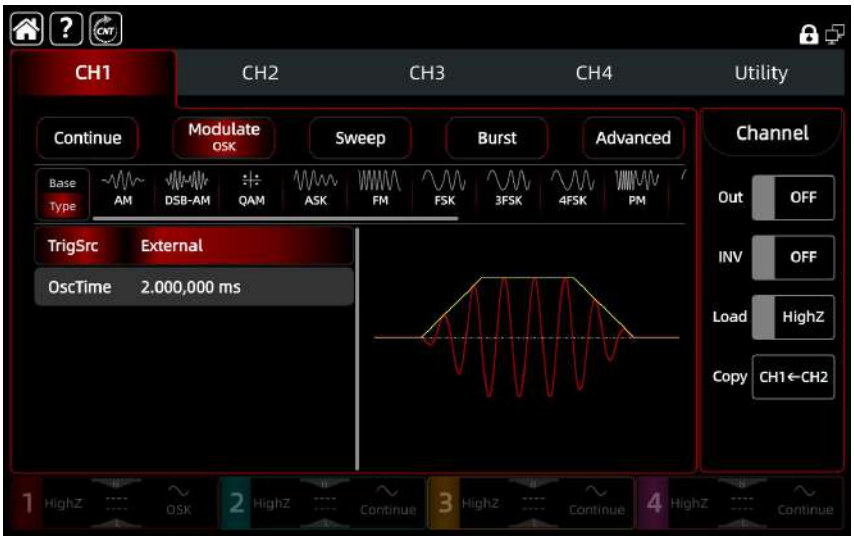
Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Modulation Source Setting

This series provides two modulation source options: internal and external.

After OSK mode is enabled, the default modulation source (Internal) is displayed. The modulation source can be switched using the multi-function rotary knob in the OSK interface, or by pressing TrigSrc→Internal, then selecting External.



1) Internal Source

When the modulation source is set to internal, the modulation waveform is a sine wave. The OSK rate controls the phase relationship between the start and stop of oscillation.

2) External Source

When the modulation source is external, the Rate option is hidden from the parameter list. The carrier waveform is modulated by the external signal.

The OSK output phase is determined by the logic level applied to the external digital

modulation input (FSK Trig connector) on the rear panel. For example, when the external input is at logic Low, the carrier oscillation waveform is output; when the external input is at logic High, the carrier oscillation waveform is turned off.

Oscillation Time Setting

The oscillation period refers to the period of the internal crystal oscillator. The setting range is 5 ns to 500 ms, with a default value of 2 ms.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the oscillation period. Alternatively, tap OscTime on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

OSK Rate Setting

When the modulation source is set to internal, switching frequency between the carrier phase and the modulation phase. After OSK mode is enabled, the OSK rate can be configured within a range of 1 μHz to 2 MHz, with a default value of 100 Hz.

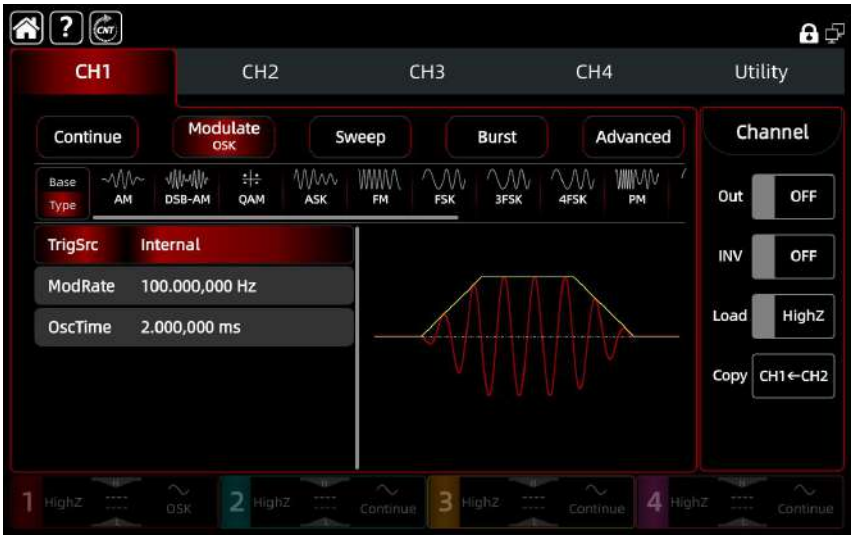
Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation rate. Alternatively, tap ModRate on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Comprehensive Example

In OSK mode, set an internal 2 kHz, 2 Vpp sine waveform as the carrier, set the rate to 100 Hz, and set the oscillation period to 1 μs. The setting steps are as follows.

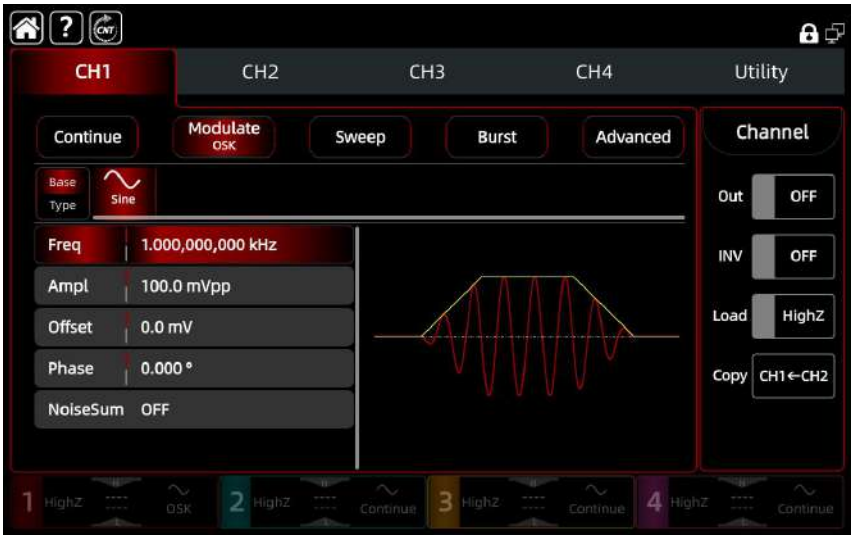
1) Enable OSK Mode

Press the CH1 button, then tap Modulate→OSK on the screen to enable OSK mode.



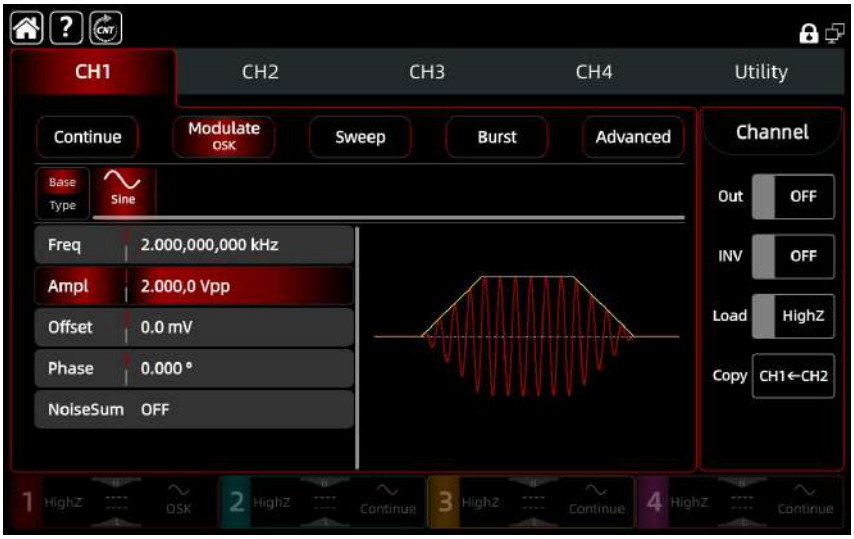
2) Set Carrier Wave and Parameters

Tap Base/Type to select the sine wave as the carrier wave. The OSK carrier waveform supports sine only. Since the default setting is sine, no changes are required in this case.



Tap Freq, use the numeric keypad to enter 2, and select kHz as the unit.

Tap Ampl, use the numeric keypad to enter 2, and select Vpp as the unit.

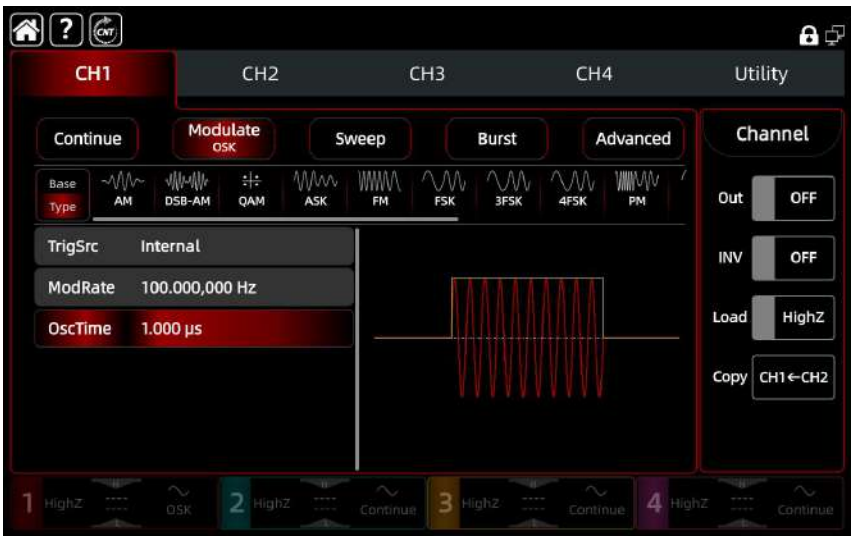


3) Set OSK Rate

After configuring the carrier wave parameters, tap Base/Type to return to the modulation setting interface.

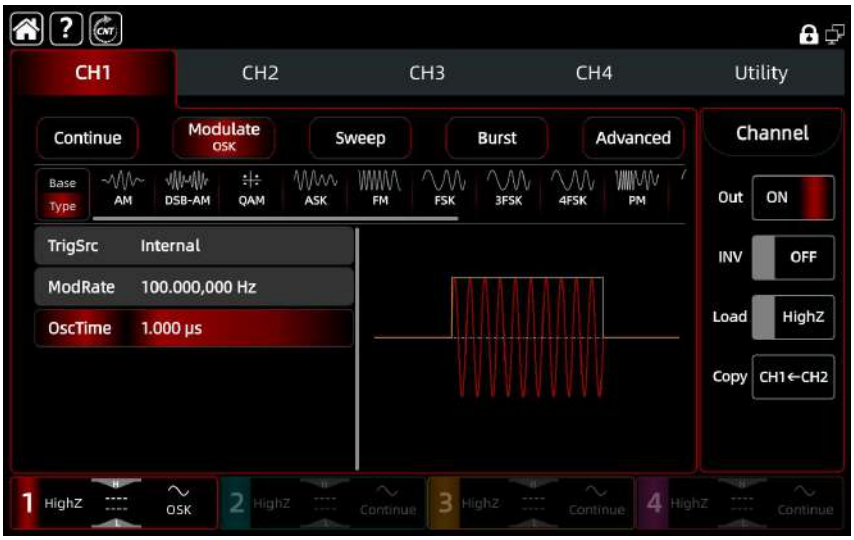
Tap ModRate, use the numeric keypad to enter 100, and select Hz as the unit.

Tap OscTime, use the numeric keypad to enter 1, and select μs as the unit.

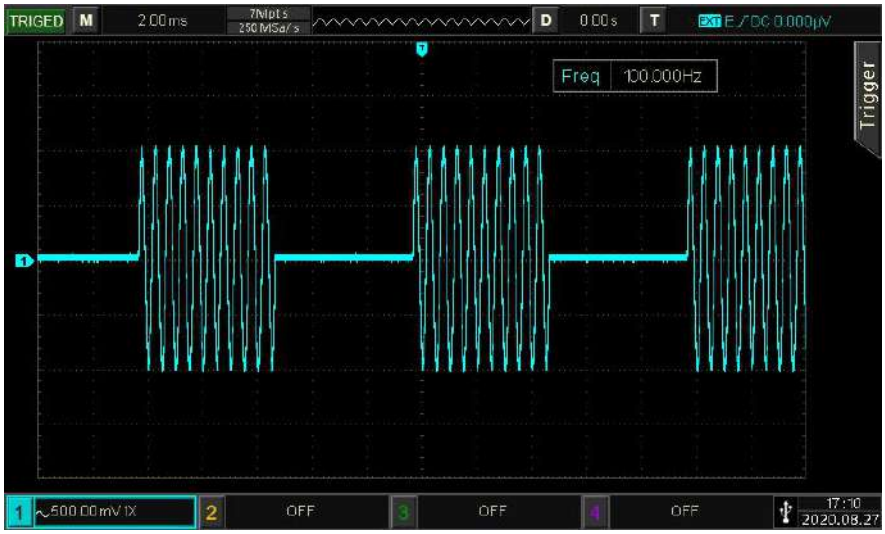


4) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the OSK waveform through an oscilloscope as shown in the following figure.

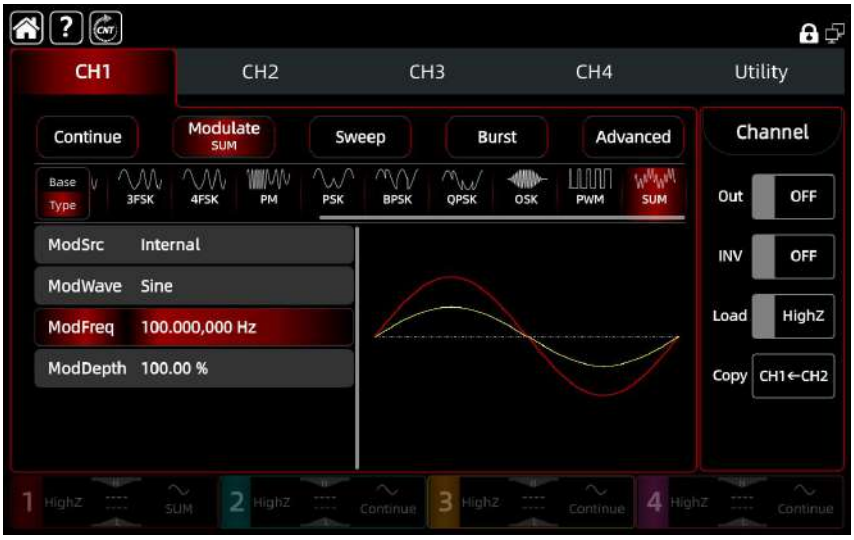


4.1.12 Sum Modulation (SUM)

In SUM mode, the modulated waveform consists of a carrier waveform and a modulation waveform. The output waveform is the sum of the carrier waveform amplitude multiplied by the carrier modulation factor and the modulation waveform amplitude multiplied by the modulation factor. The modulation mode of each channel is independent, allowing the same or different modulation modes to be configured for each channel.

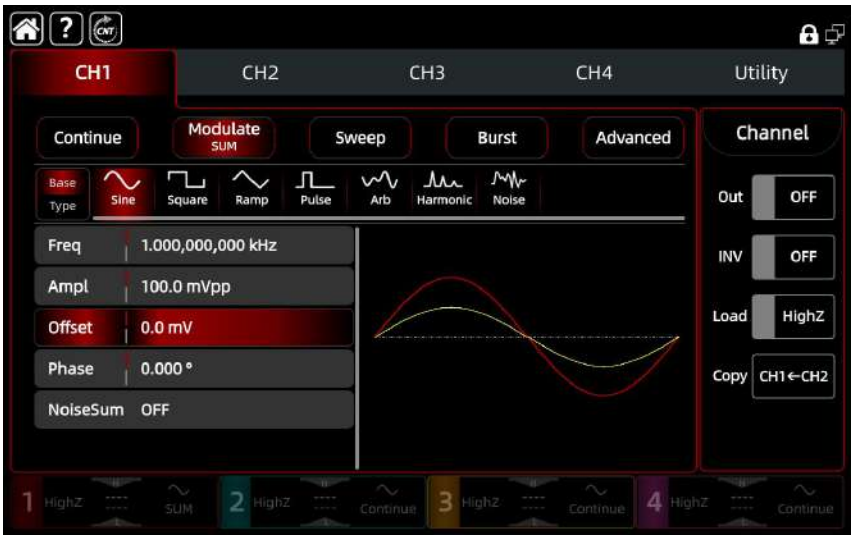
Select SUM Mode

Press the CH1 button, then tap Modulate →SUM key to enable SUM mode. The instrument will output the modulated waveform according to the current setting and the carrier wave.



Carrier Wave Setting

The SUM carrier wave can be set to sine, square, ramp, pulse, harmonic, noise, or arbitrary (except DC). The default is sine wave. After selecting SUM mode, tap Base/Type to choose a different carrier waveform.



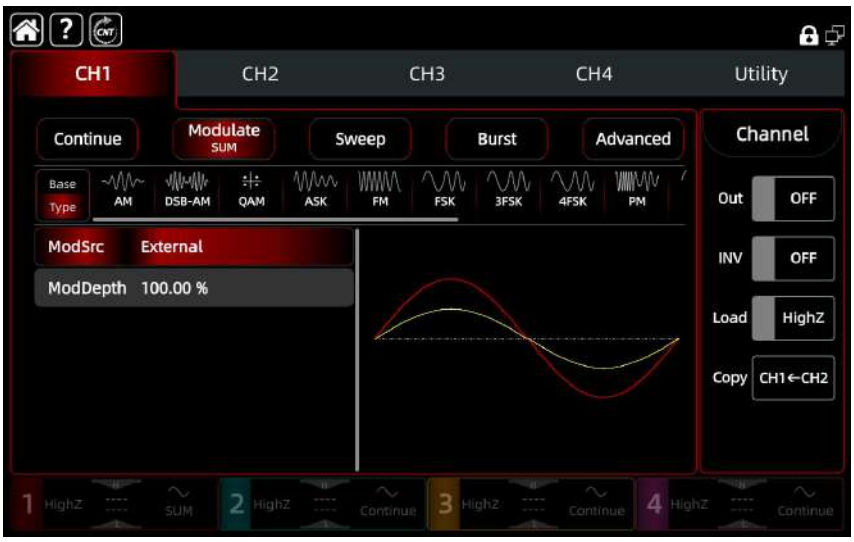
Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Modulation Source Setting

This series provides two modulation source options: internal and external.

After SUM mode is enabled, the default modulation source (Internal) is displayed. The modulation source can be switched using the multi-function rotary knob in the SUM interface, or by pressing ModSrc→Internal, then selecting External.



1) Internal Source

When the modulation source is set to internal, the modulation waveform can be sine, square, rising ramp, falling ramp, arbitrary, or noise. The default waveform is sine.

After SUM modulation is enabled, the modulation waveform defaults to Sine. Rotate the multi-function rotary knob or tap Modulate→Sine to select a different waveform on the SUM setting interface.

- Square wave: duty cycle 50%
- Rising ramp wave: symmetry 100%
- Falling ramp wave: symmetry 0%
- Arbitrary wave: waveform length limited to 2 kpts when using the Auto Point Select method
- Noise wave: white Gaussian noise

2) External Source

When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform. The SUM modulation depth is controlled by the ±5 V signal level applied to the external analog modulation input (Modulation In connector) on the rear panel. For example, when the modulation depth in the parameter list is set to 100%, the SUM output amplitude reaches its

maximum at an external modulation input of +5 V and its minimum at −5 V.

Modulation Wave Frequency Setting

After the SUM function is enabled, when the modulation source is set to internal, the modulation wave frequency can be configured. The frequency range is 1 μHz to 2 MHz, with a default value of 100 Hz.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation frequency. Alternatively, tap vv on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform.

Modulation Depth Setting

The modulation depth indicates the percentage change in amplitude. The SUM modulation depth can be set from 0% to 100%, with a default value of 100%.

- When the modulation depth is 0%, the output is the carrier waveform.
- When the modulation depth is 100%, the output is the modulation waveform.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation depth. Alternatively, tap ModDepth on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

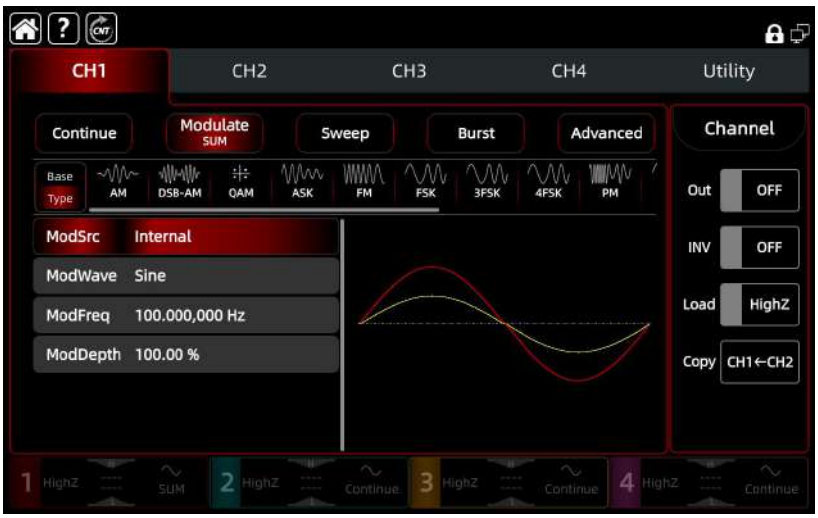
When the modulation source is set to external, the output amplitude is controlled by the ±5 V signal level applied to the external analog modulation input (Modulation In connector) on the rear panel.

Comprehensive Example

In SUM mode, set a 1 kHz sine waveform from the instrument's internal source as the modulation signal, and a 2 kHz, 200 mVpp square waveform with a 45% duty cycle as the carrier signal. Finally, set the modulation depth to 80%. The setting steps are as follows.

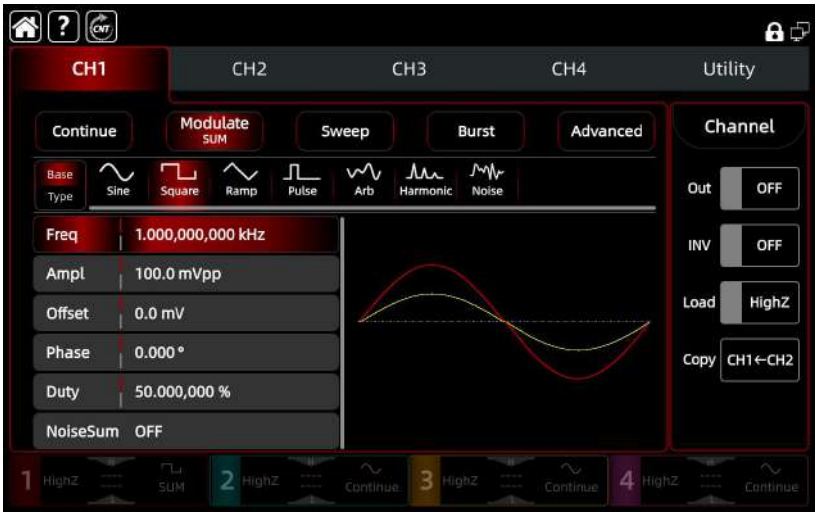
1) Enable SUM Mode

   Press the CH1 button, then tap Modulate→SUM on the screen to enable SUM mode.



2) Set Carrier Wave and Parameters

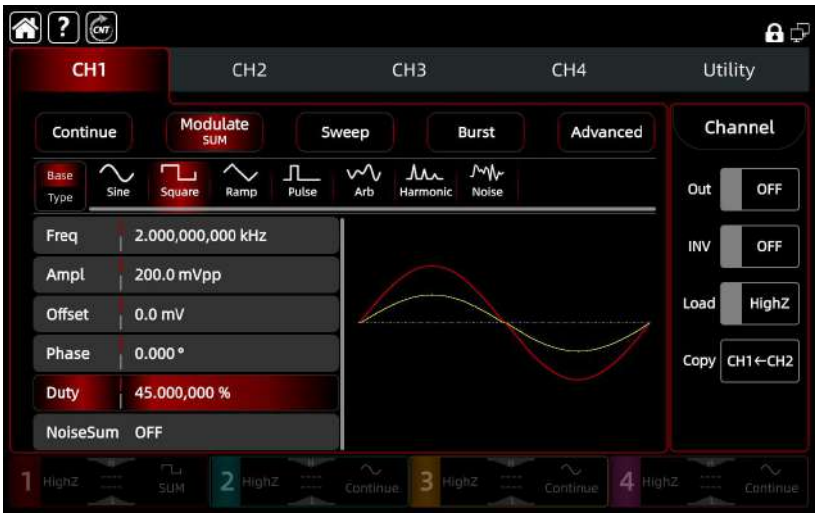
Tap Base/Type to select the square wave as the carrier wave. The default is sine wave.



Tap Freq, use the numeric keypad to enter 2, and select kHz as the unit.

Tap Ampl, use the numeric keypad to enter 200, and select mVpp as the unit.

Tap Duty, use the numeric keypad to enter 45, and select % as the unit.

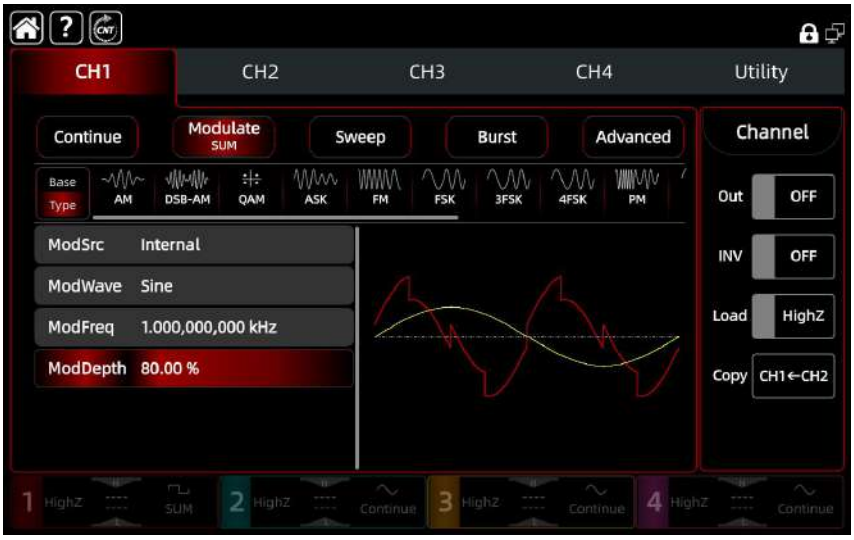


3) Set Modulation Frequency and Modulation Depth

After configuring the carrier wave parameters, tap Base/Type to return to the modulation setting interface.

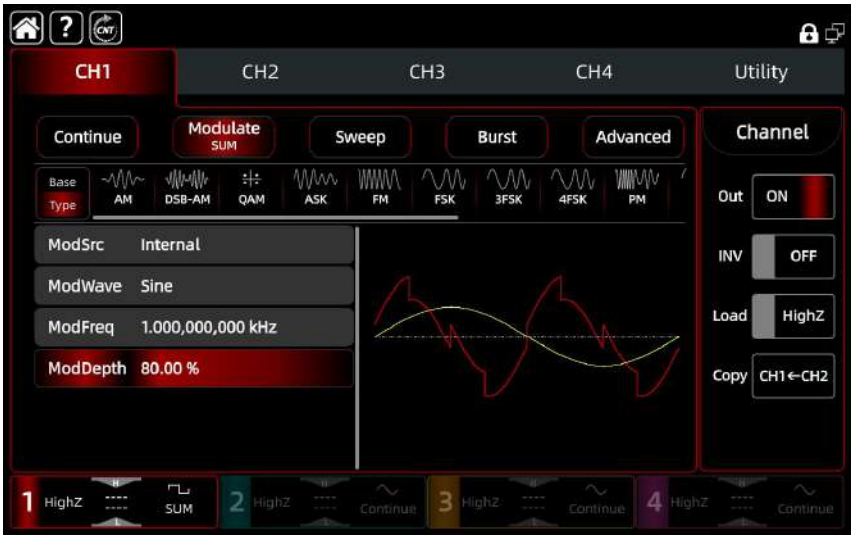
Tap ModFreq, use the numeric keypad to enter 1, and select kHz as the unit.

