User Manual

72-14120

72-14122

72-14126

Preface

Dear Users:

Hello! Thank you for choosing this brand new TENMA device. In order to correctly use the instrument, please carefully read the instruction before using it, especially "safety precautions".

If you have read the instruction, you are advised to properly keep it together with the instrument or at hand for you to look it up at any time in future use.

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Chapter 1 Safety Information

1.1 Safety Terms and Symbols

Terms in the manual

The following terms may appear in the manual:

Warning: warning statement, pointing out conditions and behaviors that may endanger life safety.

Caution: cautionary statement, pointing out conditions and behaviors that may cause damage to the product and other properties.

Terms on the product

The following terms may appear on the product:

Danger: indicate that you may be immediately harmed when reading this sign.

Warning: indicate that you may not be immediately harmed when reading this sign.

Caution: indicate that the product or other properties may be damaged.

Symbols on the product

The following symbols may appear on the product:

Symbol	Description
∼	AC
	Measuring ground terminal
	Frame ground terminal
⏻	On/Off Button
	Danger! High voltage
	Caution: please refer to the manual
	Protective ground terminal
CE	CE is registered trademark of EU
N10149	C-tick is registered trademark of Spectrum Management Agency of Australia. It indicates conformity with provisions of Australian EMC Framework formulated according to terms of Wireless Communication Act in 1992.
40	Containing at least one of six harmful substances that exceed maximum concentration value (MCV) and environment-friendly use period (EPUP) of 40 years.

1.2 General Safety Overview

This instrument is designed and produced in strict accordance with GB4793 Safety Requirements for 72-14120, 72-14122 & 72-14126 Operating Manual.

Electronic Measuring Apparatus and IEC61010-1 safety standard, up to insulation and overvoltage standard CAT II 300V and safety standard for level-II pollution.

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Please read the following preventive safety measures:

- In order to prevent electric shock or fire, please use power line and adapter dedicated to this product and approved by the country.
- This product is grounded through protective ground lead in the power line. In order to prevent electric shock, please check whether the power socket to be used for the product is grounded. Please ensure that the protective ground terminal of the product is reliably connected to the ground terminal of power line before connecting any input or output terminal other than power line.
- To avoid personal injury and prevent damage to the product or any product connected to the product. In order to avoid possible danger, the product can only be used in the specified scope. Only personnel that have received professional training can execute maintenance procedures.
- In order to prevent fire or electric shock, please pay attention to all rated values and signs of the product. Please read user's manual before connection of the product to further understand information about rated value.
- Don't use input voltage above rated value of the instrument.
- Inspect whether accessories suffer from mechanical damage before use. If so, please replace them.
- Only accessories provided for the product can be used. Please don't use accessories that are damaged.
- Don't insert metal objects into input or output terminal of the product.
- If you doubt that the product is damaged, please ask qualified maintenance personnel to inspect.
- Please don't put the product into operation when crate is opened.
- Please don't operate in humid environment.
- Please don't operate in inflammable and explosive environment.
- Keep the surface of product clean and dry.

Chapter 2

Brief Introduction of 72-14120, 72-14122 & 72-14126 Function/Arbitrary Waveform Generator

Function/arbitrary waveform generator of 72-14120, 72-14122 & 72-14126 uses direct digital synthesis to generate accurate and stable waveform output with resolution as low as 1µHz as an economic, high-performance and multi-functional dual-channel function/ arbitrary waveform generator. It can generate accurate, stable, pure and low-distortion output signal, and provide high-frequency square wave with fast rising and falling edges. Convenient operation interface, excellent technical indicator and humanized graphic display can help you finish work tasks faster and improve work efficiency. It is multi-purpose equipment that meets your present and future test requirements.

2.1 Main Characteristics

- Sine wave output of 160MHz/120MHz/80MHz, full-band resolution of 1µHz
- Pulse waveform of 50MHz (or 40MHz), adjustable time of rising, falling and duty ratio
- Sampling rate of 500MSa/s and vertical resolution of 16bit
- 6-bit high-precision frequency meter compatible with TTL level signal
- Dual channel of standard configuration and other performance, and independent output mode of channel
- Arbitrary wave storage of 8~32M points, 7GB non-volatile waveform storage
- Rich modulation types: AM,FM,PM, ASK,FSK,PSK,PWM,QAM,BPSK,QPSK,OSK,SUM
- 16bit digital arbitrary wave (TTL level) DARB
- Protocol output: I2C, SPI, RS232. (TTL level)
- Powerful upper computer software
- 8-cun high-resolution TFT color LCD
- Standard configuration interface: USB Host(max.32G), USB Device, LAN, 10MHz clock source input, 10MHz clock source output
- Support frequency sweep and pulse train output
- Easy-to-use multi-functional knob and numeric keypad

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2.2 Introduction of Panels and Keys

2.2.1 Front Panel

Function/arbitrary waveform generator of 72-14120, 72-14122 & 72-14126 provides users with simple and intuitive front panel that is easy to operate, which is shown in Figure 2-1:
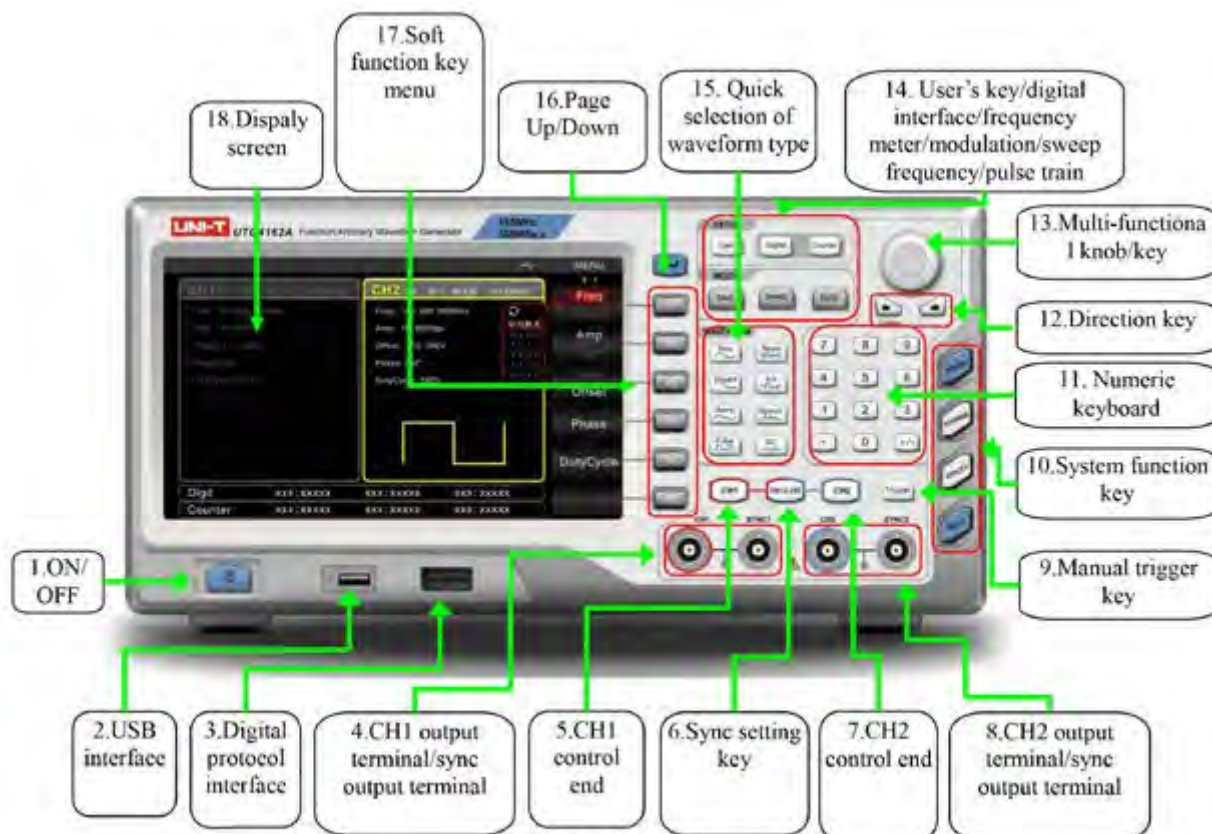
Figure 2-1 Structure of front panel

1. ON/OFF

Supply voltage of power source is AC 100V~240V. Frequency is 45Hz~440Hz. Connect the instrument to the power source with power line in accessories or other power lines up to standard. Turn on power switch below the supply hub to power on the instrument. Turn on or off the instrument: backlight of ⬛ is on (red) after normally powering on and power switch on back panel is on. Press this key, the backlight is on (green). The display screen enters funtion interface after displaying start-up interface. In order to prevent accidentally touching ON/OFF to turn off the instrument, press ON/OFF for about 1s to turn off the instrument. The backlight of the key and screen are simultaneously off after turning off the instrument.

2. USB interface

This instrument supports U disks of FAT 16 and FAT32 with maximum capacity of 32G. USB interface can be used to read any waveform data files in U disk, store or read current files of the instrument. The system program can be upgraded through the USB interface to ensure that the current program of function/arbitrary waveform generator is the latest version released by the company.

3. Protocol interface

Interface that includes RS232, I2C and SPI protocols and any 16bit digital arbitrary wave is capable of corresponding communication protocol output and used with **DIGITAL** menu.

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4. CH1 output terminal/ sync output terminal

Waveform signal and synchronous signal of output channel 1. The on-off of output signal is controlled by **CH1** or submenu under **UTILITY**.

5. CH1 control terminal

Fast switch the current channel on the screen (highlight of CH1 information tag indicates current channel, when parameter list shows information about channel 1 to set waveform parameters). If the channel is current channel (CH1 information tag is highlighted), press **CH1** to quickly turn on/off output of channel 1. Backlight of **CH1** is on and the current function mode will be displayed on the right of CH1 information tag ("BASE" or "MOD" or "SWEEP" or "BURST"), while "ON" is highlighted and CH1 output terminal outputs signal if on. Backlight of **CH1** is on and "OFF" is highlighted on the right of CH1 information tag while CH1 output terminal is turned off if off.

6. Sync setting key

Quickly set relationship between CH1 and CH2 configuration. Press this key to make the output signal of CH1 the same as that of CH2, or output signal of CH2 the same as that of CH1, or exchange the output signal of the two channels. The selection of specific mode is controlled by submenu **CH Copy** under **UTILITY** . In the submenu of **CH Copy** menu, **0:1->2** means copying CH1 setting to CH2, **1:2->1** means copying CH2 setting to CH1, and **2:1<->2** means exchanging setting of CH1 and CH2.

7. CH2 control terminal

Fast switch the current channel on the screen (highlight of CH2 information tag indicates current channel, when parameter list shows information about channel 2 to set waveform parameters). If the channel is current channel (CH2 information tag is highlighted), press **CH2** to quickly turn on/off output of channel 2. Backlight of **CH2** is on and the current function mode will be displayed on the right of CH2 information tag ("BASE" or "MOD" or "SWEEP" or "BURST"), while "ON" is highlighted and CH2 output terminal outputs signal if on. Backlight of **CH2** is on and "OFF" is highlighted on the right of CH2 information tag while CH2 output terminal is turned off if off.

8. CH2 output terminal/ sync output terminal

Waveform signal and synchronous signal of output channel 2. The on-off of output signal is controlled by **CH2** or submenu under **UTILITY**.

9. Manual trigger key

Set trigger and execute manual trigger when flashing.

10. System function key

Used for system setting, including function menus **PRESET**, **STORAGE**, **UTILITY** and **HELP**, corresponding to factory settings, waveform storage, general function and help menu.

11. Numeric keyboard

Numeric keys 0-9 for inputting required parameters, decimal point ".", symbolic key "+/-". Decimal point "." can quickly switch unit. Left direction key backspaces to clear the last bit input.

12. Direction key

Switch bit of numbers or move (leftward or rightward) cursor when setting parameters with multi-functional knob and direction key. The left key can be used to clear the last bit input when inputting with data keyboard.

13. Multi-functional knob/key

Rotate the multi-functional knob to change the number (increase the number by clockwise rotation) or select menu key. Press the multi-functional knob to select function or determine the parameters set.

14. Menu key

Control corresponding functions: user settings, digital interface, frequency meter, modulation mode, sweep frequency and pulse train output by keys **USER**, **DIGITAL**, **COUNTER**, **MOD**, **SWEEP** and **BURST**.

15. Quick selection of waveform type

Quickly select waveform type required by keys to quickly generate common waveforms you need.

16. Page Up/Down

There are 6 soft keys of function menu on the right of screen, F1-F6. When soft keys of some function menu are too many to be displayed on one page, they will be arranged on more than one page. Press this key to switch between multiple pages of soft keys.

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17. Soft function key menu

Accordingly select or check tags (on the right of function interface) through identification of soft keys, and set parameters with numeric keyboard, multi-functional knob or direction key.

18. Display screen

8-cun high-resolution TFT color LCD clearly distinguishes output state, function menu and other important information of channel 1 and 2 through different hues. Friendly system interface makes human-computer interaction simpler and improves work efficiency of users.

2.2.2 Back Panel

Back panel is shown in Figure 2-2:
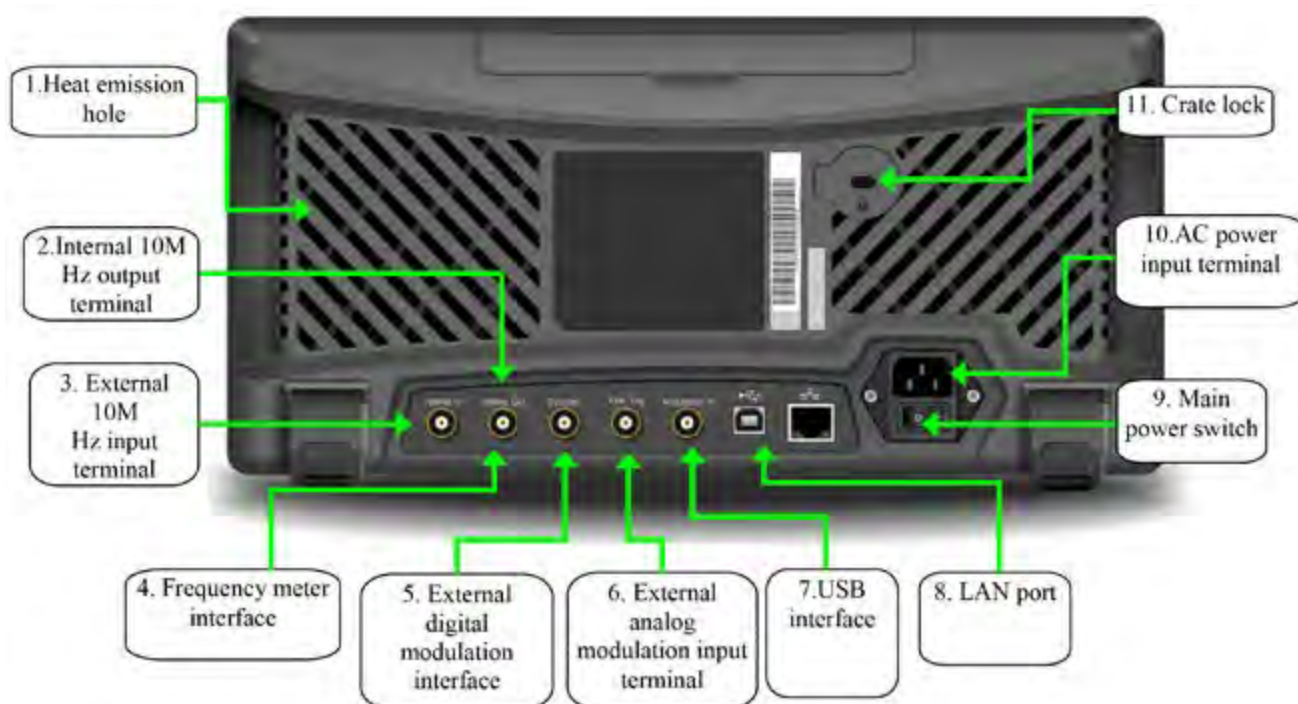
Figure 2-2 Structure of back panel

1. Heat emission hole

In order to ensure good heat dissipation of the instrument, please don't block these holes.

2. Internal 10MHz output terminal

Establish synchronous or external clock signal with reference frequency of 10 MHz for multiple function/arbitrary waveform generators. When clock source of the instrument is internal, internal 10MHz output terminal outputs an internal 10MHz clock signal.

3. External 10MHz input terminal

Establish synchronization of multiple function/arbitrary waveform generators or synchronization with external 10 MHz clock signal. When clock source of the instrument is external, external 10MHz input terminal receives an external 10MHz clock signal.

4. Frequency meter interface

Input signal through this interface when using frequency meter (compatible with TTL level).

5. External digital modulation interface

In case of modulation of ASK, FSK, PSK or OSK signal, if modulation source is external, input modulation signal through external digital modulation interface (TTL level). The corresponding output amplitude, frequency and phase are determined by signal

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level of external digital modulation interface. If trigger source of frequency sweep or pulse train is external, receive a TTL pulse with designated polarity through external digital modulation interface. This pulse can start scanning or output pulse train with designated recurring number. Input gated signal through external digital modulation interface if pulse train is gated; and output trigger signal for frequency sweep or pulse train (if trigger source is external, trigger output will be hidden in the parameter list as external digital modulation interface can not be simultaneously used for input and output).

6. External analog modulation input terminal

In case of modulation of AM, FM, PM, SUM or PWM signal, if modulation source is external, input modulation signal through external analog modulation input terminal. The corresponding modulation depth, frequency deviation, phase deviation or duty ratio deviation is controlled by ±5V signal level of external analog modulation input terminal.

7. USB interface

Connect to the upper computer software through this USB interface to realize control of the instrument by computer.

8. LAN port

LAN port can connect the instrument to LAN to realize remote control.

9. Main power switch

Power on the instrument at "I"; disconnect AC input at "O" (ON/OFF of front panel doesn't work).

10. AC power input terminal

AC power specification supported by this function/arbitrary waveform generator is: 100~240V, 45~440Hz,
power fuse: 250V, T2A.

11. Crate lock

Open the crate lock to arrange anti-theft measures for the instrument.

2.2.3 Function Interface

Function interface is shown in Figure 2-3:
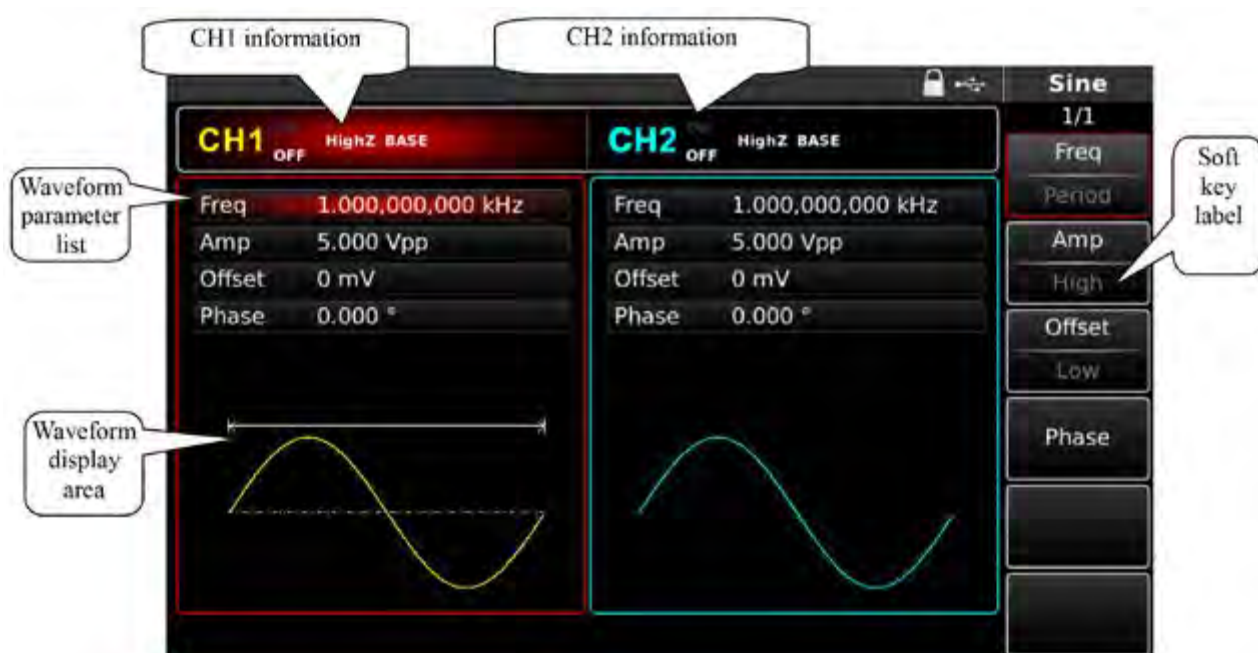
Figure 2- 1 Function interface

Detailed description:

   CH1 information: highlighted display (red in the middle of tag) means that this part of display screen displays information about channel 1. Parameters of this channel can be set. Parameters of this channel can not be set if not highlighted. Press **CH1**

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to quickly switch. Output (highlight of "ON" means that channel output is turned on, and highlight of "OFF" means that channel output is turned off) , output impedance ("HighZ" means high-impedance output, "50Ω" means 50Ω output) and effective waveform ("BASE" is basic waveform, "MOD" modulation mode, "SWEEP" frequency sweep mode, and "BURST" pulse train) will be displayed on the right of the tag.

    CH2 information: highlighted display (sky blue in the middle of tag) means that this part of display screen displays information about channel 2. Parameters of this channel can be set. Parameters of this channel can not be set if not highlighted. Press **CH2** to quickly switch. Output (highlight of "ON" means that channel output is turned on, and highlight of "OFF" means that channel output is turned off) , output impedance ("HighZ" means high-impedance output, "50Ω" means 50Ω output) and effective waveform ("BASE" is basic waveform, "MOD" modulation mode, "SWEEP" frequency sweep mode, and "BURST" pulse train) will be displayed on the right of the tag.

    Soft key tag: identify functions of soft keys of function menu and menu operation soft keys. Highlighted display: highlighted display means that color of the channel or gray in system setting is displayed in the middle of the tag, and typeface is pure white. Tag on the right of screen: the uppermost character is name of submenu, and number under the name is number of pages of submenu and the current page. For example, "1/2" means page 1 of 2 of submenu. Use Page Up/Down at the top right corner of the display area for page turning.

    Waveform parameter list: display parameters of the waveform in the form of list. If some item in the list is highlighted, parameters can be set through menu operation soft keys, numeric keyboard, direction key and multi-functional knob. If background of the character is mazarine (white in system setting), the character is being edited. Parameters can be set with direction key, numeric keyboard or multi-functional knob.

    Waveform display area: display the current waveform of the channel.

    Note: there is no waveform display area in system setting. This area is expanded into parameter list.

Chapter 3 Quick Start

3.1 General Inspection

When you get a new function/arbitrary waveform generator, you are advised to inspect the instrument according to the following steps.

3.1.1 Inspect Whether Damage is Caused by Transportation

If the packaging box or foamed plastic supplementary mat is seriously damaged, please contact with dealer of the product or local office. If the instrument is damaged during transportation, please keep the package, and notify transportation department and dealer of the product, who will arrange repair or replacement.

3.1.2 Inspect Accessories

72-14120, 72-14122 & 72-14126 accessories include power line (applicable to the destination country/region), a USB data transmission line, two BNC cables (1m), a user CD and a product warranty card. In case of lack or damage of accessories, please contact with dealer of the product or local office.

3.1.3 Inspect Complete Machine

If appearance of the instrument is damaged, the instrument runs abnormally or fails to pass performance test, please contact with dealer of the product or local office.

3.2 Output Basic Waveform

3.3.1 Set Output Frequency

The default configuration of waveform is a sine wave with frequency of 1kHz and peak-to-peak amplitude of 100mV (terminating at 50Ω) when powering on. The specific steps for changing frequency into 2.5MHz are as follows:

1. Press function key **F1**, when outline border of corresponding part in the display area is the color of corresponding channel, and "Freq" character is white, "Period" tag is gray. If the current frequency value is valid, the same frequency is used. Please press function key **F1** again to change to the set waveform period, when "Freq" character turns gray, "Period" character is highlighted, and frequency and period can be switched.

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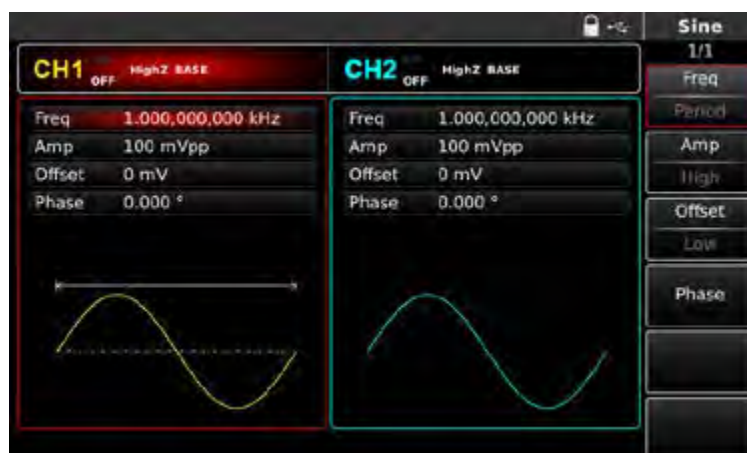
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Figure 3- 1 Setting of selected frequency

2. Input the required number 2.5 with numeric keyboard. The left direction key can be used to backspace when inputting.
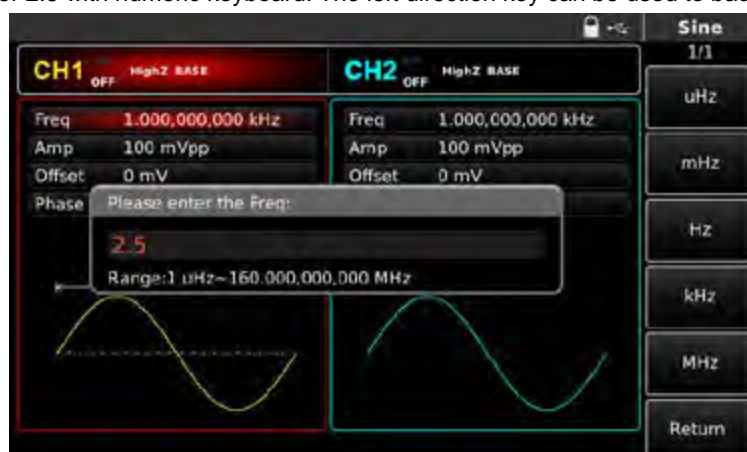

Figure 3- 2 Set frequency

3. Select required unit

Press soft key of corresponding unit. The waveform generator outputs waveform with the displayed frequency when you select unit (if output has been used). In this example, press soft key corresponding to MHz.

4. Use multi-functional knob and direction key for parameter setting

In default state, rotate multi-functional knob to switch between multiple soft keys of function menu. When setting some parameter, press the multi-functional knob to select a bit of the parameter after selecting the corresponding parameter, when the parameter bit is highlighted in blue. Rotate the multi-functional knob to adjust the number. Press left or right direction key to select different bits. Press the multi-functional knob again after setting to exit from parameter editing.

3.3.2 Set Output Amplitude

The default configuration of waveform is a sine wave with peak-to-peak amplitude of 100mV (terminating at 50Ω) when powering on. The specific steps for changing amplitude into 300mVpp are as follows:

1. Press function key F2, when outline border of corresponding part in the display area is the color of corresponding channel, and character "Amp" is white, tag "High" is gray. If the current amplitude value is valid when changing amplitude, the same amplitude is used. Press function key F2 again to quickly switch the unit (Vpp, Vrms and dBm).

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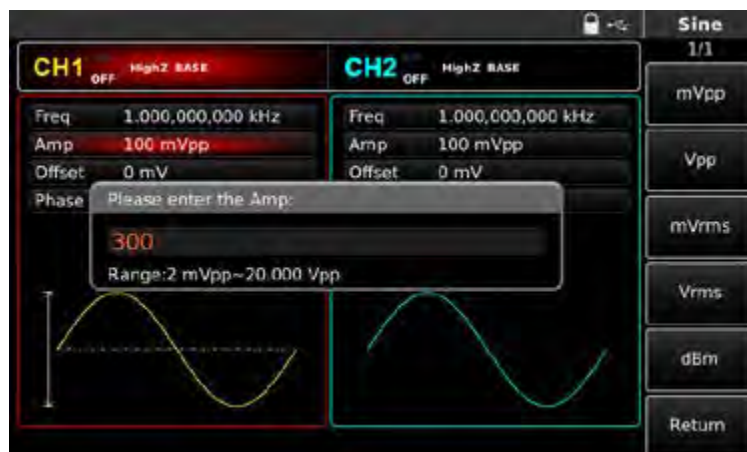2. Input required amplitude value 300 with numeric keyboard.

Figure 3- 3 Set amplitude

3. Select required unit

Press soft key of corresponding unit. The waveform generator outputs waveform with the displayed amplitude when you select unit (if output has been used). Press mVpp in this example.

Note: this parameter can also be set with multi-functional knob and direction key.

3.3.3 Set DC Offset Voltage

The default configuration of waveform is a sine wave with DC offset voltage of 0V (terminating at 50Ω) when powering on. The specific steps for changing DC offset voltage into -150mV are as follows:

1. Press function key **F3**, when outline border of corresponding part in the display area is the color of corresponding channel. If the current DC offset value is valid when changing DC offset, the same DC offset value is used. When pressing function key **F3** again, you will find that the waveform of parameter described with amplitude and DC offset has been described with high level (maximum value) and low level (minimum value). Such method for setting signal limit is very convenient for digital application.

2. Input required DC offset value -150mV with numeric keyboard.
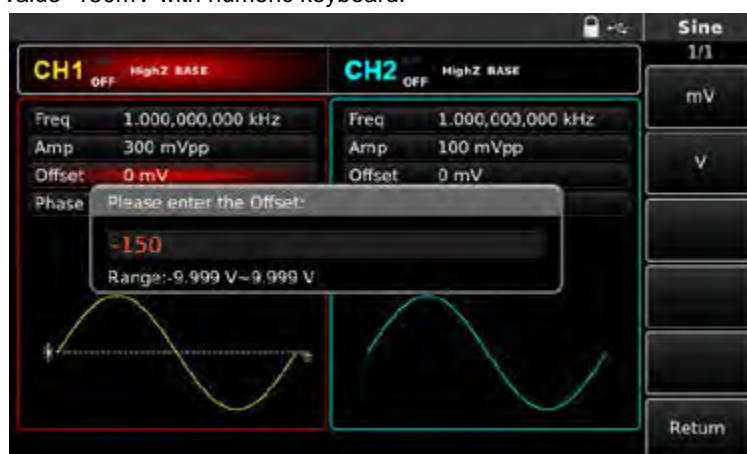
Figure 3- 4 Set offset voltage

3. Select required unit

Press soft key of corresponding unit. The waveform generator outputs waveform with the displayed DC offset when you select unit (if output has been used). Press mV in this example.

Note: this parameter can also be set with multi-functional knob and direction key.

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3.3.4 Set Square Wave

The duty ratio of square wave represents time quantum of square wave at high level in each cycle (suppose waveform is not reversed). The default duty ratio of square wave is 50% when powering on. The duty ratio is restricted by minimum pulse width specification 10ns. The specific steps for setting square wave with frequency of 1kHz, amplitude of 1.5Vpp, DC offset of 0V and duty ratio of 70% are as follows:

Press **Square**, **Freq**, **Amp** and **Duty** to set corresponding functions. Press corresponding soft key to set some parameter, then input the required value, and finally select the unit. Select corresponding value to quickly set duty ratio.

Figure 3- 5 Set duty ratio

Note: this parameter can also be set with multi-functional knob and direction key.

3.3.5 Set Pulse Wave

The duty ratio of pulse wave represents time quantum from the 50% threshold value of rising edge of the pulse to 50% threshold value of the next falling edge in each cycle (suppose waveform is not reversed). You can conduct parameter configuration for 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator to output pulse waveform with variable pulse width and edge time. The default duty ratio of pulse wave is 50% when powering on. Rising/falling edge time of 72-14126 is 5ns (72-14122 is 6ns/ 72-14120 is 7ns). The specific steps for setting pulse wave with period of 2ms, amplitude of 1.5Vpp, DC offset of 0V, duty ratio (restricted by minimum pulse width specification 10ns) of 25%, rising edge time of 200μs and falling edge time of 200μs are as follows:

Press **Pulse**, **Freq**, **Amp**, **Duty**, **Rise** and **Fall** (if tag is not highlighted, press corresponding soft function key to select), and press soft key **Freq** twice to switch between frequency and period. Input the required value, and then select the unit. When inputting value of duty ratio, input 25 and press **%** to finish input. To set falling edge time, please press soft key Page Up/Down or rotate multi-functional knob rightward when sub-tag is selected to display the next screen of sub-tags (the edge of sub-tag "selected" is the colour of channel, the sub-tag is "edited" when highlighted, such as white letters on a blue background in the figure below), press soft key **Fall** to input the required value and select the unit.

Figure 3- 6 Set falling edge time

Note: this parameter can also be set with multi-functional knob and direction key.

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3.3.6 Set DC Voltage

Output of DC voltage is setting of the above-mentioned DC offset. The default DC voltage is 0V when powering on. The specific steps for changing DC offset voltage into 3V are as follows:

1. Press **DC** and **Offset** successively for setting. When changing DC voltage (DC offset), if the current DC voltage (DC offset) value is valid, the same DC voltage (DC offset) value is used.

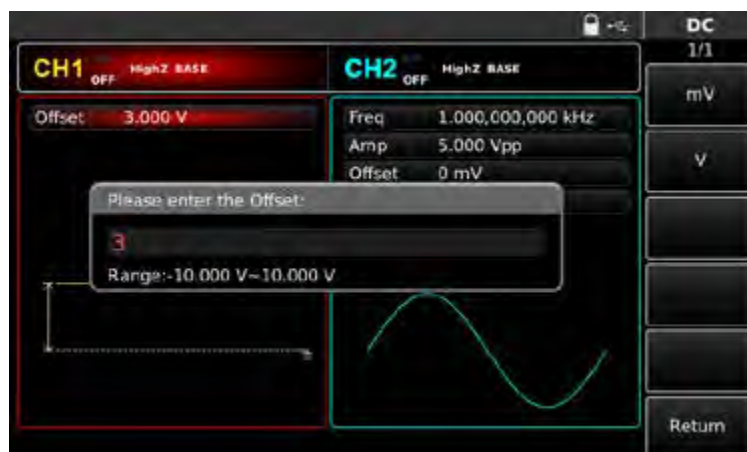2. Input the required number 3 with numeric keyboard

Figure 3- 7 Set DC voltage

3. Select required unit

Press soft key of corresponding unit. The waveform generator outputs waveform with the displayed DC offset when you select unit (if output has been used). Press V in this example. Note: this parameter can also be set with multi-functional knob and direction key.

