

# TENMA<sup>®</sup>



## USB Dual Channel Waveform Generator

**Model: 72-3555**

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## WHAT'S INCLUDED

- One Dual Channel Waveform Generator
- One power cable
- One software disc
- One user manual
- One USB cable
- Two BNC cables

**Please read these instructions carefully before use and retain for future reference.**

## IMPORTANT SAFETY INFORMATION

- When using electrical appliances basic safety precautions should always be followed.
- Use only the power cable and adaptor specified for the Generator.
- Make sure the protective ground terminal is properly grounded before making connections to its input or output terminals.
- There are no user-serviceable parts in this product. Refer servicing to qualified personnel.
- To avoid fire or electric shock, note all the rated values and marking on the product and read the manual for details before making any connection to the product.
- Do not apply working voltage higher than the rated value of the product.
- Check the Generator and cable prior to each use for damage. If any damage is found do not use.
- Do not plug any metal object into the input or output terminals of the product.
- If you deem the product to not be functioning correctly have it checked by qualified maintenance staff.
- Do not operate the product without covers open.
- Do not store or operate the product in a damp or humid environment.
- Do not store or operate the product in a flammable or explosive environment.
- Keep the product surface clean and dry at all times.
- Do not use any chemicals, abrasives or solvents that could damage the Generator.

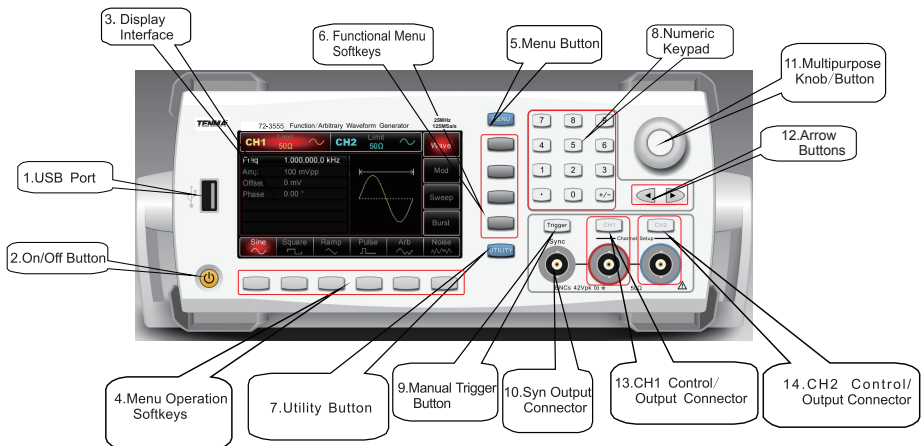
## INTRODUCTION

- The 72-3555 USB Dual Channel Waveform Generator adopts a DDS technique into its design and is capable of generating accurate and stable waveforms with the resolution as low as 1 $\mu$ Hz.
- It is a Dual Channel Function/Arbitrary Waveform Generator with multiple functions.
- The output signal is accurate, stable and pure with minimum distortion.
- The square wave offered is high in frequency and has very fast rising and falling edges.

## KEY FEATURES

- 60MHz (or 25MHz) sine wave output with 1 $\mu$ Hz resolution for full frequency range.
- 25MHz (or 5MHz) impulse waveform with adjustable time rise and fall and duty cycle.
- 250MSa/s (or 125MSa/s) sample rate and 14-bit vertical resolution.
- 6-digit high precision frequency meter compatible with TTL level signal.
- Standard dual channels with independent channel output mode.
- 1M (or 8k) arbitrary waveform memory and 48 non-volatile waveforms storage.
- Multiple modulation types: AM, FM, PM, ASK, FSK, PSK, PWM.
- Software available for use in PC.
- 4.3" high-resolution TFT colour display.
- Standard interfaces: USB Host, USB Device, optional LAN.
- Dual channels can be applied simultaneously or independently: internal/external modulation, internal/external/manual trigger.
- Support frequency sweep and burst output.
- Ease-of-use multipurpose knob and numeric keypad.

## PRODUCT OVERVIEW



### 1. USB Port

- The Generator supports USB flash drive in FAT16 and FAT32 format. Through this USB port, the Generator can read any saved waveforms from USB flash drive or store current data into the flash drive.

### 2. On/Off Button

- To power on/off the Generator, press the button; the backlight will illuminate orange and the Generator will access the power-on interface and then the functional display.

### 3. Display Screen

- The Generator features a 4.3" TFT colour display with high-resolution, which distinguishes output status, menus and other important information between CH1 and CH2 using different colours.



#### 4. Menu Operation Softkeys

- These buttons are used to control the parameters of the currently active function.

#### 5. Menu Button

- Press it and four functional labels appear: Wave, Mod, Sweep and Burst. To select one of these functions press the functional menu softkey.

#### 6. Functional Menu Softkeys

- Select or check the labels of softkeys (on the right of the display screen) via the corresponding identification on the labels.

#### 7. Utility Button

- Press the button for four functional labels: CH1 setting, CH2 setting, I/O (or freq meter) and system and the highlighted label (central background in grey and characters in pure white) all of which have their sub-labels on the bottom of the display screen.
- These sub-labels can help you with what the highlighted label is related to.
- Press softkeys that correspond to sub-labels to enter specific setups or information, to set up channels (e.g. set the output impedance within 1 $\Omega$ -10k $\Omega$  or to high impedance), to specify voltage limit, configure sync output, language, power-on parameters, backlight, configuration of DHCP (dynamic host configuration protocol) port, storage or recall, system information setting, help topic lists etc.

#### 8. Numeric Keypad

- Numeric keys from 0 to 9, decimal point "." and symbol key "+/-".
- The decimal point can be used to switch between units.

#### 9. Manual Trigger Button

- Manual trigger is enabled when the backlight button flashes.

#### 10. Sync Output Connector

- Synchronises signals to output all standard output functions (except DC and noise).

#### 11. Multi-purpose Knob/Button

- To modify a number or be used as directional buttons. Press the multi-purpose knob to select functions or confirm the parameter that has been set.

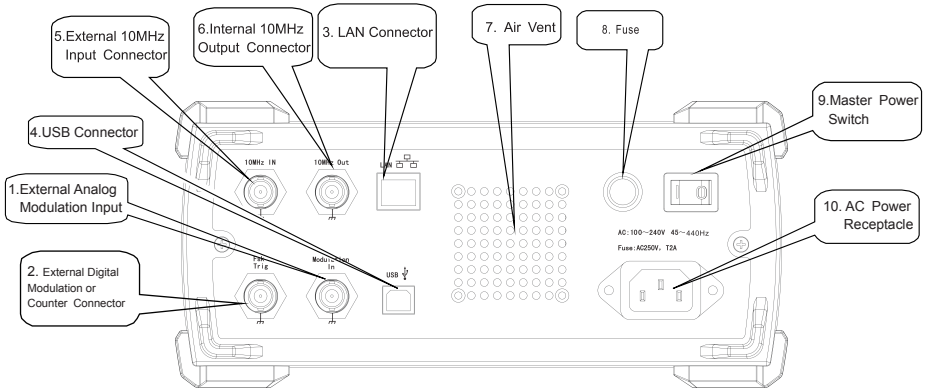
#### 12. Direction Buttons

- Switch between the numeric units or clear the digit prior to the current input or move the cursor to the right or left, when using the multifunction knob and direction key to set up parameters.

#### 13 & 14. CH1/CH2 Buttons

- Use these buttons to quickly switch the current channel displayed on the screen.
- For example, if CH1 is highlighted, then channel 1 is the current chosen channel and all displayed parameters are CH1 related.
- If the current channel is CH1 then you can press the **CH1** button to turn on or off the CH1 output quickly, or you can press **UTILITY** to enable the CH1 setting label and then use the **CH1 Setting** softkey to adjust the settings.
- Under this status, the CH1 button backlight is illuminated and synchronously the current output function mode shows up to the right of the CH1 label ("wave", or "Mod", or "Sweep", or "Impulse Train" icon) and CH1 connector output is enabled.
- With CH1 button switched off the button backlight turns off, the "Off" icon shows to the right of the CH1 label and the CH1 connector is disabled.
- The above bullet points apply to CH2 also.

## REAR PANEL



### 1. External Analogue Modulation Input Connector

- For AM, FM, PM or PWM modulation type, the terminal is used for the signal input when external modulation source is selected.
- The corresponding modulation depth or deviation value (frequency, phase or duty cycle) will be controlled by  $\pm 5V$  signal level present on this input terminal.

### 2. External Digital Modulation or Counter Connector

- For ASK, FSK or PSK modulation type, this connector is used for signal input when the external source modulation is selected.
- Output amplitude, frequency and phase will be controlled by signal levels present on this connector.
- For Sweep or Impulse Train mode, when you select external source as the trigger, it is used to accept polarised TTL pulse that can enable the sweep or impulse train with the specified cycle.
- If the impulse train is gated, you can input a gated signal via this connector.
- When using the frequency meter function you can also use the connector to input signal (compatible with TTL level signal) or output trigger signal when under Sweep or Impulse Train mode.
- When an external trigger source is selected, the Trigger Out option on the parameter list will be enconced, since this connector cannot be used for input and output terminals at the same time.

### 3. LAN Connector

- Connect the Generator to the the local network for the remote control.

### 4. USB Connector

- Connect the Generator to a PC using the USB cable.

### 5. External 10MHz Input Connector

- Use this connector to input external 10MHz reference signal after the Generator's clock source is set up externally.
- To synchronize multiple 72-3555 generators or output 10MHz reference frequency signal, use this external output connector.

### 6. Internal 10MHz Output Connector

- To output 10MHz reference signal after the Generator's clock source is set up internally.

- When you want to synchronise multiple 72-3555 generators or output 10MHz reference frequency signal, use this internal output connector.

### 7. Air Vent

- To ensure the Generator does not overheat, keep this vent uncovered.

### 8. Fuse

- To prevent damage to the Generator, the fuse will blow and disconnect the power supply if the input AC current exceeds 2A.

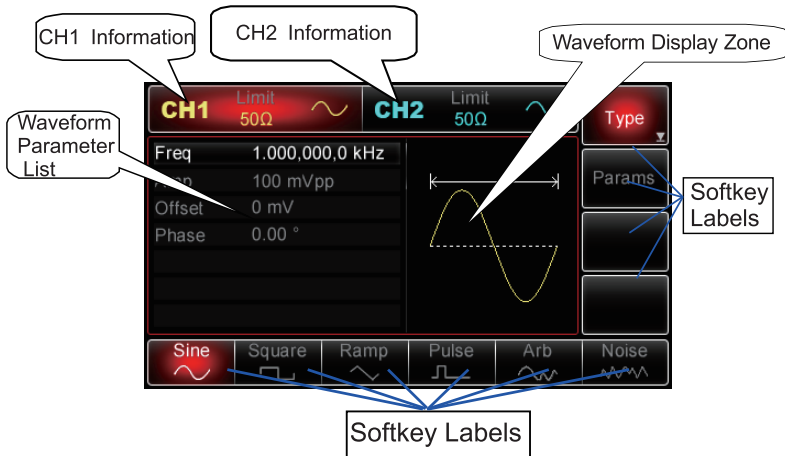
### 9. Master Power Switch

- To energize the Generator when set to “I”, otherwise set to “O” to disconnect AC input (On/Off button on the front panel will not work).

## AC POWER RECEPTACLE

AC power specification for the Generator: 100 to 240V, 45 to 440Hz, power fuse: 250V, T2 A.

### Display Interface



### CH1 and CH2 information

- When the display is highlighted (red for CH1 and blue for CH2), it indicates which channel information is enabled and which channel parameters can be set up.
- Only the highlighted channel can have its parameters changed.
- For the respective channels' display there is a "Limit" icon that represents the output amplitude limit. The limit will either be white or grey, for on and off respectively.
- The impedance value of the output terminal needs to match (adjustable within 1Ω~10kΩ, or set to high impedance, 50Ω by default).
- On the right of the display it shows the current effective waveform (waveform shape, or "Mod", "Sweep" or "Impulse Train" icon) or "Off" in grey for when the CH output connector is switched off.

### Softkey Labels

- These labels identify the current functions of the functional menu softkeys and

menu operation softkeys on the right and bottom of the display.

- The centre of the active label will be in the colour corresponding to that of the current channel, or grey in system setting and the characters are white.

### **Labels on the right of the screen**

- The labels will be highlighted when selected.
- The six softkey labels at the bottom of the screen will display options related to the label on the right.
- Note: if the currently selected label has more than one sub-catalogue, the displayed options on the bottom screen are not necessarily the sub-catalogues of the label. For instance, if types of key label are highlighted, the sub-labels for types of waveforms will be at the bottom of the screen, which are the sub-catalogue of types of key label.
- If you press the **Menu** button, the wave label will be highlighted on the right, however the labels at the bottom of the screen remain unchanged, though are not sub-catalogues of Wave.
- When the label on the right includes more than six options, press the label again to access the next screen to view more options.

### **Sub-labels at the bottom of the screen**

- When sub-label options are from the Type menu, these labels will be highlighted when active.
- When the sub-labels are from the Params menu or the Utility menu, the sub-label options correspond with parameters and are also highlighted around the edges with the same colour as that of the current channel, or grey when in the Utility menu.
- Once a sub-label has been selected, rotating the multipurpose knob or pressing the left and right buttons will cycle through the parameter that correspond to the sub-label.
- Use the multipurpose knob if you want to modify the parameter, press the multipurpose knob to begin editing the setting. Press the knob again when editing is over.
- If “sub-label” has been selected instead of “editing” status, turning the multipurpose knob or pressing the directional buttons along with the label, enables the switch between different labels (switch between different parameters accordingly in the parameter list).
- To modify parameters, you can enter the numbers directly using the numeric keypad, with the left arrow button as a delete function in this mode.
- Select the desired unit using the softkeys options at the bottom of the screen to confirm and exit editing.

### **Waveform Parameter List**

- All parameters related to the current waveform will be listed on the screen.
- They can also be accessed by pressing the Params softkey on the right of the screen.
- When the parameters are highlighted, it can be edited.
- To use the multipurpose knob, press it once and rotate it to increase or decrease the number selected, using the left and right buttons to select different digits.

- Alternatively, the number required can be typed using the numerical keypad.

## Waveform Display Zone

- No waveform displays when setting the system, so the waveform graphic zone are expanded for the parameter list.

## START

### Adjusting the Carrying Handle

- The Generator is designed with a carrying handle.
- To adjust the handle, hold it by either side and pull outwards.
- The handle will then be able to be moved into the desired position.

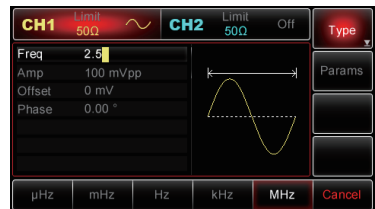
### Outputting Basic Waveforms

- Once powered on, the Generator configures a default sine wave with 100mVp-p sine wave with a 0V DC offset, with a frequency of 1kHz (into a 50Ω terminal).

