KIKUSUI

Part No. IB022481
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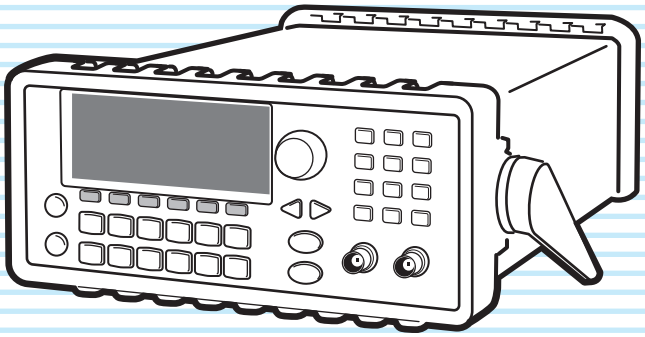
Remote Interface Manual

Waveform/Function Generator

FGA5050



Thank you for purchasing the FGA5050 Waveform/Function Generator.

About the Manuals

There are two manuals for the FGA5050: the User's Manual and the Remote Interface Manual (this manual).

The manuals are intended for users of the FGA5050 and their instructors. The manuals assume that the reader has knowledge about the electrical aspects of signal generators.

- User's Manual
  This manual is intended for first-time users of the FGA5050. It gives an overview of the FGA5050, connecting procedures, safety precautions, etc. Please read through and understand this manual before operating the product.
- Remote Interface Manual (this manual)
  This manual explains how to control the FGA5050 remotely using SCPI commands.
  The interface manual is written for readers with sufficient basic knowledge of how to control measuring instruments using a PC.

Every effort has been made to ensure the accuracy of this manual. However, if you have any questions or find any errors or omissions, please contact your Kikusui agent or distributor.

After reading, always keep the manual nearby so that you may refer to it as needed. When moving the product to another location, be sure to bring the manual as well.

You can download the most recent version of the manuals from the Kikusui Electronics Corporation website (http://www.kikusui.co.jp/en/download/).

The product that this manual covers

This manual is for the FGA5050 Waveform/Function Generator.

When contacting us about the product, please provide us with:
The model (marked on the front panel)
The serial number (marked on the rear panel)

Before reading this manual

First read the User's Manual, which includes information on the product's hardware, to avoid connecting or operating the product incorrectly.

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Notations used in this manual

- In this manual, the FGA5050 Waveform/Function Generator may be referred to as "the FGA5050."
- The term "PC" is used to refer generally to both personal computers and workstations.
- The following markings are used in the explanations in the text.

NOTE

Indicates information that you should know.

See

Indicates a reference to detailed information.

Contents

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Setup

The FGA5050 supports three types of remote interfaces: USB, LAN, and GPIB.

This chapter explains the settings that you need to configure to use the interfaces.

Remote Interface Settings

USB interface

Use a USB cable to connect the USB port on the rear panel to the PC that you want to use. When the cable is connected properly, the FGA5050 automatically configures the USB interface.

You can view the USB interface ID by pressing Utility, the IO softkey, and then the Show USB Id softkey.

GPIB interface

Only FGA5050s that are equipped with the GPIB interface card, which is a factory option, have support for GPIB.

To configure the GPIB interface, use a GPIB cable to connect the FGA5050 and the PC that you want to use, and enter a GPIB address into the FGA5050. The factory default GPIB address is 10. You can set the address to a number from 0 to 30. The address is stored in non-volatile memory, so it is not affected by the power supply or the remote interface reset command. Do not use the same address for the PC's GPIB interface card.

Configuring the GPIB interface

1. **Press Utility and then the I/O softkey.**
2. **Press the GPIB Addr softkey, and then use the numeric keypad or the rotary knob to enter the GPIB address.**
3. **Press the DONE softkey to finish entering the setting.**

LAN interface

Before you use the LAN (Local Area Network) interface, you need to configure a number of parameters. To configure the FGA5050's LAN settings correctly, contact your network administrator.

■ IP address

The IP address is a unique identifier assigned to the devices in a network. IP addresses are composed of values from 0 to 255 bytes delimited by periods. Where "nnn" is a value, an IP address looks like "nnn.nnn.nnn.nnn." The value is stored in non-volatile memory, so it is not affected when the power is turned off or the reset command is executed.

When you use DHCP, the FGA5050 automatically acquires an IP address from the DHCP server on the network. When the FGA5050 cannot acquire an IP address through DHCP, it uses the current IP address setting.

Subnet mask

To properly divide network traffic and make administration simpler, the network administrator uses subnets to divide the network. The subnet mask is the host address assignment used to identify a subnet. For example, a subnet mask of 255.255.255.0 for a host IP address of 10.10.3.101 means that the host belongs to subnets 10.10.3.1 to 10.10.3.254 (10.10.3.0 and 10.10.3.255 are reserved for special purposes). The subnet mask setting is stored in non-volatile memory, so it is not affected when the power is turned off or the reset command is executed.

When you use DHCP, the FGA5050 automatically acquires a subnet mask from the DHCP server.

Default gateway

Gateways are network devices that connect two networks. The default gateway is the IP address of the gateway that the FGA5050 is connected to. The value is stored in non-volatile memory, so it is not affected when the power is turned off or the reset command is executed.

When you use DHCP, the FGA5050 automatically acquires a default gateway IP address from the DHCP server.

Host name

The host name is an identifier that makes it possible for a human to read the name of a device. The domain name and host name indicate devices on the network. A host name can contain alphanumeric characters, dashes, and underscores.

Domain name

A domain is an administrative unit used to manage hosts on the network. Just as with the host name, the domain name is in a format that is readable by humans. A domain name can contain alphanumeric characters, dashes, and underscores.

Domains are structured hierarchically. There are top-level domains such as edu, com, and org, and below these top domains there are subdomains that indicate the name of the company, school, government organization, etc. For example, in addition to the host name “www,” the address “www.kikusui.co.jp” contains three domains: “kikusui,” “co,” and “jp” (the country domain). When the host and domain names are connected with periods, they form the overall host domain name.

DNS server

DNS (domain name service) is a service that converts domain names into IP addresses. The DNS server address is the IP address of a server that provides this service. The setting is stored in non-volatile memory, so it is not affected when the power is turned off or the reset command is executed.

Configuring the LAN interface

1. **Press Utility and then the I/O softkey.**

2. **Press the LAN softkey to enter the LAN submenu.**

   You can select whether to configure the LAN interface (by pressing the Modify Set softkey) or view the current LAN settings (by pressing the Current Config softkey).

LAN interface (continued)

3 **Press the Modify Set softkey.**

■ IP Setup submenu

4 **Press the IP Setup softkey to enter the submenu.**

- **DHCP**
  - Press the Mode softkey to switch between Man (DHCP off) and Auto (DHCP on).
  - When Man (DHCP off) is selected, you can configure the IP address, subnet mask, and default gateway values manually. When Auto (DHCP on) is selected, all of these settings are automatically acquired from the DHCP server.

- **IP address**
  - When Man (DHCP off) is selected, press the IP Addr softkey, and then use the numeric keypad to enter the IP address.
  - Press the Enter softkey to enter the setting, or press the Cancel softkey to cancel the change.

- **Subnet mask**
  - When Man (DHCP off) is selected, press the Sub Mask softkey, and then use the numeric keypad to enter the subnet mask.
  - Press the Enter softkey to enter the setting, or press the Cancel softkey to cancel the change.

- **Default gateway**
  - When Man (DHCP off) is selected, press the Def Gate softkey, and then use the numeric keypad to enter the gateway.
  - Press the Enter softkey to enter the setting, or press the Cancel softkey to cancel the change.

5 **Press the DONE softkey to return to the LAN submenu.**

■ DNS Setup submenu

6 **Press the DNS Setup softkey to enter the submenu.**

- **Host name**
  - Press the Host Name softkey to set the host name for the FGA5050. Use the numeric keypad or the cursor keys and the rotary knob to enter the desired characters and symbols.

- **Domain name**
  - Press the Domain Name softkey to set the **domain** name for the FGA5050. Use the numeric keypad or the cursor keys and the rotary knob to enter the desired characters and symbols.

- **DNS server**
  - Press the DNS Serv softkey, and then use the numeric keypad to enter the IP address of the DNS server.
  - Press the Enter softkey to enter the setting, or press the Cancel softkey to cancel the change.

7 **Press the DONE softkey to return to the LAN submenu.**

■ Viewing the current settings

8 **Press the Current Conf softkey to view the current LAN settings.**

Accessing and Operating the FGA5050 from a Web Browser

The FGA5050 has a built-in Web interface. You can control the FGA5050 through a LAN interface using Microsoft Internet Explorer or Mozilla Firefox. You do not need any other software.

The URL for the FGA5050 is http:// followed by the FGA5050's IP address.

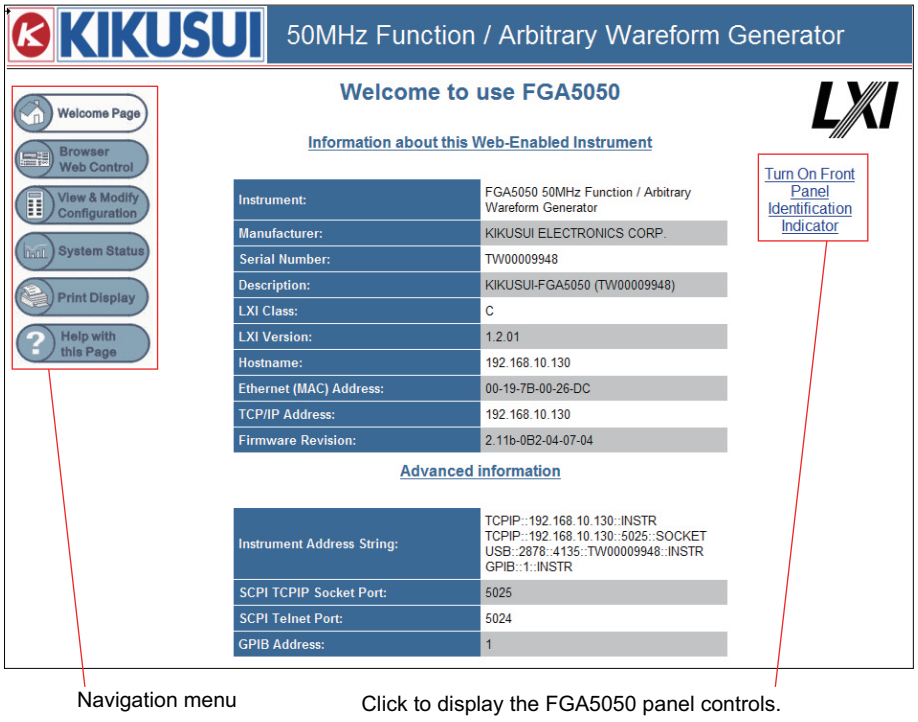
For example, if the FGA5050's IP address is 192.168.10.130, enter the following into your browser's address bar:

http://192.168.10.130

■ Welcome Page

When you first connect to the FGA5050 through the Web interface, a welcome page is displayed. The LAN settings and device information are displayed.

- You can go to other pages by clicking the items in the navigation menu.
- If you click Turn On Front Panel Identification Indicator, "Web Identify" appears on the FGA5050 display, and the FGA5050 panel controls appear on the webpage.

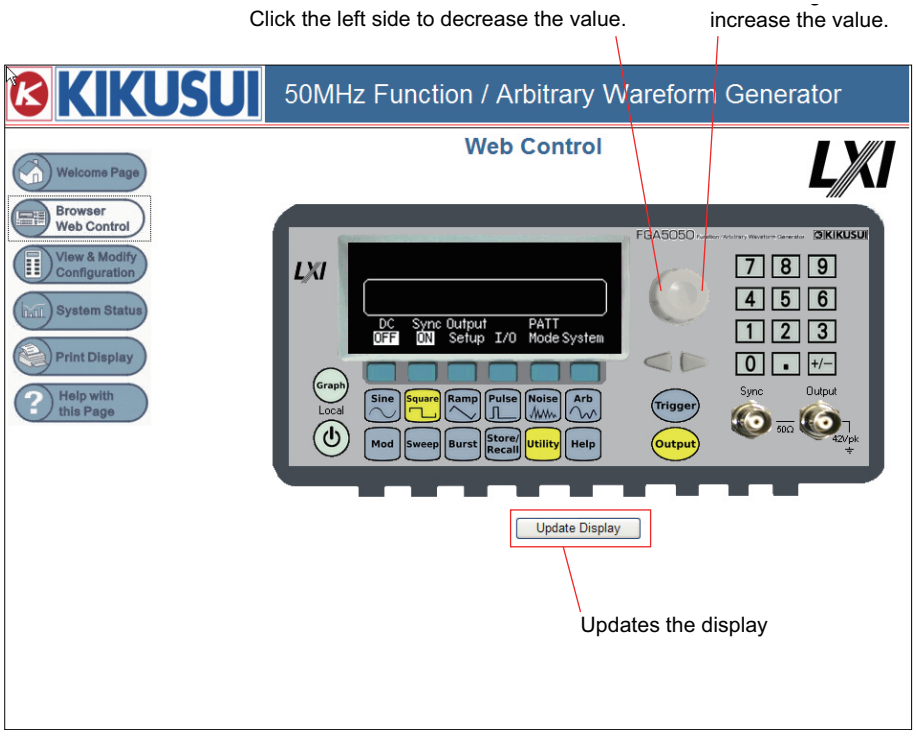


Accessing and operating the FGA5050 from a Web browser (continued)

■ Browser Web Control

On this page, you can control the FGA5050 using a virtual panel.

Clicking a key on the virtual panel is the same as pressing the key on the FGA5050 panel. The FGA5050 display also appears on the virtual panel. You can click the right side of the rotary knob on the virtual panel to increase a value and click the left side to decrease the value.



■ View & Modify Configulation

On this page, you can change LAN settings, such as the IP address.

To change the settings, press “Modify Configuration.”

■ System Status

On this page, information about the system is displayed.

■ Print Display

You can print the currently displayed webpage.

■ Help with this Page

Click here to display the help for the currently displayed webpage.

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Message Reference

This chapter explains the SCPI commands.

Message Overview

The information that is transferred between the controller (PC) and the FGA5050 is referred to as “messages.”

The FGA5050 uses the SCPI language for these messages.

The messages that the PC sends to the FGA5050 are commands. The messages that the FGA5050 sends to the PC are responses.

Commands are used to execute functions or change settings on the FGA5050 or to query the FGA5050’s settings or status. Responses are used to return the FGA5050’s settings or status.

NOTE You need to set an appropriate wait time for sending and receiving messages. Communication errors may occur if a wait time has not been set.

Command hierarchy

SCPI is an ASCII-based command language that was designed for test and measuring equipment. The command structure is composed of the common roots and nodes that are the building blocks of the SCPI subsystem. A command consists of a program header, parameters, and punctuation marks.

The following table uses the SOURce subsystem as an example to explain the hierarchy.

Program Header	Parameters	Node Level
SOURce:		Root node
FREQuency		2nd level
:STARt	{<frequency>|MINimum|MAXimum}	3rd level
:STARt?	[MINimum|MAXimum]	3rd level
:STOP	{<frequency>|MINimum|MAXimum}	3rd level
:STOP?	[MINimum|MAXimum]	3rd level
SWEep		2nd level
:SPACing	{LINear|LOGarithmic}	3rd level
:SPACing?		3rd level
:TIME	{<seconds>|MINimum|MAXimum}	3rd level
:TIME?	[MINimum|MAXimum]	3rd level

A colon (:) separates a higher node from a lower node.

SCPI command syntax

Command syntax

In this manual, SCPI commands are expressed in the following format.

Example:

STARt {<frequency>|MINimum|MAXimum}

- SCPI commands can be written in long form (with all the characters) or in short form (omitting the lowercase characters).