3.3.7 Set Sawtooth Wave

Degree of symmetry is time quantum when slope of sawtooth wave is positive in each cycle (suppose waveform is not reversed). The default degree of symmetry of sawtooth wave is 0.10% when powering on. The specific steps for setting triangular wave with frequency of 10kHz, amplitude of 2V, DC offset of 0V and degree of symmetry of 50% are as follows:

Press **Ramp**, **Freq**, **Amp**, **Offset** and **Symmetry** successively. Press corresponding soft key to set some parameter, input the required value and then select the unit. There will be tag **50%** on the right of the screen when inputting degree of symmetry. Press corresponding soft key to quickly input it. Certainly you can also output number 50 and then press **%** to finish input.
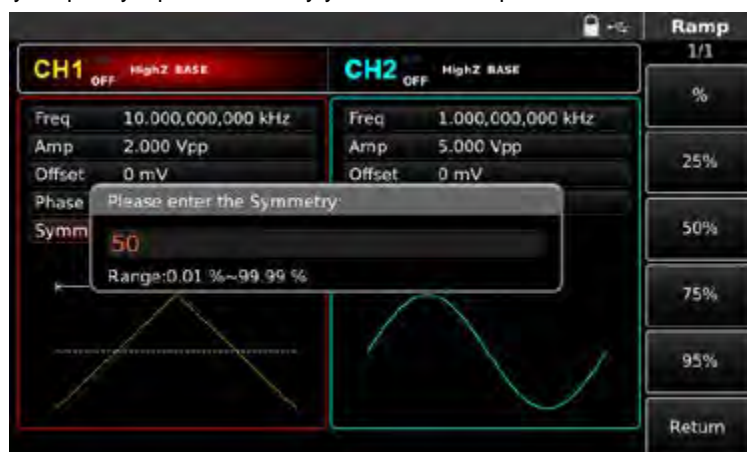

Figure 3- 8 Set degree of symmetry

Note: this parameter can also be set with multi-functional knob and direction key.

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3.3.8 Set Noise Wave

Quasi-Gaussian noise with amplitude of 100mVpp and DC offset of 0mV is default in 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator. If the amplitude and DC offset function of other waveforms are changed, the default value of noise wave has also been changed. Only the amplitude and DC offset of the noise wave can be changed. The specific steps for setting quasi-Gaussain noise with amplitude of 300mVpp and DC offset of 1V are as follows:

Press **Noise**, **Amp** and **Offset** successively for setting. Press corresponding soft key to set some parameter, input the required value and then select the unit.
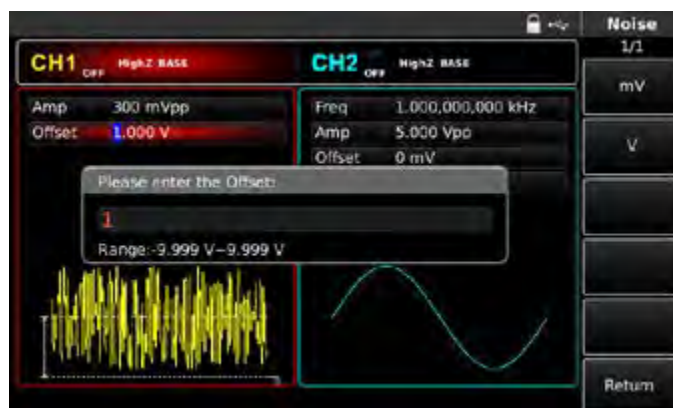

Figure 3- 9 Set noise wave

Note: this parameter can also be set with multi-functional knob and direction key.

3.3 SYNC Output

The two SYNC connectors on the front panel provide SYNC output. All standard waveform outputs (except DC and noise) are equipped with associated Sync output. Close Sync output of corresponding channel in UTILITY to prevent Sync output. Two channels are equipped with completely independent Sync signal output.

- By default, Sync signal output is on.
- Sync output is at low logic level when turned off.
- State of Sync is divided into off, on and opposition.
- Sync will not reverse with the waveform.
- Sync uses fundamental waveform as reference in fundamental wave output, and is square wave with duty ratio of 50%.
- Sync uses modulation waveform as reference in internal modulation, and is square wave with duty ratio of 50%.
- Sync uses carrier waveform as reference in external analog modulation, and is square wave with duty ratio of 50%.
- Sync uses external input waveform as reference in external FSK input modulation, and is square wave with duty ratio of 50%.
- When internal trigger of frequency sweep starts, Sync signal is at "low" level and at "high" level at midpoint of frequency sweep. Sync signal synchronizes with frequency sweep. In case of external trigger of frequency sweep, Sync is synchronous with external trigger signal. In the event of manual trigger of frequency sweep, Sync is at "high" level when frequency sweep starts and at "low" level when frequency sweep is over.
- For trigger of pulse train, Sync signal is at TTL "high" level when pulse train starts and at "low" level at midpoint of designated burst period.
- For external gated pulse train, Sync signal is consistent with external gated signal.

3.4 Frequency Measurement

This function/arbitrary waveform generator can measure frequency and duty ratio of compatible TTL level signal. The range of frequency measurement is 100mHz~200MHz. When frequency meter is used, signal of compatible TTL level is input through external frequency meter interface (Counter connector). Then press **COUNTER** to read "frequency", "period", "duty ratio", "positive pulse width" and "negative pulse width" in parameter list. When no signal is input, the parameter list of frequency meter displays the value measured last time. The frequency meter only refreshes display after signal of compatible TTL level is input into frequency meter interface (Counter connector).

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Figure 3- 10 Frequency measurement

3.5 Use Built-in Help System

Built-in help system provides context-sensitive help for any key or soft key of menu on the front panel. You can also use list of help topics to get some help about front panel operation.

1. Check list of help topics

Press **HELP** on arbitrary interface to check list of help topics available, press arbitrary operation key again to check corresponding help information, and press **HELP** again to exit.

2. Check help information that displays message

In case of exceeding the limit or any invalid configuration, function/arbitrary waveform generator will display a prompt message. Built-in help system provides additional information about the latest message. Press **HELP** to check list of help topics available, select "check the last message displayed" and press **HELP** again to exit.

Note

Local language help: built-in help system provides simplified Chinese, traditional Chinese and English versions. All messages, context-sensitive help and help topics are displayed in the selected language. To select local language, please press **Utility□System□Language** successively, and press soft key corresponding to direction tag to select the language you need (or select with multi-functional knob).

Chapter 4 Advanced Applications

4.1 Output Modulation Waveform

4.1.1 Amplitude Modulation (AM)

In amplitude modulation, the modulated waveform generally is composed of carrier wave and modulation wave. The amplitude of carrier wave will vary with that of modulation wave. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select AM

Press **MOD**, **Type** and **AM** to use AM function (if **Type** is not highlighted, press soft key **Type** to select). After AM function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output modulated waveform with the current modulation waveform and carrier wave.
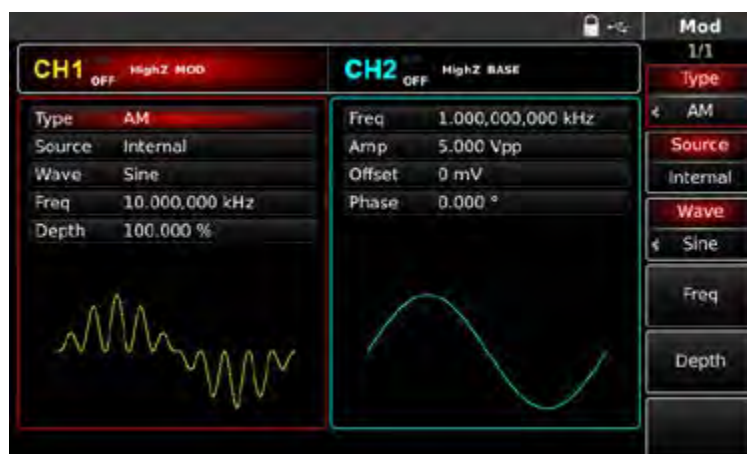
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Figure 4- 1 Select AM function

Select carrier waveform

AM carrier waveform can be sine wave, square wave, sawtooth wave or arbitrary wave (except DC), and is sine wave by default. After AM is selected, press the key of basic waveform setting to quickly set corresponding carrier waveform.
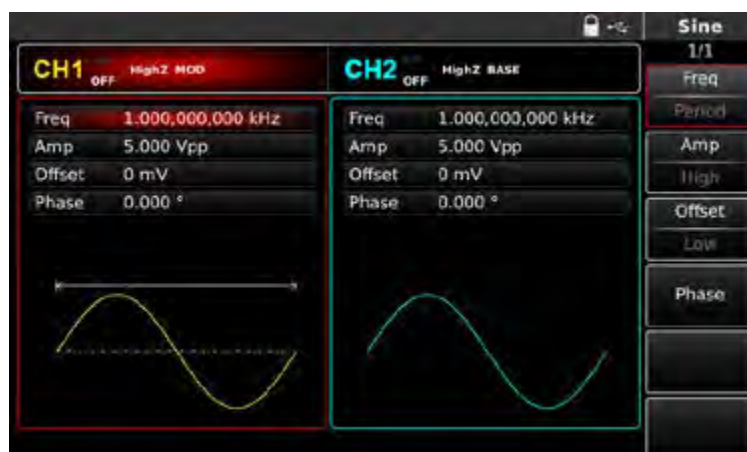

Figure 4- 2 Select carrier waveform

Set carrier frequency

Carrier frequency range varies with carrier waveform. The default frequency of all carrier waves is 1kHz. See the table below for frequency range of carrier wave:

Table 4- 1

Carrier waveform	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1μHz ~ 80MHz	1μHz ~ 120MHz	1μHz ~ 160MHz
Square wave	1μHz ~ 30MHz	1μHz ~ 40MHz	1μHz ~ 50MHz
Sawtooth wave	1μHz ~ 30MHz	1μHz ~ 40MHz	1μHz ~ 50MHz
Pulse wave	1μHz ~ 2MHz	1μHz ~ 3MHz	1μHz ~ 4MHz
Arbitrary wave	1μHz ~ 30MHz	1μHz ~ 30MHz	1μHz ~ 30MHz

To set carrier frequency, please use multi-functional knob and direction key or press corresponding keys, input the required value and select the unit.

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Select modulation source

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can select internal or external modulation source. After you use AM function, you can see that modulation source is internal by default. You can change it with multi-functional knob on AM interface or by pressing function menu **Source**.
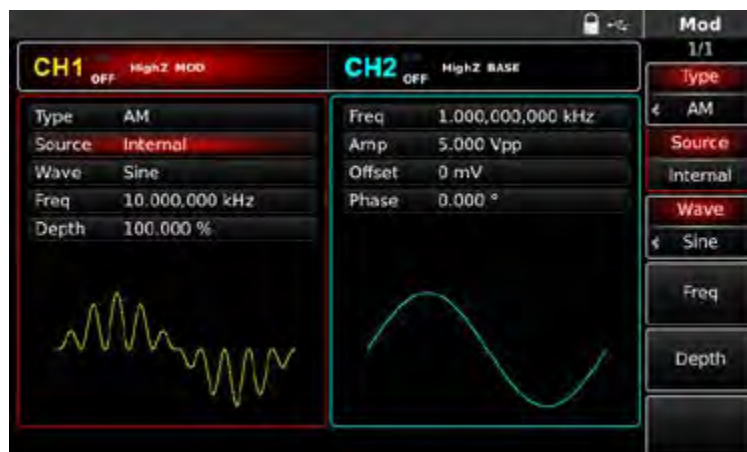

Figure 4- 3 Select modulation source

1) Internal source

In case of internal modulation source, modulation wave can be sine wave, square wave, sawtooth wave and arbitrary wave, and is sine wave by default. After you use AM function, you can see that modulation wave is sine wave by default. You can change it with multi-functional knob on AM interface or by pressing **Wave**.

Square wave: duty ratio is 50%

Sawtooth wave: degree of symmetry is 0.10%

Arbitrary wave: when selecting arbitrary wave as modulation waveform, function/arbitrary waveform generator limits length of arbitrary wave to 32Mpts by automatic test count.

2) External source

In case of external modulation source, modulation wave and frequency will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. AM depth is controlled by built-in modulation depth and ±5V signal level on external analog modulation input terminal (Modulation In connector) of back panel. For example, if modulation depth in parameter list is set to be 100%, AM output amplitude is the maximum when external modulation signal is +5V and the minimum when external modulation signal is -5V.

Set modulation wave frequency

The frequency of modulation wave can be set in case of internal modulation source. After you use AM function, you can see that frequency of modulation wave is 100Hz by default. You can change it with multi-functional knob and direction key on AM interface or by pressing **Freq**. Modulation frequency range is 2mHz~200kHz. In case of external modulation source, modulation wave and frequency will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. The frequency range of modulation signal of external input is 2mHz~20kHz.

Set modulation depth

Modulation depth is degree of amplitude change, expressed in percentage. The range of AM depth is 0%~120%, 100% by default. When modulation depth is 0%, a constant amplitude is output (half of carrier amplitude). When modulation depth is 100%, the output amplitude varies with the modulation waveform. When modulation depth is more than 100%, the instrument will not output a peak-to-peak voltage (terminating at 50Ω) more than ±5V. You can change it with multi-functional knob and direction key on AM interface or by pressing Depth. In case of external modulation source, the output amplitude of instrument is also controlled by±5V signal level on external analog modulation input terminal (Modulation In connector) of back panel. For example, if modulation depth in parameter list is set to be 100%, AM output amplitude is the maximum when external modulation signal is +5V and the minimum when external modulation signal is -5V.

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Comprehensive example

First make the instrument run in amplitude modulation (AM) mode, and then set an internal sine wave of 200Hz as modulation signal and a square wave with frequency of 10kHz, amplitude of 200mVpp and duty ratio of 45% as carrier signal. Finally set modulation depth to be 80%. The specific steps are as follows:

1)Use AM function

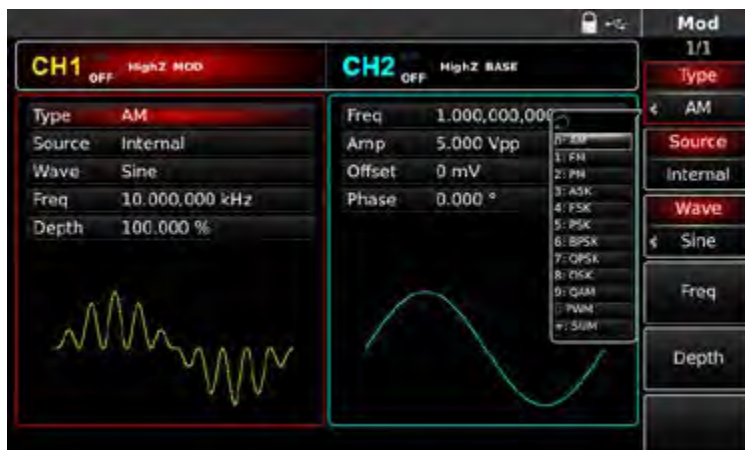Press **MOD** to use the function, and select AM function (press soft key **Type** to select if **Type** is not highlighted).

Figure 4- 4 Select AM function

2) Set modulation signal parameters

Set with multi-functional knob and direction key after using AM function. You can also press soft keys of function on the above interface for using AM function.
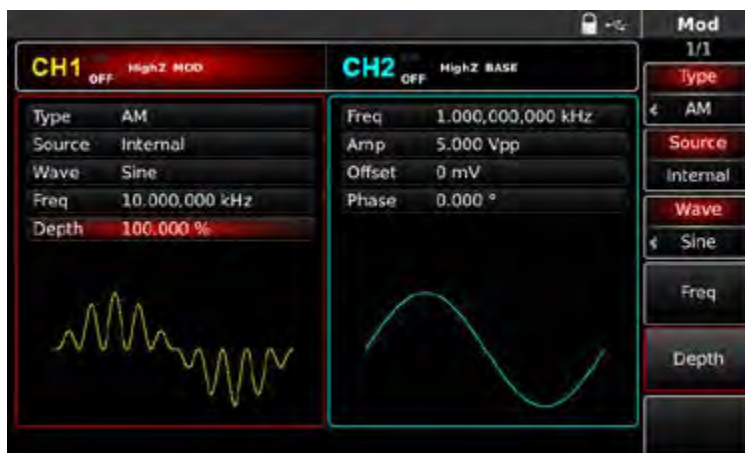
Figure 4- 5 Set modulation parameters

To set some parameter, press corresponding soft key, input the required value and select the unit.

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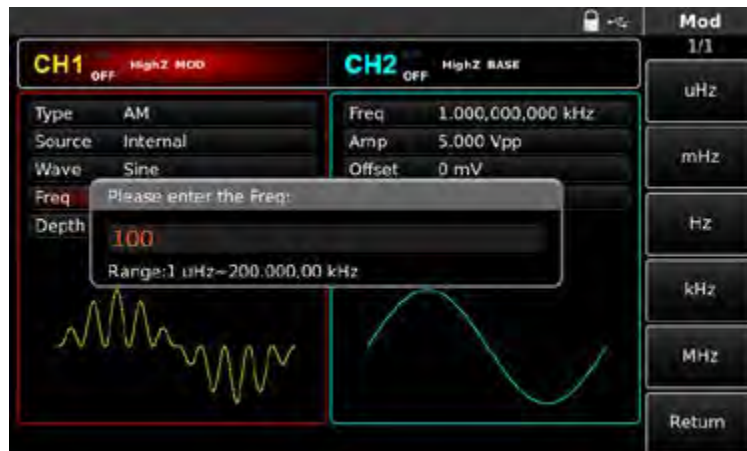
Figure 4- 6 Set frequency of modulation source

3) Set carrier signal parameters

Select type of basic waveform in modulation mode. Press **Square** to select carrier signal as square wave.

Figure 4- 7 Set carrier frequency

You can set with multi-functional knob and direction key, or press corresponding soft keys of function again.

Figure 4- 8 Select carrier duty ratio

To set some parameter, press corresponding soft key, input the required value and select the unit.

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Figure 4- 9 Set carrier duty ratio

4) Set modulation depth

Press soft key **Return** to return to the interface below to set modulation depth after setting carrier parameters.
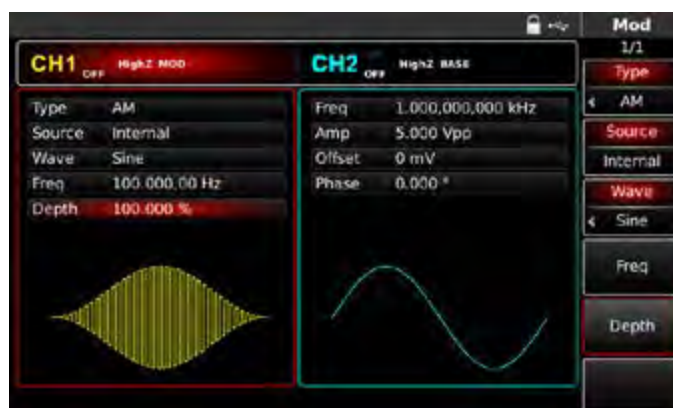
Figure 4- 10 Select modulation depth

You can set with multi-functional knob and direction key. You can also press soft key **Depth** again, input number 80 through numeric keyboard and press soft key % to set the modulation depth.
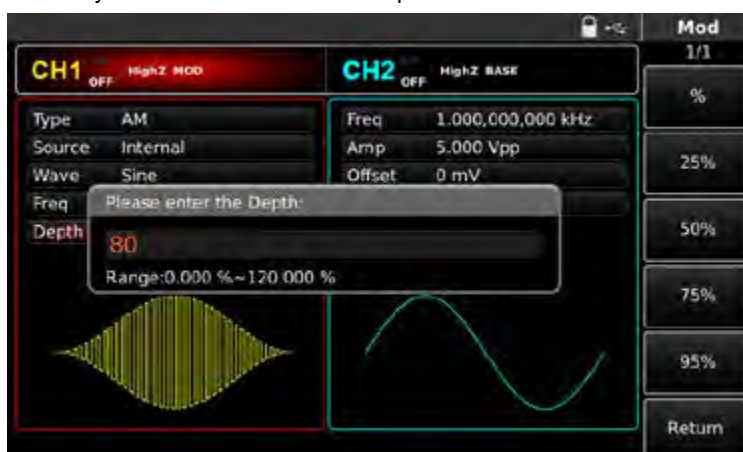
Figure 4- 11 Set modulation depth

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5)Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns gray from white, and "ON" turns white from gray, indicating that output of channel 1 is turned on.
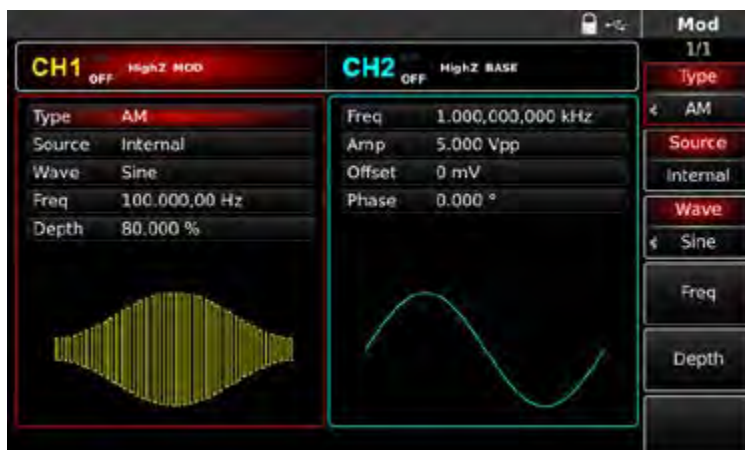
Figure 4- 12 Use channel output

Check the shape of AM modulation waveform through oscilloscope, which is shown in the figure below:
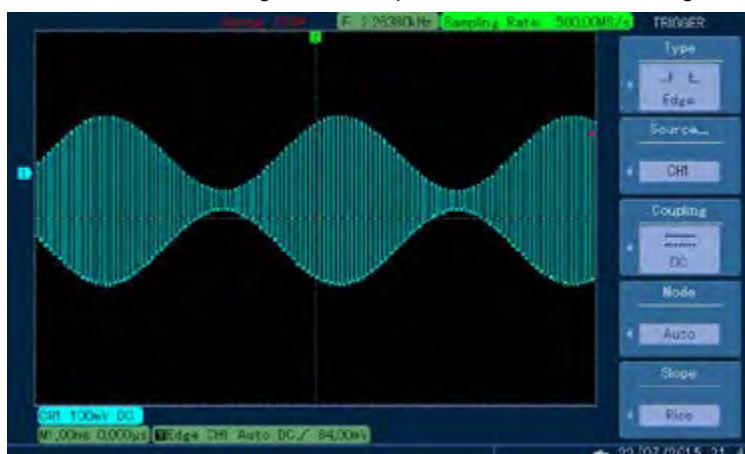
Figure 4- 13 Observe AM waveform with oscilloscope

4.1.2 Frequency Modulation (FM)

In frequency modulation, the modulated waveform generally is composed of carrier wave and modulation wave. The frequency of carrier wave will vary with amplitude of modulation wave. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select FM

Press **MOD**, **Type** and **FM** successively to use FM function (press soft key **Type** to select if **Type** is not highlighted). After fM function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output modulated waveform with the current modulation waveform and carrier wave.

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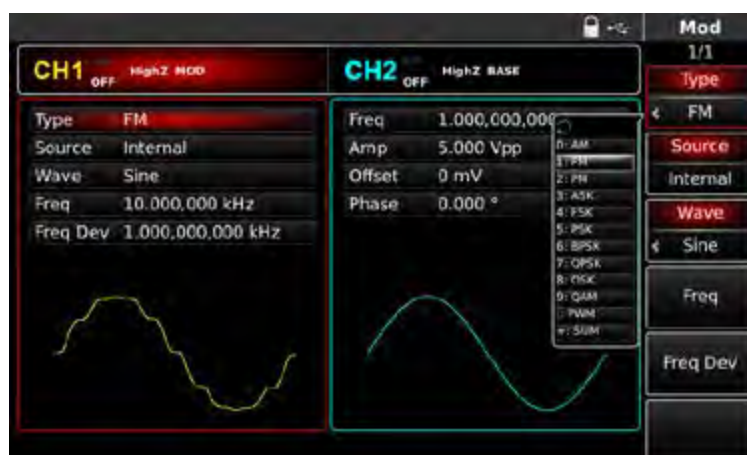
Figure 4- 14 Select FM

Select carrier waveform

FM carrier waveform can be sine wave, square wave, sawtooth wave or arbitrary wave (except DC), and is sine wave by default. After FM is selected, press the key of basic waveform setting to quickly set corresponding carrier waveform.
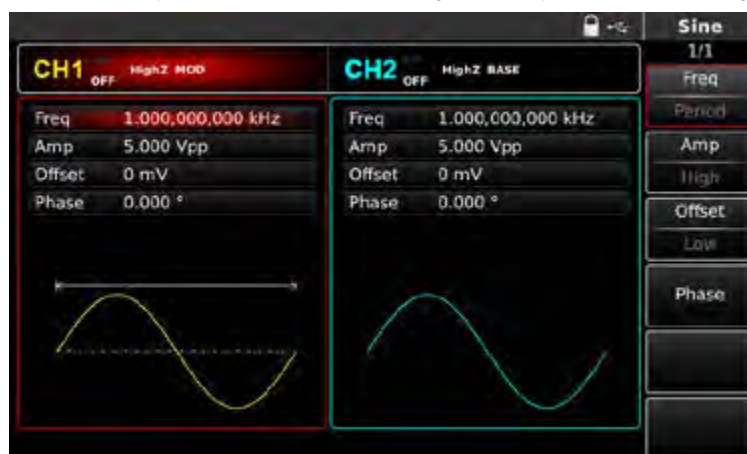

Figure 4- 15 Select carrier waveform

Set carrier frequency

Carrier frequency range varies with carrier waveform. The default frequency of all carrier waves is 1kHz. See the table below for frequency range of carrier wave:

Table 4- 2

Carrier waveform	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1μHz ~ 80MHz	1μHz ~ 120MHz	1μHz ~ 160MHz
Square wave	1μHz ~ 30MHz	1μHz ~ 40MHz	1μHz ~ 50MHz
Sawtooth wave	1μHz ~ 30MHz	1μHz ~ 40MHz	1μHz ~ 50MHz
Pulse wave	1μHz ~ 2MHz	1μHz ~ 3MHz	1μHz ~ 4MHz
Arbitrary wave	1μHz ~ 30MHz	1μHz ~ 30MHz	1μHz ~ 30MHz

To set carrier frequency, please use multi-functional knob and direction key or press **Freq**, input the required value and select the unit after selecting carrier waveform.

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Select modulation source

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can select internal or external modulation source. After you use FM function, you can see that modulation source is internal by default. You can change it with multi-functional knob on interface for using frequency modulation or by pressing **Source**.
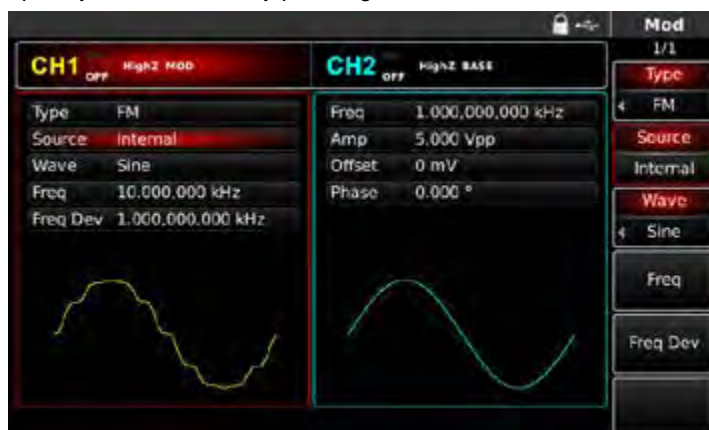

Figure 4- 16 Select modulation source

1) Internal source

In case of internal modulation source, modulation wave can be sine wave, square wave, sawtooth wave and arbitrary wave, and is sine wave by default. After you use FM function, you can see that modulation wave is sine wave by default. You can change it with multi-functional knob on interface for using frequency modulation or by pressing the key of basic waveform setting.

- Square wave: duty ratio is 50%
- Sawtooth wave: degree of symmetry is 0.10%
- Arbitrary wave: when selecting arbitrary wave as modulation waveform, function/arbitrary waveform generator limits length of arbitrary wave to 32Mpts by automatic test count.

2) External source

In case of external modulation source, modulation wave and frequency will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. Frequency deviation of FM is controlled by ±5V signal level on external analog modulation input terminal (Modulation In connector) of back panel. Output frequency of FM is more than carrier frequency at positive signal level and less than the latter at negative signal level. Lower external signal level generates less deviation. For example, if frequency deviation in parameter list is set to be 1kHz, output frequency of FM is 1kHz more than the current carrier frequency when external modulation signal is +5V and 1kHz less than the current carrier frequency when external modulation signal is -5V.

Set modulation wave frequency

The frequency of modulation wave can be set in case of internal modulation source. After you use FM function, you can see that frequency of modulation wave is 100Hz by default. You can change it with multi-functional knob and direction key on interface for using frequency modulation or by pressing Freq. Modulation frequency range is 2mHz~200kHz. In case of external modulation source, modulation wave and frequency will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. The frequency range of modulation signal of external input is 2mHz~20kHz.

Set frequency deviation

Frequency deviation is deviation of frequency of waveform subject to FM from carrier frequency. The range of FM frequency deviation is 1µHz to half of the maximum carrier frequency, 1kHz by default. You can change it with multi-functional knob and direction key on interface for using frequency modulation or by pressing **Freq**.

- Frequency deviation must not be more than carrier frequency. If the frequency deviation is more than the carrier frequency, function/ arbitrary waveform generator will automatically limit the deviation to the allowable maximum carrier frequency.
- The sum of frequency deviation and carrier frequency must not be more than the allowable maximum carrier frequency. If the frequency deviation is invalid, function/ arbitrary waveform generator will automatically limit the deviation to the allowable maximum carrier frequency.

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Comprehensive example

First make the instrument run in frequency modulation (FM) mode, and then set an internal square wave of 2kHz as modulation signal and a sine wave with frequency of 10kHz and amplitude of 100mVpp as carrier signal. Finally set frequency deviation to be 5kHz. The specific steps are as follows:

1) Use FM function

Press **MOD**, **Type** and **FM** successively (press **Type** to select if **Type** is not highlighted) to use FM function.
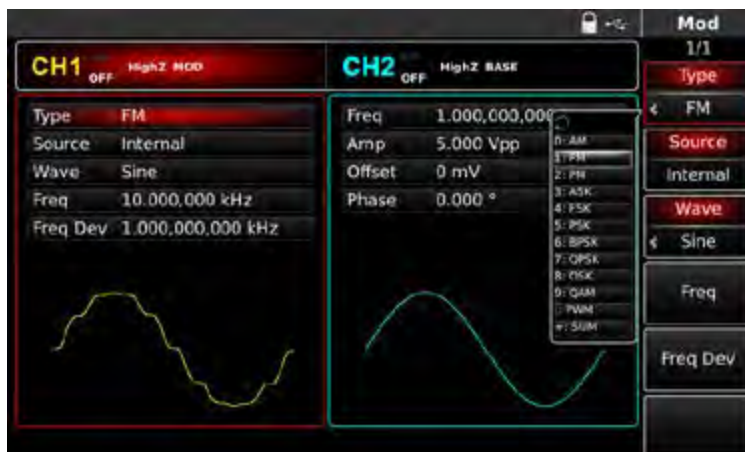

Figure 4- 17 Select FM function

2) Set modulation signal parameters

Set with multi-functional knob and direction key after using FM function. You can also press corresponding soft keys on the above interface for using FM function, when the interface below will pop up:
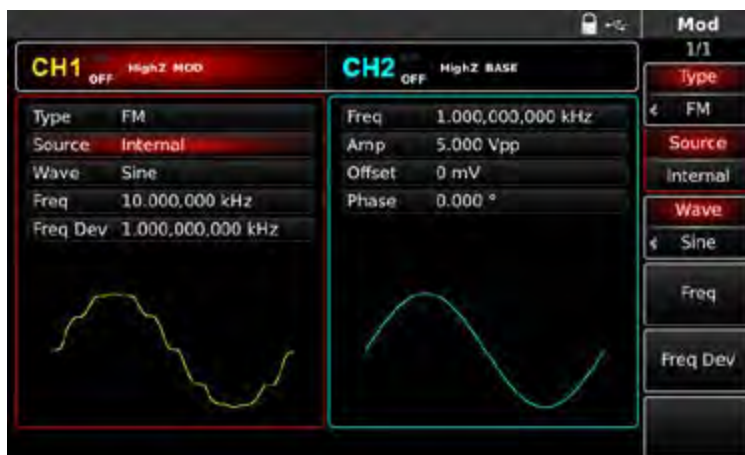
Figure 4- 18 Set modulation parameters

To set some parameter, press corresponding soft key, input the required value and select the unit.

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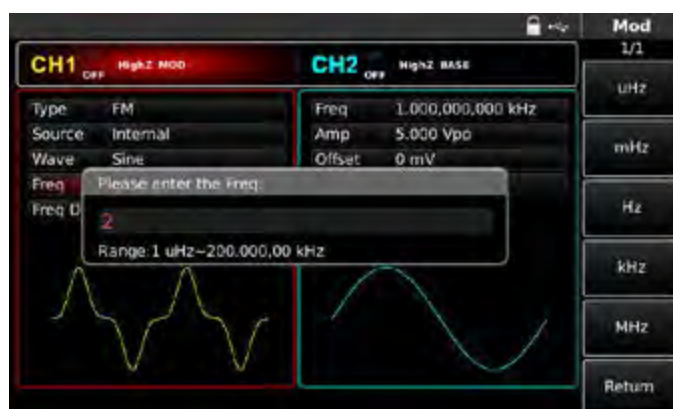
Figure 4- 19 Set frequency of modulation source

3) Set carrier signal parameters

Press **Sine** to select carrier signal as sine wave. The default carrier signal is sine wave, so it is unnecessary to change in this example.
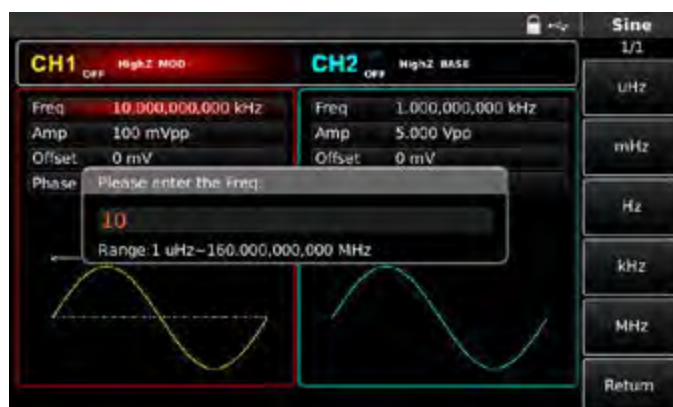
Figure 4- 20 Set carrier frequency

You can set with multi-functional knob and direction key.

