# Synthesized Function Generator

SFG-2000/SFG-2100 Series

## USER MANUAL

GW INSTEK PART NO. 82FG-21200MD



ISO-9001 CERTIFIED MANUFACTURER GW INSTEK

Good Will Instrument Co., Ltd.

No. 7-1, Jhongsing Rd., Tucheng City, Taipei County 236, Taiwan.

# Table of Contents

# SAFETY INSTRUCTIONS

This chapter contains important safety instructions that you must follow when operating SFG-2000 series and when keeping it in storage. Read the following before any operation to insure your safety and to keep the best condition for SFG-2000 series.



## Safety Symbols

These safety symbols may appear in this manual or on SFG-2000 series.

| | |
|---|---|
| **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 SFG-2000 series or to other properties. |
| | Attention Refer to the Manual |
| | Earth (ground) Terminal |





## Safety Guidelines

**General Guideline**

**CAUTION**

- Do not place any heavy object on SFG-2000 series.
- Avoid severe impacts or rough handling that leads to damaging SFG-2000 series.
- Do not discharge static electricity to SFG-2000 series.
- Use only mating connectors, not bare wires, for the terminals.
- Do not block or obstruct cooling vent opening.
- Do not perform measurements at power source and building installation site (Note below).
- Do not disassemble SFG-2000 series unless you are qualified as service personnel.

(Note) EN 61010-1:2001 specifies the measurement categories and their requirements as follows. SFG-2000 series falls under category II.

- Measurement category IV is for measurement performed at the source of low-voltage installation.
- Measurement category III is for measurement performed in the building installation.
- Measurement category II is for measurement performed on the circuits directly connected to the low voltage installation.

**Power Supply**

**WARNING**

- Input voltage: 115/230V AC +10%, −15%, 50/60Hz
- The power supply voltage should not fluctuate more than 10%.
- Connect the protective grounding conductor of the power cord to earth ground, to avoid electrical shock.

**Fuse**

**WARNING**

- Fuse type: T0.125A/ 250V
- Only service personnel are allowed to access internal fuse holders.
- Replace the fuse with the specified type and rating only, for continued fire protection.
- Disconnect the power cord before fuse replacement.
- Make sure the cause of the fuse blowout is fixed before fuse replacement.

| | |
|---|---|
| Cleaning SFG-2000 series | • Disconnect the power cord before cleaning.<br>• Use a soft cloth dampened in a solution of mild detergent and water. Do not spray any liquid into SFG-2000 series.<br>• Do not use chemicals or cleaners containing harsh materials such as benzene, toluene, xylene, and acetone. |
| Operation Environment | • Location: Indoor, no direct sunlight, dust free, almost non-conductive pollution (Note below)<br>• Relative Humidity: < 80%<br>• Altitude: < 2000m<br>• Temperature: 0°C to 40°C<br><br>(Note) EN 61010-1:2001 specifies the pollution degrees and their requirements as follows. SFG-2000 series 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".<br>• Pollution degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.<br>• Pollution degree 2: Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.<br>• 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<br>• Relative Humidity: < 80%<br>• Temperature: −10°C to 70°C |





## Power cord for the United Kingdom

When using SFG-2000 series 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 colours 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 the letter E or by the earth symbol ⏚ or coloured Green or 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, 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 moulded mains connector that requires removal /replacement must be destroyed by removal of any fuse & fuse carrier and disposed of immediately, as a plug with bared wires is hazardous if a engaged in live socket. Any re-wiring must be carried out in accordance with the information detailed on this label.

# GETTING STARTED

This chapter describes SFG-2000 series in a nutshell, including main features and front/rear/display introduction. Follow the Set Up section to properly install and power up SFG-2000 series.







## Technical background

**Traditional function generators**

SFG-2000 series uses the latest Direct Digital Synthesis (DDS) technology to generate stable, high resolution output frequency. The DDS technology solves several problems encountered in traditional function generators, as follows.

**Constant current circuit methodology**

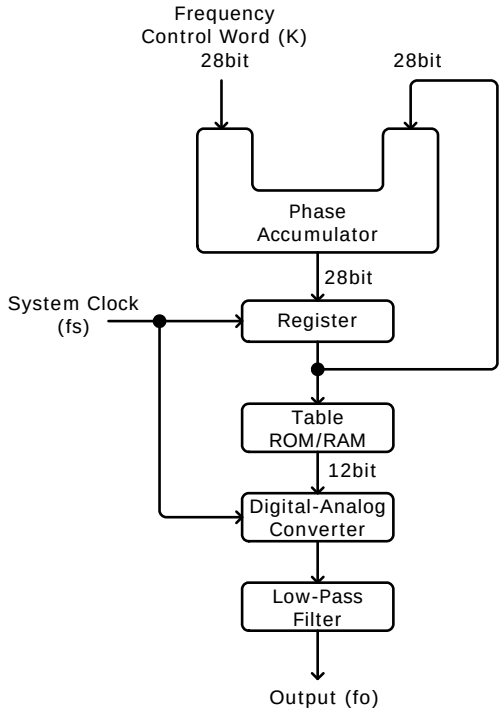
This analog function generating method uses a constant current source circuit built with discrete components such as capacitors and resistors. Temperature change inside the generator greatly affects the components characteristics which lead to output frequency change. The results are poor accuracy and stability.

**DDS methodology**

In DDS, the waveform data is contained in and generated from a memory. A clock controls the counter which points to the data address. The memory output is converted into analog signal by a digital to analog converter (DAC) followed by a low pass filter. The resolution is expressed as fs/2k where fs is the frequency and k is the control word, which contains more than 28bits. Because the frequency generation is referred to clock signal, this achieves much higher frequency stability and resolution than the traditional function generators.

**Block diagram**

DDS synthesizer consists of Phase accumulator (counter), lookout table data (ROM), Digital-to-analog converter (DAC), and Low-pass filter (LPF).




The phase accumulator adds the frequency control word K at every clock cycle fs. The accumulator output points to a location in the Table ROM/RAM. The DAC converts the digital data into an analog waveform. The LPF filters out the clock frequency to provide a pure waveform.





# Lineup/Features

## Series lineup

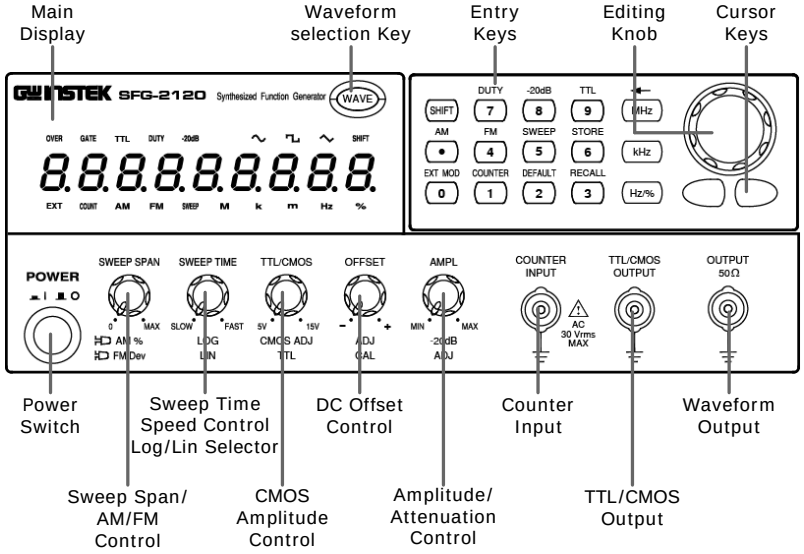
| Lineup \ Features | Duty cycle | Offset | TTL/ CMOS | Sweep | AM/ FM | Counter |
|---|---|---|---|---|---|---|
| SFG-2004 (4MHz) | ● | ● | ● | — | — | — |
| SFG-2007 (7MHz) | ● | ● | ● | — | — | — |
| SFG-2010 (10MHz) | ● | ● | ● | — | — | — |
| SFG-2020 (20MHz) | ● | ● | ● | — | — | — |
| SFG-2104 (4MHz) | ● | ● | ● | ● | ● | ● |
| SFG-2107 (7MHz) | ● | ● | ● | ● | ● | ● |
| SFG-2110 (10MHz) | ● | ● | ● | ● | ● | ● |
| SFG-2120 (20MHz) | ● | ● | ● | ● | ● | ● |

