

# INSTRUCTION MANUAL

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## 50MHz Arbitrary Waveform Generator FGX-295



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# USING THE PRODUCT SAFELY

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## ■ Summary

In order to use this product safely, read through-out this instruction manual.

Before using the product, please understand the correct use of this product.

Please contact us or your local dealer if you happen to find any obscurities within this instruction manual.

After terminated reading this instruction manual, please keep it at your around to be able to read at anytime of your need.

## ■ Pictorial indication and warning character indication

This instruction manual and product show the warning and caution items required to use this product safely. Following pictorial indication and warning character indication are provided.

<p>&lt;Pictorial indication&gt;</p> 	<p>Some part of this product or this instruction manual may show this pictorial indication. In this case, it may result with a serious danger to the body or to the product if the product was incorrectly used at this part.</p> <p>To use the part with this pictorial indication, be sure to refer with this instruction manual.</p>
<p>&lt; Warning character indication &gt;</p>  <p><b>WARNING</b></p>  <p><b>CAUTION</b></p>	<p>If you make an incorrect use of the product ignoring this indication, there is a possibility to be killed or seriously injured. These warning indications are aimed to avoid such a danger.</p> <p>If you make an incorrect use of the product ignoring this indication, there is a possibility to be slightly injured or that the product will be damaged. These warning indications are aimed to avoid such a danger.</p>

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Please acknowledge that our company does not assume any responsibilities to the breakdown or damage arose with a mal use of the product by the user or the third party except when the liability in law is admitted.

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# USING THE PRODUCT SAFELY

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## WARNING AND CAUTION

### ■ Do not remove the product's cover and panels

Never remove the product's covers and panels for any purpose. Otherwise, an electric shock or a fire may be incurred.

### ■ Warning while using the product

The following items are aimed to avoid any possible danger of life or body as well as the deterioration of the product. Be sure to follow the warning and caution as stated below.

### ■ Warning items on power supply

#### ● Power supply voltage

The rated power supply voltage is AC100V to AC240V. Check rated specification of an attached power cord when using over the power supply voltage of AC125V. There is a danger of electric shock or fire if used without check.

#### ● Power cord

**Important: The attached power cord set can only be used to this device.**

When any damage occurs on the attached power cord, stop using immediately and contact your nearest dealer. There is a danger of electric shock or fire if kept using with the damaged power cord.

#### ● Protection fuse

If an input protection fuse is blown, the product does not operate. The fuse may be changed if the product is equipped by an external fuse holder. Please refer the close for fuse change for the method of change. In any other cases, user is not allowed to change the fuse. Please contact our service center without opening the case. We will make the fuse change.

There is a danger of fire if user changes the fuse by mistake.

### ■ Warning item on grounding

If the product is equipped by a GND on the front or rear panel, be sure to ground the product to make safety use of it.

### ■ Warning item on installation environment

#### ● Operating temperature and humidity

Use the product within the operating temperature indicated in the rating column. There is a danger of fire if the product is used with the vents of the product blocked or in high ambient temperatures.

Use the product within the operating humidity indicated in the rating column. Please be careful to the dewfall made by a sudden humidity change when changing the room with different humidity. Also, do not operate with wet hands. There is a danger of an electric shock or fire.

#### ● Use in a gas

Use in and around a place where an inflammable or explosive gas or steam is generated or stored may result in an explosion and fire. Do not operate the product in such an environment. Also, use in and around a place where a corrosive gas is generated or spreading, causes a serious damage to the product. Do not use the product in such an environment.

#### ● Location to install

Do not install in a place where inclination or vibration exists. An unexpected fall down may be the cause of injury or damage.

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# USING THE PRODUCT SAFELY

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## ■ Do not let any foreign body in

You must neither insert metal or flammable materials into the product from its vent nor spill water on it. Otherwise, an electric shock and fire may occur.

## ■ Warning item on abnormality while in use

If smoke, fire, nasty smell or allophone is generated from the product while in use, stop using the product, turn off the switch and remove the power cord plug from the outlet. After confirming that no other devices catch fire, call your nearest service center or sales agent.

## ■ Input/output terminal

Maximum input to the input terminals is specified to prevent the product from being damaged.

Do not supply input, exceeding the specifications that are indicated in the "Rating" or "Caution on use" column in the instruction manual of the product. Otherwise, it will be the cause of product failure.

## ■ Calibration

All product passes through an inspection of its performances and specifications under our strict quality control while delivery from the factory. Nevertheless, slight differences may occur on its performances or specifications along with its passing age. We recommend a periodical calibration to enable to use the product in a stable status on its performances and specifications.

To proceed to the calibration, please contact your nearest service center or sales agent.

## ■ Daily maintenance

When you clean off the dirt of the product covers, panels and knobs, avoid solvents such as thinner and benzene. Otherwise, paint may peel off or the resin surface may be affected.

To wipe off the covers, panel and knobs, use a soft cloth with neutral detergent in it.

During cleaning, be careful that water, detergents and other foreign bodies do not get into the product.

If a liquid or metal gets into the product, it will be the cause of an electric shock or fire.

During cleaning, remove the power cord plug from the outlet.

Use the product correctly and safely, observing the above warning and caution items.

Since this instruction manual indicates caution items in individual items as well, observe those caution items to correctly use the product.

If you have questions or comments about the content of this instruction manual, ask us or e-mail us.

# 1. Overview

This chapter allows you to prepare for using the FGX-295 waveform generator.

Also, this Instruction Manual or the attached software, application manual may be changed without notice. For the latest version, please download from Nikke Techno's web site.

(<http://www.texio.co.jp>)

## 1-1. Preparation to use FGX-295 Arbitrary Waveform Generator

This chapter explains a basic preparation for using the FGX-295 Arbitrary Waveform Generator.

First of all, please check that there is any damage on the product or missing parts with the product. All our products are handled and inspected professionally before delivery, however if you happens to find any missing parts or damage on the product, please contact your local sales agent. Also please avoid using the propduct with any problems.

### 1-1-1. To adjust the handle

You may adjust the carrying handle to suit your needs. The following figures show how to do.

#### I. Take off the handle from the waveform genegator

【Step 1】 Turn up the handle to the vertical direction

Pull slightly outward on both sides of the handle and slowly rotate it up to 90°C to the vertical direction as shown in **Figure 2-1**.

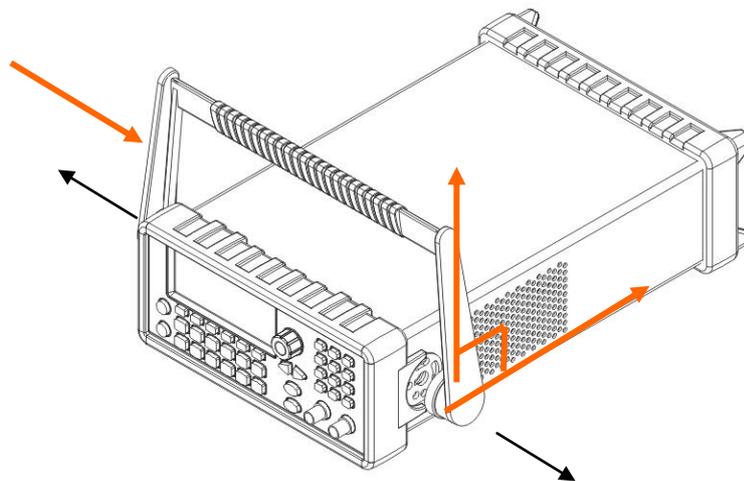


Figure 1-1

**【Step 2】 Pull out the handle**

Keeping the handle turned up to 90°, pull out the handle from the waveform generator as shown in **Figure 2-2**.

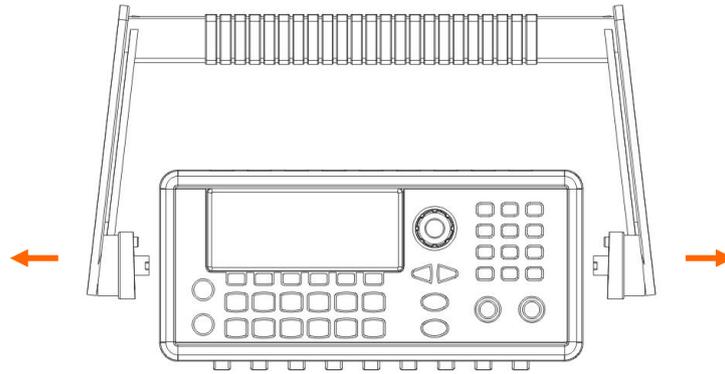


Figure 1-2

**II . Adjusting the position for your convenience**

Following are some example of position for different needs.

**【Position 1】** The default position is as below:

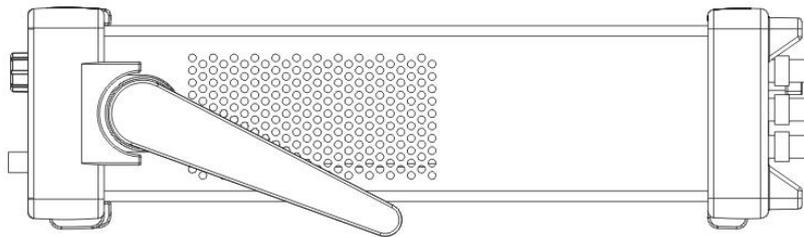


Figure 1-3

**【Position 2】** The adjusted position for usual operation is as below:

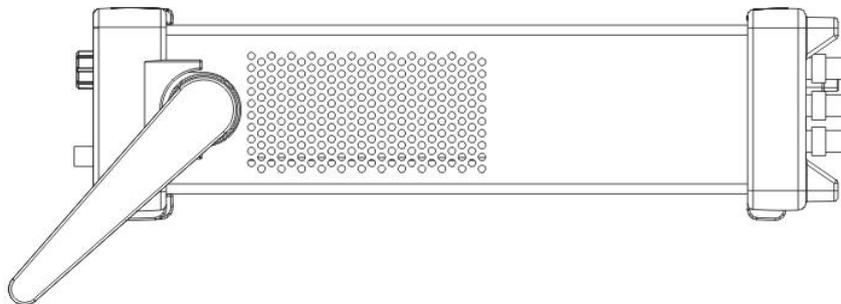


Figure 1-4

【Position 3】 The adjusted position for carrying is as below:

\* Please be careful that carrying with other position may be the cause of damage.

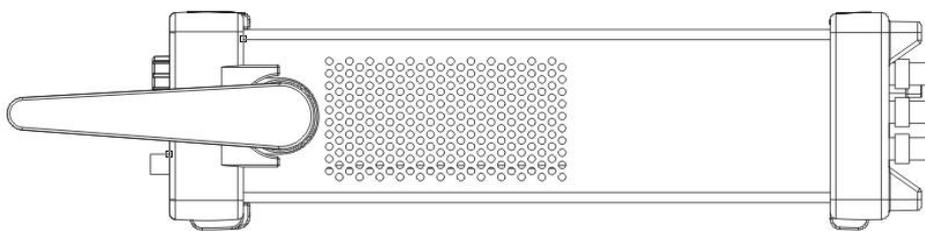


Figure 1-5

### 1-1-2. Power ON

This product is suitable with commercial power source. Therefore you may use it without change of fuse or switch of voltage. Please turn the power ON connecting the attached AC cable.

- AC100V to AC240V (50Hz/60Hz)
- AC100V to AC120V (400Hz)

【Step】 Turn the power on by pushing the power switch on the front panel as below:



Figure 1-6

“POWER ON”

### 1-1-3. Factory default setting

The below table shows the factory settings of FGX-295.

Table 1-1

	Output Configuration	Default Setting
	Function	Sine wave
	Frequency	1kHz
	Amplitude/Offset	100mVp-p/0.000Vdc
	Output Units	Vp-p
	Output Termination	50Ω
	Autorange	On
<b>Modulation</b>	Carrier	1kHz Sine(AM, FM, PM, FSK)
		1kHz Pulse(PWM)
	Mod. Waveform(AM)	100Hz Sine
	Mod. Waveform(PM, FM, PWM)	10Hz Sine
	AM Depth	100%
	FM Deviation	100Hz
	PM Deviation	180 degrees
	FSK Hop Frequency	100Hz
	FSK Rate	10Hz
	PWM Width Deviation	10μs
	Modulation State	Off
<b>Sweep</b>	Start/Stop Frequency	100Hz/1kHz
	Sweep Time	1sec.
	Sweep Mode	Linear
	Sweep State	Off
<b>Burst</b>	Burst Count	1Cycle
	Burst Width	10ms
	Burst Start Phase	0degree
	Burst State	Off
<b>System-Related Operations</b>	Power-Down Recall	Disabled
	Display Mode	ON
	Error Queue	0 errors
	Stored States, Stored Arbs	
	Output State	Off
<b>Triggering Operations</b>	Trigger Source	Internal (Immediate)
<b>Remote Interface Configuration</b>	GP-IB Address	10
	DHCP	On
	IP Address	169.254.2.20
	Subnet Mask	255.255.0.0
	Default Getaway	0.0.0.0
	DNS Server	0.0.0.0
	Host Name	None
	Domain Name	None

## 1-2. Characteristics

- Output range up to 50MHz for sine wave and 25MHz for square wave
- 5 standard waveform functions such as Sine, Square, Ramp, Pulse, Noise
- DC offset function to the standard waveform
- Arbitrary waveform function with 14 bits, 125 Mega sampling per sec
- Modulation function by AM, FM, PM, FSK, PWM methods
- Flexible frequency sweep and burst waveform output function (Linear or logarithm sweep)
- Equipped by synchronized signal output with 10MHz  $\pm$ 500Hz accuracy
- Memorizes up to 4 kinds of an arbitrary waveform with 256k points
- Visualized waveform setup method is adopted by graphical mode
- Easy and comfortable operability by combination of short cut key and rotary encoder
- Standard equipment of USB、LAN、GP-IB interface
- Standard equipment of an useful PC application

### 1-3. Operation and name of each parts

Following are the descriptions of all the connectors and buttons on both front and rear panels of FGX-295 waveform generator.

#### 1-3-1. Front panel

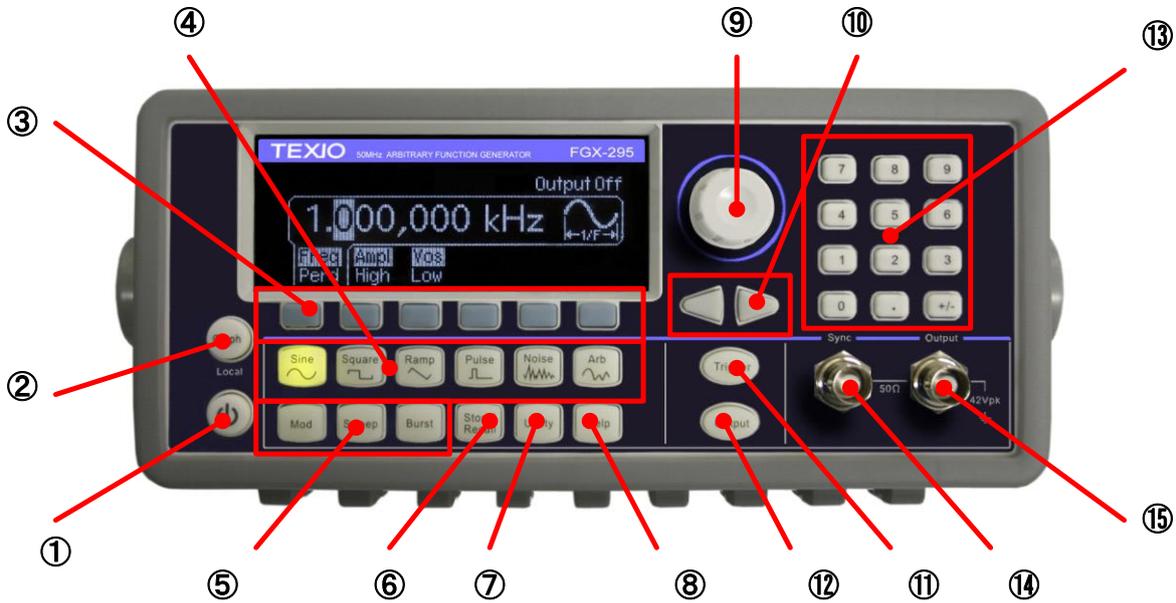


Figure 1-6

- ① Power switch : Switch to make power ON/OFF of the product.
- ② Graph/Local key : Key that changes the display mode to graphic or local menu.
- ③ Menu operation softkeys (Gray color) : Softkeys that changes or operate the function that is indicated on the display.
- ④ Waveform selection keys : Key which selects the waveform to output
- ⑤ Modulation/Sweep/Burst keys : Key that select an additional function to the output waveform (Modulation/Burst). Please refer table 1-2 for assigned function to each key.
- ⑥ Store/Recall menu key : Key that enters into the menu to save or call the status. Please refer table 1-3 for functional summary of the key.
- ⑦ Utility menu key : Key that setup the operation select of each function, basic setup of the system. Please refer table 1-4 for functional summary of the key.
- ⑧ Help key : Key that displays the help menu.
- ⑨ Variable input knob : Knob that variable inputs the data value by scroll.
- ⑩ Cursor keys : Key that moves the cursor position of the input cursor position.
- ⑪ Manual trigger key : Key that trigger outputs manually while sweep , burst mode.
- ⑫ Output key : Key that ON/OFF the setup waveform output.
- ⑬ Numeric keypad : Key that inputs the numeric value directly.
- ⑭ Sync output connector : Connector that outputs the synchronized signal of the output waveform (Except DC, noise)
- ⑮ Main signal output connector : Connector that outputs the setup waveform

\* Note: Keep pressing on each key, so that the corresponding help function will be activated and displayed.

## Function of additional function select key

Each key of additional function select key has the function as shown in table.

Table1-2

	<p>key: Setup each parameter of AM、FM、PM、FSK、PWM modulations</p> <ul style="list-style-type: none"> <li>• Select kind of modulation</li> <li>• Select Internal/External modulation source</li> <li>• Indicate AM modulation parameter (Depth, frequency, shape).</li> <li>• Indicate FM modulation parameter (Frequency deviation, frequency, shape)</li> <li>• Indicate PM modulation parameter (Phase deviation, frequency, shape).</li> <li>• Indicate FSK modulation parameter (Hop frequency, speed).</li> <li>• Indicate PWM modulation parameter (Deviation, frequency, shape)</li> </ul>
	<p>key: Setup each parameter of the frequency sweep</p> <ul style="list-style-type: none"> <li>• Select sweep mode (Linear/logarithm)</li> <li>• Sweep start/stop frequency, center frequency, select span of the frequency</li> <li>• Setup time parameter of sweep</li> <li>• Indicate marker frequency</li> <li>• Select sweep trigger source (Internal/External)</li> <li>• Edge indicate of external trigger source</li> <li>• Edge indicate of output trigger</li> </ul>
	<p>key: Setup the parameter of burst function</p> <ul style="list-style-type: none"> <li>• Select burst mode (Trigger/External gate)</li> <li>• Setup burst cycle</li> <li>• Setup phase angle of burst start</li> <li>• Setup burst cycle (Span)</li> <li>• Burst trigger source (Internal/External)</li> <li>• Select edge of external trigger source</li> <li>• Select edge of output trigger</li> </ul>

## Function of Store/Recall key

Table1-3

	<p>key: Call or save the setup status of product</p> <ul style="list-style-type: none"> <li>• Save setup status (Up to 4 kinds)</li> <li>• Create function of saving file name</li> <li>• Call function of saving file</li> <li>• Call function of delivery setup status</li> </ul>
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## Function of Utility key

Table1-4

	<p>key: Setup the basic setup of the system or related parameters</p> <ul style="list-style-type: none"> <li>• DC output voltage setup</li> <li>• ON/OFF function of Sync terminal output</li> <li>• Output terminal resistor setup</li> <li>• ON/OFF setup of output voltage auto-range</li> <li>• Polarity select of output waveform</li> <li>• GP-IB address setup</li> <li>• LAN setup (IP address, network setup)</li> <li>• Confirmation of USB ID</li> </ul>
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1-3-2. Rear panel

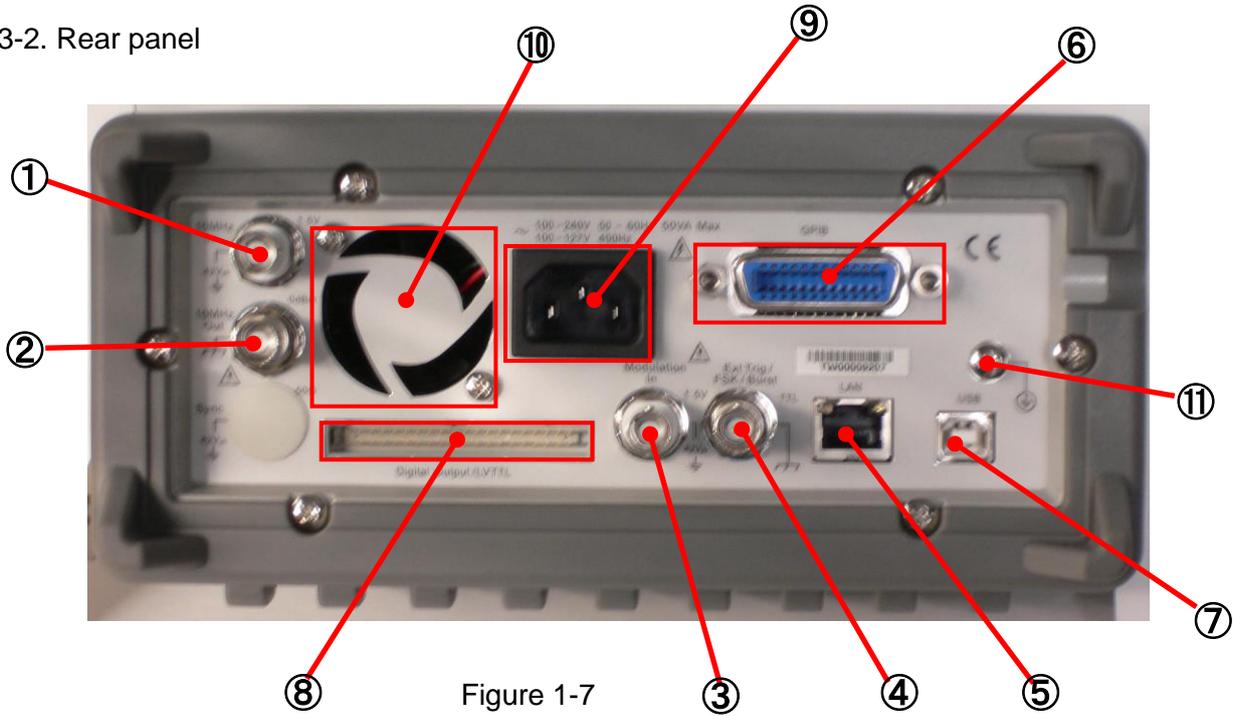


Figure 1-7

- |                                 |   |
|---------------------------------|---|
| ① 10MHz In terminal             | : Terminal that inputs the external 10MHz reference input.                  |
| ② 10MHz Out terminal            | : Terminal that outputs the internal 10MHz reference output.                |
| ③ Modulation In terminal        | : Connector that inputs the external modulation signal.                     |
| ④ Ext Trig/FSK/Burst terminal   | : Connector that outputs Trig In/Out, FSK/Burst sync signal.                |
| ⑤ LAN terminal                  | : Connector for LAN interface connection.                                   |
| ⑥ GP-IB terminal                | : Connector for GP-IB interface.  |
| ⑦ USB terminal                  | : Connector for USB interface.  |
| ⑧ Digital Output/LVTTL terminal | : Connector for output the parallel data of the created arbitrary waveform. |
| ⑨ AC IN terminal                | : Connector for input the AC power.   |
| ⑩ Vent                          | : Eruption type's ventilation hole  |
| ⑪ Frame ground                  | : Ground connector to earth the product.                                    |

## 2. Basic operations

This chapter describes the basic operations and method for setup that are commonly used to setup a waveform output. Operations to output a specific waveforms are covered in Chapter 4.

### 2-1. Display indication mode

Each time that you push on  key, the display indication will change over menu and graphical mode. Menu mode (Figure 2-1) is to indicate directly the value of the parameter to setup. Graphical mode (Figure 2-2) enable to change visually, the parameter of the waveform.