To set some parameter, press corresponding soft key, input the required value and select the unit.
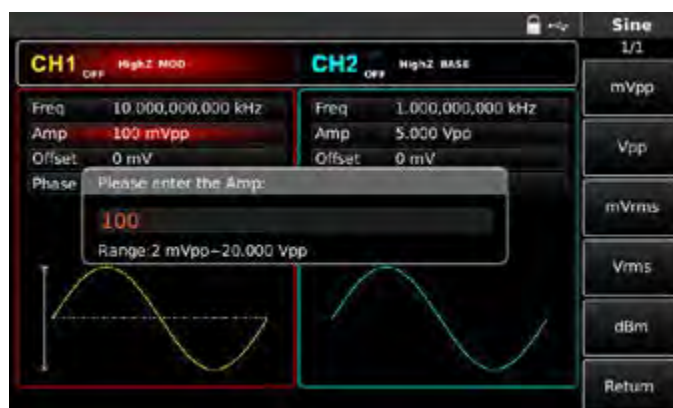
Figure 4- 21 Set carrier amplitude

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4) Set frequency deviation

Press **MOD** to return to the interface below to set frequency deviation after setting carrier parameters.
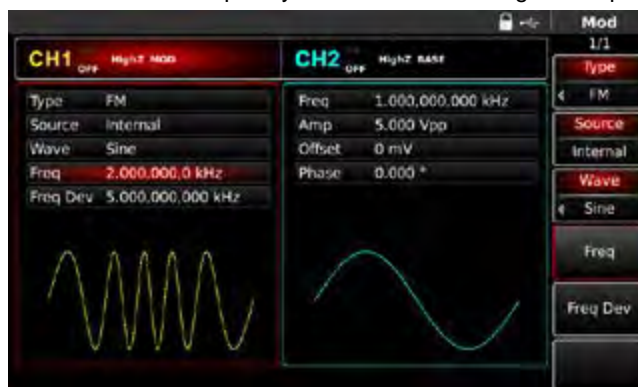
Figure 4- 22 Return to FM setting

You can set with multi-functional knob and direction key. You can also press **Freq Dev** again, input number 5 through numeric keyboard and press soft key **kHz** to set the frequency deviation.
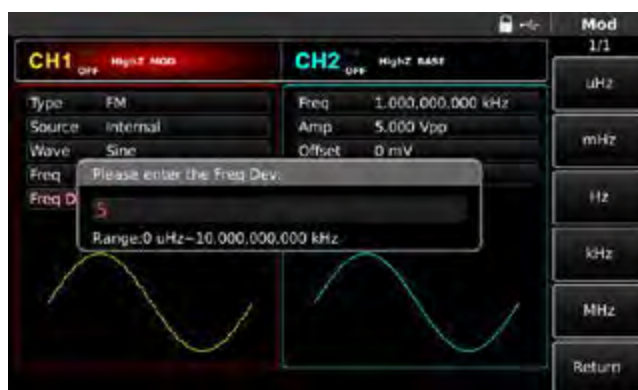
Figure 4- 23 Set frequency deviation

5) Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns gray from white, and "ON" turns white from gray, indicating that output of channel 1 is turned on.
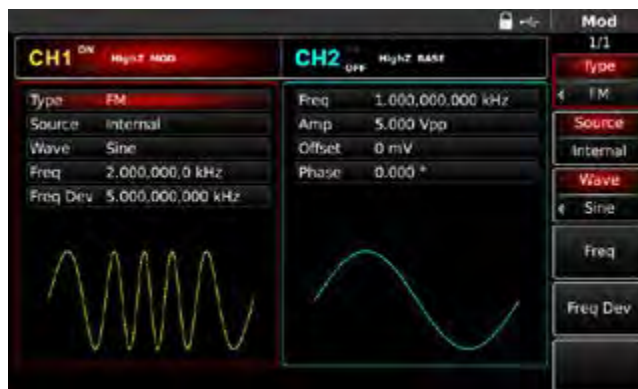
Figure 4- 24 Use channel output

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Check the shape of FM modulation waveform through oscilloscope, which is shown in the figure below:

Figure 4- 25 Observe waveform with oscilloscope

4.1.3 Phase Modulation (PM)

In phase modulation, the modulated waveform generally is composed of carrier wave and modulation wave. The phase of carrier wave will vary with amplitude of modulation wave. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select PM

Press **MOD**, **Type** and **PM** successively to use PM function (if **Type** is not highlighted, press soft key **Type** to select). After PM function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output modulated waveform with the current modulation waveform and carrier wave.
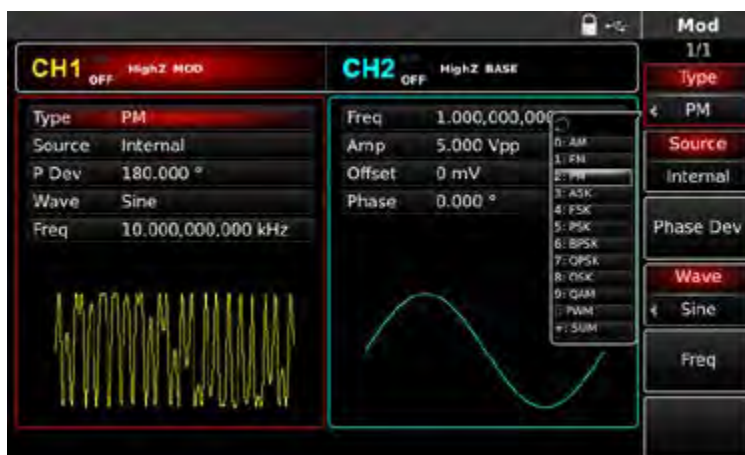
Figure 4- 26 Select PM function

Select carrier waveform

PM carrier waveform can be sine wave, square wave, sawtooth wave or arbitrary wave (except DC), and is sine wave by default. After PM is selected, press the key of basic waveform setting to enter the interface for setting carrier wave.

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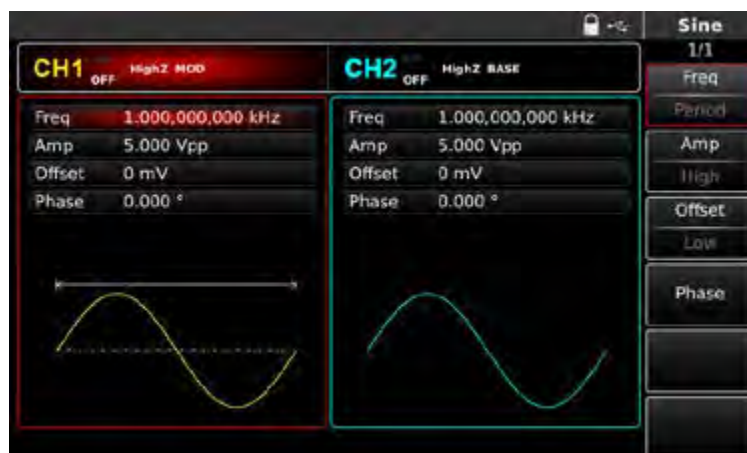
Figure 4- 27 Select carrier waveform

Set carrier frequency

Carrier frequency range varies with carrier waveform. The default frequency of all carrier waves is 1kHz. See the table below for frequency range of carrier wave:

Table 4- 3

Carrier waveform	Frequency		
	72-14120	**72-14122**	**72-14126**
Sine wave	1µHz ~ 80MHz	1µHz ~ 120MHz	1µHz ~ 160MHz
Square wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Saw tooth wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Pulse wave	1µHz ~ 2MHz	1µHz ~ 3MHz	1µHz ~ 4MHz
Arbitrary wave	1µHz ~ 30MHz	1µHz ~ 30MHz	1µHz ~ 30MHz

To set carrier frequency, please use multi-functional knob and direction key or press **Freq**, input the required value and select the unit after selecting carrier waveform.

Select modulation source

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can select internal or external modulation source. After you use PM function, you can see that modulation source is internal by default. You can change it with multi-functional knob on interface for using phase modulation or by pressing **MOD** and **Source** successively.
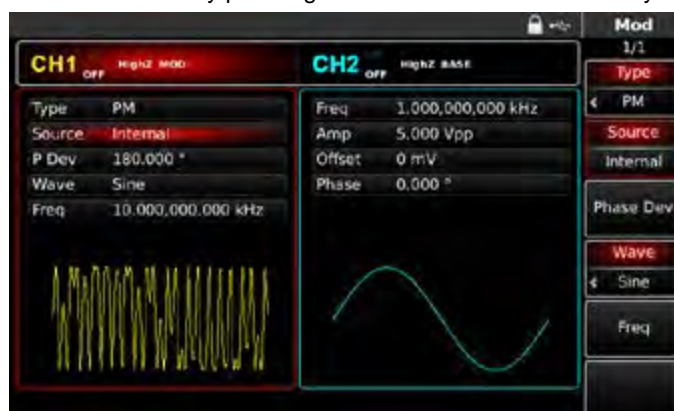
Figure 4- 28 Select modulation source

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1) Internal source

In case of internal modulation source, modulation wave can be sine wave, square wave, sawtooth wave and arbitrary wave, and is sine wave by default. After you use PM function, you can see that modulation wave is sine wave by default. You can change it with multi-functional knob on interface for using phase modulation function or by pressing the key of basic waveform type setting.

Square wave: duty ratio is 50%

Sawtooth wave: degree of symmetry is 0.10%

Arbitrary wave: when selecting arbitrary wave as modulation waveform, function/arbitrary waveform generator limits length of arbitrary wave to 32Mpts by automatic test count.

2) External source

In case of external modulation source, modulation wave and frequency will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. Phase deviation of PM is controlled by ±5V signal level on external analog modulation input terminal (Modulation In connector) of back panel. For example, if phase deviation in parameter list is set to be 180º, phase shift is 180º when external modulation signal is +5V, and lower external signal level generates less deviation.

Set modulation wave frequency

The frequency of modulation wave can be set in case of internal modulation source. After you use PM function, you can see that frequency of modulation wave is 100Hz by default. You can change it with multi-functional knob and direction key on interface for using phase modulation or by pressing **Freq**. Modulation frequency range is 2mHz~200kHz. In case of external modulation source, modulation wave and frequency will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. The frequency range of modulation signal of external input is 100Hz~20kHz.

Set phase deviation

Phase deviation is change in phase of waveform subject to PM relative to carrier phase. The range of PM phase deviation is 0º~360º, 180º by default. You can change it with multi-functional knob and direction key on interface for using phase modulation or by pressing **Phase Dev**.

Comprehensive example

First make the instrument run in phase modulation (PM) mode, and then set an internal sine wave of 200Hz as modulation signal and a sine wave with frequency of 900Hz and amplitude of 100mVpp as carrier signal. Finally set phase deviation to be 200º. The specific steps are as follows:

1) Use PM function

Press **MOD**, **Type** and **PM** successively (press soft key **Type** to select if **Type** is not highlighted) to use PM function.
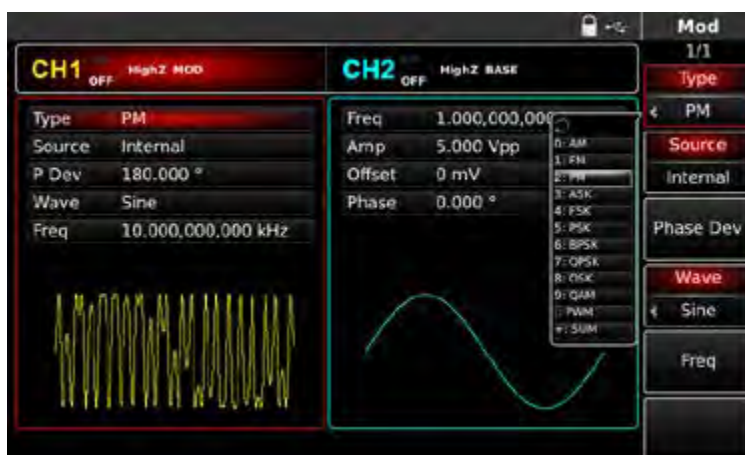

Figure 4- 29 Select PM function

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2) Set modulation signal parameters

Set with multi-functional knob and direction key after using PM function. You can also press corresponding soft keys of function on the above interface for using PM function, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.
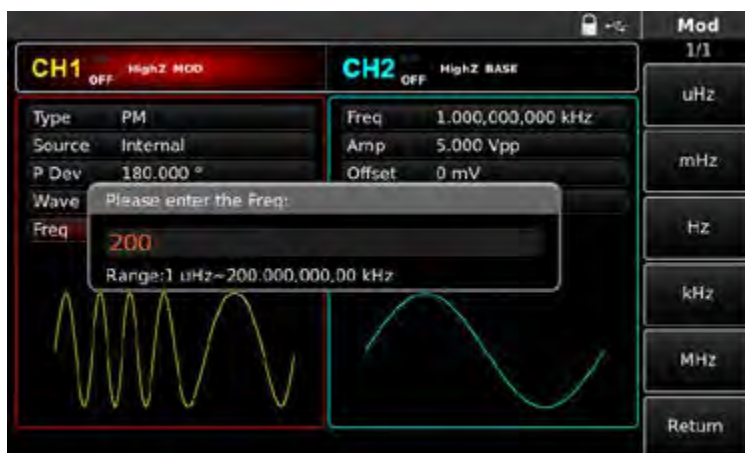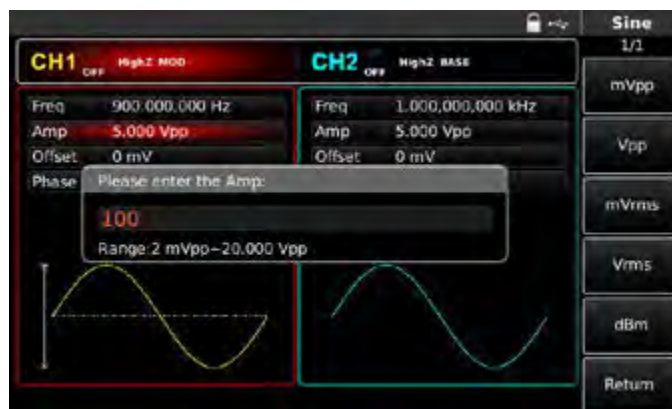

Figure 4- 30 Set modulation parameters

3) Set carrier signal parameters

Press the key of basic waveform setting **Sine** to select carrier signal as sine wave when PM modulation signal is on. The default carrier signal is sine wave, so it is unnecessary to change in this example.
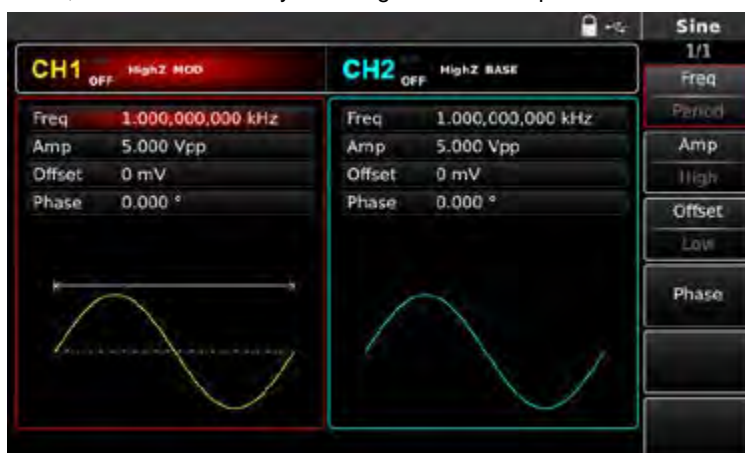
Figure 4- 31 Set carrier frequency

You can set with multi-functional knob and direction key. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.

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Figure 4- 32 Set carrier amplitude

4) Set phase deviation

Press **MOD** to return to the interface below to set phase deviation after setting carrier parameters.
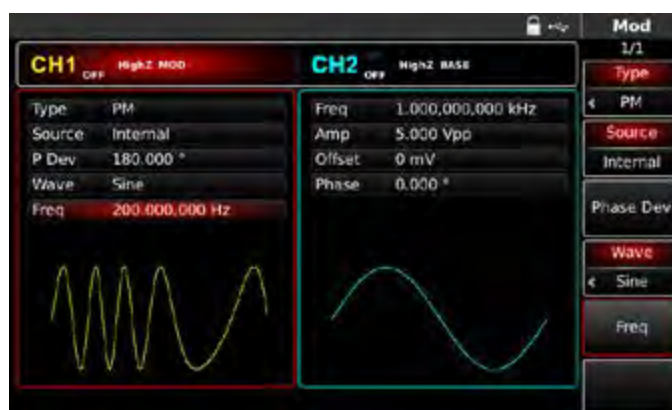
Figure 4- 33 Set modulation parameters

You can set with multi-functional knob and direction key. You can also press soft key **Phase Dev** again, input number 200 through numeric keyboard and press soft key **⁰** to set phase deviation.
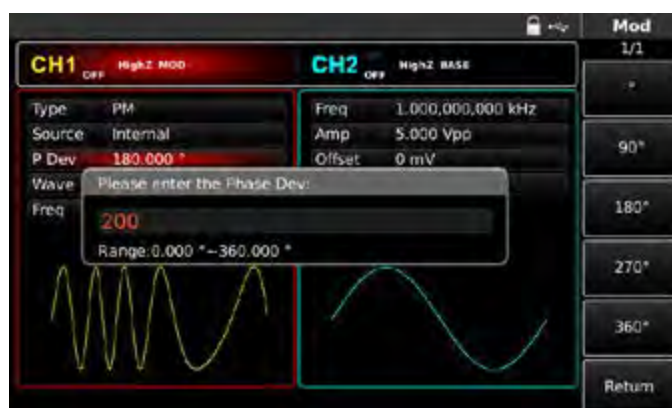
Figure 4- 34 Set phase deviation

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5) Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns gray from white, and "ON" turns white from gray, indicating that output of channel 1 is turned on.
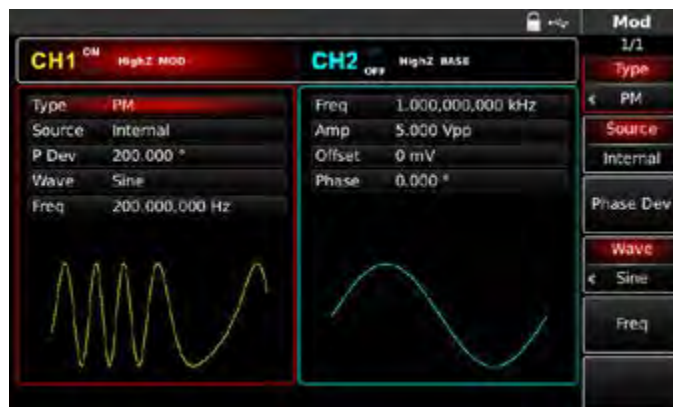
Figure 4- 35 Use channel output

Check the shape of PM modulation waveform through oscilloscope, which is shown in the figure below:

Figure 4- 36 Observe PM waveform with oscilloscope

4.1.4 Amplitude Shift Keying (ASK)

In amplitude shift keying, ASK expresses digital signals "0" and "1" by changing amplitude of carrier signal and outputs carrier signals with different amplitude according to logic of modulation signal. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select ASK modulation

Press **MOD**, **Type** and **ASK** successively to use ASK function (if **Type** is not highlighted, press soft key **Type** to select). After ASK function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output modulated waveform with the current ASK rate and carrier wave.

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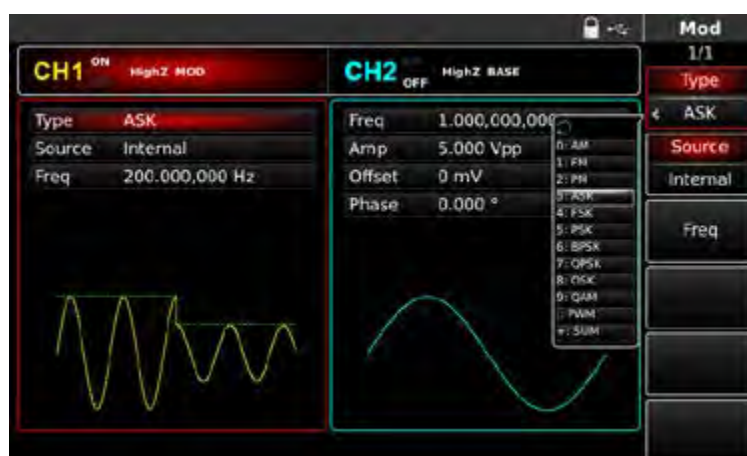
Figure 4- 37 Select ASK function

Select carrier waveform

ASK carrier waveform can be sine wave, square wave, sawtooth wave or arbitrary wave (except DC), and is sine wave by default. After ASK modulation is selected, press the key of basic waveform setting to enter the interface for selecting carrier waveform.
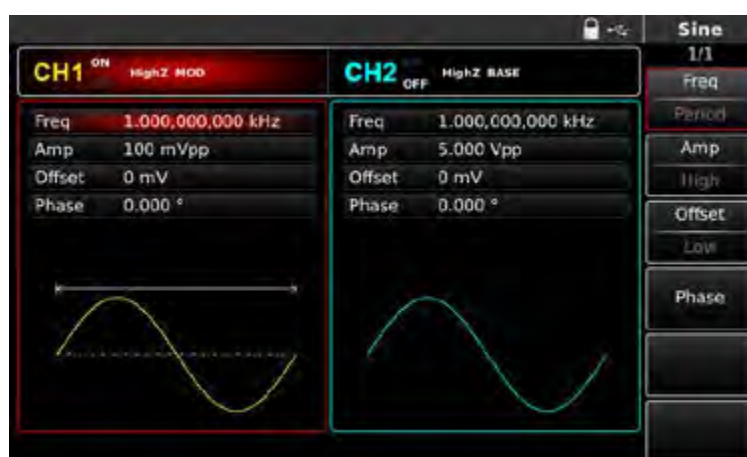
Figure 4- 38 Select carrier waveform

Set carrier frequency

Carrier frequency range varies with carrier waveform. The default frequency of all carrier waves is 1kHz. See the table below for frequency range of carrier wave:

Table 4- 4

Carrier waveform	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1µHz ~ 80MHz	1µHz ~ 120MHz	1µHz ~ 160MHz
Square wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Saw tooth wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Pulse wave	1µHz ~ 2MHz	1µHz ~ 3MHz	1µHz ~ 4MHz
Arbitrary wave	1µHz ~ 30MHz	1µHz ~ 30MHz	1µHz ~ 30MHz

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To set carrier frequency, please use multi-functional knob and direction key or press soft function key **Freq**, input the required value and select the unit after selecting carrier waveform.

Select modulation source

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can select internal or external modulation source. After you use ASK function, you can see that modulation source is internal by default. You can change it with multi-functional knob on interface for using amplitude shift keying function or by pressing Source.
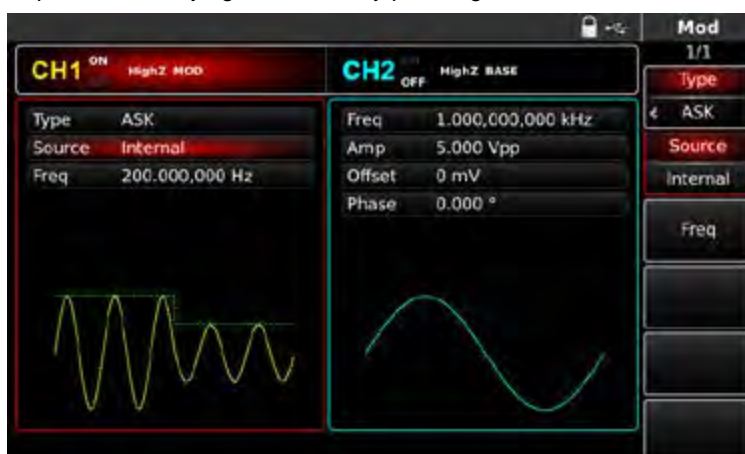
Figure 4- 39 Select modulation source

1) Internal source

In case of internal modulation source, modulation wave can be sine wave, square wave, sawtooth wave and arbitrary wave, and is sine wave by default. After you use PM function, you can see that modulation wave is sine wave by default. You can change it with multi-functional knob on interface for using phase modulation function or by pressing the key of basic waveform type setting.

Square wave: duty ratio is 50%

Sawtooth wave: degree of symmetry is 0.10%

Arbitrary wave: when selecting arbitrary wave as modulation waveform, function/arbitrary waveform generator limits length of arbitrary wave to 32Mpts by automatic test count.

2) External source

In case of external modulation source, rate will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. ASK output amplitude is determined by logic level on external digital modulation interface (FSK Trig connector). For example, when external input logic is low, the current carrier amplitude is output; when external input logic is high, output amplitude is less than the current carrier amplitude.

Set ASK rate

The frequency of ASK amplitude jump can be set in case of internal modulation source. After you use ASK function, you can set ASK rate, which is in the range of 2mHz~1MHz and 100Hz by default. You can change it with multi-functional knob and direction key on the interface for using ASK function or by pressing **Freq**.

Comprehensive example

First make the instrument run in ASK mode, and then set an internal logic signal of 300Hz as modulation signal and a sine wave with frequency of 15kHz and amplitude of 2Vpp as carrier signal. The specific steps are as follows:

Note: only the frequency of this signal can be set. This frequency is the rate of ASK amplitude jump. Logic signal is configured by the instrument.

1) Use ASK function

Press **MOD**, **Type** and **ASK** successively (press soft key **Type** to select if **Type** is not highlighted) to use ASK function.
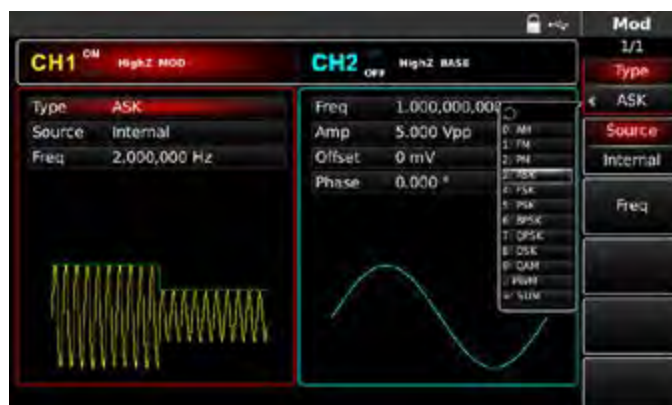
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Figure 4- 40 Select ASK function

2) Set carrier signal parameters

Press the key of basic waveform type setting **Sine** to select carrier signal as sine wave. The default carrier signal is sine wave, so it is unnecessary to change in this example.
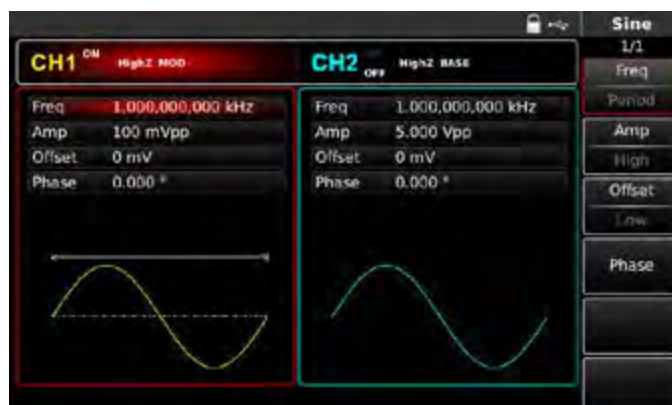

Figure 4- 41 Set carrier parameters

You can set with multi-functional knob and direction key. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.
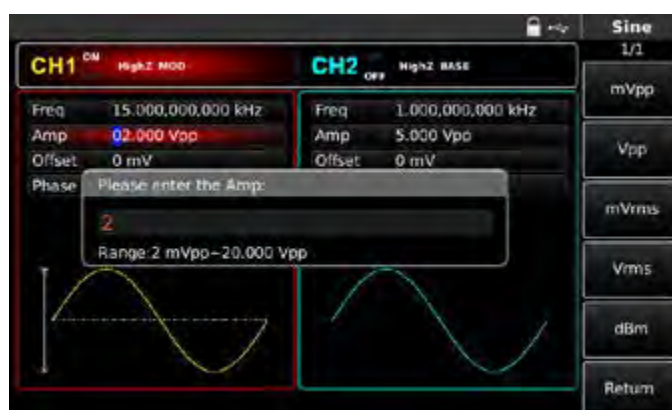
Figure 4- 42 Set carrier amplitude

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3) Set ASK rate

Press MOD to return to the interface below to set ASK rate after setting carrier parameters.

Figure 4- 43 Set ASK rate

You can set with multi-functional knob and direction key. You can also press soft function key **Freq** again, input number 300 through numeric keyboard and press soft key **Hz** to set ASK rate.
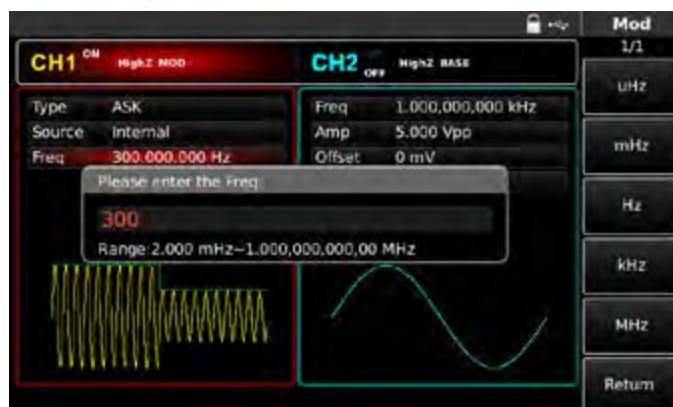
Figure 4- 44 Set ASK rate

4) Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns gray from white, and "ON" turns white from gray, indicating that output of channel 1 is turned on.
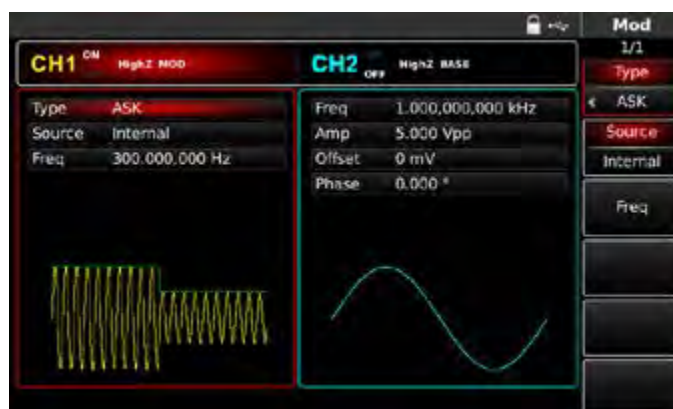
Figure 4- 45 Use channel output

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Check the shape of ASK modulation waveform through oscilloscope, which is shown in the figure below:

Figure 4- 46 Observe ASK waveform with oscilloscope

4.1.5 Frequency Shift Keying (FSK)

The function/arbitrary waveform generator can move between two preset frequency (carrier frequency and hopping frequency) in frequency shift keying. Frequency of carrier signal or hopping signal is output according to logic of modulation signal. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select FSK modulation

Press **Menu**, **Type** and **FSK** successively to use FSK function (if **Type** is not highlighted, press soft key **Type** to select). After FSK function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output modulated waveform with the current setting.
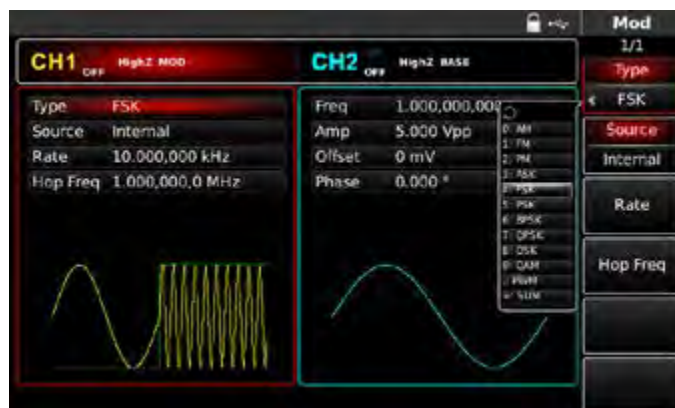
Figure 4- 47 Select FSK function

Select carrier waveform

FSK carrier waveform can be sine wave, square wave, sawtooth wave or arbitrary wave (except DC), and is sine wave by default. After FSK modulation is selected, press the key of basic waveform setting to select carrier waveform.

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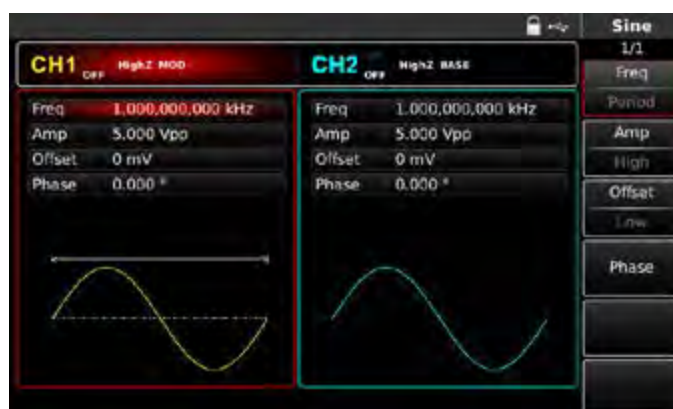
Figure 4- 48 Select carrier waveform

Set carrier frequency

Carrier frequency range varies with carrier waveform. The default frequency of all carrier waves is 1kHz. See the table below for frequency range of carrier wave:

Table 4- 5

Carrier waveform	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1µHz ~ 80MHz	1µHz ~ 120MHz	1µHz ~ 160MHz
Square wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Saw tooth wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Pulse wave	1µHz ~ 2MHz	1µHz ~ 3MHz	1µHz ~ 4MHz
Arbitrary wave	1µHz ~ 30MHz	1µHz ~ 30MHz	1µHz ~ 30MHz

To set carrier frequency, please use multi-functional knob and direction key or press soft function key **Freq**, input the required value and select the unit after selecting carrier waveform. If the current carrier waveform meets your requirements, you can also directly set carrier frequency in the interface of FSK modulation, providing more flexible and intuitive input mode for you.