### Setting Output Frequency

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

- Press **Menu**→**Wave**→**Params**→**Freq** button or softkey.
- When you change the frequency, the same frequency is used if the current frequency value is valid for the new application.
- To modify the waveform period at this moment, press the **Freq** softkey again to toggle between "Period" and "Freq" labels.
- Enter the desired number "2.5" using the numeric keypad.



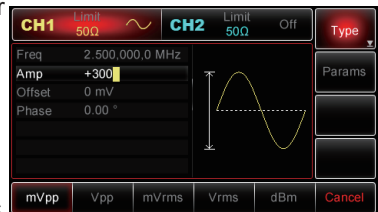
### Select the desired unit

- Press the softkey that corresponds with the desired unit.
- Once the unit is selected, the Generator outputs the waveform with the displayed frequency (if the output has been enabled).
- In this example, press the **MHz** softkey.  
Note: You can also use the multipurpose knob and direction buttons together to set this parameter.

### Setting Output Amplitude

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

- Press **Menu**→**Wave**→**Params**→**Amp** button or softkey.
- When you change the amplitude, the same amplitude is used if the current amplitude value is valid for the new application.
- Press the **Amp** softkey again to quickly switch between different units (Vpp, Vrms and dBm).
- Enter the desired number "300" via the numeric keypad.



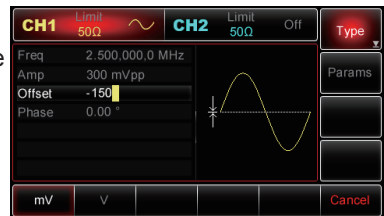
### Select the desired unit

- Press the softkey that corresponds with the desired unit.
- Once the unit is selected, the Generator outputs the waveform with the displayed frequency (if the output has been enabled).
- In this example, press the **mVpp** softkey.  
Note: You can also use the multipurpose knob and direction buttons together to set this parameter.

### SETTING DC OFFSET VOLTAGE

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

- Press **Menu**→**Wave**→**Params**→**DC offset** button or softkey.
- When you change the DC offset, the same DC offset is used if the current DC offset value is valid for the new application.
- Press the **DC offset** softkey again and you will find the original waveform that is defined by the amplitude and the DC offset will change into the one using high level (Max) and low level (Min).
- Enter the desired number “1150mV” using the numeric keypad.



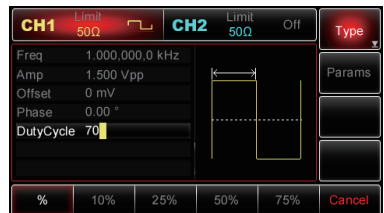
### Select the desired unit

- Press the softkey that corresponds with the desired unit.
- Once the unit is selected, the Generator outputs the waveform with the displayed DC offset.
- In this example, press the **mV** softkey.  
Note: You can also use the multipurpose knob and direction buttons together to set this parameter.

### SETTING THE SQUARE WAVE

- The duty cycle of square wave represents the amount of time per cycle that the square wave is at a high level (on the assumption that the waveform is not inverted).
- Once powered on, the duty cycle of the square wave defaults at 50%.
- The duty cycle is limited by 20ns minimum pulse width.
- To set the frequency to 1kHz, amplitude 1.5Vpp, DC offset to 0V and duty cycle to 70% for the square wave, follow the below steps:

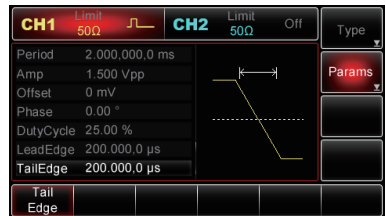
- Press **Menu**→**Wave**→**Type**→**Square**→**Params** softkey.
- In order to set up the required parameters, press the softkey that corresponds to the parameter, then enter the desired value and finally select the desired unit.



Note: You can also use the multipurpose knob and direction buttons together to modify the parameters.

## SETTING THE PULSE WAVEFORM

- The duty cycle of square wave represents the amount of time from 50% threshold of rising edge to 50% threshold of next falling edge per cycle (on the assumption that the waveform is not inverted).
- You can configure the generator to output a pulse waveform with a variable pulse width and edge time.
- Once powered on, the duty cycle of pulse waveform is 50% and the rising/falling edge time is 1 $\mu$ s by default.
- To set the period to 2ms, the amplitude to 1.5Vpp, DC offset to 0V, duty cycle to 25%, rising edge time to 200 $\mu$ s and falling edge time to 200 $\mu$ s for the pulse waveform, follow the steps below:
- Press **Menu**→**Wave**→**Type**→**Pulse**→**Params** button or softkey (if the Type label is not highlighted, press the **Type** softkey again to select), then press **Freq** softkey to switch from Frequency to Period.
- Then enter the period value and select the desired unit.
- To enter duty cycle value, press the softkey that corresponds to 25% on the bottom of the screen to directly enter the number, or you can also enter the number “25” and press % to complete input.
- To set the falling edge time, press the **Params** softkey again or turn the multipurpose knob clockwise to access the next parameter page and then press the **TailEdge** softkey and enter the desired value and select the desired unit.  
Note: You can also use the multipurpose knob and direction buttons together to modify the parameters.



## SETTING DC VOLTS

The DC waveform voltage varies with the current DC offset. Modifying DC offset will change the default value of DC voltage (DC offset).

Once powered on, the DC voltage defaults at 0V.

To set DC voltage to 3V, follow the below steps:

- Press **Menu**→**Wave**→**Type**→**DC**. When you change, DC Volts (DC offset) is used if the current DC voltage (DC offset) is valid for the new application.
- Enter the number “3” using the numeric keypad.



### Select the desired unit

- Press the softkey that corresponds with the desired unit.
- Once the unit is selected, the Generator outputs the waveform with the displayed DC offset.
- In this example, press the **V** softkey.

Note: You can also use the multipurpose knob and direction buttons together to modify DC offset.

## SETTING THE RAMP WAVEFORM

- Symmetry represents the amount of time per cycle when the ramp is positive.
- Once powered on, the ramp symmetry is 100% by default.
- To configure triangle waveform with the frequency set to 10kHz, the amplitude to 2V, DC offset to 0V and duty cycle to 50%, follow the steps as shown below.
- Press **Menu**→**Wave**→**Type**→**Ramp**→**Params**.
- To set the required parameters, press the corresponding softkey at first and then enter the desired value and the desired unit.
- When entering the symmetry value, you can press the softkey corresponding to the 50% label to directly input, or input “50” and press “%” to complete the input.



Note: You can also use the multipurpose knob and direction buttons together to modify the parameters.

## SETTING THE NOISE WAVEFORM

The standard Gaussian noise has a 100mVpp amplitude and 0mV DC offset by default. The default noise waveform also changes accordingly if the amplitude and DC offset functions of other waveforms have been modified.

Only the amplitude and DC offset of the noise waveform are available to modify.

To set standard Gaussian noise amplitude to 300mVpp and DC offset to 1V, follow the below steps:

- Press **Menu**→**Wave**→**Type**→**Noise**→**Params**.
- To set the required parameters, press the corresponding softkey and then enter the desired value and the desired unit.

Note: You can also use the multipurpose knob and direction buttons together to modify the parameters.

## FREQUENCY MEASUREMENT

- The Generator can measure the frequency (ranging from 100MHz~200MHz) of compatible TTL level signal and the duty cycle of it.
- When using the frequency meter function, compatible TTL level signal is input through external digital modulation or through frequency meter port (FSK Trig/CNT connector).
- By pressing **Utility**→**Freq Meter** to read, “frequency”, “cycle” and “duty cycle” can be read out from the parameter list.
- The previously measured value is displayed in the parameter list as always when there is no signal input.
- Frequency meter display refreshes only if compatible TTL level signal is input through external digital modulation or frequency meter port.

## USING THE BUILT-IN HELP SYSTEM

- The built-in help system offered by the Generator provide a context-sensitive assistance on any front-panel button or menu softkey.
- The design of the help topics list also helps with some front-panel operations.



### View help information of a function key

- Pressing any softkey for 3 seconds, for example, the **Menu** button, will display a help message for that button.
- Press **Return** to exit the help function.

### View help information of displayed messages

- The Generator will display a message whenever the limit is exceeded or any configuration is not valid.

### Local language help

- The built-in help system is available in English, simple Chinese and traditional Chinese.
- All messages, context-sensitive help information and help topics are displayed in the selected language.
- To select local language, press **Utility**→**System**→**Language**, then press the arrow label softkey to select the desired language (or turn the multipurpose knob to select).

## ADVANCED APPLICATIONS

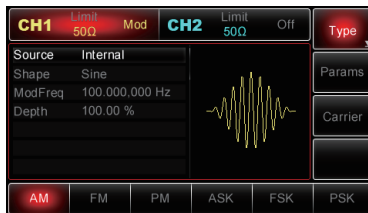
### OUTPUTTING MODULATED WAVEFORMS

#### Amplitude Modulation (AM)

- In amplitude modulation, a modulated waveform consists of a carrier and modulation shape.
- The carrier amplitude varies according to the changing amplitude of modulation shape.
- CH1 and CH2 of the Generator can be modulated independently with modulation types applied with the same or different modes.

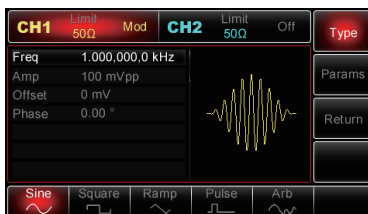
#### Selecting AM

- Press **Menu**→**Mod**→**Type**→**AM** to enable the AM function.
- With the AM function enabled, the Generator will output the modulated waveform according to current settings of modulation shape and the carrier.



#### Selecting the Carrier

- The AM carrier shape can be: sine wave, square wave, ramp or arbitrary waveform (except DC). It is sine wave by default.
- When AM is selected, press **Carrier** to access carrier waveforms to select interfaces.



## Setting Carrier Frequency

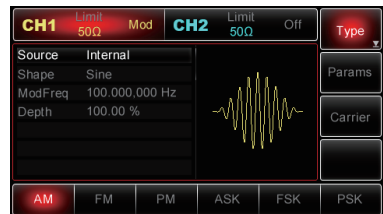
- Carrier frequency ranges could be different and depend on different carrier waves selected.
- The default is at 1kHz for all functions. See the table below for details:

Carrier Wave	Min. Value	Max. Value
Sine	1 $\mu$ Hz	25MHz
Square	1 $\mu$ Hz	5MHz
Ramp	1 $\mu$ Hz	400kHz
Pulse	500 $\mu$ Hz	5MHz
Arbitrary	1 $\mu$ Hz	5MHz

- To set the carrier frequency, select the carrier waveform first and then use the multipurpose knob and direction buttons to set up the parameters or press **Params**→**Freq** softkeys in turn, enter the desired frequency value and select the desired unit to complete the input.

## Selecting Modulation Source

- The Generator can select an internal or external source for modulation. With AM enabled, the modulation source defaults at internal.
- To modify the parameter, switch on AM interface first, then turn the multipurpose knob or press **Params**→**Source**→**External** softkeys to complete the change.



## Internal Source

- When you select internal source, the modulation shape can be: sine, square, up ramp, down ramp, arbitrary, noise.
- After AM is enabled, the modulation shape defaults at sine.
- To modify this parameter, switch on AM interface first and then turn the multipurpose knob or press **Params**→**Shape** softkey and select the waveform desired.
  - Square: 50% duty cycle
  - Up ramp: 100% symmetry
  - Down ramp: 0% symmetry
  - Arbitrary: when arbitrary waveform is selected as the modulation shape, the waveform is automatically sampled to limit wavelength to 1000 points.
  - Noise: White Gaussian

## External Source

- When you select the external source for modulation, the modulation shape and modulation frequency items hide from the parameter list and the carrier is modulated by an external waveform.
- Modulating depth is controlled by  $\pm 5V$  signal level on the external analogue modulation connector (Modulation In) on the rear panel.

- For example, modulation depth in the parameter list has been set to 100%, when +5V external modulation signal is applied, AM output amplitude goes up to maximum value; AM output amplitude goes down to the minimum with external signal applied at -5V.

## SETTING MODULATION SHAPE FREQUENCY

- Modulating frequency is available to set up when you select internal modulation source.
- With AM enabled, the modulation frequency defaults at 100Hz. To change the frequency, use the multipurpose knob and direction buttons or press **Params**→**ModFreq** softkeys to select from 50kHz to 2MHz.
- If the source is chosen externally, modulation shape and frequency options won't show on the parameter list.
- In this case, the carrier is modulated by an external waveform at a frequency of 0Hz to 20kHz.

### Setting Modulation Depth

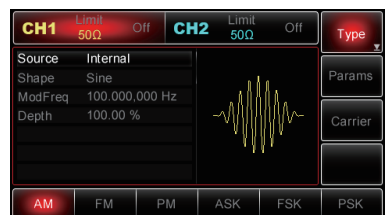
- Modulating depth is expressed with a percentage and represents amplitude variation.
- AM amplitude depth can be selectable from 0%~120%, the default value is 100%.
- When modulating depth is at 0%, the output amplitude is a constant value (half of the set value of carrier amplitude).
- At 100%, the output amplitude varies according to the modulation shape. At greater than 100%, the Generator will not output one exceeding  $\pm 5V$  Peak-Peak voltage (into  $50\Omega$  terminal).
- To modify modulation depth, use the multipurpose knob and direction buttons or press **Params**→**Depth**.
- When you select external source for the modulation, the output amplitude is also controlled by  $\pm 5V$  signal level presented on the External Analogue Modulation Input (Modulation In) Connector.
- For instance, if modulating depth in the parameter list has been set to 100% then when the modulation signal is +5V, AM output is at the maximum amplitude; at -5V, AM output will go down to the minimum amplitude.

### Applications

- Firstly, enable AM mode of the Generator.
- To set a 200Hz sine wave from internal source as modulation signal with a square wave (200mVpp, 45% duty cycle, 10kHz) as the carrier and modulating depth at 80%, follow the steps below:

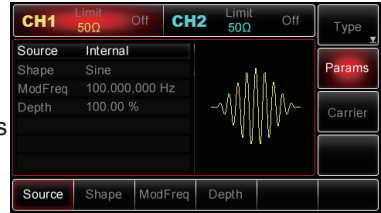
#### 1) Enabling AM function

- Press **Menu**→**Mod**→**Type**→**AM** to enable the AM function.

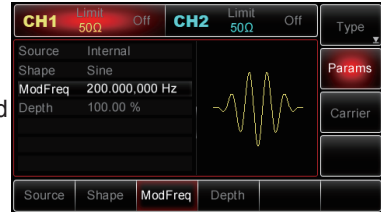


## 2) Setting Modulation Signal Parameters

- With AM function enabled, use the multipurpose knob and direction buttons to complete the setup. You can also press **Params** in AM interface to reveal the display as shown right:

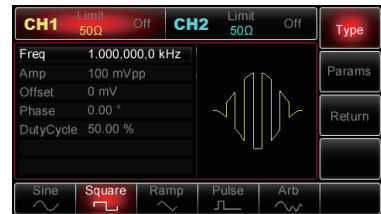


- To set the desired parameter press the corresponding softkey, then enter in the desired value and select the unit as required.