Tap ModDepth, use the numeric keypad to enter 80, and select % as the unit.

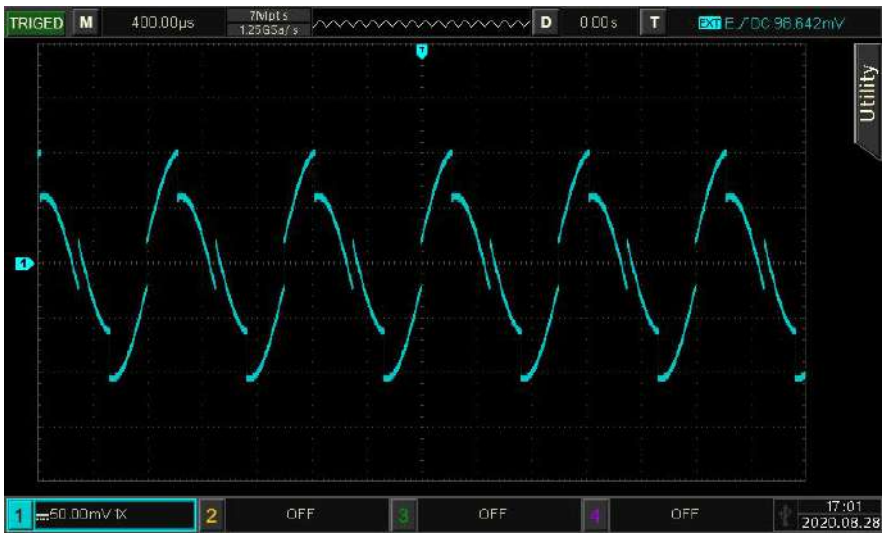


4) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



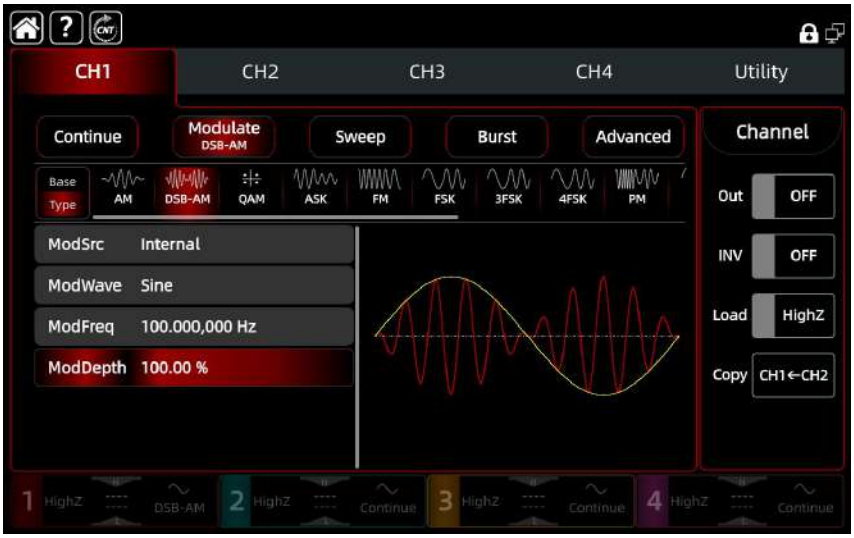
View the SUM waveform through an oscilloscope as shown in the following figure.



4.1.13 Double-Sideband Amplitude Modulation (DSB-AM)

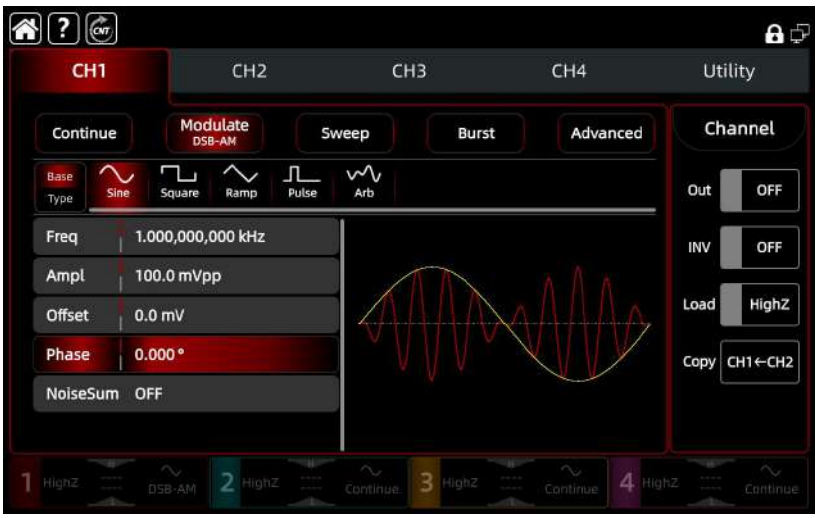
Select DSB-AM Mode

Press the CH1 button, then tap Modulate → DSB-AM key to enable DSB-AM mode. The instrument will output the modulated waveform according to the current setting and the carrier wave.



Carrier Wave Setting

The DSB-AM carrier wave can be set to sine, square, ramp, pulse, or arbitrary (except DC). The default is sine wave. After selecting DSB-AM mode, tap Base/Type to choose a different carrier waveform.



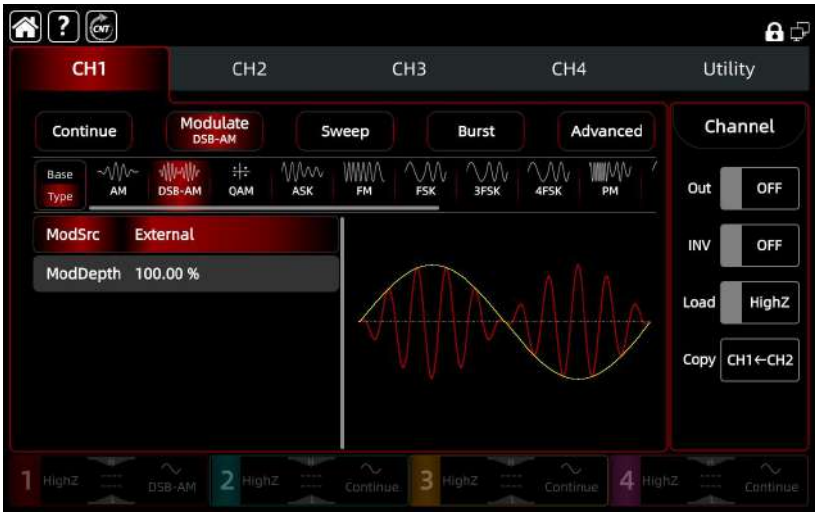
Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Modulation Source Setting

This series provides two modulation source options: internal and external.

After DSB-AM mode is enabled, the default modulation source (Internal) is displayed. The modulation source can be switched using the multi-function rotary knob in the DSB-AM interface, or by pressing ModSrc→Internal, then selecting External.



1) Internal Source

When the modulation source is set to internal, the modulation waveform can be sine, square, rising ramp, falling ramp, arbitrary, or noise. The default waveform is sine.

After DSB-AM modulation is enabled, the modulation waveform defaults to Sine. Rotate the multi-function rotary knob or tap Modulate→Sine to select a different waveform on the DSB-AM setting interface.

- Square wave: duty cycle 50%
- Rising ramp wave: symmetry 100%

- Falling ramp wave: symmetry 0%
- Arbitrary wave: waveform length limited to 2 kpts when using the Auto Point Select method
- Noise wave: white Gaussian noise

2) External Source

When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform. The DSB-AM modulation depth is controlled by the ±5 V signal level applied to the external analog modulation input (Modulation In connector) on the rear panel. For example, when the modulation depth in the parameter list is set to 100%, the DSB-AM output amplitude reaches its maximum at an external modulation input of +5 V and its minimum at −5 V.

Modulation Wave Frequency Setting

After the DSB-AM function is enabled, when the modulation source is set to internal, the modulation wave frequency can be configured. The frequency range is 1 μHz to 2 MHz, with a default value of 100 Hz.

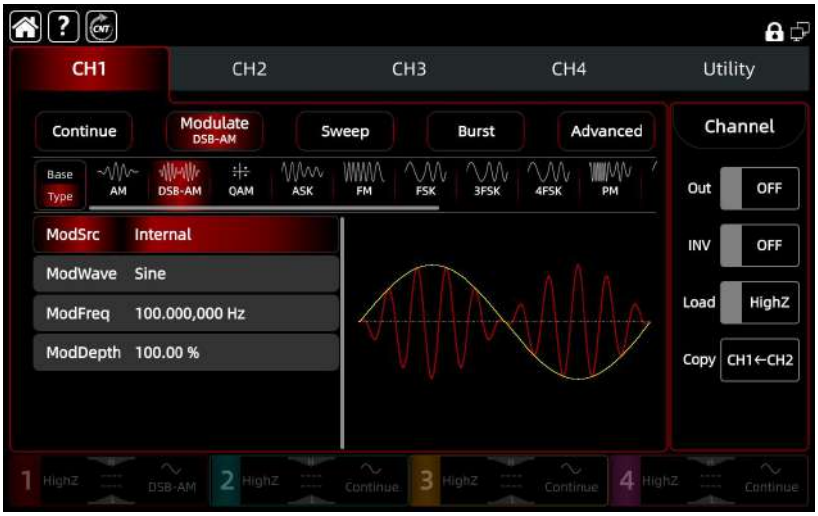
Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation frequency. Alternatively, tap ModFreq on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface. When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform.

Comprehensive Example

In DSB-AM mode, set an internal 1 kHz square waveform as the modulation signal, and a 2 kHz, 2 Vpp sine waveform as the carrier signal. The setting steps are as follows.

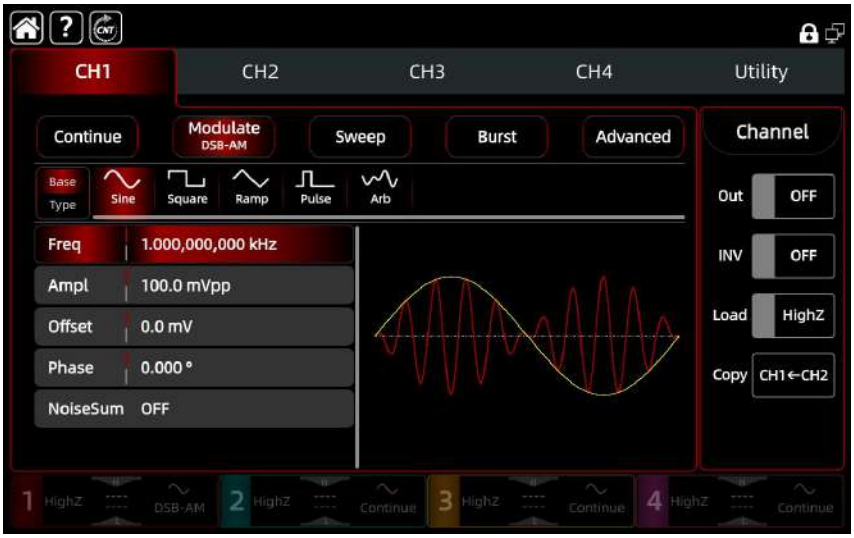
1) Enable DSB-AM Mode

Press the CH1 button, then tap Modulate→ DSB-AM on the screen to enable DSB-AM mode.



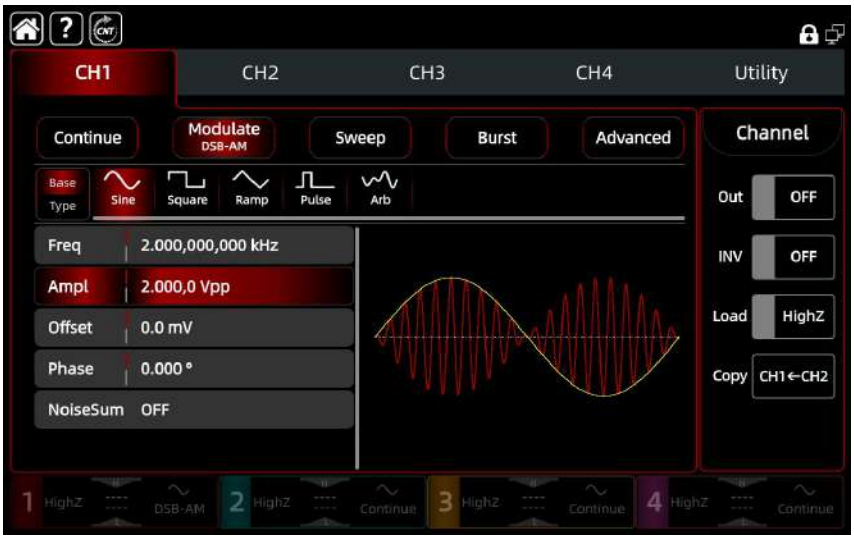
2) Set Carrier Wave and Parameters

Tap Base/Type to select the sine wave as the carrier wave. Since the default setting is sine, no changes are required in this case.



Tap Freq, use the numeric keypad to enter 2, and select kHz as the unit.

Tap Ampl, use the numeric keypad to enter 2, and select Vpp as the unit.

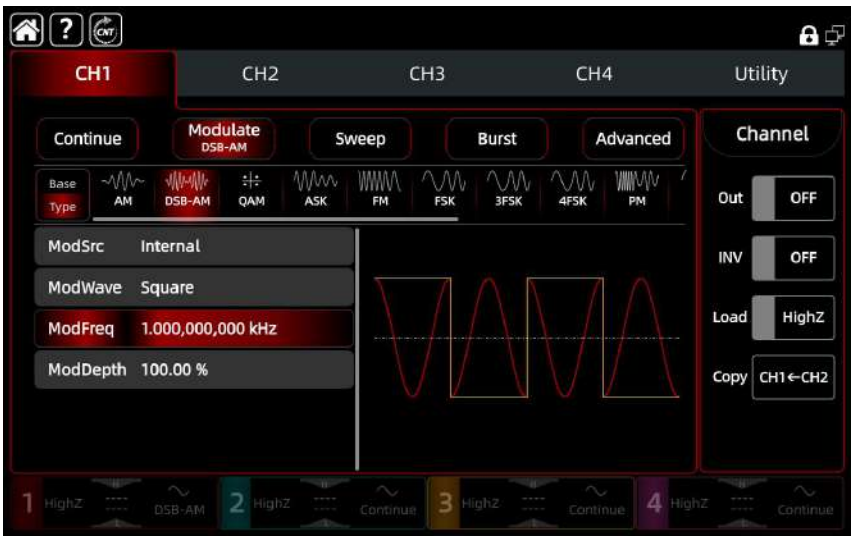


3) Set Modulation Waveform and Modulation Depth

After configuring the carrier wave parameters, tap Base/Type to return to the modulation setting interface.

Tap ModWave to select the square wave as the modulation wave.

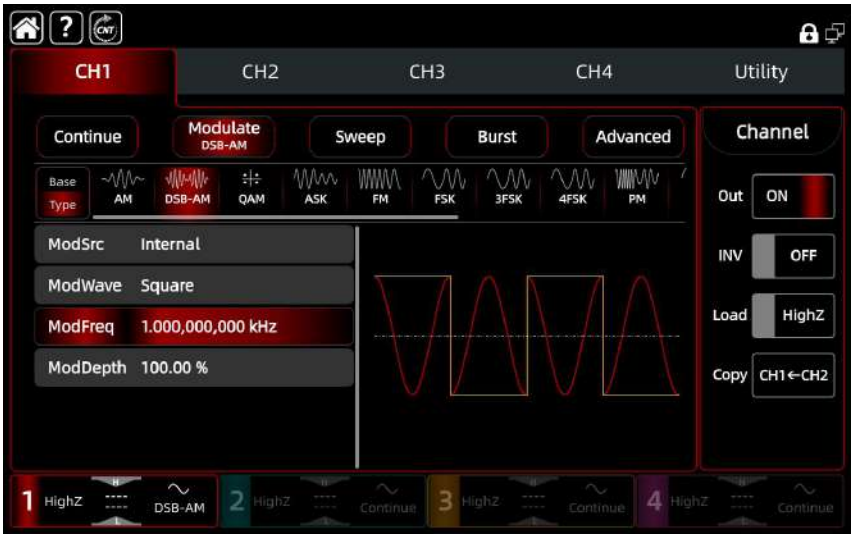
Tap ModFreq, use the numeric keypad to enter 1, and select kHz as the unit.



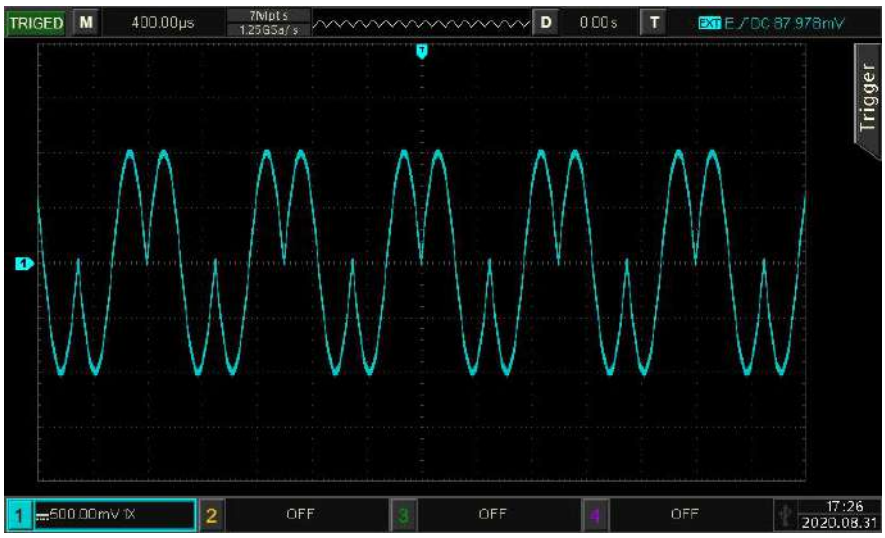
4) Enable Channel Output

Tap Out option to turn on the output, or press the CH1 button on the front panel to quickly enable the CH1 output. The output can also be enabled from the Utility interface by tap Utility→Channel Setting, and then tap CH1 to turn on the output. Alternatively, double-click the channel tab at the bottom of the screen to toggle between ON and OFF.

After the channel output is enabled, the CH1 button backlight turns on. At the same time, the CH1 status label changes from gray to the highlighted "DSB-AM," indicating that Channel 1 output is enabled.



View the DSB-AM waveform through an oscilloscope as shown in the following figure.



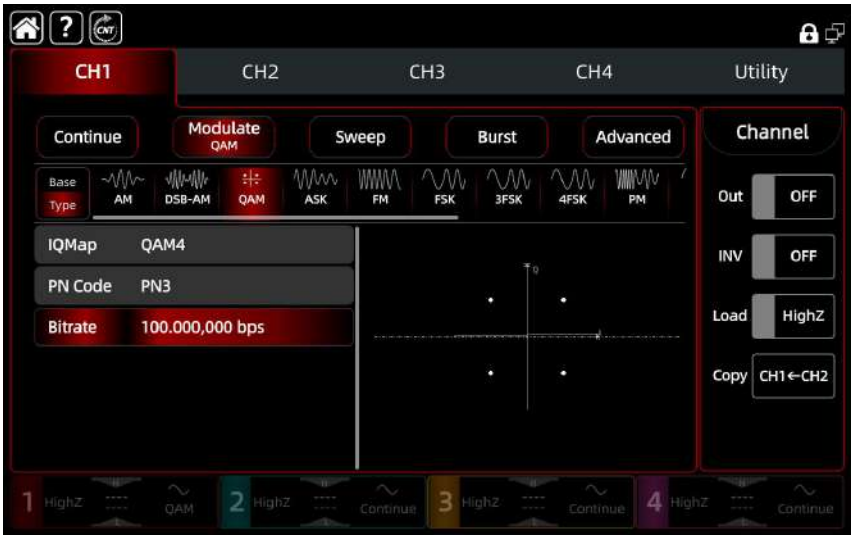
4.1.14 Quadrature Amplitude Modulation (QAM)

In QAM mode, set two carrier signals of the same frequency with a 90° phase difference (commonly represented as Sin and Cos), and use a baseband signal to modulate the carrier. The series supports seven QAM modulation types: QAM4, QAM8, QAM16, QAM32, QAM64, QAM128, and QAM256.

Note: It is recommended to use the 10 MHz reference output of this instrument as the reference clock input for the demodulation device, or to use the demodulation device's reference clock as the signal clock. Accurate demodulation is achieved through clock synchronization, which eliminates phase differences.

Select QAM Mode

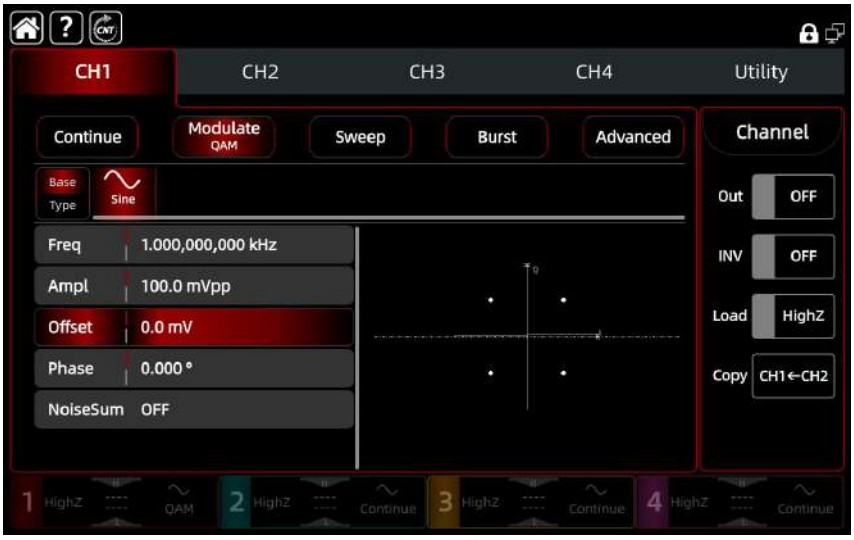
Press the CH1 button, then tap Modulate → QAM key to enable QAM mode. The instrument will output the modulated waveform according to the current setting and the carrier wave.



Carrier Wave Setting

The carrier waveform in QAM mode is fixed as a sine wave. When QAM is selected, the waveform

automatically switches to sine. On the modulation function interface, tap Base/Type displays only the sine waveform among the available base waveforms.



Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Modulation Type Setting

The modulation mode determines the constellation diagram layout, which varies according to the selected modulation type.

Tap IQMap to open the options list and select one of the following: QAM4, QAM8, QAM16, QAM32, QAM64, QAM128, or QAM256.

Symbol Setting

This series supports selection of an internal modulation source. After the QAM function is enabled, the symbol is preset to PN7 by default.

Rotate the multi-function rotary knob, or tap PN Code→PN3 to select one of the following: PN3, PN5, PN7, PN9, PN11, PN13, PN15, PN17, PN21, PN23, PN25, PN27, PN29, PN31, or PN33.

Modulation Rate Setting

When the modulation source is set to internal, switching frequency between the carrier phase and the modulation phase. After QAM mode is enabled, the modulation rate can be configured within a range of 1 μbps to 2 Mbps, with a default value of 100 bps.

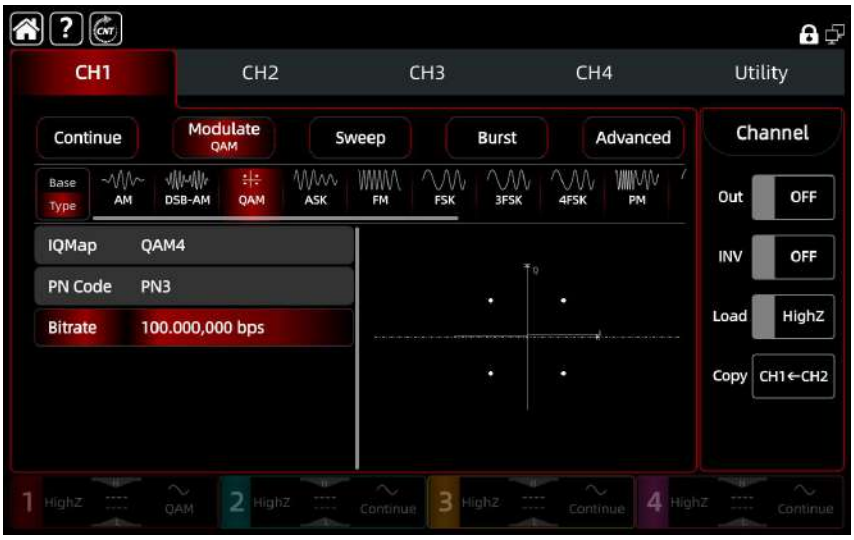
Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation rate. Alternatively, tap ModRate on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Comprehensive Example

In QAM mode, set an internal 2 kHz, 2 Vpp sine waveform as the carrier signal, set the bitrate to 100 bps, the modulation mode to QAM64, and the data source to PN7. The setting steps are as follows.

1) Enable QAM Mode

Press the CH1 button, then tap Modulate→ QAM on the screen to enable QAM mode.

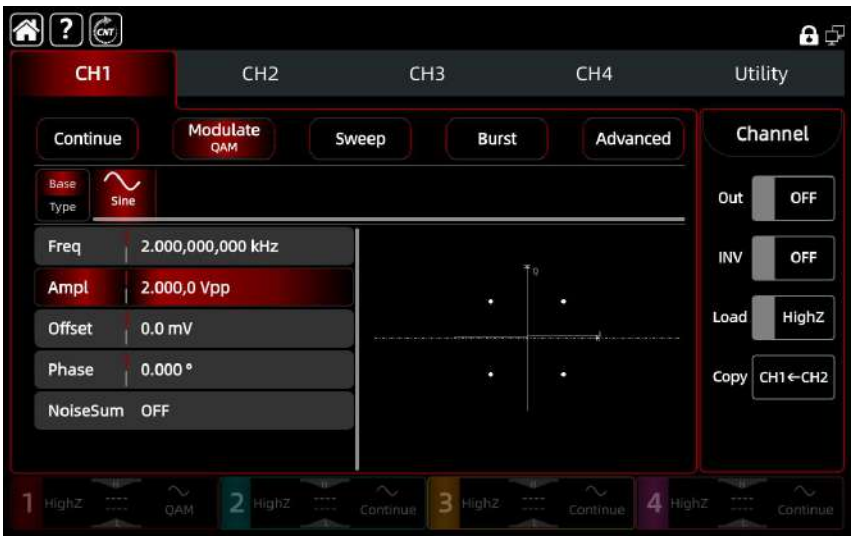


2) Set Carrier Wave and Parameters

Tap Base/Type to select the sine wave as the carrier wave. The QAM carrier waveform supports sine only. Since the default setting is sine, no changes are required in this case.

Tap Freq, use the numeric keypad to enter 2, and select kHz as the unit.

Tap Ampl, use the numeric keypad to enter 2, and select Vpp as the unit.



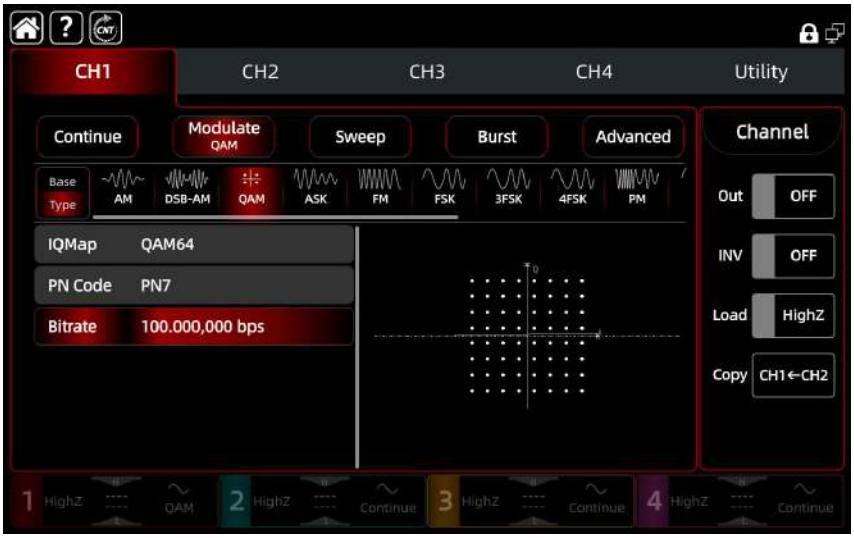
3) Set IQ Type and Symbol

After configuring the carrier wave parameters, tap Base/Type to return to the modulation setting interface.

