# Arbitrary Function Generator Module

AFG-125/225/125P/225P

ISO-9001 CERTIFIED MANUFACTURER

**GW INSTEK**

# 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<br>⚠ CAUTION | • Do not place heavy objects on the instrument.<br>• Do not place flammable objects on the instrument.<br>• Avoid severe impact or rough handling that may damage the function generator.<br>• Avoid discharges of static electricity on or near the function generator.<br>• Use only mating connectors, not bare wires, for the terminals.<br>• The instrument should only be disassembled by a qualified technician. |
|---|---|
| Power Supply<br>⚠ WARNING | • DC Input voltage: 5V/2A.<br>• Do not exceed an input voltage of 5V±5%. |
| Fuse<br>⚠ WARNING | • Fuse type: F3.15A/125V.<br>• Only qualified technicians should replace the fuse.<br>• To ensure fire protection, replace the fuse only with the specified type and rating.<br>• Disconnect the power and all test leads before replacing the fuse.<br>• 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 ~ 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.

# GETTING STARTED

This chapter gives a brief overview of how to install the AFG-125/225/125P/225P module onto the GDS-2000A.

# AFG-125/225/125P/225P Overview

The AFG-125, AFG-225, AFG-125P and AFG-225P are arbitrary function generator modules for use with the GDS-2000A series DSOs. The options require the DH2-FH1 module extension bay to secure the module to the DSO. This user manual will explain how to become familiar with the arbitrary function generator modules. The Getting Started chapter will introduce the modules with an overview of the features and installation of the APP and accompanying PC software. The Operation chapter will go over the operation details while the AFG225PC software chapter will explain how to use the PC software.

Note1: The AFG-125/225/125P/225P are only supported with GDS-2000A series DSOs with firmware version V1.19 or above installed.

Note2: Throughout this manual *AFG-125* will refer to both the AFG-125 and the AFG-125P, unless stated otherwise. Similarly, *AFG-225* will refer to both the AFG-225 and AFG-225P, unless stated otherwise.

## Model Lineup

| Model | AFG-125 | AFG-125P | AFG-225 | AFG-225P |
|---|---|---|---|---|
| Frequency Range | 0.1uHz-25MHz | | | |
| Output Channels | 1 | 1 | 2 | 2 |
| Power Output | None | Yes | None | Yes |

## Main Features

Performance
- DDS signal generator
- 1μHz resolution over the full range
- 20ppm frequency stability
- Arbitrary Waveform Capability

  120 MSa/s sample rate

  60 MSa/s repetition rate

  4 k-point waveform length

  4k waveform memory, 10 groups

  User-defined output

  DWR (Direct waveform reconstruction) capability

  PC waveform editing

Features
- Sine, Square, Ramp, Pulse & Noise as standard waveforms
- Internal LIN/LOG sweeps with marker output
- AM, FM, FSK, SUM modulation
- Triggered burst function
- Save/recall 10 setup memories
- Output overload protection

Interface
- USB interface as standard
- AWES (arbitrary waveform editing software) PC software

Power Supply
(AFG-125P/
225P only
- 2.5V/3.3V/5V supply output
- 0.6A current output

## Accessories

| Part Number | Description |
|---|---|
| DH2-FH1 | Module extension bay |
| GTL-254 | USB A – USB A/B converter |
| | Quick start guide |
| | CD User manual |

## Optional Accessories

| Part Number | Description |
|---|---|
| GPA-501 | Power adapter |
| GTL-246 | USB Type A – Type B cable |
| GTL-201A | Ground lead |

# Panel Overview

## Front Panel

Power Supply
Status LEDs    GND    SYNC Output    CH1 Output

Negative Output    Positive Output    CH2 Output
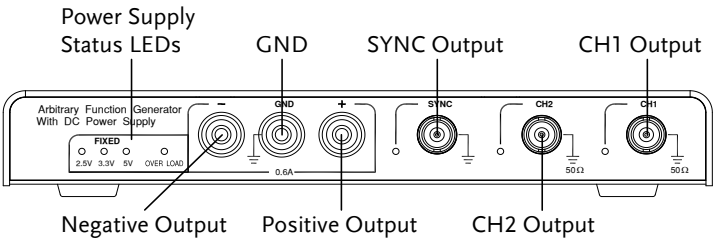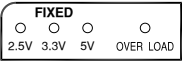
| Power Supply Status LEDs | | These LEDs indicate the immediate status of the power supply function on the AFG-125/225: |
|---|---|---|
| | 2.5V | 2.5V output is on |
| | 3.5V | 3.5V output is on |
| | 5V | 5V output is on |
| | OVER LOAD | Overload condition |

| Negative Output | Negative output port |
|---|---|
| GND | Ground port |
| Positive Output | Positive output port |

| SYNC | Sync output. A TTL signal is output as the sweep marker or sync output signal. See page 50 for sweep details or page 34 for sync details. |
|---|---|

| CH1 | CH1 (Signal 1) output. |
|---|---|

| | | |
|---|---|---|
| CH2 | **CH2**<br>$50\Omega$ | CH1 (Signal 2) output (AFG-225 only). |
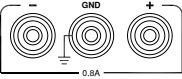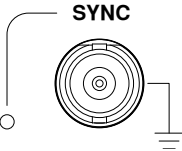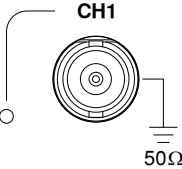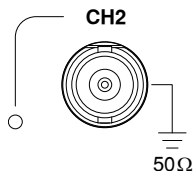
## Rear Panel

Vent        USB Device Port        Input Power
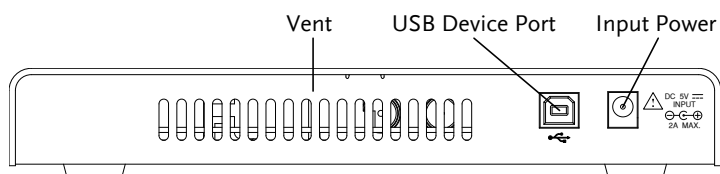
| | | |
|---|---|---|
| Vent | Cooling vent. | |
| USB Device Port | | Interfaces with the GDS-2000A and can also provide power. |
| Input Power | DC 5V<br>INPUT<br>2A MAX | Input power source: DC 5V; 2A max. |
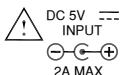
# DH2-FH1 Housing Installation

Background          The DH2-FH1 consists of 2 housings that are
                    attached to the feet on the underside of the case.

⚠Note              Make sure the power is turned off before installing the
                   AFG-125/225 module.

Steps              1.  Slip the housing over the front of the feet on the
                       GDS-2000A.

                   2.  Make sure that the rear tab clips securely over
                       the fan vent grid on the rear panel, as shown
                       below.
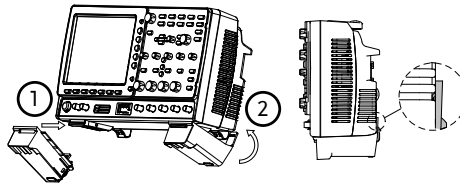


                   3.  The AFG-125/225 module is not ready to be
                       installed.

# Module Installation/Removal

Background | The AFG-125/225 modules are installed into the area that is left between both of the DH2-FH1 housings.

⚠️ Note | Make sure the power is turned off before installing the AFG-125/225 module.

Installation Steps | 1. Slide the module into the slot that was created between the DH2-FH1 housings. The front of the module should be facing forwards.
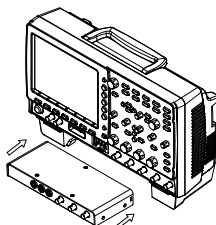


2. Make sure the module is secure. The module will click into place when it is inserted properly.

3. Make sure the GDS-2000A is turned off before proceeding.

4. Connect one end of the GTL-254 USB cable to the rear panel USB Device port and to the USB Host port. Connect the other end to the Device port on the AFG-125/225, as shown below.

5. Turn the power back on. The AFG-125/225 will now be accessible in the Option menu.
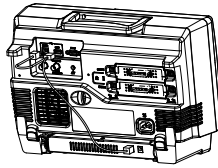
Removal

1.  At the rear of the housings are two tabs. Pull both tabs outwards.

2.  The module can now be slid out from the housing (back to front).
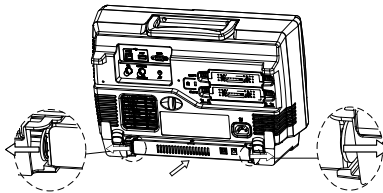
# USB Configuration

| | |
|---|---|
| Background | The USB Device port needs to be configured to provide power for the AFG-125/225 if an external power supply is not used. |

Steps

1. As shown previously in the "AFG-125/225 Module Installation/Removal" section, connect the GTL-254 USB cable.

2. Press the *Utility* key then *I/O* from the bottom menu.

    Utility

    I/O
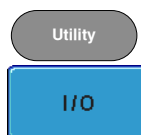
3. From the side menu press *USB Device Port* and select *USB Power*.

    USB Device Port ■
    USB Power

    USB Power

The port will now supply power to the AFG-125/225.

⚠ Caution   The USB Device Port should be reconfigured to "Computer" or "Printer" when the AFG-125/225 is not used. Failure to do so may damage the PC or printer when connected in the "USB Power" mode.