## Main features

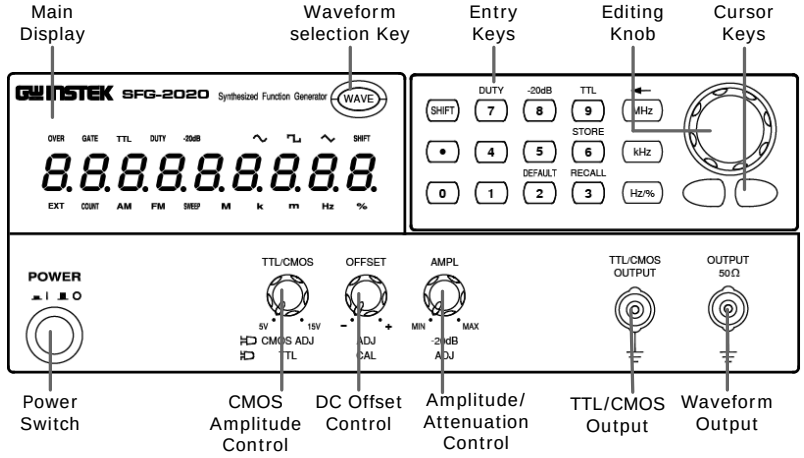
| | |
|---|---|
| Performance | • High resolution using DDS and FPGA technology<br>• High frequency accuracy: 20ppm<br>• Low distortion: −55dBc<br>• High resolution 100mHz maintained at full range |
| Features | • Wide output frequency range: 4, 7, 10, 20MHz<br>• Various output waveforms: Sine, Square, and Triangle<br>• TTL/CMOS output<br>• Variable DC offset control<br>• Output overload protection<br>• Store/recall: 10 settings<br>• Counter up to 150MHz high frequency (SFG-2100 series)<br>• AM/FM with internal and external (SFG-2100 series)<br>• Sweep mode with LINE and LOG (SFG-2100 series) |
| Input/Output Terminals | • Frequency output<br>• TTL/CMOS output<br>• Counter input (SFG-2100 series)<br>• External modulation input (SFG-2100 series) |

# Front Panel

## SFG-2100 series front panel




## SFG-2000 series front panel







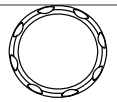
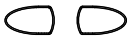

**Main display**

| | |
|---|---|
| 8. (7 segment) | Shows the waveform frequency, counter frequency, and duty cycle. |
| OVER | For SFG-2100 series only. In the counter mode, indicates that the leftmost digit (100MHz) is hidden but contains a real number. For counter details, see page40. |
| GATE | For SFG-2100 series only. In counter mode, indicates gate selection. For counter details, see page40. |
| TTL | Indicates that the TTL or CMOS output is enabled. For TTL/CMOS details, see page31. |
| DUTY | For square waveform only. Indicates that the duty cycle is being edited. For square waveform details, see page25. |
| -20dB | Indicates that the waveform output is attenuated by −20dB. For attenuation details, see page29. |
| SWEEP | For SFG-2100 series only. Indicates that the sweep mode is activated. For sweep details, see page35. |
| FM AM | For SFG-2100 series only. Indicates that FM or AM mode is enabled. For modulation details, see page37 (AM) or page38(FM). |
| COUNT | For SFG-2100 series only. Indicates that the counter mode is enabled. For counter details, see page40. |
| EXT | For SFG-2100 series only. Indicates that the external modulation input is used. For details, see page37 (AM) or page39(FM). |

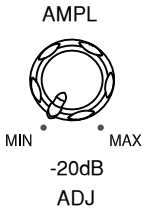
| | | |
|---|---|---|
| |  | Indicates the waveform shape: Sine, Square, and Triangle. For details, see page26. |
| | SHIFT | Indicates that the Shift key is pressed. |
| | M k m Hz | Indicates the output frequency: MHz, kHz, or Hz. |
| | % | Indicates the duty cycle unit. For duty cycle details, see page28. |
| **Waveform selection key** | WAVE | Selects the waveform shape: sine, square, and triangle. For details, see page26. |
| **Entry keys** | Enters frequency, duty cycle, and various parameters. | |
| | 1 • 2 MHz | 1.2MHz |
| | 3 7 kHz | 37kHz |
| | 4 5 Hz/% | 45% (in duty cycle mode)<br>45Hz (in frequency mode) |
| | DUTY<br>SHIFT 7 | Enter duty cycle (page28). |
| | -20dB<br>SHIFT 8 | Attenuate the waveform output by −20dB (page29). |
| | TTL<br>SHIFT 9 | Enables TTL/CMOS output (page31). |
| | ←<br>SHIFT MHz | Deletes previous entry (backspace). |
| | AM<br>SHIFT • | Selects Amplitude Modulation (page37). |
| | FM<br>SHIFT 4 | Selects Frequency Modulation (page38). |
| | SWEEP<br>SHIFT 5 | Selects sweep mode (page35). |





| | | |
|---|---|---|
| | STORE<br>SHIFT 6 | Stores the parameter setting (page42). |
| | RECALL<br>SHIFT 3 | Recalls the parameter setting (page42). |
| | DEFAULT<br>SHIFT 2 | Recalls the default parameter setting (page43). |
| | COUNTER<br>SHIFT 1 | Switches to counter mode (page40). |
| | EXT MOD<br>SHIFT 0 | Accepts external modulation signal (page37-AM) or (page38-FM). |
| **Editing knob** |  | Increases (right turn) or decreases (left turn) the frequency or duty cycle. |
| **Cursor keys** |  | Moves the editing point left or right in case of manual editing. |
| **Waveform output** | OUTPUT 50Ω<br>  | Outputs sine, square, and triangle waveform. BNC terminal, 50Ω output impedance. |
| **TTL/CMOS output** | TTL/CMOS OUTPUT<br>  | Outputs TTL or CMOS output waveform, BNC terminal. For TTL/CMOS mode details, see page31. |
| **Counter input**<br>  <br>Max AC 30Vrms | COUNTER INPUT<br>  | Accepts signals for frequency counting. BNC, AC 30Vrms maximum. For counting mode details, see page40. |

**Amplitude/ Attenuation control**

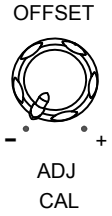



Sets the sine/square/triangle waveform amplitude. Turn left (decrease) or right (increase).

When pulled out, attenuates the sine/square/triangle waveform amplitude by −20dB. The −20dB display turns On.

For details, see page29.

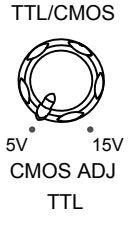
**DC offset control**




When pulled out, sets the DC offset level for sine/square/triangle waveform. Turn left (decrease) or right (increase). The range is −5V ~ +5V, in 50Ω load.

For details, see page30.

**CMOS amplitude control**



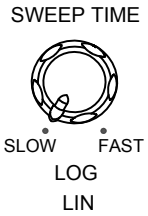

This knob becomes effective when the TTL/CMOS output is enabled (page31).

Selects TTL as output.

When pulled out, selects CMOS as output. Sets the CMOS output level. Turn left (decrease) or right (increase).

**Sweep speed control**

**Log/Linear sweep selector**




This knob is available in SFG-2100 series only. It becomes effective in sweep time mode.

Sets the sweep speed. Turn left (slow) or right (fast). The range is 1 ~ 30 seconds. For sweep details, see page35.

Selects linear sweep.