Tap IQMap and select the IQ type to QAM64.

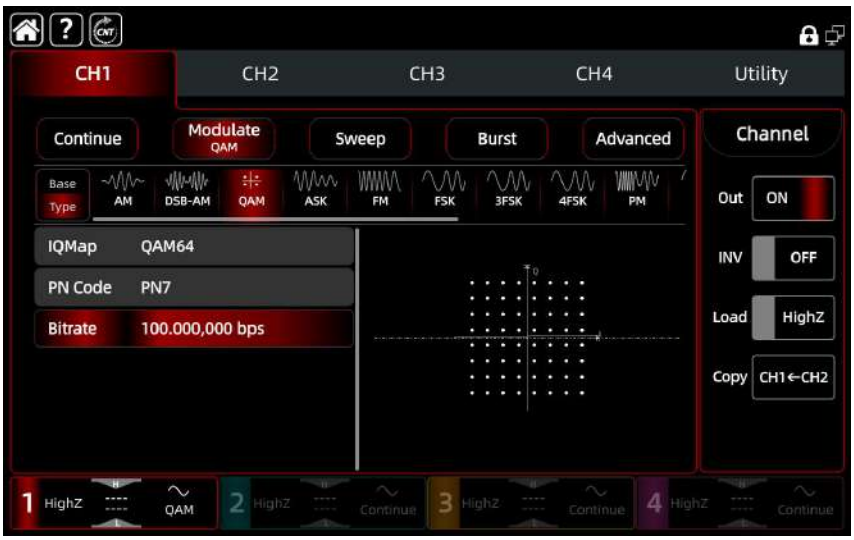
Tap PN Code and select the symbol to PN7.

Tap Bitrate, use the numeric keypad to enter 100 bps. The default value is 100 bps.

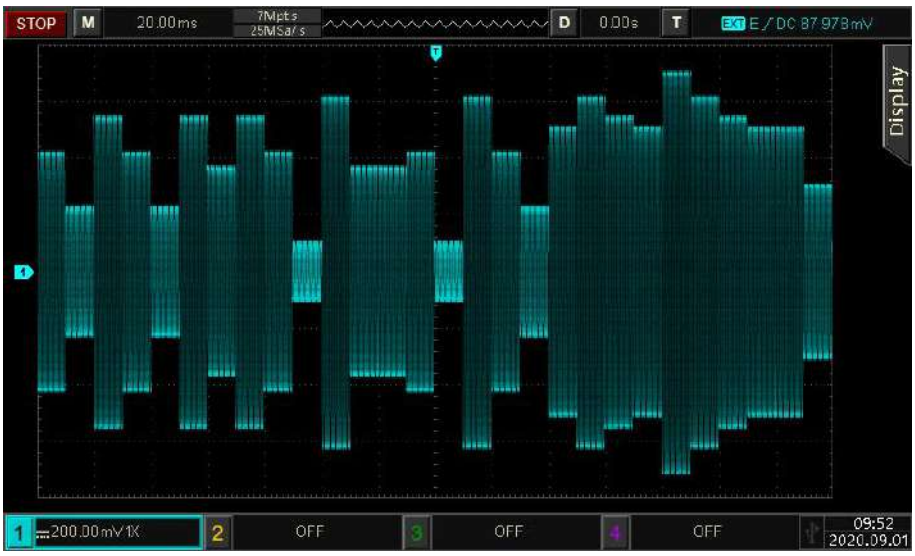


4) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the QAM waveform through an oscilloscope as shown in the following figure.



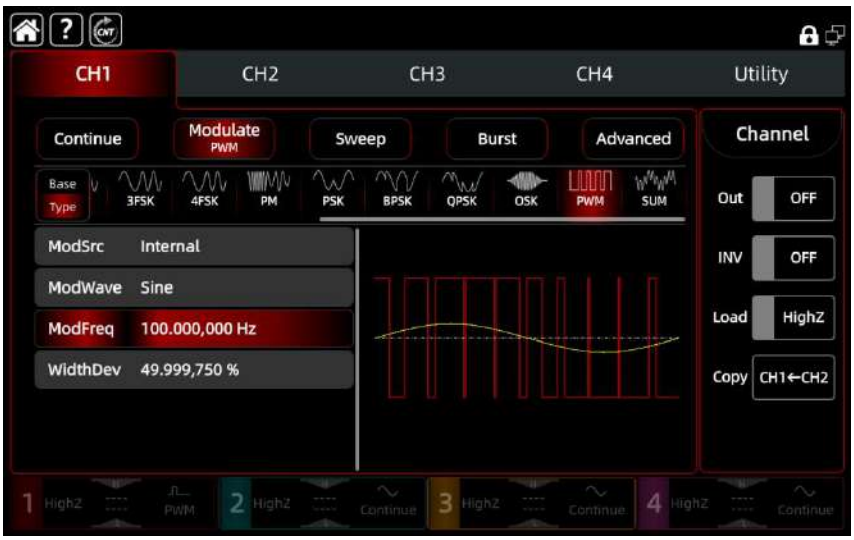
4.1.15 Pulse Width Modulation (PWM)

In PWM mode, the modulated waveform consists of a carrier waveform and a modulation waveform. The pulse width of the carrier waveform changes according to the amplitude of the modulation waveform.

The modulation mode of each channel is independent, allowing the same or different modulation modes to be configured for each channel.

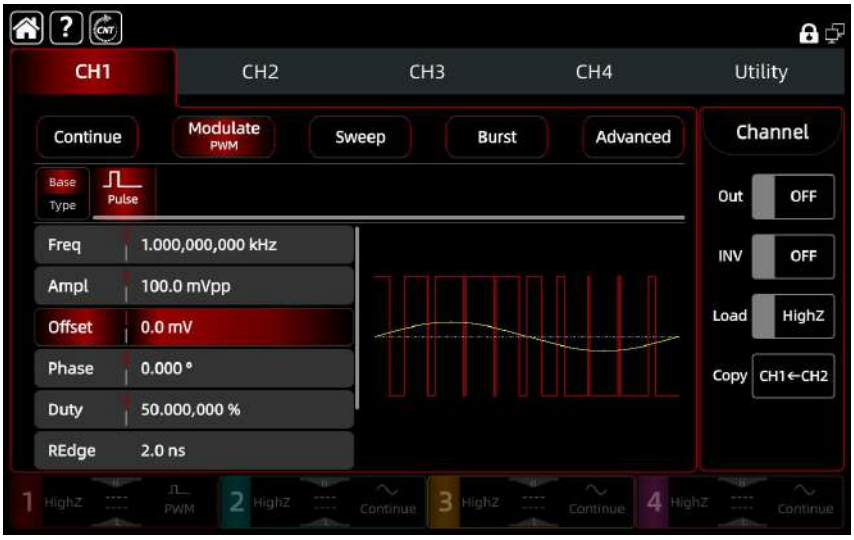
Select PWM Mode

Press the CH1 button, then tap Modulate PWM key to enable PWM mode. The instrument will output the modulated waveform according to the current setting and the carrier wave.



Carrier Wave Setting

The carrier waveform in PWM mode is fixed as a pulse wave. When PWM is selected, the waveform automatically switches to pulse. On the modulation function interface, tap Base/Type displays only the sine waveform among the available base waveforms.



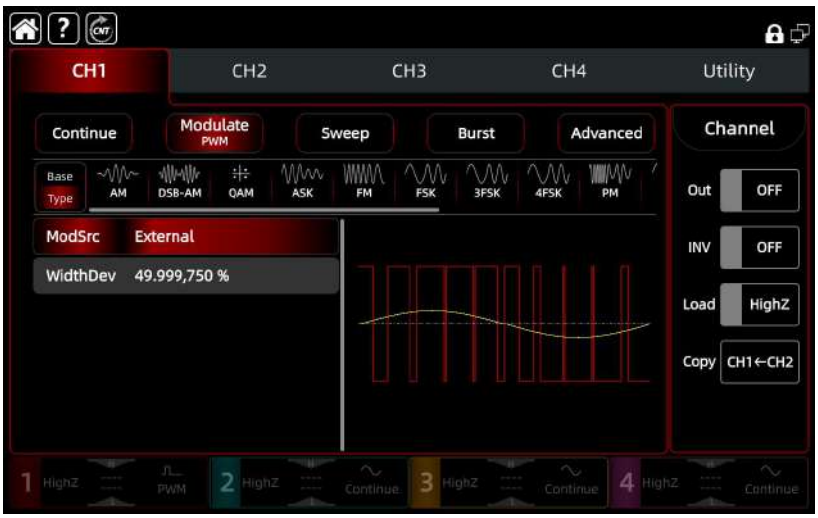
Carrier Wave Frequency

Refer to the *Carrier Wave Frequency* in the Amplitude Modulation (AM) section for more details.

Modulation Source Setting

This series provides two modulation source options: internal and external.

After PWM mode is enabled, the default modulation source (Internal) is displayed. The modulation source can be switched using the multi-function rotary knob in the PWM interface, or by pressing ModSrc→Internal, then selecting External.



1) Internal Source

When the modulation source is set to internal, the modulation waveform can be sine, square, rising ramp, falling ramp, arbitrary, or noise. The default waveform is sine.

After PWM modulation is enabled, the modulation waveform defaults to Sine. Rotate the multi-function rotary knob or tap Modulate→Sine to select a different waveform on the SUM setting interface.

- Square wave: duty cycle 50%
- Rising ramp wave: symmetry 100%
- Falling ramp wave: symmetry 0%
- Arbitrary wave: waveform length limited to 2 kpts when using the Auto Point Select method
- Noise wave: white Gaussian noise

2) External Source

When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform. The PWM modulation depth is controlled by the ±5 V signal level applied to the external analog modulation input (Modulation In connector) on the rear panel. For example, if the duty cycle deviation in the parameter list is set to 15%, the duty cycle of the carrier pulse waveform increases by 15% when the external modulation signal is at +5 V. Lower external signal levels result in proportionally smaller deviations.

Modulation Wave Frequency Setting

After the PWM function is enabled, when the modulation source is set to internal, the modulation wave frequency can be configured. The frequency range is 1 μHz to 2 MHz, with a default value of 100 Hz.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the modulation

frequency. Alternatively, tap ModFreq on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface. When the modulation source is set to external, the modulation waveform and frequency parameters are hidden in the parameter list. The carrier is modulated by an external waveform.

Duty Cycle Deviation Setting

The duty cycle deviation represents the variation of the PWM-modulated waveform relative to the current duty cycle of the carrier (pulse) waveform.

The configurable PWM duty cycle deviation range is 0% to 49.999750%, with a default value of 50%. Rotate the multi-function rotary knob, in combination with the arrow keys to set the pulse width deviation. Alternatively, tap WidthDev on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

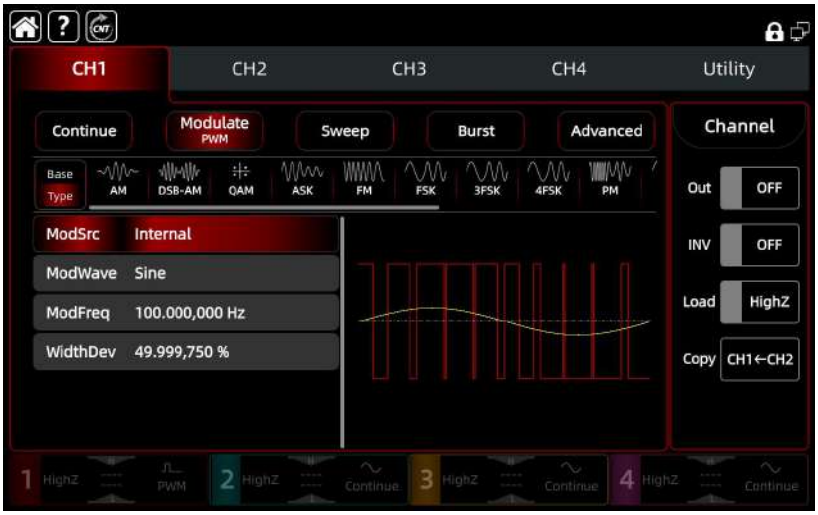
- Duty cycle deviation is the deviation of the modulated waveform relative to the duty cycle of the original pulse waveform, expressed as a percentage (%).
- The duty cycle deviation must not exceed the duty cycle of the current pulse waveform.
- The sum of the duty cycle deviation and the current pulse duty cycle must be ≤ 99.99%.
- The allowable duty cycle deviation is constrained by the minimum achievable pulse duty cycle and the current edge time.

Comprehensive Example

In PWM mode, configure a 1 kHz internal sine wave as the modulating signal, and set a pulse waveform with a frequency of 10 kHz, amplitude of 2 Vpp, duty cycle of 50%, and rise/fall time of 100 ns as the carrier signal. Then set the duty cycle deviation to 40%. The setting steps are as follows.

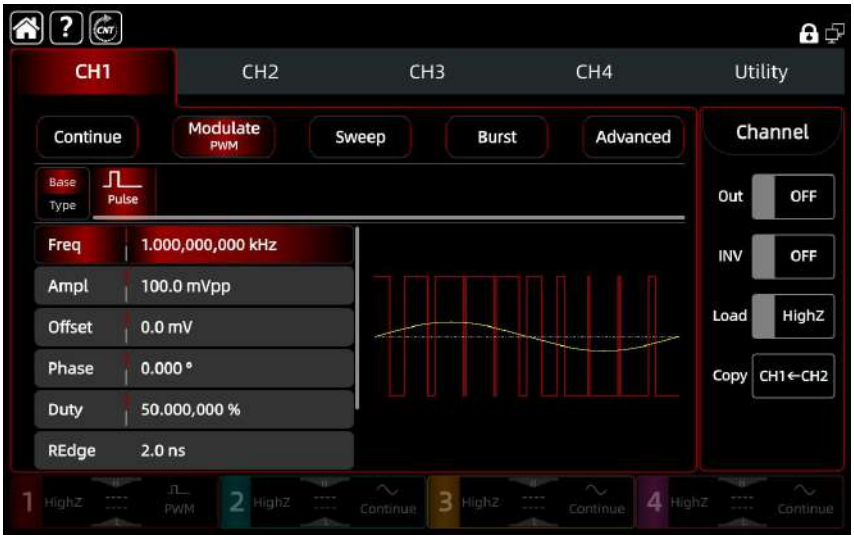
1) Enable PWM mode

   Press the CH1 button, then tap Modulate→ PWM on the screen to enable PWM mode.



2) Set Carrier Wave and Parameters

Tap Base/Type and select the carrier wave. The PMW carrier wave can only be pulse wave.

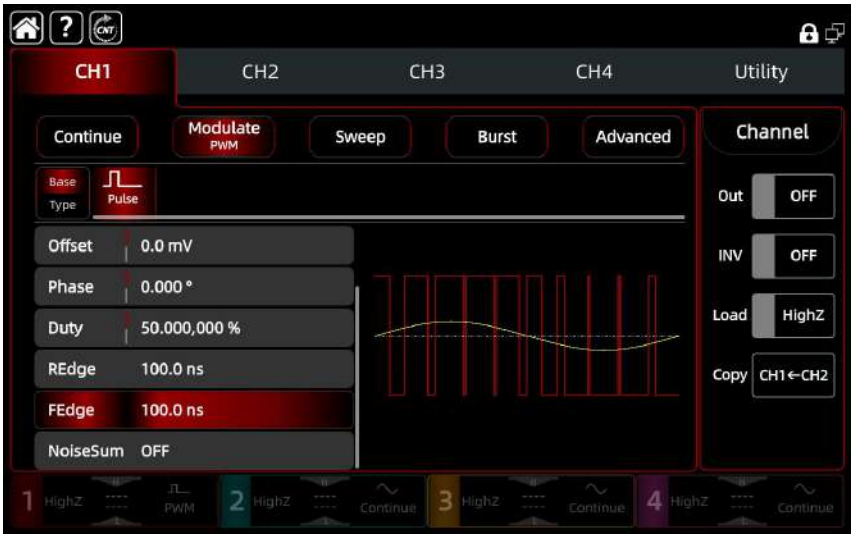


Tap Freq, use the numeric keypad to enter 10, and select kHz as the unit.

Tap Ampl, use the numeric keypad to enter 2, and select Vpp as the unit.

Tap REdge, use the numeric keypad to enter 100, and select ns as the unit.

Tap FEdge, use the numeric keypad to enter 100, and select ns as the unit.

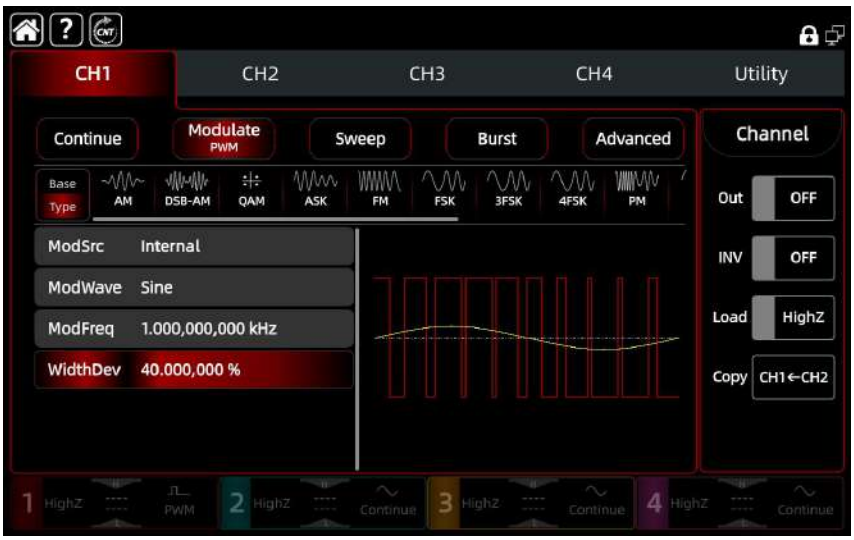


3) Set Modulation Frequency and Pulse Width Deviation

After configuring the carrier wave parameters, tap Base/Type to return to the modulation setting interface.

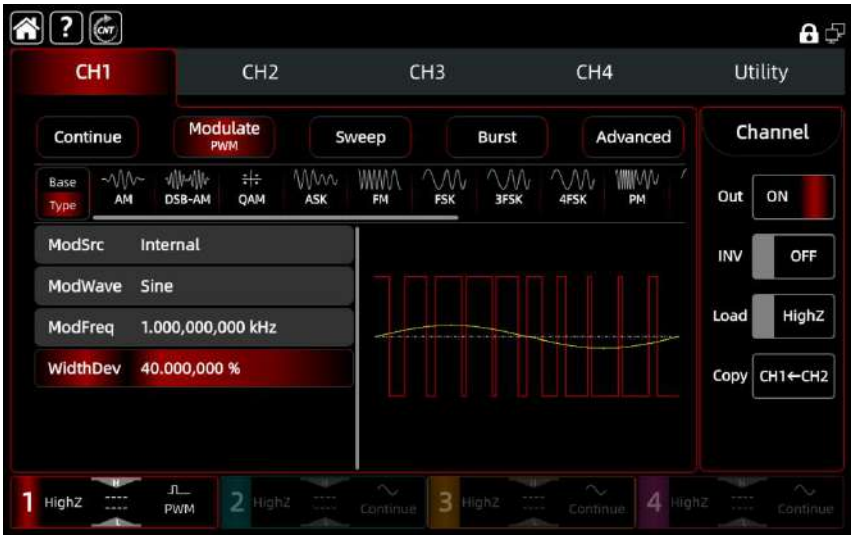
Tap ModFreq, use the numeric keypad to enter 1, and select kHz as the unit.

Tap WidthDev, use the numeric keypad to enter 40, and select % as the unit.

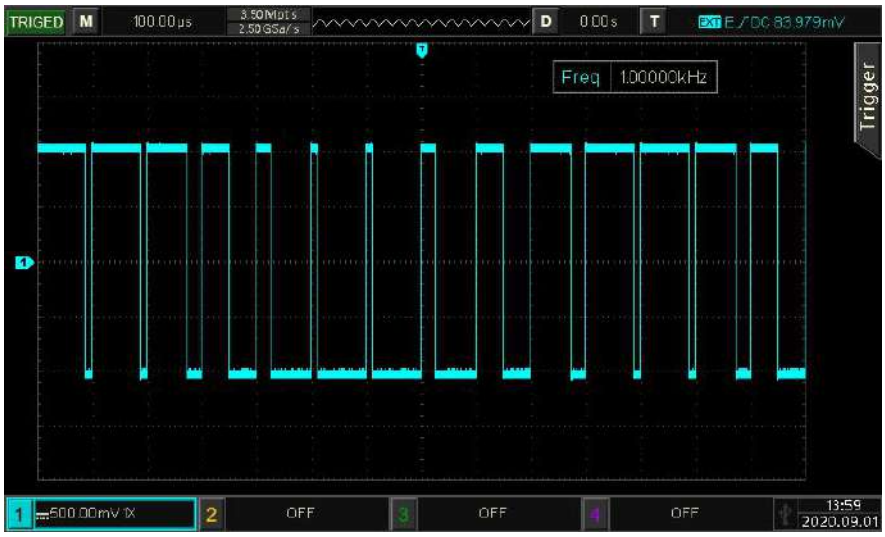


4) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the PWM waveform through an oscilloscope as shown in the following figure.



4.2 Sweep Waveform Output

When frequency sweep mode is selected, the function/arbitrary waveform generator outputs a signal whose frequency varies from the start frequency to the stop frequency according to the selected sweep type: linear, logarithmic, step, or list, within the specified sweep time. The trigger source can be set to internal, external, or manual.

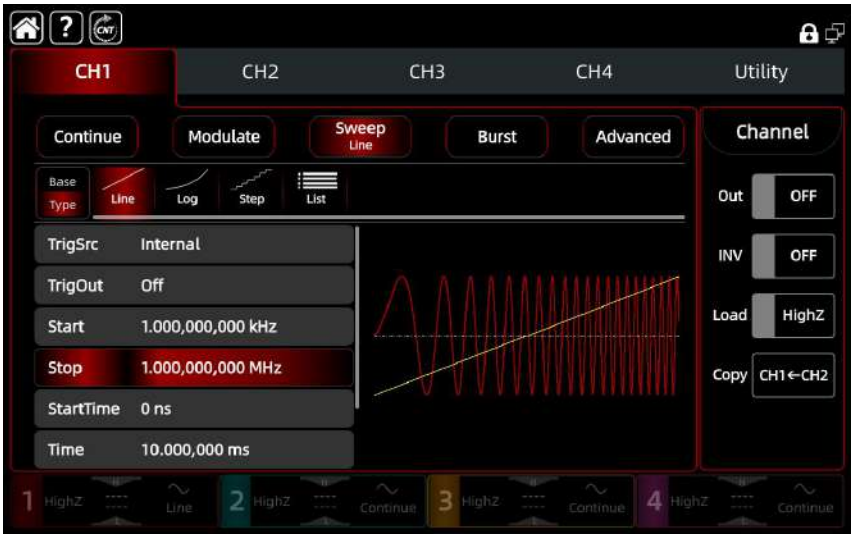
Frequency sweep operation is supported for sine, square, ramp, pulse, and arbitrary waveforms (excluding DC).

The modulation mode of each channel is independent, allowing the user to configure the same or different modulation modes for each channel.

4.2.1 Frequency Sweep

1) Enable Frequency Sweep Mode

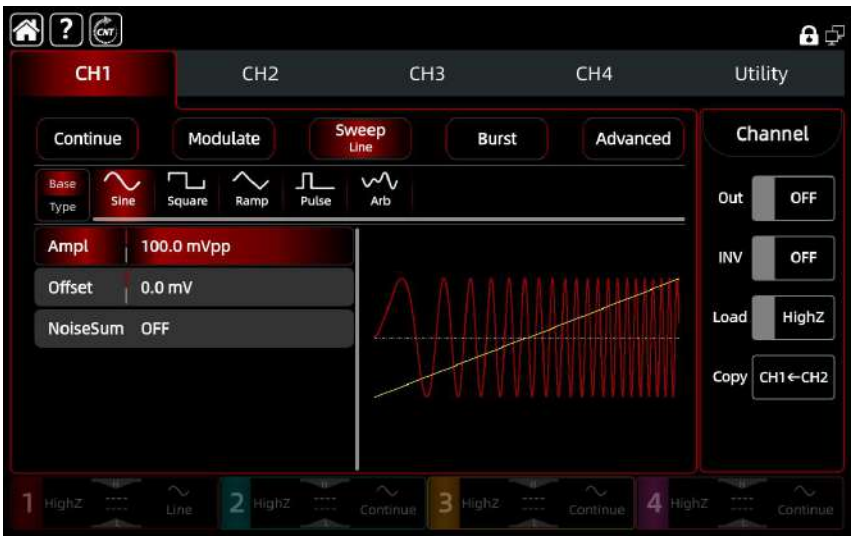
Press the CH1 button, then tap Sweep to enable frequency sweep mode. The instrument will output the frequency-swept waveform according to the current setting.



2) Select Frequency Sweep Waveform

The frequency sweep waveform can be sine, square, ramp, pulse, or arbitrary. The default waveform is sine.

After selecting the frequency sweep waveform, tap Base/Type and select the carrier wave.



4.2.2 Start and Stop Frequency

The start frequency and stop frequency define the lower and upper limits of the frequency range for frequency to sweep. The function/arbitrary waveform generator always sweeps from the start frequency to the stop frequency and then returns to the start frequency.

Tap Sweep to enter the frequency sweep setting interface. Rotate the multi-function rotary knob, in combination with the arrow keys to set the start or stop frequency. Alternatively, tap Start or Stop on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

Note

- When start frequency < stop frequency, the function/arbitrary waveform generator sweeps from low frequency to high frequency.
- When start frequency > stop frequency, the function/arbitrary waveform generator sweeps from high frequency to low frequency.
- When start frequency = stop frequency, the function/arbitrary waveform generator outputs the fixed frequency.

The start frequency is 1 MHz and stop frequency is 10 MHz by default. The range of start and stop frequency is vary with frequency sweep wave, the frequency range for each frequency sweep wave see the table as follows.

Carrier Frequency	Frequency					
	UTG4254X		UTG4164X		UTG4104X	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Sine Wave	1μHz	250MHz	1μHz	160MHz	1μHz	100MHz
Square Wave	1μHz	100MHz	1μHz	80MHz	1μHz	50MHz
Ramp Wave	1μHz	20MHz	1μHz	20MHz	1μHz	20MHz

Pulse Wave	1μHz	100MHz	1μHz	80MHz	1μHz	50MHz
Arbitrary Wave	1μHz	50MHz	1μHz	50MHz	1μHz	50MHz

4.2.3 Sweep Mode

In frequency sweep setting interface, tap Sweep to select linear, logarithmic, step or list.

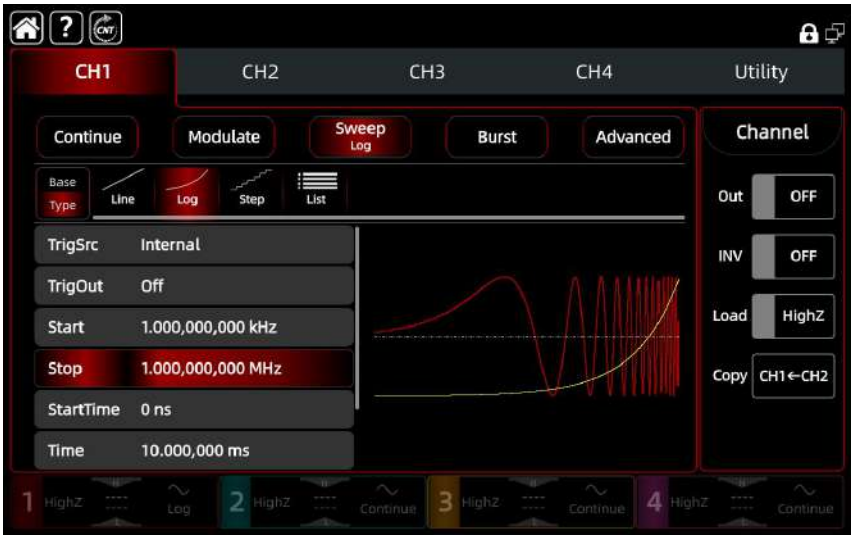
Linear: During a frequency sweep, the waveform generator changes the output frequency in a linear mode.