# AFG App Installation

Background

Install the AFG app as you would any application for the GDS-2000A series.

The AFG app file (AFG.gz) can be found on the User Manual CD under the APP directory.

For the latest files and information for applications, see the GW Instek website: www.gwinstek.com or contact your nearest distributor.

Steps

1. Make sure the DH2-FH1 and AFG-125/225 are installed and turned on.

Panel Operation

2. Insert a USB flash drive that has the AFG app file (AFG.gz) copied onto it into the front panel USB port.
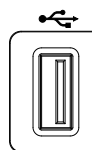
3. Press the *Utility* key then the *File Utilities* soft-key.
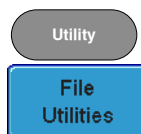
4. Navigate to the desired file in the USB file path.
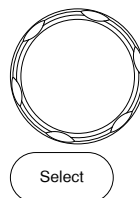
   When the AFG.gz file has been found, press the *Select* key twice to start the installation.

5. The installation will complete in a few seconds. When finished a pop-up message will appear asking you to restart the GDS-2000A.

6. Restart the GDS-2000A.

# Uninstalling the AFG App

Background     The AFG app can be uninstalled from the TEST menu, like the other optional apps.

Panel Operation    1. Press the *Test* key.

> Test
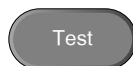
1. Press the *APP* button from the bottom menu.

> APP.

2. Use the *Variable* knob to select the AFG app.
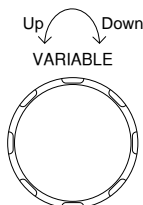


2. Press *Uninstall* on the side menu twice. Once to select and once to confirm uninstallation.

> Uninstall

3. The uninstallation process is complete when a message showing "Please turn off the oscilloscope and turn on again" appears.

# **Q**UICK REFERENCE

This chapter describes the menu tree for the AFG-125/225.

# Options Menu Tree

## Option Key

Accesses the functions in the Option menu.

Option

| Logic Analyzer | Function Gen 1 | Function Gen 2 | DVM | AFG | I/O |

| Logic Analyzer | → | Goes to the Logic Analyzer menu |
| Function Gen 1 | → | Goes to the Function Generator menu for the GEN 1 output |
| Function Gen 2 | → | Goes to the Function Generator menu for the GEN 2 output |
| I/O | → | Goes to the options I/O menu |
| AFG | → | Goes to the options AFG menu |
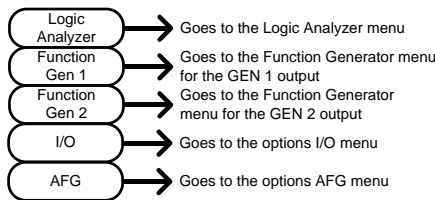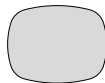
*Note: Any option that is not installed/turned on will be grayed-out.

## Arbitrary Function Generator

Setup the AFG-225/125 arbitrary function generator.

Note: The Power Supply function is only available for the AFG-125P and AFG-225P

The Dual Chan and Sync Setup functions are only available for the AFG-225 and AFG-225P.

| Output Setup | Signal 1 Setup | Signal 1 Setup | State Disp | UTIL | Power Supply |

**Output Setup:**
- Select: Signal 1 / Signal 2
- Output: On / Off
- Load: 50Ω / High Z
- Phase: -180.0º~180.0º
- S_Phase

**State Disp:** ON / OFF

**UTIL:**
- Dual Chan
- Preset
- Sync Setup

**Sync Setup (Sync):**
- Sync: On / Off
- Source: Signal 1 / Signal 2
- Mode: Carrier / Marker
- Polarity: Normal / Inverted

**Freq Cpl Type:**
- OFF / Offset / Ratio
- Offset: -999.99Hz ~ 24.999MHz
- Ratio: 0.001 ~ 1000.000

**Power Supply (Freq Cpl):**
- Freq Cpl
- Ampl Cpl: On / Off
- Tracking: OFF / ON / Inverted
- S_Phase
- Go Back

| Signal 1 Setup / Signal 2 Setup | → Goes to the Signal 1/2 Setup menu |
| Power Supply | → Goes to the Power Supply menu |

## Arbitrary Function Generator – Signal 1/2 Setup

Setup the signal type for each channel. From the AFG Arbitrary Function Generator menu on page 22.

```
Waveform Mode        ARB      MOD      Sweep     Burst     Go Back

Sine               ARB      MOD      Sweep     Burst      N Cycle
                   On       On       On        On
Square             Off      Off      Off       Off
                                                           Cycles
Pulse              Load     AM       Type                  1~65535 cycles
                                     Linear
Ramp               Edit     FM       Log                   Infinite

Noise          Output Confirm  FSK   Start                 Phase
                                     1µHz~ 25MHz           -360º ~ 360º
               More 1 of 2  More 1 of 2  1µHz~ 15MHz       Period
                                     (Square)              1ms ~ 500
                                     1µHz~ 1MHz            seconds
                                     (Ramp)
                                                           TRIG set
                                     Stop
               Frequency    PM       1µHz~ 25MHz
               User                  1µHz~ 15MHz
               1µHz ~ 60MHz SUM      (Square)
                                     1µHz~ 1MHz            INT
               Amplitude            (Ramp)
               1mVpp to                               Manual Trigger
               2.5Vpp       More 1 of 2
               (into 50Ω)                                  Delay
               2mVpp to 5Vpp                               0~655350 nS
               (open-circuit)
               Offset                SWP Time              Go Back
                                     0.001 ~ 500.000
               ±1.25Vpk ac+dc        Sec
               (into 50Ω)            Span
               ±2.5Vpk ac+dc         1µHz ~ 25MHz
               (Open circuit)        1µHz ~ 15MHz
               Rate                  (Square)
               User                  1µHz ~ 1MHz
               2µHz ~ 120MHz         (Ramp)
                                     Center
               More 2 of 2          450Hz ~ 25MHz
                                     450Hz ~ 15MHz
                                     (Square)
                                     450Hz ~ 1MHz
                                     (Ramp)               Marker
       AM                                                  On
                                     Marker               Off
       FM                                                 Frequency
                                     More 2 of 2          1µHz ~ 25 MHz
       FSK                                                1µHz ~ 1 MHz
                                                          (Ramp)
       PM
                                                          Go Back
       SUM        Goes to the Signal 1 Setup menu -MOD part II
```

## Arbitrary Function Generator – MOD part II

Configures AM, FM, FSK, PM or SUM modulation. From the Arbitrary Function Generator – Signal 1/2 Setup – MOD menu on page 23.

| AM | FM | FSK | PM | SUM |
|---|---|---|---|---|

**AM**

**Depth**
0.0% ~ 120.0%
**AM Freq**
0.002Hz ~ 20kHz
**Shape**
Sine
Square
Triangle
UpRamp
DnRamp

Go Back

**FM**

**Freq Dev**
DC~25MHz
DC~15MHz
(square)
DC~1MHz
(Ramp)
**FM Freq**
0.002Hz ~ 20kHz
**Shape**
Sine
Square
Triangle
UpRamp
DnRamp

Go Back

**FSK**

**Hop Freq**
1 µHz~25MHz
(sine)
1 µHz~15MHz
(Square, Pulse)
1 µHz~1MHz
(Ramp)
**FSK Rate**
0.002Hz ~ 100kHz

Go Back

**PM**

**Phase Dev**
0.0º ~ 360º
**PM Freq**
0.002Hz ~ 20kHz
**Shape**
Sine
Square
Triangle
UpRamp
DnRamp

Go Back

**SUM**

**SUM Ampl**
0.0% ~ 100.0%
**SUM Freq**
0.002Hz ~ 20kHz
**Shape**
Sine
Square
Triangle
UpRamp
DnRamp

Go Back

## Power Supply

Power supply menu for the AFG-125P and AFG-225P.

**Power Supply**

**Power**
On
Off
**Shape**
2.5V
3.3V
5V

# OPERATION

# Basic Operation

## Entering the AFG Menu

Background        Like the other options for the GDS-2000A, the AFG
                  option can be accessed via the front panel option
                  key.

Panel Operation   1. Press the *Option* key.                    Option

                  2. Press *AFG* from the bottom menu          AFG
                     to enter the first level of the AFG       AFG-225
                     menu. (The model type will shown
                     below the icon)

AFG Menu
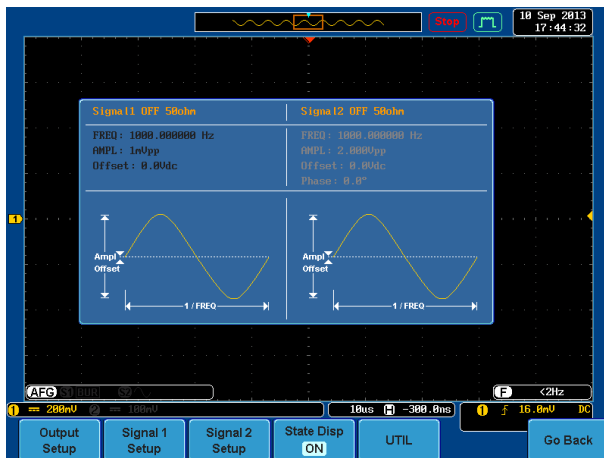
## State Display

Background    The state display function provides a visual display of the status of each channel and the function that is used.