## 3) Setting Carrier Signal Parameters

- Press **CarrierTypeSquare** (if the Type label is not highlighted, press **Type** softkey again) to select the square wave as the carrier signal.



- Use the multipurpose knob and direction buttons to complete the setup. You can press **Params** in the interface above to pop up the display (right):



- To set the desired parameter, press the corresponding softkey and then enter in the desired value and select the unit as required.



#### 4) Setting Modulating Depth

- With the carrier parameters setup finished, press the **Return** softkey to return to the interface (right) and then set the modulating depth.

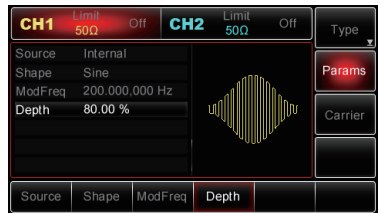


- Use the multipurpose knob and direction buttons to complete the setup. You can press **Params**→**Depth** softkeys, then key in “80” using the numeric keypad and press the % softkey to finish the setting.

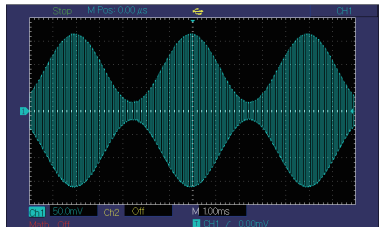


#### 5) Enabling Channel Output

- Press **CH1** button on the front panel to switch on CH1 output or press **Utility** to open the menu and press **CH1** setting to enable the output.
- With channel output enabled, the CH1 button will illuminate and the “Off” icon in grey to the right of “CH1” label will change to “Mod” in yellow, indicating CH1 output has been enabled.



- View AM modulated waveform with an oscilloscope (right).

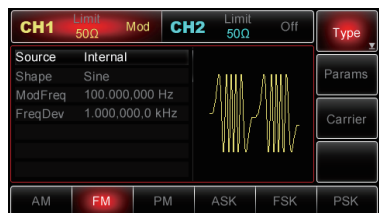


### FREQUENCY MODULATION (FM)

- In FM, the modulated waveform consists of the carrier and modulation shape.
- The carrier frequency varies according to the change of amplitude in the modulation shape.
- CH1 and CH2 of the Generator can be modulated independently with modulation types applied with the same or different ones.

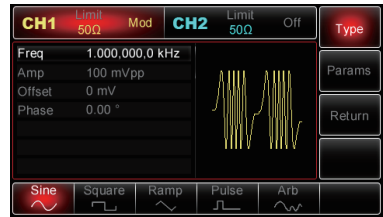
#### Selecting FM

- Press **Menu**→**Mod**→**Type**→**FM** to enable FM function.
- With FM enabled already, the Generator will output the modulated waveform according to modulation shape currently set and the modulated waveform output by the carrier wave.



## Selecting the Carrier

- The FM carrier wave can be: sine, square, ramp or arbitrary waveform (except DC). The default is sine.
- When FM is selected, press **Carrier** to access the carrier waveforms to select interface.



## Setting Carrier Frequency

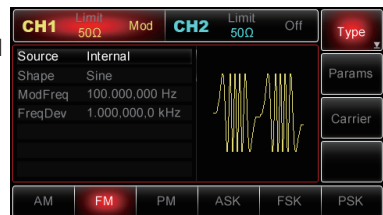
- Carrier frequency ranges could be different and depend on different carrier waves selected. The default is at 1kHz for all functions.
- See the following table for details:

Carrier Wave	Min. Value	Max. Value
Sine	1μHz	25MHz
Square	1μHz	5MHz
Ramp	1μHz	400kHz
Pulse	500μHz	5MHz
Arbitrary	1μHz	5MHz

- To set the carrier frequency, select the carrier waveform first and then use multipurpose knob and direction buttons to set up the parameters or press **Params**→**Freq** softkeys, enter the desired frequency value and select the desired unit to complete the setting.

## Selecting Modulation Source

- The Generator offers both internal and external modulation source.
- With FM enabled, the modulation source defaults at Internal.
- To modify the parameter, switch on the FM interface first, then turn the multipurpose knob or press **Params**→**Source**→**Ext** softkeys to modify.



## Internal Source

When you select internal source, the modulation shape can be: sine, square, up ramp, down ramp, arbitrary or noise. The default is sine.

After FM is enabled, the modulation shape defaults at sine. To modify the parameter, switch on the FM interface, turn the multipurpose knob or press **Params**→**Wave** softkeys to select.

- Square: 50% Duty Cycle
- UpRamp: 100% Symmetry
- DownRamp: 0% Symmetry
- Arbitrary: When arbitrary waveform is selected as the modulation shape, the waveform is automatically sampled and limited to 1,000 points.
- Noise: White Gaussian

## External Source

- When you select external modulation source, modulation shape and modulation frequency items will no longer show on the parameter list.
- FM frequency deviation is controlled by  $\pm 5V$  signal level present on the External Analogue Modulation Input (Modulation In) connector on the rear panel.
- When the signal level is positive, the Generator will output a frequency greater than the carrier frequency, or less than the carrier frequency if the signal level is negative.
- External signal with lower level generates smaller deviation. For example, if the frequency deviation in the parameter list is set to 1kHz, the external modulation shape will be at +5V when FM output frequency equals Carrier Frequency +1kHz; and at -5V the FM output frequency equals Carrier Frequency -1kHz.

## SETTING MODULATION SHAPE FREQUENCY

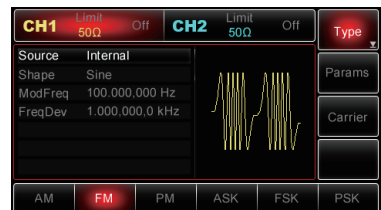
- Modulating frequency is available to set up when you select internal modulation source.
- With FM enabled, the modulation frequency defaults at 100Hz. To change the frequency, use the multipurpose knob and direction buttons or press **Params**→**ModFreq** softkeys to select from 50kHz to 2MHz.
- If the source is chosen externally, modulation shape and frequency options won't show on the parameter list.
- In this case, the carrier is modulated by an external waveform at a frequency of 0Hz to 20kHz.

## Setting Frequency Deviation

- Frequency deviation represents the deviation of the frequency of modulated waveform from the carrier frequency.
- FM frequency deviation can be settable from 1 $\mu$ Hz to a half of the maximum frequency value of the current carrier. The default is 1kHz.
- To change the deviation, switch on FM interface, use the multipurpose knob and direction buttons together or press **Params**→**FreqDev** to change the frequency deviation.
- Frequency deviation  $\leq$  carrier frequency. If you set a frequency deviation value greater than carrier frequency, the Generator will automatically limit the deviation to the maximum value allowed with the current carrier frequency.
- Frequency deviation + carrier frequency  $\leq$  the maximum value allowed with the current carrier frequency. If you set the frequency deviation to an invalid value, the Generator will automatically limit the deviation to a maximum value allowed with the current carrier frequency.

## Applications

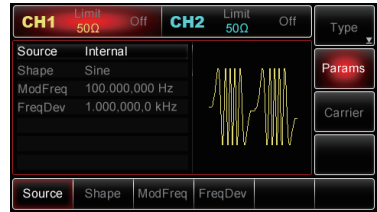
Set up the FM mode of the Generator. To set a 2kHz square wave from internal source as modulation signal with a sine wave (100mVpp) as the carrier with frequency deviation of 5kHz, follow the next steps:



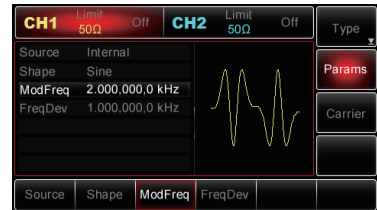
Press **Menu**→**Mod**→**Type**→**FM** to switch on FM function.

### Setting modulation signal parameters

- With FM interface enabled above, use the multipurpose knob and direction buttons to complete the setup.
- You can also press **Params** on the interface above to reveal the display (right):

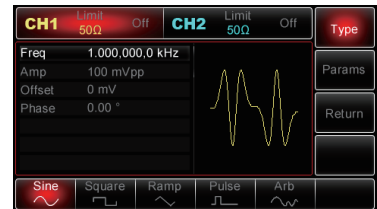


- To set the desired parameter, press the corresponding softkey, then enter the desired value and select the unit as required.

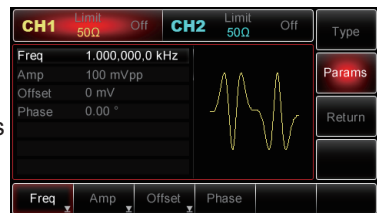


### Setting Carrier Parameters

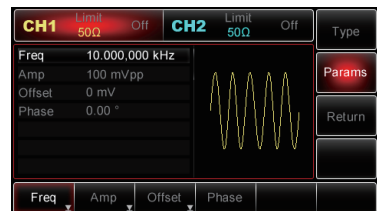
- Press **Carrier**→**Type**→**Sine** to select the sine wave as the carrier signal. The default is sine, so there is no need to modify.



- Use the multipurpose knob and direction buttons to complete the setup, or you can press the **Params** softkey in the interface to present the display as shown right:



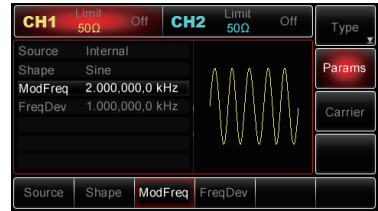
- To set the desired parameter, press the corresponding softkey, then enter the desired value and select the unit as required.



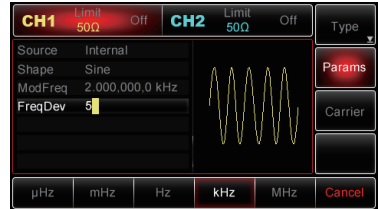


## Setting Frequency Deviation

- With the carrier setup finished, press the **Return** softkey to return to the following interface and set frequency deviation.

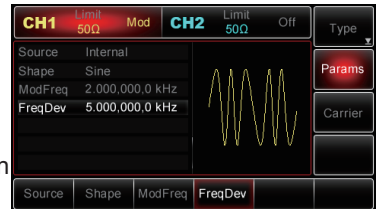


- Use multipurpose knob and direction buttons to complete the setup, or you can press the **Params**→**FreqDev** softkeys, then key in '5' using the numeric keypad and press the **kHz** softkey to finish the setting.

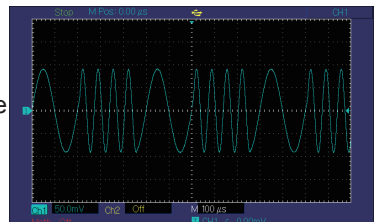


## Enabling Channel Output

- Press the **CH1** button on the front panel to switch on CH1 output directly, or press **Utility** then press **CH1** to enable output.
- With the channel output enabled, the backlight of the CH1 button illuminates and "Off" in grey to the right of the CH1 label changes to "Mod" in yellow, indicating that CH1 has been enabled.



- View FM modulation shape with an oscilloscope as shown right:

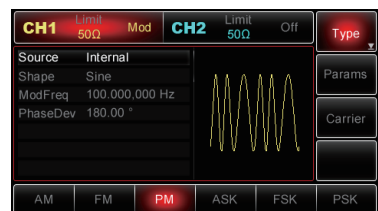


## PHASE MODULATION (PM)

- A PM waveform consists of the carrier and modulation shape. The carrier phase varies according to the changing amplitude of modulation shape. CH1 and CH2 of the Generator can be modulated independently with modulation types applied with the same one or different ones.

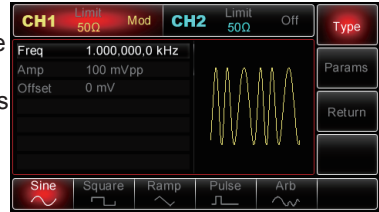
## Selecting PM

- Press **Menu**→**Mod**→**Type**→**Phase** to enable PM function. With PM enabled, the Generator will output the modulated waveform according to current setting of modulation shape and the carrier wave.



## Selecting the Carrier Wave

- The PM carrier wave can be: sine wave, square wave, ramp or arbitrary waveform (except DC). It is sine by default. When PM is selected, press **Carrier** to access carrier waves to select.



## Setting Carrier Frequency

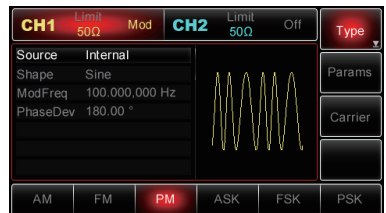
- Carrier frequency ranges could be different and depend on different functions selected. The default is at 1kHz for all functions. See the table below for details:

Functions	Min. Value	Max. Value
Sine	1 $\mu$ Hz	25MHz
Square	1 $\mu$ Hz	5MHz
Ramp	1 $\mu$ Hz	400kHz
Pulse	500 $\mu$ Hz	5MHz
Arbitrary	1 $\mu$ Hz	5MHz

- To set the carrier frequency, select the carrier waveform first, then use the multipurpose knob and direction buttons to set up the parameter or press **Params**→**Freq** softkeys, enter the desired frequency value and select the desired unit to complete the setting.

## Selecting Modulation Source

- The Generator can offer both internal and external modulation source. With PM enabled the modulation source defaults at Internal.
- To modify the parameter, switch on the PM interface, turn the multipurpose knob, or press **Params**→**ModSrc**→**Ext** softkeys to select.



## Internal Source

When you select Internal Source, the modulating waveform can be: sine, square, up ramp, down ramp, arbitrary, noise. The default is sine.

Once PM is enabled, the modulating shape defaults at sine. To modify the parameter, switch on PM interface, turn the multipurpose knob or press **Params**→**Shape** softkeys to select.

- Square: 50% Duty Cycle
- UpRamp: 100% Symmetry
- DownRamp: 0% Symmetry
- Arbitrary: When arbitrary waveform is selected as the modulation shape, the waveform is automatically sampled and limited to 1,000 points.
- Noise: White Gaussian

## External Source

- When you select External Source for modulation, the modulation shape and frequency items won't show on the parameter list and the carrier is modulated by an external waveform.
- Phase deviation is controlled by  $\pm 5V$  signal level presented on external analogue input (Modulation In) connector on the rear panel.
- For instance, phase deviation in the parameter list defaults to  $180^\circ$ , when external modulation signal  $+5V$  is applied, the PM deviation will also be  $180^\circ$ .
- For external signal with lower level, the deviation will be smaller.

## Setting Modulation Shape Frequency

- Modulating frequency is available to set up when you select internal modulation source.
- With PM enabled, the modulation frequency is 100Hz by default. To change the frequency, switch on PM interface, use the multipurpose knob and direction buttons or press **Params**→**ModFreq** softkeys to select from 50kHz to 2MHz.
- If the source is chosen externally, the modulation shape and modulation frequency options don't show on the parameter list, and the carrier is modulated by an external waveform at a frequency from 0Hz to 20kHz.

