Arbitrary Function Generator

AFG-2000 Series

USER MANUAL

GW INSTEK PART NO. 82AF-21200E01

ISO-9001 CERTIFIED MANUFACTURER

GW INSTEK

The information in this manual was correct at the time of printing. However, Good Will continues to improve its products and therefore reserves the right to change the specifications, equipment, and maintenance procedures at any time without notice.

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Table of Contents

SAFETY INSTRUCTIONS

This chapter contains important safety instructions that should be followed when operating and storing the function generator. Read the following before any operation to ensure your safety and to keep the function generator in the best condition.

Safety Symbols

These safety symbols may appear in this manual or on the instrument.

 WARNING	Warning: Identifies conditions or practices that could result in injury or loss of life.
 CAUTION	Caution: Identifies conditions or practices that could result in damage to the function generator or to other objects or property.
	DANGER High Voltage
	Attention: Refer to the Manual
	Protective Conductor Terminal
	Earth (Ground) Terminal
	DANGER Hot Surface

Double Insulated

Do not dispose electronic equipment as unsorted municipal waste. Please use a separate collection facility or contact the supplier from which this instrument was purchased.

Safety Guidelines

General Guideline

CAUTION

- Do not place heavy objects on the instrument.
- Do not place flammable objects on the instrument.
- Avoid severe impact or rough handling that may damage the function generator.
- Avoid discharges of static electricity on or near the function generator.
- Use only mating connectors, not bare wires, for the terminals.
- The instrument should only be disassembled by a qualified technician.

(Measurement categories) EN 61010-1:2010 specifies the measurement categories and their requirements as follows. The instrument falls under category II.

- Measurement category IV is for measurement performed at the source of a low-voltage installation.
- Measurement category III is for measurement performed in a building installation.
- Measurement category II is for measurement performed on circuits directly connected to a low voltage installation.
- Measurement category I is for measurements performed on circuits not directly connected to Mains.

Power Supply

WARNING

- AC Input voltage: 100 ~ 240V AC, 50 ~ 60Hz.
- Connect the protective grounding conductor of the AC power cord to an earth ground to prevent electric shock.

Fuse ⚠ WARNING	• Fuse type: F1A/250V. • Only qualified technicians should replace the fuse. • To ensure fire protection, replace the fuse only with the specified type and rating. • Disconnect the power cord and all test leads before replacing the fuse. • Make sure the cause of fuse blowout is fixed before replacing the fuse.
Cleaning the function generator	• Disconnect the power cord before cleaning the function generator. • Use a soft cloth dampened in a solution of mild detergent and water. Do not spray any liquid into the function generator. • Do not use chemicals containing harsh products such as benzene, toluene, xylene, and acetone.
Operation Environment	• Location: Indoor, no direct sunlight, dust free, almost non-conductive pollution (Note below) and avoid strong magnetic fields. • Relative Humidity: < 80% • Altitude: < 2000m • Temperature: 0°C to 40°C (Pollution Degree) EN 61010-1:2010 specifies pollution degrees and their requirements as follows. The function generator falls under degree 2. Pollution refers to "addition of foreign matter, solid, liquid, or gaseous (ionized gases), that may produce a reduction of dielectric strength or surface resistivity". • Pollution degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence. • Pollution degree 2: Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected. • Pollution degree 3: Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation which is expected. In such conditions, equipment is normally protected against exposure to direct sunlight,

	precipitation, and full wind pressure, but neither temperature nor humidity is controlled.
Storage environment	• Location: Indoor • Relative Humidity: < 70% • Temperature: -10°C to 70°C
Disposal 	Do not dispose this instrument as unsorted municipal waste. Please use a separate collection facility or contact the supplier from which this instrument was purchased. Please make sure discarded electrical waste is properly recycled to reduce environmental impact.

Power cord for the United Kingdom

When using the function generator in the United Kingdom, make sure the power cord meets the following safety instructions.

NOTE: This lead/appliance must only be wired by competent persons

⚠ WARNING: THIS APPLIANCE MUST BE EARTHED

IMPORTANT: The wires in this lead are coloured in accordance with the following code:

Green/ Yellow:	Earth
Blue:	Neutral
Brown:	Live (Phase)

As the colours of the wires in main leads may not correspond with the coloured marking identified in your plug/appliance, proceed as follows:

The wire which is coloured Green & Yellow must be connected to the Earth terminal marked with either the letter E, the earth symbol ⏚ or coloured Green/Green & Yellow.