The state display is on by default.

The state display is also used as a visual guide when editing/creating an ARB waveform.

State Display



Signal1 Status

Signal1 Function Settings

Signal2 Status

Signal2 Function Settings

Signal1 Function Visual Display

Signal2 Function Visual Display
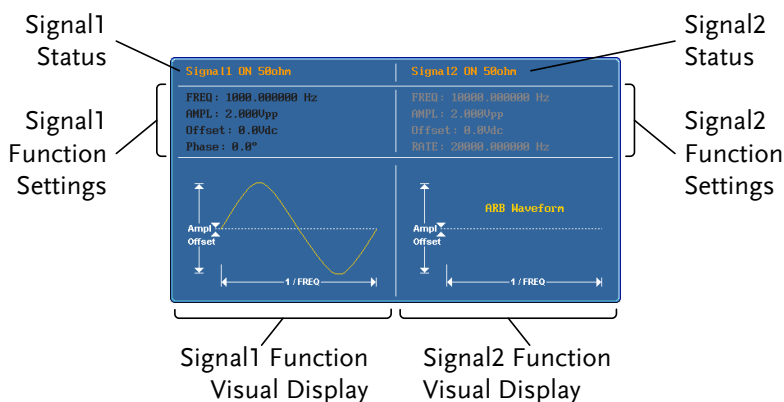
Panel Operation    1. From the first level AFG menu, press *State Disp* to toggle the display pop-up on or off.

## Selecting a Basic Waveform

Background       The AFG-125/225 can output 5 different types of
                 basic waveforms: Sine, Square, Pulse, Ramp,
                 Noise.

                 The basic waveforms can be output as is or they
                 can be used as the baseband waveforms for the
                 modulation functions or as the primary waveforms
                 for the sweep and burst functions.

Connection       1. The AFG-125/225 arbitrary function has 2
                    output channels, CH1 and CH2. Each output
                    can be selected individually.

                 2. Connect a BNC cable
                    to the appropriate
                    output (CH1 or CH2).
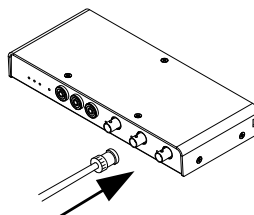
Panel Operation  1. From the first level AFG menu,
                    select *Signal 1 Setup* or *Signal 2
                    Setup* from the bottom menu to
                    select the output channel.

                 2. Press *Waveform Mode* from the
                    bottom menu and then select a
                    waveform from the side menu.

                    Waveforms    Sine, Square, Pulse Ramp, Noise

                 3. See page 29 to set the output        Page 29
                    settings and turn the output on.

## Turning the Output On

Background          The AFG-125/225 can output 5 different types of basic waveforms: Sine, Square, Pulse, Ramp, Noise.

The basic waveforms can be output as is or they can be used as the baseband waveforms for the modulation functions or as the primary waveforms for the sweep and burst functions.

Connection         1. The AFG-125/225 arbitrary function has 2 output channels, CH1 and CH2. Each output can be selected individually.

2. Connect a BNC cable to the appropriate output (CH1 or CH2).
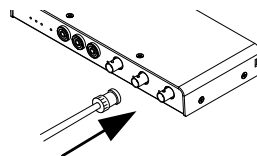
Steps              1. Press the *Output Setup* key to set the amplitude.


Output Setup

2. From the side menu choose the output parameters
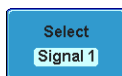

Select Signal 1

Choose the signal that will be output:

Signal 1:      CH1
Signal 2:      CH2
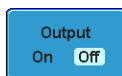

Output On Off

Turns the output of the selected signal on/off.


Load 50Ω High Z
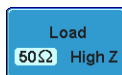
Sets the output impedance to 50Ω or High Z.

| | |
|---|---|
| Phase<br>0.0° | Sets the output phase relative to 0°. |
| S_Phase | Synchronizes the phase of both channels on dual channel models. |
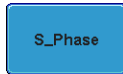
The signal will be output as soon as the output is turned on.

## Dual Channel Tracking

| | |
|---|---|
| Background | As only the The AFG-225 has dual channels, it has a number of tracking functions not available on the AFG-125. The tracking functions are listed below. |

| Dual Channel Functions | Function | Description |
|---|---|---|
| | Frequency Coupling | Frequency coupling will couple the channel outputs by frequency. Frequency coupling can be achieved by frequency offset or by a frequency ratio. |
| | Amplitude Coupling | Amplitude coupling will couple the both channel outputs by amplitude. Any changes in amplitude in one channel is reflected in the other channel. |
| | Tracking | There are two tracking modes, ON and Inverted. When turned on, tracking performs frequency and amplitude tracking so the channels behave as a single channel. When set to inverted, the one channel will output the inverse of the other. |
| | S_Phase | S_Phase will synchronize the phase of both channels. |

| | |
|---|---|
| Steps | 1. From the first level AFG menu, press *UTIL* and then press *Dual Chan* on the side menu. |
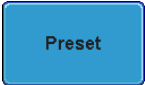
Dual Chan

2.  From the side menu choose the
    relevant tracking function(s):

| | |
|---|---|
| **Freq Cpl** | Turns frequency coupling on and sets the type of frequency coupling: |
| **Offset** 0.0Hz | Offset: Sets frequency coupling as an offset. |
| **Ratio** 1.000 | Ratio: Sets frequency coupling as a ratio. |
| **Ampl Cpl** OFF | Turns amplitude coupling on or off. |
| | Ampl Cpl:  OFF, ON |
| **Tracking** Inverted | Turns tracking on or off, or turns tracking on and inverts the output of the second output. |
| | Tracking:  OFF, ON, INVERTED |
| **S_Phase** | Press *S_Phase* to synchronize the phase of the both channels. |

## Recalling the Preset Settings

| | |
|---|---|
| Background | Recalling the preset settings will effectively reset the settings to the factory defaults. |

| Preset Settings | | |
|---|---|---|
| | Waveform Mode | Sine |
| | Frequency | 1kHz |
| | Amplitude | 1.000Vpp |
| | Offset | 0.0Vdc |
| | Phase | 0.0° |
| | Load | 50Ω |
| | Output | Off |
| | ARB | Off |
| | MOD | Off |
| | Sweep | Off |
| | Burst | Off |
| | Frequency Coupling* | Off |
| | Amplitude Coupling* | Off |
| | Tracking* | Off |
| | *Only applicable to the AFG-225. | |

| | |
|---|---|
| Steps | 1. From the first level of the AFG menu, press *UTIL*. |

<div style="text-align:right">UTIL</div>

2. Press *Preset.* The preset settings will be recalled straight away.

<div style="text-align:right">Preset</div>

## Sync Setup

| | |
|---|---|
| Background | The sync output signal is output from the SYNC port on the front panel. The sync output signal is based on either the channel 1 or channel 2 output signals. Each periodic type of waveform output function has an associated sync output signal.

The characteristics of the sync output depend on the selected signal source. |

| | | |
|---|---|---|
| Sync Signal Output | Sine, Square, Pulse, Ramp Source | For these types of waveforms, the sync output is a square wave pulse. The pulse is high for the positive transition of the waveform and low for the negative transition. The signal is a TTL level signal. |

Sine output ........................................ 0V
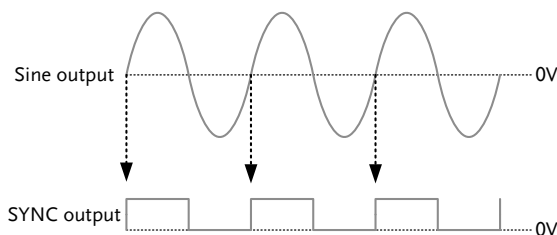
SYNC output ........................................ 0V

MOD waveform Source

The sync output is a positive pulse for the positive transition of the modulating waveform and low for the negative transition. The signal is a TTL level signal.
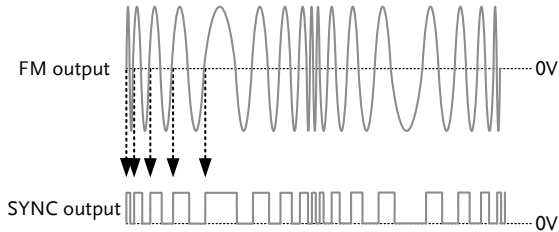


Arbitrary Waveform Source

The ARB function can output either carrier or marker signals.

Carrier: The sync output is a single TTL positive pulse for the positive transition of the ARB waveform and low for the negative transition.