Logarithmic: The waveform generator changes the output frequency in a logarithmic mode.

Step: The frequency sweep is performed in a specified number of steps from the start frequency to the stop frequency.

List: The frequency sweep is executed according to the list setting.

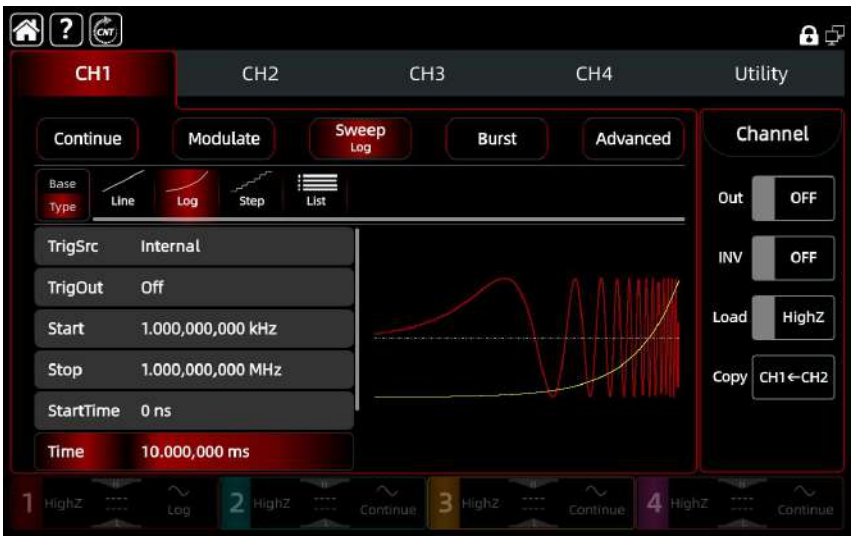
The default sweep mode is linear. To change the frequency sweep mode, after the frequency sweep is enabled, tap Line, Log, Step, List to select the desired mode.



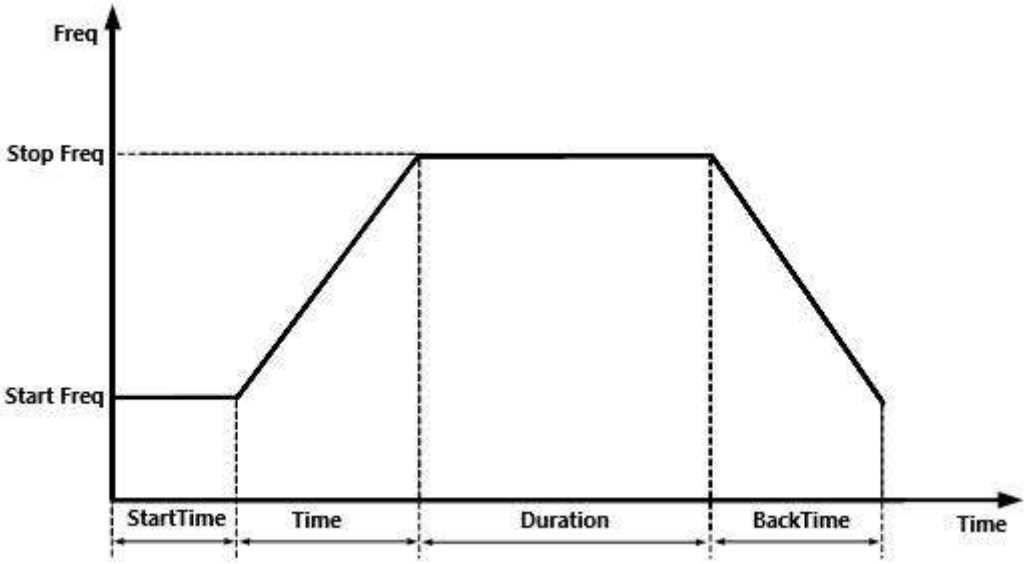
4.2.4 Sweep Time

In frequency sweep mode, the sweep time can be set within the range of 1 ms to 500 s, with a default value of 10 ms.

Tap Time on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the frequency sweep setting interface.



Sweep time specifies the time required to sweep from the start frequency to the stop frequency, as shown in the figure below.



4.2.5 Start Time

Start time specifies the time for the sweep to remain at the start frequency. After the start time expires, the generator continues to sweep at varied frequencies according to the current sweep type.

The default time is 0 s, with a resolution of 1 ms, and a configurable range of 0 s to 3600 s.

Tap StartTime on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the frequency sweep setting interface.

4.2.6 Duration

Duration refers to the time period during which the generator continues to output at the stop frequency after completing the sweep from the start frequency.

The default time is 0 s, with a resolution of 1 ms, and a configurable range of 0 s to 3600 s.

Tap Duration on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the frequency sweep setting interface.

Duration is related to the sweep mode, trigger source, return time, and sweep time.

T= Start time + sweep time + Duration + Return time

- Linear Sweep

  Internal trigger source: T + 1 ms ≤ 8,000 s

  Manual trigger/external trigger: T ≤ 250,000 s

- Log Sweep/Step Sweep: T ≤ 500 s

After the start or duration time is modified, the instrument will sweep from the specified start frequency again.

4.2.7 Return Time

Return time specifies the time to return from the stop frequency to the start frequency.

The default time is 0 s, with a resolution of 1 ms, and a configurable range of 0 s to 3600 s.

Tap BackTime on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the frequency sweep setting interface.

4.2.8 Sweep Trigger Source

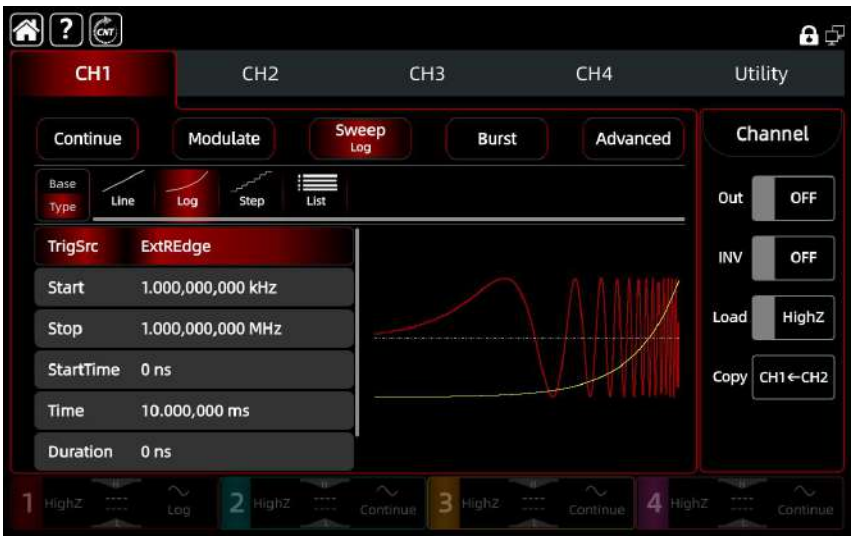
The instrument outputs a single sweep when a trigger signal is received and waits for the next trigger. The sweep trigger source can be internal trigger, external (external rising edge or external falling edge), or manual trigger.

Rotate the multi-function rotary knob to select the desired sweep trigger source, or tap TrigSrc→ Internal on the screen to select external (external rising edge or external falling edge), or manual trigger.

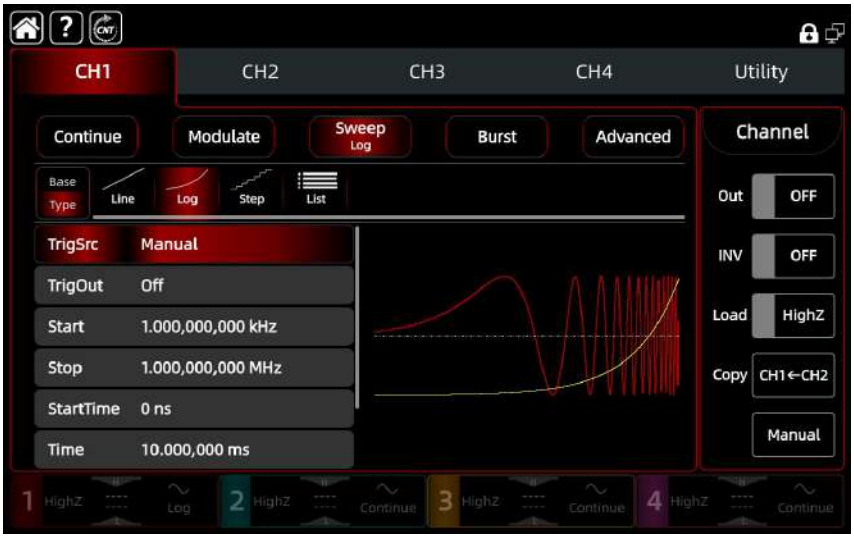
When the trigger source is set to internal, the waveform generator outputs a continuous frequency sweep, with the sweep rate determined by the sweep time.

When the trigger source is set to external, the waveform generator responds to a hardware trigger applied to the external digital modulation interface (FSK Trig connector) on the rear panel. Each time a TTL pulse with the specified polarity is received, the generator initiates a single frequency sweep.

Note: When the trigger source is set to External, the trigger output option in the parameter list is hidden. This is because the trigger output is also routed through the external digital modulation interface (FSK Trig connector), which cannot simultaneously function as both an external trigger input and an internal trigger output.



When the trigger source is set to manual, the Manual option is displayed in the current channel settings on the right side of the screen. Tap Manual to initiate a single frequency sweep.



4.2.9 Trigger Output

When the trigger source is set to internal or manual, a TTL-compatible trigger signal (square wave) can be output via the external digital modulation interface (FSK Trig connector).

The default setting is Off. Rotate the multi-function rotary knob to switch the trigger output to turn on, or tap TrigOut→Off on the screen to select rising edge or falling edge.

- Internal Trigger: The signal generator outputs a 50% duty cycle square wave through the FSK Trig connector at the start of each frequency sweep. The trigger cycle is determined by the configured sweep time.
- Manual Trigger: The signal generator outputs a pulse with a width greater than 1 μs through the FSK Trig connector at the start of the frequency sweep.
- External Trigger: The Trigger Output option in the parameter list is hidden. This is because the

trigger output is also routed through the FSK Trig connector, which cannot function simultaneously as an external trigger input and an internal trigger output.

4.2.10 Trigger Edge

The edge can be specified regardless of whether the FSK Trig connector is configured as an input or an output.

When used as an input (trigger source set to External):

External rising edge: The rising edge of the external signal triggers the output of a frequency sweep.

External falling edge: The falling edge of the external signal triggers the output of a frequency sweep.

When used as an output (trigger source set to internal or manual, and trigger output is enabled):

Rising edge: The trigger signal is output on the rising edge.

Falling edge: The trigger signal is output on the falling edge.

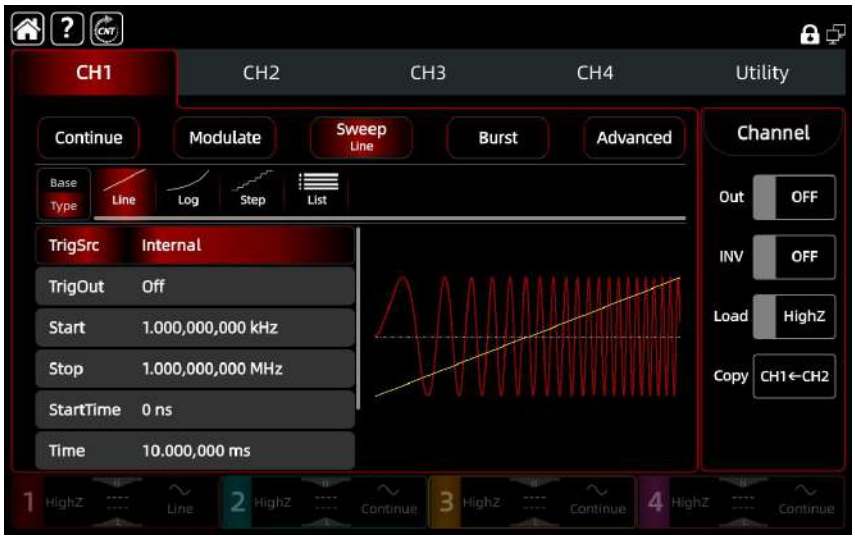
The default setting is rising edge.

4.2.11 Comprehensive Example

In the frequency sweep mode, set a square wave with an amplitude of 1 Vpp and a 50% duty cycle as the sweep waveform. Set the sweep mode to linear, the start frequency to 1 kHz, the stop frequency to 50 kHz, and the sweep time to 2 ms. Finally, trigger and output the sweep waveform using the rising edge of the internal trigger. The setting steps are as follows.

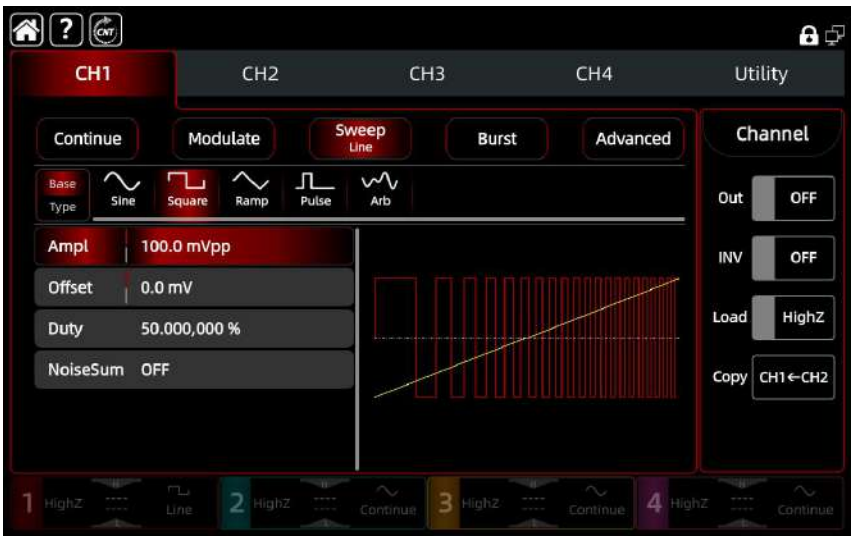
1) Enable Linear Sweep

Press the CH1 button, then tap Sweep→ Line on the screen to enable linear sweep mode.



2) Select Frequency Sweep Waveform

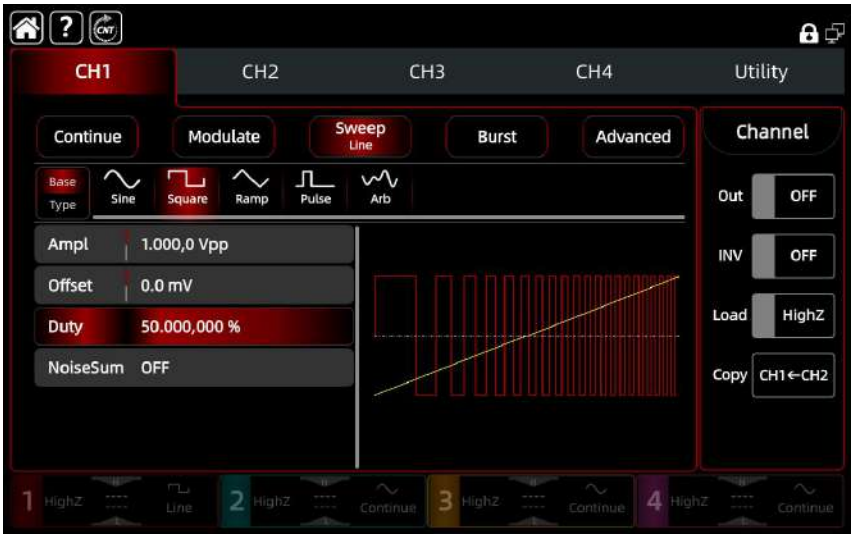
Tap Base/Type to select the square as carrier wave. The default is sine wave.



Tap Ampl, use the numeric keypad to enter 1, and select Vpp as the unit.

Tap Duty, use the numeric keypad to enter 50, and select % as the unit.

The default is 50%



3) Set Start/Stop Frequency, Sweep Time, Trigger Source, and Trigger Edge

After configuring the carrier wave parameters, tap Base/Type to return to the sweep setting interface.

Tap Start, use the numeric keypad to enter 1, and select kHz as the unit.

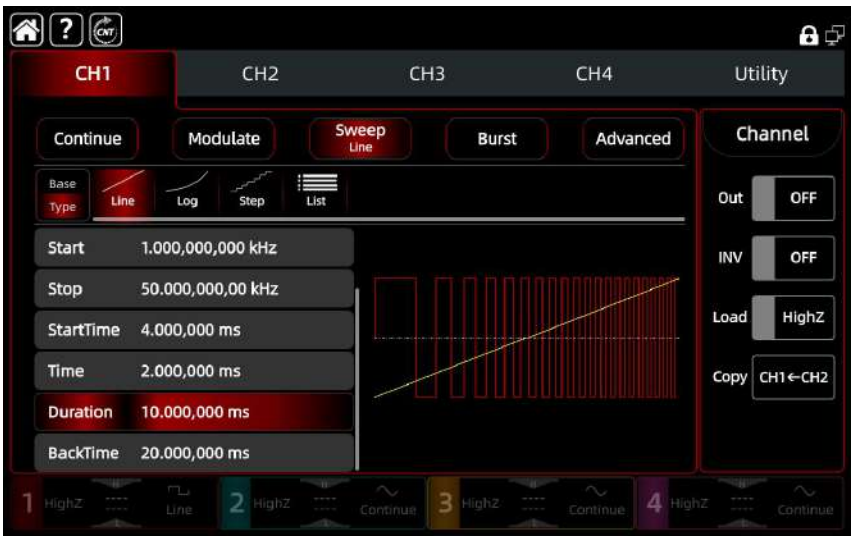
Tap Stop, use the numeric keypad to enter 50, and select kHz as the unit.

Tap StartTime, use the numeric keypad to enter 4, and select ms as the unit.

Tap Time, use the numeric keypad to enter 2 and select ms as the unit.

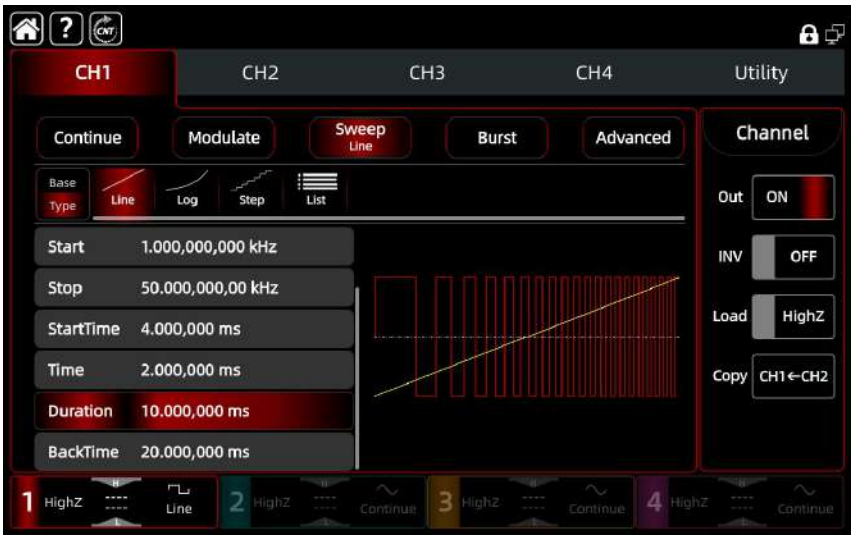
Tap Duration, use the numeric keypad to enter 10, and select ms as the unit.

Tap BackTime, use the numeric keypad to enter 20, and select ms as the unit.



4) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the linear sweep waveform through an oscilloscope as shown in the following figure.

4.3 Burst Output

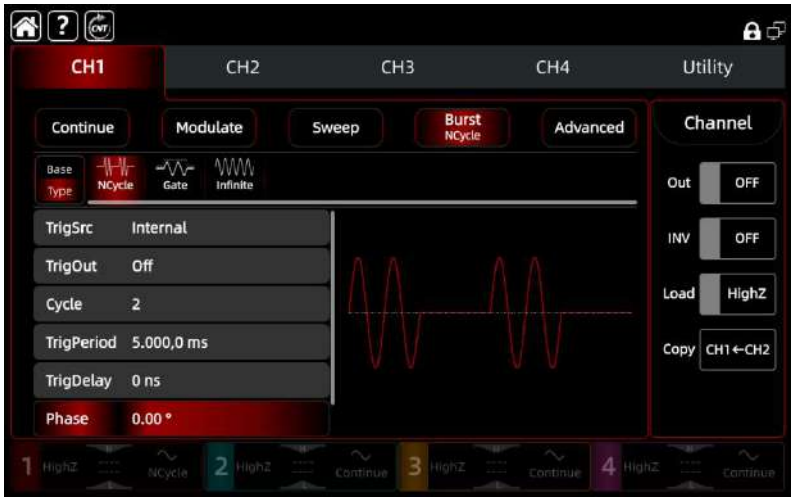
The signal generator can output a waveform with a specified number of cycles, referred to as a burst. This series supports burst output controlled by internal and external Triggers, and offers three burst types: N-cycle, gate, and infinite. Burst output is available for sine waves, square waves, ramp waves, pulse waves, and arbitrary waves (except DC).

The modulation mode of each channel is independent, allowing the user to configure the same or different modulation modes for each channel.

4.3.1 Burst

1) Enable Burst Mode

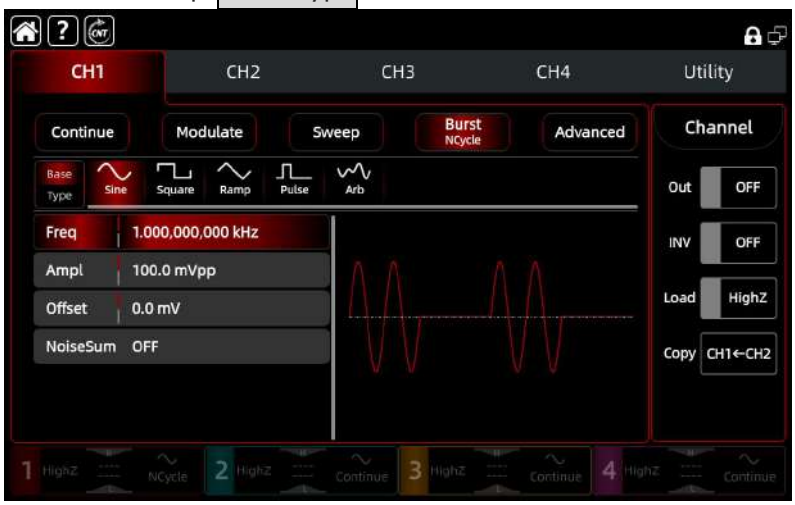
Press the CH1 button, then tap Burst to enable burst mode. The instrument will output the burst according to the current setting.



2) Select Waveform

N-cycle, gate, and infinite mode supports the following waveforms: sine wave, square wave, ramp wave, pulse wave, and arbitrary wave (except DC).

After the burst is enabled, tap Base/Type and select the waveform.



3) Set Waveform Frequency

In N-cycle and gate mode, the waveform frequency defines the signal frequency during the burst period.

In N-cycle mode, the burst is output according to the specified number of cycles and the waveform frequency.

In gate mode, the burst is output at the waveform frequency while the trigger signal is at a high level.

Note

The waveform frequency is different from the burst period. The burst period specifies the interval between bursts (applicable only in N-Cycle Mode). The default frequency of each waveform is 1 kHz, and the configurable range is shown in the following table.

Carrier Frequency	Frequency					
	UTG4254X		UTG4164X		UTG4104X	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Sine Wave	1μHz	250MHz	1μHz	160MHz	1μHz	100MHz
Square Wave	1μHz	100MHz	1μHz	80MHz	1μHz	50MHz
Ramp Wave	1μHz	20MHz	1μHz	20MHz	1μHz	20MHz
Pulse Wave	1μHz	100MHz	1μHz	80MHz	1μHz	50MHz
Arbitrary Wave	1μHz	50MHz	1μHz	50MHz	1μHz	50MHz

Rotate the multi-function rotary knob, in combination with the arrow keys to set the waveform frequency. Alternatively, tap Freq on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the modulation setting interface.

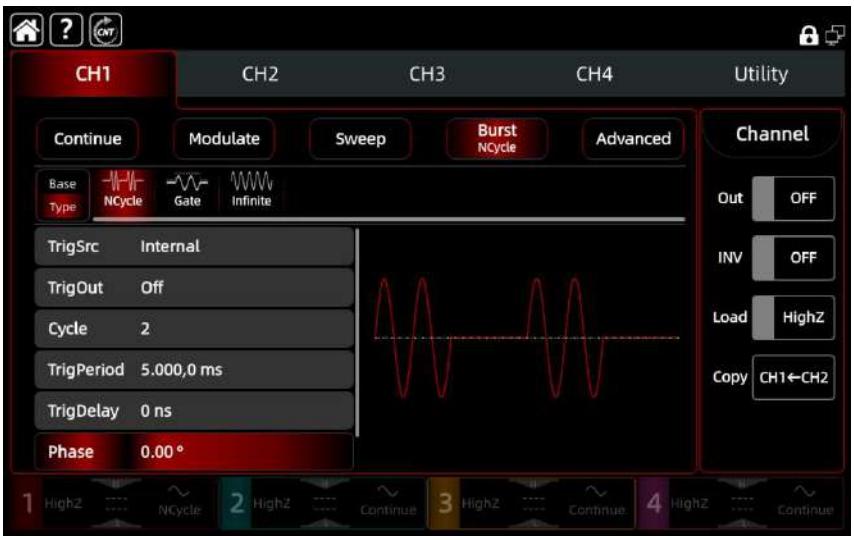
4.3.2 Burst Type

This series can output three types of burst: N-cycle, gate, and infinite. The default type is N-cycle.

1) N-Cycle

After the burst is enabled, tap NCycle to enter the N-cycle mode. The waveform generator outputs a waveform with the designated number of cycles (burst count). After the specified number of cycles is output, the waveform generator stops and waits for the next trigger. In this mode, the trigger source can be set to internal or external.

Rotate the multi-function rotary knob to select the trigger source, or tap TrigSrc on the screen to change it.

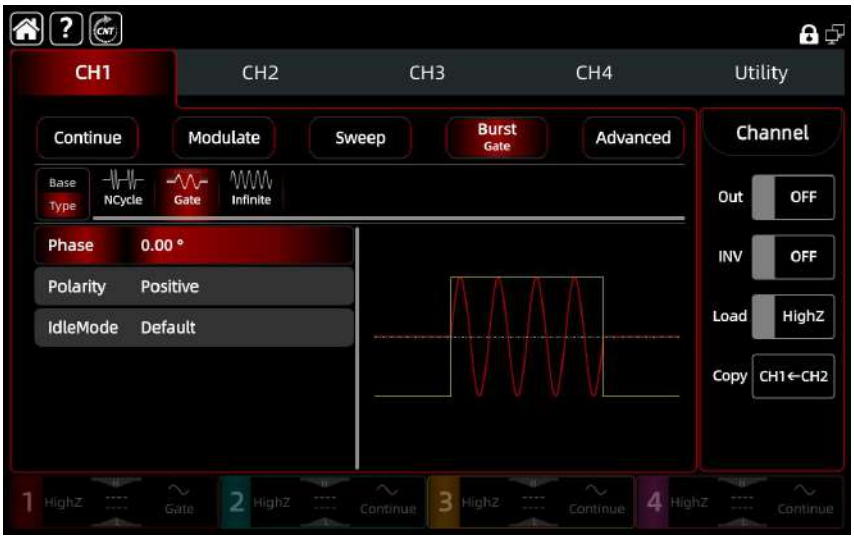


2) Gate

After the burst is enabled, tap Gate to enter the gate mode. In gate mode, the parameter list automatically hides the options for trigger source, trigger edge, trigger period, and cycle count, because only the external trigger is supported. The waveform generator operates based on the hardware trigger received from the external digital modulation interface (FSK Trig connector) on the rear panel.