The wire which is coloured Blue must be connected to the terminal which is marked with the letter N or coloured Blue or Black.

The wire which is coloured Brown must be connected to the terminal marked with the letter L or P or coloured Brown or Red.

If in doubt, consult the instructions provided with the equipment or contact the supplier.

This cable/appliance should be protected by a suitably rated and approved HBC mains fuse: refer to the rating information on the equipment and/or user instructions for details. As a guide, a cable of 0.75mm² should be protected by a 3A or 5A fuse. Larger conductors would normally require 13A types, depending on the connection method used.

Any exposed wiring from a cable, plug or connection that is engaged in a live socket is extremely hazardous. If a cable or plug is deemed hazardous, turn off the mains power and remove the cable, any fuses and fuse assemblies. All hazardous wiring must be immediately destroyed and replaced in accordance to the above standard.

GETTING STARTED

The Getting started chapter introduces the function generator's main features, appearance and introduces a quick instructional summary of some of the basic functions. For comprehensive operation instructions, please see the operation chapter.

Main Features

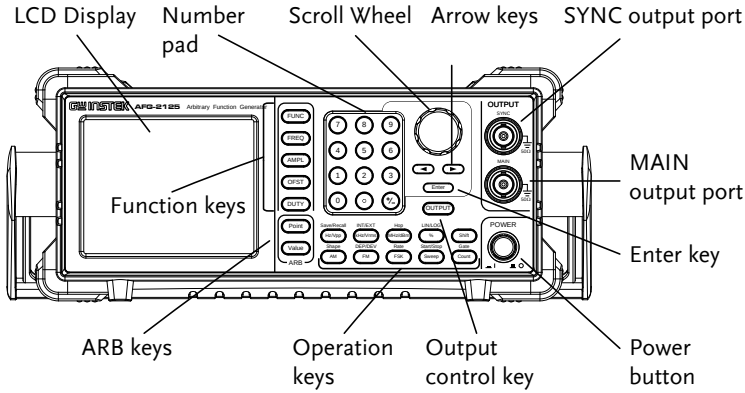
Model name	AFG-2005	AFG-2105	AFG-2012	AFG-2112	AFG-2025	AFG-2125
Frequency Range	0.1Hz~5MHz		0.1Hz~12MHz		0.1Hz~25MHz	
Output waveform	Sine, Square, Ramp, Noise, ARB					
Amplitude range	0.1Hz~20MHz 1 mVpp to 10 Vpp (into 50Ω) 2 mVpp to 20 Vpp (open-circuit)					
	20MHzHz~25MHz 1 mVpp to 5 Vpp (into 50Ω) 2 mVpp to 10 Vpp (open-circuit)					
Variable Offset	✓	✓	✓	✓	✓	✓
Variable Duty	✓	✓	✓	✓	✓	✓
SYNC (TTL) output	✓	✓	✓	✓	✓	✓
Save/Recall	✓	✓	✓	✓	✓	✓
Sweep operation	—	✓	—	✓	—	✓
AM	—	✓	—	✓	—	✓
FM	—	✓	—	✓	—	✓
FSK	—	✓	—	✓	—	✓
Frequency Counter	—	✓	—	✓	—	✓