Select modulation source

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can select internal or external modulation source. After you use FSK function, you can see that modulation source is internal by default. You can change it with multi-functional knob on the interface for using FSK function or by pressing **Source**.

Figure 4- 49 Select modulation source

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1) Internal source

In case of internal modulation source, modulation wave can be sine wave, square wave, sawtooth wave and arbitrary wave, and is sine wave by default. After you use PM function, you can see that modulation wave is sine wave by default. You can change it with multi-functional knob on interface for using phase modulation function or by pressing the key of basic waveform type setting.

- Square wave: duty ratio is 50%
- Sawtooth wave: degree of symmetry is 0.10%
- Arbitrary wave: when selecting arbitrary wave as modulation waveform, function/arbitrary waveform generator limits length of arbitrary wave to 32Mpts by automatic test count.

2) External source

In case of external modulation source, rate will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. FSK output frequency is determined by logic level on external digital modulation interface (FSK Trig connector). For example, when external input logic is low, carrier frequency is output; when external input logic is high, hopping frequency is output.

Set hopping frequency

After you use FSK function, you can see that default hopping frequency is 1MHz. You can change it with multi-functional knob and direction key on interface for using FSK function or by pressing **Hop Freq**. The range of hopping frequency depends on carrier waveform. See the table below for frequency range of carrier wave:

Table 4- 6

Carrier waveform	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1µHz ~ 80MHz	1µHz ~ 120MHz	1µHz ~ 160MHz
Square wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Saw tooth wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Pulse wave	1µHz ~ 2MHz	1µHz ~ 3MHz	1µHz ~ 4MHz
Arbitrary wave	1µHz ~ 30MHz	1µHz ~ 30MHz	1µHz ~ 30MHz

Set FSK rate

The frequency between carrier frequency and hopping frequency can be set in case of internal modulation source. After you use FSK function, you can set FSK rate, which is in the range of 2mHz~100kHz and 100Hz by default. You can change it with multi-functional knob and direction key on the interface for using FSK function or by pressing **Rate**.

Note: FSK rate can only be changed after FSK function is used. Press **MOD**, **Type** and **FSK** successively (press soft key **Type** to select if **Type** is not highlighted) to use FSK function.

Comprehensive example

First make the instrument run in FSK mode, and then set an internal sine wave of 2kHz and 1Vpp as carrier signal. Set hopping frequency to be 800Hz. Finally set frequency between carrier frequency and hopping frequency to be 200Hz. The specific steps are as follows:

1)Use FSK function

Press **MOD**, **Type** and **FSK** successively (press soft key **Type** to select if **Type** is not highlighted) to use FSK function.
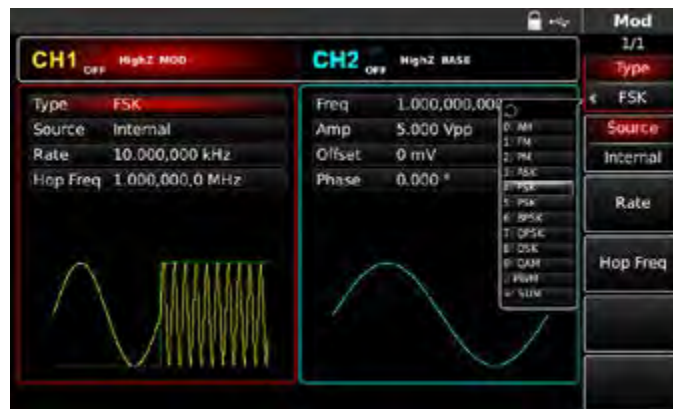
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Figure 4- 50 Select FSK function

2) Set carrier signal parameters

Press **Sine** to select carrier signal as sine wave. The default carrier signal is sine wave, so it is unnecessary to change in this example.

You can set with multi-functional knob and direction key. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.
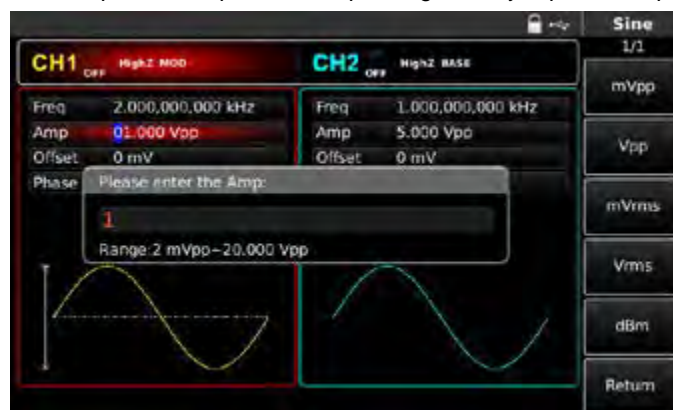

Figure 4- 51 Set carrier parameters

3) Set hopping frequency and FSK rate

Press **MOD** to return to the interface below after setting carrier parameters:
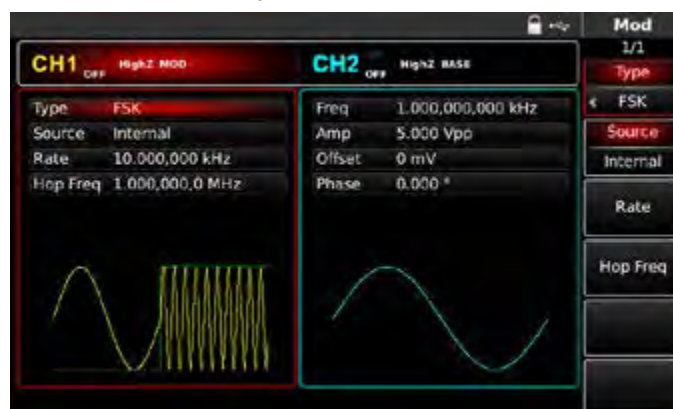
Figure 4- 52 Set modulation amplitude

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You can set with multi-functional knob and direction key directly on this interface. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.
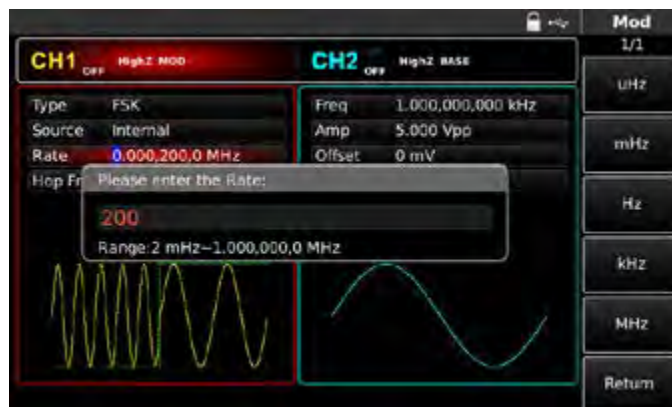
Figure 4- 53 Set FSK rate

4) Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns gray from white, and "ON" turns white from gray, indicating that output of channel 1 is turned on.
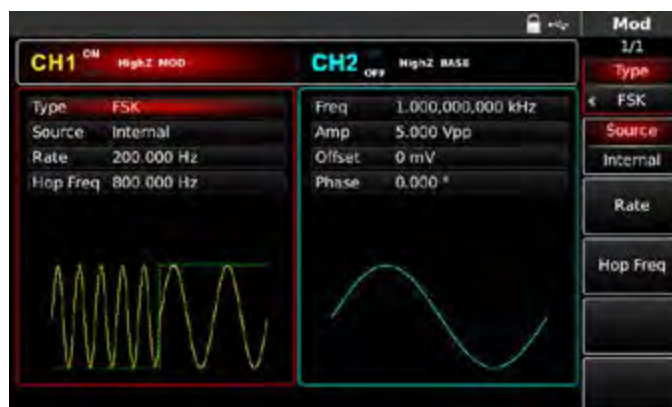
Figure 4- 54 Use channel output

Check the shape of FSK modulation waveform through oscilloscope, which is shown in the figure below:

Figure 4- 55 Observe FSK waveform with oscilloscope

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4.1.6 Phase Shift Keying (PSK)

The function/arbitrary waveform generator can move between two preset phases (carrier phase and modulation phase) in phase shift keying. Phase of carrier signal or modulation signal is output according to logic of modulation signal. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select PSK modulation

Press **MOD**, **Type** and **PSK** successively to use PSK function (if **Type** is not highlighted, press soft key Type to select). After PSK function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output modulated waveform with the current carrier phase and modulation phase.
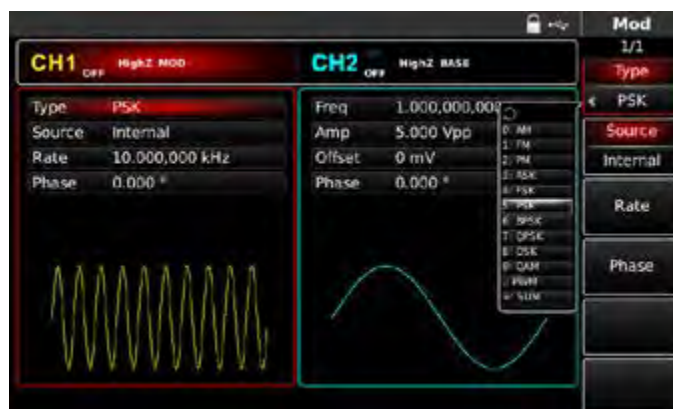
Figure 4- 56 Select PSK function

Select carrier waveform

PSK carrier waveform can be sine wave, square wave, sawtooth wave or arbitrary wave (except DC), and is sine wave by default. After PSK modulation is selected, press the key of basic waveform setting to select carrier waveform.
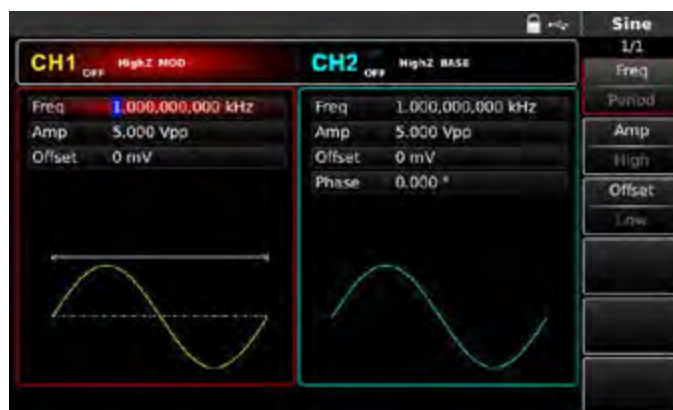
Figure 4- 57 Select carrier waveform

Set carrier frequency

Carrier frequency range varies with carrier waveform. The default frequency of all carrier waves is 1kHz. See the table below for frequency range of carrier wave:

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Table 4- 7

Carrier waveform	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1μHz ~ 80MHz	1μHz ~ 120MHz	1μHz ~ 160MHz
Square wave	1μHz ~ 30MHz	1μHz ~ 40MHz	1μHz ~ 50MHz
Saw tooth wave	1μHz ~ 30MHz	1μHz ~ 40MHz	1μHz ~ 50MHz
Pulse wave	1μHz ~ 2MHz	1μHz ~ 3MHz	1μHz ~ 4MHz
Arbitrary wave	1μHz ~ 30MHz	1μHz ~ 30MHz	1μHz ~ 30MHz

To set carrier frequency, please use multi-functional knob and direction key or press soft key **Freq**, input the required value and select the unit after selecting carrier waveform.

Select modulation source

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can select internal or external modulation source. After you use PSK function, you can see that modulation source is internal by default. You can change it with multi-functional knob on the interface for using PSK function or by pressing soft function key **Source**.

Figure 4- 58 Select modulation source

1) Internal source

In case of internal modulation source, modulation wave can be sine wave, square wave, sawtooth wave and arbitrary wave, and is sine wave by default. After you use PM function, you can see that modulation wave is sine wave by default. You can change it with multi-functional knob on interface for using phase modulation function or by pressing the key of basic waveform type setting.

• Square wave: duty ratio is 50%
• Sawtooth wave: degree of symmetry is 0.10%
• Arbitrary wave: when selecting arbitrary wave as modulation waveform, function/arbitrary waveform generator limits length of arbitrary wave to 32Mpts by automatic test count

2) External source

In case of external modulation source, rate will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. PSK output phase is determined by logic level on external digital modulation interface (FSK Trig connector). For example, when external input logic is low, carrier phase is output; when external input logic is high, modulation phase is output.

Set PSK rate

The frequency between carrier phase and modulation phase can be set in case of internal modulation source. After you use PSK function, you can set PSK rate, which is in the range of 2mHz~1MHz and 10kHz by default. You can change it with multi-functional knob and direction key on the interface for using PSK function or by pressing **Rate**.

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Set modulation phase

Modulation phase is change in phase of waveform subject to PSK modulation relative to carrier phase. The range of PSK modulation phase is 0º~360º, 180º by default. You can change it with multi-functional knob and direction key on interface for using PSK function or by pressing **Parameter Phase** successively.

Comprehensive example

First make the instrument run in PSK mode, and then set an internal sine wave of 2kHz and 2Vpp as carrier signal. Finally set frequency between carrier phase and modulation phase to be1kHz and phase to be 180º. The specific steps are as follows:

1) Use PSK function

Press **MOD**, **Type** and **PSK** successively (press soft key Type to select if **Type** is not highlighted) to use PSK function.
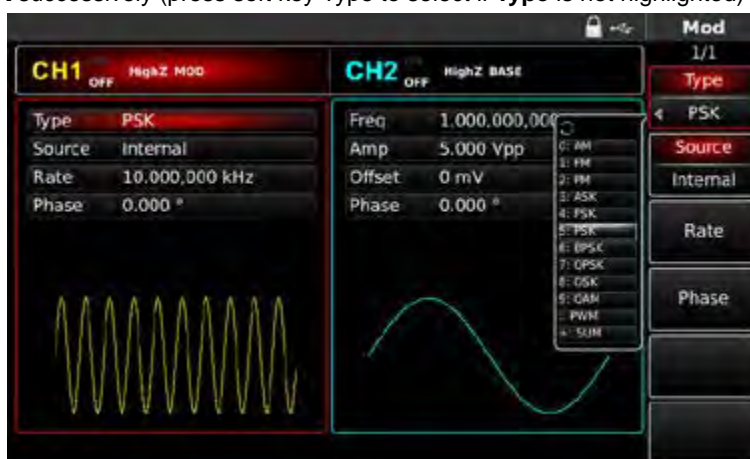
Figure 4- 59 Select PSK function

2) Set carrier signal parameters

Press the key of basic waveform type setting Sine to select carrier signal as sine wave. The default carrier signal is sine wave, so it is unnecessary to change in this example. You can set with multi-functional knob and direction key. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.
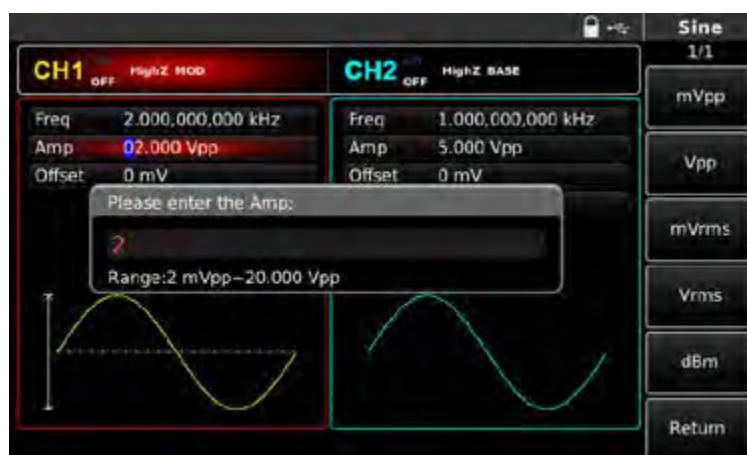
Figure 4- 60 Set modulation parameters

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3) Set PSK rate and modulation phase

Press **MOD** to return to the interface below after setting carrier parameters:
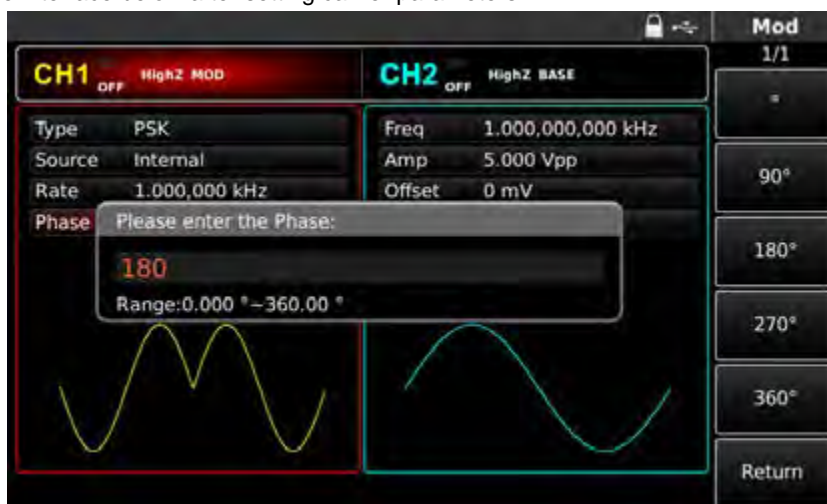
Figure 4- 61 Set modulation parameters

You can set with multi-functional knob and direction key directly on this interface. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.

4) Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of CH1 is on after channel output is turned on, "OFF" on the right of CH1 information tag turns grey from white, and "ON" turns white from grey, indicating that output of channel 1 is turned on.
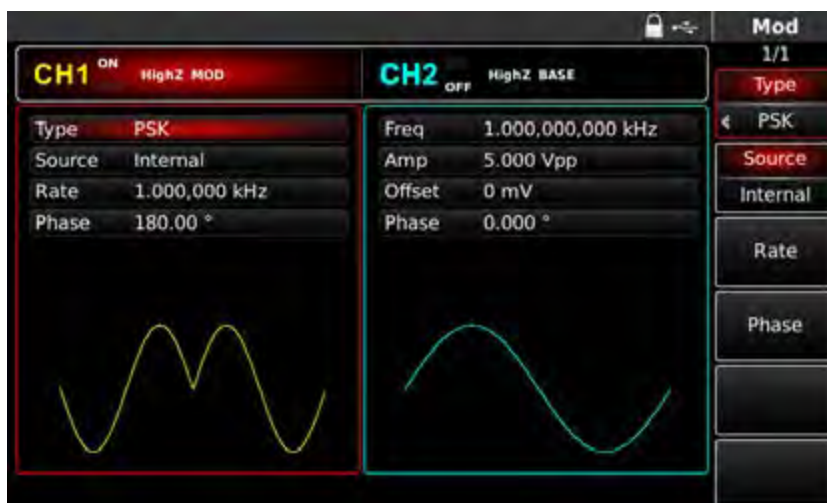
Figure 4- 62 Use channel output

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Check the shape of PSK modulation waveform through oscilloscope, which is shown in the figure below:
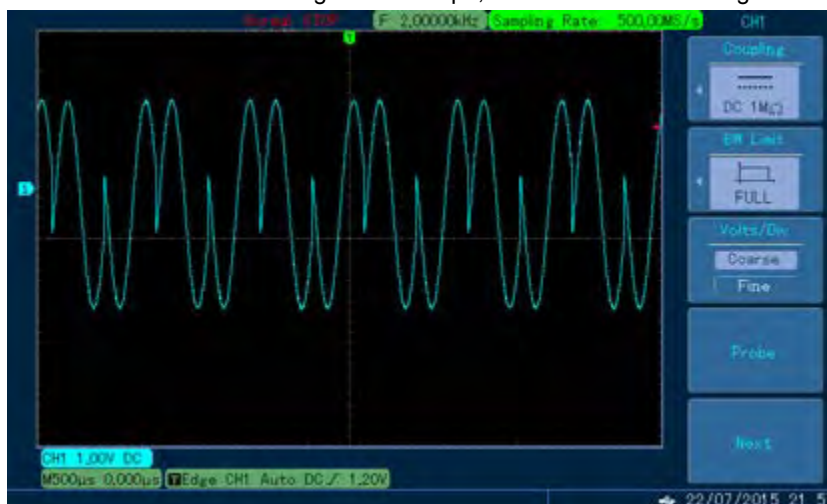
Figure 4- 63 Observe PSK waveform with oscilloscope

4.1.7 Binary Phase Shift Keying (BPS)

The function/arbitrary waveform generator can move between two preset phases (carrier phase and modulation phase) in binary phase shift keying, expressing 0 and 1. Phase of carrier signal or modulation signal is output according to logic of modulation signal. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select BPSK modulation

Press **MOD**, **Type** and **BPSK** successively to use BPSK function (if **Type** is not highlighted, press soft key **Type** to select). After BPSK function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output modulated waveform with the current carrier phase (0° by default and unadjustable) and modulation phase.
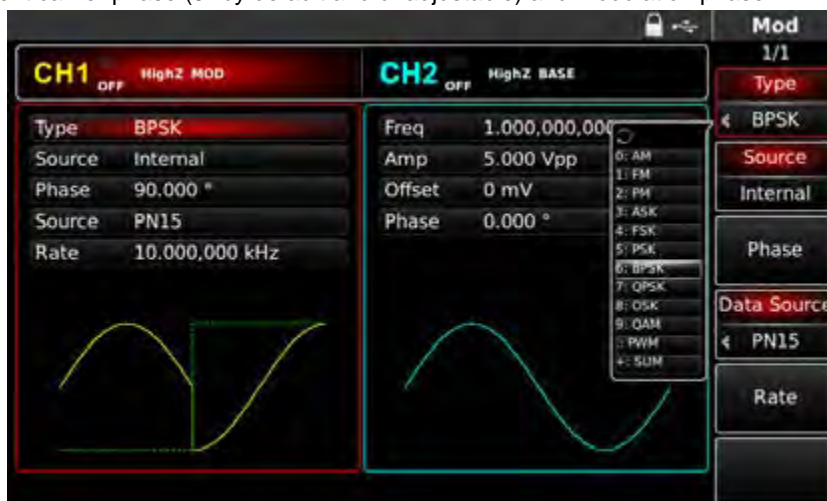
Figure 4- 64 Select BPSK function

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Select carrier waveform

BPSK carrier waveform can be sine wave, square wave, sawtooth wave or arbitrary wave (except DC), and is sine wave by default. After PSK modulation is selected, press the key of basic waveform setting to select carrier waveform.
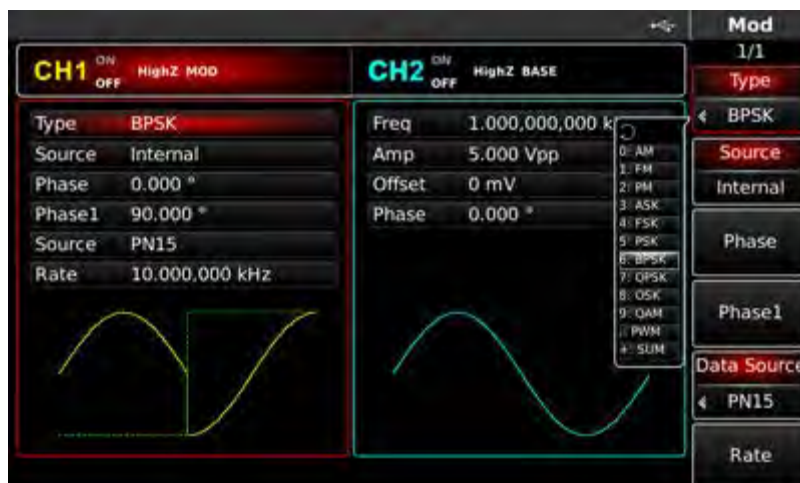
Figure 4- 65 Select carrier waveform

Set carrier frequency

Carrier frequency range varies with carrier waveform. The default frequency of all carrier waves is 1kHz. See the table below for frequency range of carrier wave:

Table 4- 8

Carrier waveform	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1µHz ~ 80MHz	1µHz ~ 120MHz	1µHz ~ 160MHz
Square wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Saw tooth wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Pulse wave	1µHz ~ 2MHz	1µHz ~ 3MHz	1µHz ~ 4MHz
Arbitrary wave	1µHz ~ 30MHz	1µHz ~ 30MHz	1µHz ~ 30MHz

To set carrier frequency, please use multi-functional knob and direction key or press soft key **Freq**, input the required value and select the unit after selecting carrier waveform.

Select modulation source

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can select internal or external modulation source. After you use BPSK function, you can see that modulation source is internal by default. You can change it with multi-functional knob on the interface for using PSK function or by pressing soft function key **Source**.

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Figure 4- 66 Select modulation source

1) Internal source

In case of internal modulation source, modulation wave can be sine wave, square wave, sawtooth wave and arbitrary wave, and is sine wave by default. After you use PM function, you can see that modulation wave is sine wave by default. You can change it with multi-functional knob on interface for using phase modulation function or by pressing the key of basic waveform type setting.

- Square wave: duty ratio is 50%
- Sawtooth wave: degree of symmetry is 0.10%
- Arbitrary wave: when selecting arbitrary wave as modulation waveform, function/arbitrary waveform generator limits length of arbitrary wave to 32Mpts by automatic test count.

2) External source

In case of external modulation source, rate will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. BPSK output phase is determined by logic level on external digital modulation interface (FSK Trig connector). For example, when external input logic is low, carrier phase is output; when external input logic is high, modulation phase is output.

Set BPSK rate

The frequency between carrier phase and modulation phase can be set. After you use BPSK function, you can set BPSK rate, which is in the range of 2mHz~1MHz and 10kHz by default. You can change it with multi-functional knob and direction key on the interface for using PSK function or by pressing **Rate**.

Set PN code

The relationship between carrier phase and modulation phase can be set in case of internal modulation source. After you use BPSK function, you can set PN code, which is divided into four types: PN15, PPN21, 01 and 10. You can change it with multi-functional knob and direction key on the interface for using PSK function or by pressing **Data Source**.

Set modulation phase

Modulation phase is change in phase of waveform subject to PSK modulation relative to carrier phase. The range of BPSK modulation phase is 0º~360º, 90º by default. You can change it with multi-functional knob and direction key on interface for using PSK function or by pressing **Phase**.

Comprehensive example

First make the instrument run in BPSK mode, and then set an internal sine wave of 2kHz and 2Vpp as carrier signal. Finally set carrier phase and initial modulation phase to be 90 º, frequency between phases to be 1kHz and PN code to be PN15. The specific steps are as follows:

Use BPSK function

Press **MOD**, **Type** and **BPSK** successively (press soft key **Type** to select if **Type** is not highlighted) to use BPSK function.

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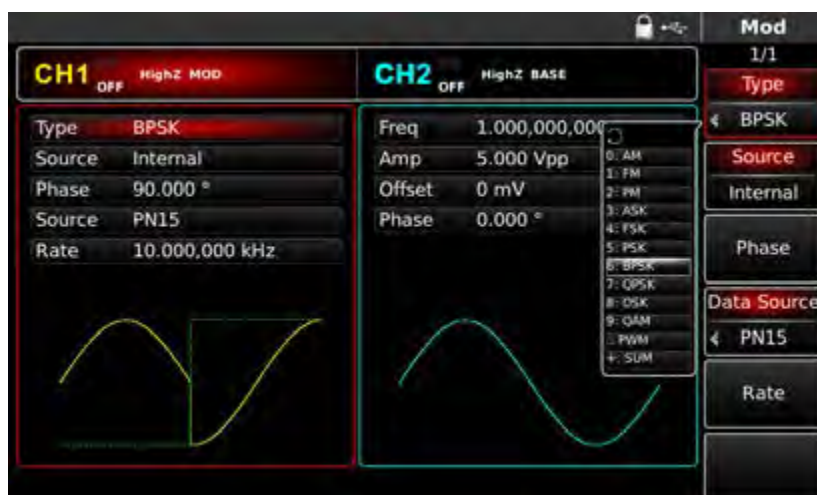
Figure 4- 67 Select BPSK function

2) Set carrier signal parameters

Press the key of basic waveform type setting **Sine** to select carrier signal as sine wave. The default carrier signal is sine wave, so it is unnecessary to change in this example. You can set with multi-functional knob and direction key. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.
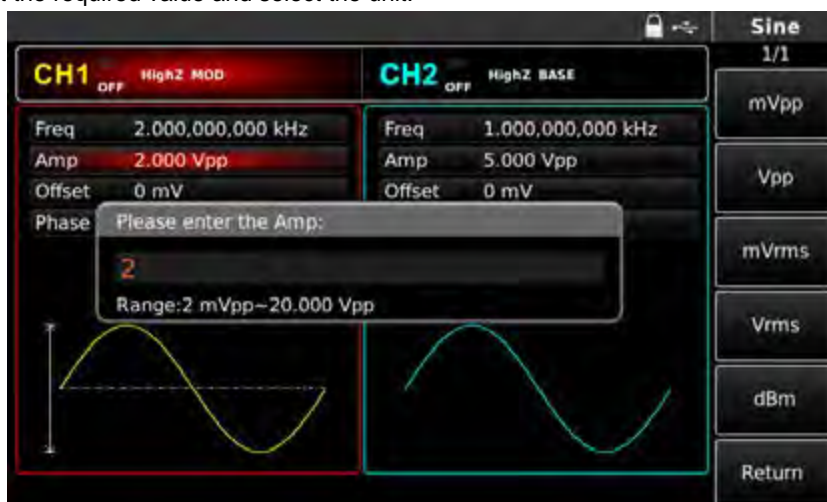
Figure 4- 68 Set carrier parameters

3) Set BPSK initial phase, rate, modulation phase and PN code

Press **MOD** to return to the interface below after setting carrier parameters:

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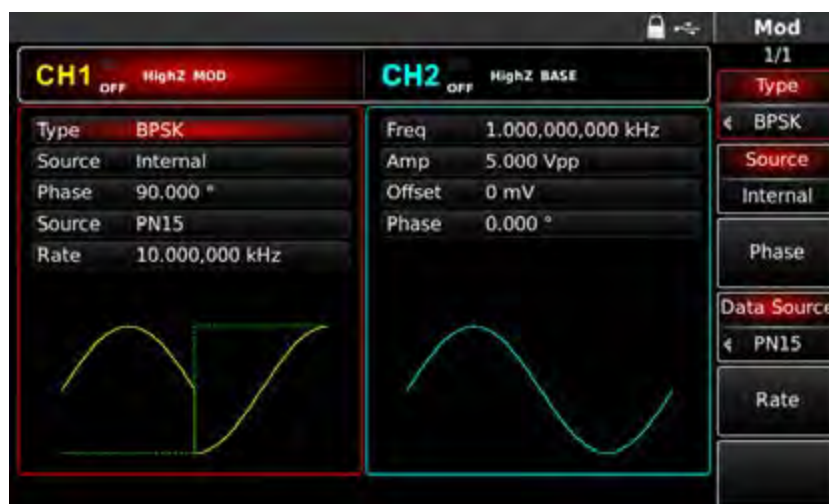
Figure 4- 69 Set modulation parameters

You can set with multi-functional knob and direction key directly on this interface. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.
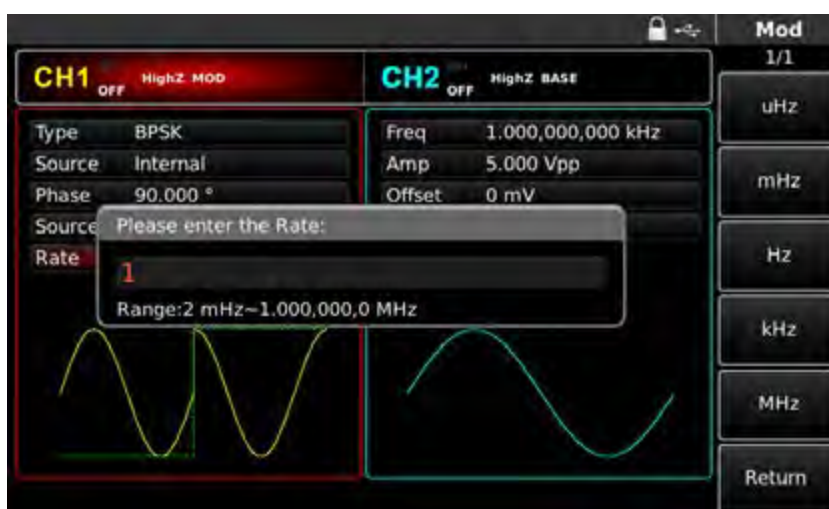
Figure 4- 70 Set modulation rate

4) Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns grey from white, and "ON" turns white from grey, indicating that output of channel 1 is turned on.

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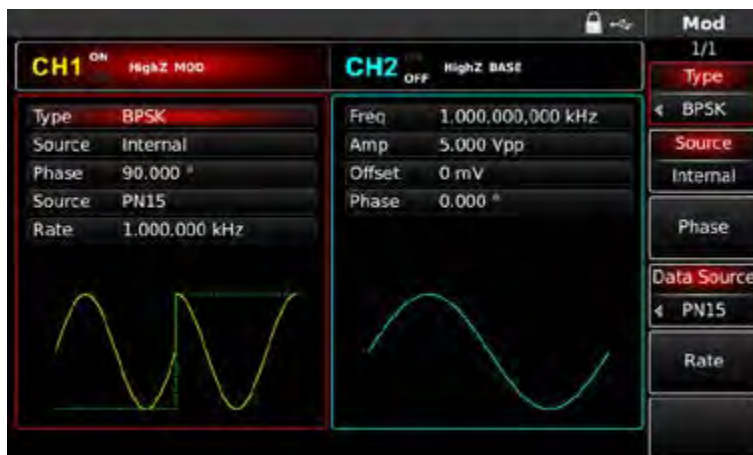
Figure 4- 71 Use channel output

Check the shape of BPSK modulation waveform through oscilloscope, which is shown in the figure below:

Figure 4- 72 Observe BPSK waveform with oscilloscope

4.1.8 Quadrature Phase Shift Keying (QPSK)

The function/arbitrary waveform generator can move between four preset phases (carrier phase and 3 modulation phases) in QPSK. Phase of carrier signal or modulation signal is output according to logic of modulation signal. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select QPSK modulation

Press **MOD, Type** and **QPSK** successively to use QPSK function (if **Type** is not highlighted, press soft key **Type** to select). After QPSK function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output modulated waveform with the current carrier phase and modulation phase.