Marker: A single TTL level positive pulse is output at the start of each period of the ARB waveform.
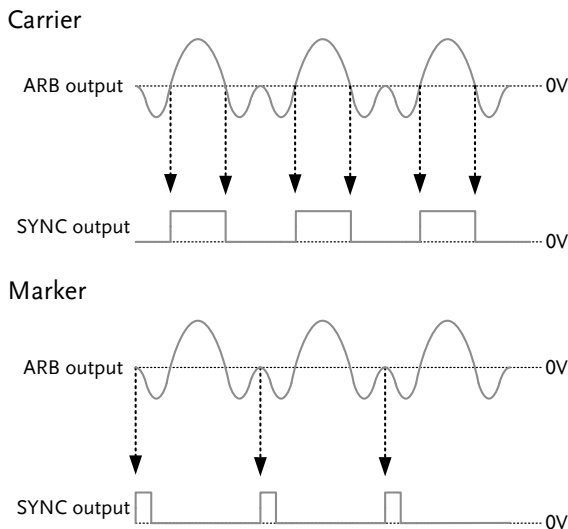
Carrier



Marker



| Sweep Source | The sweep function can output either carrier or marker signals. |
| --- | --- |
| | Carrier: The sync signal output is a positive TTL level pulse for the positive transition of the sweep waveform and low for the negative transition. |
| | Marker: The marker signal output is a TTL level positive pulse from the "marker" frequency to the stop frequency and a low level signal from the start frequency to the "marker" frequency. See page 50 to set the marker settings. |
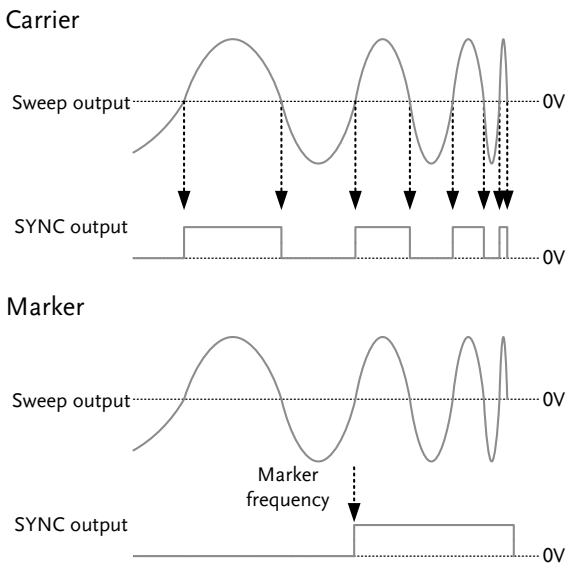
Carrier



Marker



| Burst Source | Like the sweep function, the burst function can output Carrier or Marker signals from the SYNC output. |
| --- | --- |
| | Carrier: The sync signal output is a positive TTL level pulse for the positive transition (0V and above) of the burst waveform and low for the negative transition. |
| | Marker: The marker signal output is a TTL level positive pulse for the duration of the burst period and low for the remainder of waveform period |

Carrier



Marker
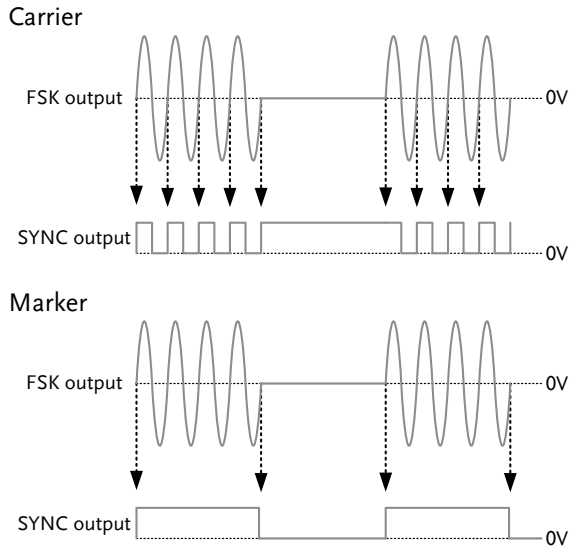


Steps

1. From the first level of the AFG menu, press *UTIL* and then press *Sync Setup* on the side menu.

   [Sync Setup]

2. From the side menu choose the sync setting:
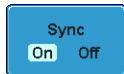
   [Sync On Off]   The Sync function will turn the sync output on for all waveforms except for noise.

   (Note: If *Marker* is turned on in the *Sweep* function, the *Sync On* setting will be overridden.
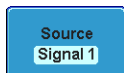
   [Source Signal 1]   Selects the source signal on which to base the sync signal.

   Source:          Signal 1, Signal 2
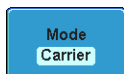
   [Mode Carrier]   When *Sync* is on, You can force the sync signal to follow the carrier or the marker* mode.

   Mode:            Carrier, Marker
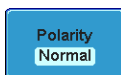
| Polarity Normal | The polarity can be set to Normal or Inverted. |

Polarity:        Normal, Inverted

⚠ Note          The marker mode can only be used for the ARB and mod waveforms.

For the Sweep function, the marker output must be turned on in the Sweep function menu. It cannot be activated in the Sync Setup menu. See page 51 to turn the marker option on.

# Modulation

## AM Modulation

| | |
|---|---|
| Background | The AM Modulation function can set the carrier frequency (AM Freq), amplitude modulation depth (Depth) and carrier waveform (Shape). |

| | | |
|---|---|---|
| Steps | 1. Set the carrier waveform and frequency. You can set the carrier waveform and frequency in the *Selecting a Basic Waveform* section. | Page 26 |

2. From the first level of the AFG menu, press the *Signal 1 Setup* or *Signal 2 Setup* key to select the signal source.

> Signal 1 Setup

3. From the bottom menu press *MOD*.

> MOD

4. From the side menu turn *MOD* On and then select the *AM* modulation.

> MOD
> On   Off

> AM

⚠ Note    Only one modulation mode can be active at any one time. The function generator also will not allow sweep, burst or ARB mode to be used with a modulation function. Activating a modulation mode will turn the previous modulation mode off.

5. Select the AM parameters from the side menu:

| | |
|---|---|
| Depth 100.0% | Sets the amplitude modulation depth:  0~ 120% |
| AM Freq 100.00Hz | Sets the AM frequency: 2 mHz~20kHz. |
| Shape Sine | Sets the carrier waveform shape: Sine, Square, Triangle, Upramp, Dnramp. |

6.  See page 29 to set the output settings and turn the output on.                Page 29
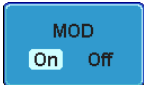
Example
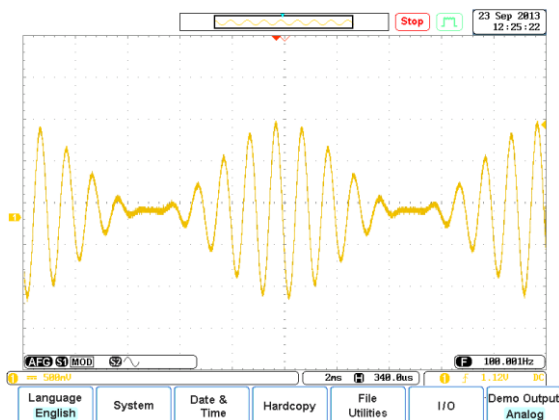


Amplitude Modulation

## FM Modulation

| | |
|---|---|
| Background | The FM Modulation function can set the carrier frequency (FM Freq), frequency deviation (FM DEV) and carrier waveform (Shape). |

| | | |
|---|---|---|
| Steps | 1. Set the carrier waveform and frequency. You can set the carrier waveform and frequency in the *Selecting a Basic Waveform* section. | Page 26 |
| | 2. From the first level of the AFG menu, press the *Signal 1 Setup* or *Signal 2 Setup* key to select the signal source. | **Signal 1 Setup** |
| | 3. From the bottom menu press *MOD*. | **MOD** |
| | 4. From the side menu turn *MOD* On and then select the *FM* modulation. | **MOD** [On] Off |
| | | **FM** |

| | |
|---|---|
| ⚠️ Note | Only one modulation mode can be active at any one time. The function generator also will not allow sweep, burst or ARB mode to be used with a modulation function. Activating a modulation mode will turn the previous modulation mode off. |

     5. Select the FM parameters from the side menu:

| | |
|---|---|
| **Freq Dev** 100.0Hz | Sets the frequency deviation: DC~25MHz DC~15MHz(square) DC~1MHz (Ramp) |
| **FM Freq** 100.00Hz | Sets the FM frequency: 2mHz~20kHz. |
| **Shape** Sine | Sets the carrier waveform shape: Sine, Square, Triangle, Upramp, Dnramp. |

6.  See page 29 to set the output       Page 29
    settings and turn the output on.

Example
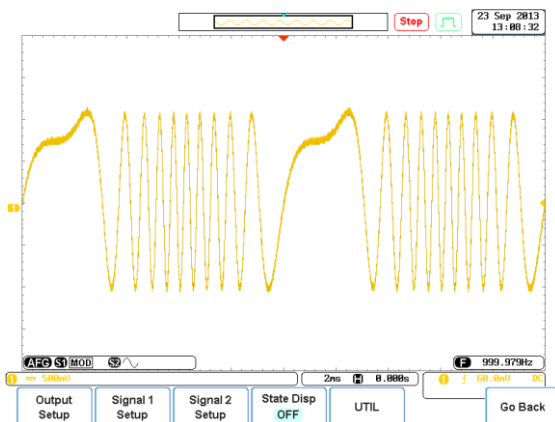


Frequency Modulation

## FSK Modulation

Background

The FSK Modulation function can set the hop frequency (FSK Hop) and the frequency-shift keying rate (FSK Rate). FSK Modulation essentially jumps between the carrier frequency and the hop frequency at a rate determined by the FSK rate frequency.