## SETTING PHASE DEVIATION

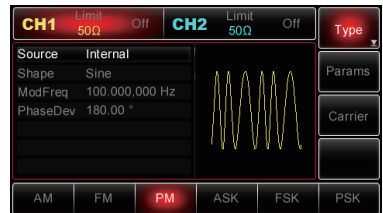
- Phase deviation represents variation of the phase of PM modulated waveform from the carrier phase.
- PM phase deviation can be settable from  $0^\circ$  to  $360^\circ$ . The default is at  $180^\circ$ .
- To modify the parameter, switch on the PM interface, use the multipurpose knob and direction buttons or press **Params**→**PhaseDev** to change.

## Applications

Enable PM mode. To set a 200Hz sine wave from the internal source as modulation signal, with a sine wave (100mVpp at 900Hz) as the carrier with phase deviation at  $200^\circ$ , follow the below steps:

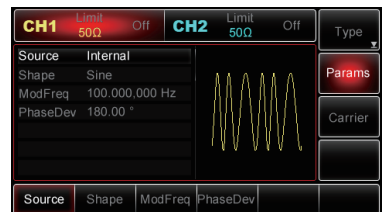
### Enabling PM Function

- Press **Menu**→**Mod**→**Type**→**PM** to switch on PM function.

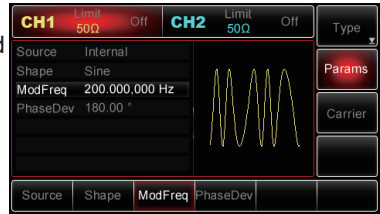


### Setting Modulation Signal Parameters

- With PM function switch enabled above, use the multipurpose knob and direction buttons to complete the setup or you can press **Params** on the interface above to see the display as shown right:

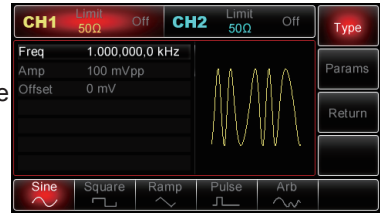


- To set a desired parameter, press the corresponding softkey, then enter in the desired value and select the unit as required.

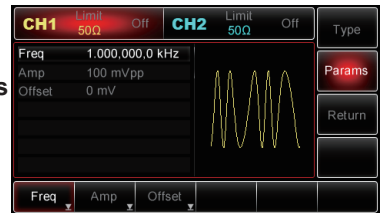


### Setting Carrier Parameters

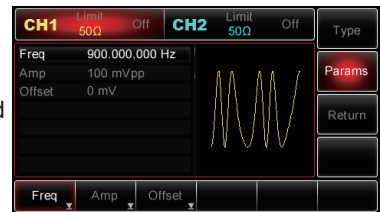
- Press **Carrier**→**Type**→**Sine** to select sine wave as carrier signal. The default is a sine wave.



- Use the multipurpose knob and direction buttons to complete the setup, or press **Params** on the interface above to bring up the display shown to the right (compared with FM, PM parameter list doesn't include Phase option):

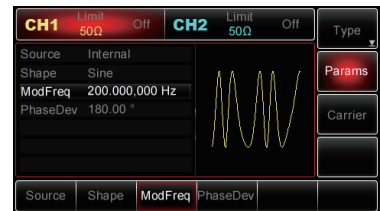


- To set a desired parameter, press the corresponding softkey, then enter in the desired value and select the unit as required.

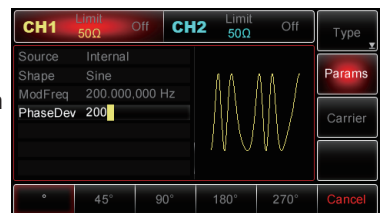


### Setting Phase Deviation

- When the carrier setup has finished, press the **Return** softkey to return to the interface shown right and then set phase deviation.

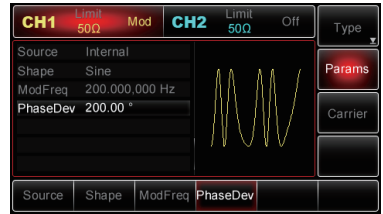


- Use the multipurpose knob and direction buttons to complete the setup, or press **Params**→**PhaseDev** softkeys, before keying in '200' using the numeric keypad and press the softkey to finish the setting.

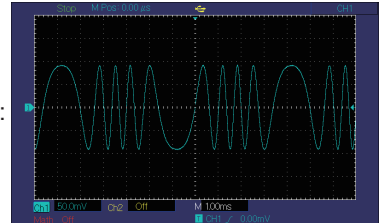


## Enabling Channel Output

- Press the **CH1** button on the front panel to switch on CH1 output directly, or press **Utility** after the label appears and press **CH1 Setting** to enable output.
- With CH1 output enabled, the backlight of the CH1 button will illuminate and “Off” in grey to the right of the CH1 label will change to “Mod” in yellow, which indicates the CH1 output has been enabled.



- The PM modulated waveform with oscilloscope:

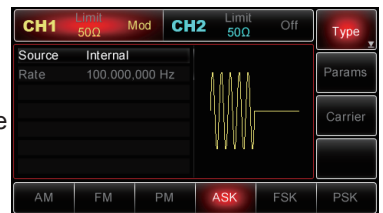


## AMPLITUDE-SHIFT KEYING (ASK) MODULATION

- In ASK, the amplitude variation applied on the carrier signal can reflect the state of digital signal “0” and “1”.
- The high/low logic of modulation signal controls the output of carrier signal in different amplitude. CH1 and CH2 of the Generator can be modulated independently with modulation types applied with the same one or different ones.

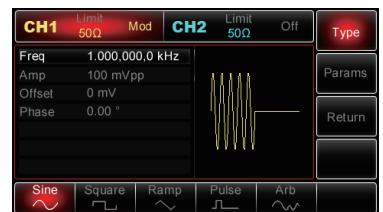
### Selecting ASK

- Press **Menu**→**Mod**→**Type**→**ASK** to enable ASK function.
- With ASK enabled, the Generator will output the modulated waveform at current setting of ASK rate and according to the carrier.



### Selecting the Carrier Wave

- The ASK carrier wave can be: sine wave, square wave, ramp or arbitrary waveform (except DC). It is sine wave by default.
- When ASK is selected, press **Carrier** to access carrier wave.



### Setting Carrier Frequency

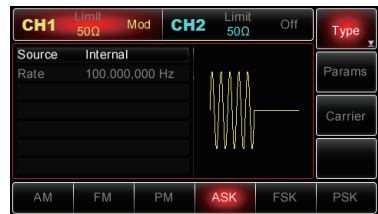
- Carrier frequency ranges could be different and depend on the different carrier wave selected.
- The default is at 1kHz for all functions. See the table on page 26 for details.

Waveform	Min. Value	Max. Value
Sine	1 $\mu$ Hz	25MHz
Square	1 $\mu$ Hz	5MHz
Ramp	1 $\mu$ Hz	400kHz
Pulse	500 $\mu$ Hz	5MHz
Arbitrary	1 $\mu$ Hz	5MHz

- To set the carrier frequency, select the carrier wave first and then use the multipurpose knob and direction buttons to set up the parameter or press **Params**→**Freq** softkeys, enter the desired frequency value and select the desired unit to complete the setting.

### Select Modulation Source

- The Generator has both an Internal and External modulation input.
- With ASK enabled, the modulation source defaults to the Internal Modulation Source.
- To modify the parameter, turn on the ASK interface, turn the multipurpose knob or press **Params**→**Source**→**Ext** softkeys to select.



### Internal Source

- When you select Internal Modulation Source, the modulation shape is the square wave (built-in and unchangeable) with 50% of duty cycle.
- You can change the ASK rate to define the rate at which the modulated waveform shifts.

### External Source

- When you select the External Modulation Source, the rate option won't show on the parameter list and the carrier is modulated by an external waveform.
- The ASK output amplitude is controlled by logic level presented on the external digital modulation (FSK Trig) connector on the rear panel.
- For example, when low external logic level input presents, ASK output amplitude is the current set carrier signal amplitude. When high external logic level input presents, ASK output amplitude is less than current set carrier signal amplitude.

### Setting ASK Rate

- ASK rate is available to set up when you select the Internal Modulation Source.
- With ASK enabled, ASK rate is 100Hz by default and is available to be set up from 100kHz to 2MHz.
- To change the parameter, switch on the ASK interface first, then use the multipurpose knob and direction buttons or press **Params**→**Rate** softkeys to select.

### Applications

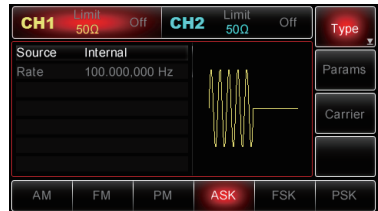
- Switch on the ASK mode of the Generator and then set a 300Hz logic signal as

modulation signal from the Generator itself, with a sine wave (2Vpp, at 15kHz) as the carrier, follow the steps below:

- Note: Logic signal is determined by the internal rate generator, and you can only set up its frequency in order to change ASK rate; this frequency represents the rate at which the output shifts.

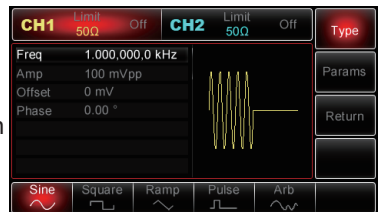
### Enabling ASK

- Press **Menu**→**Mod**→**Type**→**ASK** to switch on ASK function.

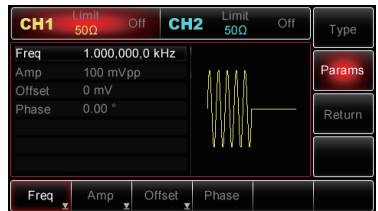


### Setting Carrier Parameters

- Press **Carrier**→**Type**→**Sine** to select the sine wave as the carrier signal. The default selection is a sine wave.

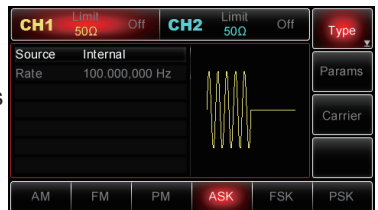


- Use the multipurpose knob and direction buttons to complete the setup or press **Params** on the interface again and the display will show as seen to the right:

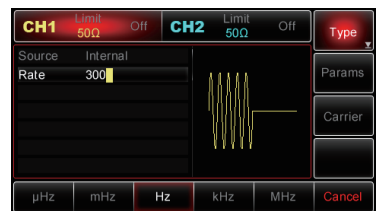


### Setting ASK Rate

- With the carrier parameter setup finished, press the **Return** softkey to return to the interface (right) and then set the ASK rate.

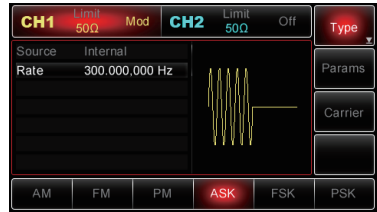


- Use the multipurpose knob and direction buttons to complete the setup, or you can also press **Params**→**Rate** softkeys, then enter in “300” using numeric keypad and press the **Hz** softkey to set ASK rate.

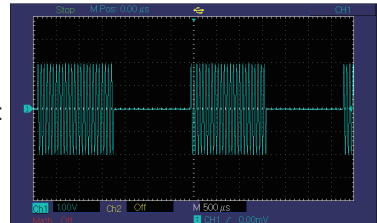


## Enabling Channel Output

- Press the **CH1** button on the front panel to switch on CH1 output quickly, or press **Utility** and then press **CH1 Setting**, once the label appears, to enable the output.
- With CH1 output enabled, the backlight of the CH1 button will illuminate and “Off” in grey to the right of the CH1 label will change to “Mod” in yellow, which indicates the CH1 output has been enabled.



- ASK modulated waveform with an oscilloscope:

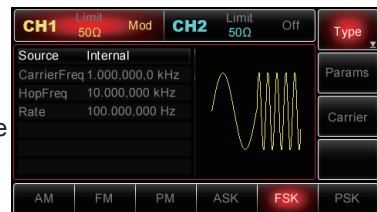


## FREQUENCY-SHIFT KEYING (FSK) MODULATION

- In FSK, the Generator shifts between two preset frequency values (carrier frequency and hop frequency).
- The logic high/low level determines the output of the carrier frequency or hop frequency.
- CH1 and CH2 of the Generator can be modulated independently with modulation types applied with the same one or different ones.

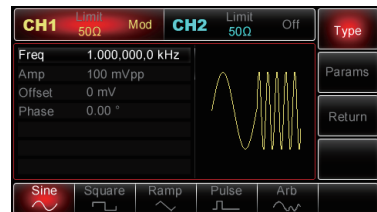
### Selecting FSK

- Press **Menu**→**ModType**→**FSK** to enable FSK function.
- With FSK enabled, the Generator will output the modulated waveform according to the current settings.



### Selecting the Carrier Wave

- FSK carrier wave can be: sine wave, square wave, ramp or arbitrary waveform (except DC). It is sine by default.
- When FSK is selected, press **Carrier** to access the carrier wave to choose.



### Setting Carrier Frequency

- Carrier frequency ranges could be different and depend on different carrier wave selected.
- The default is at 1kHz for all functions. See the table for details.

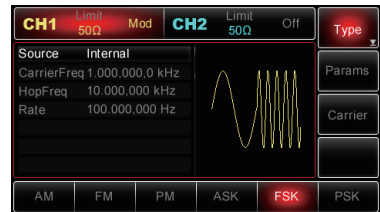


Functions	Min. Value	Max. Value
Sine	1 $\mu$ Hz	25MHz
Square	1 $\mu$ Hz	5MHz
Ramp	1 $\mu$ Hz	400kHz
Pulse	500 $\mu$ Hz	5MHz
Arbitrary	1 $\mu$ Hz	5MHz

- To set the carrier frequency, please select the carrier wave first, and then use the multipurpose knob and direction buttons to set up the parameter or press **Params**→**Freq** softkeys, enter the desired frequency value and select the desired unit to finish the setting.
- If the current carrier wave is exactly as required, you just need to set up the carrier frequency and make the input more direct and flexible.

### Selecting Modulation Source

- The Generator can offer both an internal and external modulation source.
- With FSK enabled, the modulation source defaults to the internal source.
- To modify the parameter, switch on the FSK interface, turn the multipurpose knob or press **Params**→**ModSrc**→**Ext** softkeys to select.



### Internal Source

- When you select internal modulation source, the modulation shape is square wave with a duty cycle of 50%.
- You can change FSK rate to specify the rate at which the modulated waveform shifts between carrier frequency and hop frequency.

### External Source

- When you select external modulation source, the 'Rate' option will not show on the parameter list and the carrier is modulated by an external waveform.
- The output frequency is controlled by logic level presented on the external digital modulation (FSK trig) connector on the rear panel.
- For instance, when the logic low level presents, the carrier frequency is output. With a logic high level, hop frequency is output.

### Setting Hop Frequency

- With FSK enabled, the hop frequency is 10kHz by default.
- To modify the parameter, turn on FSK interface first, then use the multipurpose knob and direction buttons or press **Params**→**HopFreq** to select.
- Hop frequency ranges depend on the carrier wave selected. See the following table for details.