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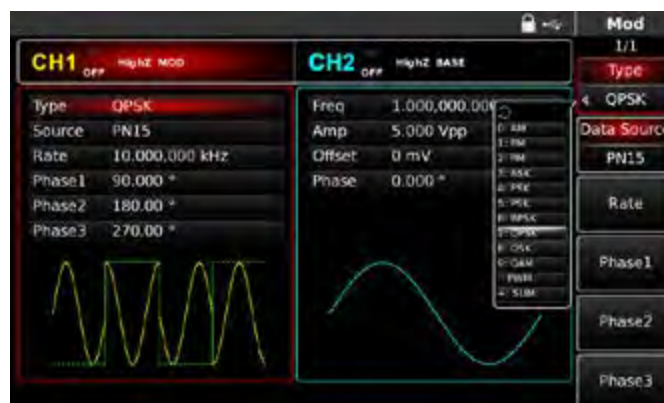
Figure 4- 73 Select QPSK function

Select carrier waveform

QPSK carrier waveform can be sine wave, square wave, sawtooth wave or arbitrary wave (except DC), and is sine wave by default. After QPSK modulation is selected, press the key of basic waveform setting to select carrier waveform.
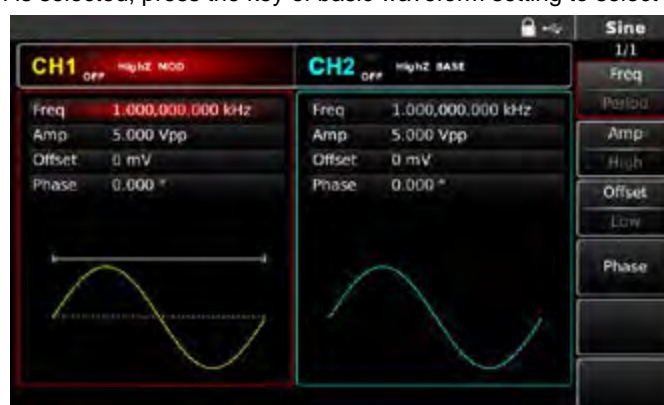
Figure 4- 74 Select carrier waveform

Set carrier frequency

Carrier frequency range varies with carrier waveform. The default frequency of all carrier waves is 1kHz. See the table below for frequency range of carrier wave:

Table 4- 9

Carrier waveform	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1µHz ~ 80MHz	1µHz ~ 120MHz	1µHz ~ 160MHz
Square wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Saw tooth wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Pulse wave	1µHz ~ 2MHz	1µHz ~ 3MHz	1µHz ~ 4MHz
Arbitrary wave	1µHz ~ 30MHz	1µHz ~ 30MHz	1µHz ~ 30MHz

To set carrier frequency, please use multi-functional knob and direction key or press soft key **Freq**, input the required value and select the unit after selecting carrier waveform.

Select modulation data source

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72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can select PN15 or PN21. After you use QPSK function, you can see that modulation data source is PN15 by default. You can change it with multi-functional knob on the interface for using PSK function or by pressing soft function key **Data Source**.
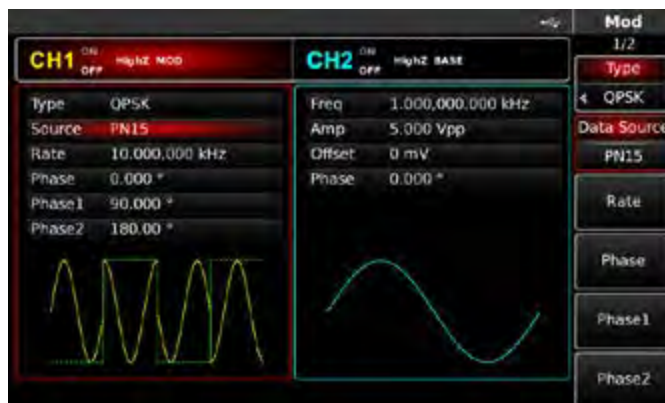
Figure 4- 75 Select modulation source

Set QPSK rate

The frequency between carrier phase and modulation phase can be set. After you use QPSK function, you can set QPSK rate, which is in the range of 2mHz~1MHz and 10kHz by default. You can change it with multi-functional knob and direction key on the interface for using PSK function or by pressing **Rate**.

Set modulation phase

Modulation phase is change in phase of waveform subject to QPSK modulation relative to carrier phase. The range of QPSK modulation phase is 0º~360º. The three default modulation sources are 90º, 180º and 270º. You can change it with multi-functional knob and direction key on interface for using PSK function or by pressing **Phase1**, **Phase2** and **Phase3**.

Comprehensive example

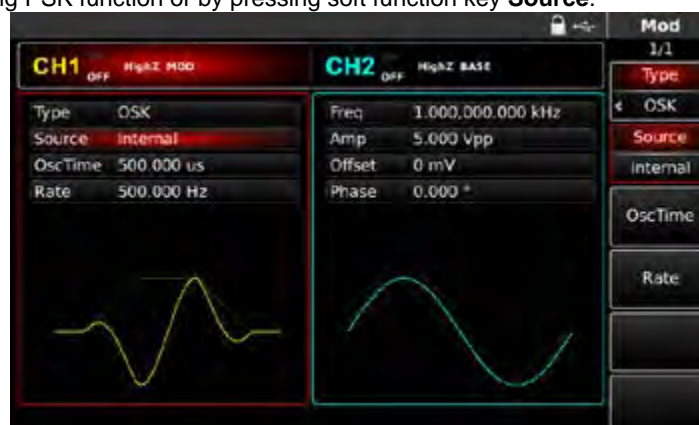First make the instrument run in QPSK mode, and then set an internal sine wave of 2kHz and 2Vpp as carrier signal. Finally set the three carrier phases and initial modulation phase to be 90º, 180º and 270º, frequency between phases to be 1kHz, and PN code to be PN15. The specific steps are as follows:

1) Use QPSK function

Press **MOD**, **Type** and **QPSK** successively (press soft key **Type** to select if **Type** is not highlighted) to use QPSK function.
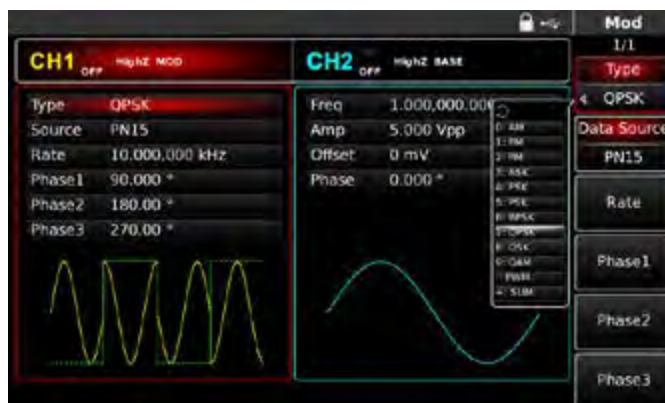
Figure 4- 76 Select QPSK function

2) Set carrier signal parameters

Press the key of basic waveform type setting **Sine** to select carrier signal as sine wave. The default carrier signal is sine wave, so it is unnecessary to change in this example. You can set with multi-functional knob and direction key. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.

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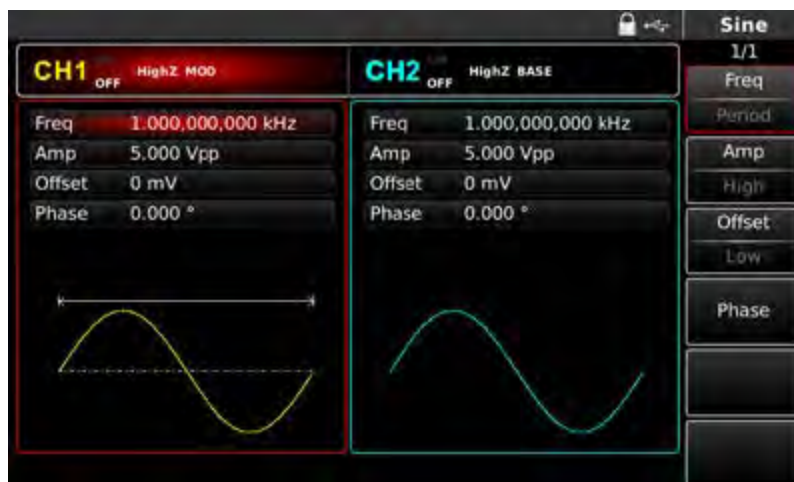
Figure 4- 77 Set carrier parameters

3) Set QPSK rate, modulation phase and PN code

Press **MOD** to return to the interface below after setting carrier parameters:
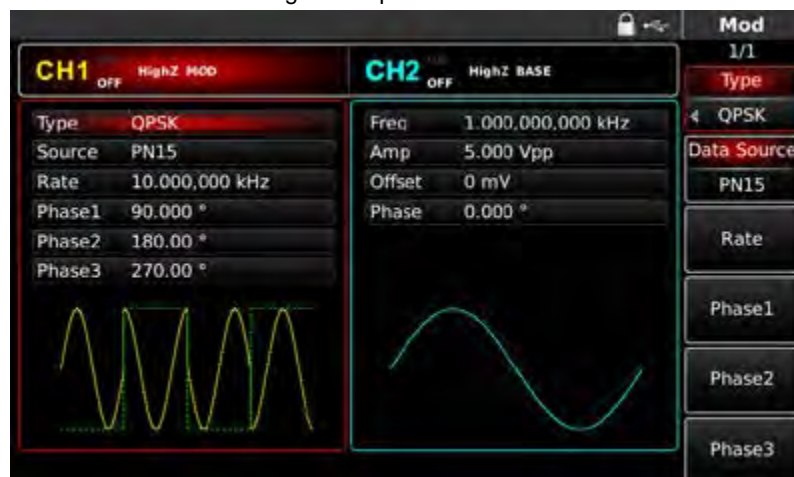
Figure 4- 78 Set QPSK parameters

You can set with multi-functional knob and direction key directly on this interface. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.

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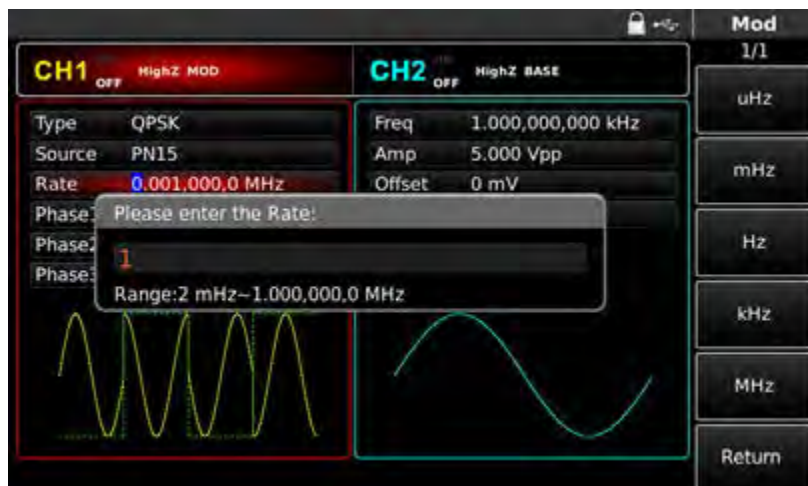
Figure 4- 79 Set QPSK rate

4) Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns grey from white, and "ON" turns white from grey, indicating that output of channel 1 is turned on.
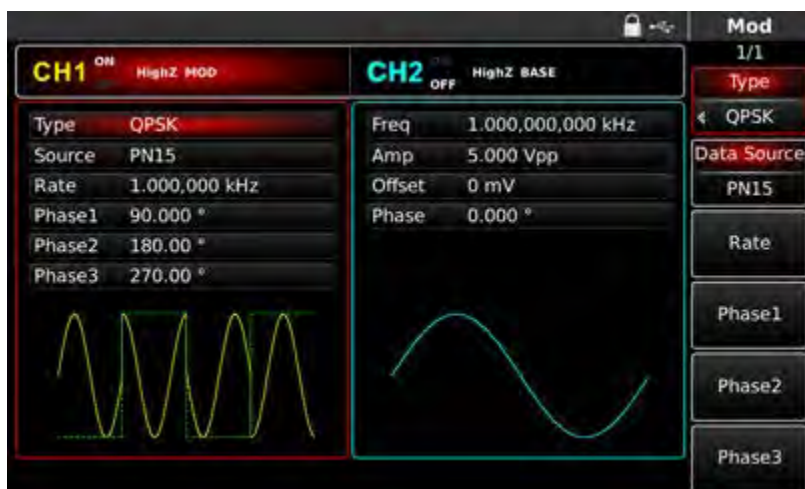
Figure 4- 80 Use channel output

Check the shape of QPSK modulation waveform through oscilloscope, which is shown in the figure below:

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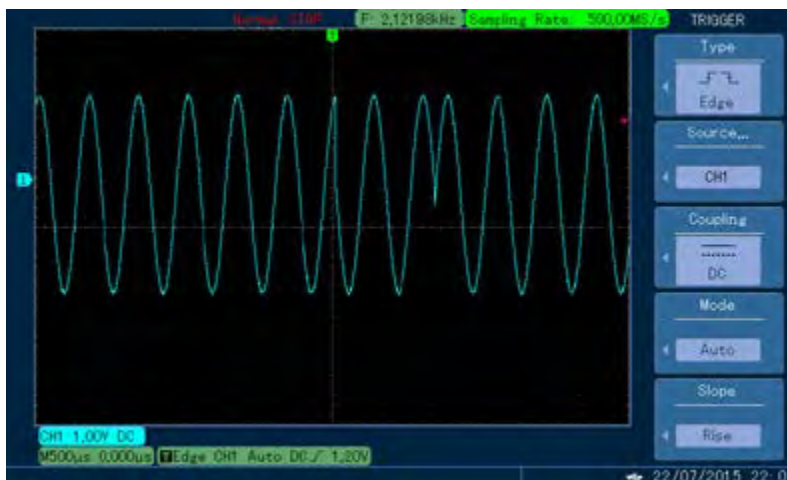
Figure 4- 81 Observe QPSK waveform with oscilloscope

4.1.9 Oscillation Keying (OSK)

The function/arbitrary waveform generator can output a sinusoidal signal of intermittent oscillation in OSK. Carrier waveform is output when internal crystal oscillator starts oscillation; output is stopped when internal crystal oscillator stops oscillation. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select OSK modulation

Press **MOD**, **Type** and **OSK** successively to use BPSK function (if **Type** is not highlighted, press soft key **Type** to select).After OSK function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output modulated waveform with the current carrier phase (0º by default and unadjustable) and modulation phase.
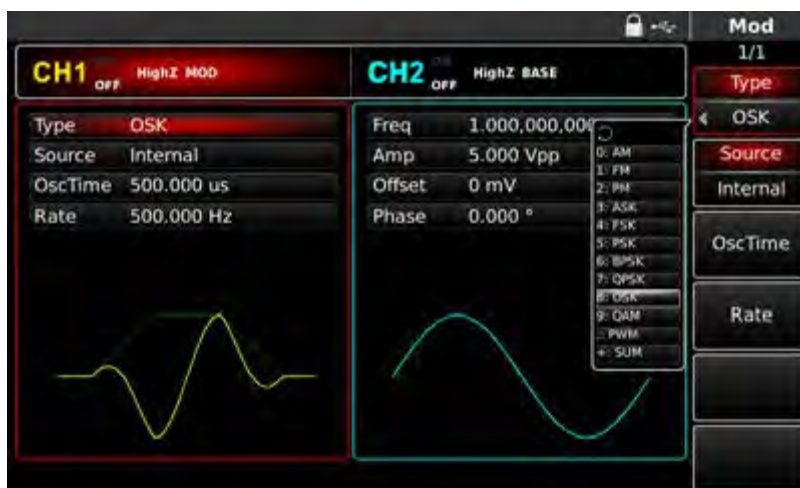
Figure 4- 82 Select OSK function

Select carrier waveform

OSK carrier waveform is sine wave.

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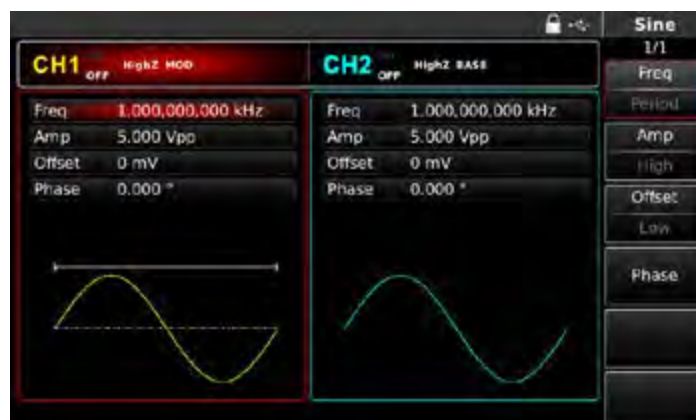
Figure 4- 83 Select carrier waveform

Set carrier frequency

The default frequency of carrier wave is 1kHz. See the table below for frequency range of carrier wave:

Table 4- 10

Carrier wave-form	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1μHz~ 80MHz	1μHz ~ 120MHz	1μHz ~ 160MHz

To set carrier frequency, please use multi-functional knob and direction key or press soft key **Freq**, input the required value and select the unit.

Select modulation source

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can select internal or external modulation source. After you use PSK function, you can see that modulation source is internal by default. You can change it with multi-functional knob on the interface for using PSK function or by pressing soft function key **Source**.

Figure 4- 84 Select modulation source

1) Internal source

In case of internal modulation source, internal modulation wave is sine wave. The phase relation between oscillation starting and stop can be designated by setting OSK rate.

2) External source

In case of external modulation source, rate will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. OSK output phase is determined by logic level on external digital modulation interface (FSK Trig connector). For example, when external input logic is low, carrier phase is output; when external input logic is high, modulation phase is output.

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Set OSK rate

The frequency between carrier phase and modulation phase can be set in case of internal modulation source. After you use OSK function, you can set QPSK rate, which is in the range of 2mHz~1MHz and 500Hz by default. You can change it with multi-functional knob and direction key on the interface for using PSK function or by pressing **Rate**.

Set oscillation period

Oscillation period is oscillation period of internal crystal oscillator. Press soft function key **OcsTime** to highlight it, and input the required value through numeric keyboard or direction key and knob, which is in the range of 8ns -1ms and 50µs by default.

Comprehensive example

First make the instrument run in OSK mode, and then set an internal sine wave of 2kHz and 2Vpp as carrier signal. Set rate to be 100Hz and oscillation period to be 1µs. The specific steps are as follows:

1) OSK function

Press **MOD, Type** and **OSK** successively (press soft key **Type** to select if **Type** is not highlighted) to use OSK function.

Figure 4- 85 Select OSK function

2) Set carrier signal parameters

Press the key of basic waveform type setting **Sine** to select carrier signal as sine wave. The default carrier signal is sine wave, so it is unnecessary to change in this example. You can set with multi-functional knob and direction key. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.

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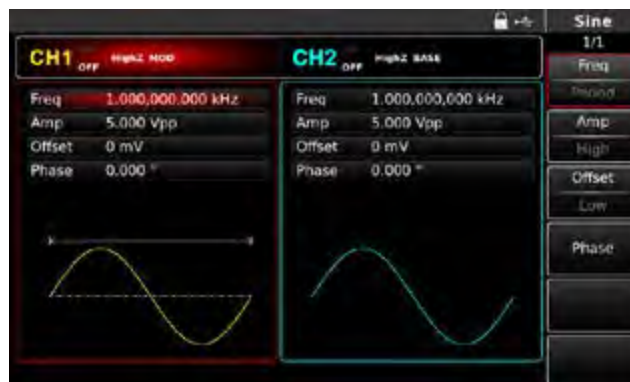
Figure 4- 86 Set carrier parameters

3) Set OSK rate, modulation phase and PN code

Press **MOD** to return to the interface below after setting carrier parameters:
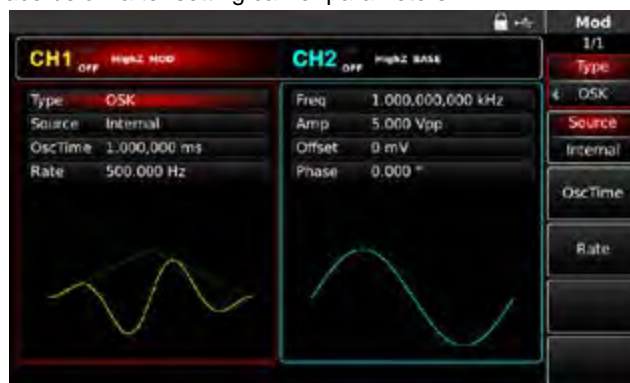
Figure 4- 87 Set modulation parameters

You can set with multi-functional knob and direction key directly on this interface. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.
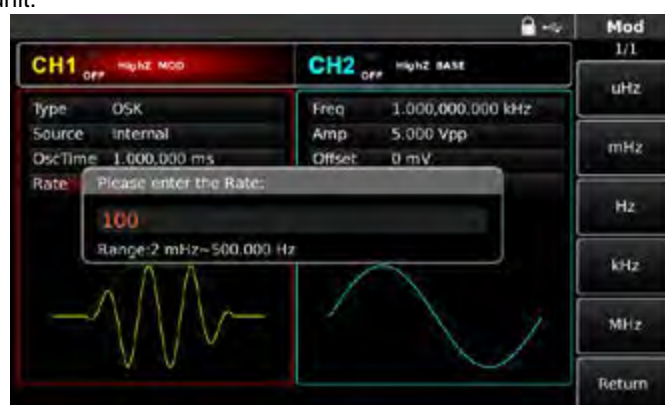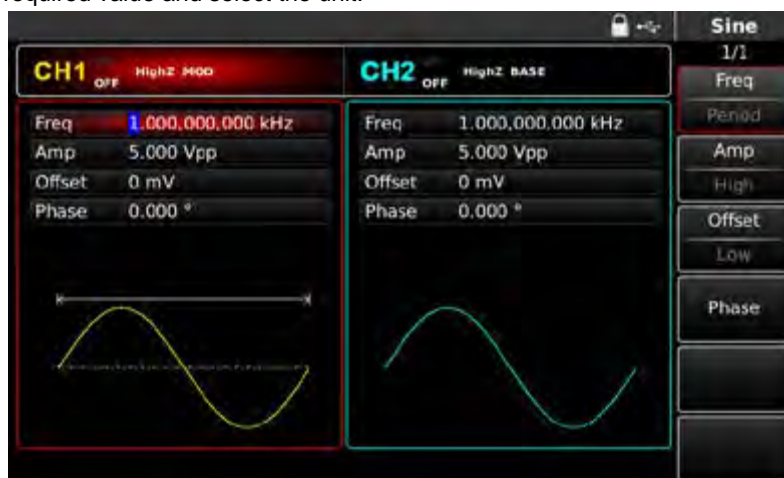

Figure 4- 88 Set modulation rate

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4) Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns grey from white, and "ON" turns white from grey, indicating that output of channel 1 is turned on.
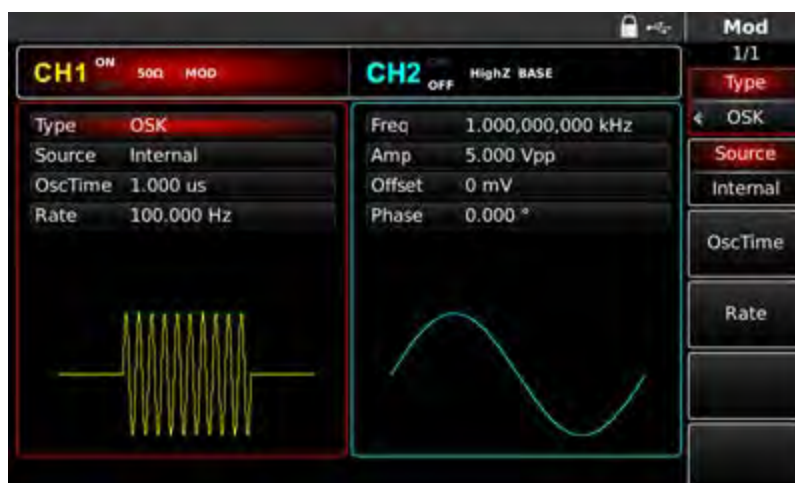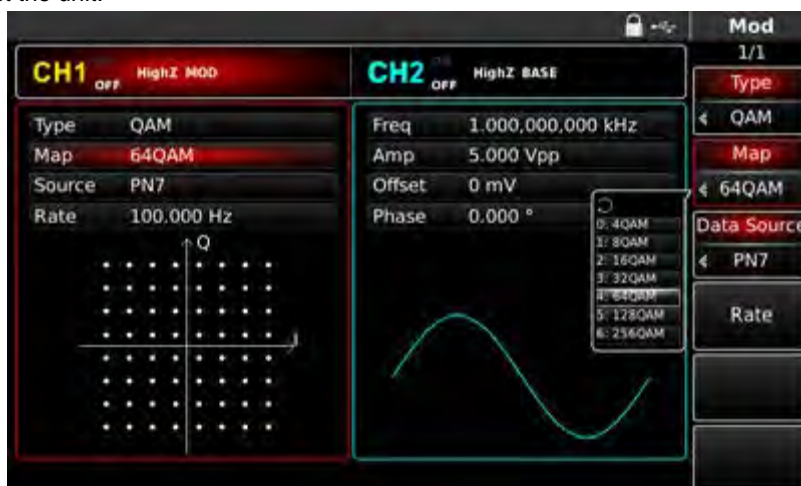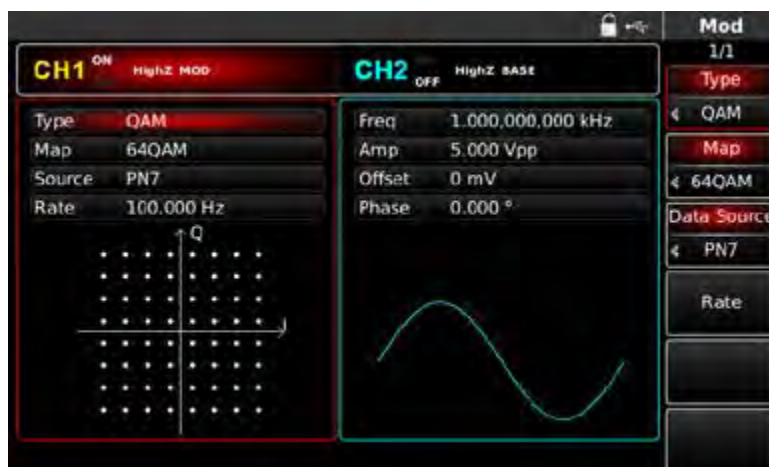

Figure 4- 89 Use channel output

Check the shape of OSK modulation waveform through oscilloscope, which is shown in the figure below:
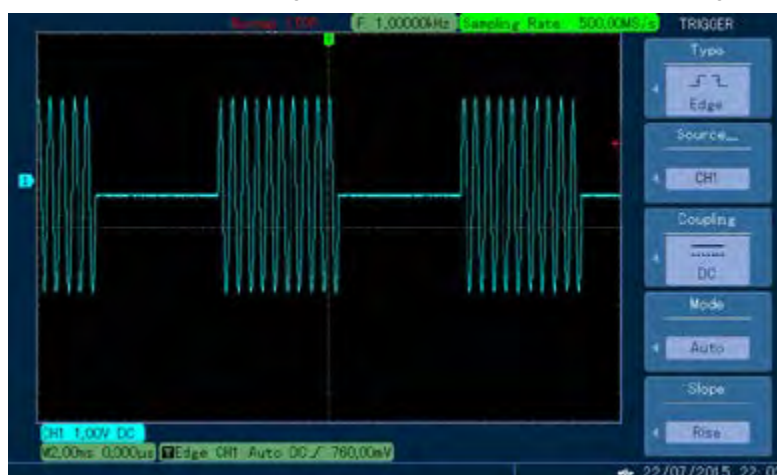
Figure 4- 90 Observe OSK waveform with oscilloscope

4.1.10 Quadrature Amplitude Modulation (QAM)

In QAM, two signals of the same frequency but with phase difference of 90° are used as carrier wave, which is subject to amplitude modulation with baseband signal. 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can output seven modulation modes: 4QAM, 8QAM, 16QAM, 32QAM, 64QAM, 128QAM and 256QAM. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select QAM

Press **MOD, Type** and **QAM** successively to use QAM function (if **Type** is not highlighted, press soft key **Type** to select). After QAM function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output modulated waveform with the current carrier phase (0º by default and unadjustable) and modulation phase.

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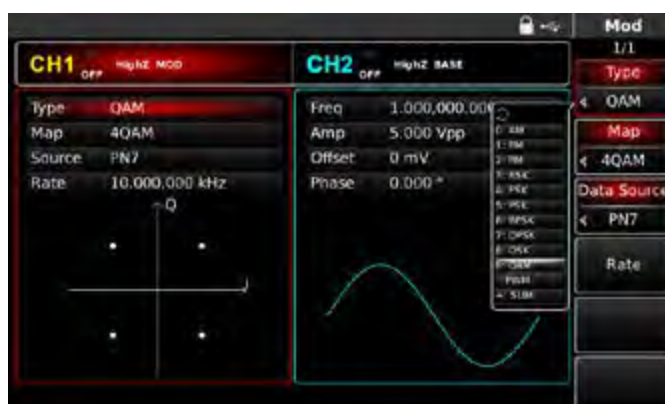
Figure 4- 91 Select QAM function

Select carrier waveform

QAM carrier waveform is sine wave.
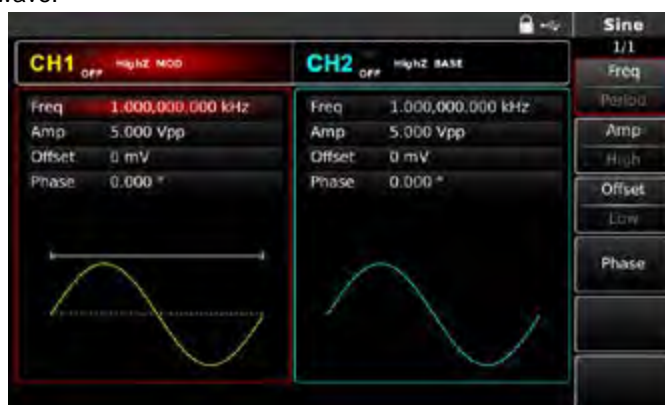
Figure 4- 92 Select carrier waveform

Set carrier frequency

Table 4- 11

Carrier waveform	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1μHz~ 80MHz	1μHz ~ 120MHz	1μHz ~ 160MHz

To set carrier frequency, please use multi-functional knob and direction key or press soft key **Freq**, input the required value and select the unit after selecting carrier waveform.

Set modulation mode

Modulation mode is subsection of constellation, which varies with the modulation mode selected. Press soft function key **Map** to highlight it, and input the required period value through numeric keyboard or direction key and knob, which can be 4QAM, 8QAM, 16QAM, 32QAM, 64QAM, 128QAM or 256QAM.

Comprehensive example

First make the instrument run in QAM mode, and then set an internal sine wave of 2kHz and 2Vpp as carrier signal. Set rate to be 100Hz and modulation mode to be 64QAM. The specific steps are as follows:

1) QAM function

Press **MOD, Type** and **QAM** successively (press soft key **Type** to select if **Type** is not highlighted) to use QAM function.

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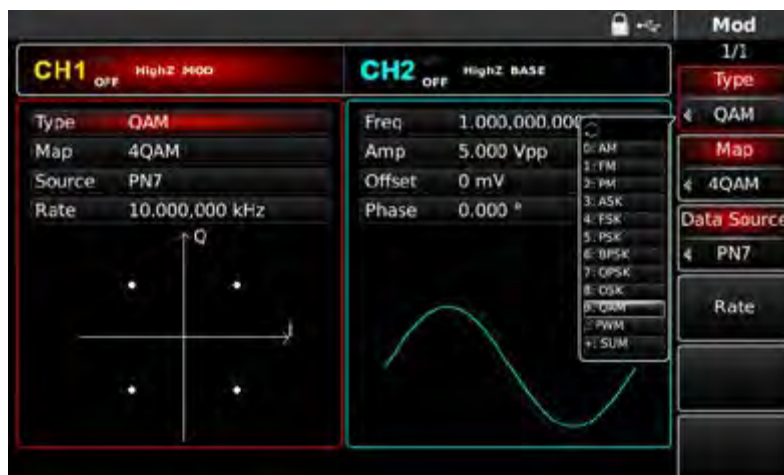
Figure 4- 93 Select QAM function

3) Set carrier signal parameters

Press the key of basic waveform type setting **Sine** to select carrier signal as sine wave. The default carrier signal is sine wave, so it is unnecessary to change in this example. You can set with multi-functional knob and direction key. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.

Figure 4- 94 Set carrier parameters

3) Set QAM modulation mode, PN code and modulation rate

Press MOD to return to the interface below after setting carrier parameters:

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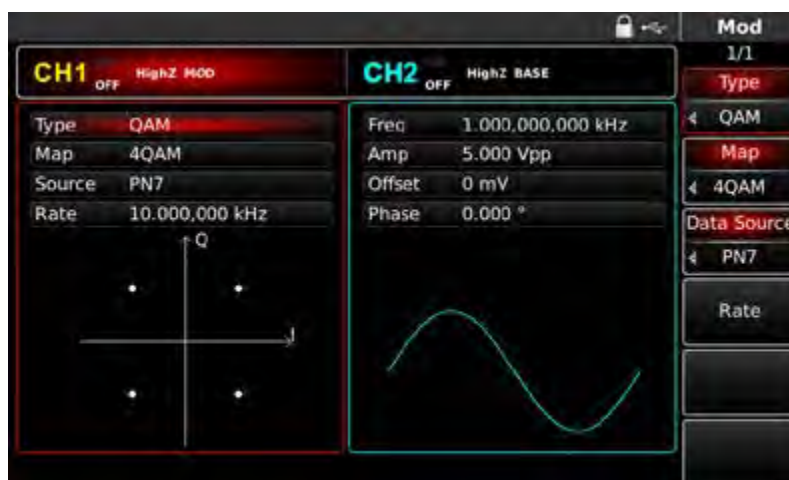
Figure 4- 95 Set modulation parameters

You can set with multi-functional knob and direction key directly on this interface. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.

Figure 4- 96 Set modulation rate

4) Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns grey from white, and "ON" turns white from grey, indicating that output of channel 1 is turned on.

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Figure 4- 97 Use channel output

Check the shape of QAM modulation waveform through oscilloscope, which is shown in the figure below:

Figure 4- 98 Observe QAM waveform with oscilloscope

4.1.11 Sum Modulation (SUM)

In SUM, the modulated waveform generally is composed of carrier wave and modulation wave. The output waveform is obtained by the sum of product of carrier amplitude and modulation factor and product of amplitude of modulation wave and modulation factor. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select SUM

Press **MOD, Type** and **SUM** successively to use SUM function (if **Type** is not highlighted, press soft key **Type** to select). After SUM function is used, UTG4000A function/arbitrary waveform generator will output modulated waveform with the current modulation waveform and carrier wave.