Steps

1. Set the carrier waveform and frequency. You can set the carrier waveform and frequency in the *Selecting a Basic Waveform* section.

Page 26

2. From the first level of the AFG menu, press the *Signal 1 Setup* or *Signal 2 Setup* key to select the signal source.

Signal 1
Setup

3. From the bottom menu press *MOD*.

MOD

4. From the side menu turn *MOD* On and then select the *FSK* modulation.

MOD
On   Off

FSK

⚠ Note

Only one modulation mode can be active at any one time. The function generator also will not allow sweep, burst or ARB mode to be used with a modulation function. Activating a modulation mode will turn the previous modulation mode off.

5. Select the FSK parameters from the side menu:

| Hop Freq 100.00Hz | Sets the hop frequency:<br>1µHz~25MHz (Sine)<br>1µHz~15MHz (Square, Pulse)<br>1µHz~1MHz (Ramp) |
|---|---|
| FSK Rate 10.00Hz | Sets the FSK rate:<br>2mHz~100kHz. |

6. See page 29 to set the output settings and turn the output on.                    Page 29

Example
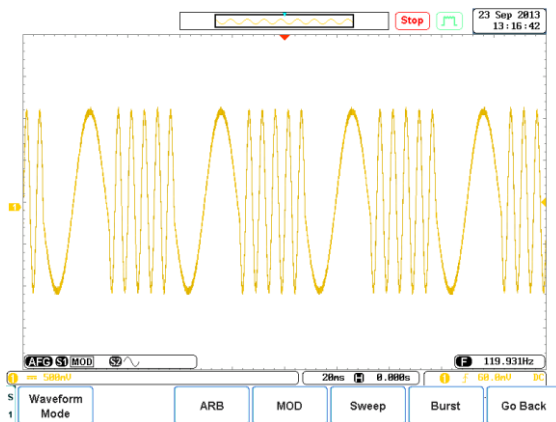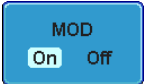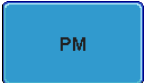


Frequency-Shift Keying Modulation

## PM Modulation

| | |
|---|---|
| Background | The PM Modulation function can set the phase modulation frequency (PM Freq), phase deviation (Phase Dev) and the PM shape (Shape).

The phase deviation of the carrier waveform deviates from a reference phase value in proportion to changes in the modulating waveform. |

| | | |
|---|---|---|
| Steps | 1. Set the carrier waveform and frequency. You can set the carrier waveform and frequency in the *Selecting a Basic Waveform* section. | Page 26 |
| | 2. From the first level of the AFG menu, press the *Signal 1 Setup* or *Signal 2 Setup* key to select the signal source. | Signal 1 Setup |
| | 3. From the bottom menu press *MOD*. | MOD |
| | 4. From the side menu turn *MOD* On, press *more 1 of 2* and then select the *PM* modulation. | MOD  On  Off

PM |

⚠ Note    Only one modulation mode can be active at any one time. The function generator also will not allow sweep, burst or ARB mode to be used with a modulation function. Activating a modulation mode will turn the previous modulation mode off.
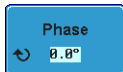
5. Select the PM parameters from the side menu:

| Phase Dev 180.0° | Sets the phase deviation: 0° ~ 360° |

| PM Freq 100.00Hz | Sets the phase modulation frequency: 2mHz ~ 20kHz |

| Shape Sine | Sets the PM wave shape: Sine, Square, Triangle, UpRamp, DnRamp. |

6. See page 29 to set the output          Page 29
   settings and turn the output on.

Example
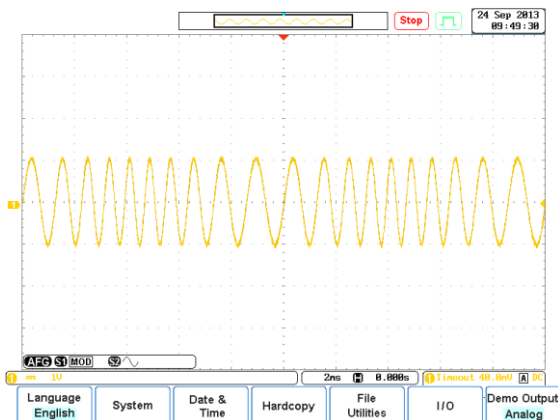


Pulse Modulation

## SUM Modulation

Background          The SUM Modulation function can set the SUM amplitude (SUM Ampl) the carrier frequency (SUM Freq) and carrier waveform (Shape).

In general SUM modulation adds a modulating signal to a carrier wave. Typically, sum modulation is used to add noise to a carrier wave. The modulating signal is added as a percentage of the carrier amplitude.

Steps             1. Set the carrier waveform and frequency. You can set the carrier waveform and frequency in the *Selecting a Basic Waveform* section.

Page 26

2. From the first level of the AFG menu, press the *Signal 1 Setup* or *Signal 2 Setup* key to select the signal source.

Signal 1 Setup

3. From the bottom menu press *MOD*.

MOD

4. From the side menu turn *MOD* On, press *more 1 of 2* and then select the *SUM* modulation.
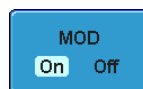
MOD
On   Off

SUM

⚠ Note          Only one modulation mode can be active at any one time. The function generator also will not allow sweep, burst or ARB mode to be used with a modulation function. Activating a modulation mode will turn the previous modulation mode off.

5.  Select the SUM parameters from the side menu:

| SUM Ampl
| 🔄 50.0% | Sets the SUM amplitude (relative to the carrier): 0.0% ~ 100.0%

| SUM Freq
| 100.00Hz | Sets SUM modulation frequency: 2mHz ~ 20kHz

| Shape
| Sine | Sets the SUM wave shape.

6.  See page 29 to set the output          Page 29
    settings and turn the output on.

Example
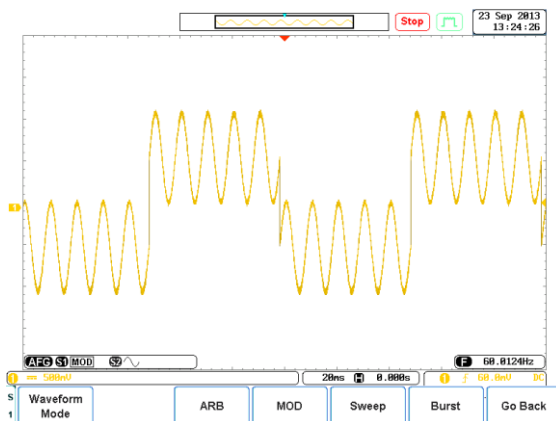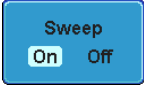


SUM Moduation

# Sweep
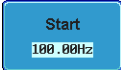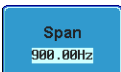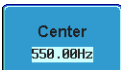
## Sweep

Background | The AFG-125/225 can perform a sweep for sine, square or ramp waveforms. In Sweep mode, the function generator will sweep from a start frequency to a stop frequency. The sweep can be performed in a linear or logarithmic fashion. The AFG-125/225 can also output a TTL signal from the SYNC output when the marker function is turned on.

Steps | 1. Set the carrier waveform and frequency. You can set the carrier waveform and frequency in the *Selecting a Basic Waveform* section. | Page 26

2. From the first level of the AFG menu, press the *Signal 1 Setup* or *Signal 2 Setup* key to select the signal source.

> Signal 1 Setup

3. From the bottom menu press *Sweep*.

> Sweep

4. From the side menu turn *Sweep* On.

> Sweep
> On  Off

⚠️ Note | Only one modulation mode can be active at any one time. The function generator also will not allow sweep, burst or ARB mode to be used with a modulation function. Activating a modulation mode will turn the previous modulation mode off.

5.  Select the sweep parameters from the side
    menu:

| | |
|---|---|
| **Type** `Linear` | Selects the type of sweep: logarithmic or linear. |
| **Start** `100.00Hz` | Sets the start frequency*: 1μHz ~ 25MHz 1μHz ~ 15MHz (Square) 1μHz ~ 1MHz (Ramp) |
| **Stop** `1.00kHz` | Sets the Stop frequency*: 1μHz ~ 25MHz 1μHz ~ 15MHz (Square) 1μHz ~ 1MHz (Ramp) |
| **more** `1 of 2` | Press to access the remaining sweep settings, shown below: |
| **SWP Time** `1.00SEC` | Sets the sweep time: 1ms ~ 500s. |
| **Span** `900.00Hz` | Sets the Span*: 1μHz ~ 25MHz 1μHz ~ 15MHz (Square) 1μHz ~ 1MHz (Ramp) |
| **Center** `550.00Hz` | Sets the center frequency*. |

⚠️ Note    *Setting the Start and Stop frequencies will override the Span and Center settings, and conversely setting the Span and Center settings will override the Start and Stop settings.

Marker    6.  To set a marker signal, press Marker and turn Marker On. The marker will output a TTL-level square wave signal at the designated frequency from the SYNC output port.