  SCPI commands can be transmitted in either long form or short form.
- SCPI commands are not case sensitive. STAR, Star, and star are all received as the short form of the STARt command.

  START, Start, and start are all received as the long form of the STARt command.
- A space separates a program header and its parameters.
- Multiple parameters are separated by commas.
- Compound commands can be created through the concatenation of two commands with a semicolon.

  Example

  BURSt:MODE TRIG; NCYCles 10

  This compound command sends the same commands as the two following commands.

  BURS:MODE TRIG

  BURS:NCYCles 10
- Program headers are separated by colons.
- By using colons and semicolons, you can concatenate commands of different subsystems.

  Example

  BURS:STATe ON;:TRIG:SOUR EXT

Special symbols and characters

The special symbols and characters that are used in this manual for the SCPI command syntax are explained below.

Symbol or character	Definition
< >	Character strings inside the < and > symbols indicate program data. Do not include the < and > symbols in the actual program.
{ }	Characters and numbers delimited by "|" inside the { and } symbols indicate that one of the delimited items is to be selected. Do not include the { and } symbols in the actual program.
[ ]	Character strings inside [and] indicate optional data. When optional data is not sent with the program, the default value is sent. Do not include the [and] symbols in the actual program.

SCPI command syntax (continued)

Queries

You can query the settings and status of the FGA5050.

To make a query, append a question mark to the end of the program header section.

NOTE If you want to send two queries on separate lines, send the second query after you have received the response to the first one. If you send query commands on two lines at the same time, you may receive an incomplete response.

Terminating character strings

The command strings sent to the FGA5050 are terminated with <new line> characters. The IEEE-488 EOI (end or identify) message is treated the same as <new line> characters, so you can use the EOI message instead of <new line> characters as the end of a command string. You can also use <carriage return> + <new line>.

When a command string is terminated, the current SCPI command path is reset to the root level.

Parameters

The SCPI language defines various data formats for use in messages.

■ Numeric parameters

Commands that require numeric parameters can contain all widely used decimal expressions, including optional signs, decimal points, and scientific notation. They can also contain special numeric parameter values, such as MINimum and MAXimum. You can also attach an engineering unit suffix (such as MHz or kHz) to a numerical parameter when you send it. When the FGA5050 can only accept specific values, it automatically rounds the input parameter values. The following is a command that contains a numeric parameter.

```
FREQuency:STARt {<frequency>|MINimum|MAXimum}
```

■ Discrete parameters

Discrete parameters are used for settings that have a limited number of values (such as BUS, IMMediate, and EXTernal). Like command keywords, discrete parameters can be transmitted in short form or long form, and they are not case-sensitive.

Query responses are always given in all caps in short form. The following is a command that contains a discrete parameter.

```
TRIGger:SOURce {BUS|IMMediate|EXTernal}
```

■ Boolean parameters

Boolean parameters can be either true or false. The FGA5050 recognizes parameter values of “OFF” and “0” as indicating false Boolean values. The FGA5050 recognizes parameter values of “ON” and “1” as indicating true Boolean values. The FGA5050 only responds to Boolean parameter queries with “0” or “1.” The following is a command that contains a Boolean parameter.

```
SWEep:STATe {OFF|ON}
```

■ Character string parameters

You can enter any combination of ASCII characters for a character string parameter. Character strings are enclosed by single or double quotation marks. The opening and closing quotation marks must match (you cannot mix single and double quotation marks). If you want to include a quotation mark as part of the string, enter consecutive quotation marks (with no characters between them). The following is a command that contains a character string parameter.

```
DISPlay:TEXT <quoted string>
```

Using the MIN and MAX parameters

For most commands, you can enter MINimum or MAXimum as the parameter. For example, instead of selecting a specific frequency, you can use MIN to specify the minimum frequency or MAX to specify the maximum frequency.

Example

```
FREQuency:STARt {<frequency>|MINimum|MAXimum}
```

APPLy Commands

APPL:SIN

Generates a sine wave with the specified frequency, amplitude, and DC offset.

Command `APPLy:SINusoid [<frequency>[,<amplitude>[,<offset>]]]`

APPL:SQU

Generates a square wave with the specified frequency, amplitude, and DC offset. The duty cycle is automatically set to 50 %.

Command `APPLy:SQUare [<frequency>[,<amplitude>[,<offset>]]]`

APPL:RAMP

Generates a ramp wave with the specified frequency, amplitude, and DC offset. The symmetry is automatically set to 100 %.

Command `APPLy:RAMP [<frequency>[,<amplitude>[,<offset>]]]`

APPL:PULS

Generates a pulse wave with the specified frequency, amplitude, and DC offset. The duty cycle or pulse width setting set for the current edge time setting and “hold” (the FUNC:PULS:HOLD command) is held. However, the FGA5050 will adjust the pulse width or edge time according to the frequency limit of the pulse wave.

Command `APPLy:PULSe [<frequency>[,<amplitude>[,<offset>]]]`

APPL:NOIS

Generates a noise wave with the specified frequency, amplitude, and DC offset. A waveform is generated immediately after this command is executed. The frequency parameter has no effect on the noise wave, but you still need to specify a frequency or “DEFault.” The settings are retained and applied the next time you select a different waveform.

Command `APPLy:NOISe [<frequency|DEFault>[,<amplitude>[,<offset>]]]`

APPL:DC

Generates DC voltage at the specified level. You can set the DC voltage to a value within the range of ±5 Vdc (into 50 Ω) or ±10 Vdc (open). A waveform is generated immediately after this command is executed.

The frequency and amplitude parameters have no effect on the DC output, but you still need to specify a frequency or “DEFault.” The settings are retained and applied the next time you select a different waveform.

Command `APPLy:DC [<frequency|DEFault>[,<amplitude|DEFault>[,<offset>]]]`

APPL:USER

Generates the arbitrary waveform that has been selected through the use of the FUNC:USER command at the specified frequency, amplitude, and offset.

Command `APPLy:USER [<frequency>[,<amplitude>[,<offset>]]]`

APPL

Queries the current setting. You can append the response to this command to an APPL: command in your programming application to put the FGA5050 in a specific state.

Command `APPLy?`

Response In response to APPLy?, the FGA5050 returns a character string enclosed in quotation marks. The character string indicates each parameter in the following order: waveform, frequency, amplitude, and then offset.

Output Configuration Commands

FUNC

See p.40, p.41

Use this command to select an output waveform.

If you select “USER,” the FGA5050 generates the waveform that has been selected through the use of the **FUNC:USER** command. For details, see **FUNC USER** under “Arbitrary Waveform Commands.”

Command
```
FUNCtion {SINusoid|SQUare|RAMP|PULSe|NOISe|DC|USER}
FUNCtion?
```

Response In response to FUNC?, the FGA5050 returns “SIN,” “SQU,” “RAMP,” “PULS,” “NOIS,” “DC,” or “USER.”

FREQ

Sets the output frequency.

Command
```
FREQuency {<frequency>|MINimum|MAXimum}
FREQuency? [MINimum|MAXimum]
```

Response In response to FREQ?, the FGA5050 returns the frequency in Hz of the currently selected waveform.

VOLT

Sets the output amplitude.

The minimum value with a 50 Ω load is 10 mVpp. The maximum value is the maximum amplitude of the selected waveform (up to 10 Vpp with a 50 Ω load depending on the selected waveform and offset voltage).

Command
```
VOLTage {<amplitude>|MINimum|MAXimum}
VOLTage? [MINimum|MAXimum]
```

VOLT (continued)

- The offset amplitude and offset voltage are related to Vmax as indicated below.

  |Voffset| + Vpp ÷ 2 ≤ Vmax

  Here, Vmax is the maximum peak voltage of the selected output connector (5 V with a 50 Ω load and 10 V with a high-impedance load). The FGA5050 prioritizes the recently set output amplitude. The offset amplitude is adjusted according to the output amplitude, and this can lead to a “Settings conflict” error.
- Output connector limitations: When the output termination setting changes, the output amplitude is automatically adjusted. For example, when you change the output termination from a 50 Ω load to a high-impedance load, the offset voltage is doubled, and this affects the output amplitude. Also, when you change the output termination from a high-impedance load to a 50 Ω load, the offset voltage is halved.
- When the output termination is set to a high-impedance load, the output amplitude unit is Vpp instead of dBm.
- For arbitrary waveforms, if the waveform data points do not span the full range of the output DAC (digital-to-analog converter), the maximum DC offset and maximum amplitude are limited.
- You can also set the output amplitude by specifying a high and low level. For example, if you set the high level to +2 V and the low level to -3 V, the amplitude is 5 Vpp (with a DC offset of -0.5 V).
- While the amplitude is being changed, the switching of the output attenuators can lead to temporary disruptions in the output waveform at certain voltages. The amplitude is controlled, so even when the range is changed, the output voltage does not exceed the specified value. You can prevent this disruption by using the VOLT:RANG:AUTO command to disable voltage autoranging.
- To generate a DC voltage level, select DC voltage using the FUNC DC command, and then set the offset voltage level using the VOLT:OFFS command. You can set the DC voltage level within the range of ±5 Vdc with a 50 Ω load and ±10 Vdc with a high-impedance load.

Response In response to VOLTage?, the FGA5050 returns the unit that has been selected through the use of the VOLT:UNIT command.

VOLT:OFF

Sets the DC offset voltage. The default setting is 0 V. The allowable range is determined by the selected waveform and amplitude.

Command
```
VOLTage:OFFSet {<offset>|MINimum|MAXimum}
VOLTage:OFFSet? [MINimum|MAXimum]
```

- The output amplitude and offset voltage are related to Vmax as indicated below.

  |Voffset| + Vpp ÷ 2 ≤ Vmax

  Here, Vmax is the maximum peak voltage of the selected output termination (5 V with a 50 Ω load and 10 V with a high-impedance load). The FGA5050 prioritizes the recently set output amplitude. The offset amplitude is adjusted according to the output amplitude, and this can lead to a “Settings conflict” error.
- When the output termination setting changes, the offset limit is automatically adjusted. For example, when you change the output termination from a 50 Ω load to a high-impedance load, the offset voltage is doubled, and this affects the output amplitude. Also, when you change the output termination from a high-impedance load to a 50 Ω load, the offset voltage is halved.
- For arbitrary waveforms, if the waveform data points do not span the full range of the output DAC (digital-to-analog converter), the maximum DC offset and maximum amplitude are limited.
- You can also set the output amplitude by specifying a high and low level. For example, if you set the high level to +2 V and the low level to -3 V, the amplitude is 5 Vpp (with a DC offset of -0.5 V).

Response In response to VOLT:OFF?, the FGA5050 returns the DC offset voltage of the currently selected waveform.

VOLT:HIGH

Use this command to specify the high level. The initial high level setting is +50 mV for all waveforms.

Command
```
VOLTage:HIGH {<voltage>|MINimum|MAXimum}
VOLTage:HIGH? [MINimum|MAXimum]
```

- The high and low level are always limited by the following inequalities.

  Vhigh - Vlow ≤ Vpp (max)

  Vhigh, Vlow ≤ Vpp (max) / 2

  Here, Vpp (max) is the maximum peak-to-peak amplitude of the selected output connector (10 Vpp with a 50 Ω load and 20 Vpp with a high-impedance load). If you specify a value that falls outside of the above range, the FGA5050 automatically specifies the maximum allowable value and generates a “Data out of range” error.
- The high level must always be higher than the low level. If the high level is lower than the low level, a “Setting conflict” error occurs, and the FGA5050 automatically specifies a high level that is 1 mV higher than the specified low level.
- You can also specify the offset by specifying a high and low level. For example, if you set the high level to +2 Vpp and the low level to -3 V, the amplitude is 5 V (with a DC offset of -0.5 V).
- When the output termination setting is changed, the voltage level is automatically adjusted. For example, if you change the output termination from a 50 Ω load to a high-impedance load, the voltage on the display is doubled, and if you change the output termination from a high-impedance load to a 50 Ω load, the voltage is halved.
- To invert the waveform around the offset voltage, use the OUTP:POL command.

Response In response to VOLT:HIGH?, the FGA5050 returns the high level value.

VOLT:LOW

Use this command to specify the low level. The initial low level setting is -50 mV for all waveforms.

Command
```
VOLTage:LOW {<voltage>|MINimum|MAXimum}
VOLTage:LOW? [MINimum|MAXimum]
```

- The high and low level are always limited by the following inequalities.

  Vhigh - Vlow ≤ Vpp (max)

  Vhigh, Vlow ≤ Vpp (max) / 2

  Here, Vpp (max) is the maximum peak-to-peak amplitude of the selected output connector (10 Vpp with a 50 Ω load and 20 Vpp with a high-impedance load). If you specify a value that falls outside of the above range, the FGA5050 automatically specifies the maximum allowable value and generates a “Data out of range” error.
- The high level must always be higher than the low level. If the high level is lower than the low level, a “Setting conflict” error occurs and the FGA5050 automatically specifies a high level that is 1 mV higher than the specified low level.
- You can also specify the offset by specifying a high and low level. For example, if you set the high level to +2 and the low level to -3 V, the amplitude is 5 Vpp (with a DC offset of -0.5 V).

VOLT:LOW (continued)

- When the output termination setting is changed, the voltage level is automatically adjusted. For example, if you change the output termination from a 50 Ω load to a high-impedance load, the voltage on the display is doubled, and if you change the output termination from a high-impedance load to a 50 Ω load, the voltage is halved.
- To invert the waveform around the offset voltage, use the OUTP:POL command.

Response In response to VOLT:LOW?, the FGA5050 returns the low level value.

VOLT:RANG

Turns voltage autoranging on or off. The default setting is for voltage autoranging to be on. When autoranging is on, the optimum settings for the output amplitude and the attenuators are selected. When autoranging is off, the current settings are used.

Command
```
VOLTage:RANGe:AUTO {OFF|ON|ONCE}
VOLTage:RANGe:AUTO?
```

- "ONCE" turns autoranging on and then turns it off after the optimum settings have been selected.
- The APPLy command takes priority over this command and turns autoranging on.
- You can prevent the temporary disruption that occurs when the amplitude changes and the attenuators are switched by turning autoranging off. However, if the amplitude falls below the expected range of change, the amplitude and offset accuracy may be reduced.

Response In response to VOLT:RANG:AUTO?, the FGA5050 returns "0" (OFF) or "1" (ON).

VOLT:UNIT

Select the output amplitude unit. The default setting is VPP. You must use the same unit for the front panel and the remote interface.

If you do not set a unit in the APPLy or VOLT command, the FGA5050 will use the unit specified by this command. However, when the output termination is set to a high-impedance load, the output amplitude unit is changed to Vpp instead of dBm.

Command
```
VOLTage:UNIT {VPP|VRMS|DBM}
VOLTage:UNIT?
```

Response In response to VOLT:UNIT?, the FGA5050 returns "VPP," "VRMS," or "DBM."

FUNC:SQU:DCYC

Sets the square wave duty cycle. The duty cycle is the time during a square wave cycle when the wave is at the high level (assuming that the waveform polarity is not inverted). The default setting is 50 %. The duty cycle can be set to a value between 20 % and 80 % when the waveform frequency is 10 MHz or less or to a value between 40 % and 60 % when the waveform frequency is greater than 10 MHz.

Command
```
FUNCtion:SQUare:DCYCle {<percent>|MINimum|MAXimum}
FUNCtion:SQUare:DCYCle? [MINimum|MAXimum]
```

- The APPLy command takes priority over this command and sets the duty cycle to 50 %.
- The duty cycle setting is retained and applied the next time you use a square wave.

- When you use a square wave as the modulation signal for AM, PM, FM, or PWM, a 50 % duty cycle is used.
- When you are using a square wave, if the duty cycle doesn't match the frequency, the FGA5050 automatically adjusts the duty cycle to match the frequency. A "Settings conflict" error is generated by the remote interface.