ARB	✓	✓	✓	✓	✓	✓
USB Interface	✓	✓	✓	✓	✓	✓

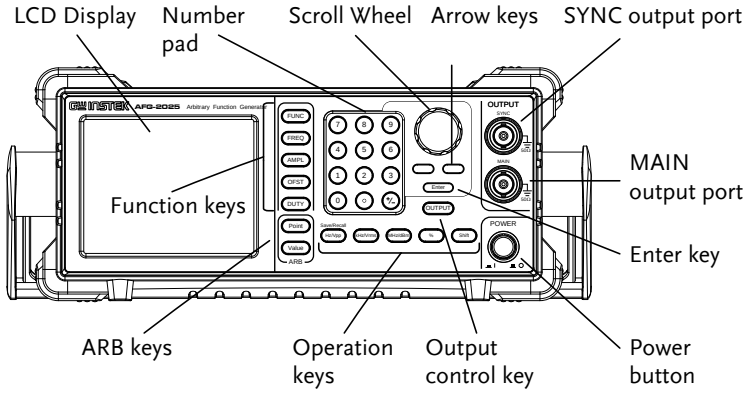
Performance	• DDS technology using an FPGA provides high resolution waveforms • 25MHz DDS (Direct Digital Synthesis) signal output series • 0.1Hz resolution • Full Function Arbitrary Waveform Capability 20 MSa/s sample rate 10 MHz repetition rate 4 k-point waveform length 10-bit amplitude resolution Ten 4k waveform memories
Features	• Sine, Square, Ramp, Noise • Int/Ext AM, FM, FSK modulation • Modulation/sweep signal output • Save/recall 10 groups of setting memories • Output overload protection • ARB (Arbitrary Waveform) can be edited with PC software
Interface	• USB interface as standard • 3.5 inch LCD

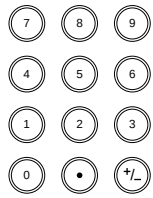
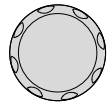
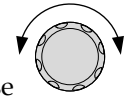
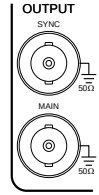
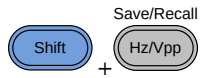
Panel Overview

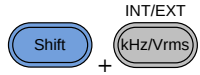
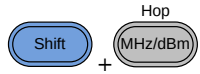
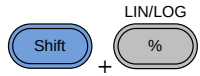
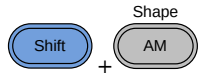
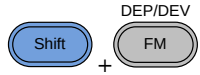
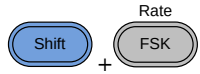
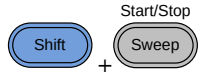
AFG-2105/2112/2125 Front Panel

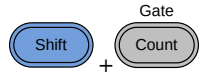
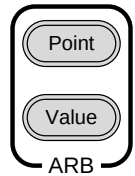


AFG-2005/2012/2025 Front Panel



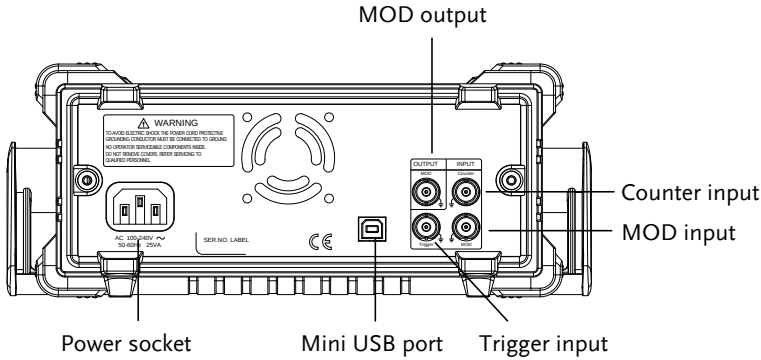
LCD display	3.5 inch, 3 color LCD display.	
Keypad		The digital keypad is used to enter values and parameters. The keypad is often used in conjunction with the selection keys and variable knob.
Scroll Wheel		The scroll wheel is used to edit values and parameters in steps of 1 digit. Used in conjunction with the arrow keys.  Decrease Increase
Arrow keys		Used to select digits when editing parameters.
Output ports		SYNC output port (50Ω impedance). Main output port (50Ω impedance).
Enter key		Used to confirm input values.
Power button		Turns the instrument power on/off.
Output control key		Turns the output on/off.
Operation keys		Selects Hz or Vpp units.
		Saves or recalls waveforms from memory.
		Selects kHz or Vrms units.

	Sets the source to internal or external for the modulation and FSK functions*.
	Selects MHz or dBm units.
	Sets the "Hop" frequency for FSK modulation*.
	Selects % units.
	Sets the sweep to linear or logarithmic*.
	The shift key is used to select the secondary functions on the operation keys.
	The AM key is used to turn AM modulation on/off*.
	Selects the modulation waveform*.
	The FM key is used to turn FM modulation on/off*.
	Selects the modulation depth or the frequency deviation*.
	Selects FSK modulation*.
	Sets the AM, FM, FSK modulation and sweep function rate*
	Selects the Sweep function*.
	Sets the Start or Stop frequency*.
	Turns the frequency counter on/off*.