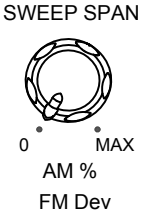
When pulled out, selects logarithmic sweep.





**Sweep span control**

**AM/FM modulation control**




This knob is available in SFG-2100 series only. It becomes effective in sweep mode and AM/FM mode.

In Sweep mode: Sets the sweep span. Turn left (narrow) or right (wide). The range is 1 ~ 100. For sweep details, see page36.

In AM/FM mode:

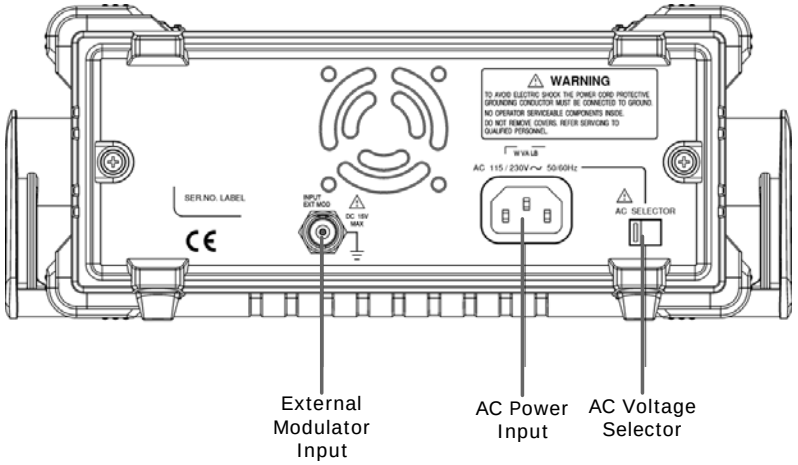
Sets the FM deviation (page38). Turn left (decrease) or right (increase). The range is over −50kHz ~ +50kHz, centered at 1MHz.

When pulled out, sets the AM depth (page37). Turn left (shallow) or right (deep). The range is 0 ~ 100%.

**Power switch**


Turns the main power On/Off. For power up sequence, see page20.

## Rear Panel



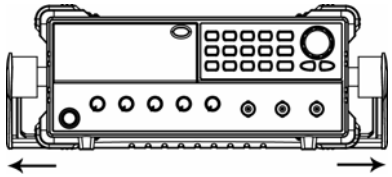

| | |
|---|---|
| **External Modulator Input** | Accepts the modulation signal from external device. BNC male connector, 10Vp-p maximum. SFG automatically switches the modulation signal from internal to external. For modulation details, see page37 (AM) or page38(FM). |
| **AC Power Input** | Accepts the AC power cord. 115 or 230V, 50/60Hz. |
| **AC Voltage Selector** | Selects 115V or 230V for power source.<br>AC 100/110/120V → select 115V.<br>AC 220/230/240V → select 230V.<br>⚠ Improper selection might lead to internal fuse blowout. |



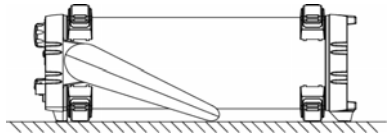


## Set Up

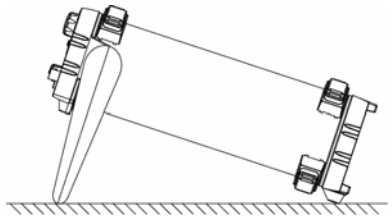
### Tilt stand



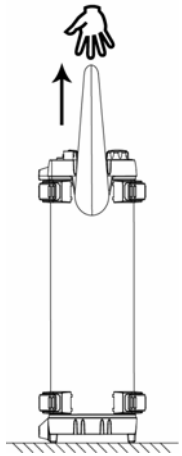
Pull out the handle sideways and rotate it.



Place SFG horizontally,



Or tilt stand.

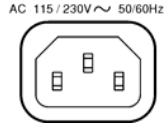


Place the handle vertically for hand carry.

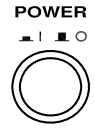
## Power up

1. Select the AC voltage on the rear panel accordingly.
   AC 100/110/120V→select 115V.
   AC 220/230/240V→select 230V.

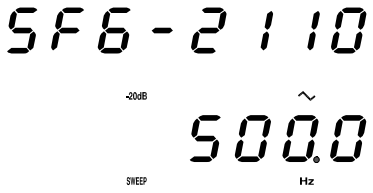

2. Connect the power cord.




3. Push and turn On the main power switch on the front panel.




4. The display shows model name and the last setup. Example: SFG-2110, 500Hz triangle wave in sweep mode and −20dB attenuation enabled

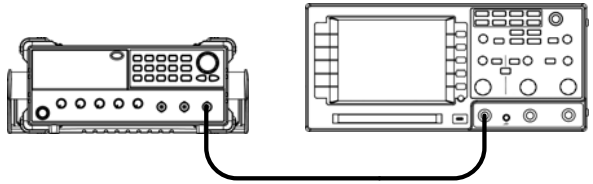



## Recall the default setting

Press SHIFT (DEFAULT) 2 to recall the default setup. SFG shows the message "done", and outputs 10kHz sine wave.


## Functionality check

Connect SFG output to measurement device such as oscilloscope and check the waveform characteristics.







# Operation Shortcuts

Here are the collections of operation example shortcuts.

| | | |
|---|---|---|
| Sine wave 250Hz, −20dB amplitude<br>OUTPUT 50Ω | 1. Press Wave key and select Sine | WAVE ~ |
| | 2. Press 2 + 5 + 0 + Hz/% key | 2 5 0 Hz/% |
| | 3. Press Shift + 8 key (−20dB)<br>...Or pull Amplitude knob | SHIFT (-20dB) 8 -20dB<br>or AMPL ADJ |
| Triangle wave 8kHz, +2V Offset<br>OUTPUT 50Ω | 1. Press Wave key and select Triangle | WAVE ~ |
| | 2. Press 8 + kHz key | 8 kHz |
| | 3. Pull Offset knob (ADJ) and Rotate | OFFSET ADJ |
| Square Wave 1MHz, 45% duty<br>OUTPUT 50Ω | 1. Press Wave key and select Square | WAVE ⊓ |
| | 2. Press 1 + MHz key | 1 MHz |
| | 3. Press Shift + 7 key (Duty) | SHIFT (DUTY) 7 DUTY |
| | 4. Press 4 + 5 + Hz/% key<br>...Or Rotate the Scroll knob | 4 5 Hz/%<br>or |
| TTL Output 10kHz<br>TTL/CMOS OUTPUT | 1. Press Shift + 9 key (TTL) | SHIFT (TTL) 9 TTL |
| | 2. Press 1 + 0 + kHz key | 1 0 kHz |
| | 3. Press TTL/CMOS knob (TTL) | TTL/CMOS (TTL) |
| CMOS Out 10kHz, 10Vpp<br>TTL/CMOS OUTPUT | 1. Press Shift + 9 key (TTL) | SHIFT (TTL) 9 TTL |
| | 2. Press 1 + 0 + kHz key | 1 0 kHz |
| | 3. Pull TTL/CMOS knob (CMOS) and rotate | TTL/CMOS (CMOS) |