Response In response to FUNC:SQU:DCYC?, the FGA5050 returns the current duty cycle percentage setting.

FUNC:RAMP:SYMM

Sets the ramp wave symmetry. Symmetry refers to the time that the ramp wave rises during each cycle (assuming that the waveform polarity is not inverted). The range is from 0 % to 100 %. The default setting is 100 %.

Command
```
FUNCtion:RAMP:SYMMetry {<percent>|MINimum|MAXimum}
FUNCtion:RAMP:SYMMetry? [MINimum|MAXimum]
```

- The APPLy command takes precedence over the current symmetry setting and uses a symmetry of 100 %.
- The symmetry setting is retained and applied the next time you use a ramp wave.
- If you use a ramp wave as the modulation signal for AM or FM, the symmetry setting is applied.

Response In response to FUNC:RAMP:SYMM?, the FGA5050 returns the current symmetry percentage setting.

OUTP

Turns the Output connector on the front panel on or off. The default setting is for the connector to be on. When the connector is on, the Output key lights.

Command
```
OUTPut {OFF|ON}
OUTPut?
```

- The APPLy command takes precedence over the OUTP command and automatically turns the Output connector on.
- The Output connector is turned off when excessive external voltage is applied. To turn the Output connector on again after this happens, stop applying the excessive voltage, and then use this command.
- This command changes the status of the Output connector by switching an output relay. However, the output voltage will not drop to zero before the relay is switched. Therefore, during the 1 ms before the signal stabilizes, glitches may appear in the output signal. To minimize these glitches, first make the amplitude as small as possible (using the VOLTage command) before you change the output status.

Response In response to OUTP?, the FGA5050 returns "0" (OFF) or "1" (ON).

OUTP:LOAD

Select the desired output termination. You can specify a value from 1 Ω to 10 kΩ. Specifying INF sets the output termination to a high impedance (>10 kΩ). The default setting is 50 Ω. The specified value affects the amplitude, offset, high level, and low level.

Command
```
OUTPut:LOAD {<ohms>|INFinity|MINimum|MAXimum}
OUTPut:LOAD? [MINimum|MAXimum]
```

OUTP:LOAD (continued)

- When the output termination is changed, the displayed output amplitude, DC offset, high level, and low level are automatically adjusted, and no error occurs.
- There is a constant output impedance of 50 Ω on the front panel output connector of the FGA5050. When the actual load impedance differs from the specified value, the displayed amplitude, offset, high level, and low level are all inaccurate.
- When you set the Output connector to high impedance, you cannot specify the output amplitude in dBm. The unit is automatically changed to Vpp.

Response In response to OUTP:LOAD?, the FGA5050 returns the current resistance (in ohms) or "9.9E+37" to indicate high impedance.

OUTP:POL

Inverts the waveform around the DC offset voltage. The default setting is NORM, and the waveform is positive during the first part of the cycle. When the setting is INV, the waveform is negative during the first part of the cycle. Even if the waveform is inverted, the DC offset voltage remains the same, and the sync signal is not inverted.

Command
```
OUTPut:POLarity {NORMal|INVerted}
OUTPut:POLarity?
```

OUTP:SYNC

Turns the Sync connector on the front panel on or off. The default setting is for the Sync connector to be on. When the amplitude of the output waveform is low, you can reduce output distortion by turning the sync signal off. When the sync signal is off, the Sync connector output level is (logical) low.

Command
```
OUTPut:SYNC {OFF|ON}
OUTPut:SYNC?
```

- When the waveform is inverted, the Sync signal associated with the waveform is not inverted.
- The MARK command used in sweep mode takes priority over this command. When the marker frequency is enabled (and sweeping is also enabled), the OUTP:SYNC command is ignored.

Response In response to OUTP:SYNC?, the FGA5050 returns "0" (OFF) or "1" (ON).

Pulse Configuration Commands

PULS:PER

Sets the pulse period. The range is from 200 ns to 2000 s. The default setting is 1 ms.

Command

```
PULSe:PERiod {<seconds>|MINimum|MAXimum}
PULSe:PERiod? [MINimum|MAXimum]
```

- The specified period must be greater than the sum of the pulse width and the edge time. When it is smaller, the FGA5050 automatically adjusts the edge time and then the pulse width (as necessary) according to the period.

  Pulse period ≥ Pulse width + (1.6 x edge time)

  or

  Pulse period ≥ (Pulse period x duty cycle/100) + (1.6 x edge time)
- When you select a different waveform, the specified period is held. If you select a pulse wave, specify the period using the PULS:PER command, and then select another waveform, the period is applied to the new waveform.
- Even if you change the output waveform, the specified period does not change. If the specified period is larger than the period of a waveform that you select later, the FGA5050 automatically adjusts the period. A “Settings conflict” error is displayed.

Response In response to PULS:PER?, the FGA5050 returns the pulse wave period in seconds.

FUNC:PULS:HOLD

Makes the FGA5050 hold the pulse width or the duty cycle.

Command

```
FUNCtion:PULSe:HOLD {WIDTh|DCYCle}
FUNCtion:PULSe:HOLD? [WIDTh|DCYCle]
```

- WIDth: When the period changes, the pulse width is held (the minimum pulse width and edge time limits apply). When the FGA5050 receives a command specifying the duty cycle, the duty cycle is converted to an equivalent pulse width (in seconds). When pulse width modulation (PWM) is on and the period changes, the pulse width is held, and the pulse width deviation is also held. The value of the duty cycle deviation command is converted to a pulse width deviation value.
- DCYCle: When the period changes, the duty cycle is held (the minimum pulse width and edge time limits apply). When the FGA5050 receives a command specifying the pulse width, the pulse width is converted to an equivalent duty cycle (percentage). When pulse width modulation (PWM) is on and the period changes, the duty cycle is held, and the duty cycle deviation is also held. The value of the pulse width deviation command is converted to a duty cycle deviation value.

Response In response to FUNC:PULS:HOLD?, the FGA5050 returns the held pulse width value or duty cycle (percentage).

FUNC:PULS:WIDT

Sets the pulse width in seconds. The range is from 20 ns to 2000 s. The default setting is 100 μs.

Command

```
FUNCtion:PULSe:WIDTh {<seconds>|MINimum|MAXimum}
FUNCtion:PULSe:WIDTh? [MINimum|MAXimum]
```

FUNC:PULS:WIDT (continued)

- The pulse width refers to the time from the 50 % point of a rising edge of the pulse to the 50 % point of the next falling edge.
- The minimum pulse width is 20 ns. The maximum pulse width is 1999.99 s.
- The minimum pulse width Wmin is determined by the following conditions.

  When the period does not exceed 10 s, Wmin = 20 ns

  When the period is greater than 10 s and less than or equal to 100 s, Wmin = 200 ns

  When the period is greater than 100 s and less than or equal to 1000 s, Wmin = 2 μs

  When the period is greater than 1000 s, Wmin = 20 μs
- The specified pulse width must not exceed the difference between the period and the minimum pulse width.

  Pulse width ≤ Period - Wmin

  The FGA5050 adjusts the edge time first and then adjusts the pulse width to match the period. A “Setting conflict” error is generated by the remote interface, and the pulse width is adjusted.
- The specified pulse width must not exceed the difference between the period and the edge time.

  Pulse width ≤ Period - (1.6 x edge time)

  The FGA5050 adjusts the edge time first and then adjusts the pulse width to match the period. A “Data out of range” error is generated by the remote interface, and the pulse width is adjusted.
- The specified pulse width must exceed the set edge time.

  Pulse width ≥ 1.6 x edge time
- Use the FUNC:PULS:HOLD command to determine whether to hold the pulse width or the pulse duty cycle.

Response In response to FUNC:PULS:WIDTh?, the FGA5050 returns the pulse width in seconds.

FUNC:PULS:DCYC

Sets the pulse duty cycle percentage. The range is from 0 % to 100 %. The initial setting is 10 %.

Command
```
FUNCtion:PULSe:DCYCle {<percent>|MINimum|MAXimum}
FUNCtion:PULSe:DCYCle? [MINimum|MAXimum]
```

- The values that can be specified for the duty cycle are limited by the minimum pulse width (Wmin) and the edge time.

  Duty cycle ≥ Wmin/period x 100 %

  Duty cycle ≤ (1 - Wmin/period) × 100 %

  Duty cycle ≥ 1.6 × edge time/period × 100 %

  Duty cycle ≤ (1 - 1.6 × edge time/period) × 100 %

  When the period does not exceed 10 s, Wmin = 20 ns

  When the period is greater than 10 s and less than or equal to 100 s, Wmin = 200 ns

  When the period is greater than 100 s and less than or equal to 1000 s, Wmin = 2 μs

  When the period is greater than 1000 s, Wmin = 20 μs

  The FGA5050 adjusts the edge time first and then adjusts the duty cycle to match the period as necessary. A “Data out of range” error is generated by the remote interface, and the duty cycle and edge time are adjusted.

Response In response to FUNC:PULS:DCYC?, the FGA5050 returns the current duty cycle percentage.

FUNC:PULS:TRAN

Sets the rising or falling edge time in seconds.

The edge time refers to the time from the 10 % point of a rising edge to the 90 % point of a falling edge. The range is from 5 ns to 100 ns. The default setting is 5 ns.

Command

```
FUNCtion:PULSe:TRANsition {<seconds>|MINimum|MAXimum}
FUNCtion:PULSe:TRANsition? [MINimum|MAXimum]
```

- The edge time must meet the following conditions.

  Edge time ≤ 0.625 × pulse width

  or

  Edge time ≤ 0.625 × period × duty cycle/100

  When necessary, the FGA5050 adjusts the pulse width or the duty cycle to match the edge time.

Response In response to FUNC:PULS:TRAN?, the FGA5050 returns the edge time in seconds.

Amplitude Modulation Commands

AM:INT:FUNC

Sets the modulation waveform. This command is only valid when the modulation source is internal. Noise, pulse, and DC signals can be used as modulation signals, but they cannot be used as carrier waves. The default setting is to use a sine wave as the modulation signal.

Command

```
AM:INTernal:FUNCtion {SINusoid|SQUare|RAMP|NRAMp|TRIangle|NOISe|USER}
AM:INTernal:FUNCtion?
```

- SQU: The square wave duty cycle is 50 %.
- RAMP: The ramp wave symmetry is 100 %.
- NRAM: The reverse ramp wave symmetry is 0 %.
- TRI: The triangle wave symmetry is 50 %,
- USER: If you select an arbitrary waveform as the modulation signal, the waveform is automatically limited to 4 K points. Points exceeding this limit are discarded through decimation.

Response In response to AM:INT:FUNC?, the FGA5050 indicates the modulation signal by returning “SIN,” “SQU,” “RAMP,” “NRAM,” “TRI,” “NOIS,” or “USER.”

AM:INT:FREQ

Sets the modulation signal frequency. This command is only valid when the modulation source is internal. The range is from 2 mHz to 20 kHz. The default setting is 100 Hz.

Command

```
AM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}
AM:INTernal:FREQuency? [MINimum|MAXimum]
```

Response In response to AM:INT:FREQ?, the FGA5050 returns the internal modulation signal frequency (in hertz).

AM:DEP

You can specify the internal modulation depth (or percentage modulation) as a percentage. The range is from 0 % to 120 %. The initial setting is 100 %.

Command

```
AM:DEPth {<depth in percent>|MINimum|MAXimum}
AM:DEPth? [MINimum|MAXimum]
```

- If you select an external source, the modulation depth is controlled by a ±5 V external signal applied to the Modulation In connector on the rear panel. When the external modulation signal is +5 V, the output amplitude is at its maximum, and when the external modulation signal is -5 V, the output amplitude is at its minimum.
- Even when the modulation depth exceeds 100 %, the modulated output of the FGA5050 never exceeds ±5 V (with a 50 Ω load).

Response In response to AM:DEP?, the FGA5050 returns the current modulation depth percentage.

AM:SOUR

Sets the modulation signal source. If you select an external source, the carrier wave is modulated by an external waveform.

Command

```
AM:SOURce {INTernal|EXTernal}
AM:SOURce?
```

- If you select an external source, the modulation depth is controlled by a ±5 V external signal applied to the Modulation In connector on the rear panel. When the external modulation signal is +5 V, the output amplitude is at its maximum, and when the external modulation signal is -5 V, the output amplitude is at its minimum.

Response In response to AM:SOUR?, the FGA5050 indicates the modulation source by returning “INT” (internal) or “EXT” (external).

AM:STAT

Turns amplitude modulation on or off. The default setting is for amplitude modulation to be off.

To prevent multiple waveforms from being changed, turn amplitude modulation on after setting the modulation parameters.

Command

```
AM:STATe {OFF|ON}
AM:STATe?
```

Response In response to AM:STAT?, the FGA5050 returns “0” (OFF) or “1” (ON).

Frequency Modulation Commands

FM:INT:FUNC

Sets the modulation waveform. This command is only valid when the modulation source is internal (FM:SOUR INT command). Noise, pulse, and DC signals can be used as modulation signals, but they cannot be used as carrier waves. The default setting is to use a sine wave as the modulation signal.

Command

```
FM:INTernal:FUNCtion {SINusoid|SQUare|RAMP|NRAMp|TRIangle|NOISe|USER}
FM:INTernal:FUNCtion?
```

- SQU: The square wave duty cycle is 50 %.
- RAMP: The ramp wave symmetry is 100 %.
- NRAM: The reverse ramp wave symmetry is 0 %.
- TRI: The triangle wave symmetry is 50 %.
- USER: If you select an arbitrary waveform as the modulation signal, the waveform is automatically limited to 4 K points. Points exceeding this limit are discarded through decimation.

Response In response to FM:INT:FUNC?, the FGA5050 indicates the modulation signal by returning “SIN,” “SQU,” “RAMP,” “NRAM,” “TRI,” “NOIS,” or “USER.”

FM:INTernal:FREQ

Sets the modulation signal frequency. This command is only valid when the modulation source is internal. The range is from 2 mHz to 20 kHz. The default setting is 10 Hz.

Command

```
FM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}
FM:INTernal:FREQuency? [MINimum|MAXimum]
```

Response In response to FM:INTernal:FREQ?, the FGA5050 returns the modulation signal frequency in hertz.

FM:DEV

Sets the peak frequency deviation in Hz. This value indicates the peak deviation of the modulation signal frequency from the carrier wave frequency. The range is from 1 μHz to 150 kHz for ramp waves, 1 μHz to 5.05 MHz for arbitrary waveforms, 1 μHz to 12.55 MHz for square waves, and 1 μHz to 25.05 MHz for sine waves. The default setting is 100 Hz.

Command

```
FM:DEViation {<peak deviation in hertz>|MINimum|MAXimum}
FM:DEViation? [MINimum|MAXimum]
```

- The minimum peak frequency deviation is 1 μHz. The maximum deviation is determined by the following conditions.
  (1) The frequency deviation cannot be greater than the frequency of the carrier wave.
  (2) The sum of the frequency deviation and the carrier wave frequency must not be greater than the sum of the maximum frequency of the selected waveform and 100 kHz (50.1 MHz for a sine wave, 25.1 MHz for a square wave, 300 kHz for a ramp wave, and 10.1 MHz for an arbitrary waveform). If a frequency deviation that exceeds this limit is specified, the FGA5050 automatically sets it to the maximum allowable value.
- When an external source is selected, modulation is limited by the pulse width deviation setting. Modulation is also affected by whether the external waveform exceeds ±5 V. When the external signal is +5 V, the maximum frequency deviation value is generated, and when the external signal is -5 V, the minimum frequency deviation value is generated.

FM:DEV (continued)

If because of deviation, the carrier wave exceeds the frequency range for the current duty cycle (square waves only), the FGA5050 automatically sets the duty cycle to the maximum allowable value for the current carrier wave frequency.