Functions	Min. Value	Max. Value
Sine	1 $\mu$ Hz	25MHz
Square	1 $\mu$ Hz	5MHz
Ramp	1 $\mu$ Hz	400kHz
Pulse	500 $\mu$ Hz	5MHz
Arbitrary	1 $\mu$ Hz	5MHz

### Setting FSK Rate

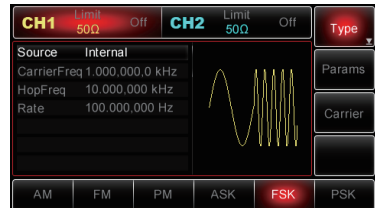
- The shifting frequency between the carrier frequency and hop frequency are available to set up when you select internal modulation source.
- With FSK enabled, the default frequency is set at 100Hz and ranges from 100kHz to 2MHz.
- To change the parameter, use the multipurpose knob and direction buttons or press **Params**→**Rate** softkeys to select.
- Note: Enable FSK function first before modifying FSK rate, press **Menu**→**Mod**→**Type**→**FSK** to enable FSK mode.

### Applications

- In this example, set a sine wave at 2kHz with an amplitude of 1Vpp as the carrier signal and set hop frequency at 800Hz and the rate at 200Hz to shift between carrier frequency and hop frequency. Follow the below steps.

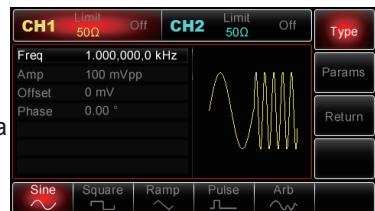
### Enabling FSK

- Press **Menu**→**Mod**→**Type**→**FSK** to switch on FSK function.

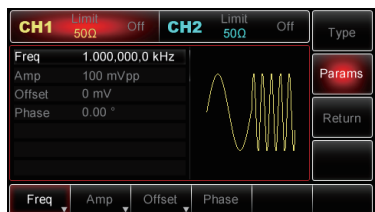


### Setting Carrier Signal Parameters

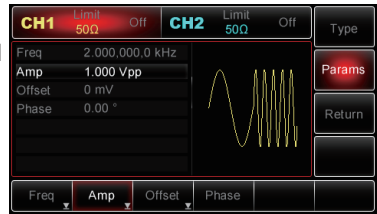
- Press **Carrier**→**Type**→**Sine** to select the sine wave as the carrier wave. The default mode is a sine wave.



- Use the multipurpose knob and direction buttons to complete the setup or press **Params** on the interface again and the display will show as seen to the right:

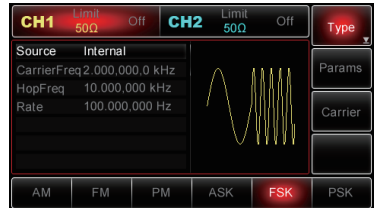


- To set the desired parameter, press the corresponding softkey, then enter in the desired value and select the unit as required.

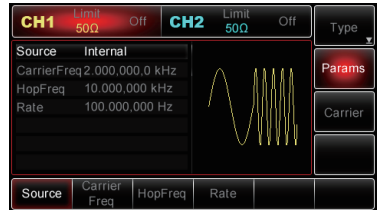


### Setting Hop Frequency and FSK Rate

- With the carrier setup finished, press the **Return** softkey to return to the interface (right):

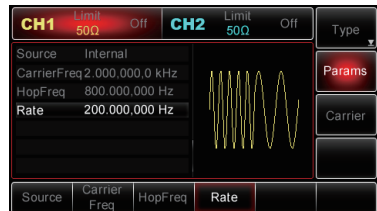


- Use the multipurpose knob and direction buttons to complete the setup, or use the **Params** softkey to open the interface.

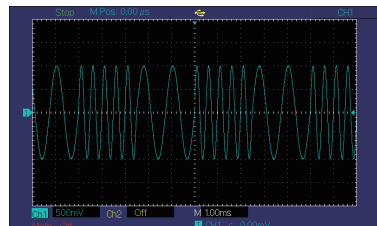


### Enabling Channel Output

- Press the **CH1** button on the front panel to switch on CH1 output directly, or use the **Utility** button; once the menu opens, press the **CH1 Setting** softkeys to enable output.
- With CH1 output enabled, the backlight of the CH1 button illuminates and “Off” in grey to the right of the CH1 label changes to “Mod” in yellow, indicating the CH1 output has been enabled.

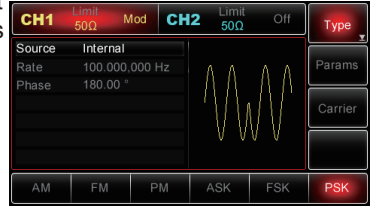


- FSK modulated waveform with an oscilloscope:



## PHASE-SHIFT KEYING (PSK) MODULATION

- In PSK, you can configure the Generator to shift the output phase between present phase values (carrier phase and modulating phase).
- The logic high/low level of modulation signal determines the output of the carrier/modulating phase.
- CH1 and CH2 of the Generator can be modulated independently with modulation types applied with the same one or different ones.

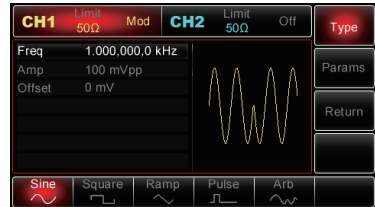


### Selecting PSK

- Press **Menu**→**Mod**→**Type**→**PSK** to enable PSK function. With PSK enabled, the Generator will output the modulated waveform according to the phase of current carrier (defaults at 0° and cannot be changed) and modulation phase.

### Selecting the Carrier Wave

- The PSK carrier wave can be: sine wave, square wave, ramp or arbitrary wave (except DC). It is a sine wave by default.
- When PSK is selected, press the **Carrier** softkey to access carrier wave to choose.



### Setting Carrier Frequency

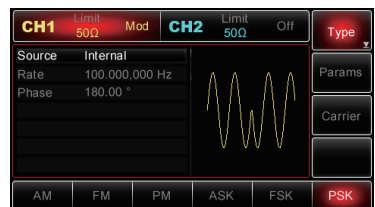
- Carrier frequency ranges could be different and depend on different carrier waves.
- The default is at 1kHz for all carriers. See the following table for details:

Functions	Min. Value	Max. Value
Sine	1μHz	25MHz
Square	1μHz	5MHz
Ramp	1μHz	400kHz
Pulse	500μHz	5MHz
Arbitrary	1μHz	5MHz

- To set the carrier frequency, select the carrier waveform first, then use the multipurpose knob and direction buttons to set up the parameter or press **Params**→**Freq** softkeys, then enter the desired frequency value and select the desired unit to finish the setting.

### Selecting Modulation Source

- The Generator can offer both an internal and external modulation source.
- With PSK enabled, the modulation source defaults to internal source.
- To modify the parameter, turn on the PSK interface first, turn the multipurpose knob or press **Params**→**Mod**→**Source**→**Ext** softkeys to modify.



## Internal Source

- When the internal source is selected, internal modulation signal is the square wave (built-in and cannot be changed) with 50% duty cycle.
- You can modify the PSK rate to define the frequency at which the output shifts between the carrier phase and the modulating phase.

## External Source

- When you select external modulation source, the 'Rate' option won't show on the parameter list and the carriers modulated by an external wave.
- PSK output phase is controlled by logic level presented on the external digital modulation connector (FSK Trig) on the rear panel.
- For instance, when logic low level presents, carrier phase is output; when logic high level presents, the modulation phase is output.

## Setting PSK Rate

- PSK Rate is available to set up when you select Internal Modulation Source. With PSK enabled, PSK Rate is 100Hz by default and ranges from 100kHz to 2MHz.
- To change the parameter, switch on PSK interface first, then use the multipurpose knob and direction buttons or press **Params**→**Rate** softkeys to finish the setting.

## Setting Modulating Phase

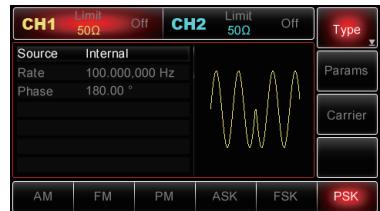
- Modulating Phase represents the phase variation of the PSK modulated waveform from carrier waveform. It ranges from 0° to 360°, and defaults to 180°.
- To modify the parameter, switch on PSK interface, then use the multipurpose knob and direction buttons or press **Params**→**Rate** softkeys to finish the setting.

## Applications

- Firstly, switch on FSK mode on the Generator.
- Set up a sine wave at 2kHz with amplitude 2Vpp as the carrier signal from the Generator itself, and PSK rate 1kHz at which the output shifts between carrier phase and modulation phase, follow the steps as shown below:

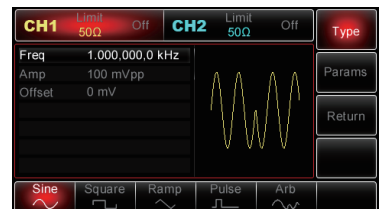
## Enabling PSK

- Press **Menu**→**Mod**→**Type**→**PSK** to switch on PSK function.

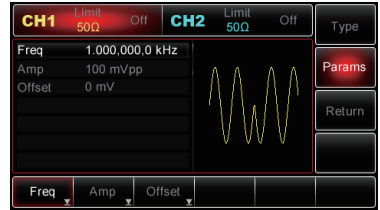


## Setting Carrier Parameters

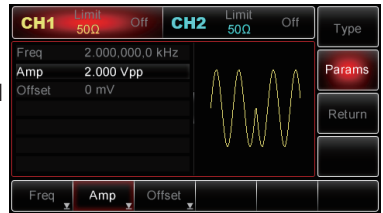
- Press **Carrier**→**Type**→**Sine** to select the sine wave as the carrier signal. Since the default is sine, there is no need to modify the signal.



- You can use the multipurpose knob and direction buttons to complete the setup, or you can press the **Params** softkey on the interface to show the display (right):

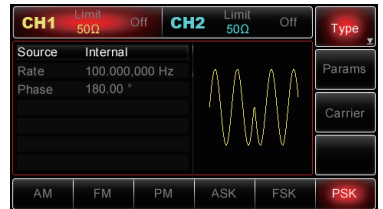


- To set the desired parameter, press the corresponding softkey, then enter in the desired value and select the unit as required.

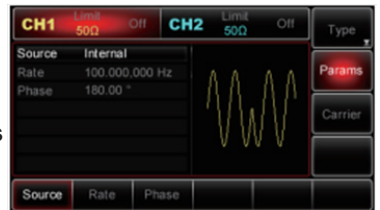


### Setting PSK Rate and Modulation Phase

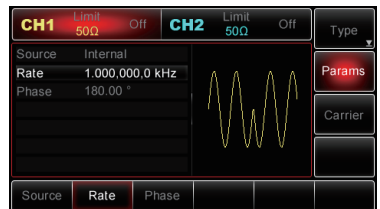
- With the carrier setup finished, press **Return MHz** to return to the interface (right).



- Use the multipurpose knob and directional buttons to complete the setup, or press **Params** to reveal the interface shown right:

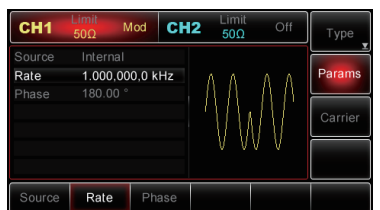


- To set the desired parameter, press the corresponding MHz, then enter the desired value and select the unit as required.



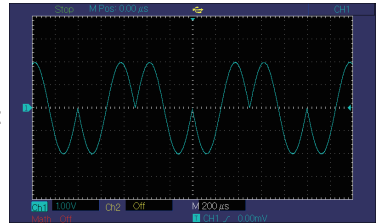
### Enabling Channel Output

- Press the **CH1** button on the front panel to switch on CH1 output directly, or use the **Utility** button; once the menu opens, press **CH1** and then the **Setting** softkey to enable output.
- With CH1 output enabled, the backlight of the CH1 button illuminates and "Off" in grey to the



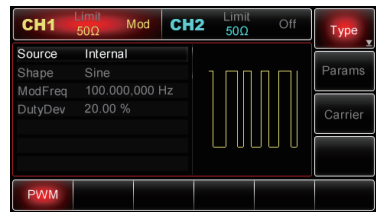
right of the CH1 label changes to “Mod” in yellow, indicating the CH1 output has been enabled.

- PSK modulated waveform with an oscilloscope:



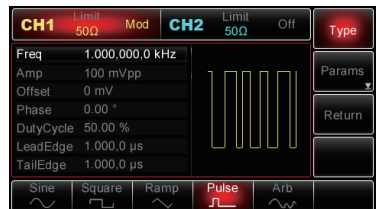
## PULSE WIDTH MODULATION (PWM)

- In PWM, the modulated waveform consists of the carrier and modulation shape.
- Pulse Width of the carrier varies according to the changing amplitude of modulation shape.
- CH1 and CH2 of the Generator can be modulated independently with modulation modes applied with the same one or different ones.
- Press **Menu**→**Mod**→**Type**→**PWM** to enable PWM function.
- With PWM enabled already, the Generator will output the modulated waveform according to current settings of modulation shape and the carrier.



### Carrier Wave

- PWM carrier can be impulse wave only.
- When PWM is selected, press **Carrier** to access the carrier wave selection interface and the ‘Pulse’ label is automatically chosen.



### Setting Carrier Frequency

- The frequency of impulse wave ranges from 500μHz to 25MHz and the default value is 1kHz.
- To set the parameter, press **Carrier MHz** to show the corresponding interface, then use the multipurpose knob & direction buttons to complete the setup, or press **Params**→**Freq MHz**, then enter in the desired value before selecting the desired unit to finish the setting.

### Selecting Carrier Duty Cycle

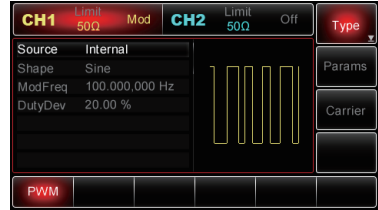
- Duty cycle of impulse wave can be set from 0.01% to 99.99% and defaults at 50%.
- To set up the duty cycle of the carrier, press **Carrier MHz** to reveal the corresponding interface, and then use the multipurpose knob and direction buttons to complete the setup, or press **Params**→**DutyCycle MHz** and then enter in the desired value, and select the desired unit to finish the setting.

## Selecting Modulation Source

- The Generator can offer both an internal and external modulation source.

With PWM enabled the modulation source defaults at internal source. To modify the parameter, turn the multipurpose knob after switching on PWM interface or press **Params**→**Mod**→**Source**→**Ext MHz** to modify.

- Note: Enable PWM function first before selecting modulation source. Press **Menu**→**Mod**→**Type**→**PWM** to switch on the PWM function.



## Internal Source

When you select Internal Source, the modulating waveform can be: sine, square, up ramp, down ramp, arbitrary, noise. The default is sine.

Once PWM is enabled, the modulating shape defaults at sine. To modify the parameter, switch on PWM interface, turn the multipurpose knob or press **Params**→**Wave MHz** softkeys to modify.