**Marker**

**Marker** `On    Off`

7. Press Frequency and set a marker frequency. The marker frequency cannot be lower than the center frequency.

| Frequency |
| 550.00Hz |

   1µHz ~ 25MHz
   1µHz ~ 1MHz (Ramp)

8. See page 29 to set the output settings and turn the output on.

Example
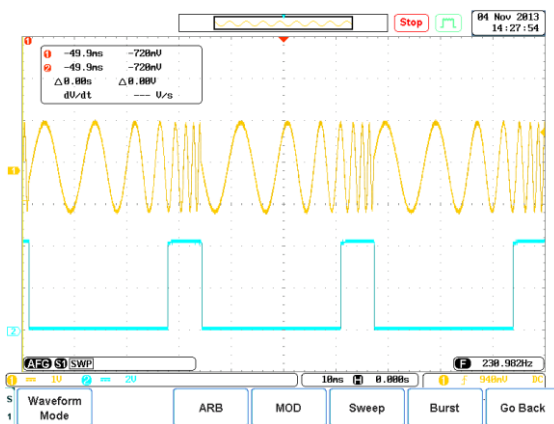


Sweep Waveform (CH1) with marker output (CH2).

# Burst

## Burst Waveform

| | |
|---|---|
| Background | The function generator can create a waveform burst with a designated number of cycles. Burst mode supports sine, square and ramp waveforms. |
| Steps | 1. Set the carrier waveform and burst frequency. You can set the carrier waveform and burst frequency in the *Selecting a Basic Waveform* section.  Page 26 |
| | 2. From the first level of the AFG menu, press the *Signal 1 Setup* or *Signal 2 Setup* key to select the signal source. |

Signal 1
Setup

3. From the bottom menu press *Burst*.

Burst

4. From the side menu turn *Burst* On.

Burst
On  Off

⚠ Note    Only one modulation mode can be active at any one time. The function generator also will not allow sweep, burst or ARB mode to be used with a modulation function. Activating a modulation mode will turn the previous modulation mode off.

5. Press *N Cycle* from the side menu.

N Cycle

6.  Select the *N Cycle* parameters from the side menu:

| | |
|---|---|
| Cycles 1 / Infinite | Sets the number of burst cycles* : 1~ 65,535, infinite. |
| Phase ↺ 0.0° | Sets the starting phase of the burst waveform. |
| Period 10nSEC | Sets the period* length in seconds for the burst waveform. |
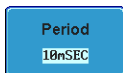
⚠ Note        *The Period setting will affect the number of cycles that can be chosen for any given frequency. The relationship is shown in the following equation:

Burst Cycle < (Burst Period x Wave Frequency)

Trigger Settings   7.  Press *Trigger set* from the side menu.

TRIG set

8.  Select the Trigger parameters from the side menu:

| | |
|---|---|
| INT | Sets the trigger as internal. An internal trigger is generated at the end of each period. |
| Manual Trigger | Sets the trigger to Manual mode. This Manual Trigger key must be pressed each time to output a burst waveform. |
| Delay 0.0SEC | Sets a delay time between the trigger and the burst waveform output: 0 ~ 655350nS. |
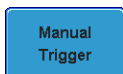
9.  See page 29 to set the output settings and to turn the output on.

Example
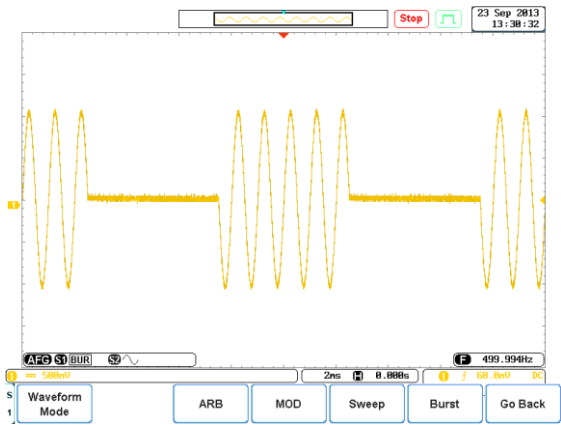


Burst Waveform

# ARB

## Loading a Preset ARB Waveform

| | |
|---|---|
| Background | The AFG-225 can load a number of different waveforms as an arbitrary waveform file: CH1~CH4, Ref1~Ref4, Wave1~Wave20, a previously saved waveform (LSF and fast CSV format*), a previously created ARB waveform or one of the 66 preset ARB waveforms**. The preset waveforms are categorized into Common, Math, Window and Engineer waveforms, as shown in the table below.

* See the DSO user manual for save file formats.
** See the appendix on page 72 for a full list and description of the preset ARB waveforms. |
| Preset waveforms | **Common:**

Absatan, Abssin, Abssinehalf, Ampalt, Attalt, Direven, Diriodd, Gauspuls, Havercos, Haversin, Negramp, N_pulse, Rectpuls, Roundhaf, Sawtooth, Sinetra, Sinever, Stair_dw, Stair_ud, Stair_up, stepresp, trapezia, tripuls

**Math:**

Arccos, Arccot, Arccsc, Arcsec, Arcsin, Arcsinh, Arctan, Arctanh, Cosh, Cot, Csc, Dlorentz, Expofall, Exporise, Gauss, Ln, Lorentz, Sec, Sech, Sinec, Sinh, Sqrt, Tan, Tanh, Xsquare

**Window:**

Barthwin, Bartlett, Blackman, Bohmwin, Chebyshe, Flattwin, Hamming, Hann, Hanning, Kaiser, Triang, Tukeywin

**Engineer:** |

Airy, Bessel, Betainc, Gamm, Legendre, Neumann

Steps

1. From the first level of the AFG menu, press the *Signal 1 Setup* or *Signal 2 Setup* key to select the signal source.

Signal 1
Setup

2. From the bottom menu press *ARB*.

ARB

3. From the side menu turn *ARB* On.

ARB
On  Off

⚠️ Note

The function generator also will not allow ARB to be turned on when sweep, burst or a modulation function is active. Turn off any other active modes before using ARB mode.

4. Press *Load* from the side menu.

Load

5. You can load an ARB waveform from one of the source channels, from internal memory or from a number of predefined waveforms:

From
CH1

Press *From* to select an input channel or internally saved waveform.

From:  CH1 ~ CH4
      Ref1 ~ Ref4
      Math
      Wave1 ~ Wave20

From File
TRIPULS.CAW

Press *From File* to load a previously saved waveform or a predefined waveform.

From File: LSF, Fast CSV, User
Preset, Common, Math,
Window, Engineer

**File Utilities**

If a previously saved waveform or predefined waveform type was chosen above, use the *File Utilities* to select the desired ARB waveform.

**Recall Now**

Press *Recall Now* to load the ARB waveform.

A message will appear on the screen when the ARB waveform is successfully recalled.

Example
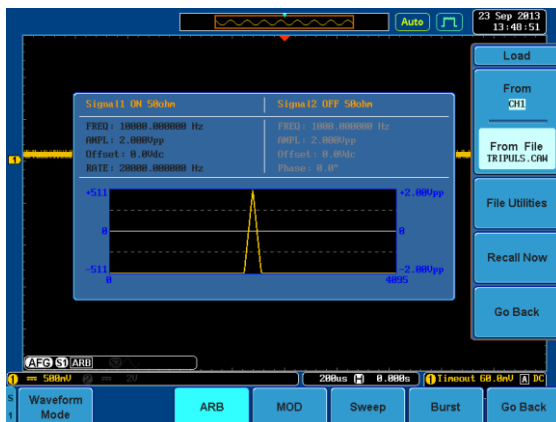


Triangle Pulse waveform

## Creating/Editing a Preset ARB Waveform

| | |
|---|---|
| Background | The AFG-125/225 has a number of methods to create and edit arbitrary waveforms. The ARB waveforms can have a maximum of 4096 (0~4095) points in length and 1023 (0±511) points in amplitude. |

| | |
|---|---|
| Editing Methods | Point/Line:<br>Creates a vertical line of a user-defined length and amplitude.<br><br>Diagonal:<br>Creates a diagonal line of a user-defined length and amplitude.<br><br>Scale:<br>Scales the full-scale of the ARB waveform.<br><br>Copy/Paste:<br>This method will copy and paste a user-defined section of the ARB waveform.<br><br>Clear:<br>This will clear a user-defined section of the ARB waveform.<br><br>Note: By default, any section of the ARB waveform that is not edited will be set to 0Vpp. By default the editing will automatically match the amplitude of each point. |

| | | |
|---|---|---|
| Steps | 1. From the first level of the AFG menu, press the *Signal 1 Setup* or *Signal 2 Setup* key to select the signal source. | Signal 1 Setup |

2. From the bottom menu press *ARB*.



3. From the side menu turn *ARB* On.
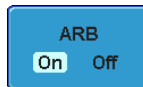


⚠ Note

The function generator also will not allow ARB to be turned on when sweep, burst or a modulation function is active. Turn off any other active modes before using ARB mode.

4. Press *Edit* from the side menu.



Point/Line Editing

5. Press *Edit Method* and choose *Point Line*.
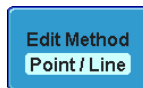


6. Press *Action* to begin editing the waveform using the Point/Line method.



7. Use the side menu to create a point or vertical line:

 Press *Address* to set the starting address of the line or point.