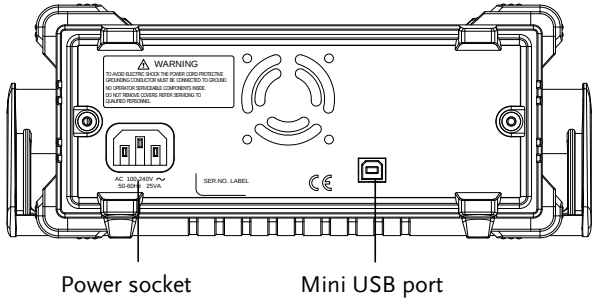
		Sets the frequency counter gate time*.
ARB edit keys		Arbitrary waveform editing keys. The Point key sets the ARB point numbers. The Value key sets the amplitude value of the selected point.
Function keys		The FUNC key is used to select the output waveform type: Sine, Square, Ramp, Noise, ARB.
		Sets the frequency of the selected waveform.
		Sets the amplitude of the selected waveform.
		The OFST sets the DC offset for the selected waveform.
		The DUTY key sets the duty cycle of square and ramp waveforms.

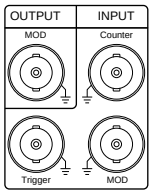
*indicates functions/features for the AFG-2105/2112/2125 only.

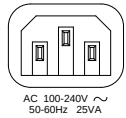
AFG-2105/2112/2125 Rear Panel



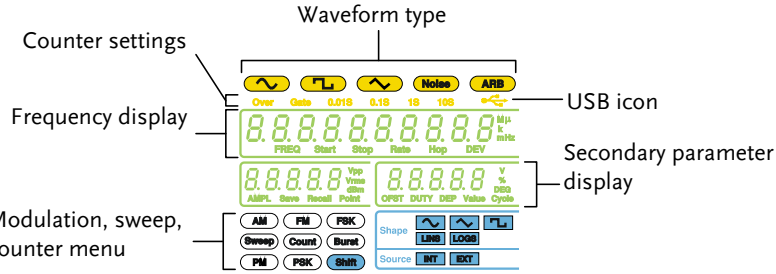
AFG-2005/2012/2025 Rear Panel



MOD output		Modulation output port.
Counter input		Counter input port.
MOD input		Modulation input port.
Trigger input		Trigger input port.
Mini USB B port		The Mini-B type USB connector is used to connect the function generator to a PC for remote control.

Power Socket Input		Power input: 100~240V AC 50~60Hz.

Display



Waveform type

Press the function key to cycle through different output waveforms.

Counter settings

Over Gate 0.01S 0.1S 1S 10S

Gate time counter settings*.

USB icon

Shows the USB interface status.

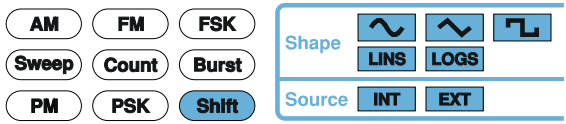
Frequency Display

Displays the main waveform frequency settings.

Secondary parameter display

Displays secondary waveform parameters and settings.

Modulation, sweep, counter menu



Displays the modulation, sweep and counter functions as well as the modulating waveform and source*.

*indicates functions/features for the AFG-2105/2112/2125 only.

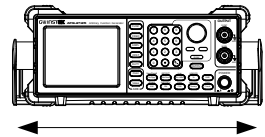
Setting up the Function Generator

Background

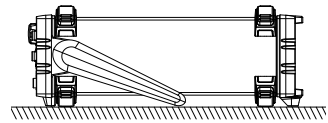
This section describes how adjust the handle and power up the function generator.

Adjusting the stand

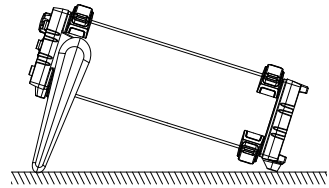
Pull out the handle sideways and rotate it.



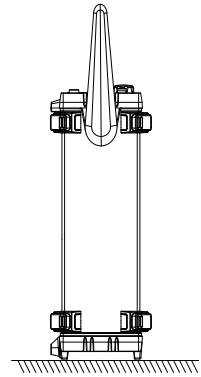
Place the AFG horizontally.