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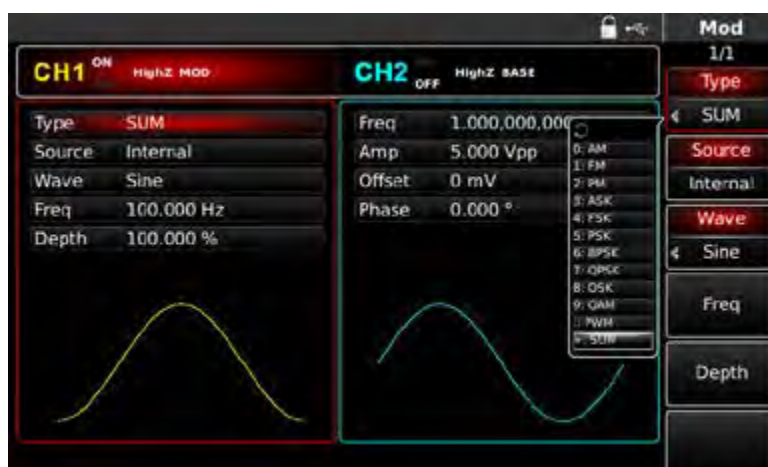
Figure 4- 99 Select SUM function

Select carrier waveform

SUM carrier waveform can be sine wave, square wave, sawtooth wave or arbitrary wave (except DC), and is sine wave by default. After SUM is selected, press the key of basic waveform setting to quickly set corresponding carrier waveform.

Set carrier frequency

Carrier frequency range varies with carrier waveform. The default frequency of all carrier waves is 1kHz. See the table below for frequency range of carrier wave:

Table 4- 12

Carrier waveform	Frequency		
	UTG4082A	UTG4122A	UTG4162A
Sine wave	1µHz~ 80MHz	1µHz ~ 120MHz	1µHz ~ 160MHz
Square wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Sawtooth wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Pulse wave	1µHz ~ 2MHz	1µHz ~ 3MHz	1µHz ~ 4MHz
Arbitrary wave	1µHz ~ 30MHz	1µHz ~ 30MHz	1µHz ~ 30MHz

To set carrier frequency, please use multi-functional knob and direction key or press corresponding key, input the required value and select the unit.

Select modulation source

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can select internal or external modulation source. After you use SUM function, you can see that modulation source is internal by default. You can change it with multi-functional knob on the interface for using SUM function or by pressing function menu **Source**.

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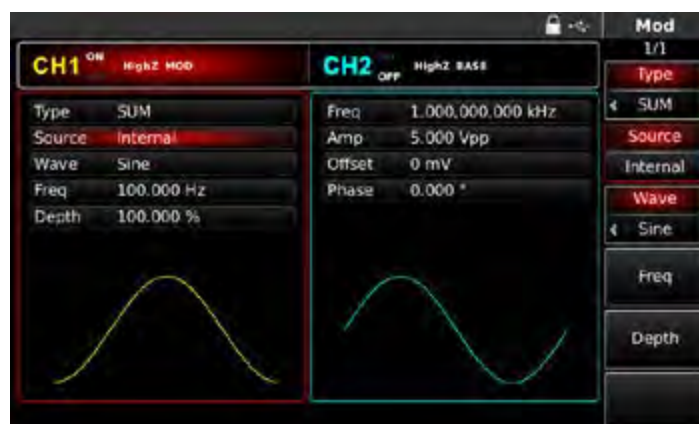
Figure 4- 100 Select modulation source

1) Internal source

In case of internal modulation source, modulation wave can be sine wave, square wave, ascending sawtooth wave, descent sawtooth wave, arbitrary wave and noise, and is sine wave by default. After you use SUM function, you can see that modulation wave is sine wave by default. You can change it with multi-functional knob on interface for using amplitude modulation function or by pressing **Wave**.

- Square wave: duty ratio is 50%
- Sawtooth wave: degree of symmetry is 0.10%
- Arbitrary wave: when selecting arbitrary wave as modulation waveform, function/arbitrary waveform generator limits length of arbitrary wave to 32Mpts by automatic test count.
- Noise: white Gaussian noise

2) External source

In case of external modulation source, modulation wave and frequency will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. SUM depth is controlled by ±5V signal level on external analog modulation input terminal (Modulation In connector) of back panel. For example, if modulation depth in parameter list is set to be 100%, SUM output amplitude is the maximum when external modulation signal is +5V and the minimum when external modulation signal is -5V.

Set frequency of modulation wave

The frequency of modulation wave can be set in case of internal modulation source. After you use SUM function, you can see that default frequency of modulation wave is 10kHz. You can change it with multi-functional knob and direction key on interface for using amplitude modulation function or by pressing **Freq**. The range of modulation frequency is 2mHz~100k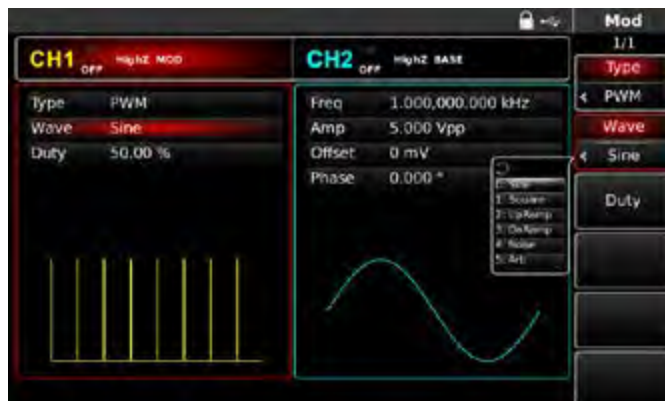Hz. In case of external modulation source, modulation wave and frequency will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. The frequency range of modulation signal of external input is 2mHz~20kHz.

Set modulation depth

Modulation depth is degree of amplitude change, expressed in percentage. The range of SUM depth is 0%~100%, 100% by default. When modulation depth is 0%, carrier wave is output. When modulation depth is 100%, modulation wave is output. You can change it with multi-functional knob and direction key on interface for using amplitude modulation function or by pressing Depth. In case of external modulation source, the output amplitude of instrument is also controlled by±5V signal level on external analog modulation input terminal (Modulation In connector) of back panel.

Comprehensive example

First make the instrument run in SUM mode, and then set an internal sine wave of 1kHz as modulation signal and a square wave with frequency of 2kHz, amplitude of 200mVpp and duty ratio of 45% as carrier signal. Finally set modulation depth to be 80%. The specific steps are as follows:

1) Use SUM function

Press **MOD** to use the function and select SUM function (press soft key **Type** to select if **Type** is not highlighted).

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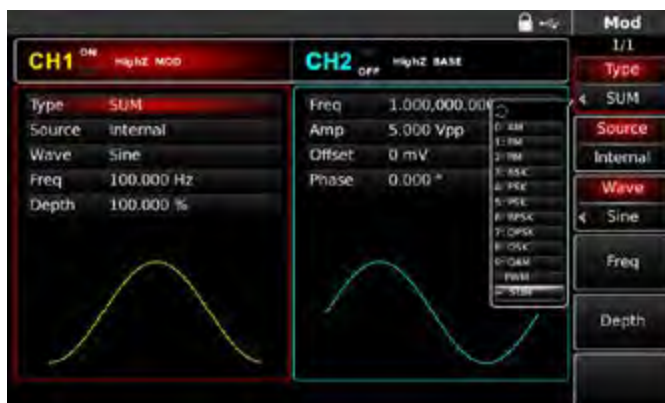
Figure 4- 101 Select SUM function

2) Set modulation signal parameters

Set with multi-functional knob and direction key after using SUM function. You can also press soft keys of function on the above interface for using SUM function. To set some parameter, press corresponding soft key, input the required value and select the unit.
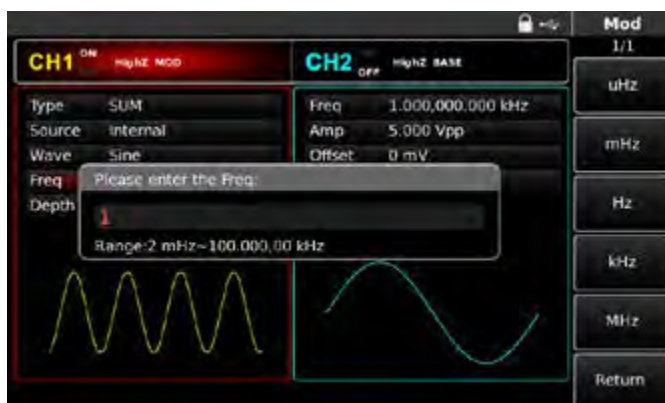
Figure 4- 102 Set modulation parameters

3) Set carrier signal parameters

Select type of basic waveform in modulation mode. Press **Square** to select carrier signal as square wave.
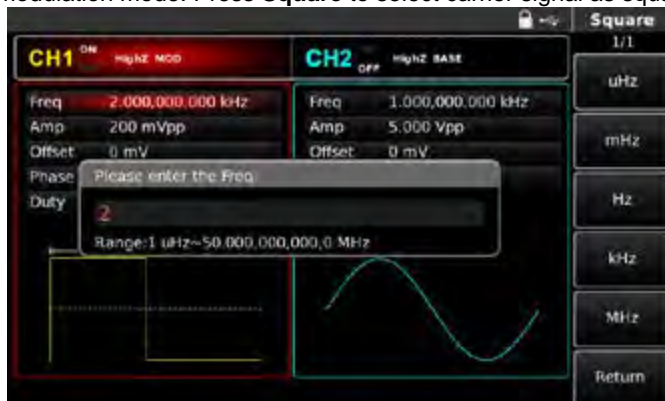
Figure 4- 103 Set carrier parameters

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You can set with multi-functional knob and direction key. You can also press corresponding soft keys of function again. To set some parameter, press corresponding soft key, input the required value and select the unit.

Figure 4- 104 Set carrier duty ratio

4) Set modulation depth

Press soft key MOD to return to the interface below to set modulation depth after setting carrier parameters. You can set with multi-functional knob and direction key. You can also press soft key Depth again, input the number 80 through numeric keyboard and press soft key % to set modulation depth.

Figure 4- 105 Set modulation depth

5) Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns grey from white, and "ON" turns white from grey, indicating that output of channel 1 is turned on.

Figure 4- 106 Use channel output

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4.1.12 Pulse Width Modulation (PWM)

In PWM, modulated waveform generally is composed of carrier wave and modulation wave. The pulse width of carrier wave will vary with the amplitude of modulation wave. The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

Select PWM

Press **MOD, Type** and **PWM** successively to use PWM function (if **Type** is not highlighted, it may be necessary to press soft key **Type** twice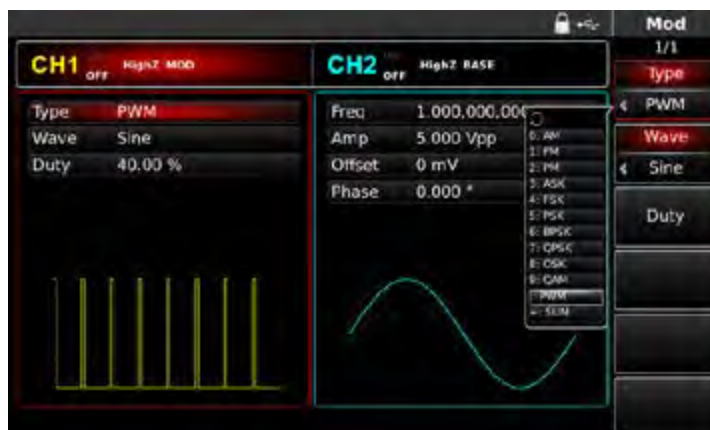 to display the next screen of sub-tags). After PWM function is used, UTG4000A function/arbitrary waveform generator will output modulated waveform with the current modulation waveform and carrier wave.
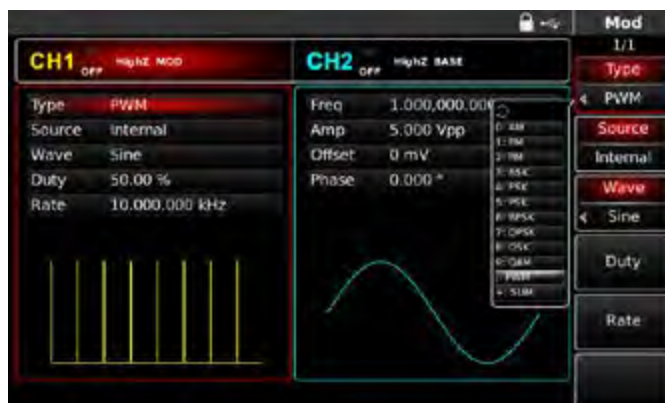
Figure 4- 107 Select PWM function

Carrier waveform

PWM carrier waveform can only be pulse wave. After PWM is selected, press **Pulse** to enter interface of carrier waveform.
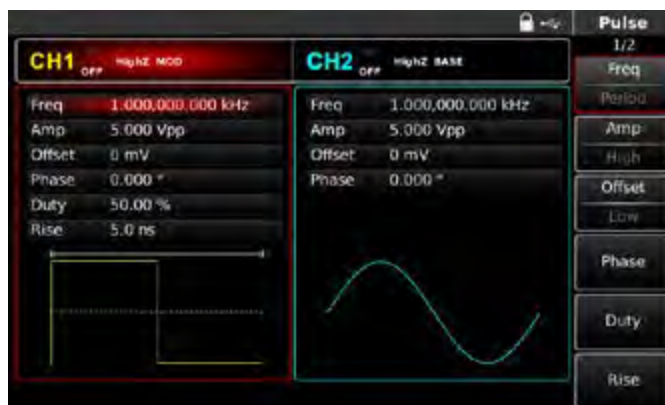
Figure 4- 108 Set carrier waveform

Set carrier frequency

The frequency range of pulse wave is 1µH~50MHz. Default frequency is 1kHz. To set carrier frequency, please use multi-functional knob and direction key in the interface or press soft function key **Freq**, input the required value and select the unit.

Set carrier duty ratio

The range of duty ratio of pulse wave is 0.01%~99.99%. Default duty ratio is 50%. To set carrier duty ratio, please use multi-functional knob and direction key in the interface or press soft function key **Duty**, input the required value and select the unit.

Select modulation source

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can select internal or external modulation source. After you use PWM function, you can see that modulation source is internal by default. You can change it with multi-functional knob on the interface for using frequency modulation function or by pressing **Source**.

Note: the modulation source can only be selected after PWM function is used. Press **MOD, Type** and **PWM** successively

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(if **Type** is not highlighted, it may be necessary to press soft key **Type** twice to display the next screen of sub-tags) to use PWM function.

Figure 4- 109   Select modulation source

1) Internal source

In case of internal modulation source, modulation wave can be sine wave, square wave, ascending sawtooth wave, descent sawtooth wave, arbitrary wave and noise, and is sine wave by default. After you use PWM function, you can see that modulation wave is sine wave by default. You can change it with multi-functional knob on interface for using PWM function or by pressing **Wave**.

- Square wave: duty ratio is 50%
- Ascending sawtooth wave: degree of symmetry is 100%
- Descent sawtooth wave: degree of symmetry is 0%
- Arbitrary wave: when selecting arbitrary wave as modulation waveform, function/arbitrary waveform generator limits length of arbitrary wave to 32Mpts by automatic test count.
- Noise: white Gaussian noise

2) External source

In case of external modulation source, modulation wave and frequency will be hidden in parameter list, when an external waveform will be used to modulate carrier waveform. Duty ratio deviation of PWM is controlled by ±5V signal level on external analog modulation input terminal (Modulation In connector) of back panel. For example, if duty ratio deviation in parameter list is set to be 15%, duty ratio of carrier signal (pulse wave) increases by 15% when external modulation signal is +5V. Lower external signal level generates less deviation.

Set duty ratio deviation

Duty ratio deviation is deviation of modulated waveform from the current carrier duty ratio. The range of PWM duty ratio is 0%~49.99%, 20% by default. You can change it with multi-functional knob and direction key on interface for using PWM function or by pressing **Duty**.

- Duty ratio deviation is change in duty ratio of modulated waveform relative to original pulse waveform (%).
- Duty ratio deviation should not be more than current duty ratio of pulse wave.
- The sum of duty ratio deviation and current duty ratio of pulse wave must be ≤99.99%.
- Duty ratio deviation is restricted by minimum duty ratio of pulse wave and the current edge time.

Comprehensive example

First make the instrument run in PWM mode, and then set an internal sine wave of 1kHz as modulation signal and a pulse wave with frequency of 10kHz, amplitude of 2Vpp, duty ratio of 50% and rising/falling time of 100ns as carrier signal. Finally set duty ratio deviation to be 40%. The specific steps are as follows:

1) Use PWM function

Press **MOD, Type** and **PWM** successively (if **Type** is not highlighted, it may be necessary to press soft key **Type** twice to display the next screen of sub-tags) to use PWM function.

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Figure 4- 110　Select PWM function

2) Set modulation signal parameters

Set with multi-functional knob and direction key after using PWM function. You can also press corresponding soft keys of function on the above interface for using PWM function, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.
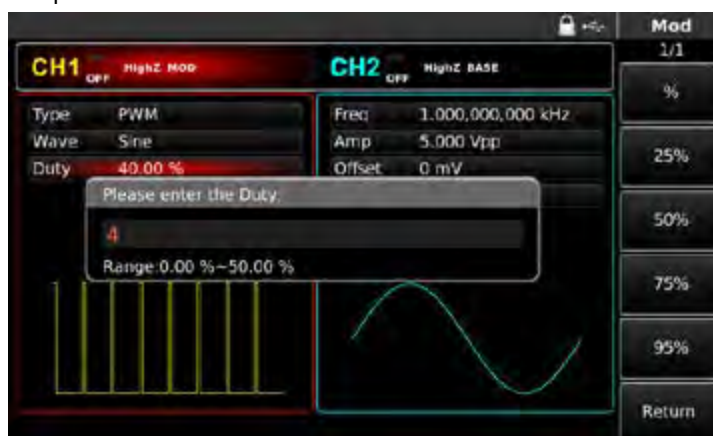
Figure 4- 111　　Set modulation parameters

3) Set carrier signal parameters

Press soft function key **Pulse** to enter the interface for setting carrier parameters in the interface for using PWM function.

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Figure 4- 112   Set carrier parameters

You can set with multi-functional knob and direction key. You can also press corresponding soft keys of function again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.
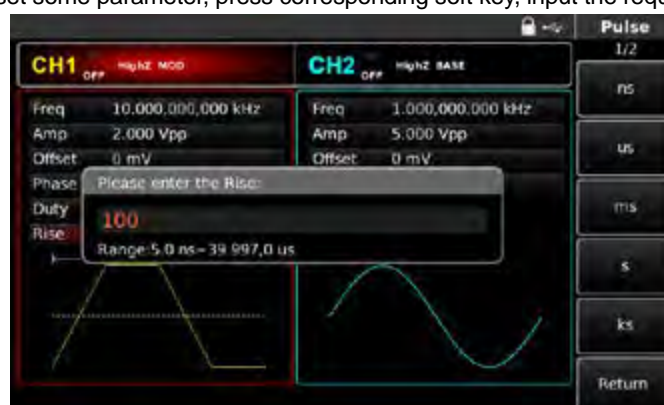
Figure 4- 113   Set rising edge

4) Set duty ratio deviation

Press **Pulse** to return to the interface below to set frequency deviation after setting carrier parameters.
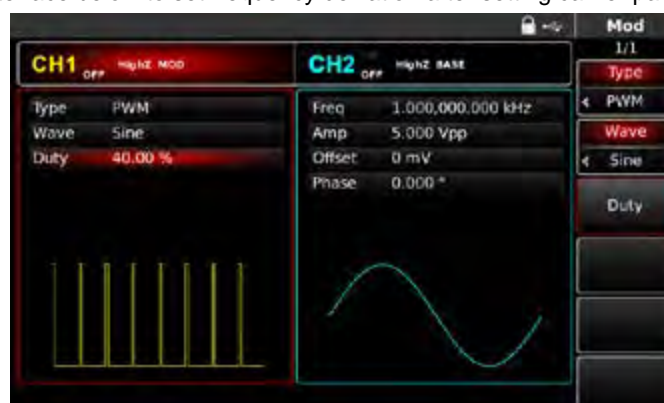
Figure 4- 114   Set modulation parameters

You can set with multi-functional knob and direction key. You can also press soft function key **Duty** again, input the number 40 through numeric keyboard and press soft key **%** to set duty ratio deviation.

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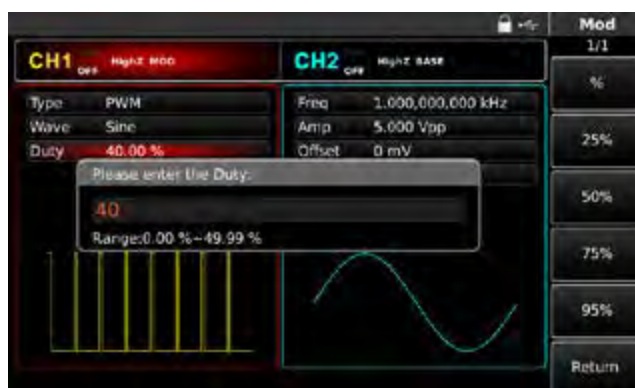
Figure 4- 115   Set duty ratio deviation

5) Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns grey from white, and "ON" turns white from grey, indicating that output of channel 1 is turned on.
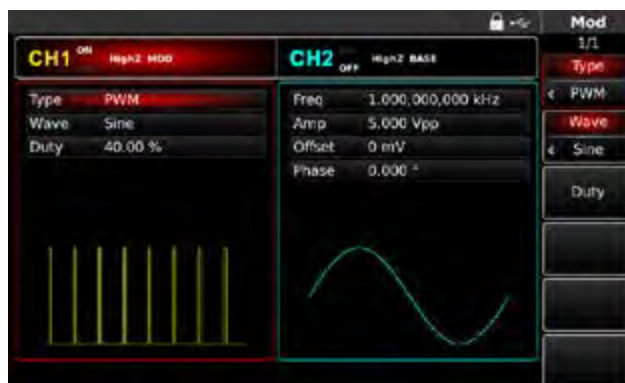
Figure 4- 116   Use channel output

Check the shape of PWM modulation waveform through oscilloscope, which is shown in the figure below:
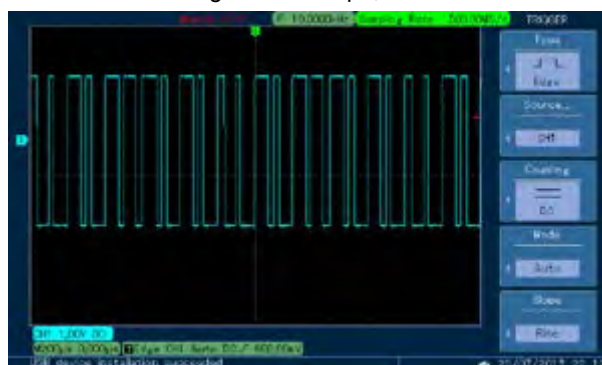
Figure 4- 117 Observe PWM waveform with oscilloscope

4.2 Output Frequency Sweep Waveform

When selecting frequency sweep mode, the output frequency of function/arbitrary waveform generator changes in a linear or logarithmic way from starting frequency to stop frequency in designated frequency sweep time. Trigger source can be internal, external or manual; it can generate frequency sweep output for sine wave, square wave, sawtooth wave and arbitrary wave (except DC). The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

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4.2.1 Select Frequency Sweep

Start frequency sweep

Press **SWEEP** to start frequency sweep. After frequency sweep is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output frequency sweep waveform with the current setting.
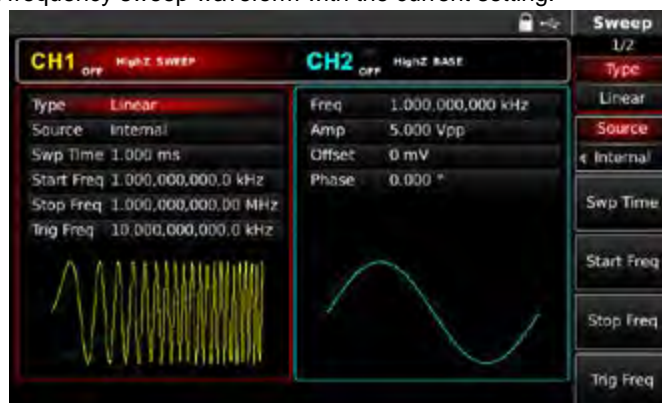
Figure 4- 118 Select SWEEP function

Select frequency sweep waveform

After frequency sweep is started, press the key of basic waveform setting to select frequency sweep waveform. For example, select square wave as frequency sweep. Press **Square** and **SWEEP**. The interface that pops up is shown in the figure below:
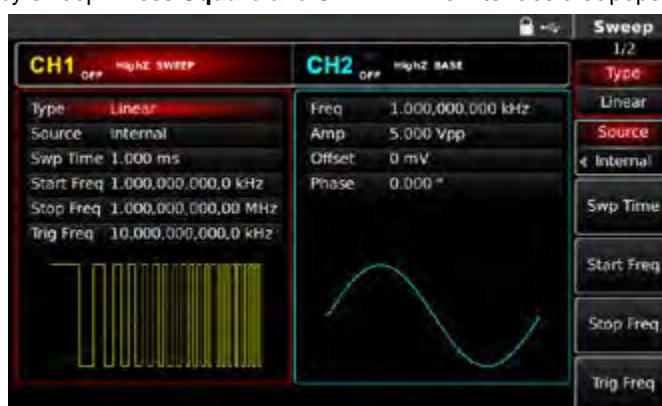
Figure 4- 119 Select frequency sweep waveform

4.2.2 Set Starting and Stop Frequency

Starting frequency and stop frequency are upper limit and lower limit of frequency sweep. Function/ arbitrary waveform generator always sweeps from starting frequency to stop frequency and then returns to starting frequency. To set starting or stop frequency, please press **SWEEP** to return to interface of frequency sweep mode after setting carrier parameters, when you can use multi-functional knob and direction key or press corresponding soft function key, input number through numeric keyboard and press corresponding soft key of unit to finish setting.

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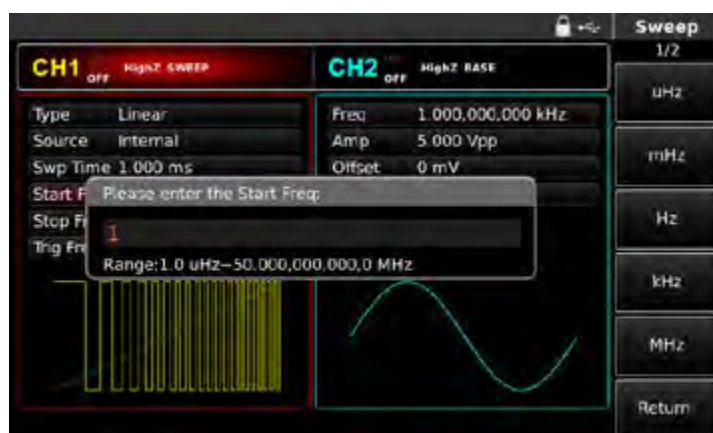
Figure 4- 120 Set frequency sweep parameters

- When starting frequency < stop frequency, function / arbitrary waveform generator sweeps from low frequency to high frequency.
- When starting frequency> stop frequency, function / arbitrary waveform generator sweeps from high frequency to low frequency.
- When starting frequency= stop frequency, function / arbitrary waveform generator outputs fixed frequency.
- The synchronous signal of frequency sweep mode is low from starting point to midpoint of frequency sweep time, and high from midpoint to end of frequency sweep time.

By default, starting frequency is 1kHz and stop frequency is 136Hz, but the range of starting and stop frequency can vary with frequency sweep waveform. See the table below for the frequency range of frequency sweep wave:

Table 4- 13

Carrier waveform	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1µHz~ 80MHz	1µHz ~ 120MHz	1µHz ~ 160MHz
Square wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Sawtooth wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Pulse wave	1µHz ~ 2MHz	1µHz ~ 3MHz	1µHz ~ 4MHz
Arbitrary wave	1µHz ~ 30MHz	1µHz ~ 30MHz	1µHz ~ 30MHz

4.2.3 Frequency Sweep Mode

For linear frequency sweep, waveform generator changes output frequency in a linear way during frequency sweep; for logarithmic frequency sweep, waveform generator changes output frequency in a logarithmic way. Linear frequency sweep mode is default. To change it, please press soft key **Type** on the interface for starting frequency sweep mode (please press **SWEEP** first to enter the interface for selecting frequency sweep waveform).

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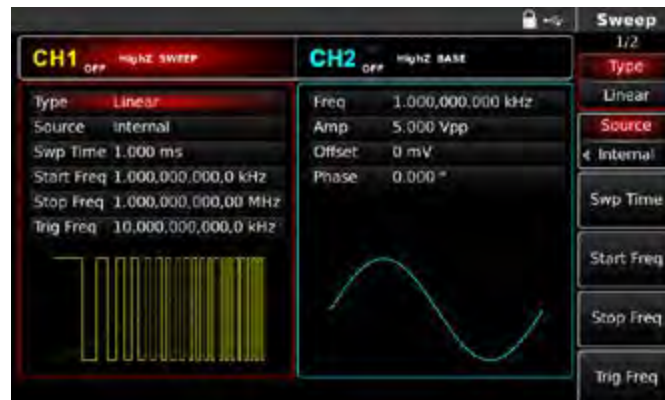
Figure 4- 121 Select linear frequency sweep
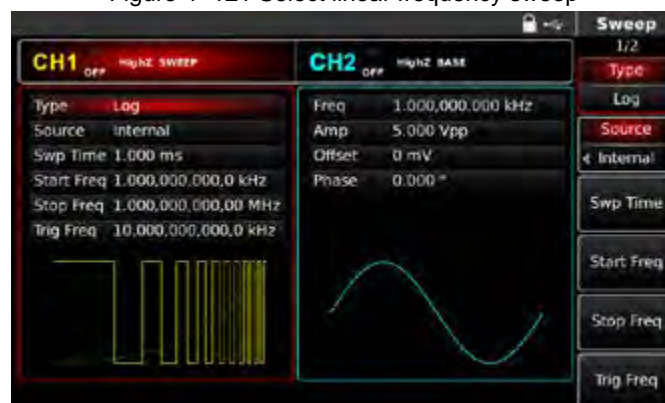
Figure 4- 122 Select logarithmic frequency sweep

4.2.4 Frequency Sweep Time

Set the time from starting frequency to stop frequency, which is 1ms by default and in the range of 1μs~500s. To change it, you can use multi-functional knob and direction key on the interface for selecting frequency sweep mode or press soft function key **Swp Time**, input number through numeric keyboard and press corresponding soft key of unit.
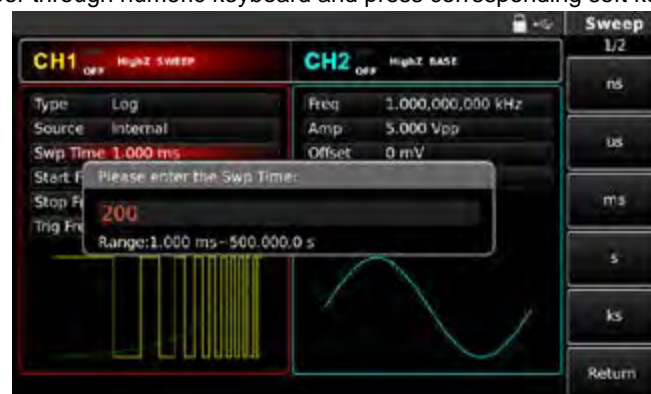
Figure 4- 123 Set frequency sweep time

4.2.5 Select Trigger Source

The signal generator generates frequency sweep output upon receiving a trigger signal and then waits for the next trigger

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signal. The trigger source of frequency sweep can be internal, external or manual. To change it, you can use multi-functional knob and direction key on the interface for selecting frequency sweep mode or press soft function key **Source**.
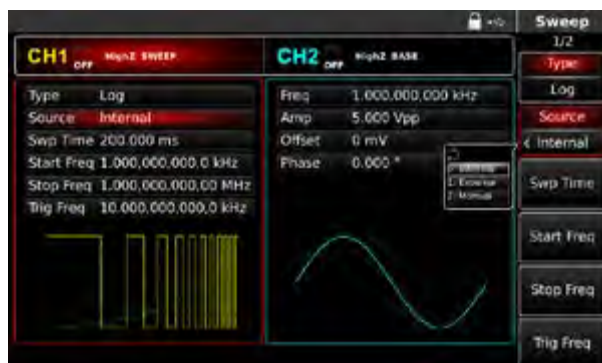
Figure 4- 124 Select trigger source

1) In case of internal trigger, waveform generator will output continuous frequency sweep, the rate of which is determined by frequency sweep time.

2) In case of external trigger, waveform generator will accept a hardware trigger that has been applied to external digital modulation interface （FSK Trig connector）of back panel. The waveform generator will start frequency sweep upon receiving a TTL pulse with designated polarity. Note: in the event of external trigger source, trigger output will be hidden in parameter list, as trigger output is also achieved through external digital modulation interface （FSK Trig connector）. This interface can not be simultaneously used as external trigger input and internal trigger output.
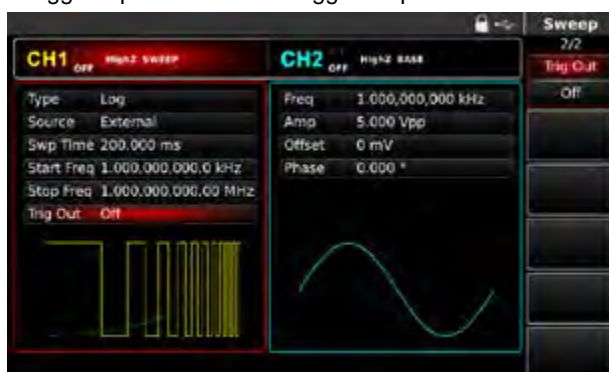
Figure 4- 125 Select external trigger source

3) In case of manual trigger, backlight of **Trigger** on front panel flashes. Frequency sweep is output upon pressing Trigger.

4.2.6 Trigger Output

In case of internal or manual trigger source, the trigger signal (square wave) can be output through external digital modulation interface （FSK Trig connector）, compatible with TTL level. The default trigger output is "OFF". To change it, you can use multi-functional knob and direction key on the interface for selecting frequency sweep mode or press Page Up/Down and soft function key **Trig Out** successively.

- In internal trigger, signal generator outputs a square wave with duty ratio of 50% from external digital modulation interface (FSK Trig connector) when frequency sweep starts. Trigger period depends on designated frequency sweep time.

- In manual trigger, signal generator outputs a pulse more than 1µs wide from external digital modulation interface (FSK Trig connector) when frequency sweep starts.

- In external trigger, trigger output will be hidden in parameter list, as trigger output is also achieved through external digital modulation interface （FSK Trig connector）. This interface can not be simultaneously used as external trigger input and internal trigger output.