Figure 2-1 Menu mode

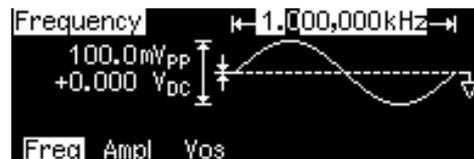


Figure 2-2 Graphical mode

### 2-2. Numerical and alphabetical entry

The value input for both indication mode, will be made by using 12 buttons on the numeric keypad or combination of the variable input rotary knob and cursor key

- Numerical entry

To enter a numeric value, select directly a desired value on the numeric keypad or use the cursor keys moving it on the display then increase or decrease the digit by turning the knob.

When using the numeric keypad, all the available units for the entry will be shown on the display. Consecutive entry of all the digit is allowed but an entry of a specific digit is possible as well by moving the cursor. The changes may be cancelled by pressing the Cancel key.

- Alphabetical entry

When entering a string of an alphabetical characters, turn the knob until the desired character appears on the display. Use the cursor keys to move the cursor for entering next character or modify the character previously entered. The +/- key may also delete the character previously entered.

## 2-3. Select for output function

This product may output following kind of waveforms. Selection of each function will be made from the front panel or by remote interface.

- Standard waveforms : FGX-295 provides five standard waveforms: sine, square, ramp, pulse and noise. The default waveform output is sine wave.
- Arbitrary waveforms : There are additional five built-in arbitrary waveforms available. Or you can create your own custom waveform with Wavepatt software which is attached to the unit.
- Modulation : The waveform generator also provides modulation for sine, square, ramp and arbitrary waveforms using AM, FM, PM, or FSK. You can also use PWM to modulate pulse waveform.
- Frequency sweeping : Linear and logarithmic frequency sweeping modes are available for sine, square, ramp and arbitrary waveforms.
- Burst operation : The burst waveforms can be generated with any one of the standard or arbitrary waveforms (except dc).

### Front-panel operation

To select a desired output function, press the corresponding button and then set up related parameters as needed. To select arbitrary wave, after selecting  key, select a desired waveform by softkey of 「Select Wform」function. Refer to Chapter 3 for setting up each individual waveform type.

To add a DC offset, after selecting  key, select softkey of 「DC ON」function then input offset voltage value pressing softkey of 「OFFSET」 function.

### Remote interface operation

`FUNCTION {SINusoid|SQUare|RAMP|PULSe|NOISe|DC|USER|PATTern}`

The APPLY command may be used to select the function, frequency, amplitude, and offset in one shot.

### Notes

- Frequency limitation: When the newly-selected function has a smaller maximum frequency, the waveform generator will automatically adjust the frequency from the old value to the new, smaller maximum value.
- Amplitude limitation: When the newly-selected function 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.

## 2-4. Setup for output frequency

The setup for the frequency or cycle is the previously set value or the factory default. Setup for output frequency will be made from the front panel or by remote interface.

Default setup value for delivery time, is set to 1kHz for all the waveforms.



Figure 2-3 Frequency setting



Figure 2-4 Width setting

### Front-panel operation

Select your desired function by pressing one of the function keys. Press the softkey under Freq/Perd and make sure Freq is highlighted (indicating the frequency mode is selected). Use the numeric keypad or the knob with cursor keys to change the value.

### Remote interface operation

FREQUENCY {<frequency>|MINimum|MAXimum}

The APPLY command may be used to select the function, frequency, amplitude, and offset in one shot.

### Notes

- Output range of the frequency: Each waveform function has its own frequency range, but the default frequency is 1 kHz for all functions. The table below lists the frequency ranges for different functions:

Table 2-1

Function	Frequency Range
Sine	1μHz to 50MHz
Square	1μHz to 25MHz
Ramp	1μHz to 200kHz
Pulse	500μHz to 10MHz
Arbitrary	1μHz to 10MHz

- Frequency limitation: When you choose a new function and the current frequency setting is larger than the maximum frequency of the new function, the waveform generator will automatically adjust the frequency to the smaller maximum value.
- Burst limitation: For internally-triggered bursts, the minimum frequency is 2.001mHz. For sine and square waveforms, frequencies above 10MHz are allowed only with an “infinite” burst count.
- Duty Cycle Limitation: There are some limits on duty cycle for square waveforms. When the frequency is greater than 10MHz, the range of the duty cycle is 40% to 60%. For other frequencies, the range of the duty cycle is 20% to 80%. If you set an out-of-limit duty cycle, the waveform generator will adjust automatically to the maximum value of the duty cycle limit range.

## 2-5. Setup for output amplitude

Setup for output amplitude value will be made from the front panel or by remote interface. The default amplitude for all functions is 100mVp-p (into 50Ω).



Figure 2-5

### Front-panel operation

Select desired function by pressing one of the function keys. Press the softkey under Ampl/High and make sure Ampl is highlighted. Use the numeric keypad or the knob with cursor keys to change the value.

### Remote interface operation

VOLTage {<amplitude>|MINimum|MAXimum}

Use this command to set units:

VOLTage:UNIT {VP-P|VRMS|DBM}

### Notes

- Setup for high-level, low-level: Specifying a high (voltage) level and a low level is equivalent to specifying amplitude and DC offset. For example, if you set the high level to +2V and the low level to -3V, the resulting amplitude will be 5Vp-p, with an offset voltage at -0.5V.



Figure 2-6



Figure 2-7

- Input unit for amplitude setup: The default output unit is Vp-p, but one may also choose from Vrms and dBm. But the output unit cannot be set to dBm if the output termination is set to “high impedance”. In such a case, the unit is automatically reset to Vp-p.

The unit setting is stored in volatile memory. The default unit (Vp-p) will be restored after a power-on cycle or a remote interface reset.

- Offset Voltage limitations: The value of output amplitude is constrained by the equation below:

$$V_{p-p} \leq 2 \times ( V_{max} - |V_{offset}| )$$

where  $V_{max}$  is the maximum peak voltage allowed for the selected output termination (5V for a 50Ω load or 10V for a high-impedance load).

- Limits with Unit Selection: The output amplitude limits may be affected by the output units selected. This symptom may occur when the units are  $V_{rms}$  or dBm due to the differences in crest factor for the various output functions. For instance, if you output a 5V $_{rms}$  square wave (into 50Ω) and then change it to the sine wave function, the waveform generator automatically adjust the output amplitude to 3.536V $_{rms}$ , which is the maximum for sine waves in  $V_{rms}$ .
- Output Termination Limits: When the Output Termination Setting is changed, the Output Amplitude is automatically adjusted. For instance, when you change the output termination from 50Ω to “high impedance”, your offset voltage doubles, thus it affects your output amplitude, and when Output Termination has been changed from “high impedance” to 50Ω, the offset voltage decreases by half.
- Arbitrary Waveform Limitations: For arbitrary waveforms, if the data points do not span the full range of the output DAC (Digital-to-Analog converter), the maximum amplitude will be limited. For example, the built-in Sinc wave does not span the full  $\pm 1$  range and thus its maximum amplitude is limited to 6.087V $_{p-p}$  (into 50Ω).
- Waveform disruption while changing amplitude: While changing amplitude, a momentary disruption in the output waveform may occur at certain voltages due to switching of the output attenuators. The amplitude is controlled, however, so the output voltage will never exceed the current setting while switching ranges. The voltage autoranging may be disabled to prevent this output disruption.

## 2-6. Setup DC offset voltage

The default DC offset voltage is 0V for all functions. To specify a non-zero DC offset value, follow the steps below.



Figure 2-8

### Front-panel operation

Select your desired function by pressing one of the function keys. Press the softkey under Vos/Low and make sure Vos is highlighted. Use the numeric keypad or the knob with cursor keys to change the value.

Selecting  key, Select softkey of 「DC ON」or 「DC OFF」function and input the offset voltage value (Only the DC voltage will be output when output is ON)

### Remote interface operation

VOLTage :OFFSet {<offset>|MINimum|MAXImum}

The APPLY command may be used to select the function, frequency, amplitude, and offset in one shot.

### Notes

Setup for high-level, low-level: Specifying a high (voltage) level and a low level is equivalent to specifying amplitude and DC offset. For example, if you set the high level to +2V and the low level to -3V, the resulting amplitude will be 5Vp-p, with DC offset at -500mV.



Figure 2-9

$$|\text{Voffset}| \leq V_{\text{max}} - V_{\text{p-p}} / 2$$

Limits with amplitude and output termination: DC offset value is constrained by the equation below:

$$|\text{Voffset}| \leq V_{\text{max}} - \frac{V_{\text{p-p}}}{2}$$

Where  $V_{max}$  is the maximum peak voltage allowed for the selected output termination (5V for a 50 $\Omega$  load or 10V for a high-impedance load).

If the specified dc offset is not valid, the waveform generator automatically adjusts it to the maximum value allowed with the specified amplitude.

Offset limit by output terminal resistor: For dc volts, the output level is actually controlled by setting the offset voltage. You can set the dc level to any value between  $\pm 5V_{dc}$  into 50 $\Omega$  or  $\pm 10V_{dc}$  into an open circuit.

Arbitrary Waveforms Limitations: For arbitrary waveforms, if the waveform data points do not span the full range of output DAC (Digital-to-Analog Converter), the maximum offset and amplitude will be limited.

## 2-7. To set high-level and low-level bounds

Setting high-level and low-level bounds provides an equivalent way to specifying amplitude and DC offset. The procedure is as follows.

### Front-panel operation

Select your desired function by pressing one of the function keys. Press the softkey under Ampl/High to toggle and make sure the High is highlighted. Use the numeric keypad or the knob with cursor keys to change the value. Press the softkey under 「Vos/Low」 to toggle and make sure Low is highlighted. Use the numeric keypad or the knob with cursor keys to change the value.

### Remote Interface operation

```
VOLTage:HIGH {<voltage>|MINimum|MAXimum}
```

```
VOLTage:LOW {<voltage>|MINimum|MAXimum}
```

## 2-8. Setup for waveform polarity

The default waveform polarity mode is Normal, in which the waveform goes positive during the first part of the wave cycle. One may change it to the Inverted mode where the waveform goes negative during the first part of the wave cycle. To set the waveform polarity mode, follow the steps below.

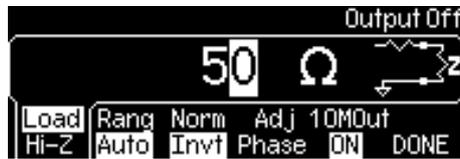


Figure 2-10

### Front-panel operation

Press Utility button  and then select the softkey under 「Output Setup». Press the softkey under 「Norm/Invt」 to toggle between Normal and Inverted. Make sure your choice is highlighted. Press the softkey under 「DONE」 to finish the selection.

### Remote interface operation

OUTPut: POLarity {NORMal|INVerted}

### Notes

- DC offset voltage: When a non-zero offset is used, the waveform is inverted relative to the offset voltage, so the offset remains the same in the inverted waveform.
- Relation with sync signal: When the waveform is inverted, the Sync signal associated with the waveform is not inverted.

## 2-9. Setup output termination

A fixed series output impedance of 50Ω to the front-panel Output connector is set in FGX-295 by default. If the actual load impedance does not match the value specified, the output amplitude and offset levels will be incorrect. To change this setting, follow the steps below.

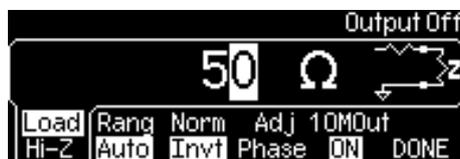


Figure 2-11

### Front-panel operation

Press the Utility button  and then press the softkey under 「Output Setup」. Make sure the Load softkey is highlighted. If not, press the softkey to toggle. Use the numeric keypad or the knob with cursor keys to change the value. If you wish to choose high impedance, press the softkey under Load to toggle and make sure 「Load/Hi-Z」 is highlighted. Press 「DONE」 to finish the entry.

## Remote interface operation

OUTPut:LOAD {<ohms>|INFinity|MINimum|MAXimum}

## Notes

- Setup value: The range for Output Termination is from 1Ω to 10kΩ, or Infinite. The default is 50Ω.
- Default value: The output termination setting is stored in non-volatile memory and it stays after power-off or a remote interface reset.
- Amplitude limit by output termination resistor : When the output termination is set to be “high impedance”, the units is automatically set to be Vp-p if dBm is previously selected.

## 2-10. ON/OFF setup for voltage auto range

The waveform generator by default turns on auto range at power-on and finds optimal settings for the output amplifier and attenuators. If auto range is turned off, FGX-295 uses the current amplifier and attenuator settings. To enable/disable voltage auto range, follow the steps below.

### Front-panel operation

Press the Utility button  and then the softkey under 「Output Setup」. Press the softkey under 「Rang」 to toggle between Auto and Hold for auto-ranging setting. Press the softkey under 「DONE」 to finish the selection.



Figure 2-12



Figure 2-13

## Remote interface operation

VOLTage:RANGe:AUTO {OFF|ON|ONCE}

Also, if function, frequency, amplitude, offset is set using APPLY command, autorange setup will automatically select 「Auto」.

## Notes

- Disruption of the waveform: While changing amplitude, you may notice a momentary disruption in the output waveform at certain voltages due to switching of the output attenuators. You may use disable the voltage autoranging to prevent this output disruption.
- Limitation when 「Hold」 is set: With auto-ranging off, the resolution and accuracy of amplitude and offset may be affected when reducing the amplitude below the expected range change. And you may not be able to achieve the minimum amplitude that is available when autoranging is on.
  - Initial value: Setup for auto range will be stored in the volatile memory. Therefore it returns to the initial status at delivery time after power OFF or reset is made by remote interface.

## 2-11. ON/OFF setup for waveform output

FGX-295 output is controlled by the output button. The output is disabled at power on by default to protect the equipment connected to FGX-295.

### Front-panel operation

To ON/OFF output, press the Output button  to toggle. The Output button becomes lit when output is enabled.

### Remote interface operation

OUTPut {OFF|ON}

Also, if function, frequency, amplitude, offset is set using APPLY command, output will automatically ON.

### Notes

- The Output is automatically disabled when an excessive external voltage is applied to the Output connector on the front panel and an error will be generated and the error message will be shown. Remove the overload from the output connector and enable the output again.

## 2-12. ON/OFF setup for Sync signal out

All the standard output functions, except dc and noise, can be associated with a Sync-out signal. The output will be made from the Sync connector on the front panel.

### Front-panel operation

To enable/disable the Sync-out signal, press the Utility button , and select softkey of 「Output Setup」 function, then the Sync softkey to toggle the setting.

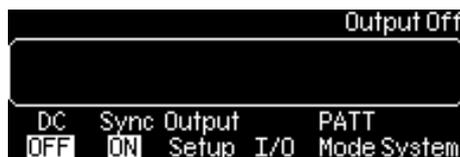


Figure 2-14

### Remote interface operation

OUTPut:SYNC {OFF|ON}

Also, if function, frequency, amplitude, offset is set using APPLY command, auto range setup of voltage will automatically select 「Auto」.

## Notes

- Connector status while output OFF: If the Sync connector is disabled, the output signal is at a logic “low” level.
- Default value: The setup for sync signal output will be stored into the volatile memory. Therefore, it will return to ON which is default setup value of delivery when the power is ON or the reset is executed by remote interface.
- Sync output for sine, ramp and pulse waveforms: For Sine, ramp and pulse waveforms, the Sync signal is a square waveform with a 50% duty cycle. The Sync signal is a TTL “high” when the waveform output is positive, relative to 0V (discard the dc offset setting). The Sync signal is a TTL “low” when the waveform output is negative, relative to 0V (discard the dc offset setting).
- Sync output for square waveforms: For Square waveforms, the Sync signal is a square waveform with the same duty cycle.
- Sync output for arbitrary waveforms: For arbitrary waveforms, the Sync signal is a square waveform with a 50% duty cycle. The Sync signal is a TTL “high” when the first waveform point is outputted.
- Sync output for internal modulation : For internal-modulated AM, FM, PM, and PWM, the Sync signal is aligned with the modulating waveform and is a square wave with a 50% duty cycle. The Sync signal is a TTL “high” during the first half of the modulating waveform.
- Sync output for external modulation: For external-modulated AM, FM, PM, and PWM, the Sync signal is aligned with the carrier waveform and is a square wave with a 50% duty cycle.
- Sync output while FSK: For FSK, the Sync signal is aligned with shifts in frequency. The Sync signal is a TTL “high” during the output of the “hop” frequency and “low” during that of the “carrier” frequency.
- Sync output while frequency sweep (Marker OFF): For frequency sweeps with Marker Off, the Sync signal is a square wave with a 50% duty cycle. The Sync signal is a TTL “high” in the first half of the sweep and “low” in the second half. The frequency of the sync signal is equal to the reciprocal of the sweep time. If the Marker is enabled, the Sync signal setting will be ignored and the Sync signal is a TTL “high” at the beginning of the sweep and transitions to “low” at the marker frequency.
- Sync output while trigger burst: For a triggered burst, the Sync signal becomes a TTL “high” when the burst is triggered. The Sync signal transitions to a TTL “low” at the end of the specified number of cycles (may not be the zero-crossing point if the waveform has a non-zero phase). If the burst count is infinite, the Sync signal works the same way described above for continuous waveforms.
- Sync output while external gate burst: If the burst generation is externally gated, the Sync signal starts at a TTL “high” with the external gate signal. However, the sync signal will not transit to a TTL “low” until the end of the last cycle (may not be the zero-crossing point if the waveform has a non-zero phase).
- Sync output while polarity inverted: When the output waveform polarity is inverted, the associated sync out signal is not affected.

## 2-13. To restore the factory default setup

This setup resets the waveform generator to its factory default settings.

Front-panel operation

Press “Store/Recall” button  and then choose 「Set to Def」 softkey. After choosing 「Yes」 to make confirmation, the waveform generator has been restored to factory default settings.

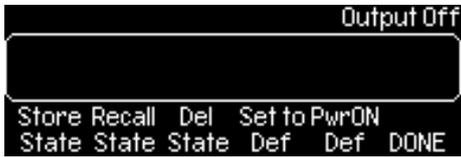


Figure 2-15

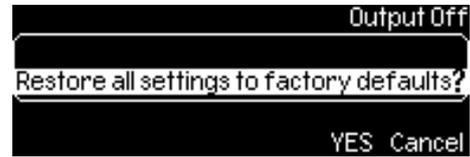


Figure 2-16

Remote interface operation

\*RST

This command will not affect to the stored product status or arbitrary wave.

### 3. Waveform output operations

This chapter describes each of the waveforms that FGX-295 provides and also the detailed explanations of front-panel, menu and remote interface operations to output the waveforms.

#### 3-1. Sine wave output

How to generate a sine wave

The default waveform output of FGX-295 is sine wave. To select sine wave while the current output function is not it, press the Sine button  to make the selection. Refer to Chapter 2 for configuring common parameters, which include frequency/width, amplitude and dc offset voltage.

To view the waveform parameters in the graph mode, press the Graph button .



Figure 3-1

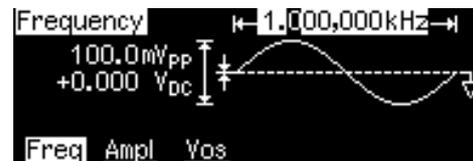


Figure 3-2

Remote interface operation

APPLY:SINusoid [<frequency>[,<amplitude>[,<offset>]]]

or

FUNCTION {SINusoid}

FREQUENCY {<frequency>|MINimum|MAXimum}

VOLTage {<amplitude>|MINimum|MAXimum }

VOLTage:OFFSet {<offset>|MINimum|MAXimum }

#### 3-2. Square wave output

A square wave consists of instantaneous transitions between two voltage levels. The duty cycle of a square wave represents the amount of time in each cycle during which the wave is at the high level (assuming that the waveform is not inverted):

$$\text{DutyCycle} = (\text{Time Interval at High Level}) / \text{Width} \times 100\%$$

How to generate a square wave

Press the Square button  to select the square wave function. Refer to Chapter 2 for configuring common parameters, including frequency/width, amplitude and dc offset voltage. Press the softkey under 「Duty Cycle」 for configuring the value. Use the knob with the cursor keys to change the value, or use the numeric keypad to enter a desired value and then press the softkey under % to finish the entry or the softkey under Cancel to cancel the changes. To view all the waveform parameters, press the Graph button .



Figure 3-3

#### Remote interface operation

APPLY:SQUare [<frequency>[,<amplitude>[,<offset>]]]

or

FUNCTion {SQUare}

FREQUency {<frequency>|MINimum|MAXimum}

VOLTage {<amplitude>|MINimum|MAXimum }

VOLTage:OFFSet {<offset>|MINimum|MAXimum }

FUNCTion:SQUare:DCYCLE {<percent>|MINimum|MAXimum }

#### Notes

- Setup of duty cycle: The default value for duty cycle is 50% and will be restored after power off or a remote interface reset as the setting is stored in volatile memory.
- When you change the output function from square wave to another, the previously-set duty cycle is remembered and will be resumed when square wave is re-selected.
- Limitation for duty cycle setup: For square waves with frequency higher than 10MHz, the range of the duty cycle is from 40% to 60%, and for square waves with lower frequency, the range of the duty cycle is from 20% to 80%.
- Frequency change: If you change frequency to a new value with which FGX-295 cannot produce the current duty cycle, it will automatically adjust the duty cycle to the closest possible value for the new frequency.
- Setup while modulation wave indication: When square wave is selected as the modulating waveform, the duty cycle is fixed at 50%. The duty cycle setting applies to square wave carrier waveform for AM, FM, PM or PWM.
- Initial value: Parameter setup for each square wave will be stored in the volatile memory. Therefore it returns to the initial status at delivery time after power OFF or reset is made by remote interface.

### 3-3. Ramp wave output

A ramp wave is a triangle waveform with adjustable symmetry. Symmetry represents the percentage of time in a cycle when the ramp wave is rising (assuming that the waveform polarity is not inverted). The default symmetry is 100%.

How to generate a ramp wave

Press the Ramp button  to select the output function.

Refer to Chapter 3 for configuring common parameters, including frequency/width, amplitude and dc offset voltage. Press the softkey under 「Sym-metry」 for configuring the value. Use the knob with the cursor keys to change the symmetry setting. Or use the numeric keypad to enter a new value and then press the softkey under % to finish the entry or the softkey under Cancel to withdraw the changes.

Press the Graph button  to view all the waveform parameters.



Figure 3-4

Remote interface operation

APPLY:RAMP [<frequency>,<amplitude>[,<offset>]]

(The command generates ramp wave with 100% symmetry)

or

FUNCTION {RAMP}

FREQUENCY {<frequency>|MINimum|MAXimum}

VOLTage {<amplitude>|MINimum|MAXimum }

VOLTage:OFFSet {<offset>|MINimum|MAXimum }

FUNCTION:RAMP:SYMMetry {<percent>|MINimum|MAXimum}

Notes

- Symmetry value is stored in volatile memory so the default setting (100%) will be restored after power-off or a remote interface reset.
- When you change the output function from ramp wave to another, the previously-set symmetry is remembered and will be resumed when ramp wave is re-selected.
- The symmetry setting does not apply to the case where ramp wave is used as the modulating wave for AM, FM, PM, or PWM.
- Initial value: Parameter setup for each ramp wave will be stored in the volatile memory. Therefore it returns to the initial status at delivery time after power OFF or reset is made by remote interface.

### 3-4. Noise waveform output

How to generate a noise wave

Press the Noise button  to select the output function. Refer to Chapter 2 for configuring common parameters such as amplitude and dc offset voltage for noise wave. Press the Graph button  to view all the waveform parameters.



Figure 3-5

Remote interface operation

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

```
FUNcTION {NOISe}
```

```
VOLTage {<amplitude>|MINimum|MAXimum }
```

```
VOLTage:OFFSet {<offset>|MINimum|MAXimum }
```

Notes

- In the APPL:NOIS command, the frequency parameter has no effect, but you still need to specify a value or “Default” for it.

### 3-5. Pulse wave output

A pulse waveform consists of a period, a pulse width, an ascending edge and a descending edge. The parameters are described further below.

#### Pulse width / Frequency

The default pulse width is 1ms (or 1kHz in frequency), and the allowable value is ranged from 100ns to 2000s (or 10MHz down to 0.5MHz in frequency). Pulse width constrains the other parameters with the following equation:

$$\text{PulseWidth} \geq \text{PulseWidth} + 1.6 \times \text{EdgeTime}$$

How to generate a pulse wave

Press the Pulse button  to choose pulse wave output.

Refer to Chapter 2 for specifying the common parameters, including 「Freq/Perd」, amplitude and dc offset voltage.

Press the softkey under Width/Duty to Toggle between setting pulse width or duty cycle.