- Square: 50% Duty Cycle
- UpRamp: 100% Symmetry
- DownRamp: 0% Symmetry
- Arbitrary: When arbitrary waveform is selected as the modulation shape, the waveform is automatically sampled and limited to 1,000 points.
- Noise: White Gaussian

## External Source

- When you select external source, modulation shape and modulation frequency items won't show on the parameter list and the carrier is modulated by an external waveform.
- PWM duty cycle deviation is controlled by  $\pm 5V$  signal level presented on the external analogue input connector (Modulation In) on the rear panel.
- For instance, if the duty cycle deviation in the parameter list is set to 15%, when external modulation signal +5V is applied, duty cycle of the carrier (Pulse waveform) will increase by 15%; the deviation will be smaller for external signal with lower level.

## Setting Modulating Frequency

- When internal source is selected, the modulation frequency can be set up. With PWM enabled, the modulation frequency is 100Hz by default.
- To modify the parameter, switch on PWM interface, then use multipurpose knob and direction buttons or press **Params**→**ModFreq** to select.
- The modulation frequency range from 50kHz to 20MHz. If external source is selected, modulation shape and modulation frequency will not be on the parameter, and the carrier (impulse wave) will be modulated by an external waveform with a modulation frequency from 0Hz to 20kHz.

## Setting Duty Cycle Deviation

Duty cycle deviation represents the variation in duty cycle of modulated waveform from



duty cycle of current carrier. The duty cycle deviation can be set from 0% to 49.99% and defaults to 20%. To modify the parameter, switch on the PWM interface, then use the multipurpose knob and direction buttons or press **Params**→**DutyDev** to modify:

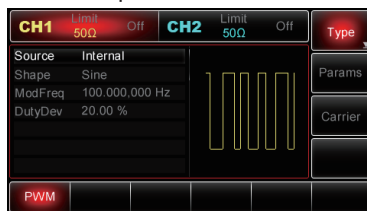
- Duty cycle deviation represents the deviation of duty cycle of modulated waveform from duty cycle of the original impulse waveform, (expressed with a percentage).
- Duty cycle deviation cannot exceed the duty cycle of current impulse waveform.
- Duty cycle deviation plus duty cycle of the current impulse waveform  $\leq 99.99\%$
- Duty cycle deviation is limited by the minimum value of duty cycle of impulse wave and the present edge time.

## Applications

Firstly, enable PM mode on the Generator. In order to set a 1kHz sine wave from the internal generator as modulation signal, to use an impulse wave with 2Vpp amplitude at a frequency of 10kHz, duty cycle at 50% and rising/falling time at 100ns for the carrier and to set the duty cycle deviation at 40%, follow the steps below.

### Enabling PWM Function

- Press **Menu**→**Mod**→**Type**→**PWM** to enable PWM function.



### Setting Modulation Signal Parameters

- With PWM function enabled, use the multipurpose knob and direction buttons to complete the setup, or press **Params** on the interface to present the display as shown right:

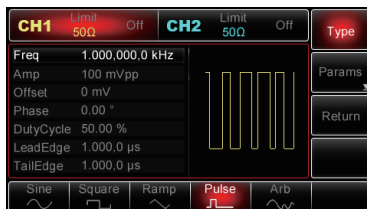


- To set a desired parameter, press the corresponding MHz and then enter in the desired value and select the unit as required.

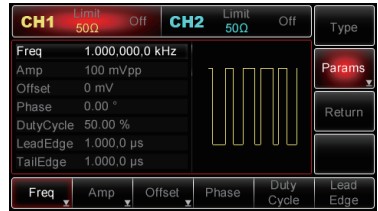


### Setting Carrier Parameters

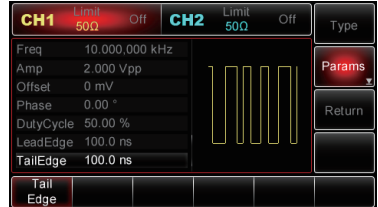
- With PWM interface displayed, press **Carrier** **MHz** to access the carrier parameter setting interface.



- Use the multipurpose knob and direction buttons to complete the setup or press **Params** again on the interface to show the display (right).



- To set the desired parameter, press the corresponding MHz softkey and then enter in the desired value and select the unit as required.



### Setting Duty Cycle Deviation

- With the carrier setup finished, press **Return MHz** to return to the following interface and then set the duty cycle deviation.



- Use the multipurpose knob and direction buttons to complete the setup or press **Params** → **DutyDev MHzs**, then enter in “40” using the numeric keypad and press **% MHz** to finish the setting.

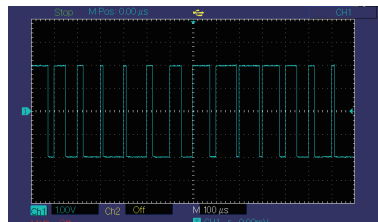


### Enabling Channel Output

- Press the **CH1** button on the front panel to switch on CH1 output directly or press **Utility** → **Ch1** → **Setting** to enable the output.
- With CH1 output enabled, the backlight of the CH1 button illuminates and “Off” in grey to the right of the CH1 label changes to “Mod” in yellow, indicating the CH1 output has been enabled.



- PWM modulated waveform with an oscilloscope:

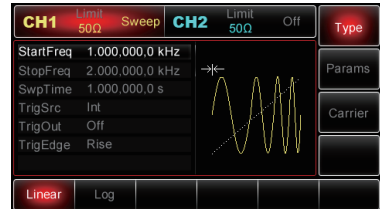


## OUTPUTTING FREQUENCY SWEEP WAVEFORMS

- In Frequency Sweep, the Generator, within the specified sweep time, steps from start frequency to stop frequency with linear or logarithmic spacing.
- Internal, external and manual trigger source are available to select. The Generator can sweep sine, square, ramp and arbitrary waveforms.
- CH1 and CH2 can be modulated independently with modulation types applied with the same one or different ones.

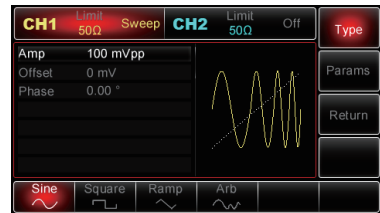
### Enabling Frequency Sweep

- Press **Menu**→**Sweep** to enable the Sweep function and with the function enabled, the Generator will output sweep waveform according to current settings.



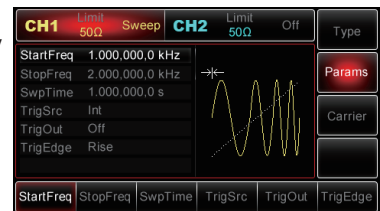
### Selecting Frequency Sweep Waveforms

- With Sweep enabled, press **Carrier** to access sweep waveforms and reveal the interface as shown right.



### Start Frequency and Stop Frequency

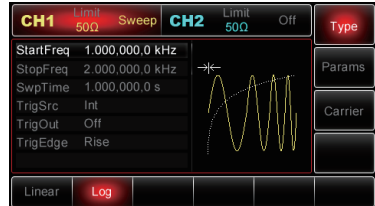
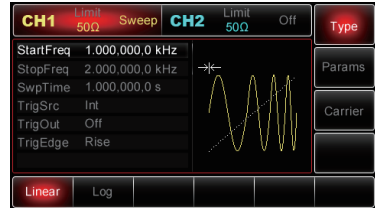
- The start frequency and stop frequency specify the high and low limits for frequency sweep.
- The Generator always moves from the start frequency to stop frequency, and returns to the start frequency again.
- To set start frequency or stop frequency, press the **Return** button to return to Sweep interface after finishing carrier parameter setup, then use the multipurpose knob and direction buttons to perform the setting, or press **Params**→**StartFreq** or **Stop Freq** to select, then enter in the desired value with numeric keypad, and press the corresponding MHz to select the desired unit and finish the setup.
- Start frequency<Stop frequency: the generator sweeps up in frequency.
- Start frequency>Stop frequency: the generator sweeps down in frequency.
- Start frequency=Stop frequency: the generator outputs a fixed frequency.
- Sweep mode synchronization signal is a signal where the period between start to middle of sweep time is low, and middle to end of sweep time is high.
- The default start frequency is 1kHz and the stop frequency default is set at 2kHz.
- Start frequency and stop frequency ranges depend on functions selected and could be different. See the following table for details.



Functions	Min. Value	Max. Value
Sine	1 $\mu$ Hz	25MHz
Square	1 $\mu$ Hz	5MHz
Ramp	1 $\mu$ Hz	400kHz
Pulse	500 $\mu$ Hz	5MHz
Arbitrary	1 $\mu$ Hz	5MHz

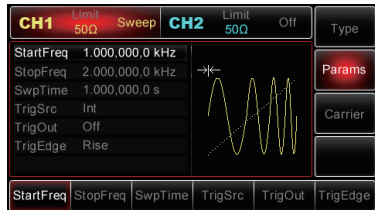
### Sweep Mode

- For linear sweep, the Generator varies the output frequency linearly during sweeping. The default is linear.
- For logarithmic sweep, the Generator varies the output frequency logarithmically during sweeping.
- To modify the parameter, press **Type**→**logarithm MHz** after switching on the Sweep interface.  
Note: if it is in sweep waveform selection interface currently, press **Return MHz** first.



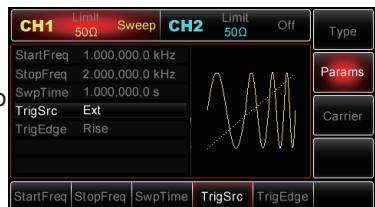
### Sweep Time

- Sweep time is the amount of time needed from start frequency to stop frequency.
- Sweep time defaults at 1s and can be set from 1ms to 500s.
- To modify the parameter, enable Sweep interface, then use the multipurpose knob and direction buttons to set up, or press **Params**→**SwpTim** to select, then enter in the desired value using the numeric keypad and use MHz to choose corresponding unit.



### Selecting Trigger Source

- The Generator will produce one sweep once it receives a trigger signal, and then wait for the next trigger. There are internal, external and manual trigger sources available for your option. To change the parameter, switch on Sweep interface, then operate the multipurpose knob together with direction buttons or press **Params**→**Trig** to complete the setup.
- When internal triggering is selected, the Generator will output a continuous sweep at a rate determined by the sweep time.



- When external triggering is selected, the Generator will accept a hardware trigger applied on the external digital modulation connector (FSK Trig).
- Every time the Generator receives a polarized TTL pulse, it will enable a single sweep.  
Note: When you select external trigger source, trigger out option won't show in the parameter list, because trigger out is executed using the FSK Trig connector, which cannot be used as external trigger input and internal trigger output at the same time.
- When manual triggering is selected, the Generator will output one sweep each time the trigger button is pressed, and the trigger button on the front panel will flash.

### Trigger Out

- When internal or manual trigger source is selected, the Generator outputs TTL-compatible signal (Square wave). Trigger Out is "Off" by default.
- To change the parameter, enable sweep interface, then use the multipurpose knob and direction buttons or press **Params**→**TrigOut**→**On MHz** to complete the setup.
- When internal trigger is selected; the Generator outputs a square wave with 50% duty cycle from external digital modulation connector (FSK Trig) at the start of the sweep. Trigger period is determined by specified sweep time.
- When manual trigger is selected, the Generator outputs a pulse with pulse width >1 $\mu$ s from external digital modulation connector (FSK Trig) at the start of the sweep.
- When external trigger is selected, the Trigger Out option won't show on the parameter list, because Trigger Out is executed through the external digital modulation connector (FSK Trig), which cannot function for both trigger input and output connector at the same time.

### Trigger Edge

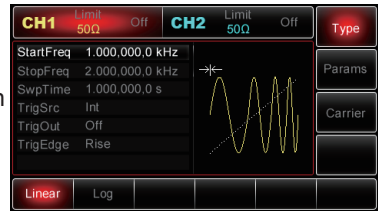
- Even if the external digital modulation connector (FSK Trig) is used as the Trigger In or Out connector, the edge can be specified for both situations.
- When it is used as Trigger In connector (external trigger source is selected), 'Rise' represents the Generator triggers on the rising edge of external signal to output one sweep, and "Fall" indicates the Generator triggers on the falling edge of external signal to output one sweep.
- When it is used as Trigger Out connector (internal or manual trigger source is selected and Trigger Out is enabled), "Rise" means the trigger signal with rising edge is output, and "Fall" is that trigger signal with falling edge is output. It defaults at 'Rise'.
- To modify the parameter, enable the sweep interface, then use the multipurpose knob together with direction buttons or press **Params**→**Trig**→**Falling** to complete the setup.

### Applications

- Firstly, enable Frequency Sweep function. To set a square wave with 1Vpp amplitude and 50% duty cycle as the frequency sweep waveform, the sweep mode to linear, the start frequency at 1kHz, the stop frequency at 50kHz, the sweep time for 2ms and to trigger on rising edge of internal source, follow the following steps.

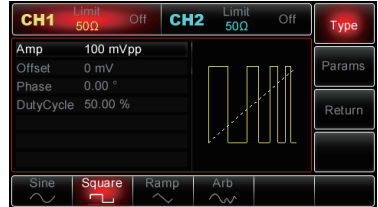
### Enabling Frequency Sweep

- Press **Menu**→**Sweep**→**Type**→**Linear** to switch on linear sweep function.



### Selecting Frequency Sweep Waveforms

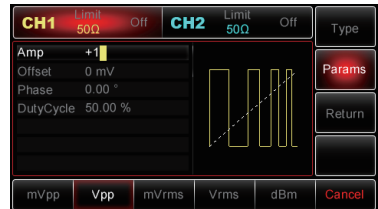
- With linear sweep enabled, press **Carrier**→**Square MHz** and the interface (right) will be on display:



- In this interface, use the multipurpose knob and direction buttons to set the amplitude, or press **Params** to reveal the display shown (right).

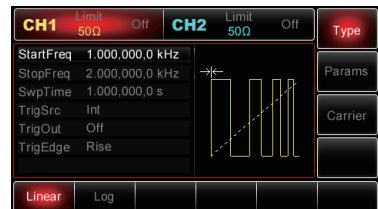


- To set the desired parameter, press the corresponding MHz, then enter in the desired value and select the unit as required.

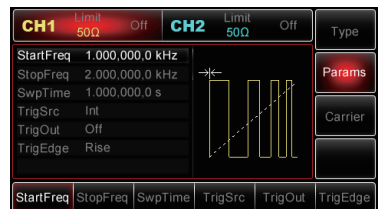


### Setting Start/Stop Frequency, Sweep Time, Trigger Source and Trigger Edge

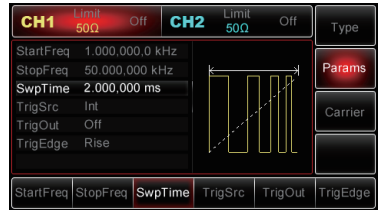
- With frequency sweep waveform and its parameters set up, press **Return MHz** to return to the interface (right).



- In the interface (above right), use the multipurpose knob and direction buttons to perform the setting, or press **Params** to show the display (right).



- To set the desired parameter, press the corresponding MHz, then enter in the desired value and select the unit as required.

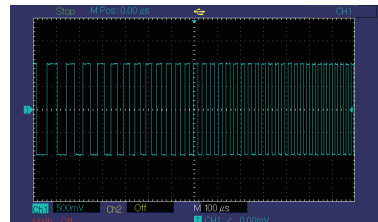


### Enabling Channel Output

- Press the **CH1** button on the front panel to switch on CH1 output directly, or press **Utility** after the label pops up, press **CH1 Setting** to enable the output.
- With CH1 output enabled, the CH1 button backlight turns on and “Off” in grey to the right of CH1 label changes into “Sweep” in yellow, indicating CH1 output has been enabled.