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4.2.7 Trigger Edge

Edge can be designated when external digital modulation interface （FSK Trig connector） is used as input. When it is used as input (i.e. internal trigger source), "rising edge" means that rising edge of external signal triggers output of a frequency sweep wave, and "falling edge" means that falling edge of external signal triggers output of a frequency sweep wave. The default edge is "rising edge". To change it, you can use multi-functional knob and direction key on the interface for selecting frequency sweep mode or press soft key **Trig Edge**.

4.2.8 Comprehensive Example

First make the instrument run in frequency sweep mode, and then set a square wave signal with amplitude of 1Vpp and duty ratio of 50% as frequency sweep wave. The frequency sweep mode is linear. Set starting frequency to be 1kHz, stop frequency to be 50kHz and frequency sweep time to be 2ms. The specific steps are as follows:

Use frequency sweep function

Press **SWEEP** and **Type** successively to display linear frequency sweep (press soft key **Type** to select if **Type** is not highlighted) to start linear frequency sweep function.
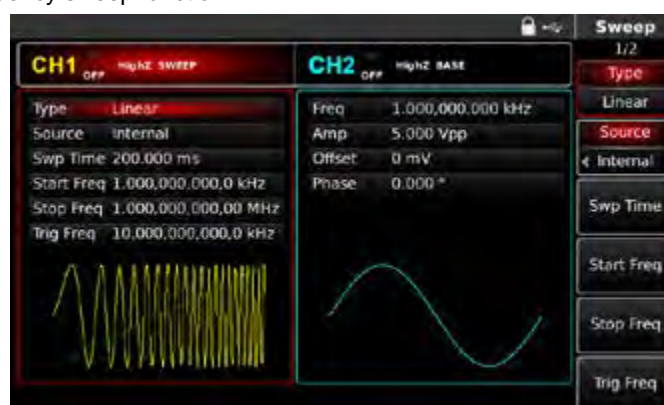
Figure 4- 126 Select SWEEP function

Select frequency sweep waveform

After linear frequency sweep function is used, press **Square** to select frequency sweep waveform, when the interface below will pop up:
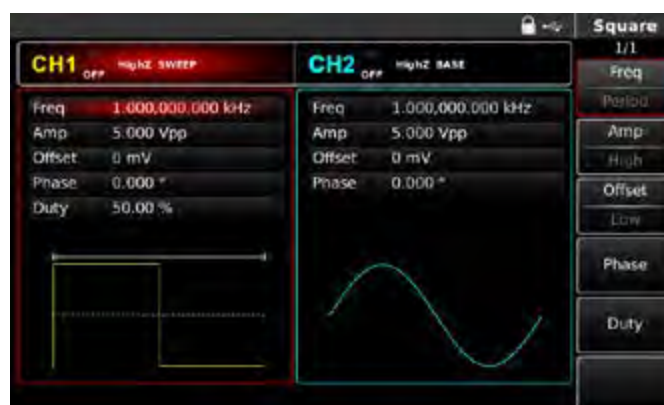
Figure 4- 127 Select frequency sweep waveform

You can set amplitude with multi-functional knob and direction key. You can also press corresponding soft function keys again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.

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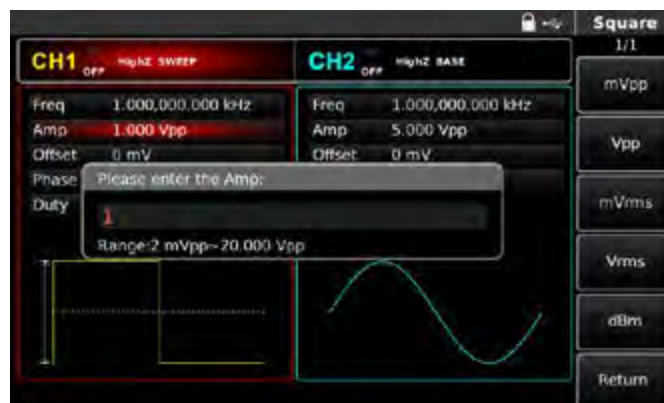
Figure 4- 128 Set waveform amplitude

Set starting/stop frequency, frequency sweep time, trigger source and edge

Press **SWEEP** to return to the interface below after selecting frequency sweep waveform and relevant parameters:
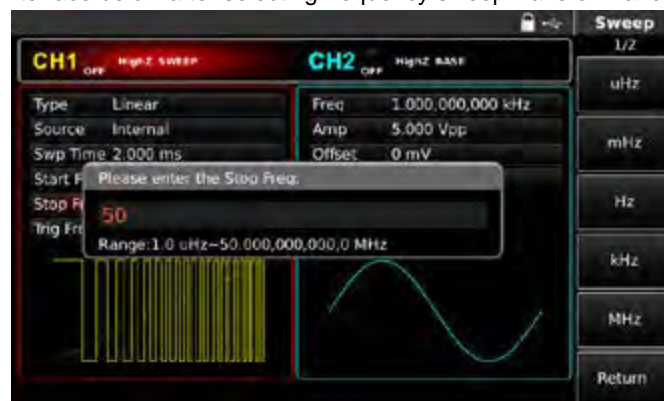
Figure 4- 129 Set frequency sweep parameters

You can set with multi-functional knob and direction key. You can also press corresponding soft function keys again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.
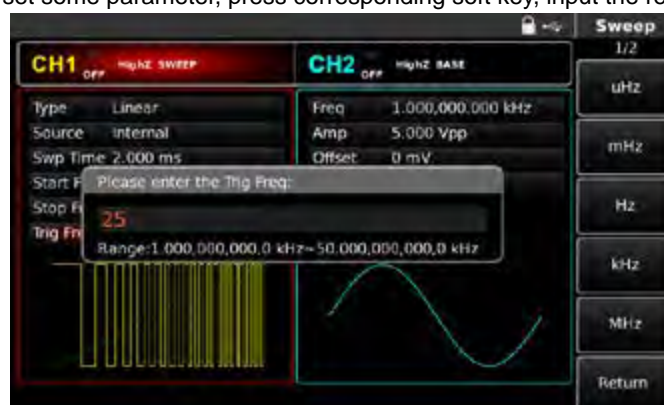
Figure 4- 130 Set trigger frequency

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Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information tag turns grey from white, and "ON" turns white from grey, indicating that output of channel 1 is turned on.
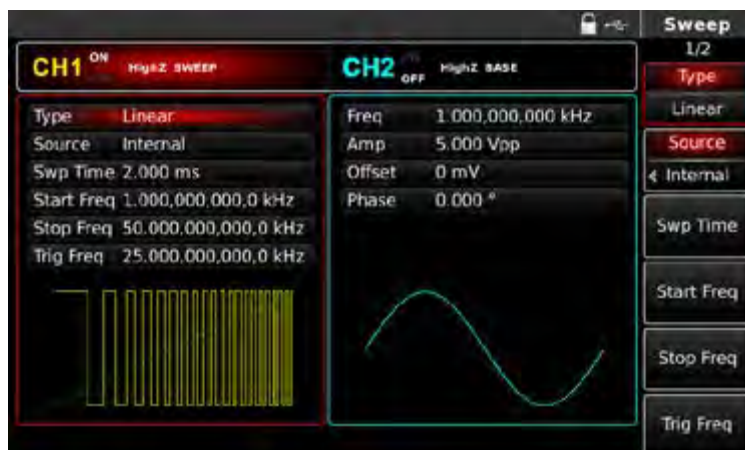
Figure 4- 131 Use channel output

Check the shape of frequency sweep waveform through oscilloscope, which is shown in the figure below:

Figure 4- 132 Observe frequency sweep waveform with oscilloscope

4.3 Output Burst

Signal generator can create a waveform with designated recurring number (known as pulse train). 72-14120, 72-14122 & 72-14126 supports control of pulse train output with internal, external or manual trigger, and three types of pulse train, including N cycle, gating and infinite. It can generate pulse train for sine wave, square wave, sawtooth wave, pulse wave, arbitrary wave (except DC) and noise (only applicable to gating pulse train). The modulation mode of the two channels is mutually independent. You can configure same or different modulation mode for channel 1 and 2.

4.3.1 Select Burst

Start Burst function

Press **BURST** to start function of pulser. After pulse train function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output pulse train with the current setting.

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Figure 4- 133 Select BURST function

Select waveform

- N cycle mode supports sine wave, square wave, sawtooth wave, pulse wave and arbitrary wave (except DC).
- Gating mode supports sine wave, square wave, sawtooth wave, pulse wave, arbitrary wave (except DC) and noise.
- Infinite mode supports sine wave, square wave, sawtooth wave, pulse wave and arbitrary wave (except DC).

After pulse train function is started, press the key of basic waveform setting to select frequency sweep waveform.
For example, press **Square**, the interface that pops up is shown in the figure below:
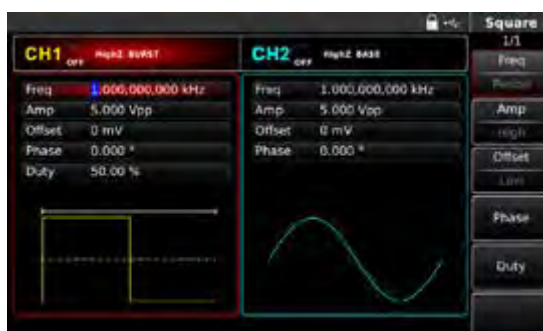
Figure 4- 134 Select waveform

Set waveform frequency

In N cycle and gating modes, waveform frequency defines signal frequency during period of pulse train. In N cycle mode, the pulse train will be output with designated cycle index and waveform frequency. In gating mode, when trigger signal is at high level, pulse train is output with waveform frequency.

Note: waveform frequency is different with period of pulse train that designates interval between pulse trains (only for N cycle mode). The default frequency of waveform is 1kHz. See the table below for the range:

Table 4- 14

Carrier waveform	Frequency		
	72-14120	72-14122	72-14126
Sine wave	1µHz~ 80MHz	1µHz ~ 120MHz	1µHz ~ 160MHz
Square wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Sawtooth wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Pulse wave	1µHz ~ 2MHz	1µHz ~ 3MHz	1µHz ~ 4MHz
Arbitrary wave	1µHz ~ 30MHz	1µHz ~ 30MHz	1µHz ~ 30MHz

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To set waveform frequency, please use multi-functional knob and direction key or press soft function key **Freq**, input the required value and select the unit after selecting waveform.

4.3.2 Type of Burst

72-14120, 72-14122 & 72-14126 can output three types of pulse train, N cycle, gating and infinite. The default type is N cycle.
N cycle mode
Press soft keys **Type** and **N Cyc** successively on the interface for starting pulse function to enter N cycle mode. In this mode, the waveform generator will output a waveform with designated recurring number (pulse train) upon receiving trigger. After outputting a designated number of cycles, the waveform generator will stop and wait for the next trigger. The trigger source of pulse train can be internal, external or manual in this mode. To change it, you can use multi-functional knob and direction key on the interface for selecting type of pulse train (as shown in the figure below) or press soft function key **Source**.
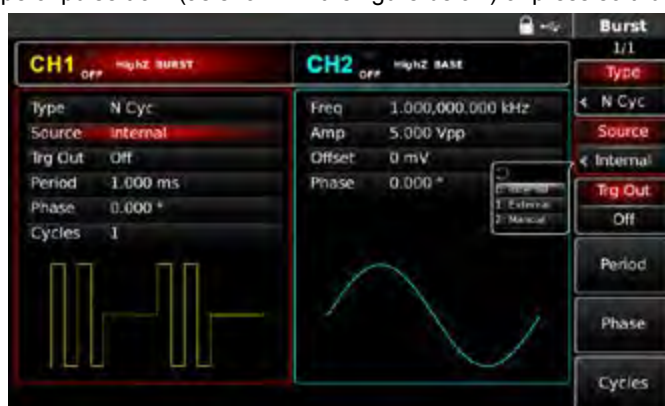
Figure 4- 135 Select N cycle mode

Gating mode
Press soft function keys **Type** and **Gated** successively on the interface for starting pulse function to enter gating mode.
In mode of gating pulse train, trigger source, trigger output, trigger edge, burst period (period of pulse train) and recurring number will be automatically hidden in parameter list. As only external trigger source can be used, waveform generator is triggered according to hardware of external digital modulation interface (FSK Trig connector) of back panel. When polarity is positive and trigger input signal is at high level, a continuous waveform is output; when trigger input signal is at low level, the current waveform period is finished first and then stop at the level corresponding to initial phase of the waveform selected. For noise waveform, when gated signal is spurious, output will be immediately stopped. Polarity can be changed with multi-functional knob and direction key on the interface for selecting gating mode (as shown in the figure below) or by pressing soft key **Trg Edge**.
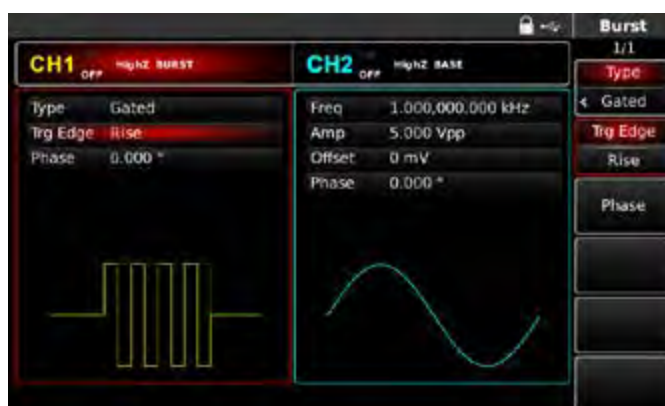
Figure 4- 136 Select gating mode

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Infinite mode

Press soft function keys **Type** and **Infinite** successively on the interface for starting pulse function to enter infinite mode. In mode of infinite pulse train, burst period (period of pulse train) and recurring number will be automatically hidden in parameter list. Infinite pulse train amounts to infinite cycle index of waveform. The signal generator outputs continuous waveform when receiving trigger signal. The trigger source of pulse train can be internal, external or manual in this mode. To change it, you can use multi-functional knob and direction key on the interface for selecting type of pulse train (as shown in the figure below) or press soft function key **Source**.
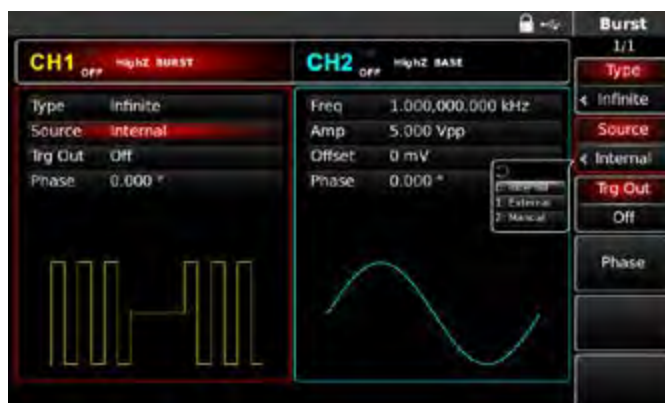
Figure 4- 137 Select infinite mode

4.3.3 Phase of Burst

Phase of pulse train is phase at starting point of pulse train. It is in the range of -360°~+360°. The default initial phase is 0°. To change it, you can use multi-functional knob and direction key on the interface for selecting type of pulse train or press soft function key **Phase**.

- For sine wave, square wave, sawtooth wave and pulse wave, 0° is the point at which the waveform passes 0V (or DC offset value) in forward direction.
- For arbitrary waveform, 0° is the first waveform point downloaded to the storage.
- Initial phase has no effect on the noise wave.

4.3.4 Period of Burst
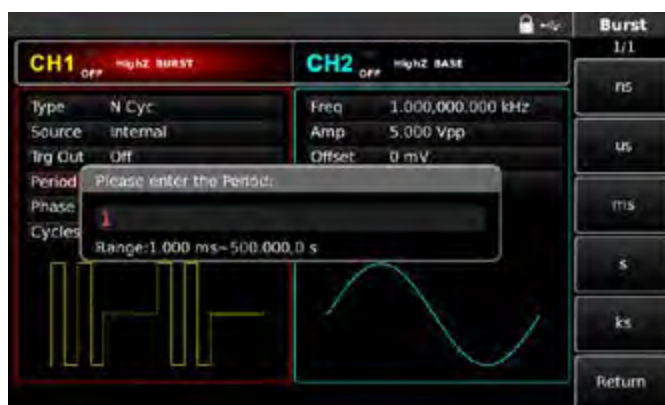
Figure 4- 138 Set period of pulse train

Burst period (period of pulse train) is only applicable to N cycle mode, and is defined as the time from one pulse train to the next pulse train. When trigger source is external or manual, burst period (period of pulse train) will be hidden in parameter list. The range of burst period (period of pulse train) is 1µs~500s; the default "burst period" is 1ms. To change it, you can use multi-functional knob and direction key or press soft key **Period** after selecting type of pulse train as N cycle.

- Burst period (period of pulse train) ≥ waveform period × recurring number (number of pulse trains). The waveform period is reciprocal of waveform frequency mentioned in "select pulse train".
- If burst period (period of pulse train) is too short, signal generator will automatically increase the period to allow output of a

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designated number of cycles.

4.3.5 Counting of Burst

In N cycle mode, counting of pulse train is used to designate the number of waveform cycles. It is in the range of 1~50000 periods and 1 by default. To change it, you can use multi-functional knob and direction or press soft function key **Cycles** after selecting type of pulse train as "N cycle".

- Recurring number≤ burst period × waveform frequency
- If recurring number exceeds the above limit, signal generator will automatically increase period of pulse train to adapt to the designated counting of pulse train (without changing waveform frequency).

4.3.6 Select Trigger Source

The signal generator generates output of pulse train upon receiving a trigger signal, and then waits for the next trigger signal. The trigger source of pulse train can be internal, external or manual. To change it, you can use multi-functional knob and direction key on the interface for selecting type of pulse train or press soft key **Source**.

1) In case of internal trigger, pulse train is output continuously with designated frequency. The frequency of pulse train output is determined by period of pulse train. The signal generator can output "N cycle" or "infinite" pulse train.

2) In case of external trigger, waveform generator will accept a hardware trigger that has been applied to external digital modulation interface （FSK Trig connector）of back panel. The waveform generator will output a pulse train upon receiving a TTL pulse with designated polarity. The signal generator can output "N cycle", "gating" or "infinite" pulse train.

3) In case of manual trigger, backlight of **Trigger** on front panel flashes. A pulse train is output upon pressing **Trigger**. The signal generator can output "N cycle" or "infinite" pulse train.

4.3.7 Trigger Output

In case of internal or manual trigger source, the trigger signal (square wave) can be output through sync output interface. The signal is compatible with TTL level.

4.3.8 Trigger Edge

Trigger edge can be designated when external digital modulation interface (FSK Trig connector) is used as input. When it is used as input (i.e. internal trigger source), "rising edge" means that rising edge of external signal triggers output of a pulse train, and "falling edge" means that falling edge of external signal triggers output of a pulse train. In gating mode, when polarity in parameter list is "positive", external signal triggers output of a pulse train at high level, and "negative polarity" means that external signal triggers output of a pulse train at low level. When it is used as output (i.e. "internal" or "manual" trigger and trigger output is "ON"), the default edge is "rising edge"..

4.3.9 Comprehensive Example

First make the instrument run in pulse train mode, and then set a sine wave signal with period of 5ms and amplitude of 500mVpp as waveform of pulse train, set type of pulse train to be N-cycle, period of pulse train to be 15ms and recurring number to be 2.The specific steps are as follows:

Use pulse train function

Press **BURST**, **Type** and **N Cyc** successively (press soft key **Type** to select if **Type** is not highlighted) to set type of pulse train to be "N-cycle" mode.

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Figure 4- 139 Set N cycle function

Select waveform of Burst

After setting N-cycle mode of pulse train, press **Sine** to select carrier signal as sine wave. The default waveform of pulse train is sine wave, so it is unnecessary to change in this example.
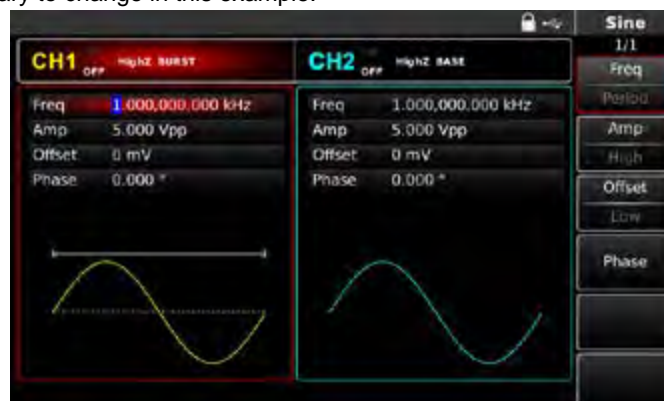
Figure 4- 140 Select waveform of pulse train

You can set amplitude with multi-functional knob and direction key (note: if frequency is displayed, only frequency can be set, which means that conversion between frequency and period can not be realized. If frequency is displayed, period of 2ms is corresponding to frequency of 500Hz. They are reciprocal, i.e. T=1/f). You can also press soft function key **Freq** again (press the soft key **Freq** twice for conversion between frequency and period in parameter list), when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.

Figure 4- 141 Set waveform amplitude

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Set period of pulse train and recurring number of waveform

Press soft function key **BURST** to return to the interface below after selecting waveform of pulse train and relevant parameters:
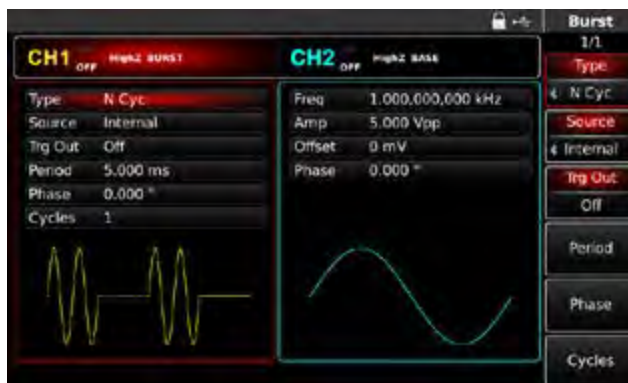
Figure 4- 142 Set pulse train parameters

You can set with multi-functional knob and direction key. You can also press corresponding soft keys of parameters again, when the interface below will pop up. To set some parameter, press corresponding soft key, input the required value and select the unit.

Figure 4- 143 Set period of pulse train

Use channel output

Press **CH1** on the front panel to quickly turn on output of channel 1. Backlight of **CH1** is on after channel output is turned on, "OFF" on the right of CH1 information label turns grey from white, and "ON" turns white from grey, indicating that output of channel 1 is turned on.
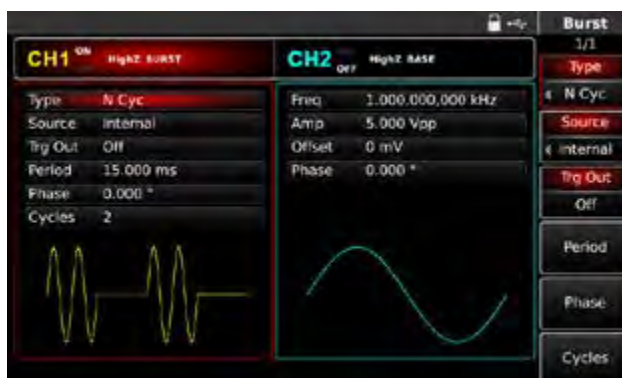
Figure 4- 144 Use channel output

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Check the shape of pulse train through oscilloscope, which is shown in the figure below:

Figure 4- 145 Observe BURST waveform with oscilloscope

4.4 Output Arbitrary Wave

72-14120, 72-14122 & 72-14126 stores 160 types of standard waveform in nonvolatile storage. See Table 4-1 (list of built-in arbitrary wave) for the name of waveform. The instrument creates and edits arbitrary waveform through upper computer software, and reads arbitrary waveform data file stored in U disk through USB interface of front panel.

4.4.1 Use Arbitrary Wave Function

Press **Arb** to use arbitrary wave function. After the function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output arbitrary waveform with the current setting.
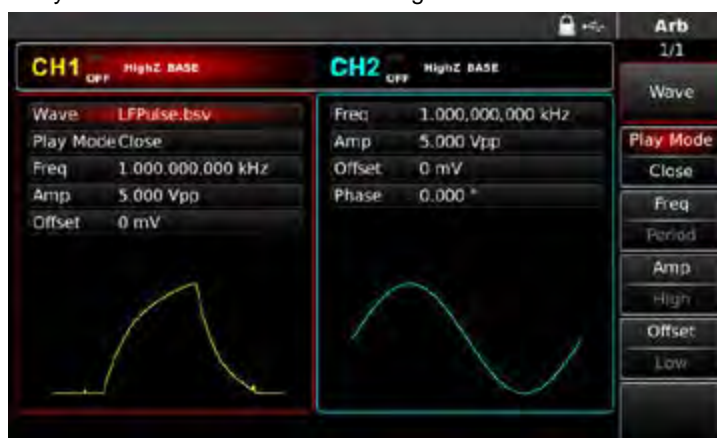
Figure 4- 146 Select Arb function

4.4.2 Point-by-point Output/Play Mode

72-14120, 72-14122 & 72-14126 supports point-by-point output of arbitrary waveform. In point-by-point output mode, signal generator automatically calculates frequency of output signal （476.837158203Hz）according to waveform length (e.g. 1,048,576 points) and sampling rate. The signal generator outputs waveform points one by one with this frequency. Point-by-point output mode can prevent loss of important waveform point. The default is "No". In such case, arbitrary waveform is output with fixed length （16k points） and frequency in parameter list through automatic interpolation of software or test count. To change it, you can use multi-functional knob and direction key on the interface for using arbitrary wave function or press **Play Mode**. When play mode is "Yes", frequency and phase will be displayed in parameter list.

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Figure 4- 147 Set point-by-point output function

4.4.3 Select Arbitrary Wave

72-14120, 72-14122 & 72-14126 allows users to output arbitrary waveform in internal or external storage of the instrument. You can select the arbitrary wave you need with multi-functional knob and direction key on the interface for using arbitrary wave function or by pressing soft keys **Arb** and **Wave** successively.

Note: use multi-functional knob and direction key or press soft keys **Arb** and **Wave** successively to select storage after inserting U disk into USB interface of front panel, and then select the arbitrary waveform you need. 72-14120, 72-14122 & 72-14126 supports *.csv or *.bsv files with waveform 8~32M points long.

Table 4- 15 List of built-in arbitrary wave

Type	Name	Description
Common (15 types)	DC	DC voltage
	AbsSine	Absolute value of sine
	AbsSineHalf	Absolute value of half sine
	AmpALT	Gain oscillation curve
	AttALT	Damped oscillation curve
	GaussPulse	Gaussian pulse
	Gaussian monopulse	Gaussian monopulse signal
	NegRamp	Inverted triangle
	NPulse	Negative pulse
	PPulse	Positive pulse
	SineTra	Sine-Tra waveform
	SineVer	Sine-Ver waveform
	StairDn	Stair down
	StairUD	Stair up/down
	StairUp	Stair up
	Trapezia	Trapezoid

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Type	Name	Description
Engine (25 types)	BandLimited	Band-limited signal
	BlaseiWave	Blasting vibration "time-vibration velocity" curve
	Butterworth	Butterworth filter
	Chebyshev1	Type I Chebyshev filter
	Chebyshev2	Type II Chebyshev filter
	Combin	Composite function
	CPulse	C-Pulse signal
	CWPulse	CW pulse signal
	DampedOsc	Damped oscillation "time-displacement" curve
	DualTone	Dual tone signal
	Gamma	Gamma signal
	GateVibar	Gate self-oscillation signal
	LFMPulse	Linear frequency modulation pulse signal
	MCNoise	Mechanical construction noise
	Discharge	Discharge curve of NI-MH battery
	Pahcur	Current waveform of brushless DC motor
	Quake	Seismic wave
	Radar	Radar signal
	Ripple	Power ripple
	RoundHalf	Hemispheric wave
	RoundsPM	RoundsPM waveform
	StepResp	Step response signal
	SwingOsc	Swing oscillation function- time curve
	TV	TV signal
	Voice	Voice signal
Maths (27 types)	Airy	Airy function
	Besselj	Class-I Bessel function
	Besselk	Besselk function
	Bessely	Class-II Bessel function
	Cauchy	Cauchy distribution
	Cubic	Cubic function
	Dirichlet	Dirichlet function
	Erf	Error function
	Erfc	Complementary error function
	ErfcInv	Inverse complementary error function
	ErfInv	Inverse error function
	ExpFall	Exponential falling function
	ExpRise	Exponential rising function
	Gammaln	Natural logarithm of Gamma function
	Gauss	Gaussian distribution or normal distribution

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Type	Name	Description
Maths (27 types)	HaverSine	Haversine function
	Laguerre	Quartic Laguerre polynomial
	Laplace	Laplace distribution
	Legend	Quintic Legendre polynomial
	Log	Denary logarithmic function
	LogNormal	Logarithmic normal distribution
	Lorentz	Lorentzian function
	Maxwell	Maxwell distribution
	Rayleigh	Rayleigh distribution
	Versiera	Versiera
	Weibull	Weibull distribution
	ARB_X2	Square function
SectMod (5types)	AM	Sectioned amplitude modulation wave of sine
	FM	Sectioned frequency modulation wave of sine
	PFM	Sectioned frequency modulation wave of pulse
	PM	Sectioned phase modulation wave of sine
	PWM	Sectioned frequency modulation wave of pulse width
Bioelect (6 types)	Cardiac	Electrocardiosignal
	EOG	Electro-oculogram
	EEG	Electroencephalogram
	EMG	Electromyogram
	Pulseilogram	Pulsilogram of common people
	ResSpeed	Respiratory speed curve of common people
Medical (4 types)	LFPulse	Low-frequency pulse electrotherapy waveform
	Tens1	Transcutaneous electric nerve stimulation waveform 1
	Tens2	Transcutaneous electric nerve stimulation waveform 2
	Tens3	Transcutaneous electric nerve stimulation waveform 3
Standard (17 types)	Ignition	Ignition waveform of automobile internal-combustion engine
	ISO16750-2 SP	Automobile starting sectional drawing with oscillation
	ISO16750-2 Starting1	Automobile voltage waveform caused by start-up1
	ISO16750-2 Starting2	Automobile voltage waveform caused by start-up 2
	ISO16750-2 Starting3	Automobile voltage waveform caused by start-up 3
	ISO16750-2 Starting4	Automobile voltage waveform caused by start-up 4
	ISO16750-2 VR	Sectional drawing of automobile working voltage in resetting
	ISO7637-2 TP1	Transient phenomena of automobile caused by power cut
	ISO7637-2 TP2A	Transient phenomena of automobile caused by inductance in wiring
	ISO7637-2 TP2B	Transient phenomena of automobile caused by turning off start-up changer
	ISO7637-2 TP3A	Transient phenomena of automobile caused by conversion
	ISO7637-2 TP3B	Transient phenomena of automobile caused by conversion
	ISO7637-2 TP4	Working sectional drawing of automobile in start-up

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Type	Name	Description
Standard (17 types)	ISO7637-2 TP5A	Transient phenomena of automobile caused by power cut of battery
	ISO7637-2 TP5B	Transient phenomena of automobile caused by power cut of battery
	SCR	SCR sintering temperature release drawing
	Surge	Surge signal
Trigonometric function Trigonome (21 types)	CosH	Hyperbolic cosine
	CosInt	Cosine integral
	Cot	Cotangent function
	CotHCon	Concave hyperbolic cotangent
	CotHPro	Convex hyperbolic cotangent
	CscCon	Concave cosecant
	CscPro	Convex cosecant
	CotH	Hyperbolic cotangent
	CscHCon	Concave hyperbolic cosecant
	CscHPro	Convex hyperbolic cosecant
	RecipCon	Concave reciprocal
	RecipPro	Convex reciprocal
	SecCon	Concave secant
	SecPro	Concave secant
	SecH	Hyperbolic secant
	Sinc	Sinc function
	SinH	Hyperbolic sine
	SinInt	Sine integral
	Sqrt	Square root function
	Tan	Tangent function
	TanH	Hyperbolic tangent
\AntiTrigonome (17 types)	ACos	Arc-cosine function
	ACosH	Arc- hyperbolic cosine function
	ACotCon	Concave arc cotangent function
	ACotPro	Convex arc cotangent function
	ACotHCon	Concave arc- hyperbolic cosine function
	ACotHPro	Convex arc- hyperbolic cosine function
	ACscCon	Concave arc cosecant function
	ACscPro	Convex arc cosecant function
	ACscHCon	Concave arc hyperbolic cosecant function
	ACscHPro	Convex arc hyperbolic cosecant function
	ASecCon	Concave arc secant function
	ASecPro	Convex arc secant function
	ASecH	Arc hyperbolic secant function
	ASin	Arcsin function

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Type	Name	Description
\AntiTrigonome (17 types)	ASinH	Arc hyperbolic sine function
	ATan	Arctan function
	ATanH	Arc hyperbolic tangent function
Window function Window (17 types)	Bartlett	Bartlett window
	BarthannWin	Corrected Bartlett window
	Blackman	Blackman window
	BlackmanH	BlackmanH window
	BohmanWin	BohmanWin window
	Boxcar	Rectangular window
	ChebWin	Chebyshev window
	GaussWin	Gaussian window
	FlattopWin	Flat-top window
	Hamming	Hamming window
	Hanning	Hanning window
	Kaiser	Kaiser window
	NuttallWin	Minimum four-item Blackman-Harris window
	ParzenWin	Parzen window
	TaylorWin	Taylaor window
	Triang	Triangle window, also Fejer window
	TukeyWin	Tukey 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

4.4.4 Create and Edit Arbitrary Waveform

72-14120, 72-14122 & 72-14126 creates and edits complicated arbitrary waveform (of any amplitude and shape) through powerful upper computer software. Please see Operation Manual of 72-14120, 72-14122 & 72-14126 Arbitrary Waveform Editing Software for specific operation.

4.5 Output Digital Protocol Coding

Signal generator can output three types of protocol coding: I2C, SPI and UART.(TTL), and support sending of continuous time and manual sending. Corresponding protocol parameters can be set in different protocol modes. Corresponding signal can be output through protocol output interface of front panel.