Use the knob with the cursor keys to change the value. Or use the numeric keypad to enter a new value and then press the softkey under % to finish the entry or the softkey under Cancel to withdraw the changes. Press the softkey under Edge Time and then follow step 4 to enter your desired value for both edges. Press the Graph button  to view all the waveform parameters.



Figure 3-6

Remote interface operation

APPLY:PULSe [<frequency>[,<amplitude>[,<offset>] ]]

or use the following commands for setting parameters of your pulse waveform:

FUNCTION {PULSe}

FREQUENCY {<frequency>|MINimum|MAXimum }

VOLTage {<amplitude>|MINimum|MAXimum }

VOLTage:OFFSet {<offset>|MINimum|MAXimum }

PULSe:PERiod {<seconds>|MINimum|MAXimum}

### Pulse width

The pulse width represents the time from the 50% point of the ascending edge to the 50% point of the following descending edge. The default pulse width is 100µs, and the possible value is ranged from 20ns to 2000s. The actual allowable range is determined as follows:

$$1.6 \times \text{EdgeTime} \leq \text{PulseWidth} \leq \text{PulsePeriod} - 1.6 \times \text{EdgeTime}$$

$$W_{\min} \leq \text{PulseWidth} \leq \text{PulsePeriod} - W_{\min}$$

where  $W_{\min}$  is the minimum allowable value determined by the following conditions on PulsePeriod:

$$W_{\min} = \begin{cases} 20 \text{ ns,} & \text{if PulsePeriod} \leq 10\text{s} \\ 200 \text{ ns,} & \text{if } 10\text{s} < \text{PulsePeriod} \leq 100\text{s} \\ 2 \mu\text{s,} & \text{if } 100\text{s} < \text{PulsePeriod} \leq 1000\text{s} \\ 20 \mu\text{s,} & \text{if } 1000\text{s} < \text{PulsePeriod} \end{cases}$$

If the specified value for PulseWidth is outside of the allowable range, the waveform generator will automatically adjust it to accommodate the given pulse period.

Select pulse wave from the  key at front panel.

Input the value of pulse width selecting softkey of 「Width/Duty」function.

The parameter setup such as frequency/cycle, amplitude, DC offset, please refer to chapter 3.

To confirm the parameter with graphical mode, select  key.



Figure 3-7

Remote interface operation

FUNCTION:PULSe:WIDTh {<seconds>|MINimum|MAXimum }

### Pulse duty cycle

Specifying pulse duty cycle is another way to define a pulse wave than specifying pulse width. Pulse duty cycle is defined as follows:

$$\text{DutyCycle} = \text{PulseWidth} / \text{PulsePeriod} \times 100\%$$

If the specified pulse duty cycle conflicts with the specified pulse width or vice versa, the most recently specified pulse duty cycle or pulse width will be accepted over the other. The default duty cycle is 10%, and the acceptable range is from 0% to 100%, with the following constraints:

$$\begin{aligned} \text{DutyCycle} &\geq W_{\text{min}} / \text{PulsePeriod} \times 100\% \\ \text{DutyCycle} &\leq (1.0 - W_{\text{min}} / \text{PulsePeriod}) \times 100\% \end{aligned}$$

where  $W_{\text{min}}$  is the minimum allowable value for pulse width defined in the previous section on pulse width. The waveform generator will adjust it to accommodate the given pulse period.

Select pulse wave from the  key at front panel.

Select softkey of 「Width/Duty」function. Input the value of duty cycle confirming that「Duty」is highlighted and select again the softkey of 「Width/Duty」function.

The value may be input such as time when 「Width」is highlighted, and duty cycle(%)when 「Duty」is highlighted.

The parameter setup such as frequency/cycle, amplitude, DC offset, please refer to chapter 3.

To confirm the parameter with graphical mode, select  key.



Figure 3-8

Remote interface operation

FUNCTION:PULSe:DCYCLE {<percent>|MINimum|MAXimum }

## Edge time

The edge time represents the time from the 10% point to the 90% point of an ascending or descending edge. The default edge time is 5ns, and the possible value is ranged from 5ns to 100ns, with the following constraint on the maximum allowable value:

$$\text{EdgeTime} \leq 0.625 \times \text{PulseWidth}$$

FGX-295 will alter the edge time when needed to accommodate the specified pulse width.

Select pulse wave from the  key at front panel.

Input the value of edge time selecting the softkey of 「EdgeTime」function

The parameter setup such as frequency/cycle, amplitude, DC offset, please refer to chapter 3.

To confirm the parameter with graphical mode, select  key.



Figure 3-9

Remote interface operation

FUNcTion:PULSe:TRANsition {<percent>|MINimum|MAXimum }

### 3-6. Arbitrary waveform output

FGX-295 waveform generator provides five built-in arbitrary waveforms and up to four user-defined arbitrary waveforms that are stored in non-volatile memory. The built-in waveforms are exponential-rise, exponential-fall, negative-ramp, sinc, and cardiac. The default arbitrary waveform is an exponential-rise wave.

For each user-defined waveform, one waveform can be created up to 262,144 (256k) points from the remote interface. If an arbitrary waveform is chosen as the modulating waveform for AM, FM, PM, or PWM, the number of points in the waveform is limited to 4k points and the extra points will be removed by an automatic decimation process.

#### User-defined waveforms

FGX-295 supports user-defined waveforms. You may use the Wavepatt waveform and pattern editor to create the waveforms you want or import the waveforms from the oscilloscope (TEXIO DCS-7500 series) that you captured previously. For more information on the user-defined waveforms, please refer to the on-line help of Wavepatt.

The outputting method is differ between built-in arbitrary waveform and user-defined one partly. These are explained respectively in the following.

#### How to output a built-in arbitrary waveform

Press the Arb button  to choose arbitrary waveform output. Select softkey for "Select Wform" function.

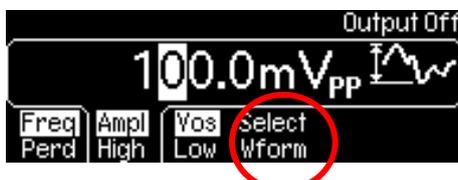


Figure 3-10

Select softkey for "Bult In" function.



Figure 3-11

Choose the desired waveform from the five built-ins by pressing the corresponding softkey.



Figure 3-12

The parameter setup such as frequency/cycle, amplitude, DC offset, please refer to chapter 2. To confirm the parameter with graphical mode, select  key.

### How to output a saved or volat arbitrary waveform

Press the Arb button  to choose arbitrary waveform output. Select softkey for "Select Wform" function.



Figure 3-13

Select softkey for "Saved Wform" or "Volat Wform" function. When arbitrary wave pattern data are saved neither, it is not displayed a menu. I choose softkey of "Delete Store" to erase a registered option wave pattern.



Figure 3-14

Choose the desired waveform from the saved waves by pressing the corresponding softkey.

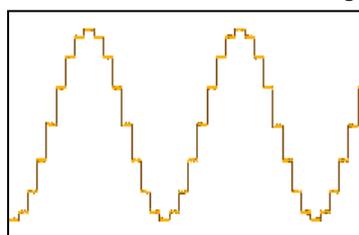


Figure 3-15

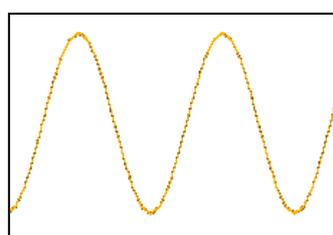
When the arbitrary wave pattern of the user definition is chosen, you can choose ON/OFF of the linear interpolation between wave pattern points in softkey of "Interp" like figure 3-17. With interpolation ON (default), the waveform editor makes a straight-line connection between points. With interpolation OFF, the waveform editor maintains a constant voltage level between points and "step-like" waveform.



Figure 3-16



Interp: OFF



Interp: ON

Choose the desired waveform from the five built-ins by pressing the corresponding softkey.

The parameter setup such as frequency/cycle, amplitude, DC offset, please refer to chapter 2. To confirm the parameter with graphical mode, select  key.

## Remote interface operation

FUNcTion USER {EXP\_RISE | EXP\_FALL | NEG\_RAMP | SINC | CARDIAC}

To download use data made from remote interface, use following commands (for references)

DATA:DAC VOLATILE, {<binary block>|<value>, <value>, ...}

DATA VOLATILE, <value>, <value>, ...

FORMat:BORDER {NORMal|SWAPped}

DATA:COPIY <destination arb name> [,VOLATILE]

DATA:CATalog?

DATA:NVOLatile:CATalog?

DATA:NVOLatile:FREE?

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

DATA:ATTRibute:CFACTOR? [<arb name>]

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

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

## 3-7. Amplitude modulation

Amplitude modulation provides a waveform in which the amplitude of the carrier waveform varies with the modulating waveform.

### How to set up amplitude modulation

To select amplitude modulation from the front panel, modulation function should be selected before setup of the parameter. Select  key to select AM modulation.



Figure 3-17

Press the softkey under「Type」and press softkey under AM to select amplitude modulation. An amplitude modulation output will be generated with the current parameters.

## Remote interface operation

AM:STATe ON

- \* To avoid changing several parameters of the waveform, select AM modulation after all other modulation parameters is set.

### Notes

- Only one type of modulation can be activated at one time. When amplitude modulation is enabled, the previously selected modulation is automatically disabled.
- Amplitude modulation cannot be enabled with sweep or burst mode at the same time. When amplitude modulation is enabled, sweep or burst mode will be disabled.

## Carrier waveform setup

The default carrier waveform is sine. One may also choose from square, ramp and arbitrary waveforms but not pulse, noise and dc waveforms. The default carrier frequency is 1kHz for all waveforms. Each carrier waveform has its own acceptable range of frequencies. To select carrier waveform, select waveform select key of front panel except  and . To select arbitrary waveform, select



key and select desired waveform using soft key of 「SelecY Wform」function.

The parameter setup such as frequency/cycle, amplitude, DC offset, please refer to chapter 2.

## Remote interface operation

FUNcTion {SINusoid|SQUare|RAMP|USER}

FREQuency {<frequency>|MINimum|MAXimum}

VOLTage {<amplitude>|MINimum|MAXimum}

VOLTage:OFFSet {<offset>|MINimum|MAXimum}

The APPLy command may be used to select the function, frequency, amplitude, and offset in one shot.

## Note

- Limitation on carrier frequency

The setup range for carrier frequency will differ along with the selected waveforms. The initial value is all set to 1kHz.

Sine	: 1μHz to 50MHz
Square	: 1μHz to 25MHz
Ramp	: 1μHz to 200kHz
Arbitrary	: 1μHz to 10MHz

## Modulating waveform

FGX-295 accepts either internal or external modulating source but not both at the same time. The default source is internal, and the default internal modulating waveform is sine wave. For internal source, one may also choose from square with 50% duty cycle, URamp (Up or Positive Ramp with 100% symmetry), DRamp (Down or Negative Ramp with 0% symmetry), triangle (ramp with 50% symmetry), noise and arbitrary waveforms. If an arbitrary waveform is chosen, the number of points in the waveform is limited to 4k points with an automatic decimation process.

## Remote interface operation

AM:INTernal:FUNcTion{SINusoid|SQUare|RAMP|NRAMP|TRIangle|NOISe|USER}

## Note

- Limitation on modulation waveform

Square : 50%duty cycle

Ramp : 100%symmetry

Triangle : 50%symmetry

Reverse ramp : 0%symmetry

Arbitrary : The number of point data for waveform will be limited to 4k so that the points over that will automatically be deleted.

## Modulating waveform setup

The default frequency for internal modulating waveform is 100Hz, and the acceptable range is from 2mHz to 20kHz.

When external source is selected, the carrier waveform is modulated with an external waveform present at the Modulation In connector on the rear panel.

## Remote interface operation

AM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}

## Modulation depth

The modulation depth controls the magnitude of the amplitude variation of the modulation output. It is defined as the following formula:

$$\text{ModulationDepth} = (\text{MaxAmplitude} - \text{MinAmplitude}) / \text{Amplitude} \times 100\%$$

Where Amplitude is the specified amplitude of the carrier waveform; MaxAmplitude and MinAmplitude are the maximum and minimum amplitudes of the resulting modulation waveform. FGX-295 is so designed that when Modulation Depth is 0%, the amplitude of the modulation waveform stays at half of the specified amplitude of the carrier waveform. As a result, MinAmplitude may be negative when ModulationDepth is larger than 100%. The default Modulation Depth is 100% and the allowable range is from 0% to 120%.

When external source is selected as the source of modulating waveform, the modulation is controlled by the specified modulation depth and the  $\pm 5V$  signal levels of the external waveform. When the external waveform is at +5V, the amplitude of the output will reach MaxAmplitude. When the external waveform is at -5V, the amplitude of the output will reach MinAmplitude.

Note that the modulation output of FGX-295 will not exceed  $\pm 5V$  peak (into a 50 $\Omega$  load) even if the modulation depth is greater than 100%.

## Remote interface operation

AM:DEPTTh {<depth in percent>|MINimum|MAXimum }

### 3-8. Frequency Modulation

Frequency modulation provides a waveform in which the frequency of the carrier waveform varies with the modulating waveform.

How to set up frequency modulation

1. Press one of the following function buttons to choose your carrier waveform: Sine, Square, Ramp, Arb. To select frequency modulation, press  key at front panel.



Figure 3-18

2. Press the Mod button to toggle on the modulation output.
3. Press the softkey under Type and press the softkey under FM to select frequency modulation. A frequency modulation output will be generated with the current parameters.
4. Press the softkey under Src to toggle between internal source (Int) and external source (Ext) for selecting modulating waveform source.
5. If internal source is selected:
  - a. Press the softkey under Shape to toggle between different types of modulating waveform.  
If arbitrary waveform (Arb) is selected as modulating signal source, the modulating signal source is depending on the previous waveform selection in arbitrary function. One may toggle the Mod key to see the arbitrary modulating waveform message that temporarily displayed on the screen.
  - b. Press the softkey under FM Freq and use numeric keypad or the knob with the cursor keys to set the desired modulating frequency.
6. Press the softkey under FreqDev to set the frequency deviation if needed. Use numeric keypad or the knob with the cursor keys to enter your value.
7. Press the Graph button to view all the waveform parameters.

#### Carrier waveform

The default carrier waveform is sine. One may also choose from square, ramp and arbitrary waveforms but not pulse, noise and dc waveforms. The default carrier frequency is 1kHz for all waveforms. Each carrier waveform has its own acceptable range of frequencies.

Refer to chapter2 for parameter setup such as frequency/interval, amplitude and DC offset.

Remote interface operation

FUNcTION {SINusoid|SQUare|RAMP|USER}

FREQUency {<frequency>|MINimum|MAXimum}

VOLTage {<amplitude>|MINimum|MAXimum}

VOLTage:OFFSet {<offset>|MINimum|MAXimum}

The APPLY command may be used to select the function, frequency, amplitude, and offset in one shot.

## Note

- Limitation on carrier frequency

The setup range for carrier frequency differ along with the selected waveform.

Sine	: 1μHz to 50MHz
Square	: 1μHz to 25MHz
Ramp	: 1μHz to 200kHz
Arbitrary	: 1μHz to 10MHz

- Setup limitation on carrier and modulation frequency

Carrier frequency should be over the modulation frequency. If it is not the case, setup value for modulation frequency will automatically be adjusted to the maximum value allowed to set.

- Setup limitation on the sum of carrier and modulation frequency

The sum of carrier and modulation frequency should not exceed maximum value of selected carrier plus 100kHz.

Sine	: 50.1MHz
Square	: 25.1MHz
Ramp	: 300kHz
Arbitrary	: 10.1MHz

## Modulating waveform

FGX-295 accepts either internal or external modulating source but not both at the same time. The default source is internal, and the default internal modulating waveform is sine wave. For internal source, one may also choose from square with 50% duty cycle, URamp (Up or Positive ramp with 100% symmetry), DRamp (Down or Negative ramp with 0% symmetry), triangle (ramp with 50% symmetry), noise and arbitrary waveforms. If an arbitrary waveform is chosen, the number of points in the waveform is limited to 4k points with an automatic decimation process.

## Remote interface operation

FM:INTernal:FUNctIon{SINusoid|SQUare|RAMp|NRAMp|TRIangle|NOISe|USER}

## Note

- Limitaion on modulation waveform

Square	: 50%duty cycle
Ramp	: 100%symmetry
Triangle	: 50%symmetry
Reverse ramp	: 0%symmetry
Arbitrary	: The number of point data for waveform will be limited to 4k so that the points over that will automatically be deleted.

## Modulating waveform setup

The default frequency for internal modulating waveform is 10Hz, and the acceptable range is from 2mHz to 20kHz.

When external source is selected, the carrier waveform is modulated with an external waveform present at the Modulation In connector on the rear panel.

Remote interface operation

FM:INTErnal:FREQUency {<frequency>|MINimum|MAXimum}

### Frequency Deviation

The frequency deviation represents the peak variation in the frequency of the modulation output based on that of the carrier waveform. The default value is 100Hz. Each type of carrier waveform has a different acceptable range as follows:

- Sine : 1μHz to 50.1MHz(at carrier frequency = 50.1MHz).
- Square : 1μHz to 25.1MHz(at carrier frequency = 25.1MHz).
- Ramp : 1μHz to 300kHz(at carrier frequency =300kHz).
- Arbitrary : 1μHz to 10.1MHz(at carrier frequency = 10.1MHz).

In addition, the maximum allowable value is constrained by the following two conditions:

- The frequency deviation must not be greater than the carrier frequency.
- The sum of frequency deviation and the carrier frequency must not be greater than the maximum frequency of the selected carrier waveform plus 100kHz; that is, 50.1MHz for sine, 25.1MHz for square, 300kHz for ramp, and 10.1MHz for arbitrary waveforms.

If a value is set greater than one of the above constraints, FGX-295 will automatically adjust it to the maximum value allowed.

When external source is selected as the source of modulating waveform, the modulation is controlled by the specified frequency deviation and the ±5V signal levels of the external waveform. When the external waveform is at +5V, the output will reach positive maximum frequency deviation; e.g., 100kHz increase from carrier frequency if the specified frequency deviation is 100kHz. When the external waveform is at -5V, the output will reach negative maximum frequency deviation; e.g., 100kHz decrease from carrier frequency if the specified frequency deviation is 100kHz.

Remote interface operation

FM:DEViation {<peak deviation in Hz>|MINimum|MAXimum }

### External modulation source setup

Modulation waveform may be selected from internal source and external source as well. To select external modulation waveform input, select FM modulation mode and switch over selecting softkey of 「Src」function.

Remote interface operation

FM:SOURce {INTErnal|EXTernal}

Note

- External modulation wave  
Selecting external modulation source, the frequency modulation will be controlled by the level of 5V signal from external input terminal.

### 3-9. Phase modulation

Phase modulation provides a waveform in which the phase of the carrier waveform varies with the modulating waveform.

How to set up phase modulation

1. Press one of the following function buttons to choose your carrier waveform: Sine, Square, Ramp, Arb. To select phase modulation, press  key at front panel.



Figure 3-19

2. Press the Mod button to toggle on the modulation output.
3. Press the softkey under Type and press the softkey under PM to select phase modulation. A phase modulation output will be generated with the current parameters.
4. Press the softkey under Src to toggle between internal source (Int) and external source (Ext) for selecting modulating waveform source.
5. If internal source is selected:
  - a. Press the softkey under Shape to toggle between different types of modulating waveform. If arbitrary waveform (Arb) is selected as modulating signal source, the modulating signal source is depending on the previous waveform selection in arbitrary function. One may toggle the Mod key to see the arbitrary modulating waveform message that temporarily displayed on the screen.
  - b. Press the softkey under PM Freq and use numeric keypad or the knob with the cursor keys to set the desired modulating frequency.
6. Press the softkey under PhaseDev to set the phase deviation if needed. Use numeric keypad or the knob with the cursor keys to enter your value.
7. Press the Graph button to view all the waveform parameters.

Remote interface operation

PM:STATE ON

- \* To avoid changing several parameters of waveforms, select phase modulation after all other parameters are set.

#### Carrier waveform

The default carrier waveform is sine. One may also choose from square, ramp and arbitrary waveforms but not pulse, noise and dc waveforms. The default carrier frequency is 1kHz for all waveforms. Each carrier waveform has its own acceptable range of frequencies.

## Remote interface operation

FUNcTion {SINusoid|SQUare|RAMP|USER}

FREQUency {<frequency>|MINimum|MAXimum}

VOLTage {<amplitude>|MINimum|MAXimum}

VOLTage:OFFSet {<offset>|MINimum|MAXimum}

The APPLY command may be used to select the function, frequency, amplitude, and offset in one shot.

## Note

- Limit for carrier frequency

The setup range for carrier frequency differ along with the selected waveform.

Sine : 1 $\mu$ Hz to 50MHz

Square : 1 $\mu$ Hz to 25MHz

Ramp : 1 $\mu$ Hz to 200kHz

Arbitrary : 1 $\mu$ Hz to 10MHz

## Modulating waveform

FGX-295 accepts either internal or external modulating source but not both at the same time. The default source is internal, and the default internal modulating waveform is sine wave. For internal source, one may also choose from square with 50% duty cycle, URamp (Up or Positive ramp with 100% symmetry), DRamp (Down or Negative ramp with 0% symmetry), triangle (ramp with 50% symmetry), noise and arbitrary waveforms. If an arbitrary waveform is chosen, the number of points in the waveform is limited to 4k points with an automatic decimation process.

## Remote interface operation

PM:INTernal:FUNcTion{SINusoid|SQUare|RAMP|NRAMP|TRIangle|NOISe|USER}

## Note

- Limitation on modulation waveform

Square : 50%duty cycle

Ramp : 100%symmetry

Triangle : 50%symmetry

Reverse ramp : 0%symmetry

Arbitrary : The number of point data for waveform will be limited to 4k so that the points over that will automatically be deleted.

## Frequency setup for modulation wave

The default frequency for internal modulating waveform is 10Hz, and the acceptable range is from 2mHz to 20kHz.

When external source is selected, the carrier waveform is modulated with an external waveform present at the Modulation In connector on the rear panel.

Remote interface operation

PM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}

Phase deviation

The phase deviation represents the peak variation in the phase of the modulation output based on that of the carrier waveform. The range of the phase deviation is from 0 to 360 degrees, and the default is 180 degrees.

Remote interface operation

PM:DEVIation {<peak deviation in Hz>|MINimum|MAXimum }

### External modulation source setup

When external source is selected as the source of modulating waveform, the modulation is controlled by the specified phase deviation and the  $\pm 5V$  levels of the external waveform. When the external waveform is at +5V, the output will reach positive maximum phase deviation; e.g., +180 degree phase shift if the specified phase deviation is 180 degrees. When the external waveform is at -5V, the output will reach negative maximum phase deviation; e.g., -180 degree phase shift if the specified phase deviation is 180 degrees.

Remote interface operation

FM:SOURce {INTernal|EXTernal}

### 3-10. FSK modulation

FGX-295 provides the capability to output FSK (Frequency-Shift Keying) modulation where the frequency of the waveform shifts between two frequencies (called “carrier frequency” and “hop frequency”). The shifting rate is determined by the internal or external modulating signal.

How to generate a FSK waveform



Figure 3-20

1. Press one of the following function buttons to choose your carrier waveform: Sine, Square, Ramp, Arb. To select FSK modulation, press  key at front panel.
2. Press the Mod button to toggle on the modulation output.
3. Press the softkey under Type and press the softkey under FSK to select FSK modulation. An FSK modulation output will be generated with the current parameters.
4. Press the softkey under Src to toggle between internal source (Int) and external source (Ext) for selecting modulating waveform source.
5. If internal source is selected, press the softkey under FSK Rate and set the desired shift rate using the numeric keypad or the knob with the cursor keys.
6. Press the softkey under Hop Freq and set the desired hop frequency using the numeric keypad or the knob with the cursor keys.
7. Press the Graph button to view all the waveform parameters.

Remote interface operation

FSKey:STATe ON

- \* To avoid changing several parameters of the waveform, select FSK modulation after all other modulation parameter is set.

### Carrier Waveform

The default carrier waveform is sine. One may also choose from square, ramp and arbitrary waveforms but not pulse, noise and dc waveforms. The default carrier frequency is 1kHz for all waveforms. Each carrier waveform has its own acceptable range of frequencies. Refer to chapter2 for parameter setup such as frequency/interval, amplitude and DC offset.

Remote interface operation

FUNCTion {SINusoid|SQUare|RAMP|USER}

FREQUency {<frequency>|MINimum|MAXimum}

VOLTage {<amplitude>|MINimum|MAXimum }

VOLTage:OFFSet {<offset>|MINimum|MAXimum }

### “Hop” Frequency

The default is 100Hz for all functions. Each carrier waveform has its own acceptable range of allowable hop frequency as follows.