Response In response to FM:DEV?, the FGA5050 returns the current peak frequency deviation in Hz.

FM:SOUR

Sets the modulation signal source. The default setting is for the FGA5050 to use an internal source (INT).

Command
```
FM:SOURce {INTernal|EXTernal}
FM:SOURce?
```

Response In response to FM:SOUR?, the FGA5050 returns “INT” or “EXT.”

FM:STAT

Turns frequency modulation on or off. The default setting is for frequency modulation to be off. To prevent multiple waveforms from being changed, turn frequency modulation on after setting the modulation parameters. On the FGA5050, you can only turn one modulation mode on at a time.

Command
```
FM:STATe {OFF|ON}
FM:STATe?
```

Response In response to FM:STAT?, the FGA5050 returns “0” (OFF) or “1” (ON).

Phase Modulation Commands

PM:INT:FUNC

Sets the modulation signal. This command is only valid when the modulation source is internal (PM:SOUR INT). Square waves, ramp waves, and arbitrary waveforms can be used as modulation signals, but pulses, noise waveforms, and DC cannot be used as carrier waves. The default setting is to use a sine wave as the modulation signal.

Command
```
PM:INTernal:FUNCtion {SINusoid|SQUare|RAMP|NRAMp|TRIangle|NOISe|USER}
PM:INTernal:FUNCtion?
```

- SQU:The square wave duty cycle is 50 %.
- RAMP:The ramp wave symmetry is 100 %.
- NRAM:The reverse ramp wave symmetry is 0 %.
- TRI:The triangle wave symmetry is 50 %.
- USER:If you select an arbitrary waveform as the modulation signal, the waveform is automatically limited to 4 K points. Points exceeding this limit are discarded through decimation.

Response In response to PM:INT:FUNC?, the FGA5050 indicates the modulation signal by returning “SIN,” “SQU,” “RAMP,” “NRAM,” “TRI,” “NOIS,” or “USER.”

PM:INT:FREQ

Sets the modulation signal frequency. This command is only valid when the modulation source is internal (PM:SOUR INT). The range is from 2 mHz to 20 kHz. The default setting is 10 Hz.

Command
```
PM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}
PM:INTernal:FREQuency? [MINimum|MAXimum]
```

Response In response to PM:INT:FREQ?, the FGA5050 returns the internal modulation frequency in Hz.

PM:DEV

Sets the phase deviation as an angle. The phase deviation indicates the peak change from the carrier wave to the modulated waveform. The range is from 0 ° to 360 °. The initial setting is 180 °. When an external source is selected, the carrier wave is modulated according to the specified phase deviation and whether the external source is within the range of ±5 V. When the external source is +5 V, the external waveform phase deviation is at its maximum, and when the external source is -5 V, the external waveform phase deviation is at its minimum.

Command
```
PM:DEViation {<peak deviation in hertz>|MINimum|MAXimum}
PM:DEViation? [MINimum|MAXimum]
```

Response In response to PM:DEV?, the FGA5050 returns the phase deviation in degrees.

PM:SOUR

Sets the modulation signal source. The default setting is INTernal (internal source). When an external source is selected, the carrier wave is modulated according to the specified phase deviation and whether the external source is within the range of ±5 V. When the external source is +5 V, the external waveform phase deviation is at its maximum, and when the external source is -5 V, the external waveform phase deviation is at its minimum.

Command
```
PM:SOURce {INTernal|EXTernal}
PM:SOURce?
```

Response In response to PM:SOUR?, the FGA5050 returns “INT” (internal) or “EXT” (external).

PM:STAT

Turns phase modulation on or off. The default setting is for phase modulation to be off. To prevent multiple waveforms from being changed, turn phase modulation on after setting the modulation parameters. On the FGA5050, you can only turn one modulation mode on at a time.

Command
```
PM:STATe {OFF|ON}
PM:STATe?
```

Response In response to PM:STAT?, the FGA5050 returns “0” (OFF) or “1” (ON).

FSK Commands

FSK:FREQ

Sets the FSK hop frequency. The range is from 1 μHz to 200 kHz for ramp waves, 1 μHz to 10 MHz for arbitrary waveforms, 1 μHz to 25 MHz for square waves, and 1 μHz to 50 MHz for sine waves. The default setting is 100 Hz.

Command `FSKey:FREQuency {<frequency>|MINimum|MAXimum}`
`FSKey:FREQuency? [MINimum|MAXimum]`

Response In response to FSK:FREQ?, the FGA5050 returns the hop frequency in Hz.

FSK:INT:RATE

Sets the FSK rate between the carrier wave frequency and the hop frequency (only when the source is an internal signal). The range is from 2 mHz to 100 kHz. The default setting is 10 Hz.

Command `FSKey:INTernal:RATE {<rate in Hz>|MINimum|MAXimum}`
`FSKey:INTernal:RATE? [MINimum|MAXimum]`

Response In response to FSK:INT:RATE?, the FGA5050 returns the FSK rate in Hz.

FSK:SOUR

Sets the FSK source. The default setting is for the source to be internal.

Command `FSKey:SOURce {INTernal|EXTernal}`
`FSKey:SOURce?`

Response In response to FSK:SOUR?, the FGA5050 returns “INT” (internal) or “EXT” (external).

FSK:STAT

Turns FSK modulation on or off. The default setting is for FSK modulation to be off. To prevent multiple waveforms from being changed, turn FSK modulation on after setting the modulation parameters. On the FGA5050, you can only turn one modulation mode on at a time.

Command `FSKey:STATe {OFF|ON}`
`FSKey:STATe?`

Response In response to FSK:STAT?, the FGA5050 returns “0” (OFF) or “1” (ON).

PWM Commands

PWM:INT:FUNC

Sets the PWM modulation signal. This command is only valid when the modulation source is internal (PWM:SOUR INT). The default setting is to use a sine wave.

Command

```
PWM:INTernal:FUNCtion {SINusoid|SQUare|RAMP|NRAMp|TRIangle|NOISe|USER}
PWM:INTernal:FUNCtion?
```

- SQU: The square wave duty cycle is 50 %.
- RAMP: The ramp wave symmetry is 100 %.
- NRAM: The reverse ramp wave symmetry is 0 %.
- TRI: The triangle wave symmetry is 50 %.
- USER: If you select an arbitrary waveform as the modulation signal, the waveform is automatically limited to 4 K points. Points exceeding this limit are discarded through decimation.

Response In response to PWM:INT:FUNC?, the FGA5050 indicates the modulation signal by returning “SIN,” “SQU,” “RAMP,” “NRAM,” “TRI,” “NOIS,” or “USER.”

PWM:INT:FREQ

Sets the modulation frequency. This command is only valid when the modulation source is internal (PWM:SOUR INT). The range is from 2 mHz to 20 kHz. The default setting is 10 Hz.

Command

```
PWM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}
PWM:INTernal:FREQuency? [MINimum|MAXimum]
```

Response In response to PWM:INT:FREQ?, the FGA5050 returns the internal modulation frequency in Hz.

PWM:DEV

Sets the pulse width deviation in seconds. The pulse width deviation is the amount of deviation from the carrier wave pulse width in units of seconds. The range is from 0 to 1000 s. The initial setting is 10 μs.

Command

```
PWM:DEViation {<deviation in seconds>|MINimum|MAXimum}
PWM:DEViation? [MINimum|MAXimum]
```

- The pulse width deviation cannot be greater than the pulse width of the carrier wave. Also, the following limitations apply:

  Pulse width deviation ≤ Pulse width - Wmin

  Pulse width deviation ≤ Period - pulse width - Wmin

  Pulse width deviation ≤ Pulse width - (1.6 × edge time)

  Pulse width deviation ≤ Period - pulse width - (1.6 × edge time)

  The relationship between the minimum pulse width (Wmin) and the pulse period is described below.

  When period ≤ 10 s, Wmin = 20 ns

  When period > 10 s but ≤ 100 s, Wmin = 200 ns

  When Period > 100 s but ≤ 1000 s, Wmin = 2 μs

  When period > 1000 s, Wmin = 20 μs

PWM:DEV (continued)

- When an external source (PWM:SOUR EXT) is selected, modulation is controlled according to the specified pulse width deviation and whether the external signal source is within the range of ±5 V. In other words, when the modulation signal is +5 V, the output pulse width is at its maximum, and when the modulation signal is -5 V, the output pulse width is at its minimum.

NOTE The operation of this command is affected by the FUNC:PULS:HOLD command. The FUNC:PULS:HOLD command determines whether the pulse width or duty cycle is held when the period is changed. When the pulse width is held, the pulse width deviation is also held. When the duty cycle is held, the duty cycle deviation is also held. When one of these values is held and a command is executed specifying the other value, the other value is automatically converted to an equivalent value.

Response In response to PWM:DEV?, the FGA5050 returns the pulse width deviation in seconds.

PWM:DEV:DCYC

Sets the duty cycle deviation percentage. The duty cycle deviation is the difference between the duty cycle of the modulation waveform and the duty cycle of the original pulse waveform. The range is from 0 % to 100 %. The initial setting is 1 %.

Command `PWM:DEViation:DCYCle {<deviation in percent>|MINimum|MAXimum}`
`PWM:DEViation:DCYCles? [MINimum|MAXimum]`

- The duty cycle deviation must not exceed the pulse duty cycle. Also, the following limitations apply:

  Duty cycle deviation ≤ Duty cycle × Wmin/period × 100
  Duty cycle deviation ≤ 100 - duty cycle - Wmin/period × 100
  Duty cycle deviation ≤ Duty cycle - (1.6 × edge time/period × 100)
  Duty cycle deviation ≤ 100 - duty cycle - (1.6 × edge time/period × 100)

  The minimum pulse width (Wmin) is determined by the pulse period.

  When period ≤ 10 s, Wmin = 20 ns
  When period > 10 s but ≤ 100 s, Wmin = 200 ns
  When period > 100 s but ≤ 1000 s, Wmin = 2 μs
  When period > 1000 s, Wmin = 20 μs
- When an external source (PWM:SOUR EXT) is selected, modulation is controlled according to the specified duty cycle deviation and whether the external signal source is within the range of ±5 V. In other words, when the external signal is +5 V, the duty cycle of the output pulse is at its maximum, and when the external signal is -5 V, the duty cycle of the output pulse is at its minimum.

NOTE The operation of this command is affected by the FUNC:PULS:HOLD command. The FUNC:PULS:HOLD command determines whether the pulse width or duty cycle is held when the period is changed. When the pulse width is held, the pulse width deviation is also held. When the duty cycle is held, the duty cycle deviation is also held. When one of these values is held and a command is executed specifying the other value, the other value is automatically converted to an equivalent value.

Response In response to PWM:DEV:DCYC?, the FGA5050 returns the duty cycle deviation percentage.

PWM:SOUR

Sets the modulation signal source. The default setting is “INT” (internal).

Command
```
PWM:SOURce {INTernal|EXTernal}
PWM:SOURce?
```

- If you select an external source, the pulse wave is modulated by an external signal. The width or duty cycle deviation is controlled by the ±5 V external signal applied to the Modulation In connector on the rear panel. When the modulation signal is +5 V, the duty cycle of the output is at its maximum, and when the modulation signal is -5 V, the duty cycle of the output is at its minimum.

Response In response to PWM:SOUR?, the FGA5050 returns “INT” (internal) or “EXT” (external).

PWM:STAT

Turns PWM on or off. The default setting is for PWM to be off. To prevent multiple waveforms from being changed, turn PWM on after setting the modulation parameters. On the FGA5050, you can only turn one modulation mode on at a time.

Command
```
PWM:STATe {OFF|ON}
PWM:STATe?
```

Response In response to PWM:STAT?, the FGA5050 returns “ “0” (OFF) or “1” (ON).

Sweep Commands

FREQ:STAR

Sets the sweep start frequency. The range is from 1 μHz to 200 kHz for ramp waves, 1 μHz to 10 MHz for arbitrary waveforms, 1 μHz to 25 MHz for square waves, and 1 μHz to 50 MHz for sine waves. The default setting is 100 Hz.

Command
```
FREQuency:STARt {<frequency>|MINimum|MAXimum}
FREQuency:STARt? [MINimum|MAXimum]
```

Response In response to FREQ:STAR?, the FGA5050 returns the sweep start frequency in Hz.

FREQ:STOP

Sets the sweep stop frequency. The range is from 1 μHz to 200 kHz for ramp waves, 1 μHz to 10 MHz for arbitrary waveforms, 1 μHz to 25 MHz for square waves, and 1 μHz to 50 MHz for sine waves. The default setting is 1 KHz.

Command
```
FREQuency:STOP {<frequency>|MINimum|MAXimum}
FREQuency:STOP? [MINimum|MAXimum]
```

Response In response to FREQ:STOP?, the FGA5050 returns the sweep stop frequency in Hz.

FREQ:CENT

Sets the center frequency for sweeping. The range is from 1 μHz to 200 kHz for ramp waves, 1 μHz to 10 MHz for arbitrary waveforms, 1 μHz to 25 MHz for square waves, and 1 μHz to 50 MHz for sine waves. The default setting is 550 Hz.

Command
```
FREQuency:CENTer {<frequency>|MINimum|MAXimum}
FREQuency:CENTer? [MINimum|MAXimum]
```

- The minimum center frequency is 1 μHz. The maximum center frequency is computed from the frequency span of the carrier wave and the maximum frequency of the waveform being used.

  Maximum center frequency = Maximum frequency - frequency span/2

Response In response to FREQ:CENT?, the FGA5050 returns the sweep center frequency in Hz.

FREQ:SPAN

Sets the frequency span for sweeping. The range is from 0 Hz to 200 kHz for ramp waves, 0 Hz to 10 MHz for arbitrary waveforms, 0 Hz to 25 MHz for square waves, and 0 Hz to 50 MHz for sine waves. The default setting is 900 Hz.

Command
```
FREQuency:SPAN {<frequency>|MINimum|MAXimum}
FREQuency:SPAN? [MINimum|MAXimum]
```

- The minimum frequency span value is 0 Hz. The maximum value is computed from the center frequency and the maximum frequency of the waveform being used.

  Maximum frequency span = 2 × (maximum frequency - center frequency)
- To sweep so that the frequency increases, specify a positive frequency span.
- To sweep so that the frequency decreases, specify a negative frequency span.
- The relationship between the frequency span and the start and stop frequencies is indicated below.

  Frequency span = Stop frequency - start frequency

Response In response to FREQ:SPAN?, the FGA5050 returns the frequency span in Hz.

SWE:SPAC

Sets the sweep mode. The default setting is the linear mode (LIN). In the linear mode (LIN), the output frequency changes linearly. In the logarithmic mode, the output frequency changes logarithmically.

Command
```
SWEep:SPACing {LINear|LOGarithmic}
SWEep:SPACing?
```

Response In response to SWE:SPAC?, the FGA5050 returns “LIN” (linear) or “LOG” (logarithmic).

SWE:TIME

Sets the time in seconds over which the sweep from the start frequency to the stop frequency continues. The range is from 1 ms to 500 s. The default setting is 1 s.

Command
```
SWEep:TIME {<seconds>|MINimum|MAXimum}
SWEep:TIME?
```

Response In response to SWE:TIME?, the FGA5050 returns sweep time in seconds.

SWE:STAT

Turns sweep mode on or off. The default setting is for sweep mode to be off. To prevent multiple waveforms from being changed, turn sweep mode on after setting the modulation parameters. On the FGA5050, you can only turn one modulation mode on at a time.

Command `SWEep:STATe {OFF|ON}`
`SWEep:STATe?`

Response In response to SWE:STAT?, the FGA5050 returns “0” (OFF) or “1” (ON).

TRIG:SOUR

See p.43

Sets the trigger source for frequency sweeping. For details, see **TRIG:SOUR** under “Trigger Commands”.