4.5.1 Description of Interface of Front Panel

Digital interface of front panel is shown in the figure below

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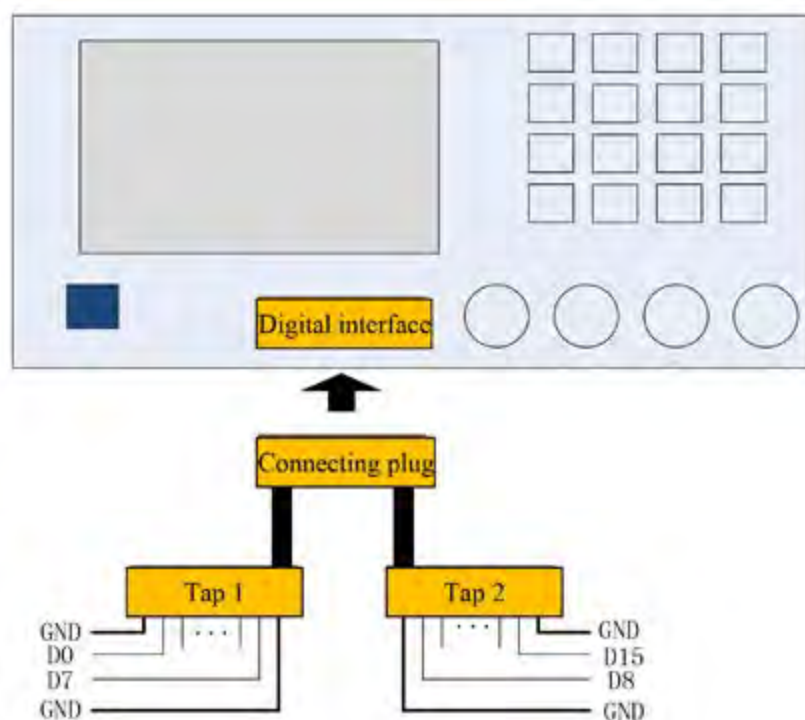
See the table below for correspondence of signal

Table 4- 16

Pin name	Function description
GND	Ground pin
D15	NC
D14	NC
D13	NC
D12	RS232_TXD, serial data sending end
D11	NC
D10	SPI_CS, SPI enable
D9	SPI_SDO, SPI data sending end
D8	SPI_CLK, SPI clock
D7	NC
D6	NC
D5	I2C_SDA, SPI data terminal
D4	I2C_SCL, SPI clock terminal
D3	NC
D2	NC
D1	NC
D0	NC

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4.5.2 UART Protocol

Function/arbitrary waveform generator can generate serial port protocol signal for parameters and output through digital interface of front panel in UART protocol mode.

Select UART

Press **DIGITAL, Type** and **Uart** successively to use UART function (if **Type** is not highlighted, press soft key **Type** to select). After UART function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output protocol signal with the current setting.

Figure 4- 148 Select UART function

Select Baud rate

The Baud rate of UART can be 110, 300, 1200, 4800, 9600, 19200, 38400, 56700, 115200, 230400, 460800, 921600 and Clock speed. After UART is selected, the default Baud rate is 9600. To set Baud rate, please use multi-functional knob and direction key after selecting protocol or press soft function key **Baud Rate** to select the required setting.

Figure 4- 149 Select Baud rate

Set bit

Different bit number can be set as required. In UART mode, there are five different modes, 4, 5, 6, 7 and 8. The default is 4. To set Baud rate, please use multi-functional knob and direction key after selecting protocol or press soft function key **Bit Type** to select the required setting.

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Figure 4- 150 Set bit

Set data sent

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can set protocol data coding to be sent. After you use UART function, you can see that data is empty by default. You can set with multi-functional knob on interface for using protocol function or by pressing Data. The data can be sent with multiple numerical systems, including decimal system, hexadecimal system and character, which is shown in the figure below.

Figure 4- 151 Set data sent

Multibyte sending can be set. The number of bytes is 8. The numeric string should be divided into digital sections not more than 255 when setting value sent. Numbers of each section are divided with Space. Press Clear to clear wrong input and press A/a to switch between capital and small letter. Press Ok after setting is finished. See the figure below.

Figure 4- 152 Set data sent

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Set sending mode

Automatic and manual sending can be set. In the state of automatic sending, the instrument sends the set protocol coding in certain time; in manual mode, the instrument sends the set protocol signal when users press the send key.

1) Automatic sending mode

Press soft function key **SendMode** to adjust to "AUTO" to set automatic sending mode of the instrument. You can set the send time. Press soft function key **Send Time** to set send time with numeric key.

Figure 4- 153 Set automatic sending

2) Manual sending mode

Press soft function key **SendMode** to adjust to "Manual" to set manual sending mode of the instrument. Press soft function key **Send**, the instrument will output the set waveform.

Figure 4- 154 Set manual sending

Set stop bit

Different stop bit width can be set in UART protocol. Press soft function key Stop Bit to set different stop bit width, which can be 1 or 2 and is 1 by default.

Figure 4- 155 Set stop bit

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Set check bit

Check mode can be set in UART protocol. Press soft function key **Parity** to set different check mode, which can be no, odd and even and is no by default.

Figure 4- 156 Set check bit

Comprehensive example

First make the instrument run in UART mode, and then set Baud rate of the instrument to be 4800, data to be decimal 5, 20, 13 or 14, check to be odd, stop bit to be 1 and sending interval to be 2ms. The specific steps are as follows:

1) Use UART function

Press **DIGITAL**, **Type** and **Uart** successively (press soft key **Type** to select if **Type** is not highlighted) to use UART function.

Figure 4- 157 Select UART function

2) Set Baud rate to be 4800

Press soft function key **Baud Rate** to set Baud rate in UART mode. You can set with multi-functional knob and direction key. You can also press corresponding soft function keys again, when the interface below will pop up. Select accordingly.

Figure 4- 158 Select Baud rate

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3) Set bit

To set Baud rate, please use multi-functional knob and direction key after selecting protocol or press soft function key **Bit Type** to select the required setting. The bit number is 8 here.

Figure 4- 159 Select bit

4) Set data sent

Press soft function key **Data** for data setting in UART mode. You can set with multi-functional knob and direction key. You can also press corresponding soft function keys again, when the interface below will pop up. Select accordingly.

Figure 4- 160 Set data sent

5) Set send time

Press soft function key **Send Mode** to set sending mode to be "AUTO" in UART mode. Press soft function key **Send Time** to set sending interval to be 2ms. You can set with numeric key.

Figure 4- 161 Set send time

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6) Set stop bit

Press soft function key **Stop Bit** to set sending mode and set stop bit to be 1 in UART mode.

Figure 4- 162 Set stop bit

7) Set check bit

Press soft function key Parity to set check bit to be "Odd" in UART mode.

Figure 4- 163 Set check bit

4.5.3 I2C Protocol

Function/arbitrary waveform generator can generate protocol signal for parameters and output through digital interface of front panel in I2C protocol mode

Select I2C

Press **DIGITAL, Type** and **I2C** successively to use UART function (if **Type** is not highlighted, press soft key **Type** to select). After I2C function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output protocol signal with the current setting.

Figure 4- 164 Select I2C function

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Set Clock

The transmitter Clock of I2C can be set. You can set with multi-functional knob and direction key after selecting protocol or by pressing soft function key **Clock** and using numeric key in the range of 10kHz~1MHz.

Figure 4- 165 Set clock

Set address information

Different address information can be set as required. 7-bit or 10-bit address can be selected in I2C mode. Press Page Up/ Down of menu and press **Addr Format** on page 2 to switch between 7-bit address and 10-bit address. The default is 7-bit address.

Figure 4- 166 Set address size

To set address value, please press soft function key **Addr** and use numeric key after selecting protocol.

Figure 4- 167 Set address information

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Set data sent

72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator can set protocol data coding to be sent. After you use I2C function, you can see that data is empty by default. You can set with multi-functional knob on interface for using protocol function or by pressing **Data** and using numeric key. The data can be sent with multiple numerical systems, including decimal system, hexadecimal system and character.

Multibyte sending can be set. The number of bytes is 8. The numeric string should be divided into digital sections not more than 255 when setting value sent. Numbers of each section are divided with **Space**. Press **Clear** to clear wrong input and press **A/a** to switch between capital and small letter. Press **Ok** after setting is finished. See the figure below.

Figure 4- 168 Set data sent

Set sending mode

Automatic and manual sending can be set. In the state of automatic sending, the instrument sends the set protocol coding in certain time; in manual mode, the instrument sends the set protocol signal when users press the send key.

1) Automatic sending mode

Press soft function key **SendMode** to adjust to "AUTO" to set automatic sending mode of the instrument. You can set the send time. Press soft function key **Send Time** to set send time with numeric key.

Figure 4- 169 Set automatic sending

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2) Manual sending mode

Press soft function key **SendMode** to adjust to "Manual" to set manual sending mode of the instrument. Press soft function key **Send**, the instrument will output the set waveform.

Figure 4- 170 Set manual sending

Comprehensive example

First make the instrument run in I2C mode, and then set address of the instrument to be 10-bit, value to be 65, I2C clock signal to be 500Hz, data to be decimal 17, 19, 23 29 or 31 and sending interval to be 5ms. The specific steps are as follows:

1) Use I2C function

Press **DIGITAL, Type** and **I2C** successively (press soft key **Type** to select if **Type** is not highlighted) to use I2C function.

Figure 4- 171 Select UART function

2) 65 Set 10-bit address of 65

Press soft function key **Addr Format** to set address bit width in I2C mode. Press this key to switch between 7-bit and 10-bit address. Set the address to be 10-bit.

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Figure 4- 172 Set 10-bit address

Press soft function key **Addr** to set the address. Set address information with numeric keyboard after pressing this key to set address value to be 65.

Figure 4- 173 Set address value

3) Set Clock

Press soft function key **Clock** for data setting in I2C mode. You can set with multi-functional knob and direction key. You can also press corresponding soft function keys again and set corresponding data to be 500 with numeric key.

Figure 4- 174 Set clock

4) Set data sent

Press soft function key **Data** for data setting in I2C mode. You can set with multi-functional knob and direction key. You can

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also press corresponding soft function keys again and set corresponding data with numeric key..

Figure 4- 175 Set data sent

5) Set send time

Press soft function key **Send Mode** to set sending mode to be "AUTO" in I2C mode. Press soft function key **Send Time** to set sending interval to be 5ms with numeric key.

Figure 4- 176 Set send time

4.5.4 SPI Protocol

Function/arbitrary waveform generator can generate SPI protocol signal for parameters and output through digital interface of front panel in SPI protocol mode.

Select SPI

Press **DIGITAL, Type** and **SPI** successively to use SPI function (if **Type** is not highlighted, press soft key **Type** to select). After SPI function is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output protocol signal with the current SPI mode.

Figure 4- 177 Select SPI function

Set SPI Clock

The sending clock of SPI can be set as required by users. Press function key **Clock** in SPI mode to set sending clock with

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numeric key in the range of 10kHz~40MHz.

Figure 4- 178 Set clock

Set data sent

Different bit number can be set as required. Set with multi-functional knob and direction key after selecting protocol or by pressing soft function key **Data** and using numeric key. The data can be sent with multiple numerical systems, including decimal system, hexadecimal system and character, which is shown in the figure below.

Figure 4- 179 Set data sent

Multibyte sending can be set. The number of bytes is 8. The numeric string should be divided into digital sections not more than 255 when setting value sent. Numbers of each section are divided with **Space**. Press **Clear** to clear wrong input and press **A/a** to switch between capital and small letter. Press **Ok** after setting is finished. See the figure below.

Figure 4- 180 Set data sent

Set sending mode

Automatic and manual sending can be set. In the state of automatic sending, the instrument sends the set protocol coding in certain time; in manual mode, the instrument sends the set protocol signal when users press the send key.

1) Automatic sending mode

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Press soft function key **SendMode** to adjust to "AUTO" to set automatic sending mode of the instrument. You can set the send time. Press soft function key **Send Time** to set send time with numeric key.

Figure 4- 181 Set automatic sending

2) Manual sending mode

Press soft function key **SendMode** to adjust to "Manual" to set manual sending mode of the instrument. Press soft function key **Send**, the instrument will output the set waveform.

Figure 4- 182 Set manual sending

Comprehensive example

First make the instrument run in SPI mode, and then set output data of the instrument to be decimal 13, 21, 34, 55 or 89, clock to be 15kHz and sending interval to be 5ms. The specific steps are as follows:

1) Use SPI function

Press **DIGITAL, Type** and **SPI** successively (press soft key **Type** to select if **Type** is not highlighted) to use SPI function.

Figure 4- 183 Select SPI function

2) Set Clock

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Press soft function key **Clock** for data setting in SPI mode. You can set with multi-functional knob and direction key. You can also press corresponding soft function keys again and set corresponding data to be 15kHz with numeric key.

Figure 4- 184 Set clock

3) Set data sent

Press soft function key **Data** for data setting in SPI mode. You can set with multi-functional knob and direction key. You can also press corresponding soft function keys again to set corresponding data with numeric key.

Figure 4- 185 Set data sent

4) Set send time

Press soft function key **Send Mode** to set sending mode to be "AUTO" in SPI mode. Press soft function key **Send Time** to set sending interval to be 5ms. You can set with numeric key.

Figure 4- 186 Set send time

4.6 Function of Digital Arbitrary Wave

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Function /arbitrary waveform generator can generate any digital signal and corresponding clock signal for parameters and output through digital interface of front panel in mode of digital arbitrary wave

Select digital arbitrary wave

Press **DIGITAL**, **Type** and **DArb** successively to use function of digital arbitrary wave (if **Type** is not highlighted, press soft key **Type** to select). After function of digital arbitrary wave is used, 72-14120, 72-14122 & 72-14126 function/arbitrary waveform generator will output signal of digital arbitrary wave with the current setting.

Figure 4- 187 Select function of digital arbitrary wave

Set Clock

The sending clock of digital arbitrary wave can be set as required by users. Press function key **Clock** in mode of digital arbitrary wave to set sending clock with numeric key in the range of 1kHz~40MHz.

Figure 4- 188 Set clock

Set data sent

Different bit number can be set as required. Set with multi-functional knob and direction key after selecting protocol or by pressing soft function key **Data** and using numeric key. The data can be sent with multiple numerical systems, including decimal system, hexadecimal system and character, which is shown in the figure below.

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Figure 4- 189 Set data sent

Multibyte sending can be set. The number of bytes is 8. The numeric string should be divided into digital sections not more than 255 when setting value sent. Numbers of each section are divided with **Space**. Press **Clear** to clear wrong input and press **A/a** to switch between capital and small letter. Press **Ok** after setting is finished. See the figure below

Figure 4- 190 Set data sent

Set sending mode

Automatic and manual sending can be set. In the state of automatic sending, the instrument sends the set protocol coding in certain time; in manual mode, the instrument sends the set protocol signal when users press the send key.

1) Automatic sending mode

Press soft function key **SendMode** to adjust to "AUTO" to set automatic sending mode of the instrument.

Figure 4- 191 Set automatic sending

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2) Manual sending mode

Press soft function key **SendMode** to adjust to "Manual" to set manual sending mode of the instrument. Press soft function key **Send**, the instrument will output the set waveform.

Figure 4- 192 Set manual sending

Comprehensive example

First make the instrument run in mode of digital arbitrary wave, and then set output data of the instrument to be decimal 27, 131, 9 or 31. The specific steps are as follows:

1) Use function of digital arbitrary wave

Press **DIGITAL, Type** and **DArb** successively (press soft key **Type** to select if **Type** is not highlighted) to use function of digital arbitrary wave.

Figure 4- 193 Select function of digital arbitrary wave

2) Set Clock

Press soft function key **Clock** for data setting in mode of digital arbitrary wave. You can set with multi-functional knob and direction key. You can also press corresponding soft function keys again and set corresponding data to be 200kHZ with numeric key.

Figure 4- 194 Set clock

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3) Set data sent

Press soft function key **Data** for data setting in mode of digital arbitrary wave. You can set with multi-functional knob and direction key. You can also press corresponding soft function keys again and set corresponding data with numeric key.

Figure 4- 195 Set data sent

4) Set sending mode

Press soft function key **Send Mode** in DArb mode to set sending mode to be "AUTO".

Figure 4- 196 Set sending mode

Chapter 5 Fault Handling

Possible faults in use of 72-14120, 72-14122 & 72-14126 and troubleshooting methods are listed below. If these faults occur, please handle them according to corresponding steps. If they can not be handled, please contact with the dealer or local office, and provide the information about your machine (method: press **Utility** and **System** successively).

5.1 No Display on Screen (Blank Screen)

If the signal generator still does not display after pressing power switch on front panel

1) Inspect whether power source is connected well.

2) Inspect whether power switch on back panel is connected well at "I".

3) Whether power switch on front panel is connected well.

4) Restart the instrument.

5) If the product still can not be used normally, please contact with the dealer or local office and let us serve you.

5.2 No Waveform Output

Setting is correct but no waveform is output

1) Inspect whether BNC cable and channel output terminal are connected correctly.

2) Inspect whether **CH1** or **CH2** is turned on.

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3) If the product still can not be used normally, please contact with the dealer or local office and let us serve you.

5.3 Fail to Correctly Recognize U Disk

1) Inspect whether U disk works normally.

2) Ensure that Flash U disk is used. The instrument does not support hard disk.

3) Restart the instrument, and insert U disk again to see whether it works normally.

4) If U disk still can not be correctly recognized, please contact with the dealer or local office and let us serve you.

Chapter 6 Service and Support

6.1 Program Upgrade of Product

Users upgrade the current program of function/arbitrary waveform generator with built-in program upgrade system after getting program upgrade package through Market Department or website of TENMA to ensure that the program of function / arbitrary waveform generator is the latest version released by TENMA.

1. Own a 72-14120, 72-14122 & 72-14126 function /arbitrary waveform generator of TENMA, and get model, hardware and software version by pressing soft keys Utility and System successively.

2. Get program file and supporting file of upgrade of model the same as that of function/arbitrary waveform generator to be upgraded through website or Market Department of TENMA, and upgrade according to steps in the supporting file.

6.2 Outline of Warranty

TENMA guarantees that the products it produces and sells are free from any defects of material and process within 3 years from authorizing the dealer to deliver them. If the product is proven to be defective during warranty period, TENMA will repair and replace according to provisions of warranty.

To arrange repair or ask for the whole warranty, please contact with the nearest sales or maintenance department of TENMA.

Except warranties provided in the outline or other applicable warranties, TENMA does not provide any other express or implied warranties, including but not limited to any implied warranties about tradability and applicability to special purpose of the product. In any case, TENMA assumes no responsibility for indirect, special or consequent loss.

Appendix A: Factory Reset State

Parameter	Factory default
Channel parameter	
Current carrier wave	Sine wave
Output load	50Ω
Sync output	Channel 1
Channel output	Off
Channel output opposition	Off
Amplitude limit	Off
Upper amplitude limit	+5V
Lower amplitude limit	-5V
Fundamental wave	
Frequency	1kHz
Amplitude	100mVpp
DC offset	0mV
Initial phase	0°

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Parameter	Factory default
Duty ratio of square wave	50%
Degree of symmetry of sawtooth wave	100%
Duty ratio of pulse wave	50%
Rising edge of pulse wave	1µs
Falling edge of pulse wave	1µs
Arbitrary wave	
Built-in arbitrary wave	Sinc
Play mode	No
AM modulation	
Modulation source	Internal
Modulation wave	Sine wave
Modulation frequency	100Hz
Modulation depth	100%
FM modulation	
Modulation source	Internal
Modulation wave	Sine wave
Modulation frequency	100Hz
Frequency deviation	1kHz
PM modulation	
Modulation source	Internal
Modulation wave	Sine wave
Modulation frequency	100Hz
Phase deviation	180°
PWM modulation	
Modulation source	Internal
Modulation wave	Pulse wave
Modulation frequency	100Hz
Deviation of duty ratio	20%
ASK modulation	
Modulation source	Internal
ASK rate	100Hz
FSK modulation	
Modulation source	Internal
FSK rate	100Hz
Hopping frequency	10kHz
PSK modulation	
Modulation source	Internal
PSK rate	100Hz
PSK phase	180°

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Parameter	Factory default
BPSK modulation	
Carrier wave	Sine
Modulation source	Internal
Phase	0°
Phase 1	90°
Coding mode	PN15
BPSK rate	10kHz
QPSK modulation	
Carrier wave	Sine
Modulation source	Internal
Coding mode	PN15
QPSK rate	10kHz
Phase	0°
Phase 1	90°
Phase 2	180°
OSK modulation	
Modulation source	Internal
Oscillation time	1ms
OSK rate	500Hz
QAM modulation	
Constellation	4QAM
Coding mode	PN15
QAM rate	500Hz
SUM modulation	
Modulation source	Internal
Modulation wave	Sine
Modulation frequency	500Hz
Modulation depth	100%
Frequency sweep	
Type of frequency sweep	Linear
Initial frequency	1kHz
Stop frequency	2kHz
Frequency sweep time	1s
Trigger source	Internal
Trigger output	Off
Trigger edge	Rising edge
Pulse train	
Mode of pulse train	N cycle
Initial phase	0°
Burst period (period of pulse train)	10ms

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Parameter	Factory default
Recurring number	1
Gated polarity	Positive polarity
Trigger source	Internal
Trigger output	Off
Trigger edge	Rising edge
UART protocol	
Baud rate	9600bps
Data bit width	4bits
Data	None
Sending mode	Automatic
Interval of send time	1ms
Stop bit	1bit
Check bit	None
I2C protocol	
Clock	100Hz
Address	0
Data	None
Sending mode	Automatic
Send time	1ms
Address bit width	7bits
SPI protocol	
Clock	1MHz
Data	None
Sending mode	Automatic
Send time	1ms
DARB	
Clock	1KHz
Data	None
Sending mode	Automatic
System parameter	
IP type	DHCP
Clock source	Internal
Clock output	Off
Sound of buzzer	On
Separator of numbers	,
Backlight	100%
Language *	Depend on factory setting

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Appendix B: Performance Index

Model	72-14120	72-14122	72-14126
Basic Characteristic			
Number of channels	Channels A/B with equivalent performance		
Waveform characteristic	7 types of standard waveform, not less than 160 types of built-in arbitrary waveform		
Output waveform	Sine(sine wave), Square(square wave), Ramp(ramp wave), Harmonic(harmonic), Pulse(pulse wave), Noise(noise), DC(DC), Arb(arbitrary wave), multiple modulation AM, FM, ASK, FSK, PSK		
LCD	8" TFT LCD, WVGA(800×480)		
Frequency Characteristic			
Sine wave	1µHz ~ 80MHz	1µHz ~ 120MHz	1µHz ~ 160MHz
Square wave	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Pulse	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Sawtooth wave	1µHz ~ 2MHz	1µHz ~ 3MHz	1µHz ~ 4MHz
16-order harmonic	1µHz ~ 30MHz	1µHz ~ 50MHz	1µHz ~ 80MHz
White noise	80MHz bandwidth (-3dB) (typical value)	120MHz bandwidth (-3dB) (typical value)	160MHz bandwidth (-3dB) (typical value)
Resolution	1 µHz		
Accuracy	Within 90 days ±50 ppm		
	Within 1 year±100 ppm		
	18°C ~ 28°C		
Temperature coefficient	< 2 ppm/°C		
Sine Spectrum Purity			
Harmonic distortion	Typical value (0dBm)		
	DC ~ 1MHz -60dBc		
	1MHz ~ 10MHz -55dBc		
	10MHz ~ 100MHz -50dBc		
	100MHz ~ 160MHz -40dBc		
Total harmonic distortion	<0.2%(DC ~ 20kHz, 1Vpp)		
Spurious signal (anharmonic)	Typical value (0dBm)		
	≤10MHz < -65 dBc		
	>10MHz <-65dBc+6dB/ octave		
Phase noise (10kHz deviation)	10 MHz: ≤-115 dBc/Hz		
Characteristic of Square Signal			
Rising/falling time	< 7ns	< 6ns	< 5ns
Overshoot	< 2% (typical value)		
Symmetry (duty ratio of 50%)	1% of period + 4ns		
Shake	1ns + 100ppm of period		

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Model	72-14120	72-14122	72-14126
Sawtooth wave			
Linearity	< 1% of peak output (typical value, 1kHz, 1Vpp, symmetry 100%)		
Symmetry	0.0% ~ 100.0%		
Characteristic of Pulse Signal			
Frequency range	1µHz ~ 30MHz	1µHz ~ 40MHz	1µHz ~ 50MHz
Pulse width	Maximum period 2000s: minimum 10ns		
Variable edge	7ns ~ 10s	6ns ~ 10s	5ns ~ 10s
Overshoot	< 2%		
Shake	1ns + 100ppm of period		
Characteristic of Arbitrary Wave			
Frequency range	1µHz ~ 20MHz	1µHz ~ 30MHz	1µHz ~ 40MHz
Waveform length	8 ~ 32M points		
Vertical resolution	16 bits (including symbols)		
Sampling rate	500MS/s		
Typical value of minimum rising/falling time (1Vpp)	< 7ns	< 6ns	< 5ns
Shake (RMS)	6ns + 30ppm		
Nonvolatile storage	7GB		
Output of Harmonic			
Harmonic number	≤16		
Harmonic type	Even harmonic, odd harmonic, all harmonics, user-defined		
Harmonic amplitude	Amplitude of each harmonic can be set		
Harmonic phase	Phase of each harmonic can be set		
Output Characteristic			
Amplitude (50Ω load)	≤20MHz:1mVpp~10Vpp	≤20MHz:1mVpp~10Vpp	≤20MHz:1mVpp~10Vpp
	≤80MHz:1mVpp~5Vpp	≤80MHz:1mVpp~5Vpp	≤80MHz:1mVpp~5Vpp
	-	≤120MHz:1mVpp~2.5Vpp	≤120MHz:1mVpp~2.5Vpp
	-	-	≤160MHz:1mVpp~1Vpp
Accuracy	-	±(1% of set value+1mVpp)	
Amplitude flatness	≤10MHz: ±0.1dB	≤10MHz: ±0.1dB	≤10MHz: ±0.1dB
	≤80MHz: ±0.2dB	≤80MHz: ±0.2dB	≤80MHz: ±0.2dB
	-	≤120MHz: ±0.4dB	≤120MHz: ±0.4dB
	-	-	≤160MHz: ±0.8dB
DC Offset			
Range (peak AC+DC)	±5V (50Ω)		
	±10V (high resistance)		
Offset accuracy	±(2% of |offset setting|+ 0.5% of amplitude+2mV)		
Waveform Output			
Impedance	50Ω typical value		
Insulation	Maximum 42Vpk to ground wire		
Protection	Short-circuit protection, waveform output is forbidden automatically in case of overload		

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Model	72-14120	72-14122	72-14126
AM Modulation			
Carrier wave	Sine wave, square wave, sawtooth wave, arbitrary wave		
Source	Internal/external		
Modulation wave	Sine wave, square wave, sawtooth wave, noise, arbitrary wave (1µHz ~ 200kHz)		
Modulation depth	0% ~ 120%		
FM Modulation			
Carrier wave	Sine wave, square wave, sawtooth wave, arbitrary wave		
Source	Internal/external		
Modulation wave	Sine wave, square wave, sawtooth wave, noise, arbitrary wave (1µHz ~ 200kHz)		
Frequency deviation	DC ~ 40MHz	DC ~ 60MHz	DC ~ 80MHz
PM Modulation			
Carrier wave	Sine wave, square wave, sawtooth wave, arbitrary wave		
Source	Internal/external		
Modulation wave	Sine wave, square wave, sawtooth wave, noise, arbitrary wave (1µHz ~ 200kHz)		
Phase deviation	0 ~ 360°		
ASK Modulation			
Carrier wave	Sine wave, square wave, sawtooth wave, arbitrary wave		
Source	Internal/external		
Modulation wave	Square wave with duty ratio of 50% (2mHz ~ 1MHz)		
FSK Modulation			
Carrier wave	Sine wave, square wave, sawtooth wave, arbitrary wave		
Source	Internal/external		
Modulation wave	Square wave with duty ratio of 50% (2mHz ~ 1MHz)		
PSK Modulation			
Carrier wave	Sine wave, square wave, sawtooth wave, arbitrary wave		
Source	Internal/external		
Modulation wave	Square wave with duty ratio of 50% (2mHz ~ 1MHz)		
BPSK Modulation			
Carrier wave	Sine wave, square wave, sawtooth wave, arbitrary wave		
Source	Internal PN code		
Modulation wave	Square wave with duty ratio of 50% (2mHz ~ 1MHz)		
QPSK Modulation			
Carrier wave	Sine wave, square wave, sawtooth wave, arbitrary wave		
Source	Internal PN code		
Modulation wave	Square wave with duty ratio of 50% (2mHz ~ 1MHz)		
OSK Modulation			
Carrier wave	Sine wave		
Source	Internal/external		
Oscillation time	8ns ~ 200s		
Keying frequency	2mHz ~ 1MHz		

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Model	72-14120	72-14122	72-14126
PWM Modulation			
Carrier wave	Pulse		
Source	Internal/external		
Modulation wave	Sine wave, square wave, sawtooth wave, noise, arbitrary wave (2mHz ~ 50kHz)		
Range of pulse width modulation	0% ~ 100%		
SUM Modulation			
Carrier wave	Sine wave, square wave, ramp wave, pulse wave, noise, arbitrary, harmonic wave		
Source	Internal/external		
Modulation wave	Sine wave, square wave, upper ramp wave, lower ramp wave, noise, arbitrary wave		
Modulation frequency	2mHz ~ 100kHz (internal) ; DC ~ 20kHz (external)		
SUM depth	0% ~ 100%		
QAM			
QAM mode	QAM4, QAM8, QAM16, QAM32, QAM64, QAM128, QAM256, (built-in constellation modulation)		
Modulation source	Built-in PNcode, PN7, PN9, PN11, PN15, PN17, PN21, PN23, PN25		
Chip rate	2mHz ~ 100kHz		
Amplitude	10mVpp ~ 10Vpp(50Ω)		
Frequency Sweep			
Carrier wave	Sine wave, square wave, sawtooth wave, arbitrary wave		
Type	Linear or logarithmic		
Frequency sweep time	1ms ~ 500s ± 0.1%		
Trigger source	Manual, external or internal		
Burst			
Waveform	Sine wave, square wave, sawtooth wave, pulse, noise and arbitrary wave		
Type	Count (1 ~ 50,000 periods), infinite, gated		
Initial and stop phase	-360° ~ +360°		
Internal cycle	1μs ~ 500 s ± 1%		
Gated source	External trigger		
Trigger source	Manual, external or internal		
Protocol Output			
SPI			
Waveform length	1~512 bytes		
Clock frequency	10kHz~40MHz		
Sending mode	Single manual trigger, continuous trigger		
Continuous trigger time interval	1ms~10s		
Output level	TTL level output		
I2C			
SPI waveform length	1~512 bytes		
Clock frequency	10kHz~1MHz		
Sending mode	Single manual trigger, continuous trigger		

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Model	72-14120	72-14122	72-14126
Continuous trigger time interval	1ms~10s		
Address	Send 7-bit/10-bit I2C address		
Output level	TTL level output		

UART

SPI waveform length	1~1K bytes		
Baud rate	110, 300, 1200, 2400, 4800, 9600, 19200, 38400, 56700, 115200, 230400, 460800, 921600, user-defined		
Data bit	4 bits, 5 bits, 6 bits, 7 bits, 8 bits		
Sending mode	Single manual trigger, continuous trigger		
Continuous trigger time interval	1ms ~ 10s		
Stop bit	1 bit, 2 bits		
Check bit	No check bit, odd, even		
Output level	TTL level output		

DARB

Waveform length	1~1K bytes		
Sampling rate	1S/s ~ 40MS/s		
Sending mode	Single manual trigger, continuous trigger (no time interval)		
Waveform resolution	Maximum 16 bits		
Output level	TTL level output		

Modulation Input

External analog modulation	<20kHz (input frequency)		
	± 5Vpk = 100% modulation		
	5kΩ (input impedance)		

Clock input/output

Range of input/output frequency	10MHz±500Hz		
Range of input/output level	TTL compatible		
Input/output impedance	10kΩ/50Ω (typical value, AC coupling)		
Locking time	<1s		

Trigger Input

Input level	TTL compatible		
Slope	Rising or falling, optional		
Pulse width	> 100 ns		
Input impedance	> 10kΩ, DC coupling		
Response time	Frequency sweep: < 500µs, typical value		
	Pulse train: < 500ns, typical value		

Trigger Output

Level	TTL compatible, access >1kΩW		
Pulse width	> 400ns, typical value		

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Model	72-14120	72-14122	72-14126
Output impedance	50Ω, typical value		
Maximum frequency	1 MHz		
Sync Output			
Level	TTL compatible		
Output impedance	50Ω, typical value		
Frequency meter			
Input level	TTL compatible (200mVpp ~ 9Vpp)		
Range of input frequency	100mHz ~ 800MHz		
Trigger level	0 ~ ±2.5V DC		
Accuracy	±51ppm		
Frequency resolution	7 bits/s		
High frequency suppression	High frequency noise suppression is turned on or off		
Adjustable trigger sensitivity	0% ~ 100.0%		
Coupled mode	DC, AC		
Interface			
Standard configuration	USB Host (maximum 32G), USB Device, LAN, 10MHz clock source input, 10MHz clock source output		
Power Source			
Supply voltage	100~240V ACrms, 45~440Hz, CAT II 300V		
Power consumption	Less than 50W		
Fuse	2A, level T, 250V		
Environment			
Temperature range	Operating: +10°C ~ +40°C		
	Non-operating: -20°C ~ +60°C		
Cooling method	Forced fan cooling		
Humidity range	Below +35°C: ≤90% relative humidity		
	+35°C ~ +40°C: ≤60%relative humidity		
Altitude	Operating below 3,000m		
	Non-operating below 15,000m		
Mechanical Specification			
Dimensions	Width		336 mm
	Height		164 mm
	Depth		108 mm
Weight	Excluding package		3.5 Kg
IP protection			
Protection level	IP2X		

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Appendix C: List of Accessories

Model	72-14120, 72-14122 & 72-14126 (dual channel)
	A power line up to local standard
	A USB data line
Standard configuration	Two BNC cables (1 m)
	A CD for users
	A product warranty card
	LAN port (72-14120, 72-14122 & 72-14126)
Optional components	Digital interface, digital cable

Appendix D: Maintenance and Cleaning

General maintenance
- Please don't store or place the instrument where LCD is exposed to direct sunlight for a long time.
- To avoid damage to the instrument or connecting line, please don't place it in mist, liquid or solvent.

Cleaning
- Please clean the instrument frequently in the light of use.
- Cut off the power, and then clean with soft cloth that is wet but not dripping (wipe floating dust off the exterior of instrument with mild detergent or clear water, don't use chemical medicine or detergent containing benzene, methylbenzene, dimethylbenzene, acetone and other potent substances).
- Please prevent scratch of LCD protection screen when cleaning instrument with LCD.
- Please protect the instrument against any corrosive liquid to prevent damage.

Warning: please confirm that the instrument is completely dry before powering on again to prevent electrical short circuit and even personal injury due to moisture

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