When the polarity is set to positive and the trigger input signal is at a high level, the waveform generator outputs a continuous waveform. When the trigger input signal is at a low level, the waveform generator completes the current waveform cycle and then stops outputting, while maintaining the level corresponding to the start phase of the selected waveform.

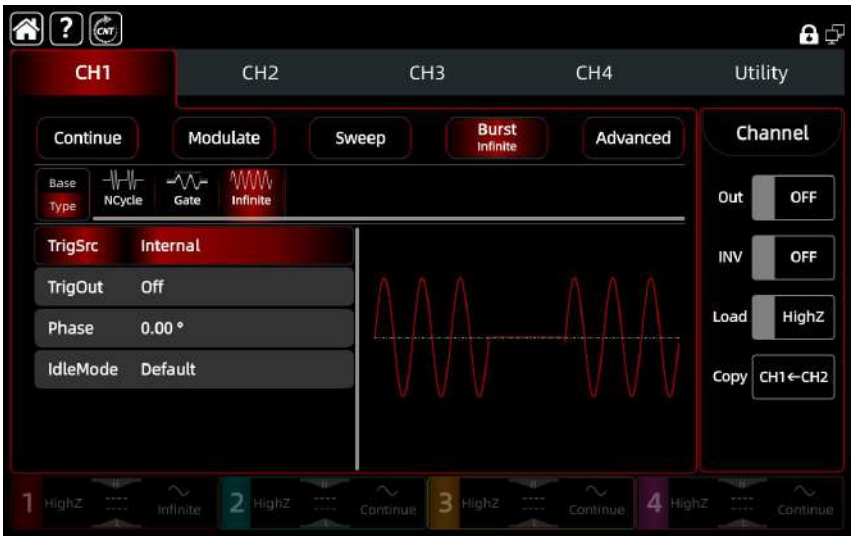
For noise waveforms, the output stops immediately when the gating signal becomes inactive. Rotate the multi-function rotary knob to select the polarity, or tap Polarity on the screen to change it.



3) Infinite

After the burst is enabled, tap Infinite to enter the infinite mode. In infinite mode, the parameter list automatically hides the options for trigger period and cycle count. Infinite burst is equivalent to setting the number of waveform cycles to infinity. The waveform generator outputs a continuous waveform upon receiving a trigger signal. In this mode, the trigger source for the burst can be set to internal or external.

Rotate the multi-function rotary knob to select the trigger source, or tap TrigSrc on the screen to change it.



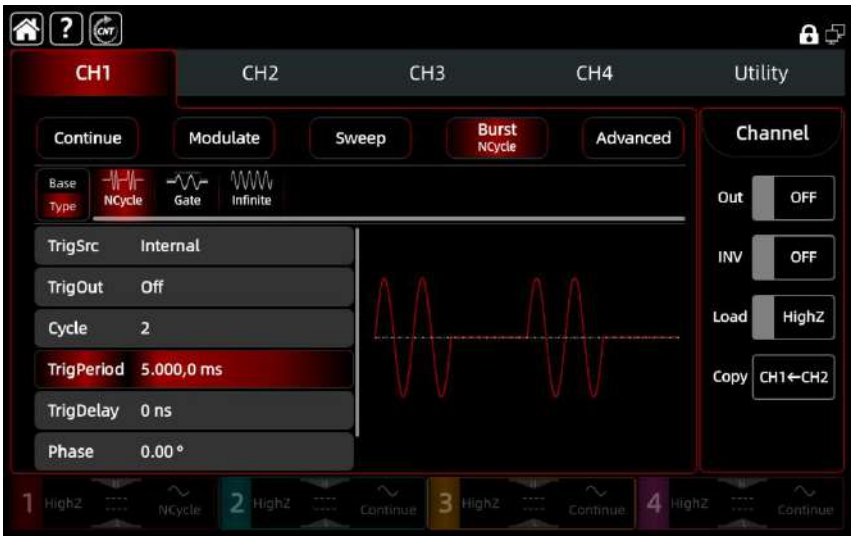
4.3.3 Start Phase

The burst phase defines the start phase of the burst and can be set from −360° to +360°. The default start phase is 0°.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the start phase. Alternatively, tap Phase on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the burst type setting interface.

- For sine, square, ramp, and impulse waves, 0° corresponds to the point where the waveform passes 0 V (or the DC offset value) in the forward direction.
- For arbitrary waveforms, 0° corresponds to the first sample point downloaded to storage.
- The start phase has no effect on noise waveforms.

4.3.4 Trigger Period



The trigger period (burst period) applies only to N-cycle mode and defines the time interval between successive pulse strings. When the trigger source is set to external, the trigger period (burst period) option in the parameter list is hidden. The burst period can be set in the range of 1 μs to 500 s, with a default value of 5 ms.

After the N-cycle mode is enabled, rotate the multi-function rotary knob, in combination with the arrow keys to set the trigger period. Alternatively, tap TrigSrc on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the burst type setting interface.

Note

- Trigger period (burst period) period ≥ Waveform period × Cycle number (burst count)
  Here, the waveform period is the reciprocal of the waveform frequency specified in *Burst*.
- If the burst period is set too short, the waveform generator will automatically increase the period to ensure that the designated number of cycles is output.

4.3.5 Burst Cycle Count

In N-cycle mode, the burst count specifies the number of waveform cycles in a burst. The valid range is 1 to 50,000, with a default value of 2.

After the N-cycle mode is enabled, rotate the multi-function rotary knob, in combination with the arrow keys to set the burst count. Alternatively, tap Cycle on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the burst type setting interface.

Note

- Cycle number < Trigger period × Waveform frequency

- If the cycle number exceeds this limit, the waveform generator will automatically increase the burst period to accommodate the designated number of cycles (the waveform frequency remains unchanged).

4.3.6 Trigger Source

The instrument generates a burst waveform when a trigger signal is received. The burst trigger source can be set to internal or external. Rotate the multi-function rotary knob to select the desired sweep trigger source, or tap TrigSrc→Internal on the screen to select external.

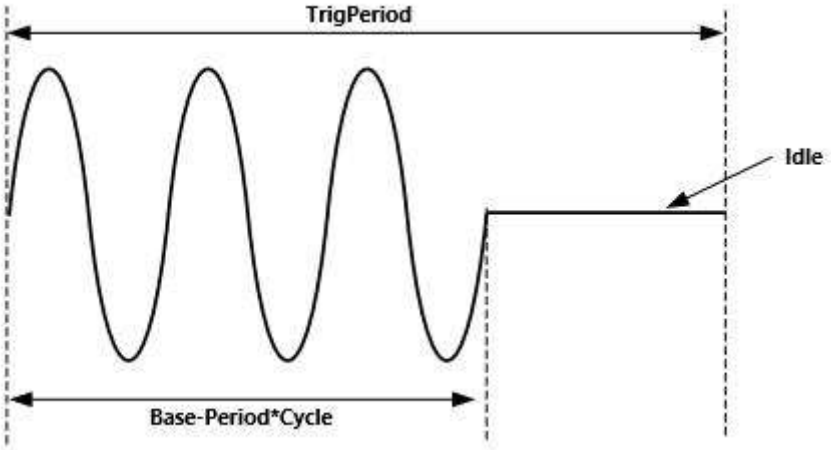
1) When the trigger source is set to Internal, the waveform generator continuously outputs bursts at the specified frequency. The burst repetition rate is determined by the burst period. The waveform generator can output N-cycle or infinite burst.
2) When the trigger source is set to external rising edge or external falling edge, the waveform generator responds to a hardware trigger applied to the external digital modulation interface (FSK Trig connector) on the rear panel. Each time a TTL pulse with the specified polarity is detected, the generator initiates a single burst. The waveform generator can output N-cycle burst, gat burst, or infinite burst.
   Rising edge: A burst is generated and output on the rising edge of the external trigger signal.
   Falling edge: A burst is generated and output on the falling edge of the external trigger signal.
3) In gate mode, when the polarity parameter is set to positive, the burst is enabled and output while the external gating signal is at a high level. When the polarity parameter is set to negative, the burst is enabled and output while the external gating signal is at a low level.
4) Manual trigger is available in N-cycle and infinite modes. When manual trigger is selected, tap Manual trigger key located at the bottom-right corner of the burst interface to initiate a trigger immediately. If the output of the corresponding channel is disabled, the trigger command is ignored.

4.3.7 Idle Level

In burst mode, when no burst is being output, the waveform generator does not turn off the output. Instead, it holds the output at a specified voltage level, referred to as the idle level.

For example, in N-cycle burst mode, the generator outputs the carrier waveform for the specified number of cycles, and then holds the output at the idle level until the next burst period begins, as shown in the figure below.

In gate burst mode, when the gate signal polarity is set to positive, the instrument outputs the idle level when the gate signal is negative.



After N-cycle is enabled, tap IdleMode to open the options list to select Default, H-Point, L-Point, Custom.

Default: The idle level is set to the voltage corresponding to the midpoint of the carrier waveform.

Maximum Level: The idle level is set to the voltage corresponding to the top point of the carrier waveform.

Minimum Level: The idle level is set to the voltage corresponding to the bottom point of the carrier waveform.

Custom: The idle level is set to a user-defined voltage. When Custom is selected, tap the Idle input field to open the virtual numeric keypad, then enter the desired value.

The configurable range is 0 to 65,535, with a default value of 0.

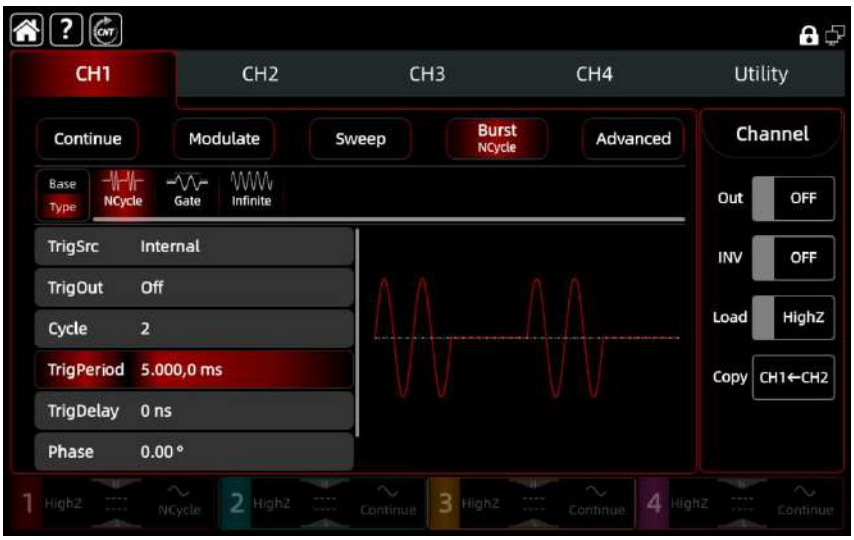
Note: When Noise is selected as the carrier waveform, the idle level is fixed at 32768 and cannot be modified.

4.3.8 Comprehensive Example

In burst mode, configure a sine wave with a period of 5 ms and an amplitude of 500 mVpp as the pulse string waveform. Set the burst type to N-cycle, the pulse string period to 15 ms, and the cycle count to 2. The setting steps are as follows.

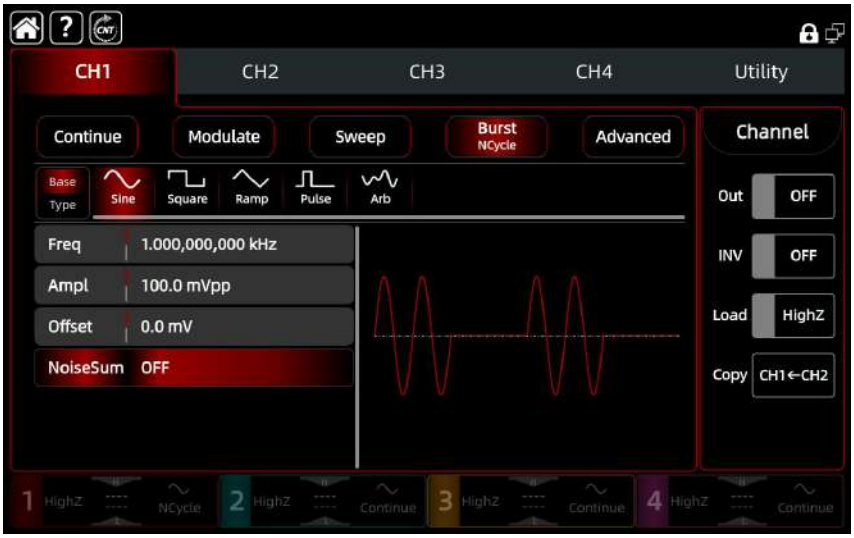
1) Enable Burst Mode

Press the CH1 button, then tap Sweep→ NCycle on the screen to enable N-cycle burst.



2) Select Carrier Wave and Parameters

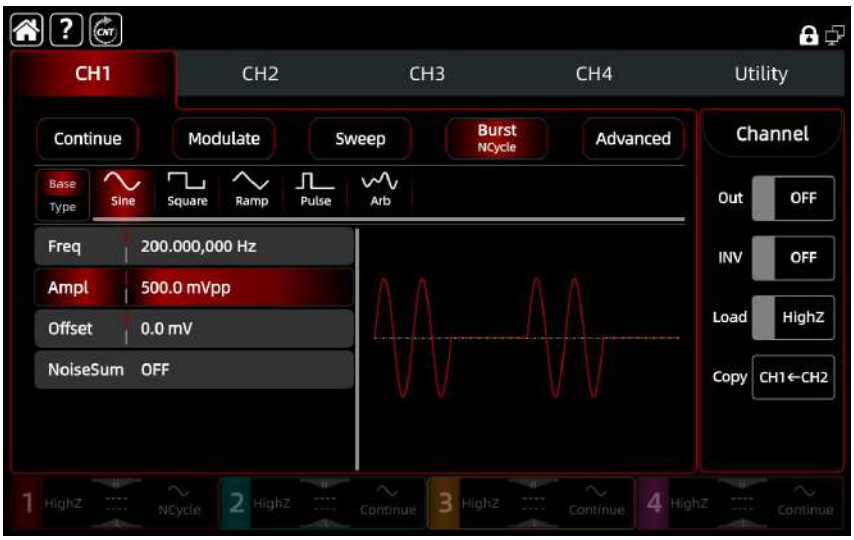
Tap Base/Type to select the sine wave as the carrier wave. Sine the default pulse wave is sine wave, no changes are required in this case.



A period of 5 ms corresponds to a frequency of 200 Hz. Period and frequency are inversely proportional, i.e. T=1/f

Tap Freq, use the numeric keypad to enter 200, and select Hz as the unit.

Tap Ampl, use the numeric keypad to enter 500, and select mVpp as the unit.

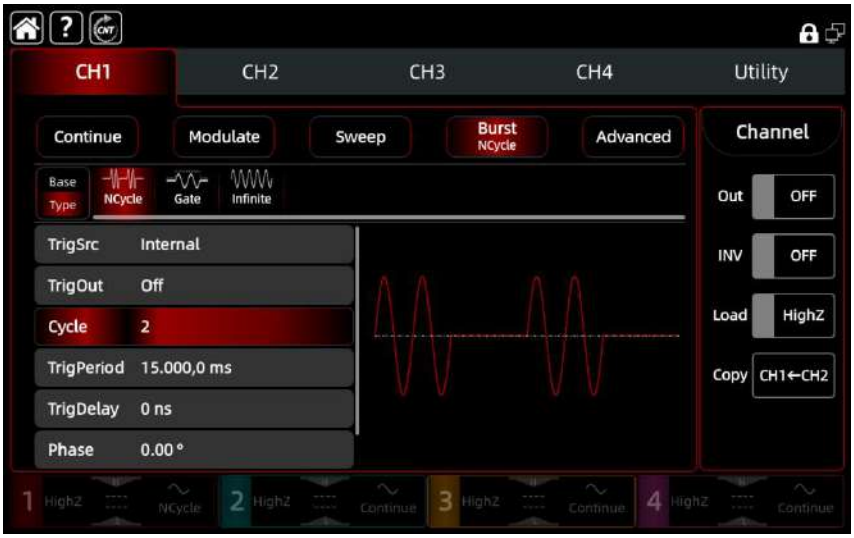


3) Set Burst Period and Waveform Cycle

After configuring the carrier wave parameters, tap Base/Type to return to the burst setting interface.

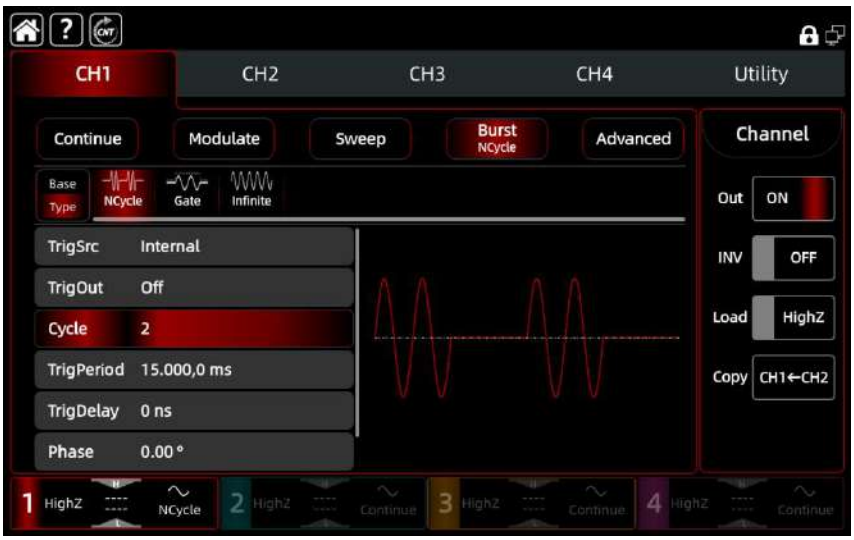
Tap TrigPeriod, use the numeric keypad to enter 15, and select ms as the unit.

Tap Cycle, use the numeric keypad to enter 2.

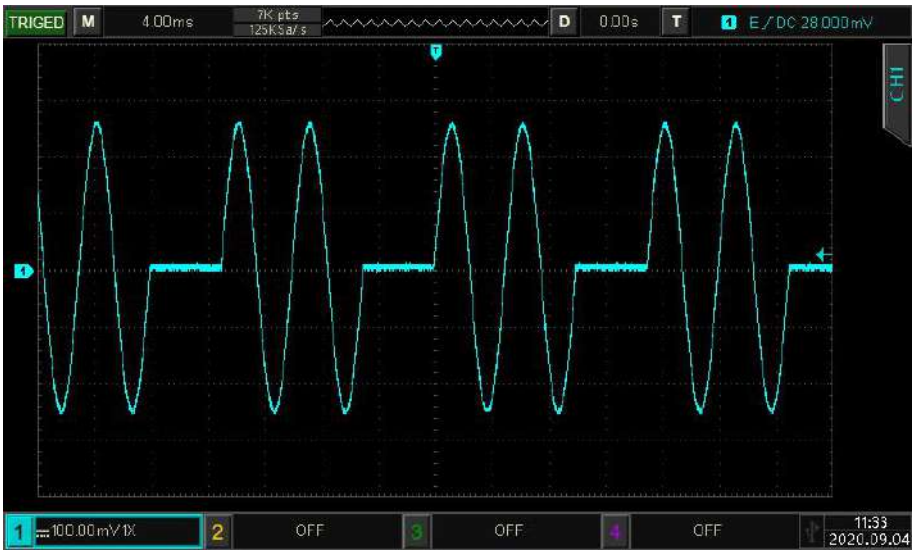


4) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the burst waveform through an oscilloscope as shown in the following figure.



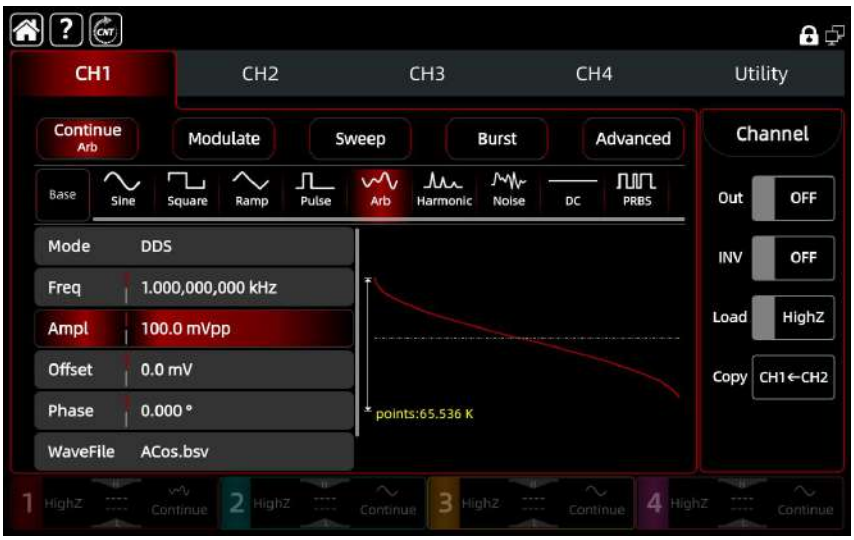
4.4 Arbitrary Waveform Output

The UTG4000X stores more than 200 standard waveforms in its non-volatile memory. In addition, users can create and edit arbitrary waveforms using PC software, and import arbitrary waveform data files from a USB flash drive via the front-panel USB port.

4.4.1 Arbitrary Waveform

Press the CH1 button, then tap Arb on the screen to enable arbitrary waveform.

The instrument will output the arbitrary waveform according to the current setting.



4.4.2 Point-by-Point Output / DDS Mode

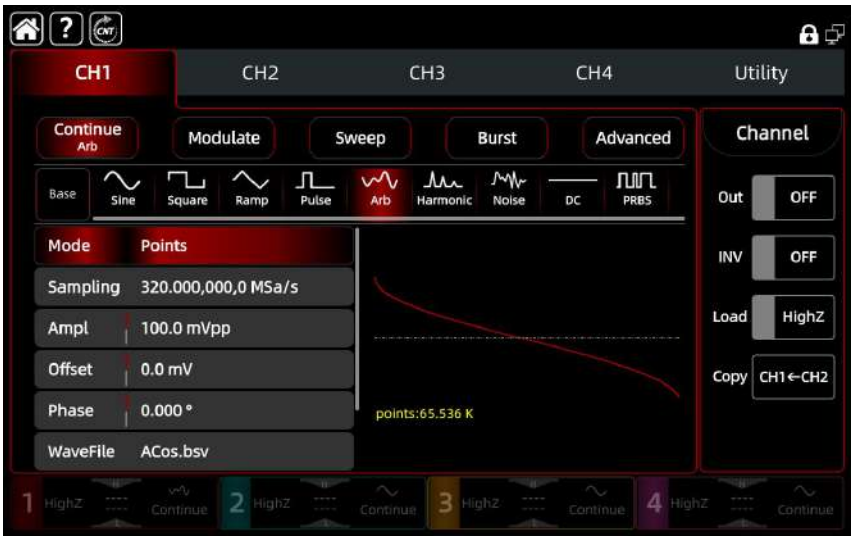
The UTG4000X supports point-by-point mode and direct digital synthesis (DDS) mode for arbitrary waveform output.

Point-by-point: In this mode, the waveform generator automatically calculates the output frequency (e.g., 4577.64 Hz) based on the waveform length (e.g., 65.536k points) and the sampling rate. The waveform points are output sequentially at this frequency, ensuring that no waveform points are lost.

DDS (default): The waveform generator outputs the arbitrary waveform by either interpolating points or extracting fixed-length segments (e.g., 8.192 points) according to the frequency specified in the parameter list.

Rotate the multi-function rotary knob to select point-by-point, or tap DDS to switch between the two modes.

The point-by-point mode interface is shown in the figure below.



4.4.3 Built-in Arbitrary Waveform

Users can select a built-in arbitrary waveform stored in the instrument.

After the arbitrary waveform function is enabled, rotate the multi-function rotary knob, in combination with the arrow keys, or tap WaveFile to select the desired arbitrary waveform.

Refer to *Appendix C Built-in Arbitrary Waveform Table* for details.

4.4.4 Arbitrary Waveform Editing Software

Complex arbitrary waveforms of any shape and amplitude can be created and edited using the accompanying PC software. For detailed instructions, refer to the *UTG4000X Arbitrary Waveform Editing Software Operation Manual*. The created waveforms can then be imported into the function/arbitrary waveform generator.

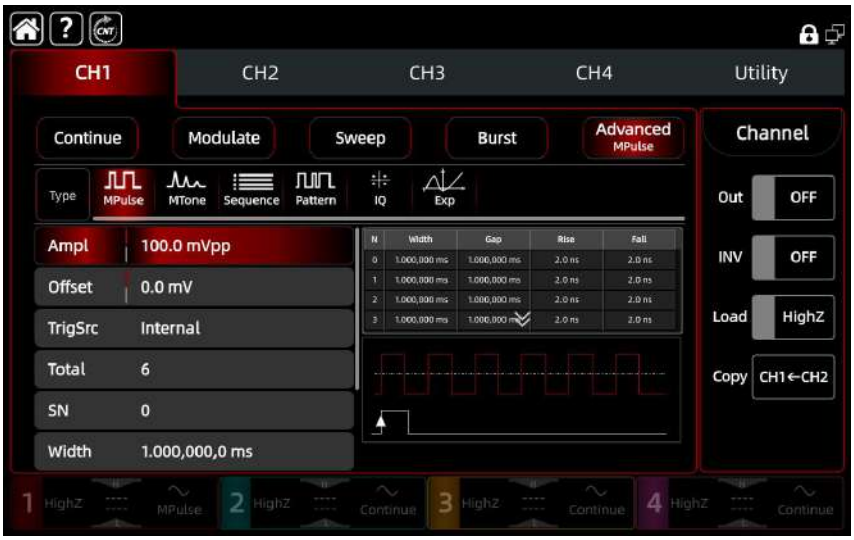
4.5 Advanced Waveform

4.5.1 Multi-Pulse

A multi-pulse signal is a sequence consisting of multiple pulses. Users can configure the number of pulses and the width of each pulse to meet specific testing requirements.

Enable Multi-Pulse

Press the CH1 button, then tap Advanced→MPulse on the screen to enable multi-pulse mode. The instrument outputs a multi-pulse waveform based on the configured number of pulses, pulse width, pulse interval, rising edge, and falling edge.



Amplitude

Set the amplitude of the multi-pulse waveform.

Note: Amplitude settings for multi-pulse waveforms do not support Vrms or dBm as units.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the amplitude. Alternatively, tap Ampl on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the multi-pulse setting interface.

DC Offset

Set the DC offset of the multi-pulse waveform.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the DC offset. Alternatively, tap Offset on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the multi-pulse setting interface.

Total Pulse Count

Set the total number of pulses in the multi-pulse waveform.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the total count. Alternatively, tap Total on the screen to open the virtual keyboard, enter the desired value to complete the setting on the multi-pulse setting interface.