TRIG:SLOP

See p.44

Sets whether the rising or falling edge of the external trigger signal is used. For details, see **TRIG:SLOP** under “Trigger Commands”.

OUTP:TRIG:SLOP

See p.44

Sets the trigger out signal edge. For details, see **OUTP:TRIG:SLOP** under “Trigger Commands”.

OUTP:TRIG

See p.44

Turns the trigger out signal on or off. For details, see **OUTP:TRIG** under “Trigger Commands”.

MARK:FREQ

Sets the marker frequency. When the marker frequency is reached during sweeping, the signal output level from the Sync connector on the front panel becomes low. The range is from 1 μHz to 50 MHz (limited to 200 kHz for ramp waves, 25 MHz for square waves, and 10 MHz for arbitrary waveforms). The default setting is 500 Hz. From the start and stop frequency, the minimum value is the lower of the two while the maximum value is the higher of the two.

The marker frequency must be between the start and stop frequency. When a value outside of the range is selected, a “Settings conflict” error occurs, and the FGA5050 automatically sets the marker frequency to the start or stop frequency, whichever is closer to the selected value.

Command `MARKer:FREQuency {<frequency>|MINimum|MAXimum}`
`MARKer:FREQuency? [MINimum|MAXimum]`

Response In response to MARK:FREQ?, the FGA5050 returns the marker frequency in Hz.

MARK

Turns frequency marker on or off. The default setting is for the frequency marker to be off. This command takes priority over the OUTP:SYNC command, so when the frequency marker is on, the OUTP:SYNC command is ignored.

Command `MARKer {OFF|ON}`
`MARKer?`

Response In response to MARK?, the FGA5050 returns “0” (OFF) or “1” (ON).

Burst Commands

BURS:MODE

Sets the burst mode. The default setting is triggered burst mode. In triggered burst mode, the FGA5050 generates a waveform with the specified number of cycles (the burst count) each time it receives a trigger signal. In external gated burst mode, the output waveform is turned on and off according to the voltage level of the external signal applied to the Trig In/Out connector on the rear panel.

Command `BURSt:MODE {TRIGgered|GATed}`
`BURSt:MODE?`

- You can specify the polarity of the Trig In/Out connector on the rear panel using the BURS:GATE:POL command.
- While the gate signal logic is true, the FGA5050 generates a continuous waveform. While the gate signal logic is false, the output stops at the same voltage level as that of the starting burst phase of the selected waveform. When the gate signal is a noise signal, the output stops immediately.
- The burst count, burst period, and trigger source are only applied to triggered burst mode.

Response In response to BURS:MODE?, the FGA5050 returns “TRIG” or “GAT.”

BURS:NCYC

Sets the number of cycles that are generated in each burst (only valid in triggered burst mode). The range is from 1 to 50000 cycles (can be set in single-cycle increments). The default setting is 1 cycle.

Command `BURSt:NCYCles {<# cycles>|INFinity|MINimum|MAXimum}`
`BURSt:NCYCles?`

- The maximum value is determined by the burst period and frequency as indicated below. You can set the trigger source to Immediate (internal) and the number of cycles to Infinite to generate a continuous burst waveform. The burst count must not exceed the product of the maximum burst period and the waveform frequency.

  Burst count < Maximum period × frequency
- The FGA5050 automatically increases the burst period to the maximum value in accordance with the specified burst count, but the waveform frequency is not changed.
- The burst count is not valid in external gated triggered burst mode. If you specify a new burst count in external gated trigger burst mode, the FGA5050 remembers the burst count and uses it when triggered burst mode is selected.

Response In response to BURS:NCYC?, the FGA5050 returns a burst count value between 1 and 50000. When the burst count has been set to Infinite, the FGA5050 returns 9.9E+37.

BURS:INT

Sets the burst period that is applied when the trigger source has been set to Immediate (internal). The burst period is ignored when an external or manual trigger source is selected (or when external gated triggered burst mode is selected). The range is from 1 μs to 500 s. The default setting is 10 ms.

Command
```
BURSt:INTernal:PERiod {<seconds>|MINimum|MAXimum}
BURSt:INTernal:PERiod? [MINimum|MAXimum]
```

- The maximum value is 500 s. The minimum value is either 1 μs or a value that depends on the burst count and frequency as indicated below.

$$\text{Burst period} > \frac{\text{Burst count}}{\text{Waveform frequency}} + 200\ \text{ns}$$

Response In response to BURS:INT?, the FGA5050 returns the burst period in seconds.

BURS:PHAS

Sets the starting phase in the units specified by the UNIT:ANGL command (degrees or radians). The range is from -360° to +360° (-2π to +2π radians). The default setting is 0° (0 radians).

Command
```
BURSt:PHASe {<angle>|MINimum|MAXimum}
BURSt:PHASe? [MINimum|MAXimum]
```

- For sine, square, and ramp waves, 0° indicates the point at which a rising edge of the waveform crosses the 0 V or DC offset line. For arbitrary waveforms, 0° indicates the first waveform point downloaded to the memory. The burst phase does not affect pulse or noise waves.
- In external gated triggered burst mode, when the gate signal logic is true, a continuous waveform is generated. While the gate signal logic is false, the output stops at the same voltage level as that of the starting burst phase of the selected waveform.

Response In response to BURS:PHAS?, the FGA5050 returns the starting phase in degrees or radians.

BURS:STAT

Turns burst mode on or off. To prevent multiple waveforms from being changed, turn burst mode on after setting the modulation parameters. On the FGA5050, you can only turn one modulation mode on at a time.

Command
```
BURSt:STATe {OFF|ON}
BURSt:STATe?
```

Response In response to BURS:STAT?, the FGA5050 returns “0” (OFF) or “1” (ON).

UNIT:ANGL

Sets the unit (degrees or radians) that is used in the BURS:PHAS command to set the burst starting point phase. The default setting is DEG (degrees). You cannot set the unit to radians from the front panel. If you switch to front panel operation after using radians in the remote interface, the FGA5050 automatically converts the unit to degrees.

Command
```
UNIT:ANGLe {DEGree|RADian}
UNIT:ANGLe?
```

Response In response to UNIT:ANGL?, the FGA5050 returns “DEG” (degrees) or “RAD” (radians).

TRIG:SOUR

See p.43

Sets the burst trigger source. For details, see **TRIG:SOUR** under “Trigger Commands”.

TRIG:SLOP

See p.44

Sets whether the rising or falling edge of the external trigger signal is used. For details, see **TRIG:SLOP** under “Trigger Commands”.

BURS:GATE:POL

Sets the logic of the external gate signal that is applied to the Trig In/Out connector on the rear panel. When you specify NORM, the high level is true, and when you specify INV, the low level is true. The default setting is NORM.

Command
```
BURSt:GATE:POLarity {NORMal|INVerted}
BURSt:GATE:POLarity?
```

Response In response to BURS:GATE:POL?, the FGA5050 returns “NORM” or “INV.”

OUTP:TRIG:SLOP

See p.44

Sets the trigger out signal edge. For details, see **OUTP:TRIG:SLOP** under “Trigger Commands”.

OUTP:TRIG

See p.44

Turns the trigger out signal on or off. For details, see **OUTP:TRIG** under “Trigger Commands”.

Arbitrary Waveform Commands

DATA VOLATILE

Downloads floating point values from -1 to +1 to volatile memory. You can download from 1 to 262144 (256 K) points per waveform. The FGA5050 acquires the specified number of points and lays them out in a manner that satisfies the waveform memory. If the specified number of points is less than 16384, the FGA5050 automatically generates a waveform that contains 16384 points. If the specified number of points is greater than 16384, the FGA5050 generates a waveform with 65536 points. If the specified number of points is greater than 65536, the FGA5050 generates a waveform with 262144 points.

Command `DATA VOLATILE, <value>, <value>, …`

- When the offset is 0 V, -1 and +1 correspond to the peak values of the waveform.
- The DATA command overwrites the waveform that is currently in the volatile memory. If you need to store this waveform, use the DATA:COPY command to copy the waveform to non-volatile memory.
- While downloading floating point values (using DATA VOLATILE) is slower than downloading binary values (DATA:DAC VOLATILE), floating point values are useful for waveforms that, like trigonometric functions, have values from -1 to +1.
- After you download the data of a waveform to the memory, you can use the FUNC:USER command to select the waveform and the FUNC USER command to generate it.
- The example below shows how to use the DATA command to download seven points to the volatile memory.

  DATA VOLATILE, 1, .67, .33, 0, -.33, -.67, -1

DATA:DAC VOLATILE

Downloads binary or decimal integers from -8191 to +8191 to volatile memory. You can download from 1 to 262144 (256 K) points per waveform in IEEE-488.2 binary blockformat. The range of values corresponds to the range of usable 14-bit DAC (digital-to-analog converter) codes. The FGA5050 acquires the specified number of points and lays them out in a manner that satisfies the waveform memory. If the specified number of points is less than 16384, the FGA5050 automatically generates a waveform that contains 16384 points. If the specified number of points is greater than 16384, the FGA5050 generates a waveform with 65536 points. If the specified number of points is greater than 65536, the FGA5050 generates a waveform with 262144 points.

Command `DATA:DAC VOLATILE, {<binary block>|<value>, <value>, …}`

- -8191 and +8191 correspond to the peak values of the waveform (when the offset is 0 V). For example, when the output amplitude is 10 Vpp, +8191 corresponds to +5 V and -8191 corresponds to -5 V.
- The DATA command overwrites the previous waveform in the volatile memory. Use the DATA:COPY command to copy the waveform to non-volatile memory.
- The example below shows how to use the DATA:DAC command to download five integer points to the volatile memory that are specified using decimal values .

  DATA:DAC VOLATILE, 8191, 4096, 0, -4096, -8191
- The example below shows how to use the DATA:DAC command to download seven integer points to the volatile memory that are specified using binary values .

  DATA:DAC VOLATILE, #214 <Binary Data>

DATA:DAC VOLATILE (continued)

NOTE

IEEE-488.2 binary block format

- In binary block format, the block header comes before the data points. The block header must conform to the following format.

  # 5 32768

  The data block starts with the pound sign (#). The second number indicates the number of digits, and the third number indicates the number of bytes (32768 bytes = 16384 points). The waveform data points are represented as 16-bit integers sent in 2 bytes. Therefore, the total number of bytes is always twice the number of data points in the waveform (and must always be an even number). For example, 32768 bytes are necessary to load a waveform with 16384 points.
- Use the FORM:BORD command to select the byte order for binary block transfers. If you specify FORM:BORD NORM (the default setting), the MSB (most-significant byte) of each data point is sent first. If you specify FORM:BORD SWAP, the LSB (least-significant byte) of each data point issent first. Most computers use the byte order specified by SWAP.

FORM:BORD

Sets the byte order for binary block transfers made using the DATA:DAC command. The default setting is NORM.

Command `FORMat:BORDer {NORMal|SWAPped}`
`FORMat:BORDer?`

Response In response to FORM:BORD?, the FGA5050 returns “NORM” or “SWAP.”

DATA:COPY

Copies the waveform to non-volatile memory.

Command `DATA:COPY <destination arb name>[, VOLATILE]`

FUNC:USER

Use to select one of the five built-in arbitrary waveforms, one of four user-defined waveforms, or the waveform currently downloaded to volatile memory.

Command `FUNCtion:USER {<arb name>|VOLATILE}`
`FUNCtion:USER?`

- The names of the five built-in arbitrary waveforms are “EXP_RISE,” “EXP_FALL,” “NEG_RAMP,” “SINC,” and “CARDIAC.” The default setting is “EXP_RISE.” To select the waveform stored in volatile memory, specify VOLATILE. This command does not generate the selected waveform. To generate a waveform, use the FUNCtion USER command. If you specify the name of a waveform that is not currently downloaded, a “Specifiedarb waveform does not exist” error is generated.

Response In response to FUNC:USER?, the FGA5050 returns “EXP_RISE,” “EXP_FALL,” “NEG_RAMP,” “SINC,” “CARDIAC,” “VOLATILE,” or the name of the user-defined waveform currently stored in volatile memory.

FUNC USER

See p.17, p.40

If you specify “USER” for the **FUNC** command under “Output Configuration Commands, the FGA5050 generates the waveform that has been selected through the use of the **FUNC:USER** command.

The selected waveform is generated with the currently specified frequency, amplitude, and offset. You can use the APPLy command or the FREQ, VOLT, and VOLT:OFFS commands to set the frequency, amplitude, and offset.

Command `FUNCtion USER`
`FUNCtion?`

- The maximum amplitude will be limited if the data points do not span the fullrange. For example, the built-in sine wave does not use the full range of binary values within ±1, and therefore its maximum amplitude is 6.087 Vpp (into 50 ohms).
- If you select an arbitrary waveform as the modulation signal, the waveform is automatically limited to 4 K points. Waveform points exceeding this limit are discarded through decimation.

Response In response to FUNC?, the FGA5050 returns “SIN,” “SQU,” “RAMP,” “PULS,” “NOIS,” “DC,” or “USER.”

DATA:CAT

Lists the names of all waveforms that can be used.

Command `DATA:CATalog?`

Response In response to DATA:CAT?, the FGA5050 returns the names of the five built-in arbitrary waveforms (stored in non-volatile memory), all the user-defined waveforms (stored in volatile memory), and “VOLATILE” when a built-in waveform is currently downloaded to volatile memory.
To delete a waveform from volatile memory or delete a user-defined waveform from non-volatile memory, use the DATA:DEL command.

DATA:NVOL:CAT

List the names of all user-defined arbitrary waveforms downloaded to non-volatile memory.

Command `DATA:NVOLatile:CATalog?`

Response In response to DATA:NVOL:CAT?, the FGA5050 returns up to four waveform names. If there is no downloaded waveform, the FGA5050 returns a null character string (” “).

DATA:NVOL:FREE

Queries the number of available slots for storing user-defined waveforms.

Command `DATA:NVOLatile:FREE?`

DATA:ATTR:AVER

Queries the average of all data points in the specified waveform (-1 ≤ average ≤ +1). The default value for arb name is the name of the currently active arbitrary waveform (FUNC:USER command). If you query a waveform that is not stored in memory, the error "Specified arb waveform does not exist" is generated.

Command `DATA:ATTRibute:AVERage? [<arb name>]`

DATA:ATTR:CFAC

Queries the crest factor of all data points in the specified waveform. The crest factor is the ratio of the waveform's peak value to its RMS value. The default value for arb name is the name of the currently active arbitrary waveform (FUNC:USER command). If you query a waveform that is not stored in memory, the error "Specified arb waveform does not exist" is generated.

Command `DATA:ATTRibute:CFACtor? [<arb name>]`

DATA:ATTR:POIN

Queries the number of data points in the specified waveform. The default value for arb name is the name of the currently active arbitrary waveform (FUNC:USER command). If you query a waveform that is not stored in memory, the error "Specified arb waveform does not exist" is generated.

Command `DATA:ATTRibute:POINts? [<arb name>]`

Response In response to DATA:ATTR:POIN?, the FGA5050 returns a value from 1 to 262144.

DATA:ATTR:PTP

Queries the peak-to-peak value of all data points in the specified waveform. The default value for arb name is the name of the currently active arbitrary waveform (FUNC:USER command). A value of "+1.0" indicates the maximum amplitude. If you query a waveform that is not stored in memory, the error "Specified arb waveform does not exist" is generated.

Command `DATA:ATTRibute:PTPeak? [<arb name>]`

Response In response to DATA:ATTR:PTP?, the FGA5050 returns a value from "0" to "+1.0."

Trigger Commands

The following commands apply to frequency sweeping and burst mode.

TRIG:SOUR

Sets the trigger source for frequency sweeping or burst mode. The FGA5050 can accept a software (BUS) trigger, an immediate (internal) trigger, or a hardware trigger applied to the Trig In/Out connector on the rear panel. The default setting is IMM (internal).