| | | |
|---|---|---|
| Linear Sweep,<br>1kHz start,<br>Sine wave 250Hz<br>OUTPUT<br>50Ω | 1. Press Wave key and select Sine | WAVE |
| | 2. Press 2 + 5 + 0 + Hz/% key | 2 5 0 Hz/% |
| | 3. Press Shift + 5 key (Sweep) | SHIFT 5 (SWEEP) SWEEP |
| | 4. Press SWEEP TIME knob (LIN) and rotate | SWEEP TIME LIN |
| | 5. Press SWEEP SPAN knob and rotate | SWEEP SPAN |
| Log Sweep,<br>10kHz start,<br>Triangle wave<br>8kHz<br>OUTPUT<br>50Ω | 1. Press Wave key and select Triangle | WAVE |
| | 2. Press 8 + kHz key | 8 kHz |
| | 3. Press Shift + 5 key (Sweep) | SHIFT 5 (SWEEP) SWEEP |
| | 4. Pull SWEEP TIME knob (LOG) and rotate | SWEEP TIME LOG |
| | 5. Press SWEEP SPAN knob and rotate | SWEEP SPAN |
| AM, Internal,<br>50% modulation,<br>sine wave 10kHz<br>OUTPUT<br>50Ω | 1. Press Wave key and select Sine | WAVE |
| | 2. Press 1 + 0 + kHz key | 1 0 kHz |
| | 3. Press Shift + .(dot) key (AM) | SHIFT . (AM) AM |
| | 4. Pull SWEEP SPAN knob (AM %) and rotate | SWEEP SPAN |
| FM, External,<br>50% deviation,<br>sine wave 1MHz<br>OUTPUT<br>50Ω | 1. Press Wave key and select Sine | WAVE |
| | 2. Press 1 + MHz key | 1 MHz |
| | 3. Input external modulation signal (EXT sign appears) | INPUT EXT MOD DC 15V MAX EXT |
| | 4. Press Shift + 4 key (FM) | SHIFT . (AM) FM |
| | 5. Push SWEEP SPAN knob (FM Dev) and rotate | SWEEP SPAN (FM Dev) |





| | | |
|---|---|---|
| Counter input,<br>sine wave 1MHz<br>COUNTER<br>INPUT | 1. Press Shift + 1 (Counter) | SHIFT 1 (COUNTER) COUNT |
| | 2. The Gate sign flashes when counted | GATE |
| Store the setting to memory No.1 | 1. Press Shift + 6 (Store) | SHIFT 6 (STORE) |
| | 2. The "Store" sign appears | StorE 0 |
| | 3. Enter the memory number (1 ~ 10) | StorE 1 |
| | 4. The "done" sign appears | donE |
| Recall the setting from memory No.1 | 1. Press Shift + 3 (Recall) | SHIFT 3 (RECALL) |
| | 2. The "Recall" sign appears | rEcALL 0 |
| | 3. Enter the memory number (1 ~ 10) | rEcALL 1 |
| | 4. The "done" sign appears | donE |

## Default Setting Contents

Recall default settings

SHIFT 2 (DEFAULT)

Press the shift key, then 2 to recall the default setting. The "done" message appears, followed by display update.

donE
10.0000 kHz

| | |
|---|---|
| Wave type | Sine wave |
| Frequency | 10.0000kHz |
| TTL/CMOS | Disabled |
| −20dB | Disabled |
| Modulation | Disabled |
| Sweep mode | Disabled |

# SINE/SQUARE/TRIANGLE WAVE








## Select the waveform

### Sine / Square / Triangle

Press WAVE key repeatedly. The corresponding icon appears on the display.

Sine waveform.

Square waveform.

Triangle waveform.

OUTPUT 50Ω

The waveform comes out from the main terminal.

10Vp-p maximum (50Ω load)

20Vp-p maximum (no load)

## Set the Frequency

### Enter frequency

Enter the waveform frequency using the numerical keys.

1 • 2 MHz — 1.2MHz

3 7 kHz — 37kHz

4 5 Hz/% — 45Hz

SHIFT MHz — Delete a number (backspace)

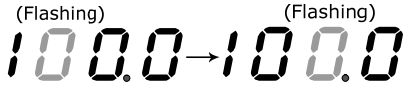
Triangle waveform frequency is limited to maximum 1MHz. When the input exceeds it, the following message (Freq-Err2) appears and forces the frequency to 1MHz.

FrEq-Err2

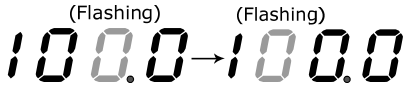
For full error message list, see page52.

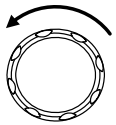
Edit frequency

Left cursor key moves the active cursor left.

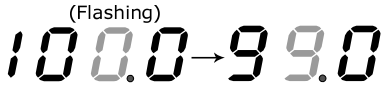


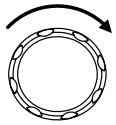

Right cursor key moves the active cursor right.



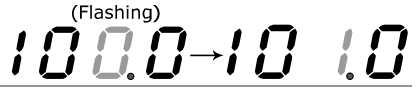



Turn the editing knob left to decrease the frequency.



Turn the editing knob right to increase the frequency.








# Set the Duty Cycle (Square Waveform)

The duty cycle setting is not available in sine/triangle waveform.

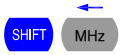
Enter duty cycle


Press the Shift key, then 7 to enter duty cycle editing mode. The duty sign appears on the display.


The default value is 50%.

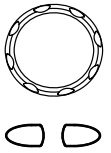
The settable range is 20% ~ 80%, 2Hz ~ 1MHz.


Use numerical keys to enter value.
Example: 45%




Delete a number (backspace)

Edit duty cycle

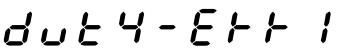


The editing knob changes the value, and the cursor keys moves the active digit (same as entering frequency).

When inactive for 5 seconds, the display automatically goes back to previous mode (frequency view).

Setting duty cycle (press 

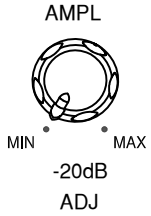
) is not available when sine or triangle waveform is activated. The following message appears.




For full error message list, see page52.

## Set Amplitude

### Normal output




Turn the Amplitude knob right (increase) or left (decrease).

The range is 10Vpp for 50Ω load.

### Attenuate by −20dB

Sine/square/triangle waveform can be attenuated by −20dB, in two ways: −40dB altogether.

**Method1**

Pull out the Amplitude knob. The output amplitude is attenuated by −20dB (no display sign).


**Method2**

Press the shift key, then 8. The output amplitude is attenuated by −20dB. The −20dB sign appears on the display.





## Set Offset

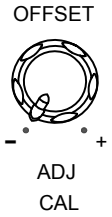
### Activate offset

SFG can add or delete offset to the sine/square/triangle waveform, thus changing the waveform vertical position. Use the OFFSET knob.

Pushed: Offset Off

Pulled: Offset On

### Adjust offset




Turn the knob right (higher position) or left (lower position).

The range is −5V ~ +5V for 50Ω load.

### Limitation

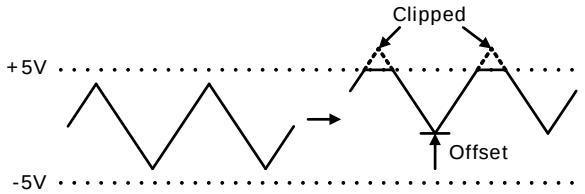
Note that the output amplitude, including the offset, is still limited to:

−5 ~ +5V (50Ω load)

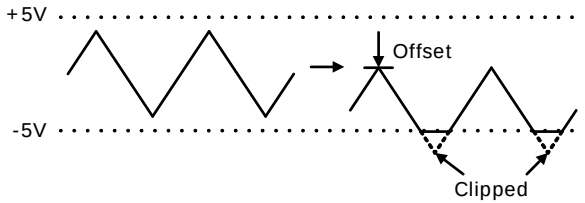
−10 ~ +10V (no load)

Therefore excessive offset leads to peak clip as below.

**Positive peak clip (50Ω)**




**Negative peak clip (50Ω)**



# TTL CMOS OUTPUT








## Select the waveform

### TTL/CMOS


Press Shift key, then 9. The TTL sign appears on the display.

TTL

The TTL/CMOS output is always On when the square wave is activated.


Push/pull the TTL/CMOS knob to select the waveform.

Pushed: TTL is selected as output.

Pulled: CMOS is selected as output.

TTL/CMOS OUTPUT

The waveform comes out from the TTL/CMOS terminal.