Serial Number of Pulse

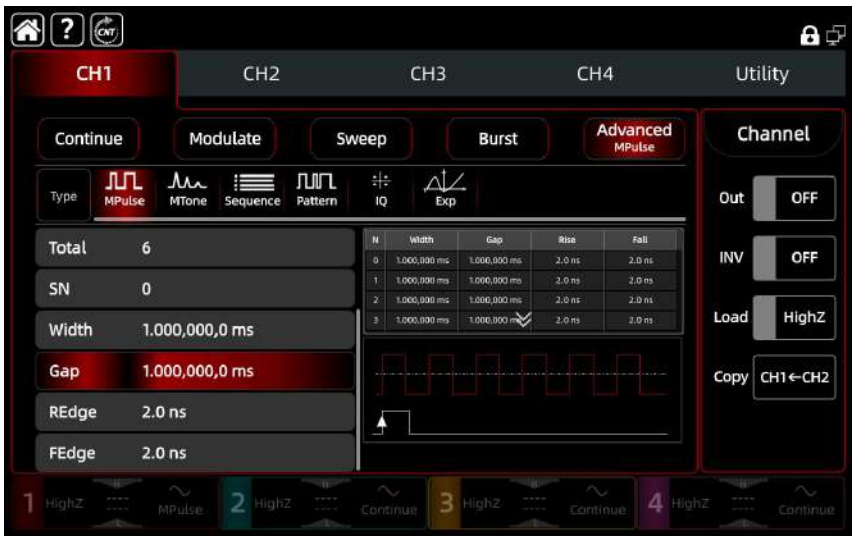
When the number of pulses is large, tap SN and enter the desired pulse number in the input box to quickly navigate it.

Pulse Width

The duration of the pulse at the high level. After the pulse number is configured, rotate the multi-function rotary knob, in combination with the arrow keys to set the pulse width. Alternatively, tap Width on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the multi-pulse setting interface.

Pulse Interval

The duration of the pulse at the low level. After the pulse number is configured, rotate the multi-function rotary knob, in combination with the arrow keys to set the pulse interval. Alternatively, tap Gap on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the multi-pulse setting interface.



Rising Edge

Set the pulse edge duration of the multi-pulse waveform. The available range is 2 ns to 1 μs, but the actual range may be limited by the pulse width and pulse interval.

After the pulse number is configured, rotate the multi-function rotary knob, in combination with the arrow keys to set the pulse interval. Alternatively, tap REdge on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the multi-pulse setting interface.

Falling Edge

Set the pulse edge duration of the multi-pulse waveform. The available range is 2 ns to 1 μs, but the actual range may be limited by the pulse width and pulse interval.

After the pulse number is configured, rotate the multi-function rotary knob, in combination with the arrow keys to set the pulse interval. Alternatively, tap FEdge on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the multi-pulse setting interface.

Trigger Source

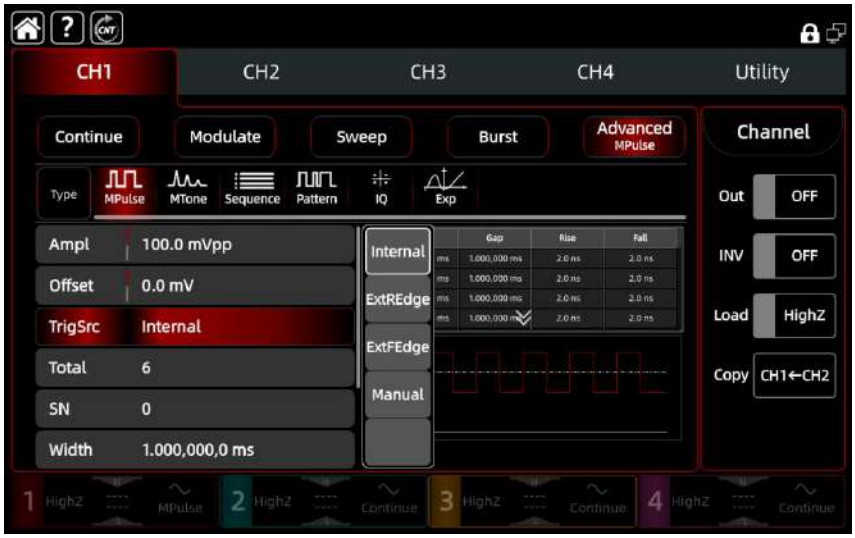
The trigger source of multi-pulse can be internal trigger, external (external rising edge or external falling edge), or manual trigger.

Rotate the multi-function rotary knob to select the desired trigger source, or tap TrigSrc→Internal on the screen to select external (external rising edge or external falling edge), or manual trigger.

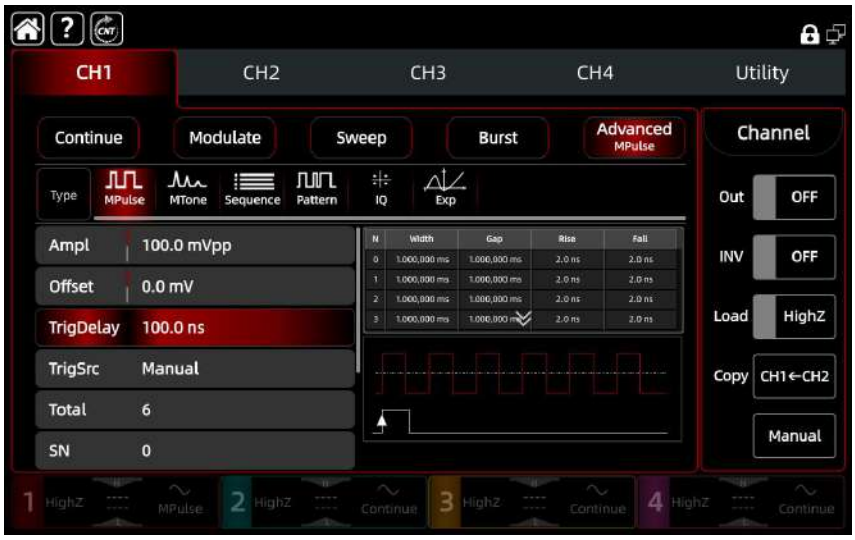
When the trigger source is set to internal, the trigger function is disabled. With the channel output enabled, the multi-pulse waveform is output immediately without waiting for a trigger signal.

When the trigger source is set to external, the waveform generator accepts a hardware trigger applied to the external digital modulation interface (FSK Trig connector) on the rear panel. Each time

the generator receives a TTL pulse with the specified polarity, it initiates a multi-pulse output.



When the trigger source is set to manual, the Manual option is displayed in the current channel settings on the right side of the screen. Tap Manual to initiate a single multi-pulse output.



Trigger Delay

Trigger delay is the time interval between when the instrument receives a trigger signal and when it begins outputting the multi-pulse waveform. The configurable range is 0 s to 1 ks.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the trigger delay . Alternatively, tap TrigDelay on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the multi-pulse setting interface.

Comprehensive Example

In multi-pulse mode, configure three pulses with the following parameters:

Pulse 0: Width 200 μs, Interval 250 μs, Rise Time 10 μs, Fall Time 20 μs

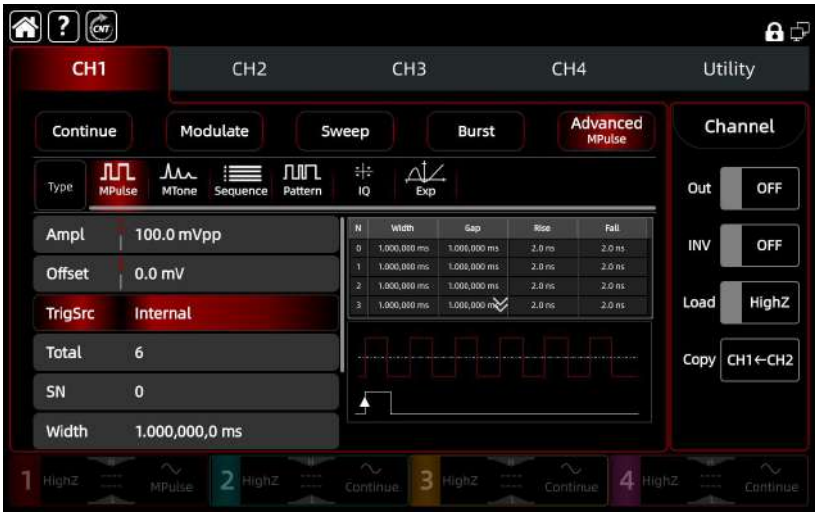
Pulse 1: Width 250 μs, Interval 300 μs, Rise Time 20 μs, Fall Time 30 μs

Pulse 2: Width 300 μs, Interval 350 μs, Rise Time 30 μs, Fall Time 40 μs

The setting steps are as follows.

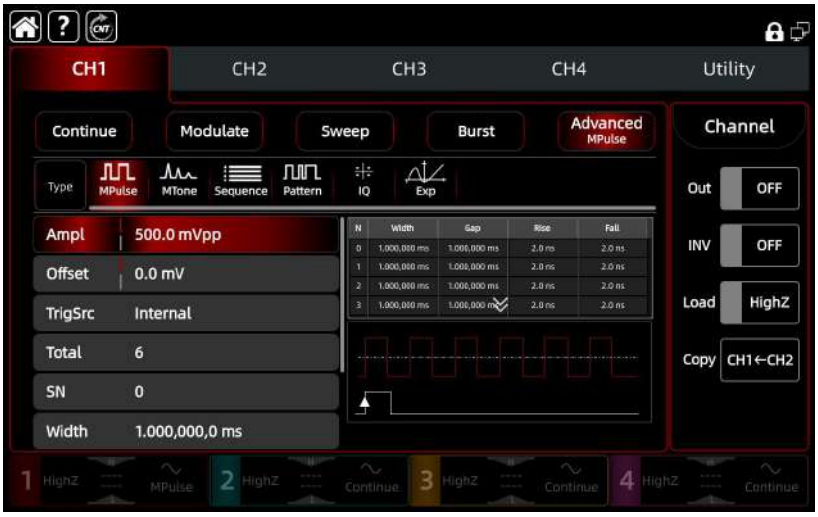
1) Enable Multi-Pulse Mode

Press the CH1 button, then tap Advanced →MPulse on the screen to enable multi-pulse mode.



2) Select Multi-Pulse Parameters

Tap Ampl, use the numeric keypad to enter 500, and select mVpp as the unit.



3) Set Pulse Width, Pulse Interval, Rising Edge and Falling Edge

After configuring the carrier wave parameters, tap Total, use the numeric keypad to enter 3.

Tap SN, use the numeric keypad to enter 0.

Then set pulse interval, rising edge, and falling edge for pulse width 0:

Tap Width, use the numeric keypad to enter 200, and select μs as the unit.

Tap Gap, use the numeric keypad to enter 250, and select μs as the unit.

Tap REdge, use the numeric keypad to enter 10, and select μs as the unit.

Tap FEdge, use the numeric keypad to enter 20, and select μs as the unit.

Tap SN, use the numeric keypad to enter 1.

Then set pulse interval, rising edge, and falling edge for pulse width 1:

Tap Width, use the numeric keypad to enter 250, and select μs as the unit.

Tap Gap, use the numeric keypad to enter 300, and select μs as the unit.

Tap REdge, use the numeric keypad to enter 20, and select μs as the unit.

Tap FEdge, use the numeric keypad to enter 30, and select μs as the unit.

Tap SN, use the numeric keypad to enter 2.

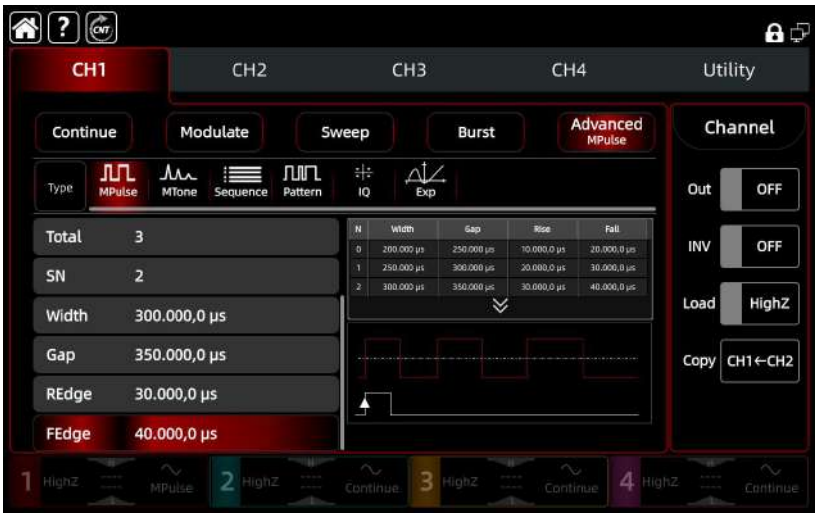
Then set pulse interval, rising edge, and falling edge for pulse width 2:

Tap Width, use the numeric keypad to enter 300, and select μs as the unit.

Tap Gap, use the numeric keypad to enter 350, and select μs as the unit.

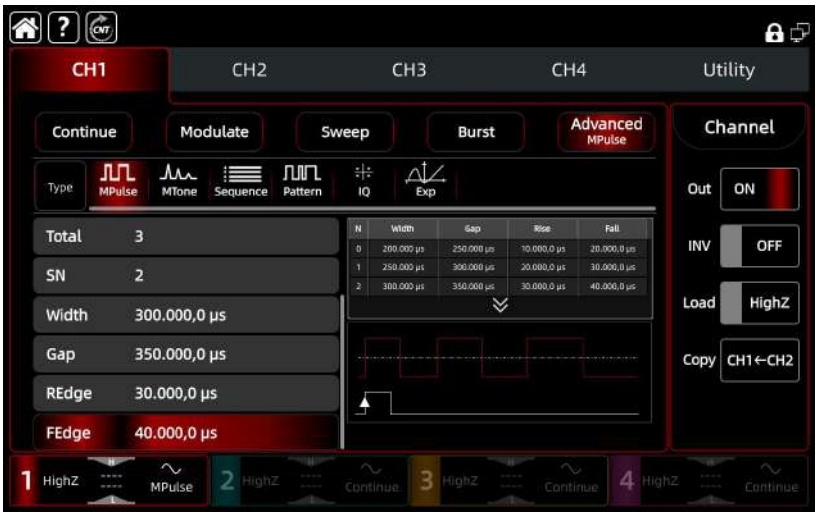
Tap REdge, use the numeric keypad to enter 30, and select μs as the unit.

Tap FEdge, use the numeric keypad to enter 40, and select μs as the unit.

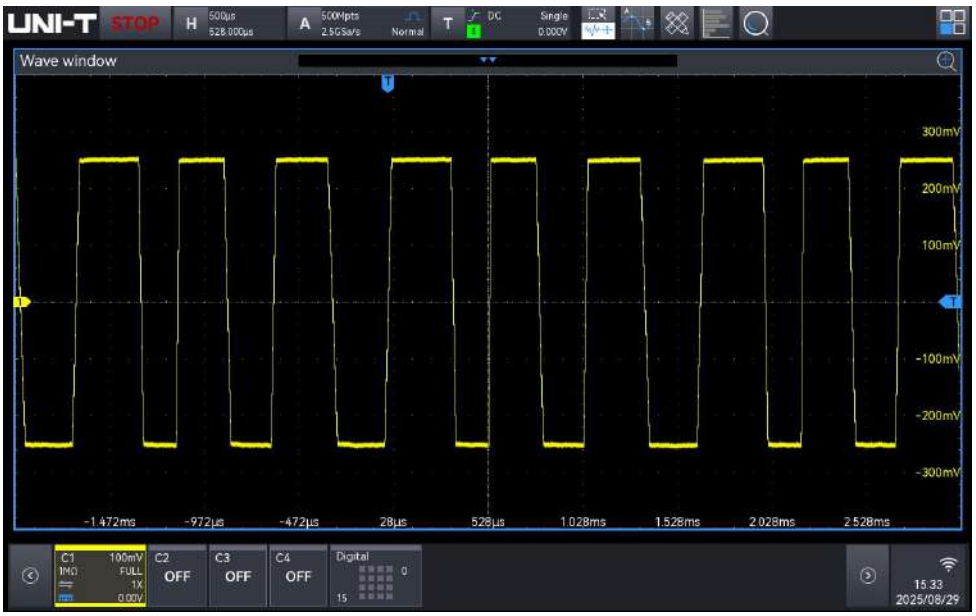


4) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the multi-pulse waveform through an oscilloscope as shown in the following figure.

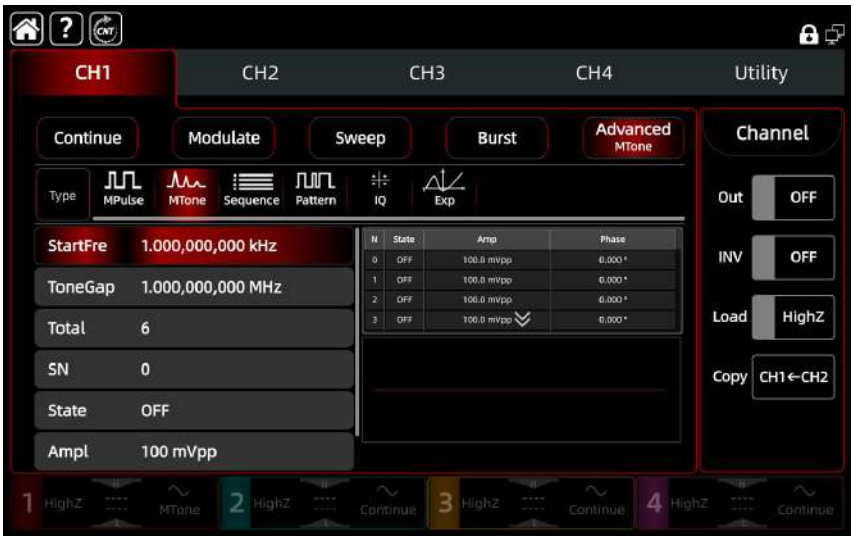


4.5.2 Multi-Tone

A multi-tone waveform is generated by superimposing multiple sine waves of different frequencies. The on/off state, amplitude, and phase of each tone can be configured independently. In the frequency domain, a multi-tone waveform is represented by multiple discrete frequency components, providing rich spectral content. This makes it widely used in the testing and measurement of audio systems, communication equipment, power electronics, and other applications.

Enable Multi-Tone

Press the CH1 button, then tap Advanced→MTone on the screen to enable multi-tone mode. The instrument outputs a multi-tone waveform based on the configured start frequency, tone spacing, and number of tones.



Start Frequency

Set the start frequency of the multi-tone waveform using the virtual keyboard. The configurable range is 1 μHz to 499.990 MHz.

In practical applications, the start frequency, tone interval, and number of tones are mutually constrained.

Start Frequency + Tone Interval × (Number of Tones − 1) ≤ 500 MHz

Their values cannot exceed the range.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the start frequency. Alternatively, tap StartFre on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the multi-tone setting interface.

Tone Spacing

Set the frequency spacing between tones of the multi-tone waveform using the virtual keyboard. The configurable range is 1 μHz to 499.999 MHz.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the frequency spacing. Alternatively, tap ToneGap on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the multi-tone setting interface.

Total Tone Count

Set the total number of tones in the multi-tone waveform. The configurable range is 1 to 30.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the frequency spacing. Alternatively, tap Total on the screen to open the virtual keyboard, enter the desired value to complete the setting on the multi-tone setting interface.

Serial Number of Tone

When the number of tones is large, tap SN and enter the desired tone number in the input box to quickly navigate to it.

State

After the serial number of tone is configured, turn on/off the specified tone.

Amplitude

Set the amplitude of the multi-tone waveform.

Note: Amplitude settings for multi-tone waveforms do not support Vrms or dBm as units.

After the serial number of tones is configured, rotate the multi-function rotary knob, in combination with the arrow keys to set the amplitude. Alternatively, tap Ampl on the screen to open the virtual

keyboard, enter the desired value, and select the appropriate unit to complete the setting on the multi-tone setting interface.

Phase

Set the phase of the multi-tone waveform. The configurable range is -360° to 360°.

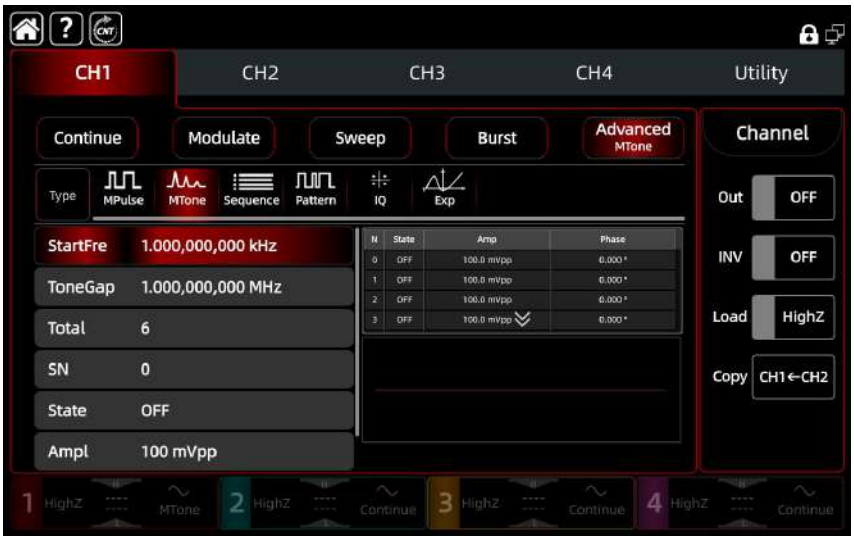
After the serial number of tones is configured, rotate the multi-function rotary knob, in combination with the arrow keys to set the phase. Alternatively, tap Phase on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the multi-tone setting interface.

Comprehensive Example

In multi-tone mode, configure three tones with the following parameters: start frequency: 1 kHz, tone spacing: 2 kHz, amplitude (per tone): 100 mVpp, phase: 0° (default).

1) Enable Multi-Pulse Mode

   Press the CH1 button, then tap Advanced→ MTone on the screen to enable multi-tone mode.

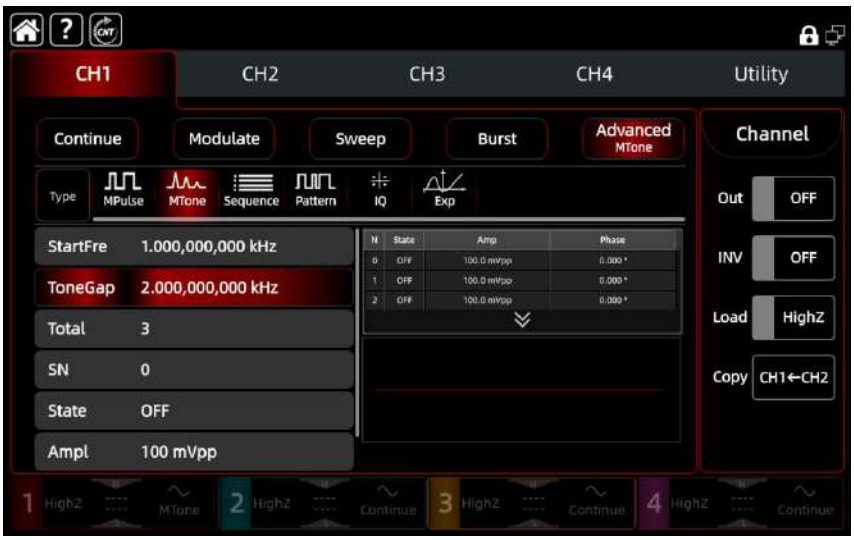


2) Set Total Tone Count, Start Frequency, and Tone Spacing

   Tap Total, use the numeric keypad to enter 3.

   Tap StartFre, use the numeric keypad to enter 1, and select kHz as the unit.

   Tap ToneGap, use the numeric keypad to enter 2, and select kHz as the unit.



3) Set Amplitude and State

Tap SN, use the numeric keypad to enter 0, and set the state and amplitude for tone 0:

Tap State to switch it On.

Tap Ampl, use the numeric keypad to enter 100, and select mVpp as the unit.

Tap SN, use the numeric keypad to enter 1, and set the state, amplitude for tone 1:

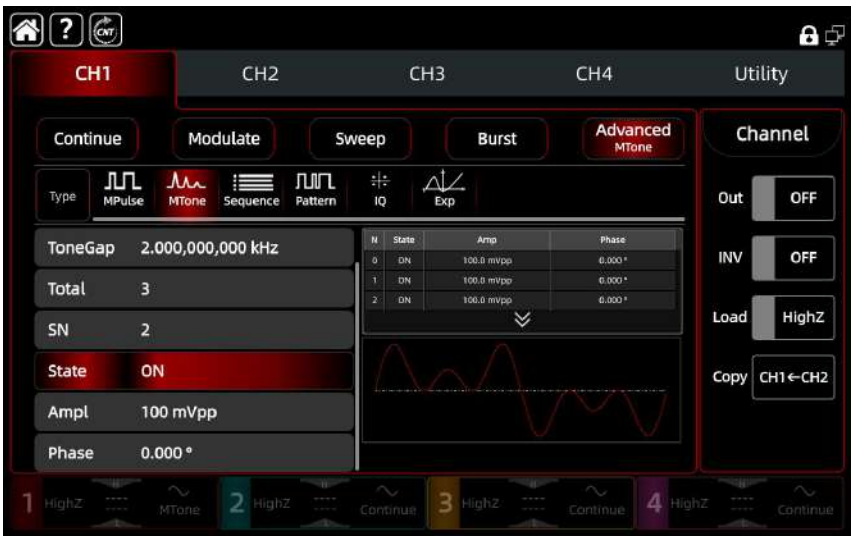
Tap State to switch it On.

Tap Ampl, use the numeric keypad to enter 100, and select mVpp as the unit.

Tap SN, use the numeric keypad to enter 1, and set the state, amplitude for tone 2:

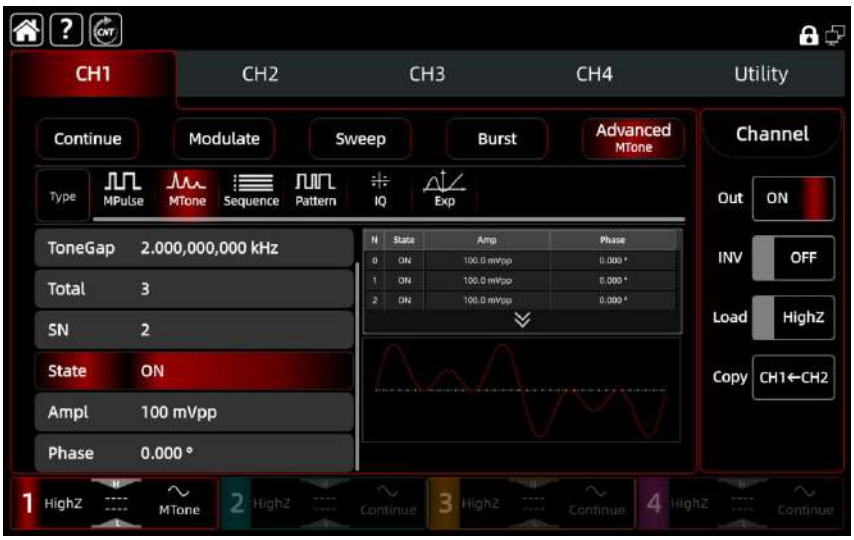
Tap State to switch it On.

Tap Ampl, use the numeric keypad to enter 100, and select mVpp as the unit.

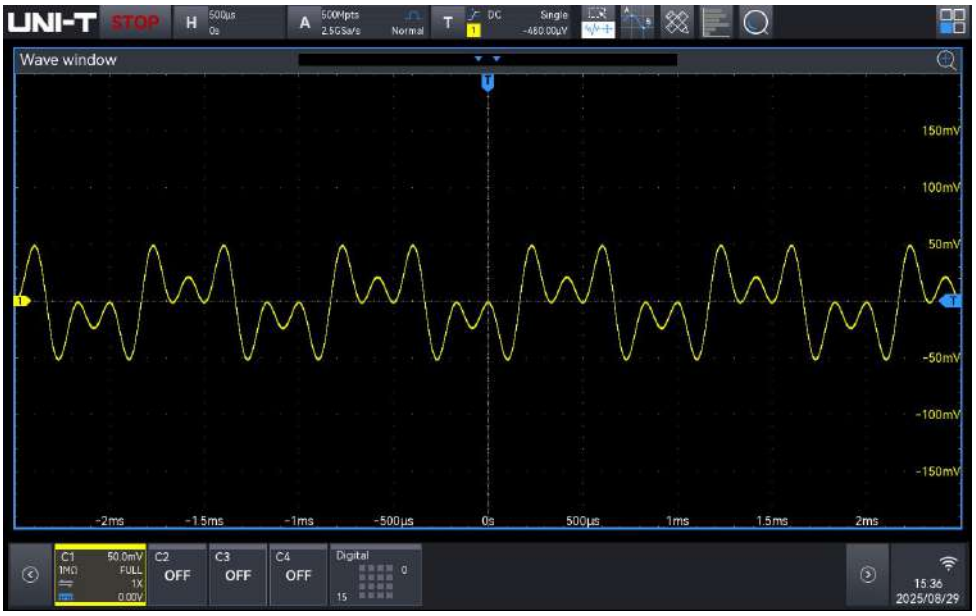


4) Enable Channel Output

Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the multi-tone waveform through an oscilloscope as shown in the following figure.