Command `TRIGger:SOURce {IMMediate|EXTernal|BUS}`
`TRIGger:SOURce?`

- When you set the source to Immediate (internal), the FGA5050 continuously generates a burst or sweep when a trigger signal is generated on the basis of the internal signal.
- When you set the source to External, the Trig In/Out connector on the rear panel is used to receive the external trigger signal. The FGA5050 generates a single burst or sweep each time a TTL pulse is applied to the Trig In/Out connector. You can set the FGA5050 to trigger on the rising or falling slope of the external trigger signal.
- When you set the source to Bus (software), the FGA5050 generates a single burst or sweep each time it receives a BUS trigger command. To trigger the FGA5050 from the remote interface, use the *TRG command. While the FGA5050 is waiting for a trigger, the Trigger key lights.

- The APPLy command automatically sets the trigger source to Immediate.
- When you select External or Bus, the burst count and burst phase are valid, but the burst period is ignored.
- To ensure synchronization when Bus is selected, send the *WAI (wait) command. When the *WAI command is executed, the FGA5050 waits for all pending operations to complete before executing the next command. For example, the following command string guarantees that before the second trigger is accepted, the first trigger is accepted and the operation is executed.

  TRIG:SOUR BUS;*TRG;*WAI;*TRG;*WAI
- You can use the *OPC? (operation complete query) command or the *OPC (operation complete) command to send a signal when the burst is complete. The *OPC? command returns “1” to the output buffer when the burst is complete. The *OPC command sets the “Operation Complete” bit (bit 0) in the standard event register to indicate that the burst is complete.

Response In response to TRIG:SOUR?, the FGA5050 returns “IMM” (internal), “BUS” (software), or “EXT” (external).

TRIG

Issues a trigger from the remote interface. Along with the valid trigger source (TRIG:SOUR command), this command can trigger a sweep or burst.

Command `TRIGger`

*TRG

The trigger command.

This is a substitute command for the IEEE 488.1 get message (Group Execute Trigger).

Command `*TRG`

TRIG:SLOP

Sets whether the rising or falling edge of the external trigger signal is used. The default setting is POS (rising edge).

Command `TRIGger:SLOPe {POSitive|NEGative}`
`TRIGger:SLOPe?`

Response In response to TRIG:SLOP?, the FGA5050 returns “POS” (rising) or “NEG” (falling).

BURS:GATE:POL

See p.38

Sets the external gate signal logic. For details, see **BURS:GATE:POL** under “Burst Commands”.

OUTP:TRIG:SLOP

Sets the trigger out signal edge. Use Positive for a pulse with a rising edge and Negative for a pulse with a falling edge. When the trigger out signal is enabled by this command, a TTL-compatible square waveform with the specified edge is output from the Trig In/Out connector on the rear panel at the beginning of a sweep or burst.

Command `OUTPut:TRIGger:SLOPe {POSitive|NEGative}`
`OUTPut:TRIGger:SLOPe?`

- When you set the trigger source to Immediate (internal) using the TRIG:SOUR IMM command, the FGA5050 outputs a square waveform with a 50% duty cycle (the rising edge is the sweep trigger) from the Trig In/Out connector on its rear panel. The period is equal to the sweep time.
- When you set the trigger source to External using the TRIG:SOUR EXT command, the FGA5050 disables the trigger out signal and uses the Trig In/Out connector for the external trigger signal.
- When you set the trigger source to Bus (software) using the TRIG:SOUR BUS command, the FGA5050 generates a pulse (pulse width > 1 μs) from the Trig In/Out connector at the beginning of a sweep.

Response In response to OUTP:TRIG:SLOP?, the FGA5050 returns “POS” (rising) or “NEG” (falling).

OUTP:TRIG

Turns the trigger out signal on or off. The default setting is for the trigger out signal to be off. When the trigger out signal is turned on, a TTL-compatible square waveform with the specified edge is output from the Trig In/Out connector on the rear panel at the beginning of a sweep or burst.

Command `OUTPut:TRIGger {OFF|ON}`
`OUTPut:TRIGger?`

Response In response to OUTP:TRIG?, the FGA5050 returns “0” (OFF) or “1” (ON).

State Storage Commands

*SAV

Stores the current instrument state to the specified non-volatile memory location.

Command `*SAV {0|1|2|3|4}`

- If there is already an instrument state stored in the specified location, it will be overwritten.
- You can only store an instrument state to memory location 0 from the remote interface. You cannot access memory location 0 from the front panel.
- If you turn the power off and then on again, memory location 0 is automatically overwritten.
- If you store the instrument state when an arbitrary waveform has been configured and then delete the waveform data later, the FGA5050 will not be able to generate the waveform.
- When you store an instrument state, the selected function, frequency, amplitude, DC offset, duty cycle, symmetry, and modulation parameters are also saved.

*RCL

Recalls the instrument state stored in the specified non-volatile memory location.

Command `*RCL {0|1|2|3|4}`

- Memory location 0 stores the FGA5050's power-on state. Memory locations 1 to 4 are empty when the instrument is shipped from the factory.
- You cannot load a state from an empty memory location.
- If you turn the power off and then on again, memory location 0 is automatically overwritten.

MEM:STAT:NAME

Assigns a custom name to the specified memory location. You can assign a name to a location from either the front panel or the remote interface, but you can only recall a state by its assigned name from the front panel.

The custom name can contain up to 12 characters. The first character must be a letter of the alphabet (A to Z), but the remaining characters can be letters, numbers, or underscores. Names cannot include spaces. You can assign the same name to different locations.

Command `MEMory:STATe:NAME {1|2|3|4} [,<name>]`
`MEMory:STATe:NAME? {1|2|3|4}`

Response In response to MEM:STAT:NAME?, the FGA5050 returns the name of the specified memory location. If the specified location does not have a custom name, the default name is returned.

MEM:STAT:DEL

Erases the instrument state from the specified memory location and returns the location name to the default setting (even if the location has a custom name). An error is generated when you try to load the instrument state from an empty memory location.

Command `MEMory:STATe:DELete {1|2|3|4}`

MEM:STAT:REC:SEL

Sets the power-on state (the stored state that is loaded when the power is turned on). The default value is 0 (default state).

Command `MEMory:STATe:RECall:SELect {0|1|2|3|4}`
`MEMory:STATe:RECall:SELect?`

Response In response to MEM:STAT:REC:SEL?, the FGA5050 returns the power-on state (from 0 to 4).0: default state, 1: state 1, 2: state 2, 3: state 3, 4: state 4

MEM:STAT:VAL

Queries the specified memory location to determine if it currently stores a valid state.

Command `MEMory:STATe:VALid? {1|2|3|4}`

Response In response to MEM:STAT:VAL? {1|2|3|4}, the FGA5050 returns “0” if no valid state is stored in the location and “1” if a valid state is stored in the location.

MEM:NST

Queries the number of memory locations available for storing the states. The FGA5050 returns “4.”

Command `MEMory:NSTates?`

System Commands

SYSTem:ERR

Queries and clears one error from the FGA5050’s error queue. Up to 20 errors can be stored in the queue. Errors are retrieved in first in, first out (FIFO) order. Every time the FGA5050 detects an error, it beeps (unless the beeper is turned off), and the error indicator lights. Errors are deleted after they are retrieved and read.

When more than 20 errors have been detected, the last error in the error queue changes to “-350, Queue Overflow.” If the errors are not retrieved from the queue, the FGA5050 will be unable to store additional errors. If there are no errors in the error queue when you try to retrieve one, the message “No error” appears.

Command `SYSTem:ERRor?`

*IDN

Queries the FGA5050’s company name, model, serial number, and revision number, in that order. The revision number contains the four numbers shown below separated by hyphens.

Firmware revision number-Boot kernel revision number-ASIC revision number-Printed circuit board revision number

Command `*IDN?`

DISP

Turns the display off or on. Turning off the display increases the speed at which commands from the remote interface are executed. Remote interface error messages are displayed even when the display is off.

Command `DISPlay {OFF|ON}`
`DISPlay?`

- The display is automatically turned on when the *RST command is executed or when you return to local panel operation.
- When you use the *SAV command to store the instrument state, the display state is also stored. When you use the *RCL command to recall the instrument state, the front-panel display will return to the stored state.

Response In response to DISP?, the FGA5050 returns “0” (OFF) or “1” (ON).

DISP:TEXT

Displays a message on the panel display. This command takes priority over the display state (DISP OFF command). Up to 12 characters can be displayed in a large font and more characters can be displayed in a small font. Characters that cannot be displayed are truncated.

When a message is shown on the front-panel display, information about the output waveform such as the frequency is not shown on the display.

Command `DISPlay:TEXT <quoted string>`
`DISPlay:TEXT?`

Response In response to DISPl:TEXT?, the FGA5050 returns the panel display.

DISP:TEXT:CLE

Clears the message shown on the front panel display. When this happens the display state setting remains unchanged.

Command `DISPlay:TEXT:CLEar`

*RST

Restores the factory default settings of the FGA5050. This command is independent from the MEM:STAT:REC:AUTO command and does not affect the stored instrument states, arbitrary waveforms, or I/O settings. Also, if the panel display is off, this command turns it on. This command will stop a sweep or burst before it completes.

Command `*RST`

*TST

Executes a complete self-test of the FGA5050.

Command `*TST?`

Response In response to *TST?, the FGA5050 returns “0” to indicate passing and “1” to indicate failure.

SYST:VERS

Queries the FGA5050's current SCPI version. The version is returned in the following format: YYYY.V. "YYYY" represents the version year and "V" represents the version number.

Command `SYSTem:VERSion?`

SYST:BEEP

Makes the FGA5050 beep once.

Command `SYSTem:BEEPer`

SYST:BEEP:STAT

Turns the beeper on or off. The default setting is "ON."

Command
```
SYSTem:BEEPer:STATe {OFF|ON}
SYSTem:BEEPer:STATe?
```

Response In response to SYST:BEEP:STAT?, the FGA5050 returns "0" (OFF) or "1" (ON).

SYST:KLOC

Turns the lock on the front panel keys on or off. The default setting is for the lock to be off. When the lock is on, the front-panel keys are locked. Before you lock the keys, you can use the SYST:KLOC:EXCL LOC command to exclude the Local key from the key lock.

Command `SYSTem:KLOCk[:STATe] {OFF|ON}`

SYST:KLOC:EXCL

Sets whether the Local key is excluded from the front panel key lock. The default setting is "NONE."

Command
```
SYSTem:KLOCk:EXCLude {NONE|LOCal}
SYSTem:KLOCk:EXCLude?
```

Response In response to SYST:KLOC:EXCL?, the FGA5050 returns "NONE" or "LOC."

SYST:SEC:IMM

Clears all instrument memory except for the boot parameters and calibration constants. Resets all FGA5050 settings to their *RST values. This command clears all user-defined state information, user-defined arbitrary waveforms, and user-defined I/O settings. Use this command to clear all memory for security purposes. To prevent unintended loss of data, avoid using this command in routine applications.

Command `SYSTem:SECurity:IMMediate`

*LRN

Returns a character string of SCPI commands (a learn string) containing the current settings. You can send the character string back to the FGA5050 to restore the settings at a later time. The character string contains approximately 1500 characters. To prevent a device error from occurring, first execute the *RST command before sending the character string to the FGA5050.

Command `*LRN?`

*OPC

Sets the OPC bit (bit 0) in the event status register when all the commands have been completed.

Use this command in triggered sweep or triggered burst mode to provide a way to poll or interrupt the computer when the *TRG command finishes.

Command `*OPC`
`*OPC?`

Response In response to *OPC?, the FGA5050 returns “1” to the output queue after all the commands have been completed.

*WAI

Use this command to wait for all pending operations to complete before executing any additional commands from the remote interface.

Command `*WAI`

Interface Commands

SYST:COMM:RLST

Sets the remote/local state of the FGA5050 over the LAN interface from a Telnet or socket session. This command provides control analogous to the IEEE-488.2 commands such as GTL (go to local) over the GPIB and USB interfaces. The default setting is Local.

Command `SYSTem:COMMunicate:RLSTate {LOCal|REMote|RWLock}`

- Local: Sets the instrument state to local, hides indicators, and locks the front-panel keys.
- REMote: Sets the instrument state to remote, displays indicators, and locks the keys.
- RWLock: Sets the instrument state to remote, displays the rwl indicator, and locks the keys.

Phase Lock Commands

PHAS

Sets the phase offset of the output waveform in the unit—degrees or radians—that has been specified beforehand by the UNIT:ANGL command (the phase offset is invalid for pulse and noise waveforms). The range is from -360 ° to 360 ° for degrees and from -2π to +2π for radians. The default setting is 0 °.

Command
```
PHASe {<angle>|MINimum|MAXimum}
PHASe? [MINimum|MAXimum]
```

- Because the phase relationship with the currently locked external signal changes, a bump or hop will occur in the output waveform as a result of the specified phase offset.
- The phase adjustment of the phase lock application has no effect on the burst phase set by the BURS:PHAS command.

Response In response to PHAS?, the FGA5050 returns the offset in degrees or radians.

PHAS:REF

Sets the zero-phase reference point quickly without changing the output. This command only changes the phase reference point; it does not change the phase offset set by the PHAS command.

Command `PHASe:REFerence`

PHAS:UNL:ERR:STAT

Enables or disables error generation when the phase lock is lost. The default setting is for error generation to be disabled. When the phase lock is lost and error generation is enabled, a “Reference phase-lock loop is unlocked” error is generated. When you turn off the FGA5050, the error setting is cleared.

Command `PHASe:UNLock:ERRor:STATe {OFF|ON}`
`PHASe:UNLock:ERRor:STATe?`

Response In response to PHAS:UNL:ERR:STAT?, the FGA5050 returns “0” (OFF) or “1” (ON).

UNIT:ANGL

See p.38

Sets the unit (degrees or radians) that is used in the PHAS command to set the phase offset of the output waveform. For details, see **UNIT:ANGL** under “Burst Commands”.

Status Reporting Commands

*STB

Queries the status byte register value.

Command `*STB?`

*SRE

Sets the service request enable register.

Command `*SRE <value>`
`*SRE?`

Parameter <value> is a decimal number (from 0 to 255) that indicates the sum of the enabled bits.

STAT:QUES:COND

Queries the QUEStionable status condition register.

Command `STATus:QUEStionable:CONDition?`

STAT:QUES

Queries the QUEStionable status event register.

Command `STATus:QUEStionable[:EVENt]?`

STAT:QUES:ENAB

Sets the QUEStionable status enable register.

Command `STATus:QUEStionable:ENABle <enable value>`
`STATus:QUEStionable:ENABle?`

*ESR

Queries the event status register value.

Command `*ESR?`

*ESE

Sets the event status enable register value.

Command `*ESE <value>`
`*ESE?`

Parameter <value> is a decimal number (from 0 to 255) that indicates the sum of the enabled bits.

*CLS

Clear the status data structure.

Command `*CLS`

STAT:PRES

Clears all bits in the questionable data enable register and the standard operation enable register.

Command `STATus:PRESet`

*PSC

Sets whether the event status enable register and service request enable register are cleared when the power is turned on (the power-on status).

Command `*PSC {0|1}`
`*PSC?`

Parameter	Value:	0	When the power is turned on, the *ESE and *SRE settings are not cleared.
		1	When the power is turned on, the *ESE and *SRE settings are cleared.

*OPC

See p.49

Sets the OPC bit (bit 0) in the event status register when all the commands have been completed. For details, see ***OPC** under “System Commands”.

Common Commands

There are commands that are common to the IEEE-488.2 and SCPI standards for functions such as resetting devices and performing self-diagnoses. These common commands start with an asterisk (“*”). These commands may have one or multiple parameters.

*CLS

See p.52

See ***CLS** under “Status Reporting Commands”.