Place the handle upright to tilt the stand.

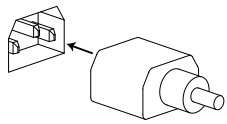


Place the handle vertically to hand carry.



Power Up

1. Connect the power cord to the socket on the rear panel.



2. Press the power button on the front panel.

3. The instrument will turn on and load the default settings (see page 33 for default settings).

The function generator is now ready to be used.

QUICK REFERENCE

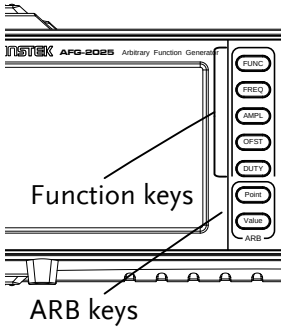
This chapter lists operation shortcuts and default factory settings. Use this chapter as a handy reference for instrument functions. This chapter is to be used as a quick reference; for detailed explanations on parameters, settings and limitations, please see the operation chapter (page 35) or specifications (page 137).

How to use the Digital Inputs

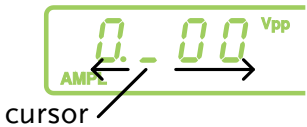
Background

The AFG-2000 has three main types of digital inputs: the number pad, arrow keys and the scroll wheel. The following instructions will show you how to use the digital inputs to edit parameters.

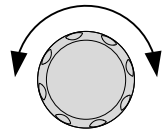
1. First select the function that must be edited pressing one of the function or ARB keys. The selected function will flash.



2. To edit a parameter, use the arrow keys to move the cursor to the digit that needs to be edited.

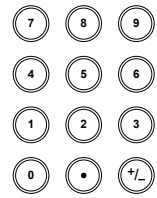


3. Use the scroll wheel to increment the parameter by the resolution of the digit under the cursor.
In the example above, the scroll wheel will increment the parameter in 0.1 volt increments.
Clockwise increases the value, counterclockwise decreases the value.



4. Press the Enter key to confirm the new parameter value.

5. Alternatively, the number pad can be used to set the value of the selected parameter.



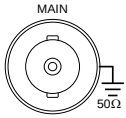
6. To finish editing with the number pad, select the unit with one of the unit keys. (Hz, kHz, MHz, Vpp, Vrms, dBm, %)

Selecting a Waveform

Sine Wave

Example: Sine Wave, 10kHz, 1Vpp, 2Vdc

Output



1. Press the **FUNC** key repeatedly to select the Sine wave.

2. Press **FREQ > 1 > 0 > kHz**.

3. Press **AMPL > 1 > Vpp.**

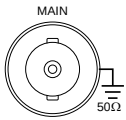
4. Press **OFST > 2 > Vpp.**

5. Press the **OUTPUT** key.

Square Wave

Example: Square Wave, 10kHz, 3Vpp, 75% duty cycle

Output



1. Press the **FUNC** key repeatedly to select the Square wave.

2. Press **FREQ > 1 > 0 > kHz**.

3. Press **AMPL > 3 > Vpp.**

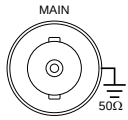
4. Press **DUTY > 7 > 5 > %.**

5. Press the output key.

Ramp Wave

Example: Ramp Wave, 10kHz, 3Vpp, 25% symmetry

Output



1. Press the **FUNC** key repeatedly to select the Ramp wave.

2. Press **FREQ > 1 > 0 > kHz**.

3. Press **AMPL > 3 > Vpp.**

4. Press **DUTY > 2 > 5 > %.**

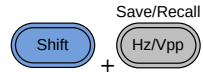
5. Press the **OUTPUT** key.

Save/Recall

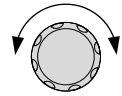
Save

Example: Save waveform to memory.

1. Press **Shift > Save/Recall.** Select **Save.**



2. Turn the scroll wheel and choose a save number.

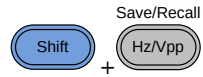


3. Press **Enter** to confirm the save file number.

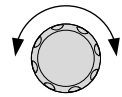
Recall

Example: Recall waveform from memory.