- Sine : 1μHz to 50MHz(at carrier frequency = 1μHz).
- Square : 1μHz to 25MHz(at carrier frequency = 1μHz).
- Ramp : 1μHz to 200kHz(at carrier frequency = 1μHz).
- Arbitrary : 1μHz to 10MHz(at carrier frequency = 1μHz).

When external source is selected as the source of modulating waveform, the modulation is controlled by the signal level of the external waveform. When the external waveform is at the logic *low* level, the carrier frequency is outputted. When a logic *high* is present, the hop frequency is outputted.

Remote interface operation

FSKey: FREQUENCY {<frequency>|MINimum|MAXimum}

### **FSK Rate**

This is the rate at which the output frequency shifts between the carrier frequency and the hop frequency when internal source is selected. The default FSK rate is 10Hz and the range is from 2mHz to 100kHz.

Remote interface operation

FSKey: INTERNAL:RATE {<rate in Hz>|MINimum|MAXimum }

### **Modulating waveform**

FGX-295 accepts either internal or external modulating source but not both at the same time. The default source is internal, and the only choice is square wave with a 50% duty cycle. When external source is selected, the carrier waveform is modulated with an external waveform present at the Trig In connector on the rear panel. The Trig In connector does not have adjustable edge polarity when used in FSK.

Remote interface operation

FSKey: SOURCE {INTERNAL|EXTERNAL}

### **Notes**

- External modulation wave  
Selecting external modulation source, the switch of carrier frequency and the hop frequency depends on the signal level. The output will be carrier wave when low level and hop frequency when high level. Note that the external input terminal (Ext Trig/FSK/Burst) differs from the input terminal (Modulation In) used for AM, FM, PM, PWM modulation.
- Maximum value for external modulation input  
The maximum frequency for external modulation input is up to 100kHz.

### 3-11. PWM waveform

FGX-295 waveform generator provides the capability to output a pulse width modulation (PWM) for pulse carrier waveforms. In PWM, the pulse width of the pulse carrier waveform varies with the modulating waveform. The pulse width can be expressed either in time units or duty cycle (i.e., percentage of the period).

How to set up PWM (pulse width modulation)



Figure 3-21

1. Press the Pulse button to select the pulse carrier waveform and then set the waveform parameters.  
To select PWM modulation, select pulse wave with  key at front panel then select  key.
2. Press the Mod button to toggle the PWM output.
3. Press the softkey under Src to toggle between internal source (Int) and external source (Ext) for selecting modulating waveform source.
4. If internal source is selected:
  - a. Press the softkey under Shape to toggle between different types of modulating waveform.  
If arbitrary waveform (Arb) is selected as modulating signal source, the modulating signal source is depending on the previous waveform selection in arbitrary function. One may toggle the Mod key to see the arbitrary modulating waveform message that temporarily displayed on the screen.
  - b. Press the softkey under PWM Freq and use numeric keypad or the knob with the cursor keys to set the desired modulating frequency.
5. Press the softkey under Width Dev and set the desired value for width deviation by the numeric keypad or the knob with the cursor keys.
6. Press the Graph button to view all the waveform parameters.

#### Remote interface operation

PWM:STATe ON

- \* To avoid changing several parameters of the waveform, select PWM modulation after all other modulation parameters is set.

#### Notes

- Pulse wave modulation  
There is only PWM modulation against the pulse wave.
- Select limit on modulation function  
1 kind only may be selected for modulation function. Simultaneous use of PWM and other modulation mode is not allowed. The modulation mode will OFF at the time of PWM modulation is selected from other modulation mode.

## Setup for pulse wave

Pulse wave only may be selected with PWM modulation.

To select parameter of pulse wave, press  key at the same time that PWM modulation is selected.

Refer to chapter2 for parameter setup such as frequency/interval, amplitude and DC offset.

## Remote interface operation

### FUNCTion PULSe

VOLTage {<amplitude>|MINimum|MAXimum}

VOLTage:OFFSet {<offset>|MINimum|MAXimum}

FUNCTion:PULSe:WIDTh {<seconds>|MINimum|MAXimum}

FUNCTion:PULSe:TRANSition {<seconds>|MINimum|MAXimum}

FUNCTion:PULSe:DCYClE{<percent>|MINimum|MAXimum}

## Pulse frequency setup

Pulse waveform is the only waveform that is available for PWM. The default period for the carrier pulse is 1ms, and the range is from 100ns to 2000s.

## Remote interface operation

PULSe:PERiod {<seconds>|MINimum|MAXimum}

## Modulating waveform

FGX-295 accepts either internal or external modulating source but not both at the same time. The default source is internal, and the default internal modulating waveform is sine wave. For internal source, one may also choose from square with 50% duty cycle, URamp (Up or Positive ramp with 100% symmetry), DRamp (Down or Negative ramp with 0% symmetry), triangle (ramp with 50% symmetry), noise and arbitrary waveforms. If an arbitrary waveform is chosen, the number of points in the waveform is limited to 4k points with an automatic decimation process.

When an external source is selected, the carrier waveform is modulated with an external waveform coming from the Modulation In connector on the rear panel.

## Remote interface operation

PWM:INTernal:FUNCTion{SINusoid|SQUare|RAMP|NRAMP|TRIangle|NOISe|USER}

## Frequency setup for modulation wave

The default frequency for internal modulating waveform is 10Hz, and the acceptable range is from 2mHz to 20kHz.

## Remote interface operation

PWM:INTernal:FREQuency {<frequency>|MINimum|MAXimum }

### Width deviation

The width deviation represents the peak variation in the pulse width of the modulation output based on that of the original pulse carrier waveform. The default deviation is 10 $\mu$ s, and the range is from 0s to 1000s. In addition, it must not be greater than the pulse width of the carrier waveform and is also constrained by the following formulas:

$$\begin{aligned} \text{WidthDeviation} &\leq \text{PulseWidth} - W_{\text{min}} \\ \text{WidthDeviation} &\leq \text{Period} - (\text{PulseWidth} + W_{\text{min}}) \end{aligned}$$

where  $W_{\text{min}}$  is the minimum pulse width.

### Remote interface operation

PWM:DEVIation {<deviation in seconds>|Minimum|Maximum}

### External modulation source setup

When external source is selected as the source of modulating waveform, the modulation is controlled by the specified width deviation and the  $\pm 5\text{V}$  levels of the external waveform. When the external waveform is at +5V, the output will reach the maximum pulse width. When the external waveform is at -5V, the output will reach the minimum pulse width.

### Remote interface operation

PWM:SOURce {INTernal|EXTernal}

### 3-12. Frequency sweep function

Frequency sweep provides the capability to generate a waveform which gradually steps from a start frequency to a stop frequency at a specified rate. It can sweep up or down in frequency with logarithmic or linear spacing. Only sine, square, ramp and arbitrary waveforms are allowed to work with frequency sweep.

How to set up frequency sweep



Figure 3-22

1. Press one of the following function buttons to choose your waveform for sweeping: Sine, Square, Ramp, Arb. To select sweep function, select  key at front panel.
2. Press the Sweep button to enable or disable the sweep mode. To enable the sweep mode, make sure the Sweep button is lit.
3. To configure the sweep mode setting, press the softkey under Type to enter the sweep mode setup menu:
  - a. To specify the Logarithmic sweep, press the softkey under Log.
  - b. To specify the Linear sweep, press the softkey under Linear.
  - c. To specify the Arbitrary sweep, press the softkey under Arb. If Arb is selected, the arbitrary wave adapted becomes the chosen arbitrary wave pattern.
4. To specify the start frequency, press the softkey under Start/Cntr to toggle. Make sure both Start and Stop are highlighted. Use the numeric keypad or the knob with cursor keys to change the value. Follow the same step to specify the stop frequency under the softkey Stop/Span.
5. To specify the center frequency, press the softkey under Start/Cntr to toggle. Make sure both Cntr and Span are highlighted. Use the numeric keypad or the knob with cursor keys to change the value. Follow the same step to specify the frequency span under the softkey Stop/Span.
6. To specify a desired sweep time, press the softkey under Sweep Time. Use the numeric keypad or the knob with cursor keys to change the value.
7. To configure the marker, press the softkey under Mkr to toggle between Freq and OFF. If Freq is selected, Use the numeric keypad or the knob with cursor keys to set the marker frequency.
8. To configure the trigger setting, press the softkey under Trig Setup to enter the trigger setup menu:
  - a. To specify the trigger source, press the softkey under Src and then select among Int (internal), Ext (external) and Man (manual).
  - b. If internal source or manual trigger is selected, you may configure the trigger out signal by pressing the softkey under Trig Out and then select among OFF, rising-edge trigger and falling-edge trigger.
  - c. If external source is selected, you may press the softkey under Slope to toggle between rising edge trigger and falling edge trigger.
  - d. Press the softkey under DONE to finish the trigger setting.
9. Press the Graph button to view all the waveform parameters.

Remote interface operation

SWEep:STATe ON

\* To avoid changing several parameters of the waveform, make sweep mode ON after all other parameters is set.

### **Start frequency and stop frequency**

The waveform generator begins sweeping from the start frequency to the stop frequency. The waveform generator will sweep down when the start frequency is greater than the stop frequency. The waveform generator will sweep up when the stop frequency is greater than the start frequency.

The default start frequency is 100Hz and the stop frequency is 1kHz. The allowable range is 1μHz to 50MHz for sine, 1μHz to 25MHz for square, 1μHz to 200kHz for ramp, and 1μHz to 10MHz for arbitrary waveforms.

Remote interface operation

FREQuency:START {<frequency>|MINimum|MAXimum }

FREQuency:STOP {<frequency>|MINimum|MAXimum }

### **Center frequency and frequency span**

Center frequency and frequency span provide another way to set the frequency sweep range. The default center frequency is 550Hz. The allowable range is 1μHz to 50MHz for sine, 1μHz to 25MHz for square, 1μHz to 200kHz for ramp, and 1μHz to 10MHz for arbitrary waveforms. The default frequency span is 900Hz. The allowable range of the frequency span is depending on center frequency setting and waveform selection. Set positive frequency span for sweeping up and negative frequency span for sweeping down.

Remote interface operation

FREQuency:CENTer {<frequency>|MINimum|MAXimum }

FREQuency:SPAN {<frequency>|MINimum|MAXimum }

### **Sweep mode**

The default sweep mode is linear where the waveform generator sweeps the frequency with spacing calculated in a linear function. In logarithmic sweep mode, the waveform generator sweeps with spacing calculated in a logarithmic function. In Arbitrary sweep mode, the waveform generator sweeps with spacing calculated in a wave pattern depending on chosen arbitrary waveform.

Remote interface operation

SWEep:SPACing {LINear|LOGarithmic|USER}

## Sweep time

The sweep time is the period of time (in seconds) required to sweep from the start frequency to the stop frequency. The number of discrete frequency points is calculated by the waveform generator according to the sweep time specified. The default sweep time is 1 second, and the range is from 1ms to 500s.

Remote interface operation

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

## Marker frequency

Marker frequency provides a way to control the Sync signal outputted on the front panel Sync connector. For sweeps with Marker On, the Sync signal is a TTL “high” at the beginning of the sweep and turns to “low” at the marker frequency. For sweeps with Marker Off, the Sync signal is a square waveform with a 50% duty cycle. That is, the Sync signal is a TTL “high” at the beginning of a sweep and turns to “low” at the midpoint of the sweep. The frequency of the Sync signal is the reciprocal of the specified sweep time.

The default marker frequency is 500 Hz. The range of the marker frequency is depending on stop frequency setting or frequency span setting. The marker frequency must be less than or equal to the maximum output frequency.

Remote interface operation

```
MARKer:FREQuency {<frequency>|MINimum|MAXimum }  
MARKer {OFF|ON}
```

## Trigger source

The waveform generator outputs a single sweep when it receives a trigger signal, and it keeps outputting the same type of waveform with the start frequency before it receives next trigger and sends out another sweep.

Trigger Source can be internal, external or manual, and the default is internal.

- With internal trigger source, the waveform generator continuously outputs sweeps with the specified sweep time.
- With external trigger source, the trigger signal is a TTL pulse with specified polarity applied to the Ext Trig connector on the rear panel. Note that the trigger period must not be less than 1ms plus the specified sweep time.
- If manual trigger is selected, the waveform generator sends out a sweep each time the Trigger button on the front panel is pressed.

Remote interface operation

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

## Trigger out signal

A “trigger out” signal is provided on the rear panel Ext Trig / FSK / Burst connector. When enabled, a TTL-compatible square waveform with either a rising or falling edge is outputted at the Ext Trig / FSK / Burst connector with the sweep output.

- With internal trigger source, a square waveform with 50% duty cycle is outputted at the Trig Out connector with the sweep output.
- With external trigger source, there is no signal outputted at the Ext Trig / FSK / Burst connector because it shares the same connector with Ext Trig for receiving the external trigger signal.
- With manual trigger, the waveform generator outputs a pulse, with pulse width > 1 $\mu$ s, at the Trig Out connector at the beginning of each sweep.

## Remote interface operation

Use this command to specify whether the sweep is triggered on the rising or falling edge:

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

Use the following commands to configure the Trig Out signal:

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

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

## 3-13. Burst operation

FGX-295 offers the burst operation to generate the selected type of waveform with specified number of cycles, called a burst. Bursts may be triggered internally or manually. Bursts can also be triggered or gated externally by the signal applied to the Ext Trig / FSK / Burst connector on the rear panel. Sine, ramp, pulse, square and arbitrary waveforms are allowed to output in both the triggered and gated burst modes. Noise is available only in the gated burst mode.

## How to set up burst output

1. Press one of the function buttons to select the burst waveform (dc is not allowed and noise is allowed only in the gated burst mode).
2. Specify the waveform frequency for the selected function.
3. Press the Burst button  to toggle the burst mode.
4. Press the N Cyc/Gated softkey to toggle between the triggered burst mode and the external gated mode. Make sure that your selection is highlighted.



Figure 3-23

## Triggered burst mode

5. Press the #Cyc/Inf softkey to toggle between finite and infinite burst count:
  - To set finite burst count, make sure #Cyc is highlighted. Then set the burst count using the numeric keypad or the knob with the cursor keys.
  - To set infinite burst count, press the #Cyc/Inf softkey to toggle and make sure Inf is highlighted.
6. Press the Start Phase softkey and enter the desired phase using numeric keypad or the knob with the cursor keys.
7. Press the Trig Setup softkey to enter the triggering setup menu:
  - a. To select a trigger source, press the Src softkey and then select among Int (internal), Ext (external) and Man (manual).
  - b. If internal source or manual trigger is selected, you may configure the trigger out signal by pressing the softkey under Trig Out and then select among OFF, rising-edge trigger and falling-edge trigger.
  - c. If external source is selected, you may press the softkey under Slope to toggle between rising edge trigger and falling edge trigger.
    - a. Press the softkey under DONE to finish the trigger setting.



Figure 3-24

8. If internal trigger source is selected, press the Burst Perd softkey and enter the desired burst period using the numeric keypad or the knob with the cursor keys.
9. Press the Graph button to view all the burst parameters.

## External gated burst

1. To specify the polarity of the external signal for gating, press the Polar softkey to toggle between Neg and . Make sure that your selection is highlighted.
2. Press the Start Phase softkey and enter the desired phase using numeric keypad or the knob with cursor keys.
3. Press the Graph button to view all the burst parameters.



Figure 3-25

## Remote interface operation

### BURSt:STATe ON

- \* To avoid changing several parameters of the waveform, select burst mode after all other parameters is set.

## Selection of burst kinds

There are two modes in burst function which is trigger burst and gate burst mode. (Simultaneous selection is not allowed) Valuable parameter on each mode is shown in table 3-1

Table 3-1

The available parameters in each burst mode.

		Burst Count	Burst Period	Burst Phase	Ext Trig Signal Polarity
Triggered mode	<b>Internal</b>	○	○	○	
	<b>External, Manual</b>	○	○		
Gated mode				○	○

### Triggered Burst Mode

This is the default burst mode. FGX-295 outputs a waveform with a specified number of cycles, called burst count, each time it receives a trigger. When the specified number of cycles is outputted, the waveform generator pauses and waits for next trigger. One may choose to trigger the bursts using internal source, to manually press the Trigger button on the front panel to trigger a burst, to apply an external signal at the Ext Trig / FSK / Burst connector on the rear panel, or to send a software trigger through the remote interface.

### External gated burst mode

In gated burst mode, the length of a burst is determined by the voltage level of the external signal applied at the Ext Trig / FSK / Burst connector on the rear panel. During the time when the external signal is logic true, the waveform generator outputs a continuous waveform. When the gate signal is logic false, the output wave remains at the same voltage level as the starting burst phase of the selected waveform. The output stops immediately following a noise burst when the gate signal becomes logic false.

### Remote interface operation

BURSt:MODE {TRIGgered|GATed}

### Polarity of external gated signal

Function that setups the polarity of the external gated signal. Initial setup value is set to 「POS」(High level).

At burst mode, select 「Pos」or「Neg」using softkey of 「Polar」function by selected status of 「Gated」(Gate mode). Softkey of 「Polar」function will switches the 「Pos」or「Neg」.

「Pos」=High level

「Neg」=Low level

Remote interface operation

BURSt:GATE:POLarity { NORMAl|INVerted }

### Waveform frequency

The *waveform frequency* defines the frequency of the output waveform while trigger signal is logic true. In the triggered mode, the specified number of cycles is outputted at the waveform frequency. In the gated mode, the waveform frequency is outputted when the external gate signal is true.

The default waveform frequency is 1kHz. The range is from 1μHz to 200kHz for ramps, 1μHz to 25MHz for square, 1μHz to 10MHz for pulse and arbitrary waveforms, 1μHz to 50MHz for Sine. In internally triggered burst mode, the minimum frequency is 2.001mHz. For sine and square waveforms, frequencies greater than 10MHz are allowed only when an infinite burst count is set.

Remote interface operation

FREQuency {<frequency>|MINimum|MAXimum}

Also, using APPLy command, function, frequency, amplitude, offset may be setup by one command as well.

Note

- Limitation on noise wave  
Within the basic wave which adopts burst function, gated burst mode only may be selected for noise wave.
- Limitation on sine, square wave  
If sine and square wave is selected for the basic wave which adopts burst function, the frequency over 10MHz, the burst count sets to infinite will only be allowed.

### Burst cycle setup

Setup the output cycle when the burst is output. This parameter is only used for the burst mode of internal, external source. The setup range for cycle number is 1 to 50,000 (or infinite) and is set by 1 cycle resolution. Initial value is set to 1 cycle.

Keeping the selected status of burst mode, select with softkey of 「#Cyc/Inf」function. Input value when 「#Cyc」is highlighted. To select infinite burst, select softkey of 「#Cyc/Inf」function again. The waveform will output pressing the trigger key keeping the status that 「Inf」 is highlighted. Press trigger key again to terminate waveform output.

Remote interface operation

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

## Note

- Operation while internal trigger burst mode.

When trigger source is selected, the designed cycle number of burst wave will be output consecutively along with the setup burst cycle.

Setup of cycle number of burst should be less than the sum of burst cycle and basic waveform frequency.

$$\text{Burst cycle number} < \text{Burst cycle} \times \text{Frequency of basic wave}$$

When the setup of the burst cycle number is over the above, the burst cycle will automatically be adjusted to the maximum value. However, the frequency of the basic wave will not be changed.

- Operation for gated burst mode

The setup for burst cycle number will be ignored when the gated burst mode is selected. However, setup change is possible since setup from the remote interface is possible while gated burst mode as well. The change will be saved and will be adopted while trigger burst mode is selected at next time.

## Burst period setup

The burst period represents the time interval between the start times of two consecutive bursts. It is only used in the internally triggered burst mode. The default burst period is 10ms and the range is from 1 $\mu$ s to 500 seconds.

The burst period must be long enough for the generator to output the specified burst count. If the burst period is set too short, the waveform generator automatically adjusts it to the shortest value that can accommodate the specified burst count and waveform frequency:

$$\text{BurstPeriod} > \frac{\text{BurstCount}}{\text{WaveformFrequency}} + 200\text{ns}$$

## Remote interface operation

BURSt:INTernal:PERiod {<seconds>|MINimum|MAXimum}

## Note

- Operation while internal trigger burst mode

When trigger burst mode is selected, a consecutive output of the designed cycle number of burst wave will be made according to the cycle setup of the burst. The setup of burst cycle is the parameter used only for internal trigger burst mode. Manual trigger, external trigger and gate mode selection will be ignored.

## **Burst phase setup**

Burst Phase defines the starting phase of a burst. The default is 0 degree and the range is from -360 degrees to +360 degrees. You can only set the burst phase in degree from the front panel operation, while degrees and radians are both available from the remote interface operation.

For sine, square and ramp waveforms, zero degree is the point at which the waveform crosses 0V or the dc offset when ascending. For arbitrary waveform, it is the first waveform point specified. The burst phase has no effect on pulse or noise waveform.

In the gated burst mode, when the gate signal turns false, the waveform generator will complete the current waveform and then stops. At this point, the output will remain at the same voltage level as the starting burst phase.

Remote interface operation

```
BURSt:PHASe {<angle>|MINimum|MAXimum}
```

## **Trigger source setup**

The default trigger source is internal, and the available options are internal, external and manual. When the waveform generator is set to be in the triggered burst mode, it generates a burst with specific number of cycles each time a trigger is received. Then it stops and waits for the next trigger event to occur. When the trigger source is internal, the bursts are outputted at a rate determined by the burst period. When the trigger source is manual, the burst is outputted only when the Trigger button is pressed.

When the trigger source is external, the waveform generator outputs a burst each time a TTL pulse with specified polarity is received at the Ext Trig connector on the rear panel. A received trigger signal is ignored during the output of a burst.

When the trigger source is set to be external or manual, the burst count and burst phase remain the same but the burst period is ignored.

Remote interface operation

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

## **Edge setup for external trigger source**

When external trigger is selected, the selection of either rising or falling edge of the input signal is possible. When external trigger source is selected, initial setup selects rising.

Selection of trigger source will select burst mode and select softkey of 「Trig Setup」function keeping the external trigger. Switching over the softkey of 「Slope」 function, switch over the rising, falling edge is possible.

Remote interface operation

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

## Trigger Out Signal

In internally or manually triggered burst mode, one may enable to output a trigger out signal at the Ext Trig connector on the rear panel that is synchronized with the burst output. When enabled, a TTL-compatible square waveform with either a rising or falling edge is outputted at the Ext Trig connector at the beginning of the burst. The trigger out signal is not available in the externally triggered burst mode as an external trigger signal is applied to the same Ext Trig connector.

With internal trigger source, the trigger out signal is a square waveform with 50% duty cycle. With manual trigger source, the trigger out signal is a pulse with pulse width > 1 $\mu$ s.

Remote interface operation

OUTPut:TRIGger:SLOPe {POSitive|NEGative}

OUTPut:TRIGger {OFF|ON}

## 3-14. Pattern output function of arbitrary wave

In addition to defining arbitrary waveforms, FGX-295 waveform generator provides the capability of outputting a specified pattern of up to 256k points in 16-bit resolution. Similar to arbitrary waveforms, pattern output provides five built-in patterns and up to four user-defined patterns that are stored in non-volatile memory. The built-in patterns are exponential-rise, exponential-fall, negative-ramp, sinc, and cardiac. The default pattern output is an exponential-rise wave.

### User-defined patterns

FGX-295 supports user-defined patterns. You may use the Wavepatt waveform and pattern editor to create the patterns you want or import the waveforms from the oscilloscope that you captured previously. For more information on the user-defined patterns, please refer to the on-line help of Wavepatt.

## How to set up pattern output

1. Press the Utility button  to enter the utility menu.
2. Press the softkey under [PATT MODE] to enter the PATTERN menu.
3. Press the softkey under Fclk/Perd to toggle between Fclk (frequency) and Perd (period).
4. Press the softkey under Start Addr (End Addr) for setting the start (end) point of the pattern to output. Use the knob with the cursor keys to change the value. Or use the numeric keypad to enter a new value and then press the softkey under Enter to finish the entry or the softkey under Cancel to withdraw the changes.
5. Press the softkey under RPT. to toggle between ON and OFF to enable/disable repeating output of the pattern.
6. Press the softkey under Select Pattern to enter selection menu:
  - a. Press the softkey under Built-In and choose the desired pattern from the five built-ins by pressing the corresponding softkey.
  - b. Press the softkey under Store Wform and choose the desired user-defined pattern by pressing the corresponding softkey.
  - c. One may delete a user-defined pattern by pressing the softkey under Delete Store and choose the pattern to delete by pressing the corresponding softkey.
7. To configure the trigger setting, press the softkey under Trig Setup to enter the trigger setup menu:
  - a. To specify the trigger source, press the softkey under Src and then select among Ext (external) and Man (manual).
  - b. If manual trigger is selected, you may configure the trigger out signal by pressing the softkey under Trig Out and then select among OFF, rising-edge trigger and falling-edge trigger.
  - c. If external source is selected, you may press the softkey under Slope to toggle between rising edge trigger and falling edge trigger.
  - d. Press the softkey under DONE to finish the trigger setting.