*ESE

See p.52

See ***ESE** under “Status Reporting Commands”.

*ESR

See p.52

See ***ESR** under “Status Reporting Commands”.

*IDN

See p.46

See ***IDN** under “System Commands”.

*LRN

See p.49

See ***LRN** under “System Commands”.

*OPC

See p.49

See ***OPC** under “System Commands”.

*PSC

See p.52

See ***PSC** under “Status Reporting Commands”.

*RCL

See p.45

See ***RCL** under “State Storage Commands”.

*RST

See p.47

See ***RST** under “System Commands”.

*SAV

See p.45

See ***SAV** under “State Storage Commands”.

*SRE

See p.51

See ***SRE** under “Status Reporting Commands”.

*STB

See p.51

See ***STB** under “Status Reporting Commands”.

*TRG

See p.43

See ***TRG** under “Trigger Commands”.

*TST

See p.47

See ***TST** under “System Commands”.

*WAI

See p.49

See ***WAI** under “System Commands”.

Appendix

A. Error Messages

B. Sample programs

A Error Messages

Error messages are displayed when an incorrect remote command is sent to the FGA5050. A command may not be correct because of incorrect command syntax, command parameters that violate system constraints, a hardware failure, etc.

Error messages are stored in the FGA5050's error queue and can be retrieved in first in, first out (FIFO) order. The first stored error is displayed first. The FGA5050 beeps once each time an error occurs, and the ERROR indicator lights whenever there are error messages in the error queue. After all the errors have been read from the queue, the ERROR indicator turns off.

The FGA5050 can store up to 20 errors. When there are more than 20 errors, the last error stored in the error queue (the most recent error) changes to "Queue Overflow." When this happens, as long as no errors are deleted from the queue, no additional errors can be stored. If there are no errors in the error queue, the FGA5050 returns "No error."

When the power is turned off and then on again or when the *CLS (clear status) command is executed, the errors stored in the error queue are all deleted. The *RST (reset) command does not clear the errors in the error queue.

Displaying error messages

1. **Press Help to display the help topic options.**
2. **Use the up and down softkeys to scroll through the topic options until "View remote command error queue" is highlighted.**
3. **Press the Select softkey to display the error messages.**
4. **Press the DONE softkey to leave the help topics.**

Remote interface operation

Use the following command to read one error from the error queue.

SYSTem:ERRor?

Use the following command to clear all the errors from the error queue.

*CLS

Command errors

Error code	Description
-101 Invalid character	An invalid character was detected in the command string.
-102 Syntax error	Invalid syntax was detected in the command string.
-103 Invalid separator	An invalid separator was detected in the command string.
-105 GET not allowed	GET is not allowed in a command string.
-108 Parameter not allowed	More parameters than expected were received.
-109 Missing parameter	Fewer parameters than expected were received.
-112 Program mnemonic too long	More characters than allowed in the command header were received.
-113 Undefined header	An invalid command was received.
-123 Exponent too large	A numeric parameter with exponent larger than 32,759 was detected.
-124 Too many digits	A numeric parameter with too many digits (> 255) was detected.
-128 Numeric data not allowed	A numeric parameter was received when the waveform generator was expecting a string parameter.
-131 Invalid suffix	A suffix was incorrectly specified for a numeric parameter.
-138 Suffix not allowed	A suffix is not supported for this command.
-148 Character data not allowed	A discrete parameter was received when it was not expected.
-151 Invalid string data	An invalid character string was received.
-158 String data not allowed	A character string was received when it was not allowed for this command.
-161 Invalid block data	For a definite-length block, the number of bytes of data sent does not match the number of bytes that you specified in the block header.
-168 Block data not allowed	This command does not accept the data format.
-170 to -178 Expression errors	Mathematical expressions are not acceptable for the instrument.

Execution errors

Error code	Description
-211 Trigger ignored	AGET or *TRG was received but the trigger was ignored.
-221 Settings conflict; turned off infinite burst to allow immediate trigger source	An infinite burst count is only allowed when an external or bus (software) trigger source is used.
-221 Settings conflict; infinite burst changed trigger source to BUS	An infinite burst count is only allowed when an external or bus (software) trigger source is used.
-221 Settings conflict; burst period increased to fit entire burst	The specified number of cycles in the BURS:NYNC command takes priority over the burst period and the waveform generator increased the burst period to accommodate the burst count or the waveform frequency.
-221 Settings conflict; burst count reduced to fit entire burst	Since the burst period is currently at its maximum, the waveform generator has adjusted the burst count to accommodate the waveform frequency.
-221 Settings conflict; triggered burst not available for noise	Noise function is not allowed in the triggered burst mode.
-221 Settings conflict; amplitude units changed to Vpp due to high-Z load	dBm is not available as unit when the output termination is set to “high impedance”.
-221 Settings conflict; trigger output disabled by trigger external	When using the external trigger source, the Trig Out signal is automatically disabled.
-221 Settings conflict; trigger output connector used by burst gate	If you have enabled burst , and selected gated burst mode, the Trig Out signal is automatically disabled.
-221 Settings conflict; trigger output connector used by FSK	If you have enabled FSK and is using the external trigger source, the Trig Out signal is automatically disabled.

Execution errors (continued)

Error code	Description
-221 Settings conflict; trigger output connector used by trigger external	When using the external trigger source, the Trig Out signal is automatically disabled.
-221 Settings conflict; frequency reduced for user function	The maximum output frequency for arbitrary waveform is 10 MHz. When you change function from one allowing higher frequency to arbitrary waveform, the frequency is adjusted to 10 MHz.
-221 Settings conflict; frequency changed for pulse function	The maximum output frequency for pulse waveform is 10 MHz. When you change function from one allowing higher frequency to pulse waveform, the frequency is adjusted to 10 MHz.
-221 Settings conflict; frequency reduced for ramp function	The maximum output frequency for ramp waveform is 200 kHz. When you change function from one allowing higher frequency to ramp waveform, the frequency is adjusted to 200 kHz.
-221 Settings conflict; frequency made compatible with burst mode	The maximum output frequency for an internal-triggered burst is 2.001 mHz. The waveform generator has adjusted the frequency to be compatible with the current setting.
-221 Settings conflict; burst turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; FSK turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; FM turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; AM turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; PM turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; PWM turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; sweep turned off by selection of other mode or modulation	Only one modulation can be enabled at one time.
-221 Settings conflict; not able to modulate this function	This waveform generator cannot generate an AM, FM, PM, FSK modulated waveform using the pulse, noise, or dc voltage function.
-221 Settings conflict; PWM only available in pulse function	The waveform generator can only generate PWM modulated waveform using pulse function.
-221 Settings conflict; not able to sweep this function	The waveform generator cannot generate a sweep using the pulse, noise or dc voltage function.
-221 Settings conflict; not able to burst this function	The waveform generator cannot generate a burst using the dc voltage function.
-221 Settings conflict; not able to modulate noise, modulation turned off	The waveform generator cannot generate a modulated waveform using the noise function.
-221 Settings conflict; not able to sweep pulse, sweep turned off	The waveform generator cannot generate a sweep using the pulse function.
-221 Settings conflict; not able to modulate dc, modulation turned off	The waveform generator cannot generate a dc voltage function.
-221 Settings conflict; Not able to sweep dc, sweep turned off	The waveform generator cannot generate a sweep using the dc voltage function.
-221 Settings conflict; not able to burst dc, burst turned off	The waveform generator cannot generate a burst using the dc voltage function.
-221 Settings conflict; not able to sweep noise, sweep turned off	The waveform generator cannot generate a sweep using the noise function.
-221 Settings conflict; pulse width decreased due to period	With edge time at its minimum, the waveform generator has adjusted the pulse width to accommodate the specified period.
-221 Settings conflict; pulse duty cycle decreased due to period	With edge time at its minimum, the waveform generator has adjusted pulse the duty cycle to accommodate the specified period.
-221 Settings conflict; edge time decreased due to period	The edge time has been decreased to accommodate the period.
-221 Settings conflict; pulse width increased due to large period	The waveform generator has adjusted the pulse width to a greater minimum determined by the current period.

Error code	Description
-221 Settings conflict; edge time decreased due to pulse width	The waveform generator adjusts first the edge time then the pulse width or duty cycle, then period if needed to accommodate the following the limitation: EdgeTime 0.625 x PulseWidth. In this case, the edge time is decreased by the waveform generator to accommodate the specified pulse width.
-221 Settings conflict; edge time decreased due to pulse duty cycle	The waveform generator adjusts first the edge time then the pulse width or duty cycle, the period if needed to accommodate the following the limitation: EdgeTime ≤ 0.625 x Period x DutyCycle. In this case, the edge time is decreased by the waveform generator to accommodate the pulse duty cycle.
-221 Settings conflict; amplitude changed due to function	When the new function chosen has a smaller maximum amplitude, the waveform generator will automatically adjust the amplitude from the old value to the new smaller maximum value. This may occur when the output units are Vrms or dBm due to the differences in crest factor for the various output functions.
-221 Settings conflict; offset changed on exit from dc function	In the dc voltage function, the voltage level is controlled by adjusting the offset voltage (the current amplitude is ignored). When you select a different function, the waveform generator will adjust the offset voltage as needed to be compatible with the current amplitude setting.
-221 Settings conflict; FM deviation cannot exceed carrier	The frequency deviation cannot exceed the carrier frequency, or the waveform generator will adjust the deviation to a maximum allowed value.
-221 Settings conflict; FM deviation exceeds max frequency	The sum of the carrier frequency and the deviation cannot exceed the maximum frequency for the chosen function plus 100 kHz (20.1 MHz for sine and square, 300 kHz for ramp, and 5.1 MHz for arbitrary waveforms). If you set the carrier to a value that is not valid, the waveform generator will adjust the deviation to the maximum value allowed.
-221 Settings conflict; PWM deviation decreased due to pulse parameters	The PWM deviation must follow the limitation concerning the pulse width or duty cycle, edge time, and period (see Ch 4.11 for these limitations), or the waveform generator will adjust it automatically.
-221 Settings conflict; frequency forced duty cycle change	In the square wave function, if you change the frequency to a value that cannot produce the current duty cycle, the duty cycle will be automatically adjusted to the maximum value for the new frequency.
-221 Settings conflict; marker forced into sweep span	The marker frequency must be a value between the start and the stop frequency.
-221 Settings conflict; selected arb is missing, changing selection to default	If you delete an arbitrary waveform after storing its instrument state, you will lose the waveform data and not able to output the waveform. The built-in exponential-rise wave is outputted instead.
-221 Settings conflict; offset changed due to amplitude	When the existing offset voltage does not conform the following limitation: |Voffset| + Vpp / 2 Z Vmax, it is adjusted automatically to the maximum dc voltage allowed with the specified amplitude.
-221 Settings conflict; amplitude changed due to offset	When the existing amplitude does not conform to the following limitation: |Voffset| + Vpp / 2 Z Vmax, it is adjusted automatically to the maximum value allowed with the specified offset voltage.
-221 Settings conflict; low level changed due to high level	The high level must always be greater than the low level. If you specify a high level that is smaller than the low level, the waveform generator will adjust the low level to be 1 mV less than the high level.
-221 Settings conflict; high level changed due to low level	The high level must always be greater than the low level. If you specify a low level that is greater than the high level, the waveform generator will adjust the high level to be 1 mV greater than the low level.
-222 Data out of range; value clipped to upper limit	The specified parameter is out of range and is adjusted to the maximum value allowed.
-222 Data out of range; value clipped to lower limit	The specified parameter is out of range and is adjusted to the minimum value allowed.
-222 Data out of range; pulse edge time limited by period; value clipped to upper limit	The specified edge time does not conform within the existing period and is adjusted to the maximum value allowed.
-222 Data out of range; pulse width time limited by period; value clipped to…	The specified pulse width does not conform to the following condition and is adjusted to accommodate the period: PulseWidth ≤ Period – (1.6 x EdgeTime)
-222 Data out of range; pulse duty cycle limited by period; value clipped to…	The specified duty cycle does not conform to the following condition and is adjusted to accommodate the period: DutyCycle ≤ (1 – 1.6 x Edge time / Period) x 100%
-222 Data out of range; large period limits minimum pulse width	The minimum pulse width for pulse waves with period larger than 10 s is larger. Refer to the table of minimum pulse width in Section 4.5 for details.
-222 Data out of range; pulse edge time limited by width; value clipped to…	The specified pulse edge time does not conform to the following condition and is adjusted to accommodate the pulse width: EdgeTime ≤ 0.625 x PulseWidth
-222 Data out of range; pulse edge time limited by duty cycle; value clipped to…	The specified pulse edge time does not conform to the following condition and is adjusted to accommodate the duty cycle: EdgeTime ≤ 0.625 x Period x DutyCycle

Execution errors (continued)

Error code	Description
-222 Data out of range; period; value clipped to…	The pulse period is out of range and is adjusted.
-222 Data out of range; frequency; value clipped to…	The frequency is out of range and is adjusted.
-222 Data out of range; user frequency; value clipped to upper limit	The frequency is out of range and is adjusted to the maximum value allowed due to selection of arbitrary waveform.
-222 Data out of range; ramp frequency; value clipped to upper limit	The frequency is out of range and is adjusted to the maximum value allowed due to selection of ramp waveform.
-222 Data out of range; pulse frequency; value clipped to upper limit	The frequency is out of range and is adjusted to the maximum value allowed due to selection of pulse waveform.
-222 Data out of range; burst period; value clipped to…	The burst period is out of range and is adjusted.
-222 Data out of range; burst count; value clipped to…	The burst count is out of range and is adjusted.
-222 Data out of range; burst period limited by length of burst; value clipped to lower limit	The burst period is too short to accommodate the burst count and frequency and is adjusted to the minimum value allowed.
-222 Data out of range; burst count limited by length of burst; value clipped to upper limit	The burst count is out of range. When the immediate trigger source is selected, the burst count must be less than the product of the burst period and the waveform frequency.
-222 Data out of range; amplitude; value clipped to…	The amplitude is out of range and is adjusted.
-222 Data out of range; offset; value clipped to…	The offset voltage is out of range and is adjusted.
-222 Data out of range; frequency in burst mode; value clipped to…	The frequency is adjusted as indicated by the burst period.
-222 Data out of range; frequency in FM; value clipped to…	This message indicates that the carrier frequency is adjusted to the lower boundary determined by the FM:DEV command. The carrier frequency must be greater than or equal to the frequency deviation.
-222 Data out of range; marker confined to sweep span; value clipped to…	The specified marker frequency is out of range and is adjusted to the start or stop frequency, whichever is closer.
-222 Data out of range; pulse width; value clipped to…	The desired pulse width is limited to the upper or lower boundary as indicated by the instrument hardware.
-222 Data out of range; pulse edge time; value clipped to…	The desired edge time is limited to the upper or lower boundary as indicated by the instrument hardware.
-222 Data out of range; FM deviation; value clipped to…	The desired frequency deviation is limited to the upper or lower boundary set by the carrier frequency.
-222 Data out of range; FM deviation limited by minimum frequency	The frequency deviation is limited to the lower limit.
-222 Data out of range; FM deviation limited by maximum frequency; value clipped to upper limit	The frequency deviation cannot exceed the carrier frequency. The maximum should be limited to 25.05 MHz for sine, 12.55 MHz for square carrier waveforms and 5.05 MHz for an arbitrary waveform.
-222 Data out of range; PWM deviation	The width deviation is allowed to be in the range of 0 and the width of the underlying pulse waveform, while the duty cycle deviation is in the range of 0 and the duty cycle of the underlying pulse waveform. But this message indicates that either parameter is further limited by minimum pulse width and edge time parameters.
-222 Data out of range; PWM deviation limited by pulse parameters	The PWM deviation (width or duty cycle) is adjusted to accommodate the current pulse parameters such as pulse width/duty cycle, period and edge time.
-222 Data out of range; duty cycle; value clipped to…	The square wave duty cycle is adjusted to within 20% to 80%.
-222 Data out of range; duty cycle limited by frequency; value clipped to upper limit	The square wave duty cycle is adjusted to within 40% to 60% when the frequency is greater than 10 MHz.
-223 Too much data	An arbitrary waveform specified contains more than 262144 points. Verify the number of points in the DATA VOLATILE or DATA:DAC VOLATILE command.
-224 Illegal parameter value	An exact parameter value was expected.