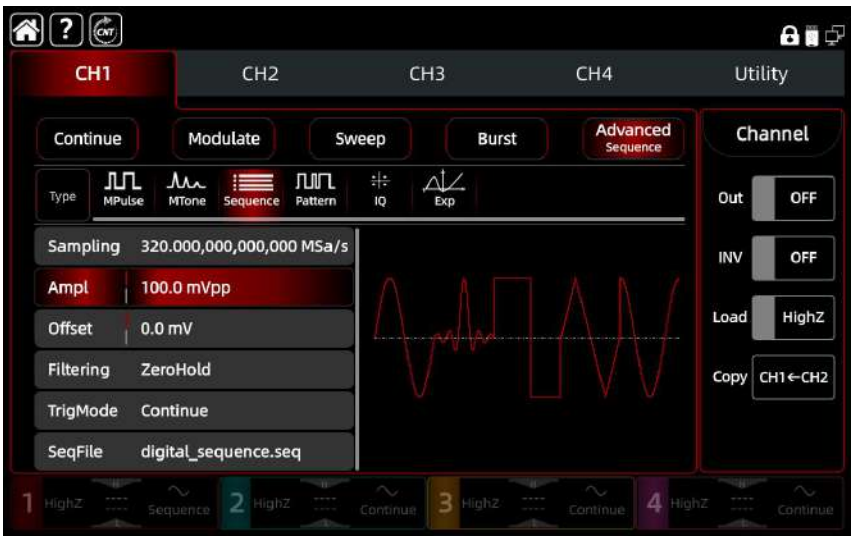


4.5.3 Sequence

A sequence is an ordered combination of multiple individual waveforms. In sequence mode, the user can define a custom sequence and save the edited sequence to internal memory or an external storage device (in *.seq format).

Enable Sequence Mode

Press the CH1 button, then tap Advanced→Sequence on the screen to enable sequence mode. The instrument outputs a sequence waveform based on the setting parameters.



Sampling

Tap Sampling to set the sampling of sequence waveform. The configurable range is 1 μSa/s to 1.25 GSa/s. The default value is 320 MSa/s.

Ampl

Set the amplitude of sequence waveform.

Note: Amplitude settings for sequence waveforms do not support Vrms or dBm as units.

DC Offset

Set the DC offset of the Sequence waveform.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the DC offset. Alternatively, tap Offset on the screen to open the virtual keyboard, enter the desired value, and select the appropriate unit to complete the setting on the Sequence setting interface.

Filter Mode

Tap Filtering to switch between two filter modes: zero-order hold, linear interpolation.

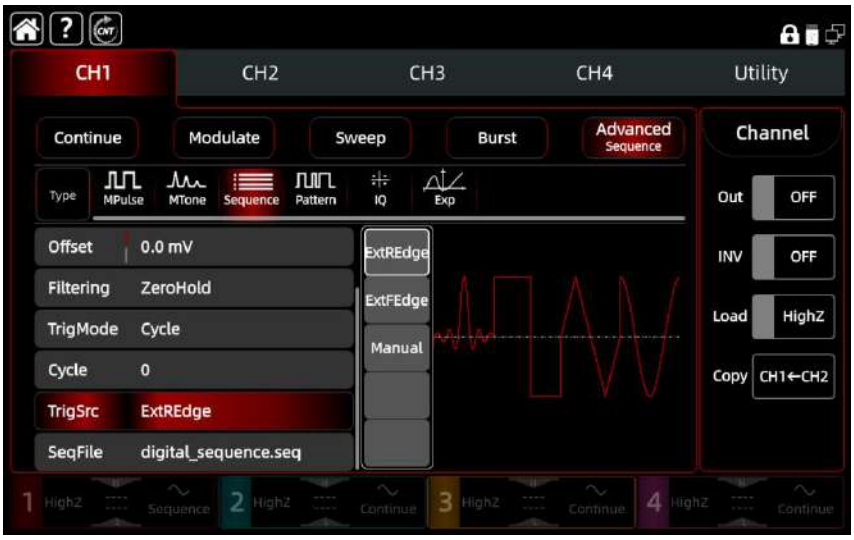
TrigMode

Click the TrigMode key to expand the optional trigger modes: continue, cycle, and gate.

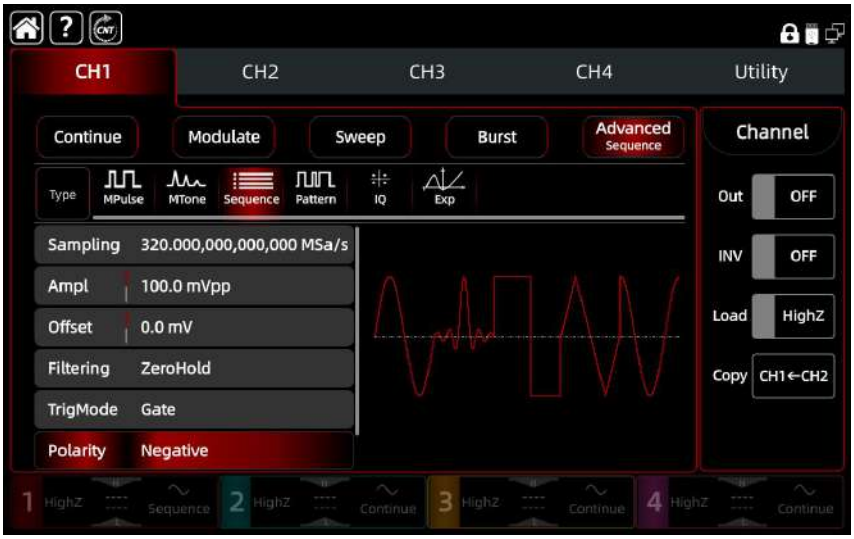
Select the continue mode, the parameter list automatically hides the trigger source and cycle number options, which is equivalent to setting the number of waveform cycles to infinity, and the signal generator outputs a continuous waveform when it receives the trigger signal.

The cycle mode is selected, and each time a trigger is received, the waveform generator will output a waveform with a specified number of cycles. After a specified number of cycles have been output, the waveform generator stops and waits for the next firing. The trigger source of pulse train in this mode can be external trigger and manual. If you want to change in the interface of the sequence (as shown below), you can use the multi-function knob and the direction key to cooperate or press the

TrigSrc soft key to complete the change.



Select the gate mode, and the parameter list automatically hides the trigger source and cycle number options. Because only external trigger sources can be used, the waveform generator is triggered according to the hardware of the external digital modulation interface (FSK Trig interface) on the rear panel. When the polarity is set to positive polarity and the trigger input signal is high, a continuous waveform is output. When the trigger input signal is low, the current waveform cycle is first completed and then stopped while remaining at the level corresponding to the starting phase of the selected waveform. The polarity can be changed in the gated mode interface (as shown below) by using the multi-function knob and the arrow keys or by pressing the Polarity soft key.



Sequence File

Tap SeqFile to open the option list for selection.After selecting the sequence file to be loaded, click Load, and the instrument will open this file in the sequence editing table and apply it to the current channel.

4.5.4 Pattern

The pattern function generates user-defined digital signal sequences for debugging and verification of digital circuits and systems.

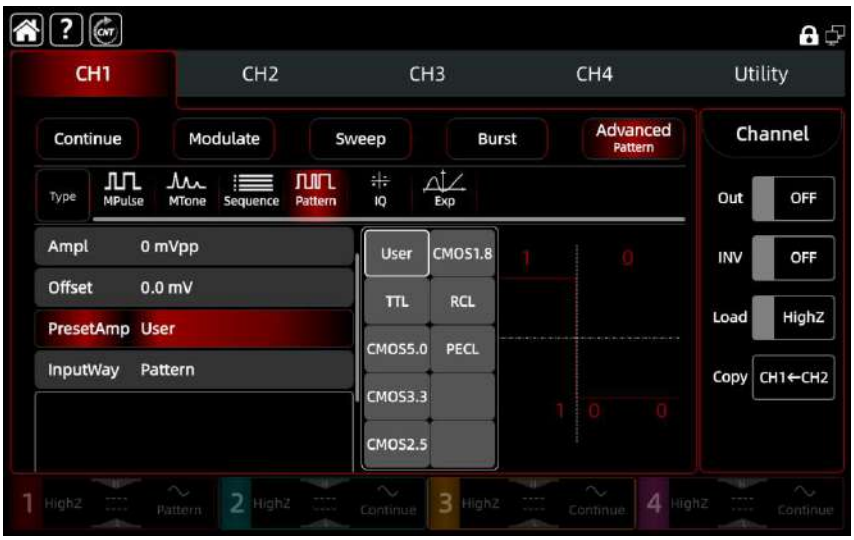
Enable Pattern Mode

Press the CH1 button, then tap Advanced→Pattern on the screen to enable pattern mode. The instrument outputs a pattern waveform based on the setting parameters.

On the pattern setting interface, tap data editing area under InputWay to open the virtual keyboard to enter symbol data, as shown in the following figure.

Output Amplitude

On the pattern setting interface, tap PresetAmp to open the options list and select a preset amplitude.



The amplitude and offset values for each preset amplitude are as follows:

TTL: Amplitude 5.0 Vpp, Offset 2.5 Vdc

CMOS5.0: Amplitude 5.0 Vpp, Offset 2.5 Vdc

CMOS3.3: Amplitude 3.3 Vpp, Offset 1.65 Vdc

CMOS2.5: Amplitude 2.5 Vpp, Offset 1.25 Vdc

CMOS1.8: Amplitude 1.8 Vpp, Offset 900 mVdc

RCL: Amplitude 5.2 Vpp, Offset -2.6 Vdc

PECL: Amplitude 800 mVpp, Offset 2.0 Vdc

Select User for the preset amplitude, then press the Ampl key to manually set the amplitude.

Baud Rate

On the pattern setting interface, tap Baudrate, use the virtual keyboard to set the baud rate. The configurable range is 1 μbps to 300 Mbps. The default value is 9.6 kbps.

Input Type

On the pattern setting interface, tap InputWay to open the options list and select Pattern or File.

Pattern: Sets the input mode of the pattern generator to custom symbols. When Pattern is selected, click the data input keypad at the bottom of the menu to define a segment of data. The maximum input length is 4000 characters for binary data, and 1000 characters for hexadecimal data or KD symbols.

File: Imports user-defined symbols via internal or external memory. When File is selected, click the file path input box or the import icon on the right side, select the target file from the pop-up storage menu, and then click Load. After the file is successfully loaded, the data type of the imported file is displayed on the import icon: B (Binary), H (Hexadecimal), S (KD Symbols).

The maximum importable data length depends on the data format of the file content: binary data is limited to 64 M characters, while hexadecimal data and KD symbols are limited to 12 M characters.

Code Type

On the pattern setting interface, tap Encoding to open the options list and select NRZ, RZ, or ME.

NRZ: Non-Return-to-Zero coding.

RZ: Unipolar Return-to-Zero coding.

ME: Manchester coding. A low-to-high transition in the middle of a bit represents “0”, while a high-to-low transition in the middle of a bit represents “1”.

Data Format

When the input data type is set to Pattern, tap Format to open the options list and select Binary, Hexadecimal, or KD Symbols.

Symbol Data

When the input data type is set to Pattern, tap data editing area under InputWay to open the virtual keyboard to enter symbol data.

Binary: When the data format is set to Binary, the available keys are 0, 1, Comma (,), Space, Back, and Enter; all other keys are disabled.

Hexadecimal: When the data format is set to Hexadecimal, the available keys are 0–9, A–F, Space, Comma (,), Back, and Enter; all other keys are disabled.

KD Symbols: When the data format is set to KD Symbols, the available keys are 0–9, K, D, Dot (.), Comma (,), Space, Back, and Enter; all other keys are disabled.

8B10B Coding

8B10B coding encodes a byte (8-bit data) into 10-bit data. This function is available only when the input symbol or imported file data format is set to KD Symbols; otherwise, it remains hidden.

After the 8B10B coding is enabled, the coding polarity can be configured. Coding polarity indicates whether the number of “1”s or “0”s is greater in the first code value after encoding.

The available options are RD+ and RD-.

RD+: more 0s than 1s, or an equal number of 0s and 1s

RD-: fewer 0s than 1s, or an equal number of 0s and 1s

4B5B Coding

4B5B coding encodes 4-bit data into 5-bit data. This function is available only when the input symbol or imported file data format is set to Hexadecimal; otherwise, it remains hidden.

Comprehensive Example

In pattern mode, configure the pattern data with the following parameters:

Data format: Binary

Input mode: Pattern

Coding type: Manchester Coding

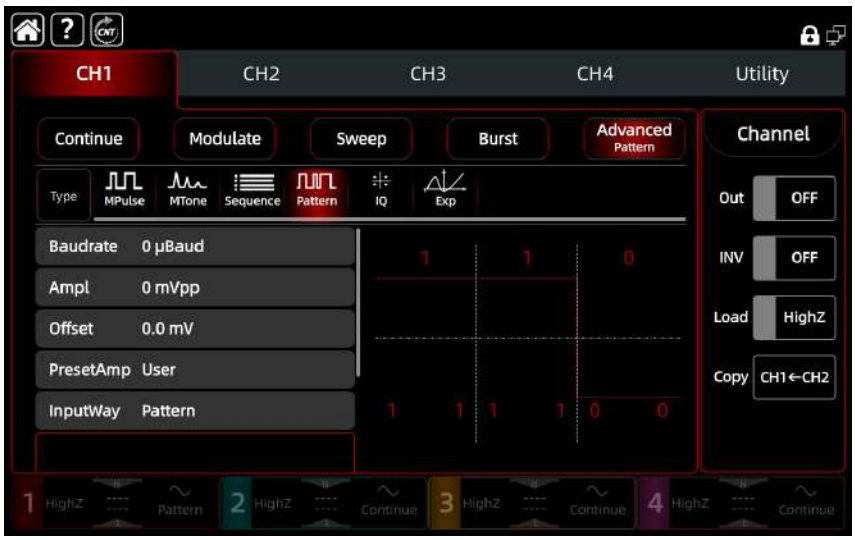
Amplitude: 100 mVpp (Custom)

Baud Rate: 10 kBaud

The setting steps are as follows.

1) Enable Pattern Mode

   Press the CH1 button, then tap Advanced→Pattern on the screen to enable pattern mode.

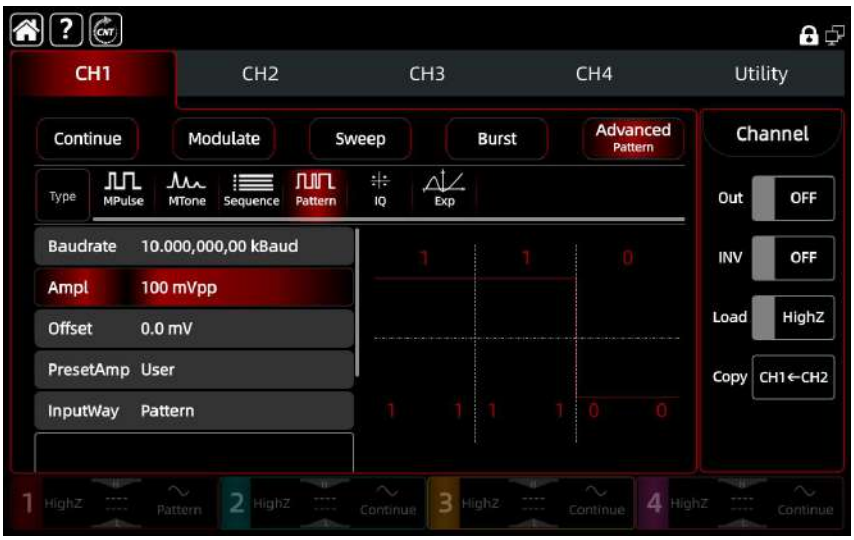


2) Set Baud Rate and Amplitude

   Tap Baudrate, use the numeric keypad to enter 10, and select kBaud as the unit.

   Tap PresetAmp and select User.

   Tap Ampl, use the numeric keypad to enter 100, and select mVpp as the unit.



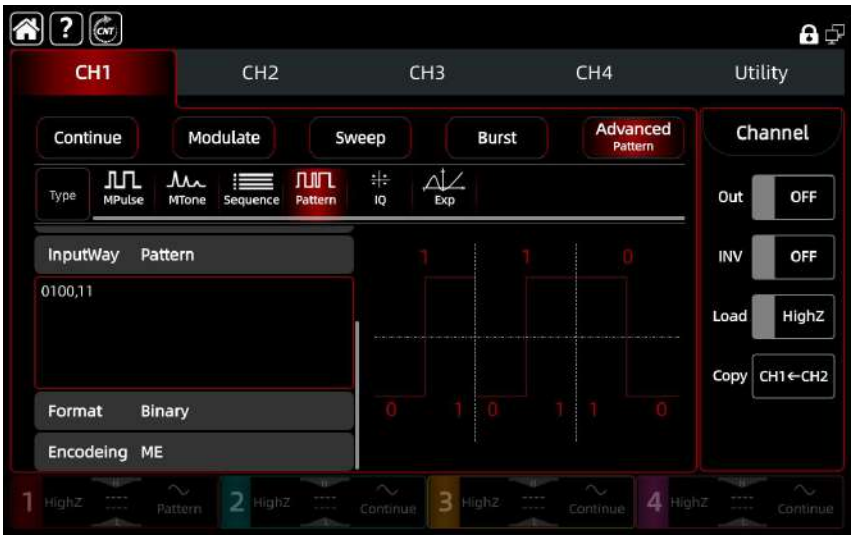
3) Set Input Mode, Data Format, Coding Type, and Symbol Data

Tap InputWay and select Pattern.

Tap Format and select Binary.

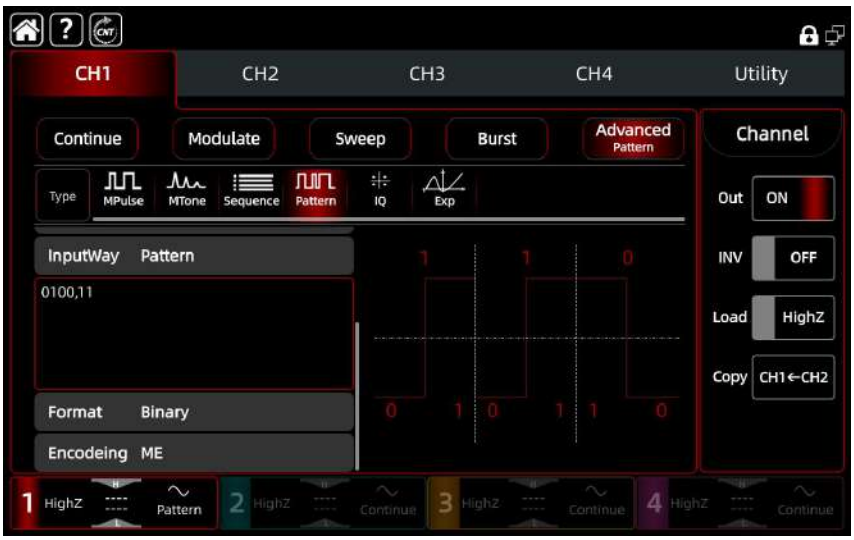
Tap Encoding and select ME.

Then, tap data editing area under InputWay to open the virtual keyboard to enter 010011, and tap Enter to complete the setting.



4) Enable Channel Output

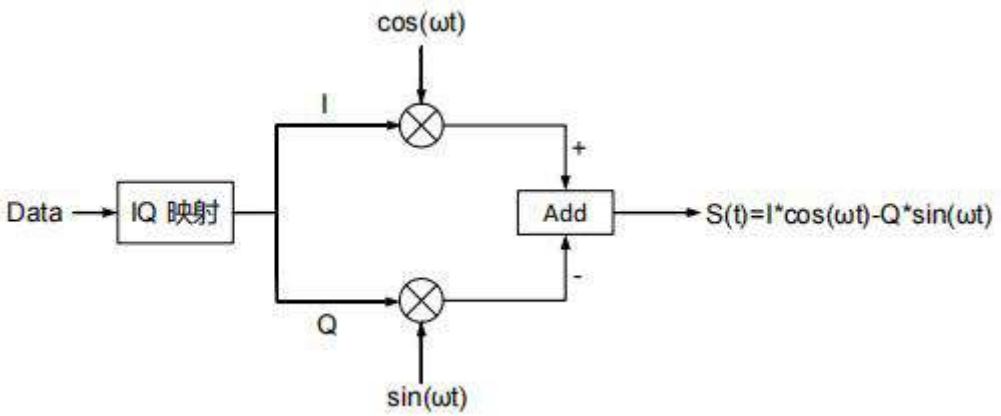
Press the CH1 button to enable the channel output. When the button indicator is illuminated, the channel output is active.



View the pattern waveform through an oscilloscope as shown in the following figure.

4.5.5 IQ

In the IQ modulation function, the input symbol data is mapped to the corresponding I (In-Phase) and Q (Quadrature) channel data according to the specified mapping rules (modulation). The two-channel data is then modulated by the carrier wave to generate the S (t) signal. The block diagram of the IQ modulation principle is shown in the figure below.



Note:

IQ Modulation requires the use of two-channel resources: Channels 1 and 2 work together to output IQ modulation, and Channels 3 and 4 work together to output IQ modulation.

In IQ output mode, the channel output impedance (configured via the Output Impedance setting) is fixed at 50 Ω and cannot be modified.

Amplitude

Set the amplitude of IQ waveform.

Note: Amplitude settings for IQ waveforms do not support Vrms or dBm as units.

When the center frequency = 0, the amplitude value represents the magnitude of the I/Q signal.

When the center frequency ≠ 0, the signal is output only via the I-channel, and the amplitude value equals the root mean square (RMS) value of the I-channel output Irms.

Sampling

The sampling rate (Fs) is derived from the oversampling point parameter, following the conversion formula: Fs = Fsymb* Oversampling point

Tap Sampling to set the IQ sampling rate of IQ waveform. The configurable range is 1 μSa/s to 1.25 GSa/s, with a default value of 1 MSa/s.

CenterFre

When the center frequency = 0, the instrument operates in baseband I/Q mode, where CH1 functions as the I-channel output and CH2 functions as the Q-channel output.

When the center frequency ≠ 0, the instrument operates in IF signal mode. In this case, the I-channel and Q-channel signals are fed into the quadrature modulator for carrier modulation before output. The output of the quadrature modulator is then routed to CH1 after undergoing wideband compensation.

Tap CenterFre to set the center frequency of IQ waveform. The configurable range is 0 Hz to 2 MHz,

with a default value of 0 Hz.

Amplitude Gain Balance

The amplitude gain balance adjusts the amplitude difference between the I and Q channels.

Tap GainB to set the gain balance of IQ waveform. The configurable range is -500 dB to 500 dB, with a default value of 0 dB.

Phase Angle Adjustment

Phase angle adjustment of the Q-channel is used to compensate for the phase imbalance between the I and Q channels.

Tap PhaAdjust to set the phase angle adjustment of IQ waveform. The configurable range is -360 to 360°, with a default value of 0°.

I Offset

DC Offset of the I-channel is adjusted in conjunction with the DC offset of the Q-channel to compensate for the offset imbalance between the I and Q channels.

Tap I-Offset to set the I offset of IQ waveform. The configurable range is -10 V to 10 V, with a default value of 0 mV.

Q Offset

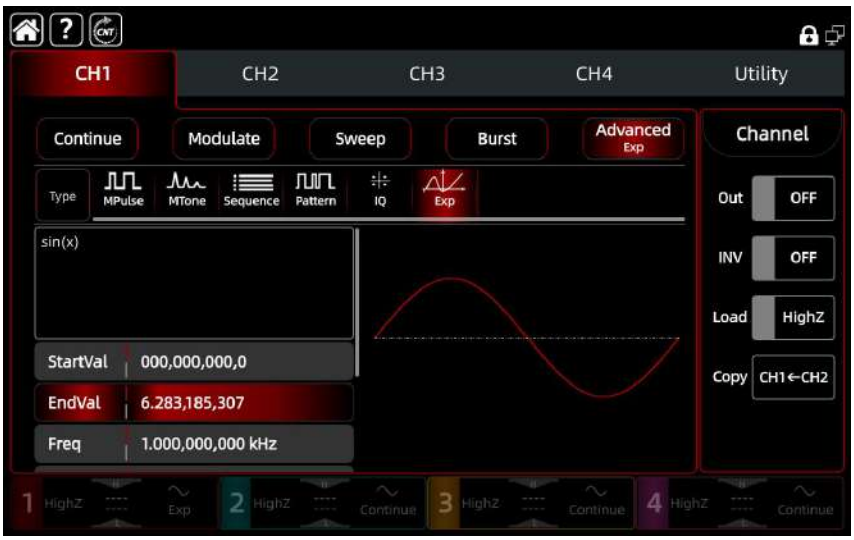
Tap Q-Offset to set the Q offset of IQ waveform. The configurable range is -10 V to 10 V, with a default value of 0 mV.

IQ File

Tap IQ-File to select an IQ waveform file for editing, copying, renaming, deleting, or loading.

4.5.6 Expression

An expression refers to a meaningful combination of numbers, operators, digital grouping symbols (parentheses), free variables, and other elements arranged so that a numerical value can be derived. Expressions are used to describe the output waveform. Its basic form is: Vout = f (x), for example, f (x) can be defined as: (x-1)*x*(x+1).



Input Expression

The expression supports mixed operations using 18 types of functions.

Press the CH1 button, then tap Advanced→Exp on the screen to enable expression mode. The instrument outputs an expression waveform based on the configured expression, start value, end value, and bitrate.

Start Value

Since the signal output by the signal generator is a repetition of a signal with a finite duration, it is necessary to define the range of the variable in the expression f (x). The range of x is determined by the start value and end value.

After the expression is configured, tap StartVal to open the virtual keyboard and enter the desired value.

End Value

The variable in the expression f (x) is defined by the start value and end value.

After the expression is configured, tap EndVal to open the virtual keyboard and enter the desired value.

Frequency

Set the frequency of the expression waveform.

After the expression is configured, tap Freq to open the virtual keyboard, enter the desired value, and select the unit to complete the setting.

Comprehensive Example

The default formula for the expression is sin(x), with a default start value of 0.

Using the parameters below as an example:

Formula cos(x)

End value: 6.2831852

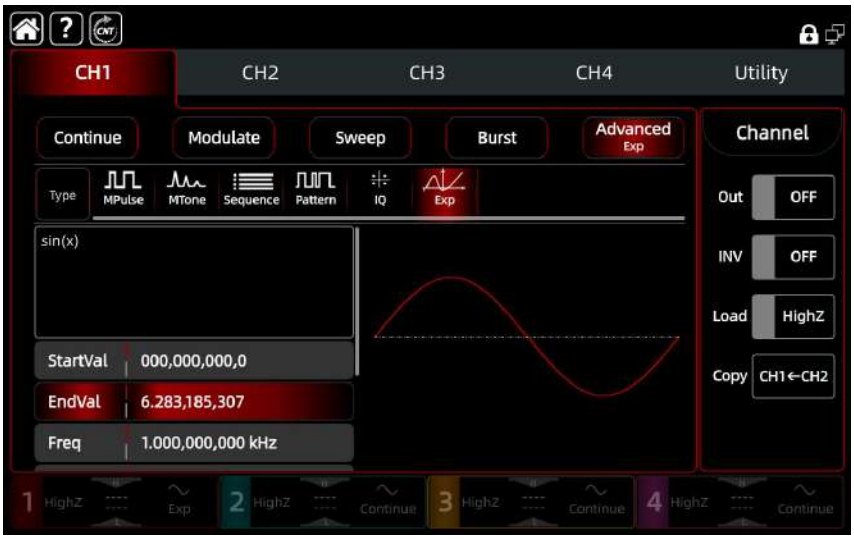
Frequency: 200 kHz

Amplitude: 200 mVpp.