## Pattern Out

This is a parallel interface including an edge-selectable clock and 16-bit data. You can use this interface to send any data through this interface at the speed 1uHz to 50MHz.

Press the soft key [PATT Mode]  to select Pattern Mode

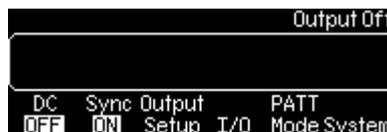


Figure 3-26

Set the frequency of the pattern clock, 1uHz to 50MHz.



Figure 3-27

Select file name of the pattern, such as EXP\_RISE, EXP\_FALL, NEG\_RAMP, SINC, CARDIAC. This setting is same as arbitrary waveform selection.



Figure 3-28

Set the start address (min. 1) of the pattern.



Figure 3-29

Set the end address of the pattern.



Figure 3-30



Figure 3-31

Set the trigger source of the pattern, such as from EXT or BUS. (Please note that there is no IMM internal trigger.)

Set the Trigger slope of the pattern out to be a positive (rising) edge or a negative (falling) edge.

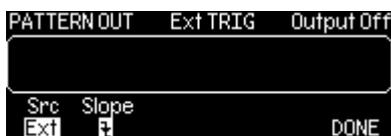


Figure 3-32

Set the pattern repeat again, yes (ON) or no (OFF).

Select which clock edge to latching data of the pattern, positive (rising) edge or negative (falling) edge.



Figure 3-33

## Remote interface operation

PATTERN OUT Commands: (Add Pattern Out Commands)

FUNCTION:PATTERN {data name}

Select file name of the pattern, such as EXP\_RISE, EXP\_FALL, NEG\_RAMP, SINC, CARDIAC.

FUNCTION:PATTERN?

Inquire and gain the file name of the pattern.

DIGital:PATTERN:FREQuency {<frequency>, MINimum, MAXimum}

Set the frequency of the pattern, 1uHz to 50MHz.

DIGital:PATTERN:FREQuency? {MINimum, MAXimum}

Inquire and gain the minimum or maximum frequency of the pattern.

DIGital:PATTERN:STARt {<address>, MINimum, MAXimum}

Set the start address (min. 1) of the pattern.

DIGital:PATTERN:STARt? {MINimum, MAXimum}

Inquire and gain the start address of the pattern.

DIGital:PATTERN:STOP {<address>, MINimum, MAXimum}

Set the end address of the pattern.

DIGital:PATTERN:STOP? {MINimum, MAXimum}

Inquire and gain the end address of the pattern.

DIGital:PATTERN:REPeat {ON, OFF}

Set the pattern repeat again, yes (ON) or no (OFF).

DIGital:PATTERN:REPeat?

Inquire and gain the pattern out status, repeated or not.

DIGital:PATTERN:CLOCK {POS, NEG}

Set the latching data clock of the pattern to be a positive (rising) edge or a negative (falling) edge.

DIGital:PATTERN:CLOCK?

Inquire and gain the latch data clock status of the pattern in positive (rising) or negative (falling) edge.

DIGital:PATTERN:TRIGger:SOURce {EXT, BUS}

Set the trigger source of the pattern, such as from EXT or BUS. (Please note that there is no IMM internal trigger.

DIGital:PATTERN:TRIGger:SOURce?

Inquire and gain the trigger source of the pattern.

DIGital:PATTERN:TRIGger:SLOPe {POS, NEG}

Set the Trigger slope of the pattern to be a positive (rising) edge or a negative (falling) edge.

DIGital:PATTERN:TRIGger:SLOPe?

Inquire and gain the trigger slope status of the pattern.

DIGital:PATTERN:OUTPut:TRIGger {OFF, ON}

Set the trigger of the pattern out to be ON or OFF.

DIGital:PATTERN:OUTPut:TRIGger?

Inquire or gain the trigger status of the pattern out.

DIGital:PATTERN:OUTPut:TRIGger:SLOPe {POS, NEG}

Set the Trigger slope of the pattern out to be a positive (rising) edge or a negative (falling) edge.

### DIGital:PATtern:OUTPut:TRIGger:SLOPe?

Inquire and gain the trigger slope status of the pattern out in positive (rising) or negative (falling) edge.

### DATA:PATTERN VOLATILE, <binary block>

Download binary values into volatile memory. You can download from 1 to 262144 (256k) points per waveform in IEEE-488.2 binary block format.

### Digital Output/LVTTL terminal

The attached 40 pin parallel out cable will be connected to the receiver or devices.

### Digital Output/LVTTL pin out structure

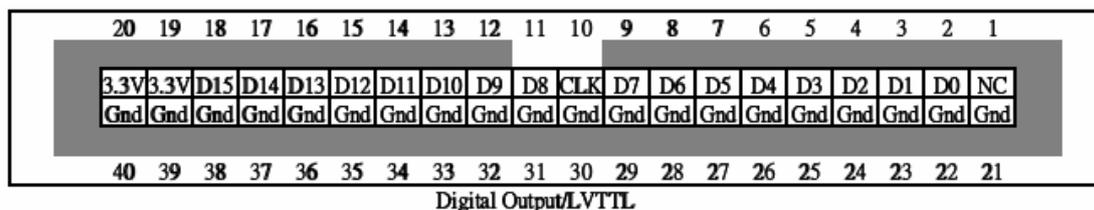


Figure 3-34

## 4. System operations

This chapter explains the basic system related operations such as trigger or device status etc.

### 4-1. Trigger function

This feature is only available for bursts and sweeps. There are three options to choose from: internal triggering, external triggering and manual triggering. The default is the internal triggering in which the waveform generator continuously outputs the selected waveform.

The Ext Trig connector on the rear panel is used to receive the external trigger signal. The waveform generator outputs a burst or a sweep each time the Ext Trig connector receives a TTL pulse. One may instruct the waveform generator to trigger on the ascending edge or the descending edge of the external trigger signal.

In manual triggering, the waveform generator outputs a burst or a sweep each time the Trigger button on the front panel is pressed. The Trigger button is lit when the waveform generator is waiting for the next trigger event. Triggering is disabled when functions other than burst or sweep is chosen.

#### How to choose a trigger source

1. Press the Trig Setup softkey after burst or sweep is activated.
2. Press the Src softkey and then select among Int (internal), Ext (external) and Man (manual). After your selection is made, the trigger setting will be shown on the display.
3. Press the DONE softkey to finish the setting.

Note that the trigger source setting is stored in volatile memory. The default setting will be restored after the power is cycled.

#### Remote interface operation

TRIGger:SOURce {IMMediate|EXTernal|BUS}

When parameter for output waveform using AppLy command, internal trigger will automatically selected for trigger source.

#### How to specify the trigger slope with external trigger source

1. After choosing Ext as your trigger source, press the softkey under Slope to toggle between rising edge trigger and falling edge trigger.
2. Press DONE to finish the setting.

#### Remote interface operation

TRIGger:SLOPe {POSitive|NEGative}

## Software trigger function

In software triggering, a bus command is sent through the remote interface to trigger the waveform generator. The waveform generator outputs a burst or a sweep when it receives one such command. The operation is similar to the Trigger button on the front panel for manual triggering.

### Remote interface operation

TRIGger:SOURCe BUS

and send one of the following commands to trigger:

\*TRG

TRIGger

## External trigger function

An external signal is applied at the Ext Trig connector on the rear panel in the following five operation modes:

- Externally-modulated FSK mode: The carrier frequency is outputted when a logic low level is present at the connector, and the hop frequency is outputted when a logic high level is present. The maximum shifting rate is 100kHz.
- Triggered sweep mode: The waveform generator outputs a sweep on the specified edge each time a TTL pulse is received at the Ext Trig connector.
- Triggered burst mode: The waveform generator outputs a burst each time a TTL pulse with specified polarity is received at the Ext Trig connector.
- External gated burst mode: The waveform generator outputs a continuous waveform when the external signal is true. When the external signal turns false, the waveform generator completes the current cycle and then stops at the same voltage level as the starting burst phase. For noise waveform, the output stops immediately when the external signal turns false.

## Trigger out signal function

FGX-295 may be configured to send out a TTL-compatible square wave at the Ext Trig connector on the rear panel with either a rising or a falling edge at the beginning of a sweep or burst.

- With internal trigger source, the trigger out signal is a square wave with 50% duty cycle. The period of the trigger out signal is equal to the sweep time or the burst period.
- With the manual trigger or BUS trigger source, the trigger out signal is a pulse with pulse width > 1 $\mu$ s.
- With external trigger source, there is no trigger out signal as the Ext Trig connector is used to receive the trigger input signal.

### How to set up the trigger out signal

1. After sweep or burst mode is activated, press the Trig Setup softkey to enter the trigger setup submenu.
2. Press the Trig Out softkey and then select among OFF, rising-edge trigger and falling-edge trigger.
3. Press the softkey under DONE to finish the setting.

Remote interface operation

OUTPut:TRIGger:SLOPe {POSitive|NEGative}

OUTPut:TRIGger {OFF|ON}

## 4-2. Status saving function

FGX-295 provides five storage locations in non-volatile memory for user to store instrument state. The stored instrument state holds all the parameters for the selected function, including the waveform, frequency, dc offset, amplitude, duty cycle, symmetry, modulation type and modulation parameters.

But the first location, indexed at "0", is assigned the factory default settings. The user cannot change the data.

The user may assign a custom name to any of these locations (1 - 4) from the remote interface. The name can contain up to 12 characters, but the first character has to be a letter and the rest of them can be numbers, letters or the underscore character ("\_").

### How to store/recall the instrument state

1. Press the Store/Recall button  to enter the instrument state submenu.

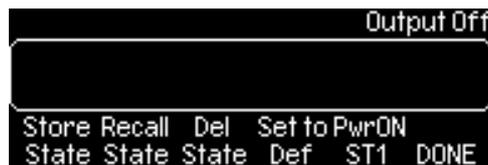


Figure 4-1

2. To store an instrument state, press the softkey under Store State to enter the store-state submenu:
  - a. Press the softkey under your desired location number to choose the location (only 1 to 4 are available from front panel operation).
  - b. You may specify a name for the selected memory location. Use the numeric keypad and the knob with the cursor keys for entry.
  - c. Press the Store State softkey to store the present setting in the memory or the Cancel softkey to cancel.



Figure 4-2

3. To recall a saved state, press the Recall State softkey to enter the recall-state submenu:
  - a. Press the softkey under your desired location number to recall the state from that memory location.
  - b. Press the Recall State softkey to restore from the selected state in the memory or the Cancel softkey to cancel.



Figure 4-3

4. To delete a saved state, press the Del State softkey to enter the delete-state submenu:
  - a. Press the softkey under your desired location number for deletion.
  - b. Press the Delete State softkey to delete the selected state or the Cancel softkey to cancel.

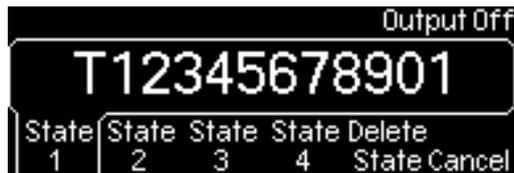


Figure 4-4

5. To set the power-on state (i.e., the instrument state restored when the waveform generator is powered on), press the Power On softkey to enter the power-on-state submenu:
  - a. Press the softkey under your desired location number or the softkey under State Def (factory default).
  - b. Make sure your selection is present under the Power On softkey.

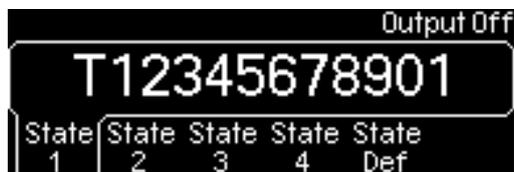


Figure 4-5

6. To restore the instrument state to the factory default, press the softkey under Set to Def. A message will be displayed for you to confirm the action. Press the Yes softkey to confirm or the Cancel key to cancel the operation. See Figure 4-19.

Remote interface operation

- \*SAV {1|2|3|4}
- \*RCL {0|1|2|3|4}
- MEMory:STATE:NAME {1|2|3|4} [,<name>]
- MEMory:STATE:RECall:SELEct {0|1|2|3|4}

### 4-3. Display control function

FGX-295 provides an option to turn off the front display screen. One may choose to do it for security reason or for speeding up the command execution from the remote interface. This option is available from the remote operation only.

#### Remote interface operation

Use this command to turn off the front panel display:

DISP OFF

Use this command to display a message and turn the display back on:

DISP:TEXT 'message to display'

Use this command to clear the current message on display.

DISP:TEXT CLEAR

#### Notes

- The display is automatically enabled when the waveform generator is powered on, the \*RST (reset) command is issued or it is returned to the local front-panel operation.
- Error messages are always displayed even when the display is turned off.
- The display setting may be saved with the \*SAV command. When the instrument state is restored using the \*RCL command, the display setting will return to the saved state.

### 4-4. Beeper function

FGX-295 normally lets out a beeper when an error is detected. One may turn off the beep when needed. The beeper setting is stored in non-volatile memory, so the setting remains even after the waveform generator is turned off or the reset command is issued from the remote operation.

#### How to turn ON/OFF the beeper

1. Press the Utility button  and then press the softkey under System to enter system related submenu.
2. Press the Beep softkey to toggle between ON and OFF.

#### Remote interface operation

To beep one time, use the command below.

SYSTem:BEEPer

To setup ON/OFF of beeper, use following command.

SYSTem:BEEPer:STATe {OFF|ON}

#### 4-5. Sound ON/OFF function

FGX-295 normally sounds when the operation buttons and knob are used. One may turn off the sound when needed. The sound setting is stored in non-volatile memory, so the setting remains even after the waveform generator is turned off or the reset command is issued from the remote operation.

##### How to turn ON/OFF the beeper

1. Press the Utility button  and then press the softkey under System to enter system related submenu.
2. Press the Sound softkey to toggle between ON and OFF.

##### Remote interface operation

To beep one single time, use the command below.

```
SYSTem:SOUNd
```

To setup ON/OFF of beeper, use following command.

```
SYSTem:SOUNd:STATe {OFF|ON}
```

#### 4-6. Error store function

The waveform generator can store up to 20 syntax or hardware errors in its error queue. Each error string may contain up to 255 characters. The waveform generator beeps every time it detects an error (unless the beeper is turned off). Errors are stored in first-in-first-out (FIFO) order and they are cleared once read. To clear the error queue from the remote interface, use the \*CLS command. The error queue will not be cleared by the \*RST command, but will be cleared when the waveform generator is turned off. Refer to Chapter 6 for more details about the error queue and error messages.

##### How to read error messages

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

##### Remote interface operation

Use this command to read one error from the error queue:

```
SYSTem:ERRor?
```

Use this command to clear all the errors in the error queue:

```
*CLS
```

##### Notes

- Clear condition of error message  
Stored error message will be cleared along with following 3 conditions.  
When power ON  
When \*CLS command is issued from remote interface

When reading error queue

- Data for error queue

When over 20 errors occurred, the last error saved into the error queue will be replaced by 「Queue Overflow」 and any following errors will not be stored until error queue is cleared. Also, if there is no error, 「No error」will be returned.

#### 4-7. Self test function

##### **Self test operation**

Select  key. Select soft key of 「System」function and select softkey of 「Test Cal」function and select softkey of 「Self Test」then the self test will be executed. 「Self-Test Passed」message appears which guarantee the normal operation of the product.

## 5. Remote interface function

FGX-295 supports three remote interfaces: USB, LAN and GP-IB (IEEE-488). For GP-IB, you will need an additional GP-IB interface card installed. This chapter describes the operations for setting up these remote interfaces and lists the SCPI (Standard Commands for Programmable Instrument) commands available to control the waveform generator remotely. For first time SCPI users, refer to Appendix B for the introductory materials on SCPI commands.

### 5-1. Remote interface setup

FGX-295 have built in a web server, one may use the Internet Explorer of Microsoft® or Firefox of Mozilla Foundation to remotely control the waveform generator through the LAN interface. No extra software is needed.

#### 5-1-1. USB Interface

##### How to set up USB interface

Connect the proper USB cable to the USB connector on the rear panel and your computer. The waveform generator sets up the USB interface automatically once the cable is properly connected. You may navigate from the Utility button , the IO softkey and then the Show USB Id softkey to verify the USB interface ID.

#### 5-1-2. GP-IB Interface

Before you may set up the GP-IB interface, you need to insert the GP-IB interface card into the interface slot on the rear panel, install the FGX-295 application in your PC and execute the application. To set up the GP-IB interface, connect the waveform generator and your computer with a proper GP-IB cable and assign a GP-IB address for the waveform generator. The factory default GP-IB address is 10. It can be set to any number between 0 and 30. The address is stored in non-volatile memory, so it is not affected by power cycle or a remote interface reset command. Avoid using the same address for the GP-IB interface card in your computer.

##### How to set up GP-IB interface

1. Press the Utility button  and then the I/O softkey.
2. Press the softkey under GP-IB Addr and enter a GP-IB address using the numeric keypad or the knob.
3. Press the softkey under DONE to finish the entry.

#### Remote interface operation

There is no way to setup GP-IB address via remote interface. Please operate from the panel keys.

### 5-1-3. LAN Interface

You need to set up a few parameters before you can use the LAN (Local Area Network) interface. Contact your network administrator to obtain the correct LAN settings for your waveform generator. These settings and the corresponding configurations are described below.

#### DHCP

If DHCP is used, the device will automatically obtain an IP address from the DHCP server in the network. If FGX-295 fails to get an IP address from DHCP, the current IP address setting will be used. Setup will be stored in a non-volatile memory and will not affect while power ON or reset command of the remote interface.

#### DHCP ON/OFF setup

Select  key. Selecting softkey of 「I/O」function, sub menu will appear. Select softkey of 「LAN」function then select softkey of 「Modify Set」function from the displayed menu. Also, select softkey of 「IP Setup」function of the displayed menu and setup ON/OFF of the DHCP by softkey of 「Mode」function. Switch between (DHCP=ON) ⇔ 「Man」(DHCP=OFF: IP Manual setup of IP address) will be made each time that softkey of 「Mode」function is selected. Complete the setup value pressing softkey of 「DONE」function.

#### Remote interface operation

There is no way to setup GP-IB address via remote interface. Please operate from the panel keys.

#### Note

- IP address assign

While DHCP is in setup for 「ON」(Auto), IP address set manually will be selected if valuable IP address could not assigned

#### IP Address

An IP address is an unique identifier assigned to a device in the network. It is expressed in the dot notation: “nnn.nnn.nnn.nnn” where “nnn” is a byte value from 0 to 255. The value is stored in non-volatile memory, so it is not affected by power cycle or the remote interface reset command.

#### IP address setup

Select  key. Selecting softkey of 「I/O」function, sub menu will appear. Select softkey of 「LAN」function then select softkey of 「Modify Set」function from the displayed menu. Also, select softkey of 「IP Setup」function of the displayed menu and setup ON/OFF of the DHCP by softkey of 「Mode」function. Selecting softkey of 「Mode」function, setup menu of IP address will appear and setup will be possible. Complete the setup value pressing softkey of 「DONE」function.

#### Remote interface operation

There is no way to setup GP-IB address via remote interface. Please operate from the panel keys.

## Subnet mask

Networking administrator uses *subnetting* to divide a network so that the network traffic is well distributed and the administration process is simplified. The subnet mask represents the portion of the host address to be used to identify the subnet. For example, the subnet mask 255.255.255.0 for a host IP address 10.10.3.101 indicates that the host belongs to the subnet of hosts addressed from 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 by power cycle or the remote interface reset command.

If DHCP is used, the device will automatically obtain a subnet mask from the DHCP server.

### Subnet mask setup

Select  key. Selecting softkey of 「I/O」function, sub menu will appear. Select softkey of 「LAN」function then select softkey of 「Modify Set」function from the displayed menu. Also, select softkey of 「IP Setup」function of the displayed menu and setup ON/OFF of the DHCP by softkey of 「Mode」function. Selecting softkey of 「Mode」function, setup menu of subnet mask will appear and setup will be possible. Complete the setup value pressing softkey of 「DONE」function.

### Remote interface operation

Subnet mask may not be setup from the remote interface. Please operate from panel key.

## Default gateway

A gateway is a network device that provides connectivity between two networks. The default gateway setting is the IP address of the gateway that the waveform generator is connected to. The value is stored in non-volatile memory, so it is not affected by power cycle or the remote interface reset command.

If DHCP is used, the device will automatically obtain the IP address of the default gateway from the DHCP server.

### Default gateway setup

Select  key. Selecting softkey of 「I/O」function, sub menu will appear. Select softkey of 「LAN」function then select softkey of 「Modify Set」function from the displayed menu. Also, select softkey of 「IP Setup」function of the displayed menu and setup ON/OFF of the DHCP by softkey of 「Mode」function. Selecting softkey of 「Mode」function, setup menu of default gateway will appear and setup will be possible. Complete the setup value pressing softkey of 「DONE」function.

### Remote interface operation

Default gateway may not be setup from the remote interface. Please operate from panel key.

## Host Name

Host name is the human-readable identifier for the device. Together with the domain name (see below), the host name can uniquely represent the device in the networks just like its host IP address. Each character in the name can be a number, letter, dash (“-”) or underscore (“\_”).

### Host name setup

Select  key. Selecting softkey of 「I/O」function, sub menu will appear. Select softkey of 「LAN」function then select softkey of 「Modify Set」function from the displayed menu. Also, select softkey of 「DNS Setup」function of the displayed menu and select softkey of 「Host Name」function then input host name directly using variable input knob, cursor key, direct input key. Complete the setup value pressing softkey of 「DONE」function.

### Remote interface operation

Host name may not be setup from the remote interface. Please operate from panel key.

## Domain Name

A domain is an administration unit for managing hosts in the networks. The name of a domain, just like host name, is in human-readable format. Each character in the name can be a number, letter, dash (“-”) or underscore (“\_”).

### Domain name setup

Select  key. Selecting softkey of 「I/O」function, sub menu will appear. Select softkey of 「LAN」function then select softkey of 「Modify Set」function from the displayed menu. Also, select softkey of 「Domain Name」function of the displayed menu and select softkey of 「Domain Name」function then input host name directly using variable input knob, cursor key, direct input key. Complete the setup value pressing softkey of 「DONE」function.

### Remote interface operation

Domain name may not be setup from the remote interface. Please operate from panel key.

## DNS Server

DNS (Domain Name Service) is an internet service that translates a domain name into IP address. The DNS server address is the IP address of the server that provides this service. The setting is stored in non-volatile memory, so it is not affected by power cycle or the remoter interface reset command.

### DNS server setup

Select  key. Selecting softkey of 「I/O」function, sub menu will appear. Select softkey of 「LAN」function then select softkey of 「Modify Set」function from the displayed menu. Also, select softkey of 「DNS Setup」function of the displayed menu and select softkey of 「DNS Serv」function then input domain name using direct input key. Complete the setup value pressing softkey of 「DONE」function.

## Remote interface operation

DNS sever may not be setup from the remote interface. Please operate from panel key.

### Operation confirm of the LAN setup

Select  key. Selecting softkey of 「I/O」function, sub menu will appear. Select softkey of 「LAN」function then select softkey of 「Modify Set」function from the displayed menu. Select softkey of 「Current Conf」function within the displayed menu. Setup detail will be displayed. Scroll of the display is possible using softkey of 「↑」 or 「↓」.

## Remote interface operation

Display of the LAN setup may not be setup from the remote interface. Please operate from panel key.

## Note

- Refresh of display

The LAN setup confirmation window displays the current active setup. So, there is no change of display at the time of setup change. It will be reflected at the next power ON. Also, there is no automatic refresh when connection is made through DHCP. The new IP address information will be refreshed by selecting the key of 「Refresh」 function.