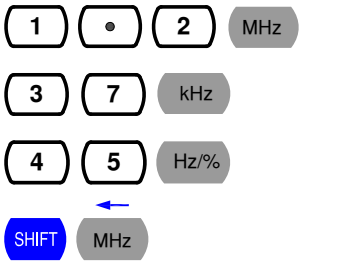
TTL: ≥3Vp-p (fixed)

CMOS: 4V±1Vp-p ~ 15±1Vp-p

## Set the Frequency

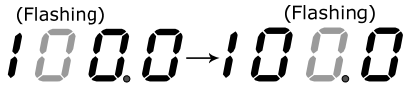
### Enter frequency

Enter the waveform frequency using the numerical keys.

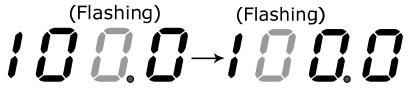


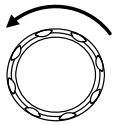
Edit frequency

Left cursor key moves the active cursor left.

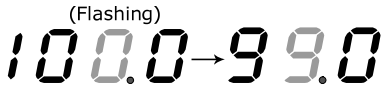


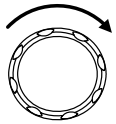

Right cursor key moves the active cursor right.



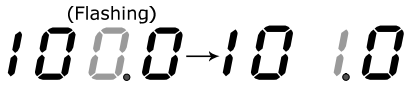



Turn the editing knob left to decrease the frequency.



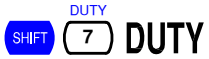



Turn the editing knob right to increase the frequency.




## Set the Duty Cycle

Enter duty cycle

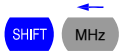



Press the Shift key, then 7 to enter duty cycle editing mode. The duty sign appears on the display.


The default value is 50%.

The settable range is 20% ~ 80%, 2Hz ~ 1MHz.


Use the numerical keys to enter value. Example: 45%

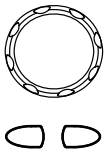



Delete a number (backspace)





Edit duty cycle

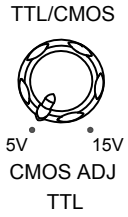


The editing knob changes the value, and the cursor keys moves the active digit (same as entering frequency).

When inactive for 5 seconds, the display automatically goes back to previous mode (frequency view).

## Set Amplitude

CMOS waveform




Use the TTL/CMOS knob.

Pushed: selects TTL output with fixed amplitude, min. 3Vp-p.

Pulled: selects CMOS output, amplitude range 4V±1Vp-p ~ 15±0.5Vp-p.

Turn the knob right (increase amplitude) or left (decrease amplitude).

# SWEEP

SFG can add sweep to the waveform output, a convenient tool for measuring the frequency response of the DUT.


- Sweep function applies only to SFG-2100 series.
- Sweep and Modulation (page37) cannot be used together.

## Activate sweep

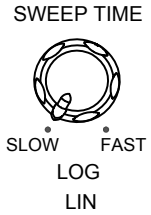
1. Output the waveform. Sine/Triangle/Square (page25) or TTL/CMOS (page31).
2. Press the Shift key, then 5 (Sweep).


3. Sweep is activated and the sign appears on the display.

**SWEEP**

When the sweep is activated, the duty cycle of Square/TTL/CMOS wave is fixed to 50%.

## Select Log/Lin Sweep




**Logarithmic Sweep:**

Pull the SWEEP TIME knob.

**Linear Sweep:**

Push the SWEEP TIME knob.

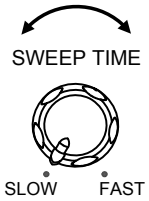




## Set Sweep Time

Sweep time sets the time it takes for a single sweep from the start frequency to the end frequency.

Rotate the SWEEP TIME knob, right (fast) or left (slow).




**Range** 1 ~ 30 seconds

Note: If the sweep time becomes too long, the stop frequency might reach the rating (4, 7, 10, or 20MHz). In this case, the frequency stays at the rating to the end.

## Set Sweep Span

Sweep span sets the frequency width of the sweep.

The current output frequency becomes the start frequency.

Rotate the SWEEP SPAN knob, right (wide) or left (narrow).


**Range** 1 ~ 100 frequency ratio

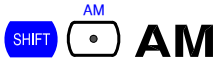
Note: In order to get the maximum span (frequency ratio), set the sweep time to a sufficient length (not too short).

# AMPLITUDE MODULATION


- AM applies only to SFG-2100 series.
- Modulation and Sweep (page35) cannot be used together.

## Activate AM

1. Output the waveform, Sine/Triangle/Square (page25).
2. Press the Shift key, then Dot (AM). AM is activated and the sign appears on the display.

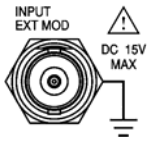



## Set AM depth


1. Pull the SWEEP SPAN knob (AM %).
2. Turn the knob left (shallow) or right (deep).

| Range | 0 ~ 100% |
|---|---|

## Use external modulating signal




SFG-2000 series uses an internal 400Hz sine wave as the default modulating signal.

1. Connect the modulating signal to the rear panel terminal.
2. Press the Shift key, then 0 (EXT MOD). External modulation is activated.


| Frequency Range | DC ~ 1MHz |
|---|---|





# FREQUENCY MODULATION


- FM applies only to SFG-2100 series.
- Modulation and Sweep (page35) cannot be used together.

## Activate FM

1. Output the waveform. Sine/Triangle/Square (page25) or TTL/CMOS (page31).
2. Press the Shift key, then 4 (FM). FM is activated and the sign appears on the display.


When FM is activated, the duty cycle of Square/TTL/CMOS wave is fixed to 50%.

## Set FM deviation

The output frequency becomes the Center Frequency.

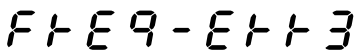

1. Push the SWEEP SPAN knob (FM Dev).
2. Turn the knob left (shallow) or right (deep).

| Deviation Range | 0 ~ ±50kHz, centered at 1MHz |
|---|---|

When the deviation is added to the center frequency, the result must be smaller than the rating frequency.

**Center Frequency + Deviation ≤ Rating(4,7,10,20MHz)**

When this rule is violated, the "Freq-Err3" error message appears and the FM setting will be cancelled.

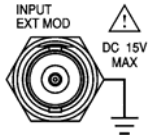



For more error message details, see page52.

Center frequency (=Output frequency) must be set within this range.

| | |
|---|---|
| SFG-2104 | 300kHz ~ 3.7MHz |
| SFG-2107 | 300kHz ~ 6.7MHz |
| SFG-2110 | 300kHz ~ 9.7MHz |
| SFG-2120 | 300kHz ~ 19.7MHz |

## Use external modulating signal




SFG-2000 series uses an internal 400Hz sine wave as the default modulating signal.

1. Connect the modulating signal to the rear panel terminal.
2. Press the Shift key, then 0 (EXT MOD). External modulation is activated.


| | |
|---|---|
| Frequency Range | 1kHz (fixed) |

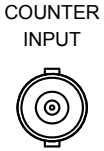




# COUNTER INPUT


Counter input applies only to SFG-2100 series.

## Activate counter




1. Connect the signal input to the Counter input terminal. Press Shift key, then 1 (Counter).


2. EXT and COUNT sign appear on the display.


3. The display shows the input signal frequency.


4. The GATE sign flashes when the gate condition is met.


| | |
|---|---|
| Range | 0 ~ 150MHz |
| Resolution | 100nHz for 1Hz input,<br>0.1Hz for 100MHz input |

## Set the gate time

Gate time sets the display update rate and counter resolution. These two parameters are in trade-off.

Short gate time = faster update, coarse resolution

Long gate time = slower update, fine resolution

To change the gate time, turn the editing knob right (increase) or left (decrease).