Device dependent errors

Error code	Description
-313 Calibration memory lost; memory corruption detected	A checksum error was detected in the non-volatile memory used to store calibration constant.
-314 Save/recall memory lost; memory corruption detected	A checksum error was detected in the non-volatile memory used to store instrument states.
-315 Configuration memory lost; memory corruption detected	A checksum error was detected in the non-volatile memory used to store configuration settings.
-350 Queue overflow	More than 20 errors were found and the error queue was full.

Query errors

Error code	Description
-410 Query INTERRUPTED	A command was received, but the output buffer contained data from a previous command (the previous data is lost).
-420 Query UNTERMINATED	A query command was sent to read the output buffer over the interface, but no such command that generates data to the output buffer was previously sent for execution.
-430 Query DEADLOCKED	An executed command generated too much data for the output buffer and the input buffer is also full. The command continues to execute but the data is lost.
-440 Query UNTERMINATED after indefinite response	The *IDN? command must be the last query command within a series of commands in a command string.

Instrument errors

Error code	Description
501 Cross-isolation UART framing error 502 Cross-isolation UART overrun error	Internal hardware failure.
580 Reference phase-locked loop is unlocked	The PHAS:UNL:ERR:STAT has been turned on and the internal phase-locked loop is currently unlocked.

Self-test errors

Error code	Description
621 Self-test failed; square-wave threshold DAC 623 Self-test failed; dc offset DAC 624 Self-test failed; null DAC 625 Self-test failed; amplitude DAC	A possible malfunctioning DAC, failed DAC multiplexer (U8_2) channels, or associated circuitry.
626 Self-test failed; waveform filter path select relay 627 Self-test failed; -10 dB attenuator path 628 Self-test failed; -20 dB attenuator path 629 Self-test failed; +20 dB amplifier path	These errors indicate that the specified relay is not properly switched or the attenuator/amplifier does not provide the expected attenuation or gain. These self-tests use the internal ADC to verify whether the output path relays, output amplifier (+20 dB), and output attenuators properly operate or not.
630 Self-test failed; internal ADC over-range; condition 631 Self-test failed; internal ADC measurement error	A probable ADC failure.
632 Self-test failed; square/pulse DAC test failure	A probable failure of the square/pulse DAC (U10_7).

Arbitrary waveform errors

Error code	Description
770 Nonvolatile arb waveform memory corruption detected	A checksum error was found in the non-volatile memory used to store arbitrary waveform. As a result, the arbitrary waveform cannot be retrieved.
781 Not enough memory to store new arb waveform; use DATA:DELETE	All non-volatile memory locations are occupied. There is no room to store a new waveform.
781 Not enough memory to store new arb waveform; bad sectors	Due to storage hardware failure, new waveforms cannot be saved.
782 Cannot overwrite a built-in waveform	The five built-in waveform names (“EXP_RISE”, “EXP_FALL”, “NEG_RAMP”, “SINC”, and “CARDIAC”) are reserved and cannot be used with DATA:COPY command.
784 Name of source arb waveform for copy must be VOLATILE	When using the DATA:COPY command, the data source must be the VOLATILE one.
785 Specified arb waveform does not exist	Before using DATA:COPY command to copy from the volatile memory, be sure to download the waveform to it using the DATA VOLATILE or DATA:DAC VOLATILE command.
787 Not able to delete the currently selected active arb waveform	Deleting the waveform that is currently outputting is not allowed.
788 Cannot copy to VOLATILE arb waveform	You can only use DATA:COPY command to copy from VOLATILE, not to VOLATILE.
800 Block length must be even	The binary data are represented as 16-bit integers. They are sent in groups of two bytes (DATA:DAC VOLATILE command).
810 State has not been stored	The storage location specified in the *RCL command was never used in previous *SAV commands. You cannot recall instrument state from an empty storage location.

B Sample Programs

Introduction

Five example programs are included in this appendix to demonstrate how to control the FGA5050 using SCPI commands. All of these programs are written in Microsoft Visual C++ 6.0 and use NI-VISA.

If you want to modify the example programs or create your own programs, you will need to install NI-VISA.

- To use GPIB, install a GPIB interface card and its drivers on the PC.
- To use USB or LAN, install a version of NI-VISA that supports USB or LAN.

All the sample application programs in this chapter are intended to be used with Microsoft Visual C++ 6.0 and NI-VISA through USB.

To use VISA in another Visual C++ project, you have to configure the environmental variables in Microsoft Visual C++ 6.0. The procedure for doing so is described below.

- In VC++, after you enter Tools\Options\Directories\include, enter the “Include” path offered by NI-VISA, such as C:\VXIPNP\WinNT\include.
- In the Project folder, add C:\VXIPNP\WinNT\lib\msc\visa32.lib.

To view accurate information for using the USB interface, execute Utility/IO/Show USB Id (for the USB interface).

```
char instrDesc[]="USB0::2878::4135::xxxxxxxxxx::INSTR";
```

To communicate over a GPIB or LAN interface, instead of the USB setting below (1), you need to use the GPIB setting (2) or the LAN setting (3).

```
(1) char instrDesc[]="USB0::2878::4135::xxxxxxxxxx::INSTR";
(2) char instrDesc[]="GPIB0::10:: INSTR";     //GPIB control,Address:10
(3) char instrDesc[]="TCPIP0::192.168.0.123::inst0::INSTR";//IP address:192.168.0.123
```

Program 1: Simple sine wave

This program selects a sine wave as the waveform and then sets the frequency, amplitude, and offset of the waveform.

```
//A Simple Sine Waveform
#include <visa.h>
#include <stdio.h>
#include <ctype.h>
#include <dos.h>

void main (int argc,char *argv[])
{
      ViSession defaultRM,vi=0;
      ViStatus status;
      char instrDesc[]="USB0::2878::4135::xxxxxxxxxx::INSTR";

      viOpenDefaultRM (&defaultRM);

      status = viOpen(defaultRM,instrDesc, VI_NULL,VI_NULL, &vi);
      if (status != VI_SUCCESS){
           printf("Can not Open device:\"%s\"\n",instrDesc);
           return;
      }
      //This program sets up a waveform by selecting the waveshape
      //and adjusting the frequency, amplitude, and offset.

      viPrintf(vi,"*RST\n");
      viPrintf(vi,"FUNCtion SINusoid\n");//Select waveshape
      // Other options are SQUare, RAMP, PULSe, NOISe, DC, and USER
      viPrintf(vi,"OUTPut:LOAD 50\n");  //Set the load impedance in Ohms
      //(50 Ohms default)
      // May also be INFinity, as when using oscilloscope or DMM
      viPrintf(vi,"FREQuency 12500\n"); //Set the frequency.
      viPrintf(vi,"VOLTage 1.25\n");    //Set the amplitude in Vpp.
      //Also see VOLTage:UNIT
      viPrintf(vi,"VOLTage:OFFSet 0.5\n");//Set the offset in Volts
      //Voltage may also be set as VOLTage:HIGH and VOLTage:LOW for low level
      //and high level
      viPrintf(vi,"OUTPut ON\n");       // Turn on the instrument output

      viClose (vi);
      viClose (defaultRM);
}
```

Program 2: Amplitude modulation

This program configures an AM waveform using lower-level SCPI commands. It also shows how to use the *SAV command to store the instrument configuration in the internal memory of the FGA5050.

```
//Amplitude Modulation
#include <visa.h>
#include <stdio.h>

void main (int argc,char *argv[])
{
      ViSession defaultRM,vi=0;
      ViStatus status;
      char instrDesc[]="USB0::5710::5100::TW00009009::0::INSTR";

      viOpenDefaultRM (&defaultRM);

      status = viOpen(defaultRM,instrDesc, VI_NULL,VI_NULL, &vi);
      if (status != VI_SUCCESS){
            printf("Can not Open device:\"%s\"\n",instrDesc);
            return;
      }
      // This program uses low-level SCPI commands to configure
      // the function gnerator to output an AM waveform.
      // This program also shows how to use "state storage" to
      // store the instrument configuration in memory.

      viPrintf(vi,"*RST\n");
      viPrintf(vi,"OUTPut:LOAD 50\n");  //Output termination is 50 Ohms
      viPrintf(vi,"FUNCtion:SHAPe SINusoid\n");//Carrier shape is sine
      viPrintf(vi,"FREQuency 6000;VOLTage 3\n");//Carrier freq is 6 kHz @ 3 Vpp

      viPrintf(vi,"AM:INTernal:FUNCtion SINusoid\n");//Modulating shape is sine

      viPrintf(vi,"AM:INTernal:FREQuency 300\n");//Modulation freq = 300 Hz
      viPrintf(vi,"AM:DEPTh 90\n");      //Modulation depth = 90%
      viPrintf(vi,"AM:STATe ON\n");      //Turn AM modulation on
      viPrintf(vi,"OUTPut ON\n");        //Turn on the instrument output
      viPrintf(vi,"*SAV 2\n");           //Store state in memory location 2
      // Use the "*RCL 2" command to recall the stored state output

      viClose (vi);
      viClose (defaultRM);
}
```

Program 3: Linear sweep

This program creates a linear sweep for a sine wave, sets the start and stop frequencies, and sets the sweep time.

```
//Linear Sweep
#include <visa.h>
#include <stdio.h>

void main (int argc,char *argv[])
{
      ViSession defaultRM,vi=0;
      ViStatus status;
      char instrDesc[]="USB0::5710::5100::TW00009009::0::INSTR";

      viOpenDefaultRM (&defaultRM);

      status = viOpen(defaultRM,instrDesc, VI_NULL,VI_NULL, &vi);
      if (status != VI_SUCCESS){
            printf("Can not Open device:\"%s\"\n",instrDesc);
            return;
      }
      //This program sets up a linear sweep using a sinusoid
      //waveform. It sets the start and stop frequency and sweep
      //time.

      viPrintf(vi,"*RST\n");
      viPrintf(vi,"FUNCtion SINusoid\n");//Select waveshape
      viPrintf(vi,"OUTPut:LOAD 50\n");  //Set the load impedance to
      // 50 Ohms (default)
      viPrintf(vi,"VOLTage 1\n");       //Set the amplitude to 1 Vpp.
      viPrintf(vi,"SWEep:SPACing LINear\n");//Set Linear or LOG spacing
      viPrintf(vi,"SWEep:TIME 1\n");    //Sweep time is 1 second
      viPrintf(vi,"FREQuency:STARt 100\n");//Start frequency is 100 Hz
      viPrintf(vi,"FREQuency:STOP 20e3\n");//Stop frequency is 20 kHz
      //Frequency sweep limits may also be set as FREQuency:CENTer and
      viPrintf(vi,"OUTPut ON\n");       //Turn on the instrument output
      viPrintf(vi,"SWEep:STATe ON\n");  //Turn sweep on

      viClose (vi);
      viClose (defaultRM);
}
```

Program 4: Pulse wave

This program configures a pulse waveform by setting the pulse width, period, and high and low levels. Then it increases the edge time.

```
//A Pulse Waveform
#include <visa.h>
#include <stdio.h>
#include <windows.h>

void main (int argc,char *argv[])
{
      ViSession defaultRM,vi=0;
      ViStatus status;
      char instrDesc[]="USB0::5710::5100::TW00009009::0::INSTR";
      int i;

      viOpenDefaultRM (&defaultRM);

      status = viOpen(defaultRM,instrDesc, VI_NULL,VI_NULL, &vi);
      if (status != VI_SUCCESS){
            printf("Can not Open device:\"%s\"\n",instrDesc);
            return;
      }
      //This program sets up a pulse waveshape and adjusts the edge
      //time. It also shows the use of high and low voltage levels
      //and period. The edge time is adjusted by 5 nsec increments.

      viPrintf(vi,"*RST\n");
      viPrintf(vi,"FUNCtion PULSe\n");   //Select pulse waveshape
      viPrintf(vi,"OUTPut:LOAD 50\n");   //Set the load impedance to
      // 50 Ohms (default)
      viPrintf(vi,"VOLTage:LOW 0\n");    //Low level = 0 V
      viPrintf(vi,"VOLTage:HIGH 0.75\n");//High level = .75 V
      viPrintf(vi,"PULSe:PERiod 1e-3\n");//1 ms intervals
      viPrintf(vi,"PULSe:WIDTh 100e-6\n");//Pulse width is 100 us
      viPrintf(vi,"PULSe:TRANsition 10e-9\n");//Edge time is 10 ns
      //(rise time = fall time)
      viPrintf(vi,"OUTPut ON\n");        //Turn on the instrument output

      for(i=0;i<19;i++){                 //Vary edge by 5 nsec steps
            viPrintf(vi,"PULSe:TRANsition %E\n",0.00000001 + i * 0.000000005);
            Sleep(300);                  //Wait 300 msec
      }

      viClose (vi);
      viClose (defaultRM);
}
```

Program 5: Pulse width modulation (PWM)

This program configures a pulse waveform by setting its duty cycle and then gradually modulates the waveform using a triangle waveform.

```
//Pulse Width Modulation (PWM)
#include <visa.h>
#include <stdio.h>

void main (int argc,char *argv[])
{
      ViSession defaultRM,vi=0;
      ViStatus status;
      char instrDesc[]="USB0::5710::5100::TW00009009::0::INSTR";

      viOpenDefaultRM (&defaultRM);

      status = viOpen(defaultRM,instrDesc, VI_NULL,VI_NULL, &vi);
      if (status != VI_SUCCESS){
            printf("Can not Open device:\"%s\"\n",instrDesc);
            return;
      }
      //This program uses low-level SCPI commands to configure
      //the function gnerator to output an PWM waveform.
      //The pulse is set up with a duty cycle of 35% and a depth
      //of 15%, and will vary in width from 20% to 50% with the
      //modulation. The pulse may also be configured in time
      //units (pulse width and deviation) rather than duty cycle
      //if preferred.

      viPrintf(vi,"*RST\n");
      viPrintf(vi,"OUTPut:LOAD 50\n");  //Set the load impedance to
      // 50 Ohms (default)
      viPrintf(vi,"FUNCtion:SHAPe PULSe\n");//Carrier waveshape is pulse
      viPrintf(vi,"FREQuency 5000\n");  //Carrier frequency is 5 kHz
      viPrintf(vi,"VOLTage:LOW 0\n");   //Set parameters to 5 V TTL
      viPrintf(vi,"VOLTage:HIGH 5\n");
      viPrintf(vi,"FUNCtion:PULSe:DCYCle 35\n");//Begin with 35% duty cycle
      viPrintf(vi,"PWM:INTernal:FUNCtion TRIangle\n");//Modulating waveshape
      //is triangle
      viPrintf(vi,"PWM:INTernal:FREQuency 2\n");//Modulation frequency is 2 Hz
      viPrintf(vi,"PWM:DEViation:DCYCle 15\n");//Modulation depth is 15%
      viPrintf(vi,"PWM:SOURce INTernal\n");//Use internal signal for
      //modulation
      //If using an external signal for PWM, connect the signal to the
      //rear-panel BNC and use the command PWM:SOURce EXTernal
      viPrintf(vi,"PWM:STATe ON\n");    //Turn PWM modulation on
      viPrintf(vi,"OUTPut ON\n");       //Turn on the instrument output

      viClose (vi);
      viClose (defaultRM);
}
```