### 5-1-4. Response switch of \*idn? command

Company and model name which is included in the response message when \*idn? is issued may be changed. When the mode in I/O is set to COMP, it will change to the words previously set by command. The relation between the mode setup and response message will be as following.

Mode setup	Response message
Native(Initial value)	TEXIO , FGX-295, <Serial Number>, <Revision code>(Fixed value)
Comp	<b>Use setup,</b> <Serial Number>, <Revision code>

### Method for changing response message

1. Issue following command via USB. Alphanumeric only is allowed to setup. Insert one half angle space between the command S and " .

syst:idns "(User setup word)"

2. Select softkey of 「I/O」function selecting  key at front panel.
3. Switch the display for Comp pressing soft key of 「MODE」function.

## 5-2. Remote interface commands

You may instruct your FGX-295 waveform generator to output waveforms using the SCPI (Standard Commands for Programmable Instrument) commands after the selected remote interface is appropriately set up. This section lists the SCPI commands available for remotely controlling the waveform generator. For first time SCPI users, refer to Appendix B for the introductory materials on SCPI commands.

Note that the following conventions are used in SCPI command syntax. The triangle brackets, <>, indicate that you must specify a value for the enclosed parameter. The square brackets, [], indicate that the parameter is optional and can be omitted. The curly braces, {}, enclose the parameter choices for a given command string. A vertical bar, |, separates several choices for a parameter.

### The APPLy Commands

```
APPLy:SINusoid [<frequency>[,<amplitude>[,<offset> ] ] ]
APPLy:SQUare [<frequency>[,<amplitude>[,<offset> ] ] ]
APPLy:RAMP [<frequency>[,<amplitude>[,<offset> ] ] ]
APPLy:PULSe [<frequency>[,<amplitude>[,<offset> ] ] ]
APPLy:NOISe [<frequency>|DEF>[,<amplitude>[,<offset> ] ] ]
APPLy:DC [<frequency>|DEF>[,<amplitude>[,<offset> ] ] ]
APPLy:USER [<frequency>[,<amplitude>[,<offset> ] ] ]
APPLy?
```

### Output Configuration Commands

```
FUNCTion {SINusoid|SQUare|RAMP|PULSe|NOISe|DC|USER}
FUNCTion?
FREQUency {<frequency>|MINimum|MAXimum}
FREQUency? [MINimum|MAXimum]
VOLTage {<amplitude>|MINimum|MAXimum}
VOLTage? [MINimum|MAXimum]
VOLTage:OFFSet {<offset>|MINimum|MAXimum}
VOLTage:OFFSet ?[MINimum|MAXimum]
VOLTage:HIGH {<voltage>|MINimum|MAXimum}
VOLTage:HIGH? [MINimum|MAXimum]
VOLTage:LOW {<voltage>|MINimum|MAXimum}
VOLTage:LOW? [MINimum|MAXimum]
VOLTage:RANGe:AUTO {OFF|ON|ONCE}
VOLTage:RANGe:AUTO?
VOLTage:UNIT {Vp-p|Vrms|dBm}
VOLTage:UNIT?
FUNCTion:SQUare:DCYCLE {<percent>|MINimum|MAXimum}
FUNCTion:SQUare:DCYCLE? [MINimum|MAXimum]
FUNCTion:RAMP:SYMMetry {<percent>|MINimum|MAXimum}
```

FUNcTION:RAMP:SYMMetry? [MINimum|MAXimum]  
OUTPut {OFF|ON}  
OUTPut?  
OUTPut:LOAD {<ohms>|INFINITY|MINimum|MAXimum}  
OUTPut:LOAD? [MINimum|MAXimum]  
OUTPut:POLarity {NORMal|INVerted}  
OUTPut:POLarity?  
OUTPut:SYNC {OFF|ON}  
OUTPut:SYNC?

### **Pulse Configuration Commands**

PULSe:PERiod {<seconds>|MINimum|MAXimum}  
PULSe:PERiod? [MINimum|MAXimum]  
FUNcTION:PULSe:HOLD {WIDTh|DCYCLE}  
FUNcTION:PULSe:HOLD? [WIDTh|DCYCLE]  
FUNcTION:PULSe:WIDTh {<seconds>|MINimum|MAXimum }  
FUNcTION:PULSe:WIDTh? [ MINimum|MAXimum ]  
FUNcTION:PULSe:DCYCLE {<percent>|MINimum|MAXimum }  
FUNcTION:PULSe:DCYCLE ? [MINimum|MAXimum]  
FUNcTION:PULSe:TRANsition {<seconds>|MINimum|MAXimum }  
FUNcTION:PULSe:TRANsition? [MINimum|MAXimum ]

### **Amplitude Modulation Commands**

AM:INTernal:FUNcTION{SINusoid|SQUare|RAMP|NRAMP|  
TRiangle|NOISe|USER}  
AM:INTernal:FUNcTION?  
AM:INTernal:FREQUency {<frequency>|MINimum|MAXimum}  
AM:INTernal:FREQUency? [MINimum|MAXimum]  
AM:DEPTH {<depth in percent>|MINimum|MAXimum }  
AM:DEPTH? [MINimum|MAXimum ]  
AM:SOURce {INTernal|EXTernal}  
AM:SOURce?  
AM:STATe {OFF|ON}  
AM:STATe?

### **Frequency Modulation Commands**

FM:INTernal:FUNcTION{SINusoid|SQUare|RAMP|NRAMP|  
TRiangle|NOISe|USER}  
FM:INTernal:FUNcTION?  
FM:INTernal:FREQUency {<frequency>|MINimum|MAXimum}  
FM:INTernal:FREQUency? [MINimum|MAXimum]  
FM:DEVIation {<peak deviation in Hz>|MINimum|MAXimum}

FM:DEVIation? [MINimum|MAXimum]

FM:SOURce {INTernal|EXTernal}

FM:SOURce?

FM:STATe {OFF|ON}

FM:STATe?

### **Phase Modulation Commands**

PM:INTernal:FUNCTion{SINusoid|SQUare|RAMP|NRAMP|  
TRlangle|NOISe|USER}

PM:INTernal:FUNCTion?

PM:INTernal:FREQUency {<frequency>|MINimum|MAXimum}

PM:INTernal:FREQUency? [MINimum|MAXimum]

PM:DEVIation {<peak deviation in Hz>|MINimum|MAXimum}

PM:DEVIation? [MINimum|MAXimum]

PM:SOURce {INTernal|EXTernal}

PM:SOURce?

PM:STATe {OFF|ON}

PM:STATe?

## FSK Commands

FSKey: FREQUency {<frequency>|MINimum|MAXimum }  
FSKey: FREQUency? [MINimum|MAXimum]  
FSKey:INTernal:RATE{<rate in Hz>|MINimum|MAXimum }  
FSKey:INTernal:RATE? [MINimum|MAXimum]  
FSKey:SOURce {INTernal|EXTernal}  
FSKey:SOURce?  
FSKey:STATe {OFF|ON}  
FSKey:STATe?

## PWM Commands

PWM:INTernal:FUNcTion{SINusoid|SQUare|RAMP|NRAMp|  
TRIangle|NOISe|USER}  
PWM:INTernal:FUNcTion?  
PWM:INTernal:FREQUency {<frequency>|MINimum|MAXimum}  
PWM:INTernal:FREQUency? [MINimum|MAXimum]  
PWM:DEViation {<deviation in seconds>|MINimum|MAXimum}  
PWM:DEViation? [MINimum|MAXimum]  
PWM:DEViation:DCYClE {<deviation in percent>|MINimum|MAXimum}  
PWM:DEViation:DCYClE? [MINimum|MAXimum]  
PWM:SOURce {INTernal|EXTernal}  
PWM:SOURce?  
PWM:STATe {OFF|ON}  
PWM:STATe?

## Sweep Commands

FREQUency:START {<frequency>|MINimum|MAXimum}

FREQUency:START? [MINimum|MAXimum]

FREQUency:STOP{<frequency>|MINimum|MAXimum}

FREQUency:STOP? [MINimum|MAXimum]

FREQUency:CENTer {<frequency>|MINimum|MAXimum}

FREQUency:CENTer? [MINimum|MAXimum]

FREQUency:SPAN{<frequency>|MINimum|MAXimum}

FREQUency:SPAN? [MINimum|MAXimum]

SWEep:SPACing {LINear|LOGarithmic|USER}

SWEep:SPACing?

SWEep:TIME {<seconds>|MINimum|MAXimum}

SWEep:TIME? [MINimum|MAXimum]

SWEep:STATe {OFF|ON}

SWEep:STATe?

TRIGger:SOURce {IMMediate|EXTernal|BUS}

TRIGger:SOURce?

TRIGger:SLOPe {POSitive|NEGative}

TRIGger:SLOPe?

OUTPut:TRIGger:SLOPe {POSitive|NEGative}

OUTPut:TRIGger:SLOPe?

OUTPut:TRIGger {OFF|ON}

OUTPut:TRIGger?

MARKer:FREQUency {<frequency>|MINimum|MAXimum}

MARKer:FREQUency? [MINimum|MAXimum]

MARKer {OFF|ON}

MARKer?

## Burst Commands

BURSt:MODE {TRIGgered|GATED}  
BURSt:MODE?  
BURSt:NCYCles {<#cycles>|INFinity|MINimum|MAXimum}  
BURSt:NCYCles? [MINimum|MAXimum]  
BURSt:INTernal:PERiod {<seconds>|MINimum|MAXimum }  
BURSt:INTernal:PERiod? [MINimum|MAXimum]  
BURSt:PHASe {<angle>|MINimum|MAXimum }  
BURSt:PHASe? [MINimum|MAXimum]  
BURSt:STATe {OFF|ON}  
BURSt:STATe?  
UNIT:ANGLe {DEGree|RAdIAN}  
UNIT:ANGLe?

For triggered burst

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

For external source on "Ext Trig" connector

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

For external gated burst

Burst:GATE:POLarity {NORMal|INVerted}  
Burst:GATE:POLarity?

For trigger out

OUTPut:TRIGger:SLOPe {POSitive|NEGative}  
OUTPut:TRIGger:SLOPe?  
OUTPut:TRIGger {OFF|ON}  
OUTPut:TRIGger?

## Arbitrary Waveform Commands

DATA VOLATILE, <value>, <value>,...  
DATA:DAC VOLATILE, {<binary block>|<value>, <value>,...}  
FORMat:BORDER {NORMal|SWAPped}  
FORMat:BORDER?  
DATA:COPY <destination arb name> [, VOLATILE]  
FUNction:USER {<arb name>|VOLATILE}  
FUNction:USER?  
FUNction USER  
FUNction?  
DATA:CATalog?  
DATA:NVOLatile:CATalog?  
DATA:NVOLatile:FREE?  
DATA:ATTRibute:AVERage? [<arb name>]  
DATA:ATTRibute:CFACtor? [<arb name>]  
DATA:ATTRibute:POINts? [<arb name>]  
DATA:ATTRibute:PTPeak? [<arb name>]

## Triggering Commands

TRIGger:SOURce {IMMEDIATE|EXTERNAL|BUS}

TRIGger:SOURce?

TRIGger

\*TRG

For external source on "Ext Trig" connector

TRIGger:SLOPe {POSitive|NEGative}

TRIGger:SLOPe?

For external gated burst

Burst:GATE:POLarity {NORMAL|INVERTed}

Burst:GATE:POLarity?

For trigger out

OUTPut:TRIGger:SLOPe {POSitive|NEGative}

OUTPut:TRIGger:SLOPe?

OUTPut:TRIGger {OFF|ON}

OUTPut:TRIGger?

## State Storage Commands

\*SAV{1|2|3|4}

\*RCL{0|1|2|3|4}

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

MEMory:STATe:NAME? {1|2|3|4}

MEMory:STATe:DELeTe {1|2|3|4}

MEMory:STATe:RECall:SELeCt {0|1|2|3|4}

MEMory:STATe:RECall: SELeCt?

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

MEMory:NSTates?

## System-related Commands

SYSTem:ERRor?  
\*IDN?  
DISPlay {OFF|ON}  
DISPlay?  
DISPlay:TEXT <quoted string>  
DISPlay:TEXT?  
DISPlay:TEXT:CLEar  
\*RST  
\*TST?  
SYSTem:VERSion?  
SYSTem:BEEPer  
SYSTem:BEEPer:STATe {OFF|ON}  
SYSTem:BEEPer:STATe?  
SYSTem:KLOCK[:STATe] {OFF|ON}  
SYSTem:KLOCK:EXCLude {NONE|LOCAL}  
SYSTem:KLOCK:EXCLude?  
SYSTem:SECurity:IMMEDIATE  
\*LRN?  
\*OPC  
\*OPC?  
\*WAI

## Interface Configuration Commands

SYSTem:COMMunication:RLState {LOCAL|REMOTE|RWLOCK}

## Phase-lock Commands

PHASe {<angle>|MINimum|MAXimum}  
PHASe? [MINimum|MAXimum]  
PHASe:REFerence  
PHASe:UNLock:ERRor:STATe {OFF|ON}  
PHASe:UNLock:ERRor:STATe?  
UNIT:ANGLe {DEGREE|RADIAN}  
UNIT:ANGLe?

## Status Reporting Commands

\*STB?  
\*SRE <enable value>  
\*SRE?  
STATus:QUEStionable:CONDition?  
STATus:QUEStionable[:EVENT]?  
STATus:QUEStionable:ENABle <enable value>  
STATus:QUEStionable:ENABle?  
\*ESR?  
\*ESE <enable value>  
\*ESE?  
\*CLS  
STATus:PRESet  
\*PSC {0|1}  
\*OPC

## IEEE 488.2 Common Commands

\*CLS  
\*CLS  
\*CLS  
\*ESE<enable value>  
\*ESE?  
\*ESR?  
\*IDN?  
\*LRN?  
\*OPC  
\*OPC?  
\*PSC {0|1}  
\*PSC?  
\*RST  
\*SAV{1|2|3|4}  
\*RCL{0|1|2|3|4}  
\*SRE <enable value>  
\*SRE?  
\*STB?  
\*TRG  
\*TST?

## 6 Error message

Error messages are issued when an incorrect remote command is sent to your FGX-295 waveform generator for execution. This may occur for reasons such as incorrect command syntax, giving the parameters of a command that violate some system constraints, hardware failures and so. All possible error messages are categorized and listed in this chapter for your reference. If you cannot find a particular error message in this chapter, contact your service representative.

Error messages are stored in an error queue in FGX-295 and may be retrieved in the first-in-first-out (FIFO) order. The first error returned is the first error that was stored. FGX-295 beeps once each time an error occurs and the ERROR annunciator is lit whenever some error messages are found in the error queue. Only when all the errors in the queue are read, the ERROR annunciator is turned off.

Should more than 20 errors have existed, the last error stored in the queue (the most recent error) is replaced with -350, "Queue Overflow". No additional errors are saved until errors are read and cleared from the queue. If there is no error in the error queue, the waveform generator returns +0, "No Error".

The error queue is cleared with a power cycle or a \*CLS (clear status) command. The \*RST (reset) command does not clear the error queue.

### How to read error messages

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

### Remote interface operation

Use this command to read one error from the error queue:

SYSTem:ERRor?

Use this command to clear all the errors in the error queue:

\*CLS

## 6-1. Command errors

### -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.

## 6-2. Execution errors

-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 Vp-p 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.

-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 10MHz. When you change function from one allowing higher frequency to arbitrary waveform, The frequency is adjusted to 10MHz.

-221 Settings conflict; frequency changed for pulse function

The maximum output frequency for pulse waveform is 10MHz. When you change function from one allowing higher frequency to pulse waveform, the frequency is adjusted to 10MHz.

-221 Settings conflict; frequency reduced for ramp function

The maximum output frequency for ramp waveform is 200kHz. When you change function from one allowing higher frequency to ramp waveform, the frequency is adjusted to 200kHz.

-221 Settings conflict; frequency made compatible with burst mode

The maximum output frequency for an internal-triggered burst is 2.001mHz. 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.

-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:  $\text{EdgeTime} \leq 0.625 \times \text{PulseWidth}$ . 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:  $\text{EdgeTime} \leq 0.625 \times \text{Period} \times \text{DutyCycle}$ . 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 100kHz (50.1MHz for sine and square, 300kHz for ramp, and 10.1MHz 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 3.11 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 is not in conformity with the following limitation:

$|V_{\text{offset}}| + V_{p-p} / 2 \leq V_{\text{max}}$ , 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 is not in conformity with the following limitation:

$|V_{\text{offset}}| + V_{p-p} / 2 \leq V_{\text{max}}$ , 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 1mV 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 1mV 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 is not in conformity with 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 is not in conformity with the following condition and is adjusted to accommodate the period:

$$\text{PulseWidth} \leq \text{Period} - (1.6 \times \text{EdgeTime})$$

-222 Data out of range; pulse duty cycle limited by period; value clipped to...  
The specified duty cycle is not in conformity with the following condition and is adjusted to accommodate the period:

$$\text{DutyCycle} \leq (1 - 1.6 \times \text{Edge time} / \text{Period}) \times 100\%$$

-222 Data out of range; large period limits minimum pulse width  
The minimum pulse width for pulse waves with period larger than 10s is larger.

-222 Data out of range; pulse edge time limited by width; value clipped to...  
The specified pulse edge time is not in conformity with the following condition and is adjusted to accommodate the pulse width:

$$\text{EdgeTime} \leq 0.625 \times \text{PulseWidth}$$

-222 Data out of range; pulse edge time limited by duty cycle; value clipped to...  
The specified pulse edge time is not in conformity with the following condition and is adjusted to accommodate the duty cycle:

$$\text{EdgeTime} \leq 0.625 \times \text{Period} \times \text{DutyCycle}$$

-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 25.05MHz for sine, 12.55MHz for square carrier waveforms and 5.05MHz 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 10MHz.

-223 Too much data

An arbitrary waveform specified contains more than 262,144 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.

### 6-3. Device dependent errors

-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.

#### 6-4. Query errors

##### -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.

#### 6-5. Instrument errors

##### -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.

#### 6-6. Self test errors

##### -621 Self-test failed; square-wave threshold DAC

A possible malfunctioning DAC, failed DAC multiplexer (U8\_2) channels, or associated circuitry.

##### -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; -10dB attenuator path

##### -628 Self-test failed; -20dB attenuator path

##### -629 Self-test failed; +20dB 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 (+20dB), and output attenuators properly operate or not.

-630 Self-test failed; internal ADC over-range; condition

A probable ADC failure.

-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).

## 6-7. Arbitrary waveform errors

-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.

-786 Not able to delete a built-in arb waveform

Deleting the built-in waveform is not allowed.

-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.

## Appendix

This appendix contains the performance specifications of the FGX-295. It covers the AC, DC, Resistance, Temperature, and Frequency/Period characteristics under a variety of conditions. It also contains the general characteristics and accuracy calculations for your convenience. A lot of efforts are made to make sure these specifications serve your needs for production, engineering and/or research purposes. All specification applies to FGX-295 unless noted otherwise.

### Appendix A: Specifications

Output waveform			
Standard	Sine wave, square wave, ramp, triangular wave, pulse, noise, and DC		
Internal option	Index rise, Index fall, Reverse ramp, Sin(X)/X, Electrocardiographic wave		
Waveform characteristics			
Sine wave	Frequency	1μHz to 50MHz	
	Frequency smoothness ※ <sup>1</sup> (1kHz Standard)	< 100kHz	±0.1dB
		100kHz to 5MHz	±0.15dB
		5MHz to 20MHz	±0.3dB
		20MHz to 50MHz	±0.5dB
	Harmonics distortion ※ <sup>1,2</sup>	1μHz to 20kHz	-65dBc
		20kHz to 100kHz	-65dBc (< 1Vp-p)、-60dBc (≥ 1Vp-p)
		100kHz to 1MHz	-50dBc (< 1Vp-p)、-45dBc (≥ 1Vp-p)
		1MHz to 20MHz	-40dBc (< 1Vp-p)、-35dBc (≥ 1Vp-p)
	20MHz to 50MHz	-35dBc (< 1Vp-p)、-30dBc (≥ 1Vp-p)	
All harmonics distortion ※ <sup>1,2</sup>	≤ 0.06% (DC to 20kHz、≥ 0.5Vp-p)		
Spurious ※ <sup>1</sup>	1μHz to 1MHz	-70dBc	
	1MHz to 50MHz	-70dBc + 6dB/Octave	
Phase noise (10kHz Offset)	Principal value - 115dBc / Hz (≥ 1MHz、≥ 0.1Vp-p)		
Square wave	Frequency	1μHz to 25MHz	
	Rise/ Fall time	< 10ns	
	Overshoot	< 2%	
	Variable duty cycle	20% to 80% (≤ 10MHz)	
		40% to 60% (> 10MHz)	
	Asymmetry	1% + 5ns of the frequency (At 50% duty)	
Jitter (RMS)	200ps (≥ 1MHz、≥ 0.1Vp-p)		
Ramp, Triangle wave	Frequency	1μHz to 200kHz	
	Linearity	< 0.1% of the output peak	
	Symmetry	0.1% to 100.0%	
Pulse	Frequency	500μHz to 10MHz	
	Pulse length	Min 20ns、10ns Resolution (≤ Cycle 10s)	
	Variable edge time	< 10ns to 100ns	
	Overshoot	< 2%	
	Jitter (RMS)	200ps (≥ 1MHz、≥ 0.1Vp-p)	
Noise	Bandwidth	Principal value 20MHz	

Arbitrary	Frequency	1μHz to 10MHz	
	Wave form length	2k to 256k Points	
	Amplitude resolution	14bits (Including sign)	
	Sampling rate	125MS/s	
	Rise/ Fall time	Min 30ns (Principal value)	
	Linearity	<0.1% from peak output	
	Settling time	<250ns to 0.5% from final value	
	Jitter (RMS)	6ns + 30ppm	
	Number of waveform allowed to save	4 waveforms (The sum of Arbitrary and Pattern output waveforms)	
<b>Common characteristics</b>			
Frequency	Resolution	1μHz	
Amplitude	Range	50Ω Terminal	10mVp-p to 10Vp-p
		Open edge	20mVp-p to 20Vp-p
	Accuracy ※1 (When 1kHz)	(±1% of setup) ±1mVp-p	
	Unit	Vp-p, Vrms, dBm	
	Resolution	4 digits	
DC Offset	Range (AC + DC Peak)	50Ω Terminal	±5Vp-p
		Open edge	±10Vp-p
	Accuracy ※1	(±2% of offset setup) + (±0.5% of amplitude setup) ±2mV	
	Resolution	4 digits	
Main output	Impedance	Principal value 50Ω	
	Insulation	42kVpk against earth	
	Protection	Short-circuit protection, Invalidate automatically the main output by overload	
Sync Out	Level	TTL (Impedance: Approx 50Ω)	
Internal frequency standard	Accuracy	90 days	±10ppm
		1 year	±20ppm
External frequency standard (Input)	Lock range	10MHz ± 500Hz	
	Level	100mVp-p to 5Vp-p	
	Impedance	Principal value 1kΩ (AC Coupling)	
	Lock time	<2 seconds	
External frequency standard (Output)	Lock range	10MHz	
	Level	Principal value 632mVp-p (0dBm)	
	Impedance	Principal value 50Ω (AC Coupling)	
Phase offset	Range	−360° to +360°	
	Resolution	0.001°	
	Accuracy	8ns	

Modulation		
AM	Carrier	Sine wave, Square wave, Ramp, Arbitrary
	Signal source	Internal or external
	Internal modulation	Sine wave, Square wave, Ramp, Triangle wave, Noise, Arbitrary
	Frequency(Internal)	2mHz to 20kHz
	Modulation depth	0.0% to 120.0%
FM	Carrier	Sine wave, Square wave, Ramp, Arbitrary
	Signal source	Internal or external
	Internal modulation	Sine wave, Square wave, Ramp, Arbitrary
	Frequency(Internal)	2mHz to 20kHz
	Deflection	DC to 25MHz
PM	Carrier	Sine wave, Square wave, Ramp, Arbitrary
	Signal source	Internal or external
	Internal modulation	Sine wave, Square wave, Ramp, Arbitrary
	Frequency(Internal)	2mHz to 20kHz
	Deflection	0.0° to 360.0°
PWM	Carrier	Pulse
	Signal source	Internal or external
	Internal modulation	Sine wave, Square wave, Ramp, Arbitrary
	Frequency(Internal)	2mHz to 20kHz
	Deflection	0.0° to 360.0°
FSK	Carrier	Sine wave, Square wave, Ramp, Arbitrary
	Signal source	Internal or external
	Internal modulation	Square wave of 50% duty cycle
	Frequency(Internal)	2mHz to 100kHz
External modulation input ※ <sup>3</sup>	Deflection	±5V Full scale
	Input resistance	Principal value 8.7kΩ
	Bandwidth	DC to 20kHz
Sweep	Waveform	Sine wave, Square wave, Ramp, Arbitrary
	Type	Linear or logarithm
	Direction	Up or down
	Sweep time	1ms to 500 Sec
	Trigger	Internal or external, single (Manual)
	Marker	Falling edge of synchronized signal (Waveform is programmable)
Burst ※ <sup>4</sup>	Waveform	Sine wave, Square wave, Ramp, Triangle wave, Noise, Arbitrary
	Type	Internal or external
	Start/Stop Phase	-360° to +360°
	Internal cycle	1μs to 500 Sec
	Gate/Source	External trigger
	Trigger/Source	Internal or external, single (Manual)

Trigger		
Trigger input	Level	TTL Compatible
	Slope	Rising or falling
	Pulse length	> 100ns
	Impedance	> 10k $\Omega$ , DC Coupling
	Delay	< 500ns
Trigger output	Level	TTL Compatible, Termination $\geq$ 1k $\Omega$
	Pulse length	> 400ns
	Impedance	Principal value 50 $\Omega$
	Maximum speed	1MHz
	Fan-out	Connectable up to 4 $\times$ FGX-295
Parallel output		
Clock output	Frequency	1 $\mu$ Hz to 50MHz
Data output	Level	TTL Compatible, Termination $\geq$ 2k $\Omega$
	Impedance	Principal value 110 $\Omega$
	Data length	2k to 256k Points $\times$ 16 bits length
General specifications		
Power supply	Voltage range	100V to 240V (50Hz/60Hz), 100V to 120V (400Hz)
	Power consumption	Max 80VA
Operational environment	Guaranteed specification of temperature range	18 $^{\circ}$ C to 28 $^{\circ}$ C (Humidity below 80% without dew condensation)
	Operational temperature range	0 $^{\circ}$ C to 55 $^{\circ}$ C (Humidity below 80% without dew condensation)
	Preserve temperature range	-10 $^{\circ}$ C to 60 $^{\circ}$ C (Humidity below 80% without dew condensation)
	Operational altitude	Max 2,000m
Others	Interface	USB (Type-B), GP-IB, LAN
	External measurements	W224mm $\times$ H107mm $\times$ L380mm
	Weight	Approx 3.6kg
	Safety standard	In accordance with EN61010-1:2010 (3rd Edition) standard
	EMC Standard	In accordance with EN61326-1:2006 standard
	Attachments	Power cord, USB Cable, Parallel out cable, CD-ROM (Application software, User's manual)

**Notice:**

※<sup>1</sup> Set auto-range to valid

※<sup>2</sup> Set DC offset to 0V

※<sup>3</sup> Use trigger input (Max 1MHz) at FSK

※<sup>4</sup> Sine wave and square wave over 10MHz, will setup an unlimited burst numbers.