## Gate time / Resolution table

The following table shows the relationship between counter frequency, gate time, resolution, and display.

| Input | Gate time | Resolution | Display |
|---|---|---|---|
| 1Hz | 0.01s | 100μHz | 1.0000Hz |
| | 0.1s | 10μHz | 1.00000Hz |
| | 1s | 1μHz | 1.000000Hz |
| | 10s | 100nHz | 1.0000000Hz |
| 10Hz | 0.01s | 100μHz | 10.0000Hz |
| | 0.1s | 10μHz | 10.00000Hz |
| | 1s | 1μHz | 10.000000Hz |
| | 10s | 100nHz | 10.0000000Hz |
| 100Hz | 0.01s | 1mHz | 100.000Hz |
| | 0.1s | 100μHz | 100.0000Hz |
| | 1s | 10μHz | 100.00000Hz |
| | 10s | 1μHz | 100.000000Hz |
| 1kHz | 0.01s | 10mHz | 1.00000kHz |
| | 0.1s | 1mHz | 1.000000kHz |
| | 1s | 100μHz | 1.0000000kHz |
| | 10s | 10μHz | 1.00000000kHz |
| 1MHz | 0.01s | 10Hz | 1.00000MHz |
| | 0.1s | 1Hz | 1.000000MHz |
| | 1s | 100mHz | 1.0000000MHz |
| | 10s | 10mHz | 1.00000000MHz |
| 10MHz | 0.01s | 100Hz | 10.0000MHz |
| | 0.1s | 10Hz | 10.00000MHz |
| | 1s | 1Hz | 10.000000MHz |
| | 10s | 100mHz | 10.0000000MHz |
| 100MHz | 0.01s | 100Hz | 100.0000MHz |
| | 0.1s | 10Hz | 100.00000MHz |
| | 1s | 1Hz | 100.000000MHz |
| | 10s | 100mHz | 00.0000000MHz* |

**Over sign**

* The OVER sign shows that the 100MHz digit contains a real number but hidden from the display. It turns On under the following condition.

- Input frequency: ≥100MHz
- Gate Time: 10s

To view the 100MHz digit, switch to smaller gate time such as 1s or 0.1s.

OVER





# STORE/RECALL SETTING

STORE 6 RECALL 3 DEFAULT 2

## Store the panel setting

SHIFT STORE 6

Press the Shift key, then 6 to store the current panel setting to internal memories.
Memory range: 0 ~ 9 (10 set)

The "Store 0" sign appears.


Enter the memory number, 0 ~ 9. (for example, 1)

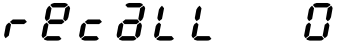

The "done" sign appears.


## Recall the panel setting

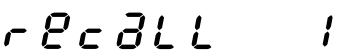
SHIFT RECALL 3

Press the Shift key, then 3 to recall a panel setting stored in internal memories.
Memory range: 0 ~ 9 (10 set)

The "recall 0" sign appears.




Enter the memory number, 0 ~ 9. (for example, 1)




The "done" sign appears and the panel setting changes accordingly.

## Recall the default panel setting

DEFAULT
SHIFT 2

Press the shift key, then 2 to recall the default panel setting.

The "done" message appears.

done

The panel is updated with the default setting.

~
10.0000
k Hz

| | |
|---|---|
| Wave type | Sine wave |
| Frequency | 10.0000kHz |
| TTL/CMOS | Disabled |
| –20dB | Disabled |
| Modulation | Disabled |
| Sweep mode | Disabled |





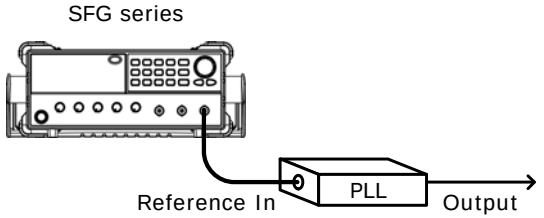
# APPLICATION EXAMPLES

## Reference Signal for PLL System

**Description**

The SFG output can be used as a cost-effective reference signal for Phase-Locked-Loop system. Directly connect SFG output to PLL input.

**Block diagram**

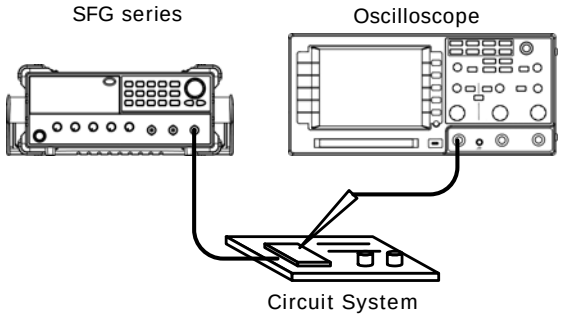



## Trouble-Shooting Signal Source

**Description**

The SFG output can be used as the signal source to test the failed part in a circuit system. Isolate the problematic part from the rest, feed the SFG output as a stimulus, and observe the outcome using an oscilloscope.

**Block diagram**

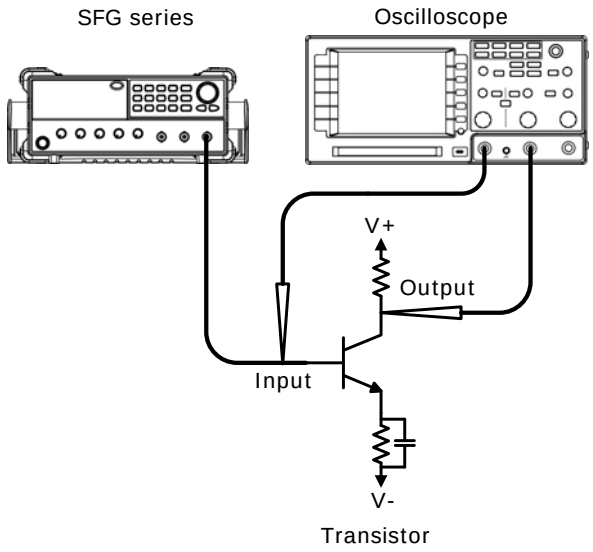


# Transistor DC Bias Characteristics Test

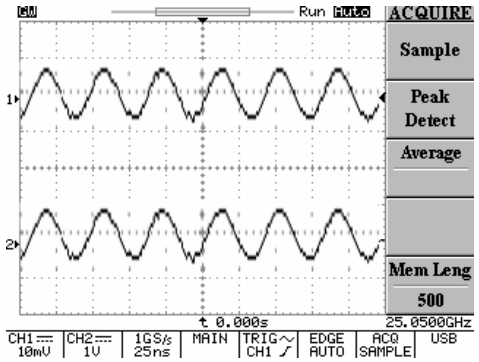
**Description**

Use SFG-2000 series as the signal source for a transistor. Compare the transistor input/output waveform using the oscilloscope. Adjust the DC voltage source to find out the maximum output without distorting the waveform.

**Block diagram**




**Oscilloscope display**





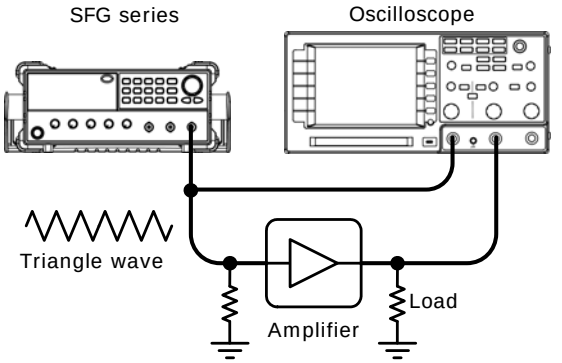



# Amplifier Over-Load Characteristic Test

**Description**

Use the triangle wave output from SFG-2000 series to check the amplifier output distortion caused by overload. The common sine wave is not the ideal source in this case. Observe the linearity of the triangle waveform using an oscilloscope.