The setting steps are as follows.

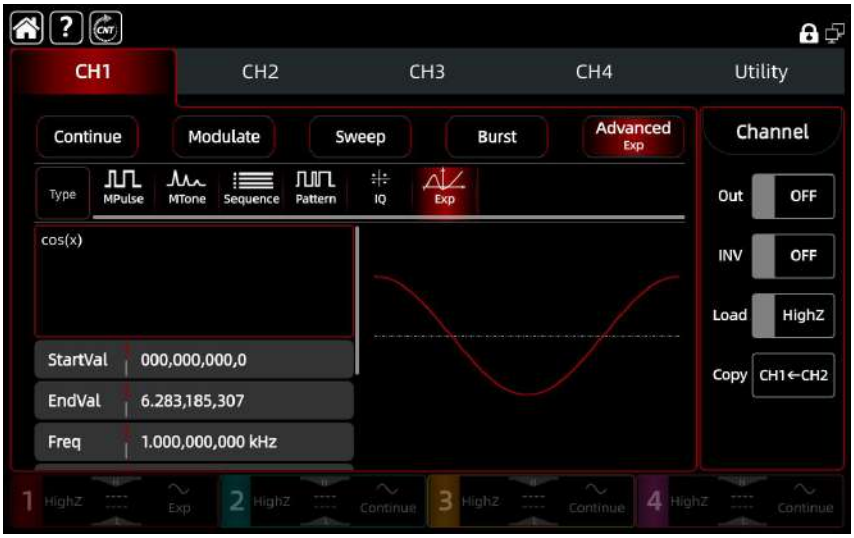
1) Enable Expression Mode

Press the CH1 button, then tap Advanced →Exp on the screen to enable expression mode.



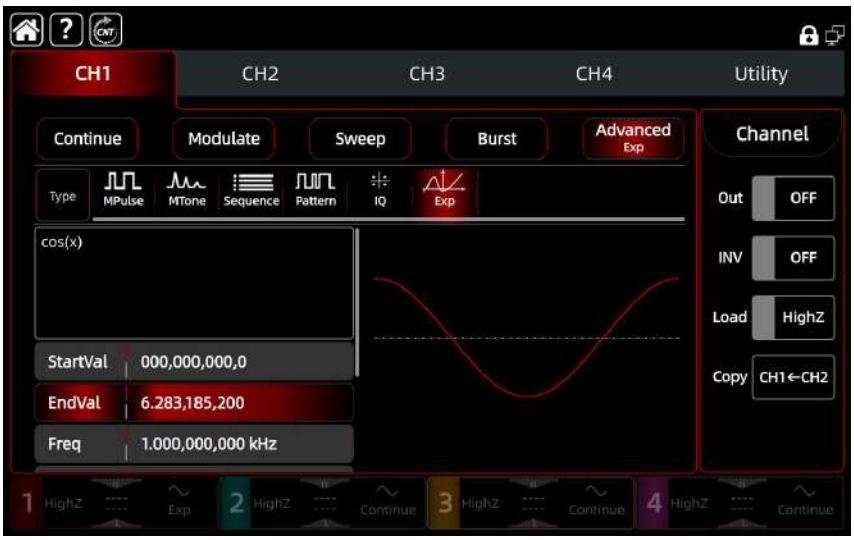
2) Set the Expression

Press the left arrow key to clear the expression edit box. Then, select cos from the expression menu and select x from the operator menu below, and press Enter to complete the setting.



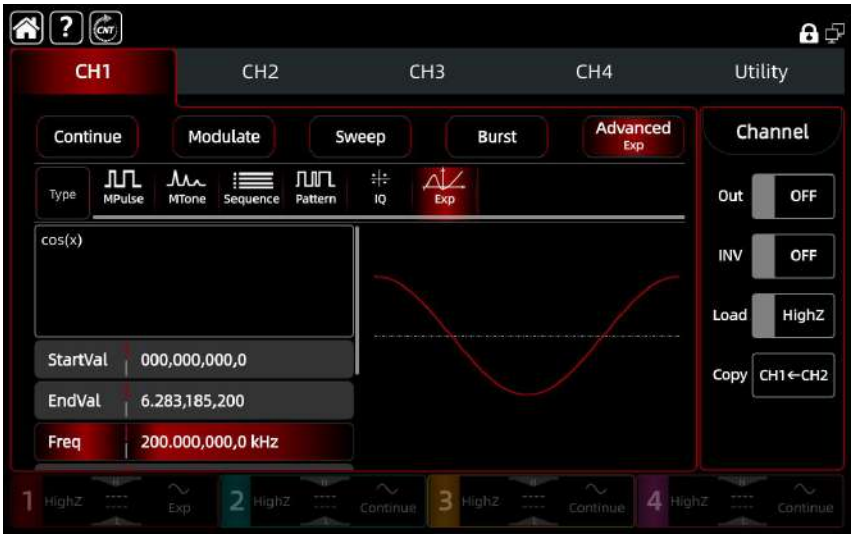
3) Set the Stop Value

Tap EndVal, use the numeric keypad to enter 6.2831852.



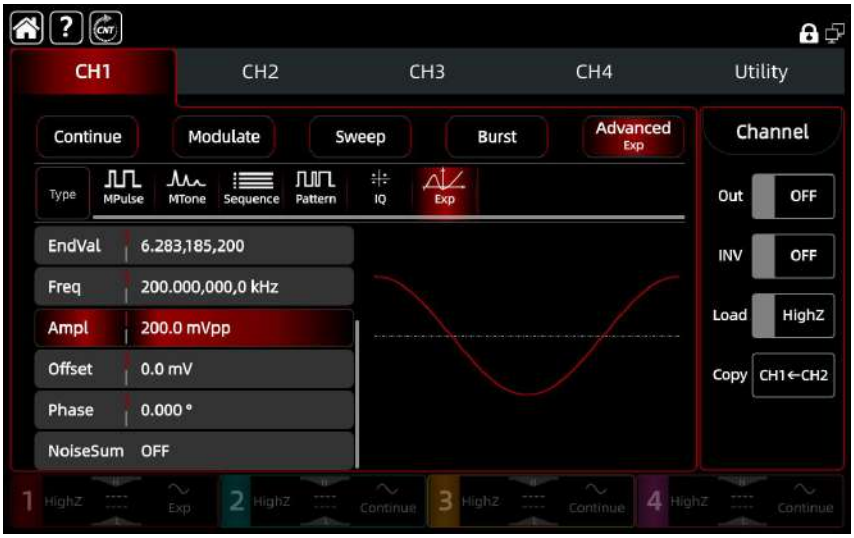
4) Set Bitrate

Tap Freq, use the numeric keypad to enter 200, and select kHz as the unit.



5) Set Amplitude

Tap Ampl, use the numeric keypad to enter 200, and select mVpp as the unit.



4.6 Digital Protocol

The waveform generator can output three types of protocol encoding: IIC, SPI, and UART (TTL). The corresponding protocol parameters can be configured in each protocol mode. After the digital protocol is enabled, the output terminal on the front panel outputs the corresponding signal.

4.6.1 SPI Protocol

In SPI mode, configure the waveform generator to generate configurable SPI protocol signals.

SPI Mode

Press the Utility button, then tap Digital →SPI on the screen to enable SPI mode. The instrument outputs SPI protocol signals based on the current settings.

Clock

The SPI transmission clock can be configured as required by the user. The configurable range is 1 Hz to 50 MHz.

In SPI mode, tap the frequency value under Clock to open the virtual keyboard, enter the desired value, and select the unit to complete the setting.

Data Format

The SPI data format is user-defined and can be set to Hexadecimal or Character mode.

In SPI mode, tap Format to set SPI format.

Bitrate

The number of data bits can be adjusted as needed.

Tap data input area on the right side, select the input data according to actual requirements, and press the Enter key to complete data input, as shown in the following figure.

Transmission Mode

Two transmission modes are available: auto, manual.

- Auto Transmission

  In auto transmission mode, the instrument transmits the configured protocol code once at a specified time interval. Tap the SendType option and select Auto (default mode). After the output is enabled, the protocol signal is transmitted continuously and automatically through the channel terminal.

- Manual Transmission

  In manual transmission mode, the instrument transmits the configured protocol signal once each time the user presses the Send. Tap SendType and select Manual (default is Auto). Then, tap Send on the right side of the data field to output the configured waveform once.

Time Interval

If the transmission mode is set to Auto, set the data transmission interval according to actual requirements. The configurable is 20 ns to 1000 s.

Tap the numeric value under Interval to open the virtual keyboard, enter the desired value, and select the unit to complete the setting.

Comprehensive Example

In SPI mode, configure the instrument to output data as hexadecimal values 13, 21, 34, 55, 89, set the clock frequency to 15 kHz, and set the transmission interval to 5 ms. The setting steps are as follows.

1) Enable SPI Mode

   Press the Utility button, then tap Digital →SPI on the screen to enable SPI mode.

2) Set Clock and Time Interval

Tap the frequency value under Clock to open the numeric keyboard and enter 15, and select kHz as the unit.

Tap the frequency value under Interval to open the numeric keypad and enter 5, and select ms as the unit.

Tap data input area to enter 13, 21, 34, 55, 89.

3) Enable Output

Tap OFF to switch the output to ON.

In this configuration, CH2 outputs SPI-SCLK, CH3 outputs SPI-CS, and CH4 outputs SPI-MOSI, as shown in the figure below.

4.6.2 IIC Protocol

In IIC mode, configure the waveform generator to generate configurable IIC protocol signals.

IIC Mode

Press the Utility button, then tap Digital →IIC on the screen to enable IIC mode. The instrument outputs IIC protocol signals based on the current settings.

Clock

The IIC transmission clock can be configured as required by the user. The configurable range is 1 Hz to 50 MHz.

In IIC mode, tap the frequency value under Clock to open the virtual keyboard, enter the desired value, and select the unit to complete the setting.

Data Format

The IIC data format is user-defined and can be set to Hexadecimal or Character mode.

In IIC mode, tap Format to set IIC format.

Bitrate

The number of data bits can be adjusted as needed.

Tap data input area on the right side, select the input data according to actual requirements, and press the Enter key to complete data input, as shown in the following figure.

Transmission Mode

For details, refer to *4.6.1* "Transmission Mode".

Time Interval

If the transmission mode is set to Auto, set the data transmission interval according to actual requirements. The configurable is 20 ns to 1000 s.

Tap the numeric value under Interval to open the virtual keyboard, enter the desired value, and select the unit to complete the setting.

Comprehensive Example

In IIC mode, configure the instrument to output a 10-bit address with a value of 65, set the IIC clock frequency to 15 kHz, set the output data to decimal values 07, 19, 23, 29, 31, and set the transmission interval to 5 ms.

The setting steps are as follows.

1) Enable IIC Mode

   Press the Utility button, then tap Digital →IIC on the screen to enable IIC mode.

2) Set Clock and Time Interval

Tap the frequency value under Clock to open the numeric keyboard and enter 15, and select kHz as the unit.

Tap the frequency value under Interval to open the numeric keypad and enter 5, and select ms as the unit.

Tap data input area to enter 07, 19, 23, 29, 31

3) Enable Output

Tap OFF to switch the output to ON.

In this configuration, CH3 outputs IIC-SCL, CH3 outputs IIC-SDA, as shown in the figure below.

4.6.3 UART Protocol

In UART mode, configure the waveform generator to generate configurable UART protocol signals.

UART Mode

Press the Utility button, then tap Digital →UART on the screen to enable UART mode. The instrument outputs UART protocol signals based on the current settings.

Baud Rate

The number of data bits can be adjusted as needed. The configurable is 1 to 1000000.

In UART mode, tap the numeric value under Baudrate to open the virtual keyboard, enter the desired value, and select the unit to complete the setting.

Data Format

The UART data format is user-defined and can be set to Hexadecimal or Character mode.

In UART mode, tap Format to set UART format.

Bitrate

The number of data bits can be adjusted as needed.

Tap data input area on the right side, select the input data according to actual requirements, and press the Enter key to complete data input, as shown in the following figure.

Transmission Mode

For details, refer to *4.6.1* "Transmission Mode".

Bitrate

The number of data bits can be adjusted as needed. The default bitrate is 115200.

Tap data input area on the right side, select the input data according to actual requirements, and press the Enter key to complete data input, as shown in the following figure.

Data Bit

In UART mode, the number of data bits can be configured as required.

The available data bit options are 4, 5, 6, 7, and 8, with 8 bits as the default.

Rotate the multi-function rotary knob, in combination with the arrow keys to set the data bit. Alternatively, tap Data on the screen to open the virtual keyboard, enter the desired value to complete the setting.

Stop Bit

In UART mode, the stop bit width can be configured.

The available stop bit options are 1 and 2, with 1 bit as the default.

Parity Bit

In UART mode, the parity check mode can be configured.

Tap Verify option to select None, Odd, or Even, with None as the default.

Comprehensive Example

In UART mode, configure the instrument with an output baud rate of 4800, 8 data bits, output data as hexadecimal values 05, 20, 13, 14, odd parity, 1 stop bit, and a transmission interval of 2 ms.

The setting steps are as follows.

1) Enable UART Mode

Press the Utility button, then tap Digital →UART on the screen to enable UART mode.

2) Set Baud Rate, Data Bit, Parity Bit, and Time Interval

Tap Baudrate, use the numeric keypad to enter 4800.

Tap Data, use the numeric keypad to enter 8bit.

Tap data input area to enter 05, 20, 13, 14.

Tap Verify to select Odd.

Tap the frequency value under Interval to open the numeric keypad and enter 2, and select ms as the unit.

The data format and stop bit use the default value.

3) Enable Output

Tap OFF to switch the output to ON.

In this configuration, CH4 outputs UART-TX, as shown in the figure below.

Chapter 5 Troubleshooting

The following lists faults and troubleshooting methods during the instrument's operation. Please follow the corresponding steps to resolve them. If the issue cannot be resolved, contact the distributor or local office, and provide the instrument's device information.

To obtain the device information, press the keys in sequence: Utility →System Information

5.1 No Display (Blank Screen)

If the waveform generator remains blank with no display after pressing the front-panel power switch:

1) Verify that the power supply is properly connected.
2) Ensure that the front-panel power switch has been fully pressed.
3) Restart the instrument.
4) If the instrument still does not operate normally, contact your distributor or local service center for assistance.

5.2 No Waveform Output

If the settings are correct but the instrument does not output a waveform:

1) Verify that the BNC cable and output terminal are properly connected.
2) Ensure that the Out key is enabled.
3) If the instrument still does not operate, contact your distributor or local service center for maintenance.

Chapter 6 Maintenance

6.1 Maintenance and Cleaning

(1) General Maintenance

Keep the instrument away from the direct sunlight.

Caution

Keep sprays, liquids, and solvents away from the instrument or probe to avoid damaging the instrument or probe.

(2) Cleaning

Inspect the instrument regularly according to its operating conditions. Follow these steps to clean the external surfaces:

a) Use a soft cloth to remove dust from the exterior of the instrument.

b) When cleaning the LCD screen, handle it carefully to protect the transparent display.

c) When cleaning the dust screen, remove the screws of the dust cover with a screwdriver, then take out the dust screen. After cleaning, reinstall the dust screen in the correct sequence.

d) Disconnect the power supply before cleaning. Wipe the instrument with a damp, but not dripping, soft cloth. Do not use abrasive chemical cleaners on the instrument or probes.

Warning

Please confirm that the instrument is completely dry before use, to avoid electrical shorts or even personal injury caused by moisture.

Appendix A Factory Setting

Parameter	Factory Setting
Channel Parameter	
Channel output	OFF
Carrier wave	Sine
Output load	High resistance
Channel merge	OFF
Channel coupling	OFF
Sync output	OFF
Channel output invert	OFF
Amplitude limit	OFF
Upper limit of amplitude	+1 V
Lower limit of amplitude	-1 V
Analog modulation	OFF
Modulation source	OFF
Modulation Input	OFF
Fundamental Wave	
Frequency	1 kHz
Amplitude	100 mVpp
Frequency deviation	0 Hz
DC offset	0 mV
Start phase	0°
Duty cycle of square wave	50%
Symmetry of ramp wave	50%
Duty cycle of pulse wave	50%
Rising edge of pulse wave	2 ns
Falling edge pulse wave	2 ns
Arbitrary Wave	
Mode	DDS
Built-in arbitrary wave	ACos
Harmonic Wave	
Total order	16
Type	Odd

PRBS (Pseudorandom Bit Sequence)	
Symbol	PN3
Edge Time	20 ns
AM (Amplitude Modulation)	
Modulation source	Internal
Modulation wave	Sine
Modulation frequency	100 Hz
Modulation depth	100%
FM (Frequency Modulation)	
Modulation source	Internal
Modulation wave	Sine
Modulation frequency	100 Hz
Frequency deviation	1kHz
PM (Phase Modulation)	
Modulation source	Internal
Modulation wave	Sine
Modulation frequency	100 Hz
Phase deviation	180°
ASK (Amplitude Shift Keying)	
Modulation source	Internal
ASK rate	100 Hz
FSK (Frequency Shift Keying)	
Modulation source	Internal
FSK rate	100 Hz
Hopping frequency 1	100 kHz
3FSK (Three Frequency Shift Keying)	
Hopping frequency 2	50 kHz
3FSK (Four Frequency Shift Keying)	
Hopping frequency 3	25 kHz
PSK (Phase Shift Keying)	
Modulation source	Internal

PSK rate	100 Hz
Phase 1	0°
BPSK (Binary Phase Shift Keying)	
Symbol	PN3
Phase 2	90°
QPSK (Quadrature Phase Shift Keying)	
Phase 3	180°
Phase 4	270°
OSK (Oscillation Keying)	
Modulation source	Internal
Oscillation Time	2 ms
OSK rate	100 Hz
SUM (SUM Modulation)	
Modulation source	Internal
Modulation wave	Sine
Modulation frequency	100 Hz
Modulation depth	100%
DSB-AM (Double-Sideband Amplitude Modulation)	
Modulation source	Internal
Modulation wave	Sine
Modulation frequency	100 Hz
Modulation depth	100%
QAM (Quadrature Amplitude Modulation)	
IQ map	QAM4
Symbol	PN3
QAM rate	100 bps
PWM (Pulse Width Modulation)	
Modulation source	Internal
Modulation wave	Sine
Modulation frequency	100 Hz
Duty Cycle Deviation	49.999750%

Frequency Sweep	
Sweep type	Linear
Start frequency	1 kHz
Stop frequency	1 MHz
Sweep time	10 ms
Trigger source	Internal
Trigger output	OFF
Burst	
Burst mode	N-cycle
Start phase	0°
Trigger period (burst period)	5 ms
Cycle	2
Polarity	Positive
Trigger source	Internal
Trigger output	OFF
Multi-Pulse	
Trigger source	Internal
Total pulse count	6
Width	1 ms
Gap	1 ms
Rising edge	2 ns
Falling edge	2 ns
Multi-Tone	
Start frequency	1 kHz
Tone gap	1 MHz
Total tone count	6
State	OFF
Sequence	
Sampling rate	320 MSa/s
Filter mode	Zero-order hold
Timing	0 ns
Trigger mode	Rising edge
Pattern	
Baud rate	0 μBaud

Preset amplitude	User
Input mode	Pattern
Data format	Binary
Code format	NRZ
IQ	
Sampling rate	1 kSa/s
Center frequency	0 μHz
Gain balance	0 dB
Phase angle adjustment	0°
I offset	0 mV
Q offset	0 mV
Expression	
Start value	000
End value	6.283185307
Noise	OFF
Frequency	1 kHz
Amplitude	50 mVpp
System Parameter	
Language	Factory setting
Backlight	80%
IP type	DHCP
Clock source	Internal
Clock output	OFF
Picture format	bmp
Sound	ON

Appendix B Built-in Arbitrary Wave Table

Type	Name	Description
Common function (15 types)	AbsSine	Absolute sine wave
	AbsSineHalf	Absolute half-sine wave
	AmpALT	Amplify sine wave
	AttALT	Attenuated sine wave
	Gaussian_monopulse	Gaussian monopulse
	GaussPulse	Gaussian pulse
	NegRamp	Falling ramp
	NPulse	N-Pulse signal
	PPulse	P-Pulse signal
	SineTra	TraSine wave signal
	SineVer	VerSine wave signal
	StairUD	Stair up and down waveforms
	StairDn	Stair down waveform
	StairUp	Stair up waveform
	Trapezia	Trapezoid
Engine (25)	BandLimited	Band-limited signal
	BlaseiWave	Time-velocity curve of explosive vibration
	Butterworth	Butterworth filter
	Chebyshev1	Chebyshev 1 filter
	Chebyshev2	Chebyshev 2 filter
	Combin	Combination function
	CPulse	C-Pulse signal
	CWPulse	CW pulse signal
	DampedOsc	Time-displacement curve of damped oscillation
	DualTone	Dual-tone signal
	Gamma	Gamma signal
	GateVibar	Gate self-oscillation signal
	LFMPulse	Linear frequency modulation pulse
	MCNoise	Mechanical construction noise
	Discharge	Discharge curve of Ni-MH battery

	Pahcur	Current waveform of DC brushless motor
	Quake	Quake waveform
	Radar	Radar signal
	Ripple	Power ripple
	RoundHalf	Round half waveform
	RoundsPM	Rounds phase modulation waveform
	StepResp	Step-response signal
	SwingOsc	Kinetic energy- time curve of swing oscillation
	TV	TV signal
	Voice	Voice signal
Maths (27 types)	Airy	Airy function
	Besselj	Bessel I function
	Besselk	Modified Bessel function of the second kind
	Bessely	Bessel II function
	Cauchy	Cauchy distribution function
	Cubic	Cubic function
	Dirichlet	Dirichlet function
	Erf	Error function
	Erfc	Complementary error function
	ErfcInv	Inverted complementary error function
	ErfInv	Inverted error function
	ExpFall	Exponential fall function
	ExpRise	Exponential rise function
	GammaIn	Natural logarithm of gamma function
	Gauss	Gauss distribution (Normal distribution)
	HaverSine	HaverSine function
	Laguerre	4-times Laguerre polynomial
	Laplace	Laplace distribution
	Legend	5-times Legend polynomial
	Log10	Logarithmic function with the base of 10

	LogNormal	Logarithmic normal distribution
	Lorentz	Lorentz function
	Maxwell	Maxwell distribution
	Rayleigh	Rayleigh distribution
	Versiera	Versiera
	Weibull	Weibull distribution
	ARB_X2	Square function
SectMod (5 types)	AM	Sectioned sine amplitude modulation signal
	FM	Sectioned sine frequency modulation signal
	PFM	Sectioned pulse frequency modulation signal
	PM	Sectioned sine phase modulation signal
	PWM	Sectioned pulse width frequency modulation signal
Bioelect (6 types)	Cardiac	Cardiac signal
	EOG	Electro-Oculogram
	EEG	Electroencephalogram
	EMG	Electromyogram
	Pulseilogram	Pulsilogram
	ResSpeed	Speed curve of the respiration
Medical (4 types)	LFPulse	Waveform of the low frequency pulse electrotherapy
	Tens1	Waveform 1 of the nerve stimulation electrotherapy
	Tens2	Waveform 2 of the nerve stimulation electrotherapy
	Tens3	Waveform 3 of the nerve stimulation electrotherapy
Automotive (17 types)	Ignition	Ignition waveform of the automotive motor
	ISO16750-2 SP	Automotive starting profile with ringing
	ISO16750-2 Starting1	Automobile voltage waveform 1 due to starting
	ISO16750-2 Starting2	Automobile voltage waveform 2 due

		to starting
	ISO16750-2 Starting3	Automobile voltage waveform 3 due to starting
	ISO16750-2 Starting4	Automobile voltage waveform 4 due to starting
	ISO16750-2 VR	Automotive supply voltage profile for resetting
	ISO7637-2 TP1	Automotive transients due to disconnects
	ISO7637-2 TP2A	Automotive transients due to inductance in wiring
	ISO7637-2 TP2B	Automotive transients due ignition switching off
	ISO7637-2 TP3A	Automotive transients due to switching
	ISO7637-2 TP3B	Automotive transients due to switching
	ISO7637-2 TP4	Automotive supply profile during starting
	ISO7637-2 TP5A	Automotive transients due to battery disconnect
	ISO7637-2 TP5B	Automotive transients due to battery disconnect
	SCR	SCR sintering temperature distribution
	Surge	Surge signal
Trigonome (21 types)	CosH	Hyperbolic cosine
	CosInt	Integral cosine
	Cot	Cotangent function
	CotHCon	Concave hyperbolic cotangent
	CotHPro	Protuberant hyperbolic cotangent
	CscCon	Concave cosecant
	CscPro	Protuberant cosecant
	CotH	Hyperbolic cotangent
	CscHCon	Concave hyperbolic cosecant
	CscHPro	Protuberant hyperbolic cosecant
	RecipCon	Concave reciprocal
	RecipPro	Protuberant reciprocal

	SecCon	Concave secant
	SecPro	Protuberant secant
	SecH	Hyperbolic secant
	Sinc	Sinc function
	SinH	Hyperbolic sine
	SinInt	Integral sine
	Sqrt	Square root
	Tan	Tangent
	TanH	Hyperbolic tangent
Anti-Trigonome Function (16 types)	ACosH	Arc hyperbolic cosine
	ACotCon	Concave arc cotangent
	ACotPro	Protuberant arc cotangen
	ACotHCon	Concave arc hyperbolic cotangent
	ACotHPro	Protuberant arc hyperbolic cotangent
	ACscCon	Concave arc cosecant
	ACscPro	Protuberant arc cosecant
	ACscHCon	Concave arc hyperbolic cosecant
	ACscHPro	Protuberant arc hyperbolic cosecant
	ASecCon	Concave arc secant
	ASecPro	Protuberant arc secant
	ASecH	Arc hyperbolic secant
	ASin	Arc Sinc
	ASinH	Arc hyperbolic sine
	ATan	Arc tangent
	ATanH	Arc hyperbolic tangent
Noise (6 types)	NoiseBlue	Blue noise
	NoiseBrown	Brown noise (Red noise)
	NoiseGray	Gray noise
	NoisePink	Pink noise
	NoisePurple	Purple noise
	Noisewhite	White noise
Window Function (17 types)	Bartlett	Bartlett window
	BarthannWin	Modified Bartlett-Hann window
	Blackman	Blackman window
	BlackmanH	BlackmanH window

	BohmanWin	Bohman window
	Boxcar	Rectangle window
	ChebWin	Chebyshev window
	GaussWin	Gaussian window
	FlattopWin	Flat Top weighted window
	Hamming	Hamming window
	Hanning	Hanning window
	Kaiser	Kaiser window
	NuttallWin	Nuttall-defined minimum 4-term Blackman-Harris window
	ParzenWin	Parzen window
	TaylorWin	Taylor window
	Triang	Triangle window (Fejer window)
	TukeyWin	Tukey (tapered cosine) window
Complex Wavelets (7 types)	Complex Frequency B-spline	Complex frequency B-spline function
	Complex Gaussian	Complex Gaussian function
	Complex Morlet	Complex Morlet wavelet
	Complex Shannon	Complex Shannon function
	Mexican hat	Mexican hat wavelet
	Meyer	Meyer wavelet
	Morlet	Morlet wavelet
Other (34 types)	ABA_1_1	
	ABA_1_2	
	ALT_03	
	ALT_04	
	ALT_05	
	AUDIO	
	COIL_2_1	
	COIL_2_2	
	DC_04	
	ECT_1_2	
	EGR_2	
	EGR_3_2	
	EST_03_2	
	IAC_1_1	

	INJ_1_1	
	INJ_2	
	INJ_3	
	INJ_4	
	INJ_5_6	
	INJ_7	
	KS_1_1	
	MAF_1_1	
	MAF_1_2	
	MAF_5_3	
	MAP_1_1	
	MAP_1_2	
	MC_3	
	Mexican hat	Mexican hat wavelet
	O2PROPA1	
	O2PROPA2	
	O2SNAP	
	STAR02_1	
	TPS_1_1	
	TPS_1_2	

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