## Appendix B: Remote interface references

### B-1. Introduction to the SCPI Language

SCPI (Standard Commands for Programmable Instruments) is an ASCII-based instrument command language designed for testing and measurement instruments. It is based on a hierarchical structure, also known as a *tree system*. In this system, associated commands are grouped together under a common node or root, thus forming *subsystems*. A portion of the SOURce subsystem is shown below to explain the tree system.

SOURce:

FREQuency:

STARt {<frequency>|MINimum|MAXimum}

STARt? [MINimum|MAXimum]

FREQuency:

STOP {<frequency>|MINimum|MAXimum}

STOP? [MINimum|MAXimum]

SWEep:

SPACing {LINear|LOGarithmic}

SPACing?

SWEep:

TIME {<seconds>|MINimum|MAXimum}

TIME? [MINimum|MAXimum]

SOURce is the root keyword of the command, SWEep and FREQuency are second-level keywords, and STARt and STOP are third-level keywords. A colon ( : ) separates a command keyword from a lower-level keyword.

#### B-1-1. Command format used in this manual

The command format used in this manual is shown below:

STARt {<frequency>|MINimum|MAXimum}

Most commands (and some parameters) are expressed as a mixture of upper- and lower-case letters. The upper-case letters indicate the abbreviated part that must be specified for the command. For shorter program lines, send the abbreviated form. For better program readability, use the long form. For example, in the above syntax statement, STAR and START are both acceptable forms for the same command. You may also mix upper- or lower-case letters in a command. For example, START, star, and Star are all acceptable for the same command. Other forms, such as STA will generate an error.

Braces ( { } ) enclose parameter choices for a given command string. The braces are not sent with the command.

Vertical bars ( ↓ ) separate multiple parameter choices for a given command string.

Triangle brackets ( < > ) indicate that you must specify a value for the enclosed parameter. For example, the above START command accepts a frequency parameter enclosed in triangle brackets. The brackets are not sent with the command string. You must specify a value for the parameter such as "STAR 6000".

Some parameters are enclosed in square brackets ( [ ] ). The brackets indicate that the parameter is optional and can be omitted. The brackets are not sent with the command string. If you do not specify a value for an optional parameter, the waveform generator uses the default value.

#### B-1-2. Command Separators

A colon ( : ) is used to separate a command keyword from a lower-level keyword. You must insert a blank space to separate a parameter from a command keyword. If a command requires more than one parameter, you must use a comma between two parameters:

```
"APPL:SIN 5kHz, 3.0VPP, -2.5V"
```

A semicolon ( ; ) is used to separate commands within the same subsystem, and can reduce typing efforts. For example, sending the following command string:

```
"BURSt:MODE TRIG; NCYCles 10"
```

is the same as sending the following two commands:

```
"BURS:MODE TRIG"
```

```
"BURS:NCYCles 10"
```

Use a colon *and* a semicolon to link commands from different subsystems. For example, in the following command string, an error is generated if you do not use both the colon *and* semicolon:

```
"BURS:STATe ON;;TRIG:SOUR EXT"
```

#### B-1-3. Using the MIN and MAX parameters

You may put MINimum or MAXimum in place of a parameter for many commands. For example, consider the following command:

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

Instead of specifying a specific frequency value, you may use MIN to set the frequency to its minimum value or MAX to its maximum value.

#### B-1-4. Querying Parameter Settings

You can query the current value of a parameter by adding a question mark ( ? ) to the command. For example, the following command sets the start frequency to 5000Hz:

```
"STAR 5000"
```

You can query the start frequency by executing:

```
"STAR?"
```

You can also query the minimum or maximum start frequency allowed for the current waveform function as follows:

```
"STAR? MIN"
```

```
"STAR? MAX"
```

#### Caution

- If you send two query commands without reading the response from the first, then when you attempt to read the response, you may receive some data from the first response followed by the complete second response. To avoid this, do not send a query command without reading the response. When you cannot avoid this situation, send a device clear before sending the second query command.

#### B-1-5. SCPI command terminators

A command string sent to the multimeter must terminate with a <new line> character. The IEEE-488 EOI (end-or-identify) message is interpreted as a <new line> character and can be used to terminate a command string in place of a <new line> character. A <carriage return> followed by a <new line> is also accepted. Command string termination will always reset the current SCPI command path to the root level.

#### B-1-6. IEEE-488.2 common commands

The IEEE-488.2 standard defines a set of common commands that perform functions like reset, self-test, and status operations. Common commands always begin with an asterisk ( \* ), are four to five characters in length, and may include one or more parameters. The command keyword is separated from the first parameter by a blank space. Use a semicolon ( ; ) to separate multiple commands as shown below:

```
"*RST; *CLS; *ESE 32; *OPC?"
```

### B-1-7. SCPI Parameter Types

The SCPI language defines several different data formats to be used in program messages and response messages.

**Numeric Parameters** Commands that require numeric parameters will accept all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation. Special values for numeric parameters like MINimum, MAXimum, and DEFault are also accepted. You can also send engineering unit suffixes with numeric parameters (e.g., MHz or kHz). If only specific numeric values are accepted, the waveform generator will automatically round the input numeric parameters. The following example demonstrates a command with a numeric parameter option:

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

**Discrete Parameters** Discrete parameters are used in the settings where only a limited number of values (like BUS, IMMEDIATE, EXTERNAL) are accepted. They have the short and long forms just like command keywords. You can mix upper- and lower-case letters. Query responses will always return the short form in all upper-case letters. The following example demonstrates a command with a discrete parameter:

```
TRIGger:SOURce {BUS|IMMEDIATE|EXTERNAL}
```

**Boolean Parameters** A Boolean parameter represents a condition that is either true or false. For a false condition, the waveform generator accepts "OFF" or "0" as parameter value. For a true condition, the multimeter accepts "ON" or "1" as parameter value. When you query a Boolean parameter, the instrument will always return "0" or "1". The following example demonstrates a command with a Boolean parameter:

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

**String Parameters** A string parameter can contain any set of ASCII characters. A string must begin and end with matching quotes, either with single or double quotes. You can include the quote delimiter as part of the string by typing it twice without any characters in between. The following example demonstrates a command with a string parameter:

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

## B-2. Output data formats

Output data will be in one of the formats shown in the table below.

Type of Output Data	Output Data Format
Non-reading queries	< 80 ASCII character string
Single reading (IEEE-488)	SD.DDDDDDDDESDD<nl>
Multiple readings (IEEE-488)	SD.DDDDDDDDESDD,.....,<nl>
Single reading (RS-232)	SD.DDDDDDDDESDD<cr><nl>
Multiple readings (RS-232)	SD.DDDDDDDDESDD,.....,<cr><nl>

S Negative sign or positive sign

D Numeric digits

E Exponent

<nl> newline character

<cr> carriage return character

## B-3. Command reference

-- A to F --

-- A --

### AM:INTernal

**: FUNCTION{SINusoid|SQUare|RAMP|NRAMP|TRIangle|NOISe|USER}**

Specify the modulating waveform for the modulation. This applies only when the modulating source is internal. Noise can be a modulating waveform, but cannot be used as a carrier waveform, neither do Pulse nor dc. The default modulating waveform is a sine waveform.

### AM:INTernal

**: FUNCTION?**

Query the modulating function in amplitude modulation. "SIN", "SQU", "RAMP", "NRAM", "TRI", "NOIS" or "USER" string indicating the modulating function will be returned.

- Square waveform has 50% duty cycle.
- Ramp waveform has 100% symmetry
- Triangle waveform has 50% symmetry.
- Negative Ramp waveform has 0% symmetry.
- If an Arbitrary(USER) waveform is chosen to be the modulating waveform, it is automatically limited to 4k points. Extra points are removed using decimation.

### AM:INTernal

**: FREQUENCY{<frequency>|MINimum|MAXimum}**

Specify the frequency of the modulating waveform. This applies only when the modulating source is internal. The range is from 2mHz to 20kHz and the default is 100Hz.

**AM:INTernal****: FREQuency? [MINimum|MAXimum]**

Query the internal modulating frequency. The frequency (in hertz) of the internal modulating waveform is returned.

**AM:DEPTth {<depth in percent>|MINimum|MAXimum}**

Specify the internal modulation depth (or “percent modulation”) in percent. The range is from 0% to 120% and the default is 100%.

**Notes:**

- When an external source is selected, the modulation depth is controlled by the  $\pm 5V$  external signal applied at the Modulation In connector on the rear panel. Specifically, the output will be at the maximum amplitude when the modulating signal is at +5V, and the output will be at the minimum amplitude when the modulating signal is at -5V.
- The modulation output of FGX-295 will not exceed  $\pm 5V$  peak (into a 50 $\Omega$  load) even if the modulation depth is greater than 100%.

**AM:DEPTth? [MINimum|MAXimum]**

Query the modulation depth in amplitude modulation. The modulation depth (in percent) is returned.

**AM:SOURce {INTernal|EXTernal}**

Specify the modulating signal source. If an External source is chosen, the carrier waveform is modulated with an external waveform. The modulation depth is controlled by the  $\pm 5V$  external signal applied at the Modulation In connector on the rear panel. Specifically, the output will be at the maximum amplitude when the modulating signal is at +5V, and the output will be at the minimum amplitude when the modulating signal is at -5V.

**AM:SOURce?**

Query the modulating source in amplitude modulation. “INT” or “EXT” string indicating the modulating source will be returned.

**AM:STATe {OFF|ON}**

Disable or Enable the amplitude modulation. The default is OFF.

To avoid multiple waveform changes, you can enable AM after setting the modulation parameters.

**AM:STATe?**

“0” (OFF) or “1” (ON) will be returned.

**APPLY:****SINusoid [<frequency> [,<amplitude > [,<offset>] ]]**

Output a sine wave with specific frequency, amplitude and offset. The waveform is output as soon as the command is executed.

**APPLY:**

**SQUare** [<frequency> [,<amplitude > [,<offset>] ]]

Output a square wave with specific frequency, amplitude and offset. The duty cycle is set automatically to 50%. The waveform is output as soon as the command is executed.

**APPLY:**

**RAMP** [<frequency> [,<amplitude > [,<offset>] ]]

Output a ramp wave with specific frequency, amplitude and offset. The symmetry is set automatically to 100%. The waveform is output as soon as the command is executed.

**APPLY:**

**PULSe** [<frequency> [,<amplitude > [,<offset>] ]]

Output a pulse wave with specific frequency, amplitude and offset. The waveform is output as soon as the command is executed. This command works with the current edge time setting and the current duty cycle or pulse width setting, depending on which has been selected to "hold" (FUNC:PULS:HOLD command). However the waveform generator will adjust the pulse width or the edge time to comply with the frequency restrictions for pulse waveforms.

**APPLY:**

**NOISe** [<frequency|DEF> [,<amplitude > [,<offset>] ]]

Output Gaussian pulse wave with the specific frequency, amplitude and (dc) offset. The waveform is outputted as soon as the command is executed. The specified frequency has no effect on the noise wave, but is remembered by the waveform generator and will be used on the next function you choose.

**APPLY:**

**DC** [<frequency>|DEF [,<amplitude|DEF> [,<offset>] ]]

Output a dc voltage with the specified offset level. You can set the dc voltage to any value between  $\pm 5\text{Vdc}$  into  $50\Omega$  or  $\pm 10\text{Vdc}$  into an open circuit. The waveform is output as soon as the command is executed. The specified frequency and amplitude have no effect on the pulse wave, but are remembered by the waveform generator and will be used on the next function you choose.

**APPLY:**

**USER** [<frequency> [,<amplitude > [,<offset>] ]]

Output an arbitrary waveform currently chosen by the FUNC:USER command with the specific frequency, amplitude and offset. The waveform is output as soon as the command is executed.

## APPLy?

Query the current configuration and return a quoted string. The quoted string includes the function, frequency, amplitude and offset as in the following format:

“function frequency amplitude offset”

This command allows you to append this query response to an APPL: command in your programming application and use the result to place the waveform generator in the specified state.

-- B --

## BURSt:MODE {TRIGgered|GATed}

Specify the burst mode. The default is Triggered mode. In the triggered mode, the waveform generator outputs a waveform with specified number of cycles (burst count) each time a trigger is received from the specified trigger source. In the gated mode, the output waveform is either “on” or “off” based on the external signal level on the Ext Trig connector on the rear panel.

- Use BURS:GATE:POL command to specify the polarity of Ext Trig connector on the rear panel.
- When the gate signal is true, the waveform generator outputs a continuous waveform. When the gate signal is false, the current waveform is complete and the waveform generator stops while remaining at the voltage level corresponding to the starting burst phase of the selected waveform. And the output stops immediately in a noise waveform when the gate signal is false.
- The burst count, burst period and trigger source are for triggered burst mode only.

## BURSt:MODE?

“TRIG” or “GAT” will be returned.

## BURSt:NCYCles {<# cycles>|INFIInity|MINImum|MAXImum}

Specify the number of cycles to be output in each burst (triggered burst mode only). The range is from 1 to 50,000 cycles in 1 cycle increments and the default is 1 cycle. The maximum value depends on the burst period and frequency as shown below. Specify Infinite to generate a continuous burst waveform. When using the Immediate(Internal) trigger source (TRIG:SOUR IMM command), the burst count must be less than the product of the maximum burst period and the waveform frequency:

$$\text{Burst Count} < \text{Maximum period} \times \text{Frequency.}$$

- The waveform generator will automatically increase the burst period up to its maximum value to accommodate the specified burst count, but it won't change the waveform frequency.
- The burst count does not apply in the gated mode. However, if you specify a new burst count while in the gated mode, the waveform generator will remember it and use it when the triggered mode is selected.

### **BURSt:NCYCles?**

The burst count will be returned. The range is from 1 to 50,000, and 9.9E+37 is returned if Infinite is specified.

### **BURSt:INTernal:PERiod {<seconds>|MINimum|MAXimum}**

Specify the burst period for bursts with internal (immediate) trigger source. The burst period is ignored when external or manual trigger source is enabled (or when the gated burst mode is chosen). The range is from 1µs to 500 seconds and the default is 10ms. The maximum value is 500s, but the minimum value depends on the burst count and frequency as shown below:

$$\text{BurstPeriod} > \frac{\text{BurstCount}}{\text{WaveformFrequency}} + 200\text{ns}$$

### **BURSt:INTernal:PERiod? [MINimum|MAXimum]**

The burst period in seconds will be returned.

### **BURSt:PHASe {<angle>|MINimum|MAXimum}**

Specify the starting phase in degrees or radians according to UNIT:ANGL command. The range is from -360 degrees to +360 degrees (or from  $-2\pi$  to  $+2\pi$  radians) and the default is 0 degree (0 radians).

- For sine, square and ramp waveform, zero degrees is the point at which the waveform crosses 0V or the dc offset in a positive going direction. For arbitrary waveform, it is the first waveform point downloaded to memory. The burst phase has no effect on pulse or noise waveform.
- In the gated burst mode, when the gate signal turns false, the current waveform is complete and the waveform generator stops and the output remains at the voltage level corresponding to the starting burst phase.

### **BURSt:PHASe? [MINimum|MAXimum]**

The starting phase in degree or radians will be returned.

### **BURSt:STATe {OFF|ON}**

Disable or enable the burst mode. To avoid multiple waveform changes, you can enable burst after setting the modulation parameters. The waveform generator allows only one of burst, sweep and modulations enabled at one time. As long as one is enabled, the other will be turned off.

### **BURSt:STATe?**

“0” (OFF) or “1” (ON) will be returned.

### **BURSt:GATE:POLarity {NORMal|INVerted}**

Specify whether the waveform generator uses true-high or true-low logic levels on the rear-panel Ext Trig connector for an externally-gated burst. The default is NORM (true-high logic).

### **BURSt:GATE:POLarity?**

“NORM” or “INV” will be returned.

-- D --

**DATA VOLATILE, <value>, <value>, ...**

Download floating-point values from -1 to +1 into volatile memory. You can download from 1 to 262,144 points per waveform. The waveform generator takes the specified number of points and expands them to fill waveform memory. If the specified number is less than 16,384, the waveform generator automatically generates a waveform with 16,384 points. If the specified number is more than 16,384, a waveform with 65,536 points will be generated. And if the specified number is more than 65,536, a waveform with 262,144 will be generated.

- The values -1 and +1 correspond to the peak values of the waveform when the offset is 0V.
- The maximum amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog Converter).
- The DATA command overwrites the previous waveforms in volatile memory. If you need to save it, use DATA:COPY command to copy the waveform to non-volatile memory.
- Downloading floating-point values (using DATA VOLATILE) is slower than downloading binary values (using DATA:DAC VOLATILE) but is more convenient when using trigonometric functions which return values from -1 to +1.
- After downloading the waveform data to memory, use the FUNC:USER command to choose the active waveform and the FUNC USER command to output it.
- The following statement shows how to use the DATA command to download seven points to volatile memory.

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

### **DATA:DAC VOLATILE, {<binary block>|<value>, <value>, ...}**

Download binary or decimal integer values from -8191 to +8191 into volatile memory. You can download from 1 to 262,144 (256k) points per waveform in IEEE-488.2 binary block format or as a list of values. The range of values corresponds to the values available using internal 14-bit DAC (digital-to-Analog Converter) codes. The waveform generator takes the specified number of points and expands them to fill waveform memory. If you download less than 16,384 (16k) points, a waveform with 16,384 points will be automatically generated. If you download more than 16,384 points, a 65,536-point waveform will be generated. If you download more than 65,536 points, a 262,144-point waveform will be generated.

- The values -8191 and +8191 correspond to the peak values of the waveform (if the offset is 0V). For example, if you set the output amplitude to 10Vp-p, “+8191” corresponds to +5V and “-8191” corresponds to -5V.
- The maximum amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog converter). For example, the built-in sine wave does not use the full range of binary values between  $\pm 1$  and therefore its maximum amplitude is 6.087Vp-p (into 50 $\Omega$ ).
- The **DATA:DAC** command overwrites the previous waveform in volatile memory (and no error will be generated). Use the **DATA:COPY** command to copy the waveform to non-volatile memory.
- The non-volatile memory can store up to four user-defined waveforms. Use DATA:CAT? Command to list all waveforms stored in volatile and non-volatile memory.
- After downloading the waveform data to memory, use the FUNC:USER command to choose the active waveform and the FUNC USER command to output it.
- The following statement shows how to use the DATA:DAC command to download seven integer points using the binary block format.

DATA:DAC VOLATILE, #214

- The following statement shows how to use the DATA:DAC command to download five integer points in decimal format.

DATA:DAC VOLATILE, 8191, 4096, 0, -4096, -8191

### IEEE-488.2 Binary Block Format

In the binary block format, a block header precedes the data points. The block header follows the format below:

```
# 5 32768
```

"#" starts the data block. The second number represents the number of digits to follow and the third number represents the number of bytes to follow (65,536 bytes = 32,768 points).

A waveform data point is represented as a 16-bit integer sent in two 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, 65,536 bytes are required to load a waveform with 32,768 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 most-significant byte (MSB) of each data point is sent first. If you specify FORM:BORD SWAP, the least-significant byte (LSB) of each data point is sent first. Most computers use the "swapped" byte order.

#### Notes:

- The values  $\pm 8191$  correspond to the peak values of the waveform (if the offset is 0V).
- The maximum amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog converter). For example, the built-in sinc wave does not use the full range of binary values between  $\pm 8191$  and thus its maximum amplitude is limited to 6.087V<sub>p-p</sub> (into 50Ω).
- The DATA:DAC command overwrites the previous waveform in the volatile memory (and no error will be generated). Use the DATA:COPY command to copy the waveform to non-volatile memory.

#### **DATA:CATalog?**

List all waveform names available for use. The names of the five built-in waveforms (in non-volatile memory) and all user-defined waveforms (in volatile memory) will be returned. "Volatile" will be returned when a built-in waveform is currently downloaded to volatile memory. To remove a waveform from volatile memory or any user-defined waveforms in non-volatile memory, use DATA:DEL command.

#### **DATA:NVOLatile:CATalog?**

List the names of all user-defined arbitrary waveforms downloaded to non-volatile memory. Up to four waveform names will be returned. If there is no waveform currently downloaded, a null string "" will be returned. To remove any user-defined waveforms in non-volatile memory, use DATA:DEL command.

#### **DATA:NVOLatile:FREE?**

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

#### **DATA:DELeTe <arb name>**

Remove the specific arbitrary waveform from memory. It can be the waveforms in volatile memory or the user-defined waveforms in non-volatile memory. You cannot delete an arbitrary waveform that is currently output, or an error will be generated.

**DATA:DELeTe:ALL**

Remove all user-defined waveforms from memory. All waveforms in volatile memory and user-defined waveforms in non-volatile memory will be deleted, but the built-in waveforms in non-volatile memory will not be deleted. You cannot delete an arbitrary waveform that is currently output, or an error will be generated.

**DATA:ATTRibute:AVERAge? [<arb name>]**

Query the arithmetic average of all data points for the specified waveform ( $-1 \leq \leq$ ). The default waveform is the currently active one (FUNC:USER command). If you query a waveform which is not stored in memory, an error "Specified arb waveform does not exist" will be generated.

**DATA:ATTRibute:CFACTOR? [<arb name>]**

Query the crest factor of all data points for the specified waveform. The crest factor represents the ratio of the peak value to the RMS value of the waveform. The default waveform is the currently active one (FUNC:USER command). If you query a waveform which is not stored in memory, an error "Specified arb waveform does not exist" will be generated.

**DATA:ATTRibute:POINTS? [<arb name>]**

Query the number of data points for the specified waveform. A value from 1 to 262,144 will be returned. The default waveform is the currently active one (FUNC:USER command). If you query a waveform which is not stored in memory, an error "Specified arb waveform does not exist" will be generated.