**Block diagram**

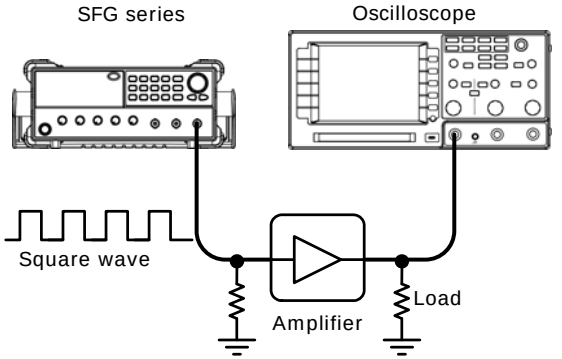



# Amplifier Transient Characteristics Test

**Description**

Use the square wave output from SFG-2000 series to check the transient frequency response of an amplifier. The common sine wave is not the ideal source in this case. Observe the waveform using an oscilloscope.

**Block diagram**



| | |
|---|---|
| **Test step** | 1. Apply a triangle waveform to the amplifier first. Adjust the waveform amplitude to make sure there is no clipping.<br>2. Switch to square waveform and adjust its frequency to the middle of the amplifier pass band, such as 20Hz, 1kHz, and 10kHz.<br>3. Observe the shape of the amplifier output. The following table shows the possible output distortions and their explanations. |
| **Transient characteristic list** |  • Amplitude reduction at low frequency<br>• No phase shift |
| |  • Low frequency boosted (accentuated fundamental) |
| |  • High frequency loss<br>• No phase shift |
| |  • Low frequency phase shift<br>• Trace thickened by hum-voltage |
| |  • High frequency loss<br>• Phase shift |
| |  • Low frequency loss<br>• Phase shift |
| |  • Low frequency loss<br>• Low frequency phase shift |
| |  • High frequency loss<br>• Low frequency phase shift |
| |  • Damped oscillation |
| **Note** | For narrow band amplifier testing, square wave may not be suitable. |



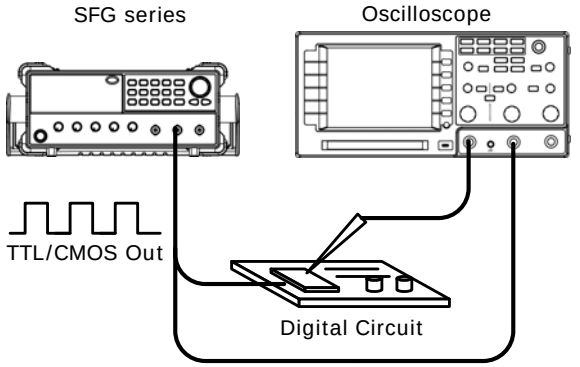


## Logic Circuit Test

**Description**

Use the TTL/CMOS output from SFG-2000 series to test digital circuits. Observe the timing relation of input/output waveform using an oscilloscope.

**Block diagram**

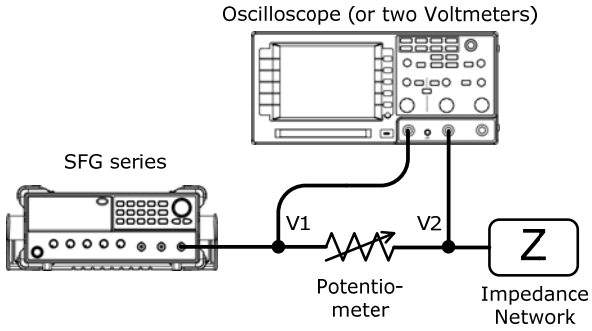



## Impedance Matching Network Test

**Description**

Use SFG-2000 series for impedance matching network: testing its frequency characteristic and matching the impedance.

**Block diagram**




**Test step**

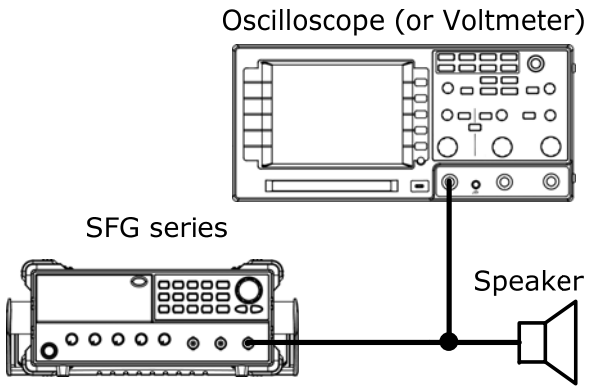
Adjust the potentiometer until V2 becomes the half of V1 (V2=0.5V1). Then the impedance Z of the network becomes identical to the potentiometer.

# Speaker Driver Test

**Description**

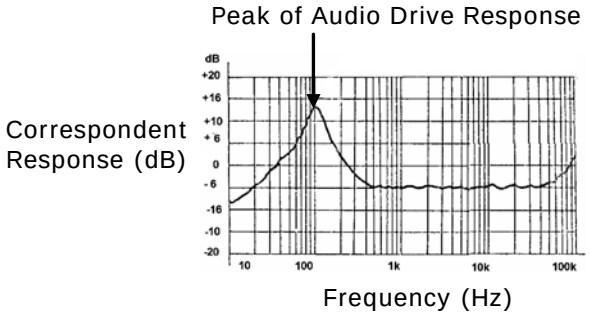
Use SFG-2000 series for testing the frequency characteristics of audio speakers. Record the volt reading versus the input signal frequency.

**Block diagram**




**Graph**

The peak voltage occurs on the resonant frequency of the speaker.








# Sweep for Speaker Test

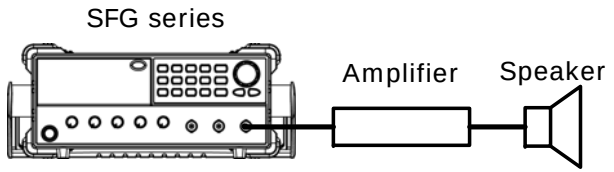
**Description**

Use the sweep feature in SFG-2000 series for testing the frequency response of an audio speaker.

**Test description**

1. Set SFG output to sine wave, 20Hz.
2. Activate sweep and set LIN/LOG, sweep time, and sweep span.
3. Change the frequency if other bands need to be tested.

**Block diagram**



# FAQ

- I pressed the Power key on the front panel but nothing happens.
- How can I get out of Counter/Sweep/Modulation/TTL/−20dB mode?
- The device accuracy does not match the specification.
- What are these error messages?

**I pressed the Power key on the front panel but nothing happens.**

Make sure the AC source voltage setting on the rear panel is correct (page21). Otherwise the internal fuse might be blown out. Contact the service personnel.

**How can I get out of Counter/Sweep/Modulation/TTL/−20dB mode?**

Press the Shift key, then the relevant numerical key. (Do the same action as you entered those modes)

For example: To get out of Counter mode, press Shift then 1.

**The device accuracy does not match the specification.**

Make sure the device is powered On for at least 30 minutes, within +20°C~+30°C. This is necessary to stabilize the unit to match the specification.

**What are these error messages?**

Several messages appear when trying to set the frequency or duty cycle in forbidden way. Page52 summarizes all the error message content.

If there is still a problem, please contact your local dealer or GWInstek at www.gwinstek.com.tw / marketing@goodwill.com.tw.