The maximum address depends on the Length setting below:

Max address = 4096 – Length

Range:       0 ~ 4095
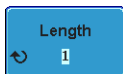
 Press *Length* to set the length of the line. The maximum length depends on the address set above:

Max length = 4096 – Address

Length       1 ~ 4096
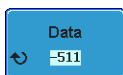
| | Press Data to set the amplitude of the point/line. |
|---|---|
| Data ↻ -511 | |

Data          -511 ~ 0 ~ +511
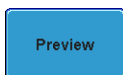
| Preview | When the point/line has been edited, press *Preview* to view the edited line. |
|---|---|

| Undo | Press *Undo* to cancel the point/line edit. |
|---|---|
| Done | Press *Done* to confirm and save the point/line edit. |
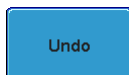
Example



Figure showing a horizontal line (black highlight)

Diagonal Editing   1. Press *Edit Method* and choose *Diagonal*.

Edit Method Diagonal
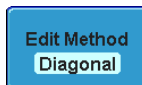
2. Press *Action* to begin editing the waveform using the Diagonal method.

Action

3. Use the side menu to create a diagonal line:

Press *Addr1/Data1* to set the first data point for the diagonal line. Press once to set the Addr1, press again to set Data1 (amplitude).

| | |
|---|---|
| Addr1 range: | 0 ~ 4095 |
| Data1 range: | ±511 |

Press *Addr2/Data2* to set the second data point for the diagonal line. Press once to set the Addr2, press again to set Data2 (amplitude).

| | |
|---|---|
| Addr2 range: | 0 ~ 4095 |
| Data2 range: | ±511 |

When the line has been edited, press *Preview* to view the edited line.

Press *Undo* to cancel the line edit.

Press *Done* to confirm and save the line edit.

Example
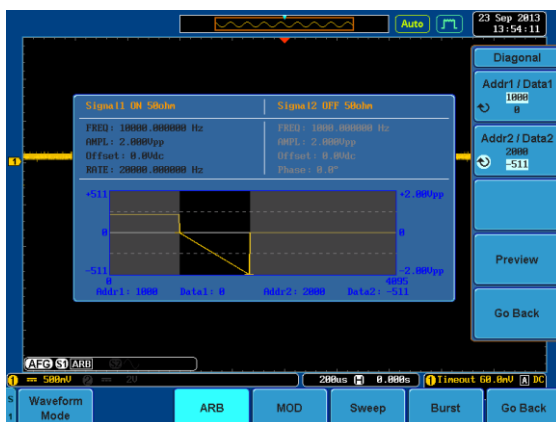


Figure showing a diagonal line (black highlight).

Scale Editing

1. Press *Edit Method* and choose *Scale*.

> **Edit Method**
> **Scale**

2. Press *Action* to begin editing the waveform using the Scale method.

> **Action**

3. Use the side menu to set the scale:

> **Scale**
> 🔄 1.0 X

The scale function sets the vertical scaling factor* for the whole ARB waveform.

Scale        0.1 ~ 10X

Example



Figure of 2.0X scaling. Notice that the waveform is clipped at the bottom.

⚠️ Note

\* If any data points that exceed a magnitude of ±511 will be clipped.

Copy / Paste

1. Press *Edit Method* and choose *Copy /Paste*.

> **Edit Method**
> **Copy / Paste**

2.  Press *Action* to enter the
    Copy/Paste menu.

    Action

3.  Use the side menu to copy a section of the ARB
    waveform:
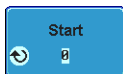
    Start
    ↻  0

    Press *Start\** to set the start address
    of the section you want to copy.

    Start range:          0 ~ 4095
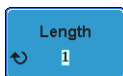
    Length
    ↻  1

    Press *Length\** to set the length of the
    section you wish to copy.

    Length range        1~ 4096
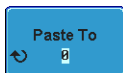
    Paste To
    ↻  0

    Press *Paste To* to choose the position
    to paste the copied section of
    waveform\*\*.

    Paste range          0~ 4095

    Preview

    When the copy and paste areas
    have been selected, press *Preview* to
    view the result.

    Undo

    Press *Undo* to cancel the
    copy/paste operation.

    Done

    Press *Done* to confirm
    and save the copy/paste
    operation.

Example
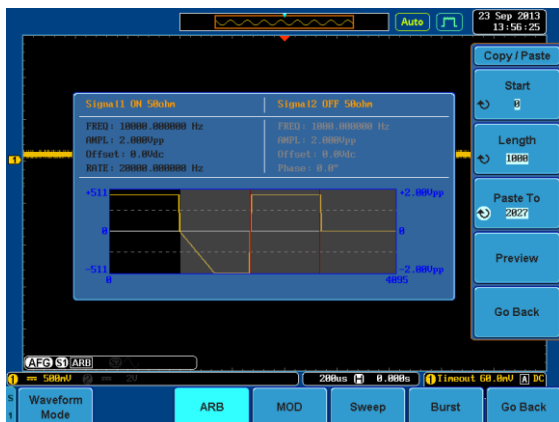


Figure showing the copied section (black) and the pasted section (red bars).

⚠ Note

\* The maximum start address depends on the Length setting: Max Start = 4096 – Length

The maximum length depends on the start address set above: Max Length = 4096 – Start

\*\* You cannot paste over an area that was originally copied. For example, if you copy from points 100 ~ 200, you cannot paste that to points 150 ~ 250. A setting conflict error will appear on the screen when the "Copy" and "Paste To" area overlap.

Clear

1.  Press *Edit Method* and choose *Clear*.

    

2.  Press *Action* to enter the Clear menu.

    

3.  Use the side menu to select a section of the ARB waveform to clear or to clear the whole ARB waveform:

| | |
|---|---|
| Start 0 | Sets the start address of the section of the ARB waveform to be cleared. |

Start range　　　　0 ~ 4095

| | |
|---|---|
| Length 1 | Sets the length of the section of the ARB waveform to be cleared. |

Length range　　　　1 ~ 4096

| | |
|---|---|
| Done | Press Done to confirm and then clear the selected section of the ARB waveform. |

| | |
|---|---|
| All | Press Done to clear the whole ARB waveform instantly. |

Example
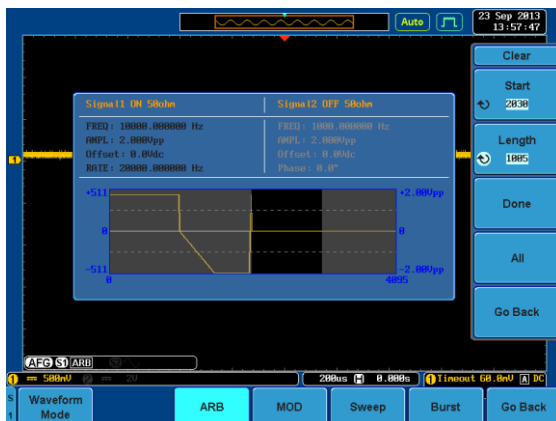


Figure showing the cleared section of the waveform.

Saving the ARB Waveform

After you have created/edited your waveform, you can save it for use at a later time. See page 56 to load a User Preset ARB waveform.

1.  Press Save Now to save the ARB waveform to the current directory.

| |
|---|
| Save Now |

## Setting ARB Output Length

Background    The Output Confirm menu allows the user to specify a section of the ARB waveform to be output.

The length of the outputted section will directly affect the possible frequency or rate of the ARB waveform. See page 68 for details.

Steps    1. From the ARB menu press *Output Confirm*.

> Output
> Confirm

2. Select the section of the ARB waveform that you wish to have output from the side menu:

> Start
> 1
>
> Length
> 4096

Press Start* to set the start address for the output section.

Press Length* to set the total length of the output section.

Example



Output section is shown in black.

| ⚠ Note | * The maximum length depends on the start address setting. |
|---|---|
| | The maximum length = 4096 – Start address. |

3.  Press Confirm to set the chosen output section.

Confirm

4.  See page 29 to set the output settings and turn the output on.

Page 29

## Setting ARB Frequency, Rate, Amplitude & Offset

| Background | The rate, frequency, amplitude and (amplitude)offset output parameters can also be set. |
|---|---|

Steps

1.  From the ARB menu press *more 1 of 2*.

more
1 of 2

2.  Select the parameters from the side menu:
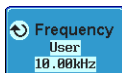
⟳ Frequency
User
10.00kHz
Sets the frequency* of the ARB waveform.
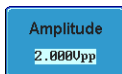
Amplitude
2.000Vpp
Sets the amplitude** of the waveform:
1mVpp to 2.5Vpp (into 50Ω)
2mVpp to 5Vpp (open-circuit)

Offset
0.0Vdc
Sets the Offset** of the ARB waveform:
±1.25Vpk ac +dc (into 50Ω)
±2.5Vpk ac +dc (Open circuit)
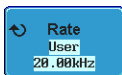
| Rate<br>User<br>20.00kHz | Sets the rate of the ARB waveform*. This will set the number of times the ARB waveform will be output each second. |

⚠ Note

*The frequency setting is inversely proportional to the Rate setting. The frequency and rate settings are also directly affected by the length of the output ARB waveform. See page 67 for setting the output length of the ARB waveform.
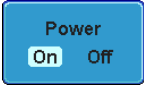
**The amplitude and offset are linked. Together the amplitude and offset cannot exceed 2.5Vpp (into 50Ω).