- Sweep waveform with an oscilloscope:



## OUTPUTTING IMPULSE TRAIN

- The Generator can create a cycle-specified waveform (name Impulse Train). Internal, manual and external triggers are available to output the train.
- There are three types of impulse trains: N-Cycle, Gated, and Infinite. The impulse train can be produced with sine, square, ramp, pulse, arbitrary (except DC) or noise (applicable for Gated type only) waveforms. CH1 and CH2 of the Generator can be modulated independently with modulation types applied with the same one or different ones.

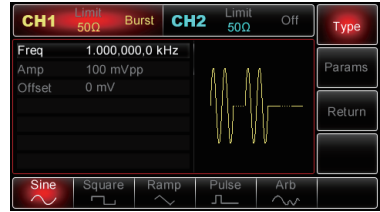
### Selecting Impulse Train

- Enable impulse train function by pressing **Menu**→**Impulse Train**.
- The Generator will output the pulse train according to the current settings.

### Selecting Waveforms

- N-Cycle Mode: Support sine, square, ramp, pulse and arbitrary (except DC) waves.
- Gated Mode: Support sine, square, ramp, pulse and arbitrary (except DC) waves and noise.
- Infinite Mode: Support sine, square, ramp, pulse and arbitrary (except DC) waves.

With pulse train function enabled, press **Carrier MHz** to select sweep waveforms and the display (right) will be shown.



### Setting Waveform Frequency

- In N-Cycle and Gated modes, waveform frequency defines the signal frequency during impulse trains.
- In N-Cycle, impulse train is output with a specified number of cycles at a specified waveform frequency.
- In Gated mode, the impulse train is output at waveform frequency when the trigger signal is at high level.
- Note: Waveform frequency is different from impulse train period; the latter is used to define the intervals between specified impulse trains (for N-Cycle only). It defaults at 1 kHz for all waveforms. Refer to following table for details:

Waveforms	Min. Value	Max. Value
Sine	1μHz	25MHz
Square	1μHz	5MHz
Ramp	1μHz	400kHz
Pulse	500μHz	5MHz
Arbitrary	1μHz	5MHz

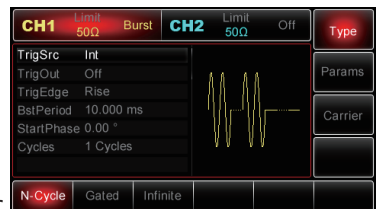
- To set waveform frequency, select the waveform first, then use the multipurpose knob and direction buttons to set up the parameter or press **Params**→**Freq MHz** and enter in the desired frequency value and select the desired unit to finish the setting.

### Impulse Train Type

- The Generator can output three types of impulse trains: N-Cycle, Gate and Infinite. It defaults at N-Cycle.

### N-Cycle

- Enable pulse function, then press **Type**→**N-Cycle MHzs** to access N-Cycle mode (if you are in the impulse train waveform selection interface currently, press **Return MHz** first).
- In N-Cycle mode, the Generator will output a waveform with a specified number of cycles (Impulse Train) every time it receives a trigger.
- After specified cycles are output, the Generator will stop and wait for the next trigger. Internal, external or manual triggering source can be selected for impulse train output.





- To modify the source, enter into burst type interface (see the figure at the bottom of page 44), then use the multipurpose knob and direction buttons or press **Params**→**TrigSrc MHzs** to complete the setup.
- Note: When the external trigger source is selected, Trigger Out option won't show on the parameter list, because Trigger Out is executed through the external digital modulation connector (FSK Trig) which cannot function as trigger input and output connectors at the same time.

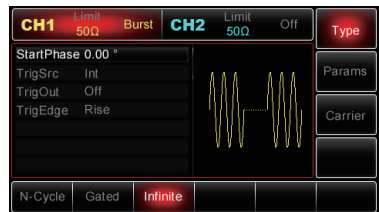
### Gated Mode

- Enable impulse function, then press **Type**→**Gated MHz** to access Gated mode (if you are in impulse train waveform selection interface currently, press **Return MHz** first).
- In Gated mode, Trigger Source, Trigger Out, Trigger Edge, Burst Period (Impulse Train Period) and Cycle Count options won't show on the parameter list.
- Since only external source can be applied, the Generator will output based on the hardware trigger applied on external digital modulation connector (FSK Trig).
- When the polarity is set to be positive and the trigger input signal goes at high level, the Generator will output a continuous waveform; when trigger input signal goes low, current waveform cycle will be finished first, and then the Generator will stop and remain on the level corresponding to the start phase of the selected waveform.
- For noise waveform, when the gated signal goes false, the output will stop immediately.
- To modify the polarity, access Gated mode interface (see above right), then use the multipurpose knob and direction buttons, or press **Params**→**Polarity MHz** to complete the setup.



### Infinite Mode

- Enable impulse function, then press **Type**→**Infinite MHz** to access Infinite mode (if you are in impulse train waveform selection interface currently, press **Return MHz** first).
- In Infinite mode, Burst Period (Impulse Train Period) and Cycle Count won't show on the parameter list, which means increasing the number of waveform cycles to an infinite count. The Generator will output continuous waveform when it receives the trigger signal.
- Trigger source can be internal, external or manual in this mode. To modify the parameter, enter the impulse train type interface (see the figure above right), use the multipurpose knob and direction buttons or press **Params**→ **TrigSrc** to complete the setup.
- Note: When the external trigger source is selected, the Trigger Out option won't show on the parameter list, because Trigger Out is executed through the external digital modulation connector (FSK Trig), which cannot function as trigger input and output connector at the same time.

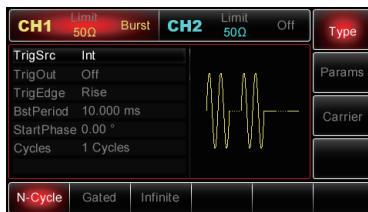


## Impulse Train Phase

- Impulse Train phase is the start phase of impulse train and ranges from  $-360^\circ$  to  $360^\circ$ . It defaults to  $0^\circ$ .
- To modify the parameter, enter the impulse train type interface, then use the multipurpose knob and direction buttons, or press **Params**→**StartPhase** to complete the setup.
- For sine, square, ramp and pulse waveforms,  $0^\circ$  represents the point at which the waveform crosses 0V (or DC offset) in a forward direction.
- For arbitrary waveform,  $0^\circ$  is the first point of waveform downloaded into the memory.
- Start phase has no impact on noise waveform.

## Impulse Train Period

- Impulse Train period is applicable for N-Cycle mode only, which is defined as the amount of time from the start of one impulse train to the start of next one.
- When external or manual trigger source is selected, Impulse Train Period won't show on the parameter list.
- Impulse Train period ranges from  $1\mu\text{s}$  to 500s and defaults at 10ms.
- To modify the parameter, set the impulse train type to N-Cycle first, then use the multipurpose knob and direction buttons together or press **Params**→**BstPeriod** to complete the modification.



## Impulse Train Count

- In N-Cycle mode, impulse train count is used to specify the number of waveform cycles. It can be set from 1 to 50,000 cycles. The default is 1.
- To modify the parameter, set impulse train type to “N-Cycle” first, and then use the multipurpose knob and direction buttons or press **Params**→**Cycles MHz** to complete the setup.
- $\text{Cycles} \leq \text{Burst Period} \times \text{Waveform Frequency}$
- If Cycle count goes beyond the limit, the Generator will automatically increase impulse train period so as to adapt to the specified impulse train count (however waveform frequency stays unchanged.)

## Selecting Trigger Source

- The Generator will output an impulse train once it receives a trigger signal; after that, it stops and waits for the next trigger.
- The impulse train trigger source can be internal, external or manual. To modify the parameter, enter the impulse train type interface first, and then use the multipurpose knob and direction buttons or press **Params**→**TrigSrc** to complete the setup.
- When the internal triggering is selected, the impulse train is output at a specified frequency determined by impulse train period. The Generator can output an “N-Cycle” or an “Infinite” type of impulse train.

- When external triggering is selected, the Generator will accept a hardware trigger applied on the external digital modulation connector (FSK Trig) on the rear panel. Every time the connector receives a polarized TTL pulse, the Generator will output one impulse train. The impulse train can be N-Cycle, Gated or Infinite type.
- Note: When you select external trigger, Trigger Out option will be enconced and won't show on the parameter list, because Trigger Out is executed through the external digital modulation connector (FSK Trig), which cannot function as trigger input and output connectors at the same time.
- When manual triggering is selected, the Generator will output one impulse train each time the Trigger button is pressed in which the backlight flashes. The Generator can output an "N-Cycle" or an "Infinite" type of impulse train.

### Trigger Out

- When internal or manual trigger source is selected, the Generator outputs TTL-compatible signal (Square wave). Trigger Out is set to "Off" by default. To modify the parameter, enter impulse train type interface first, then use the multipurpose knob and direction buttons or press **Params**→**Trig Out**→**Off MHz** to complete the setup.
- When internal triggering is selected, the Generator outputs a square wave with 50% duty cycle from external digital modulation connector (FSK Trig) at the start of the impulse train. Waveform period equals the specified impulse train period.
- When manual triggering is selected, the Generator outputs a pulse with pulse width >1μs from external digital modulation connector (FSK Trig) at the start of burst.
- When external triggering is selected, Trigger Out option won't show on the parameter list, because Trigger Out is executed through the external digital modulation connector (FSK Trig), which cannot function as both trigger input and output connector at the same time.

### Trigger Edge

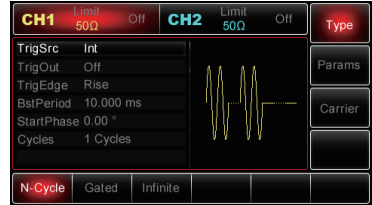
- No matter external digital modulation connector (FSK Trig) is used as Trigger In or Out connector, Trigger Edge can be specified for both situations.
- When it is used as Trigger In connector (external trigger source is selected), 'Rise' represents the Generator and triggers the rising edge of the external signal to output one impulse train, and "Fall" means that the Generator triggers the falling edge of external signal to output one impulse train.
- In Gated mode, if the polarity is 'Pos', the Generator triggers the high level to output one impulse train, otherwise it triggers the low level to output one impulse train if it is 'Neg'.
- When the connector is used as the Trigger Out connector (internal or manual trigger source is selected and Trigger Out is enabled), 'Rise' means the trigger signal with rising edge is output, and "Fall" means that the trigger signal with falling edge is output. It defaults at Rise.
- To modify the parameter, enter the impulse train type interface first, then use the multipurpose knob or direction buttons, or press **Params**→**TrigEdge**→**Falling** (Gated mode: press **Params**→**Polarity**→**Neg**) to complete the setup.

## Applications

- Firstly, enable impulse train mode.
- To set a sine wave with 500mVpp amplitude, 5ms period as impulse train waveform and set impulse train types to N-cycle with impulse train period 15ms and cycle count 2, follow the steps below:

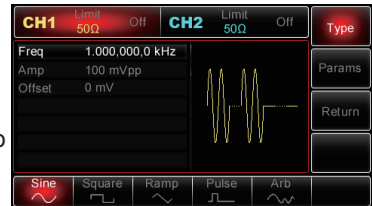
## Enabling Burst Function

- Press **Menu**→**Pulse**→**Type**→**N-Cycle** to set to impulse train type “N-Cycle” mode.

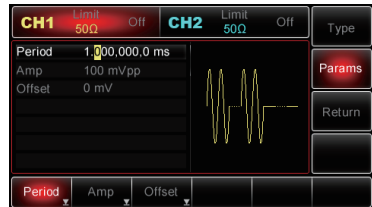


## Selecting Impulse Train Waveforms

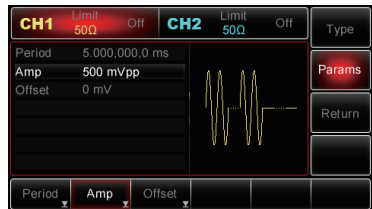
- With N-Cycle mode enabled, press **Carrier**→**Type**→**Sine MHz** to set the sine waveform as the carrier signal.
- Since default burst waveform is sine, there is no need to modify in this case.



- Then you can use the multipurpose knob and direction buttons to set the amplitude (note: if there is only frequency options available on the display, there is no toggling between frequency and period, therefore in order to set the period to 2ms, please set the display frequency to 500Hz, since they are reciprocal,  $T=1/f$ ).
- Or you can press **Params**→**Freq**→**Freq MHz** (the second press on **Freq** is to toggle between frequency and period on the parameter list), then the interface shown to the right will be on display.

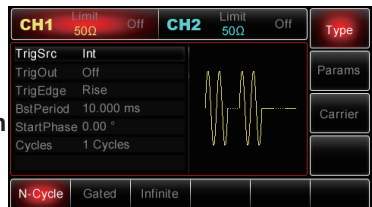


- To set the desired parameter, press the corresponding MHz, then enter in the desired value and select the unit as required.

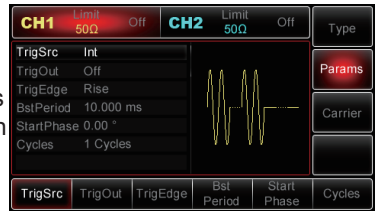


## Setting Impulse Train Period and Cycle Count

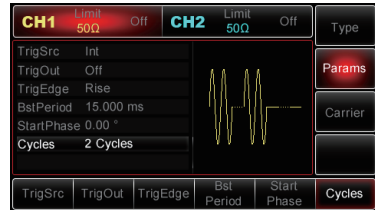
- After completing the setup of impulse train waveform and relative parameters, press **Return MHz** to go back to the interface as shown right.



- Then use the multipurpose knob and direction buttons together to perform the setting, or press **Params MHz** to bring up the interface as shown right:

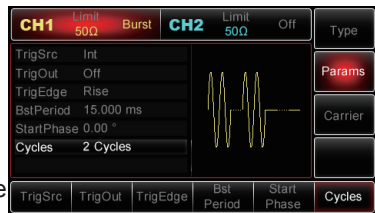


- To set the desired parameter press the corresponding MHz, then enter in the desired value and select the unit as required.

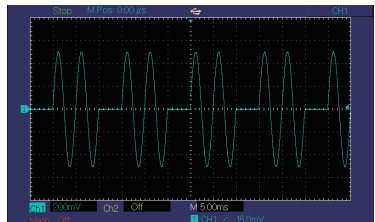


### Enabling Channel Output

- Press the **CH1** button on the front panel to switch on CH1 output directly, or press **Utility** and after the label pops up, press **CH1 Setting** to enable the output. When CH1 output is enabled, it will be indicated by the backlight of the CH1 button illuminating. Also, “Off”, in grey to the right of CH1 label, will change to “Impulse Train” in yellow.