# APPENDIX

## Error Messages

### Frequency error

FrEq-Err

| | |
|---|---|
| FrEq-Err1 | Sine and square wave frequency over range. This message appears when entering sine or square waveform frequency larger than the rating. See page26 for sine/square rating. |
| FrEq-Err2 | Triangle wave Frequency over range. This message appears when entering triangle waveform frequency larger than 1MHz. See page26 for triangle wave rating. |
| FrEq-Err3 | FM Center Frequency over range. This message appears when trying to enter FM center frequency larger than specified. See page38 for FM center frequency range. |

### Duty Cycle error

duty-Err

| | |
|---|---|
| duty-Err1 | Not square waveform. This message appears when trying to set duty cycle in non-square (=sine or triangle) waveform. For duty cycle setting, see page28 (square wave) or page33 (TTL/CMOS output). |
| duty-Err2 | Square wave frequency over range. This message appears when trying to set duty cycle when the square wave frequency is over 1MHz. For square wave frequency setting, see page26. |
| duty-Err3 | Duty over range. This message appears when the duty cycle setting goes outside 20~80% range.<br>For duty cycle range, see page28 (square wave) or page33 (TTL/CMOS output). |

# Specification

| | | | |
|---|---|---|---|
| Main | Output Function | Sine, Square, Triangle | |
| | Amplitude Range | 10Vp-p (into 50Ω load) | |
| | Impedance | 50Ω ± 10% | |
| | Attenuator | −20dB ± 1dB x2 | |
| | DC Offset | < −5V ~ >+5V (50Ω load) | |
| | Duty Range | 20% ~ 80%, 2Hz~1MHz (Square Wave) | |
| | Duty Resolution | 1% (Square Wave Only) | |
| | Display | 9 digits LED display | |
| Frequency | Sine/Square Waveform Range | SFG-2004 | 0.1Hz ~ 4MHz |
| | | SFG-2007 | 0.1Hz ~ 7MHz |
| | | SFG-2010 | 0.1Hz ~ 10MHz |
| | | SFG-2020 | 1Hz ~ 20MHz |
| | | SFG-2104 | 0.1Hz ~ 4MHz |
| | | SFG-2107 | 0.1Hz ~ 7MHz |
| | | SFG-2110 | 0.1Hz ~ 10MHz |
| | | SFG-2120 | 1Hz ~ 20MHz |
| | Triangle Waveform Range | 0.1Hz ~ 1MHz (1Hz ~ 1MHz for SFG-2020/2120) | |
| | Resolution | 0.1Hz (1Hz for SFG-2020/2120) | |
| | Stability | ±20ppm | |
| | Accuracy | ±20ppm | |
| | Aging | ±5ppm/year | |
| Sine Wave | Harmonic Distortion | ≥−55dBc, 0.1Hz ~ 200kHz<br>≥−40dBc, 0.2MHz ~ 4MHz<br>≥−30dBc, 4MHz ~ 20MHz<br>(Amplitude at maximum position without attenuating 1/10 of any combination setting, TTL/CMOS off) | |
| | Flatness | < ± 0.3dB, 0.1Hz ~ 1MHz<br>< ± 0.5dB, 1MHz ~ 4MHz<br>< ± 2dB, 4MHz ~ 10MHz<br>< ± 3dB, 10MHz ~ 20MHz<br>(At the max amplitude relating to 1kHz) | |
| Triangle Wave | Linearity | ≥ 98%, 0.1Hz ~ 100kHz<br>≥ 95%, 100kHz ~ 1MHz | |
| Square Wave | Symmetry | ±1% of period + 4ns, 0.1Hz ~ 100kHz | |
| | Rise/Fall Time | ≤ 25ns at maximum output (50Ω load) | |
| CMOS Output | Level | 4 ± 1Vpp ~ 15 ± 1Vpp, adjustable | |
| | Rise/Fall Time | ≤ 120ns | |
| TTL Output | Level | ≥ 3Vpp | |
| | Fan Out | 20 TTL Load | |





| | | |
|---|---|---|
| | Rise/Fall Time | ≤ 25ns |
| Sweep (SFG-2100 Series) | Sweep Rate | 100:1 Ratio Max, adjustable (Note1) |
| | Sweep Time | 1 ~ 30s, adjustable (Note2) |
| | Sweep Mode | Linear, Logarithmic |
| Amplitude Modulation (SFG-2100 Series) | Depth | 0 ~ 100% |
| | Frequency | 400Hz (internal), DC ~ 1MHz (external) |
| | Carrier BW | 100Hz ~ 5MHz (−3dB) |
| | External Modulating | Sensitivity: ≤ 10Vpp for 100% modulation |
| Frequency Modulation (SFG-2100 Series) | Deviation | ≥0 ~ ±50kHz, center at 1MHz |
| | Frequency | 400Hz fixed (internal), 1kHz fixed (external) |
| | External Modulating | Sensitivity: ≤ 10Vpp for 10% modulation (center at 1MHz) |
| Frequency Counter (SFG-2100 Series) | Range | 5Hz ~ 150MHz |
| | Accuracy | Time Base Accuracy ± 1 count |
| | Time Base | ±20ppm (23±5°C) after 30min warmup |
| | Max. Resolution | 100nHz for 1Hz, 0.1Hz for 100MHz |
| | Input Impedance | 1MΩ/150pf |
| | Sensitivity | ≤ 35mVrms, 5Hz ~ 100MHz<br>≤ 45mVrms, 100MHz ~ 150MHz |
| Store/Recall | 10 Groups of Setting Memories | |
| General | Power Source | AC115V/230V +10%, −15%, 50/60Hz |
| | Operation Environment | Indoor Use, Altitude Up to 2000m<br>Ambient Temperature 0 ~ 40°C<br>Relative Humidity ≤ 80%, 0 ~ 40°C<br>Relative Humidity ≤ 70%, 35 ~ 40°C<br>Install Category II / Pollution Degree 2 |
| | Storage Environment | Temperature: −10 ~ 70°C<br>Humidity: ≤70% |
| | Accessories | Instruction Manual x 1, Power Cord x 1<br>GTL-101 x 2 (SFG-2100 Series)<br>GTL-101 x 1 (SFG-2000 Series) |
| | Dimension | 107 (W) x 266 (H) x 293 (D) |
| | Weight | Approx. 3.2kg (SFG-2100 Series)<br>Approx. 3.1kg (SFG-2000 Series) |

Note1: In order to get the maximum sweep span, sweep time needs to be tuned.
Note2: If sweep time is too long, the stop frequency will stay at the maximum frequency until the end of the sweep cycle.

# Declaration of Conformity

We
**GOOD WILL INSTRUMENT CO., LTD.**
(1) No.7-1, Jhongsing Rd., Tucheng City, Taipei County, Taiwan
(2) No. 69, Lu San Road, Suzhou City (Xin Qu), Jiangsu Sheng, China
declare, that the below mentioned product
**Type of Product: Synthesized Function Generator**
**Model Number: SFG-2004, SFG-2007, SFG-2010, SFG-2020, SFG-2104, SFG-2107, SFG-2110, SFG-2120**
are herewith confirmed to comply with the requirements set out in the Council Directive on the Approximation of the Law of Member States relating to Electromagnetic Compatibility (89/336/EEC, 92/31/EEC, 93/68/EEC) and Low Voltage Directive (73/23/EEC, 93/68/EEC).
For the evaluation regarding the Electromagnetic Compatibility and Low Voltage Directive, the following standards were applied:

◎ **EMC**

| EN 61326-1: Electrical equipment for measurement, control and laboratory use — EMC requirements (1997 + A1:1998 + A2:2001 + A3:2003) | |
|---|---|
| Conducted Emission<br>Radiated Emission<br>EN 55011: Class A 1998 + A1:1999 + A2:2002 | Electrostatic Discharge<br>EN 61000-4-2: 1995 + A1:1998 + A2:2001 |
| Current Harmonics<br>EN 61000-3-2: 2000 + A2:2005 | Radiated Immunity<br>EN 61000-4-3: 2002 + A1:2002 |
| Voltage Fluctuations<br>EN 61000-3-3: 1995 + A1:2001 | Electrical Fast Transients<br>EN 61000-4-4: 2004 |
| ---------- | Surge Immunity<br>EN 61000-4-5: 1995 + A1:2001 |
| ---------- | Conducted Susceptibility<br>EN 61000-4-6: 1996 + A1:2001 |
| ---------- | Power Frequency Magnetic Field<br>EN 61000-4-8: 1993 + A1:2001 |
| ---------- | Voltage Dip/ Interruption<br>EN 61000-4-11: 2004 |

◎ **Safety**

| Low Voltage Equipment Directive 73/23/EEC & amended by 93/68/EEC |
|---|
| Safety Requirements<br>IEC/EN 61010-1: 2001 |





# INDEX