1. Press **Shift > Save/Recall.** Select **Recall.**



2. Turn the scroll wheel and choose a saved file number.



3. Press Enter to confirm the recall.

Default Settings

The default settings appear each time the power is turned on.

Output Config.	Function	Sine wave
	Frequency	1kHz
	Amplitude	100mVpp
	Offset	0.00Vdc
	Output units	Vpp
	Output terminal	50Ω
Modulation (AM/FM/FSK)	Carrier Wave	1kHz Sine wave
	Modulation waveforms	100Hz Sine wave
	AM Depth	100%
	FM Deviation	10Hz
	FSK Hop Frequency	100Hz
	FSK Frequency	500Hz
	Modulation Status	Off
Sweep	Start/Stop frequency	100Hz/1kHz
	Sweep time	1s
	Sweep rate	100Hz
	Sweep type	Linear
	Sweep status	Off
System settings	Power off signal	On
	Display mode	On
	Error queue	cleared

	Memory settings (ARB)	No change
	Output	Off
Interface config.	USB	CDC
Calibration	Calibration Menu	Restricted

OPERATION

The Operation chapter shows how to output basic waveforms and create ARB waveforms. The AFG-2105/ 2112/ 2125 can also perform advanced functions such as modulation, sweep, FSK and counter functions.

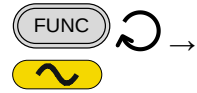
Select a Waveform

The AFG-2000 can output four standard waveforms: sine, square, ramp and noise waveforms.

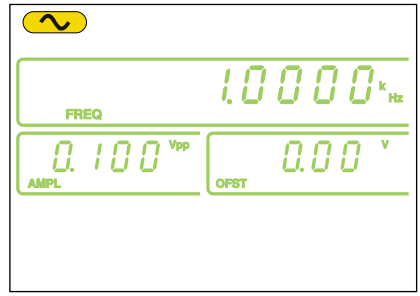
Sine, Square, Ramp, Noise Waveform

Panel Operation

1. Press the **FUNC** key repeatedly to select a standard waveform (Sine, Square, Ramp, Noise).



Example:
Sine wave



Note

The modulation, FSK, sweep and counter functions must be disabled before a standard waveform can be output.

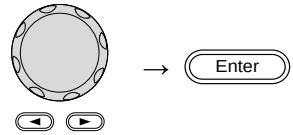
Setting the Frequency

Panel Operation

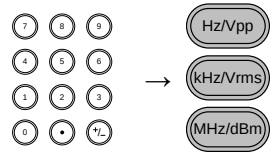
1. Press the **FREQ** key.

2. The FREQ icon will flash in the frequency display area.

3. Use the **arrow keys**, **scroll wheel** and **Enter** key to edit the frequency.



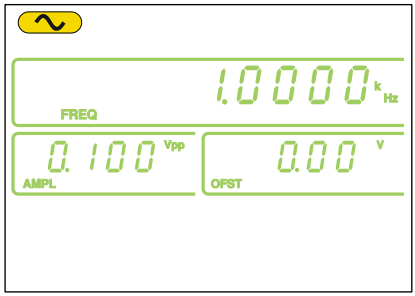
Use the **keypad** and the relevant **unit** key to enter a new frequency.



Range	Sine	0.1Hz ~ 25MHz*
	Square	0.1Hz ~ 25MHz*
	Ramp	0.1Hz ~ 1MHz

*limited to 5MHz for the AFG-2005/2105, 12MHz for the AFG-2012/2112.

Example:
FREQ = 1kHz



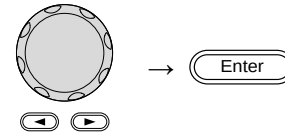
Setting the Amplitude

Panel Operation

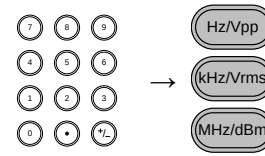
1. Press the **AMPL** key.

2. The AMPL icon will flash in the secondary display area.

3. Use the **arrow keys**, **scroll wheel** and **Enter** key to edit the amplitude.

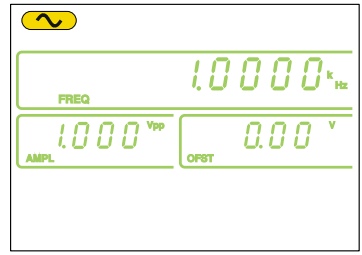


Use the **keypad** and the relevant **unit** key to enter a new amplitude.