3. See page 29 to set the output settings and turn the output on.    Page 29

# Power Supply Function

## Using the Power Supply Function (AFG-125P & AFG-225P only)

Background     The AFG-125P and AFG-225P have an additional power supply function. The power supply has three fixed output levels: 2.5V, 3.3V, 5V.

Steps          1. Press *Power Supply* from the first level of the AFG menu.

               2. Press *Power* to turn the power supply output on.

               3. Press Voltage to select one of the fixed output levels. Status LEDs on the front panel will light up appropriately.

                  Voltage       2.5V, 3.3V, 5V

⚠ Note          The current power supply has a current output of 6A and a voltage output of (2.5V, 3.3V or 5V)±5%.

              If the power supply is overload, the OVER LOAD LED on the front panel will light up.
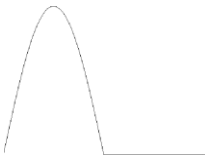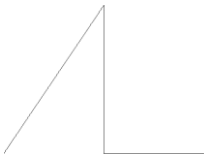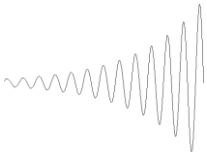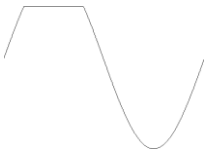
# **A**PPENDEX
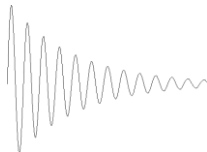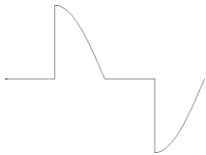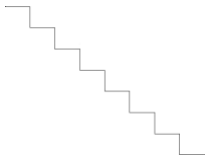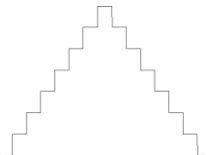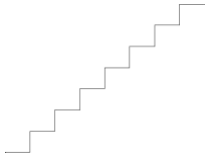
## Dimensions
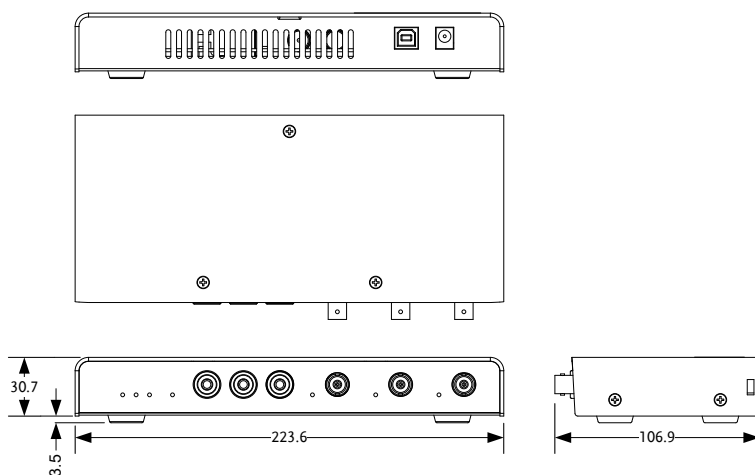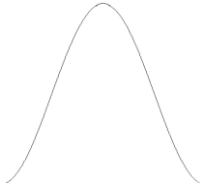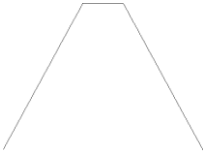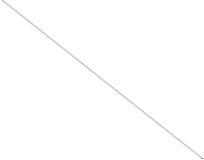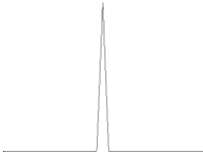
# Preset ARB Waveform

## Common
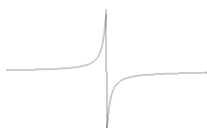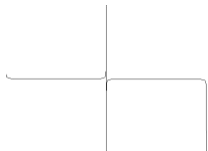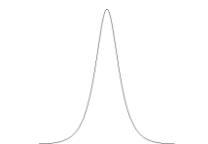
| Function | Description | Function | Description |
|---|---|---|---|
| ABSATAN | y=\|atan(x)\|<br>The absolute of atan(x) | RECTPULS | Sampled aperiodic rectangle |
| ABSSIN | y=\|sin(x)\|<br>The absolute of sin(x) | ROUNDHAF | y=sqrt(1-x^2)<br>Half round function |
| ABSSINEH | y=sin(x),0<x<pi<br>y=0,pi<x<2pi<br>Half- wave function | SAWTOOT | Sawtooth or triangle wave |
| AMPALT | y=e(x).sin(x)<br>Oscillation rise | SINETRA | Piecewise function |

| ATTALT | y=e(-x).sin(x)<br>Oscillation fall | SINEVER | Piecewise function |
|---|---|---|---|
| DIRIEVEN | Even<br>f(x)=-1^(x*(n-1)/2*pi)<br>x=0,±2*pi,±4*pi,…… | STAIR_DW | Step down |
| DIRIODD | Odd<br>f(x)=sin(nx/2)/n*sin(x/2)<br>x=±pi,±3pi，…… | STAIR_UD | Step up and step down |
| GAUSPULS | f(x)=a*e^(-(x-b)^2)/c^2)<br>Gaussian-modulated<br>sinusoidal pulse | STAIR_UP | Step up |
| HAVERCOS | y=(1-sin(x))/2<br>Havercosine function | STEPRESP | Heaviside step function |

| HAVERSIN | =(1-cos(x))/2 Haversine function | TRAPEZIA | Piecewise function |
|---|---|---|---|
| NEGRAMP | y=-x Line segment | TRIPULS | Sampled aperiodic triangle |
| N_PULSE | Negative pulse | | |
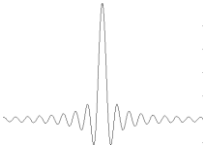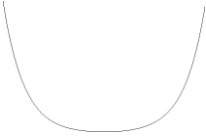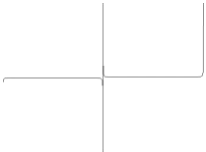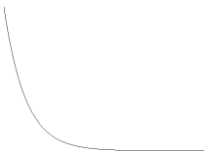
## Math
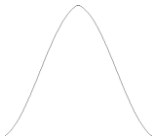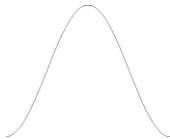
| Function | Description | Function | Description |
|---|---|---|---|
| ARCCOS | Basic trigonometric function | EXPORISE | Exponential rise |

| ARCCOT | Basic trigonometric function | GAUSS | A waveform representing a gaussian bell curve |
|--------|------------------------------|-------|-----------------------------------------------|
| ARCCSC | Basic trigonometric function | LN | Logarithm function |
| ARCSEC | Basic trigonometric function | LORENTZ | The derivative of the lorentz function $y=1/(k*x^2+1)$ |
| ARCSIN | Basic trigonometric function | SEC | Basic trigonometric function |
| ARCSINH | Basic trigonometric function | SECH | Basic trigonometric function |

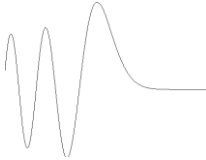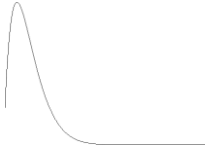| ARCTAN | Basic trigonometric function | SINEC | y=sin(x)/x |
|---|---|---|---|
| ARCTANH | Basic trigonometric function | SINH | Basic trigonometric function |
| COSH | Basic trigonometric function | SQRT | y=sqrt(x) |
| COT | Basic trigonometric function | TAN | Basic trigonometric function |
| CSC | Basic trigonometric function | TANH | Basic trigonometric function |

| DLORENTZ | The derivative of the lorentz function. y=-2x/(k*x^2+1) | XSQUARE | Parabola |
|----------|---------------------------------------------------------|---------|----------|
| EXPOFALL | Exponential decay | | |
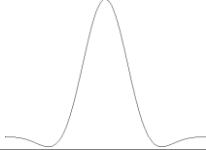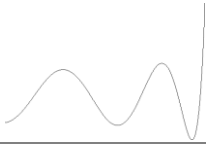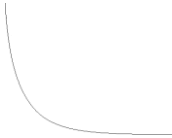
## Window

| Function | Description | Function | Description |
|----------|-------------|----------|-------------|
| BARTHWIN | Modified Bartlett-Hann window | HAMMING | The Hamming window function |
| BARTLETT | The Bartlett window is very similar to a triangular window as returned by the TRIANG function. | HANN | The Hann window function |

| BLACKMAN | The Blackman window function | HANNING | The Hanning window function |
|---|---|---|---|
| BOHMWIN | The Bohman window function | KAISER | The Kaiser window function |
| CHEBYSHE | The Chebyshev window function | TRIANG | The Triang window function |
| FLATTWIN | The Flattopwin window function | TUKEYWIN | The Tukey window function |

## Engineer

| Function | Description | Function | Description |
|---|---|---|---|
| AIRY | The Airy function | GAMM | The Gamma function |

| BESSEL | The Bessel function | LEGENDRE | Associated Legendre functions |
|--------|--------------------|--------------------|
| BETA | The Beta function | NEUMANN | The Neumann function |

# INDEX