- Impulse train waveform with an oscilloscope:

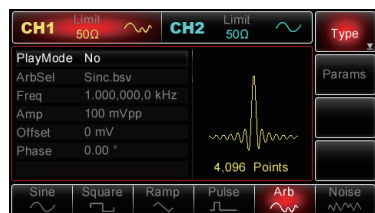


## OUTPUTTING ARBITRARY WAVEFORMS

There are up to 48 types of standard waveforms stored in non-volatile memory - see the table on pages 50 & 51 (Built-in Arbitrary Waveforms list) for detailed information. The Generator can create and edit arbitrary waveforms through PC software and read any arbitrary waveform file stored in USB flash drive through the USB port on the front panel.

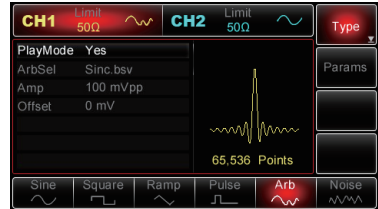
### Enabling Arbitrary Wave Function

- Press **Menu**→**Wave**→**Type**→**Arb** to enable arbitrary wave function. With arbitrary wave function enabled, the Generator will output arbitrary waveform according to the current settings.



### Point-by-Point Output/Play Mode

- The Generator supports points-by-point mode of arbitrary waveform output.
- Under point-by-point output mode the Generator will work out the output frequency based on waveform length and sample rate and then the output waveform point-by-point at this frequency, which can avoid losses of important waveform point during the output.
- The default is “off” under Off status. Through working together with its supplied software, the Generator will automatically interpolate or point to output an arbitrary waveform by sampling based on a fixed waveform length and the frequency defined on the parameter list.
- To change the play mode to “on”, enable arbitrary wave function first, then use the multipurpose knob and direction buttons, or press **Params**→**PlayMode** to set it up.
- Under On status, frequency and phase option will be enclosed and won't show on the parameter list.
- Note: The Generator doesn't support point-by-point mode, instead, it automatically interpolates or points by sampling to output an arbitrary waveform based on a fixed waveform length and the frequency defined on the parameter list.



### Selecting Arbitrary Wave

- The Generator allows users to output arbitrary waves from internal or external memory.
- To select the desired arbitrary wave, enable arbitrary wave function first, then use the multipurpose knob and direction buttons, or press **Params**→**ArbSel MHz**.
- Note: To select a desired arbitrary waveform from U disc, plug the U disc into the USB connector on the front panel, use the multipurpose and direction buttons together or press **Params**→**ArbSel** to select the memory type first, and then choose the desired arbitrary waveform.
- The Generator supports \*.csv file with arbitrary waveform length less than 400,000 points or \*.csv file with arbitrary waveform length less than 1 million points, while the Generator supports C with arbitrary waveform length less than 8,000 points or \*.csv file with arbitrary waveform length less than 8,000 points or \*.csv file.

Type	Name	Type	Name
Common Function	Sin	Common Function	Cardiac
	Square		EEG
	Ramp		DualTone
	NegRamp		AbsSine
	PPulse		StairDn
	NPulse		StairUp
	Noise		Trapezia
	Sine		

Type	Name	Type	Name
Math Function	ExpFall	Trigonometric Function	SinH
	ExpRise		CosH
	Log		SosInt
	Ln		Cot
	HaverSine		Tan
	Lorentz		TanH
	Dlorentz		Asin
	Sqrt		AsinH
	ARB x2		Acos
	Cubic		ACosH
	Gauss		Atan
	LogNormal		AtanH12
	Laplace13		FlattopWin
	Window Function		Boxcar
Triang		Hanning	
Blackman		Kaiser8	
ChebWin			

## TROUBLESHOOTING

To get information about the Generator, press **Utility**→**System**→**System**→**About**.

### No display/blank screen

If the screen is blank and has no display, even after the on/off button has been pressed:

- Make sure power supply is firmly connected to the Generator.
- Make sure the master power switch on the rear panel is in good contact and has been switched to "I".
- Restart the Generator.

### No Waveform Output

- If the settings are correct, but there is no waveform output:
- Make sure the BNC cable is properly connected to the channel output connector
- Make sure **CH1** or **CH2** button has been pressed.
- Save the current settings of the Generator to the USB, then restore the factory settings and reboot the Generator.

### Unable to recognise USB

- Make sure the USB can work normally.
- Make sure the USB in use is flash type, rather than hard-disc type as the Generator does not support the latter.

- Reboot the Generator and insert the USB for a second check.
- Note: If the Generator doesn't work after following the above guide, then please contact your point of purchase.

## UPDATING THE GENERATOR

- Contact Tenma or visit the Tenma website to obtain the latest package.
- Unzip the package and apply the embedded programme updating system to update the current programme.
- To collect information about the Generator such as model, hardware version, software version etc. switch on the Generator, then press **Utility**→**System**→**System**→**About**.

## DEFAULT SETTINGS

Parameters	Default Settings	Parameters	Default Settings
<b>Channel Parameters</b>			
Current carrier	Sine	Out load	50Ω
Sync out	CH1	CH1/CH2 output	OFF
Inverted channel output	OFF	Output limit	OFF
Limit high	+5V	Limit low	-5V
<b>Basic Waveforms</b>			
Frequency	1kHz	Amplitude	100mVpp
DC offset	0mV	Start phase	0°
Duty cycle of square wave	50%	Ramp symmetry	50%
Duty cycle of pulse	50%	Rising edge of pulse	1μs
Falling edge of pulse	1μs		
<b>Arbitrary Waveforms</b>			
Built-in arbitrary waveform	Sine	Play mode	Off
<b>AM</b>			
Modulation source	Internal	Modulation shape	Sine
Modulation frequency	100Hz	Modulation depth	100%
<b>FM</b>			
Modulation source	Internal	Modulation shape	Sine
Modulation frequency	100Hz	Modulation depth	1kHz



<b>PM</b>			
Modulation source	Internal	Modulation shape	Sine
Modulation frequency	100Hz	Frequency deviation	180°
<b>PWM</b>			
Modulation source	Internal	Modulation shape	Pulse
Modulation frequency	100Hz	Phase deviation	20%
<b>ASK</b>			
Modulation source	Internal	ASK rate	100Hz
<b>FSK</b>			
Modulation source	Internal	FSK rate	100Hz
Hop frequency	10kHz		
<b>PSK</b>			
Modulation phase	Internal	PSK rate	10Hz
PSK phase	180°		
<b>Frequency Sweep</b>			
Sweep type	Linear	Start frequency	1kHz
Stop frequency	2kHz	Sweep time	1s
Trigger source	Internal	Trigger out	Off
Trigger edge	Rise		
<b>Burst</b>			
Burst mode	N-Cycle	Start phase	0°
Burst period	10ms	Burst count	1
Gated polarity	Pos	Trigger source	Internal
Trigger out	Off	Trigger edge	Rise
<b>System Parameters</b>			
IP type	DHCP	Clock source	Internal
Clock out	Off	Beep	On
Number separator		Backlight	100%

## TECHNICAL SPECIFICATION

<b>Channel</b>	Dual
<b>Max. Frequency</b>	25MHz
<b>Sample rate</b>	125MSa/s
<b>Waveforms</b>	Sine, Square, Ramp, Pulse, Noise, DC, Arbitrary
<b>Working modes</b>	Gated, Continuous, Modulation, Sweep, Burst
<b>Modulation types</b>	AM, FM, PM, ASK, FSK, PSK, PWM

## WAVEFORM CHARACTERISTICS

<b>Sine</b>		
<b>Frequency range</b>	1 $\mu$ Hz~25MHz	
<b>Resolution</b>	1 $\mu$ Hz	
<b>Accuracy</b>	90 days: $\pm 50$ ppm, 1 year: $\pm 100$ ppm (18°C-28°C)	
<b>Harmonic distortion (typical)</b>	DC~100kHz	-60dBc
	100kHz_1MHz	-50dBc
	1MHz~25MHz	-35dBc
<b>Total harmonic distortion (typical)</b>	DC~20kHz, 1Vpp<0.2%	
<b>Spurious signal (Non-harmonic, typical)</b>	DC~1MHz, <-70dBc	
	1MHz~5MHz, <-60dBc	
	5MHz~25MHz, <-50dBc	
<b>Phase noise (typical)</b>	1kHz offset: -105dBc/Hz	
	10kHz offset: -115dBc/Hz	
	100kHz offset: -125dBc/Hz	
<b>Square</b>		
<b>Frequency range</b>	1 $\mu$ Hz~5MHz	
<b>Resolution</b>	1 $\mu$ Hz	
<b>Rise/fall time</b>	<24ns (Typical, 1kHz, 1Vpp)	
<b>Symmetry (below 50% Duty Cycle)</b>	1% of period + 4ns	
<b>Jitter (typical)</b>	1ns + 100ppm of period	
<b>Ramp</b>		
<b>Frequency range</b>	1 $\mu$ Hz~400kHz	
<b>Resolution</b>	1 $\mu$ Hz	
<b>Nonlinearity</b>	<0.1% of peak out (typical, 1kHz, 1Vpp, 100% symmetry)	
<b>Symmetry</b>	0%~100%	

<b>Pulse</b>	
<b>Frequency range</b>	500 $\mu$ Hz~5MHz
<b>Resolution</b>	1 $\mu$ Hz
<b>Pulse width</b>	40ns~2000s
<b>Variable edge</b>	20ns~2ms (typical 24ns)
<b>Overshoot (typical)</b>	<2%
<b>Jitter</b>	1ns + 100ppm of period
<b>Gaussian Noise</b>	
<b>Bandwidth</b>	Bandwidth 25MHz (-3dB) typical value
<b>DC Offset</b>	
<b>Range (peak AC + DC)</b>	$\pm$ 5V (50 $\Omega$ )
<b>Offset accuracy</b>	
<b>Arbitrary Waveform Characteristics</b>	
<b>Frequency range</b>	1 $\mu$ Hz~5MHz
<b>Resolution</b>	1 $\mu$ Hz
<b>Waveform length</b>	2~8,000 points
<b>Vertical resolution</b>	14 bits (including sign)
<b>Sample rate</b>	125MSa/s
<b>Min. rise/fall time</b>	35ns, typical
<b>Jitter (RMS, typical)</b>	15ns + 100ppm
<b>Non-volatile memory</b>	48 waveforms
<b>Waveform Output</b>	
<b>Impedance</b>	50 $\Omega$ typical
<b>Insulation</b>	Max. 42Vpk to earth
<b>Protection</b>	Short-circuited protection, all front BNC output only

## MODULATION TYPES

<b>AM</b>	
<b>Carrier waveforms</b>	Sine, Square, Ramp, Arbitrary
<b>Source</b>	Internal/External
<b>Modulating waveforms</b>	Sine, Square, Ramp, Noise, Arbitrary
<b>Modulating frequency</b>	2MHz~50kHz
<b>Modulating depth</b>	0%~120%

<b>FM</b>	
<b>Carrier waveforms</b>	Sine, Square, Ramp, Arbitrary
<b>Source</b>	Internal/External
<b>Modulating waveforms</b>	Sine, Square, Ramp, Noise, Arbitrary
<b>Modulating frequency</b>	2MHz~50kHz
<b>Frequency deviation</b>	1Hz~30MHz 1 $\mu$ Hz~12.5MHz
<b>PM</b>	
<b>Carrier waveforms</b>	Sine, Square, Ramp, Arbitrary
<b>Source</b>	Internal/External
<b>Modulating waveforms</b>	Sine, Square, Ramp, Noise, Arbitrary
<b>Modulating frequency</b>	2MHz~50kHz
<b>Phase deviation</b>	0°~360°
<b>ASK</b>	
<b>Carrier waveforms</b>	Sine, Square, Ramp, Arbitrary
<b>Source</b>	Internal/External
<b>Modulating waveforms</b>	Square wave, 50% duty cycle
<b>Modulating frequency</b>	2MHz~100kHz
<b>FSK</b>	
<b>Carrier waveforms</b>	Sine, Square, Ramp, Arbitrary
<b>Source</b>	Internal/External
<b>Modulating waveforms</b>	Square wave, 50% duty cycle
<b>Modulating frequency</b>	2MHz~100kHz
<b>PWM</b>	
<b>Carrier waveforms</b>	Pulse
<b>Source</b>	Internal/External
<b>Modulating waveforms</b>	Sine, Square, Ramp, Noise, Arbitrary
<b>Modulating frequency</b>	2MHz~50kHz
<b>Pulse width deviation</b>	0%~49.99% of pulse width
<b>Frequency Sweep</b>	
<b>Carrier waveforms</b>	Sine, Square, Ramp, Arbitrary
<b>Mode</b>	Linear, Logarithmic
<b>Sweep time</b>	1ms-500s $\pm$ 0.1%
<b>10MHz input/output</b>	10MHz $\pm$ 500Hz TTL compatible
<b>10MHz input/output impedance</b>	10k $\Omega$ (input)/50 $\Omega$ (output), typical, input DC coupling, output AC coupling

Lock time	<2s, typical
External trigger	TTL compatible
<b>Trigger Input</b>	
Input level	TTL compatible
Slope	Rise of fall, selectable
Pulse width	>100ns
Input impedance	>10Ω, DC-coupled
Latency	Sweep <500μs, typical
<b>Trigger Output</b>	
Level	TTL compatible to 500
Pulse width	>400ns typical
Output impedance	50Ω, typical
Max. frequency	1MHz
<b>Frequency Meter</b>	
Input level	TTL compatible
Input frequency range	100mHz~200MHz
Accuracy	±51ppm
Resolution	6 bit/s
Coupling	DC/AC

## GENERAL SPECIFICATION

<b>Display</b>	
Display type	4.3inch, TFT colour LCD
Display resolution	480 horizontal x 272 vertical
<b>Power</b>	
Power voltage	100-240V AC, 45~440Hz, CATII
Power consumption	<50W <40W
Fuse	2A, T-level, 250V
<b>Environment</b>	
Temperature	Operating: 10°C ~ 40°C
	Non-operating: -20°C ~ 60°C
Cooling method	Force fan cooling
Humidity range	<35°C: ≤90% RH
Altitude	Operating: up to 3,000m
	Non-operating: up to 15,000m

<b>Mechanical</b>	
<b>Size</b>	305mm x 230mm x 93mm
<b>Weight</b>	3.1kg (not inc. packaging)
	4.1kg (inc. packaging)

## **CLEANING & MAINTENANCE**

- Do not store or place the Generator in places that leaves the LCD exposed to direct sunlight.
- To avoid any damage to the Generator or the connection wires, keep them in a dry location.
- Before cleaning, disconnect the power, then wipe with a damp cloth. Do not allow water to enter the Generator.
- Do not use any chemicals, abrasive or solvents that could damage the Generator.
- Be careful not to scratch the LCD protective layer when cleaning the LCD.
- Warning: To avoid any short circuit or personal injury occurring from residual water, make sure the Generator is totally dry before plugging it in and switching it on.



### **INFORMATION ON WASTE DISPOSAL FOR CONSUMERS OF ELECTRICAL & ELECTRONIC EQUIPMENT.**

When this product has reached the end of its life it must be treated as Waste Electrical & Electronic Equipment (WEEE). Any WEEE marked products must not be mixed with general household waste, but kept separate for the treatment, recovery and recycling of the materials used. Contact your local authority for details of recycling schemes in your area.