Range	No load	2mVpp~20Vpp 2mVpp~10Vpp for 20MHz – 25MHz
	50Ω Load	1mVpp~10Vpp 1mVpp~5Vpp for 20MHz – 25MHz

Example:
AMPL= 1Vpp



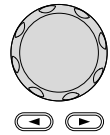
Setting the DC Offset

Panel Operation

1. Press the **OFST** key.

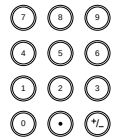
2. The OFST icon will flash in the secondary display area.

3. Use the **arrow keys**, **scroll wheel** and **Enter** key to edit the offset.



→ Enter

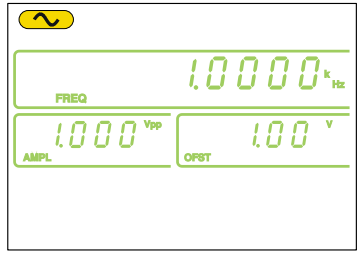
Use the **keypad** and the **Vpp** key to enter a new offset.



→ Hz/Vpp

Range	No Load (AC+DC)	±10Vpk ±5 Vpk for 20MHz–25MHz
	50Ω Load (AC+DC)	±5 Vpk ±2.5 Vpk for 20MHz–25MHz

Example:
OFST= 1VDC



Setting the Duty Cycle/Symmetry

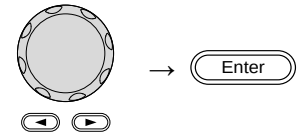
Background

The DUTY key sets the duty cycle or symmetry of the standard square or ramp waveforms.

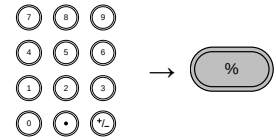
Panel Operation

1. Ensure a square or ramp waveform is selected. Page 37
2. Press the **DUTY** key. DUTY
3. The duty icon will flash in the secondary display area.

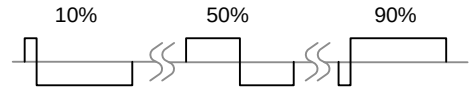
4. Use the **arrow keys**, **scroll wheel** and **Enter** key to edit the duty cycle/symmetry.



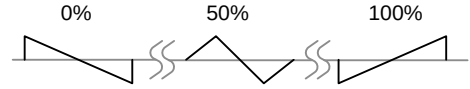
Use the **keypad** and the % key to enter a new duty cycle/symmetry.



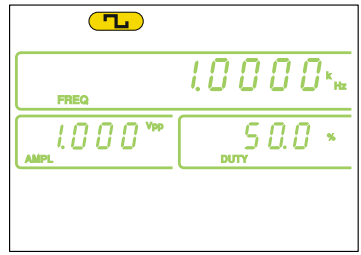
Duty Cycle Range	≤ 100kHz	1.0% ~ 99.9%
	≤ 5MHz	20.0% ~ 80.0%
	≤ 10MHz	40.0 ~ 60.0%
	≤ 25MHz	50.0% (fixed)



Symmetry Range	All frequencies	0% ~ 100%

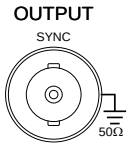


Example:
DUTY= 50.0%

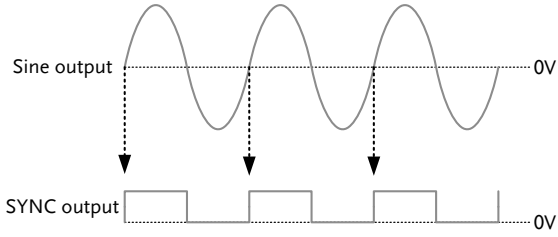


Using the SYNC Output Port

Connecting the SYNC Output Port

Background	The SYNC output port is used as a synchronization signal for function outputs. All the output signals apart from the noise output function have a synchronization signal.
Connection	Connect a BNC cable from the SYNC output port on the front panel to the desired input device. 
Note	The SYNC signal is output even when the main output is not output.

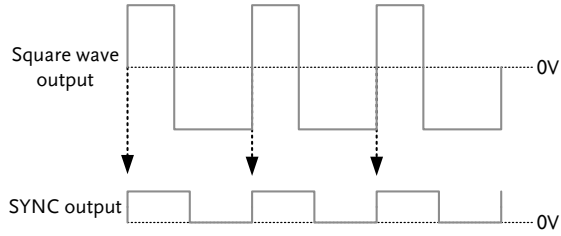
SYNC Output Signal

SYNC Output For Sine Wave	SYNC output: TTL square waveform with a 50% duty cycle. The SYNC output is at a logically high level when the sine output is positive.
Output diagram	

SYNC Output For Square Wave

SYNC output: TTL square waveform with a duty cycle corresponding to the duty cycle of the output square wave. The SYNC output is at a logically high level when the square wave output is positive.

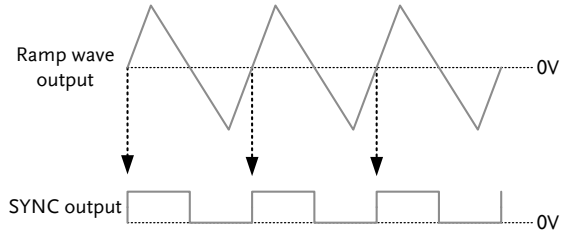
Output diagram



SYNC Output For Ramp Wave

SYNC output: TTL square waveform with a 50% duty cycle. The SYNC output is at a logically high level when the sine output is positive.

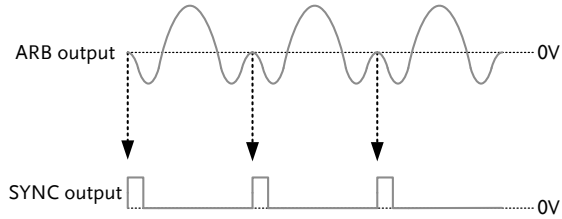
Output diagram



SYNC Output For ARB Wave

SYNC output: A single TTL positive pulse at the start of each ARB period (pulse width = 1/sample rate).

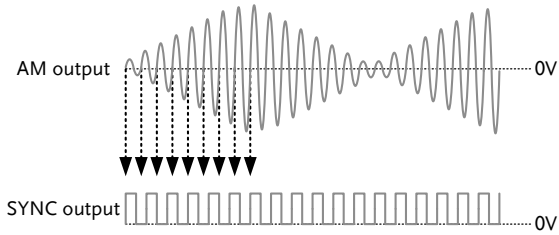
Output diagram



SYNC Output For AM

SYNC output: TTL square waveform with a 50% duty cycle. The SYNC output is at a logically high level when the modulated output is positive.

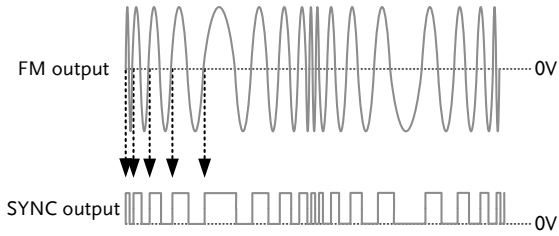
Output diagram



SYNC Output For FM

SYNC output: TTL square waveform with a 50% duty cycle. The SYNC output is at a logically high level when the modulated output is positive (The SYNC output is synchronized to the modulated output frequency).

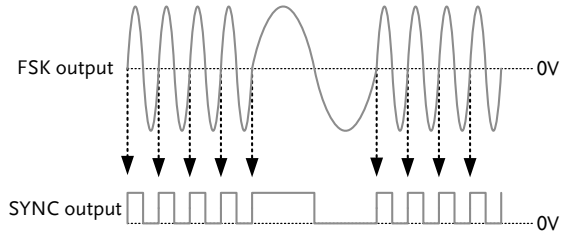
Output diagram



SYNC Output For FSK

SYNC output: TTL square waveform with a 50% duty cycle. The SYNC output is at a logically high level when the modulated output is positive (The SYNC output is synchronized to the modulated output frequency).

Output diagram



SYNC Output For Sweep

SYNC output: TTL square waveform. The SYNC output is at a logically high level when the sweep output is positive (The SYNC output is synchronized to the sweep output frequency).

Output diagram