**DATA:ATTRibute:PTPeak? [<arb name>]**

Query the peak-to-peak value of all data points for the specified waveform. The default waveform is the currently active one (FUNC:USER command). A value from "0" to "+1.0" will be returned. "+1.0" indicates a full amplitude. The maximum amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog converter). For example, the built-in sine wave does not use the full range of binary values between  $\pm 1$  and therefore its maximum amplitude is 6.087Vp-p (into 50 $\Omega$ ). If you query a waveform which is not stored in memory, an error "Specified arb waveform does not exist" will be generated.

**DISPlay {OFF|ON}**

Turn off or on the display. Disabling the front-panel display may speed up the command execution for remote interface operation. Remote interface error messages will be shown even when the display is off. Displaying a message on the front-panel display overrides the display state.

The display is automatically enabled when the waveform generator has been turned off or after \*RST command, or when you return to local (front-panel) operation.

The display state is saved when you store the instrument state using \*SAV command. Use \*RCL command to recall the instrument state and the front-panel display will return to the previous state.

**DISPlay?**

Query the display setting. Returns "0" (OFF) or "1" (ON).

**DISPlay:TEXT <quoted string>**

Show a message on the front panel display. This command overrides the display state (DISP OFF command). The allowed message can be up to 12 characters in a large font and more characters in a small font; Any additional characters will be truncated.

With a message displaying on the front-panel display, information relating to the output waveform such as frequency is not shown on the display.

**DISPlay:TEXT?**

Query the message sent to the front panel display.

**DISPlay:TEXT:CLEAr**

Clear the message shown on the front panel display.

If the display is currently enabled, this command will clear the message on the front-panel display and return the normal front-panel display mode.

If the display is currently disabled, this command will clear the message on the display, but the display remains off.

-- F --

**FM:INTernal:FUNCTion {SINusoid|SQUare|RAMP|NRAMP|TRIangle|NOISe|USER}**

Specify the shape of the modulating waveform. This applies only when the modulation source is Internal (FM:SOUR INT command). Noise can be a modulating waveform, but cannot be used as a carrier waveform, neither do Pulse nor dc. The default modulating waveform is a sine waveform.

**FM:INTernal:FUNCTion?**

Query the modulating function used in frequency modulation. "SIN", "SQU", "RAMP", "NRAMP", "TRI", "NOIS" or "USER" string indicating the modulating function will be returned.

- Square waveform has 50% duty cycle.
- Ramp waveform has 100% symmetry
- Triangle waveform has 50% symmetry.
- Negative Ramp waveform has 0% symmetry.
- If an Arbitrary(USER) waveform is chosen to be the modulating waveform, it is automatically limited to 4k points. Extra points are removed using decimation.

**FM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}**

Specify the frequency of the modulating waveform. This applies only when the modulating source is internal. The range is from 2mHz to 20kHz and the default is 10Hz.

**FM:INTernal:FREQuency? [MINimum|MAXimum]**

Query the modulating frequency in frequency modulation. The modulating waveform frequency in hertz will be returned.

**FM:DEVIation {<peak deviation in hertz>|MINimum|MAXimum}**

Specify the peak frequency deviation in hertz. This value represents the peak variation in frequency of the modulated waveform from the carrier frequency. The range is from 1µHz to 300kHz for ramps, from 1µHz to 10.1MHz for arbitrary waveforms, from 1µHz to 25.1MHz for square waveforms and from 1µHz to 50.1MHz for sine waveforms and the default is 100Hz. The minimum value is 1µHz, but the maximum value is calculated based on the frequency of the carrier waveform as below:

Maximum deviation = carrier frequency

if the carrier frequency is less than Maximum frequency/2

Maximum deviation = Maximum frequency – carrier frequency if the carrier frequency is greater than Maximum frequency/2

The frequency deviation must not be greater than the carrier frequency. If a greater value is set to be the deviation, FGX-295 waveform generator will adjust it automatically to the maximum value allowed. The sum of frequency deviation and the carrier frequency must not be greater than the maximum frequency of the function used plus 100kHz (50.1MHz for sine and 25.1MHz for square, 300kHz for ramp, and 10.1MHz for arbitrary waveforms). If a greater frequency deviation is specified, the waveform generator will automatically adjust it to the maximum value allowed.

When an external source is selected, the carrier is modulated with an external waveform. The frequency deviation is controlled by the ±5V signal on the rear panel Modulation In connector. For instance, if a deviation of 100kHz is specified, then a +5V signal level corresponds to a 100kHz increase in frequency. Lower external signal levels produce less deviation and negative signal levels reduce the frequency below the carrier frequency.

If the deviation causes the carrier waveform to exceed a frequency boundary for the current duty cycle (square waveform only), FGX-295 will automatically adjust the duty cycle to the maximum value allowed with the present carrier frequency.

**FM:DEVIation? [MINimum|MAXimum]**

Query the peak frequency deviation in frequency modulation. The peak frequency deviation in hertz will be returned.

**FM:SOURce {INTernal|EXTernal}**

Specify the modulating signal source. The default is Internal. When an external source is selected, the carrier is modulated with an external waveform. The frequency deviation is controlled by the ±5V signal on the rear panel Modulation In connector. For instance, if a deviation of 100kHz is specified, then a +5V signal level corresponds to a 100kHz increase in frequency. Lower external signal levels produce less deviation and negative signal levels reduce the frequency below the carrier frequency.

**FM:SOURce?**

Query the modulating source in frequency modulation. "INT" or "EXT" string indicating the modulating signal source will be returned.

**FM:STATe {OFF|ON}**

Disable or Enable the frequency modulation. To avoid multiple waveform changes, you can enable it after setting up the modulation parameters. The waveform generator allows only one of burst, sweep and modulations enabled at one time. As long as one is enabled, the other will be turned off.

**FM:STATe?**

“0” (OFF) or “1” (ON) will be returned.

**FORMat:BORDER {NORMal|SWAPped}**

Used only for binary block transfers. Select the byte order for binary transfers in the block mode using the DATA:DAC command. The default is NORM.

In NORM byte order, the most significant byte (MSB) of each data point is assumed first.

In SWAP byte order, the least significant byte (LSB) of each data point is assumed first. Most computers use the “swapped” byte order.

The waveform generator represents binary data as signed 16-bit integers, which are sent as two bytes. Therefore, each waveform data point requires 16 bits, which must be transferred as two bytes on the waveform generator’s interfaces.

**FORMat:BORDER?**

Query the byte order for binary transfers in the block mode. “NORM” or “SWAP” will be returned.

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

Specify the start frequency in Sweeps. The range is from 1µHz to 200kHz for ramps, from 1µHz to 10MHz for arbitrary waveforms, from 1µHz to 25MHz for square, and from 1µHz to 50MHz for sine. The default is 100Hz. The minimum value is 1µHz and the maximum value is 50MHz.

**FREQuency:STARt? [MINimum|MAXimum]**

The start frequency in sweeps will be returned.

**FREQuency:STOP {<frequency>|MINimum|MAXimum }**

Specify the stop frequency in Sweeps. The range is from 1µHz to 200kHz for ramps, from 1µHz to 10MHz for arbitrary waveforms, from 1µHz to 25MHz for square, and from 1µHz to 50MHz for sine. The default is 1kHz. The minimum value is 1µHz and the maximum value is 50MHz.

**FREQuency:STOP? [MINimum|MAXimum]**

The stop frequency in sweeps will be returned.

**FREQUENCY:CENTER {<frequency>|MINimum|MAXimum }**

Specify the center frequency in sweeps. The range is from 1µHz to 200kHz for ramps, from 1µHz to 10MHz for arbitrary waveforms, from 1µHz to 25MHz for square, and from 1µHz to 50MHz for sine. The default is 550Hz. The minimum value is 1µHz and the maximum value is calculated based on the frequency span and the maximum frequency of the function used.

$$\text{Maximum center frequency} = \text{Maximum frequency} - \text{span}/2$$

**FREQUENCY:CENTER? [MINimum|MAXimum]**

The center frequency in sweeps will be returned in hertz.

**FREQUENCY:SPAN{<frequency>|MINimum|MAXimum }**

Specify the frequency span in sweeps. The range is from 1µHz to 200kHz for ramps, from 1µHz to 10MHz for arbitrary waveforms, from 1µHz to 25MHz for square, and from 1µHz to 50MHz for sine. The default is 900Hz. The minimum value is 1µHz and the maximum value is calculated based on the center frequency and the maximum frequency of the function used.

$$\text{Maximum frequency span} = 2 \times (\text{Maximum frequency} - \text{center frequency})$$

- To sweep up in frequency, specify a positive frequency span.
- To sweep down in frequency, specify a negative frequency span.

The following equation shows the relationship between frequency span and start/stop frequency.

$$\text{Frequency span} = \text{Stop frequency} - \text{Start frequency}$$

**FREQUENCY:SPAN? [MINimum|MAXimum]**

The frequency span in hertz will be returned.

**FSKey: FREQUENCY {<frequency>|MINimum|MAXimum}**

Specify the FSK alternate (or "hop") frequency. The range is from 1µHz to 200kHz for ramps, 1µHz to 10MHz for arbitrary waveforms, from 1µHz to 25MHz for square, and from 1µHz to 50MHz for sine, and the default is 100Hz.

**FSKey: FREQUENCY? [MINimum|MAXimum]**

Query the "hop" frequency in FSK. The "hop" frequency in hertz will be returned.

**FSKey: INTERNAL:RATE {<rate in Hz>|MINimum|MAXimum }**

Specify the rate at which the output frequency "shifts" between the carrier and the hop frequency. The range is from 2mHz to 100kHz and the default is 10Hz. This FSK rate is used only when the FSK source is internal (FSK:SOUR INT).

- The modulating waveform is a square wave with a 50% duty cycle.

**FSKey: INTernal:RATE? [MINimum|MAXimum]**

Query the FSK rate. The FSK rate will be returned.

**FSKey: SOURce {INTernal|EXTernal}**

Specify the FSK source. The default is Internal.

**FSKey: SOURce?**

Query the FSK source. "INT" or "EXT" string indicating FSK source will be returned.

**FSKey: STATe {OFF|ON}**

Disable or enable FSK Modulation. The default is OFF. To avoid multiple waveform changes, you can enable it after setting up the modulation parameters.

Only one type of modulation can be activated at one time. Also when FSK modulation is activated, sweep or burst mode will be disabled.

**FSKey: STATe?**

Query the FSK state. "0" (OFF) or "1" (ON) will be returned.

**FUNCTION:PULSe:HOLD {WIDTh|DCYClE}**

Instruct the waveform generator to hold either the pulse width or the duty cycle.

- When the pulse width is held constant, the period is varied. (Minimum width and edge time restrictions apply.) If a command specifying the duty cycle is received, the duty cycle is converted into equivalent pulse width in seconds. If Pulse Width Modulation is turned on, the pulse width is held, and the width deviation is held too, as the period is varied. Duty cycle deviation commands are converted to width deviation values.
- When the duty cycle is held constant, the period is varied. (Minimum width and edge time restrictions apply.) If a command specifying the pulse width is received, the pulse width is converted into equivalent duty cycle in percent. If Pulse Width Modulation is turned on, the duty cycle is held, and the duty cycle deviation is held too, as the period is varied. Pulse width deviation commands are converted to duty cycle deviation values.

**FUNCTION:PULSe:HOLD? [WIDTh|DCYClE]**

Query either the value of the pulse width or the duty cycle being held. The value of duty cycle in percent or the value of pulse width in seconds is returned.

**FUNCTION:PULSe:WIDTh {<seconds>|MINimum|MAXimum }**

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

- The pulse width represents the time from the 50% threshold of the rising edge of the pulse to the 50% threshold of the next falling edge.
- The minimum value of the pulse width is 20 ns and the maximum value is 1999.99 seconds.
- The minimum pulse width is restricted by the period as below:

Wmin=20 ns when period is not greater than 10s.

Wmin=200 ns when period is greater than 10s, but not greater than 100s.

Wmin=2µs when period is greater than 100s, not greater than 1000s.

Wmin=20µs when period is greater than 1000s.

- The specified pulse width must be less than the difference between the period and the minimum pulse width.

$$\text{Pulse Width} \leq \text{Period} - W_{\text{min}}$$

The waveform generator adjusts the edge time first, and then the width if necessary to accommodate the period. From the remote interface, a “Setting conflict” error is generated and the pulse width is adjusted.

- The specified pulse width must be less than the difference between the period and the edge time.

$$\text{Pulse Width} \leq \text{Period} - (1.6 \times \text{Edge time})$$

The waveform generator adjusts the edge time first, and then the width if necessary to accommodate the period. From the remote interface, a “Data out of range” error is generated and the pulse width is adjusted.

- The specified pulse width must be greater than the total time of one edge:

$$\text{Pulse Width} \geq 1.6 \times \text{Edge time}$$

- Among the pulse width and pulse duty cycle, the FUNC:PULS:HOLD command determines which of them is to be held and it affects this function when the waveform generator adjusts the period.

**FUNCTION:PULSe:WIDTh? [MINimum|MAXimum ]**

Query the pulse width. The pulse width in seconds will be returned.

**FUNCTION:PULSe:DCYCLE {<percent>| MINimum|MAXimum }**

Specify the pulse duty cycle in percent. The range is from 0 percent to 100 percent. The default is 10 percent. The minimum value is approximately 0 percent and the maximum value is approximately 100 percent.

- The definition of the pulse duty cycle is described below:

$$\text{Duty Cycle} = 100 \times \text{Pulse width/Period}$$

Where the pulse width represents the time from the 50% threshold of the rising edge of the pulse to the 50% threshold of the next falling edge.

- The duty cycle is restricted by minimum pulse width and edge time, which prevents you from setting exactly 0 percent or 100 percent.
- The minimum pulse width affects the value of the specified pulse duty cycle as below:

$$\text{Duty Cycle} \geq 100 \times W_{\text{min}}/\text{Period}$$

And

$$\text{Duty Cycle} \leq 100 \times (1 - W_{\text{min}}/\text{Period})$$

where

$W_{\text{min}}=20\text{ns}$  when period is not greater than 10s.

$W_{\text{min}}=200\text{ns}$  when period is greater than 10s, but not greater than 100s.

$W_{\text{min}}=2\mu\text{s}$  when period is greater than 100s, not greater than 1000s.

$W_{\text{min}}=20\mu\text{s}$  when period is greater than 1000s.

The waveform generator adjusts the pulse duty cycle when needed to accommodate the specified pulse period. From the remote interface, a “Data out of range” error is generated and the pulse duty cycle is adjusted.

- The specified pulse duty cycle may affect the edge time.  
The waveform generator adjusts the edge time first, and then the duty cycle if necessary to accommodate the period. From the remote interface, a “Data out of range” error is generated and the duty cycle and edge time will be restricted as below:

$$\text{Duty cycle} \geq 100 \times (1.6 \times \text{Edge time})/\text{Period}$$

And

$$\text{Duty cycle} \leq 100 \times (1 - (1.6 \times \text{Edge time})/\text{Period})$$

- Among the pulse width and pulse duty cycle, the FUNC:PULS:HOLD command determines which of them is to be held and it affects this function when the waveform generator adjusts the period.

**FUNCTION:PULSe:DCYCLE? [MINimum|MAXimum]**

Query the pulse duty cycle. The duty cycle in percent will be returned.

**FUNCTION:PULSe:TRANSition {<seconds> MINimum|MAXimum }**

Specify the edge time in seconds for both the rising and the falling edges.

The edge time represents the time from the 10% threshold to 90% threshold of each edge. The range for edge time is from 5ns to 100ns, and the default is 5ns. The minimum value is 5ns and the maximum value is 100ns.

- The specified edge time must fit in within the specified pulse width as shown below. The waveform generator will adjust the edge time if necessary to accommodate the specified pulse width or duty cycle.

$$\text{Edge time} \leq 0.625 \times \text{Pulse width}$$

or

$$\text{Edge time} \leq 0.625 \times \text{Period} \times \text{Duty cycle}/100$$

**FUNCTION:PULSe:TRANSition? [MINimum|MAXimum]**

Query the edge time. The edge time in seconds is returned.

**FUNCTION:RAMP:SYMMetry {<percent>| MINimum|MAXimum }**

Specify the symmetry percentage for ramp waves. Symmetry represents the amount of time per cycle that the ramp wave is rising (supposing the waveform polarity is not inverted). The range is from 0% to 100% and the default is 100%.

- The APPLY command overrides the current symmetry setting and used 100% symmetry.
- The specified symmetry is remembered and will be used when you change the function and then come back to ramp waves.
- The symmetry setting does not apply when you use a ramp wave as the modulating wave in AM or FM.

**FUNCTION:RAMP:SYMMetry? [MINimum|MAXimum]**

Query the current symmetry setting in percent.

**FUNCTION:SQUare:DCYCLE {<percent>| MINimum|MAXimum }**

Specify the duty cycle percentage for square waves. Duty cycle represents the time per cycle that a square wave is at its high level (supposing the waveform polarity is not inverted). The default is 50%. The range is from 20% to 80% when the waveform frequency is not greater than 10MHz and from 40% to 60% when the waveform frequency is greater than 10MHz.

- The APPLY commands overrides this command and sets the duty cycle to 50%.
- The specified duty cycle is remembered and will be used when you change the function and then come back to square waves.
- The duty cycle setting does not apply when you use square wave as the modulating wave in AM, PM, FM, or PWM. The duty cycle of 50% for square waves is used.
- When you use the square waveforms, but then later specify a frequency that cannot produce the current duty cycle, the waveform generator automatically adjust the duty cycle to accommodate the newly specified frequency. From the remote interface, a "Settings conflict" error will be generated.

### **FUNCTION:SQUare:DCYCLE? [MINimum|MAXimum]**

Query the current duty cycle in percent.

### **FUNCTION:USER {<arb name>|VOLATILE}**

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

The names of the five built-in arbitrary waveforms are “EXP\_RISE”, “EXP\_FALL”, “NEG\_RAMP”, “SINC”, and “CARDIAC”. The default is “EXP\_RISE”. If a waveform stored in volatile memory is desired, specify the VOLATILE parameter. This command does not output the chosen waveform. Use FUNCTION USER command to output the waveform.

If you specify a waveform name that is not currently downloaded, a “Specified arb waveform does not exist” error is generated.

### **FUNCTION:USER?**

Query the selection of waveform specified by FUNCTION USER {<arb name>|VOLATILE} command.

### **FUNCTION USER**

Select the arbitrary waveform function and output the current arbitrary waveform. The selected waveform is output using the current frequency, amplitude and offset settings. You can use the APPLY command or the FREQ, VOLT, and VOLT:OFFS commands to specify the frequency, amplitude, and offset.

The maximum amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog converter). For example, the built-in sine wave does not use the full range of binary values between  $\pm 1$  and therefore its maximum amplitude is 6.087Vp-p (into 50 $\Omega$ ).

When you use an arbitrary waveform as your modulating waveform(“USER”), the waveform is automatically limited to 4k points. Extra waveform points are removed using decimation.

### **FUNCTION?**

Query the selection made by FUNCTION USER command. One of the strings “SIN”, “SQU”, “RAMP”, “PULS”, “NOIS”, “DC”, and “USER” will be returned.

-- I to O --

-- I --

**\*IDN?**

Query the waveform generator's identification string which contains four fields separated by commas. The descriptions of these four fields are shown below:

Manufacturer's Name, Model Number, Serial Number, Revision Code

The Revision code contains four numbers separated by dashes.

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

-- L --

**\*LRN?**

Query the waveform generator and return a string of SCPI commands containing the current settings (learn string). You can then send the string back to the instrument to restore this state at a later time. For proper operation, do not modify the string before sending it back to the waveform generator. The string should contain about 1,500 characters. To avoid possible instrument errors, execute the \*RST command first, and then send the string back to the waveform generator.

-- M --

**MARKer {OFF|ON}**

Disable or enable the frequency marker. The default is OFF. When the frequency marker is off, the signal output from the *Sync* connector is the normal Sync signal for the carrier waveform.

The OUP:SYNC command is overridden by the setting of the MARK command, so when the marker frequency is turned on ( and the sweep mode is also turned on), the OUP:SYNC command is ignored.

**MARKer?**

"0" or "1" indicating the enable state of the frequency marker will be returned.

**MARKer:FREQuency {<frequency>|MINimum|MAXimum}**

Specify the marker frequency. The signal on the front-panel *Sync* connector goes to a logic low at the marker frequency during the sweep. The range is from 1µHz to 50MHz (limited to 200kHz for ramps and 10MHz for arbitrary waveforms) and the default is 500Hz. The minimum value is the lower one of the start and stop frequencies and the maximum value is the higher one of the start and stop frequencies.

The marker frequency must be a value between the specified start and stop frequencies. If you select an out-of-range value, a "Settings conflict" error is generated and the waveform generator will automatically set it to either the start or the stop frequency depending on which is the closer one.

**MARKer:FREQuency? [MINimum|MAXimum]**

Query the marker frequency.

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

Assign a custom name for the specified storage 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 name from the front panel.

The custom name can contain up to 12 characters. The first character must be a letter (A-Z), but the remaining characters can be letters, numbers or the underscore character ("\_"). Blank spaces are not allowed. Assigning the same name to different locations is allowed. You cannot assign a name to storage location "0".

**MEMory:STATe:NAME? {1|2|3|4}**

Query the name of the specified storage location. If the specified location has no custom name, its default name will be returned.

**MEMory:STATe:DELeTe {1|2|3|4}**

Erase the instrument state from the specified storage location, including the custom name specified to that location, if any, and restore the default name. You cannot recall the instrument state from a storage location that is empty or an error will be generated.

**MEMory:STATe:RECall:SELeCt {0|1|2|3|4}**

Select power-on state from stored state when power is turned on. The default is "0" (default state).

**MEMory:STATe:RECall: SELeCt?**

Query the power-on state when power is turned on. The value 0 to 4 will be returned. 0: default state, 1: state 1, 2: state 2, 3: state 3, 4: state 4

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

Query the specified storage location to determine if it currently stores a valid instrument state. "0" is returned when there is no valid state stored in that location and "1" is returned when there is a valid state stored in that location.

## **MEMory:NStates?**

Query the number of storage locations available for storing the states. "5" is returned.

-- O --

## **\*OPC**

Set the "Operation complete" bit (bit 0) in the Standard Event Register after all of the previous commands have been completed. Other commands may be executed before the bit is set. This command is used in the triggered sweep or triggered burst modes to provide a way to poll or interrupt the computer when the \*TRG command is complete.

## **\*OPC?**

Returns "1" to the output buffer after the previous commands have been completed. Other commands can not be executed until this command completes.

## **OUTPut {OFF|ON}**

Disable or enable the Output connector on the front panel. The default is OFF. The Output key is lit when enabled.

- The APPLY command overrides the current OUTP command setting and automatically enables the Output connector.
- The Output connector will be disabled when an excessive external voltage is applied to it. To re-enable it, remove the excessive voltage and use this command to enable it again.
- This command changes the state of the output connector by switching the output relay. However, this command does not zero the voltage to be output before switching the relay. Thus, the output signal may have "glitches" for about a millisecond until the signal stabilizes. You can minimize these glitches by first setting the amplitude to the minimum (using the VOLTage command) and the offset to zero (using the VOLTage:OFFSet command) before changing the output state.

## **OUTPut?**

"0" or "1" indicating the on/off state of the Output connector on the front panel is returned.

## **OUTPut:LOAD {<ohms>|INFinity|MINimum|MAXimum}**

Select the desired output termination. It can be any value (in ohms) between 1Ω and 10kΩ. INF sets the output termination to "high impedance" (>10kΩ). The default is 50Ω. The specified value is used for amplitude, offset, and high/low level settings.

- When the output termination is changed, the displayed output amplitude, offset, and high/low levels are automatically adjusted, and no errors will be generated.
- The waveform generator has a fixed series output impedance of 50Ω to the front-panel Output connector. If the actual load impedance is different than the specified value, the displayed amplitude, offset and high/low levels will be incorrect.
- When the output termination is set to "high impedance", you cannot specify the output

amplitude in dBm. The unit will be automatically converted to Vp-p.

**OUTPut:LOAD? [MINimum|MAXimum]**

Query the current load setting in ohms. Return the current load setting or “9.9E+37” meaning “high impedance”.

**OUTPut:POLarity { NORMal|INVerted }**

Invert the waveform relative to the offset voltage. The default is NORM, in which the waveform goes positive during the first part of the cycle and in INV mode the waveform goes negative during the first part of the cycle. The offset remains the same when the waveform is inverted and the Sync signal is not inverted.

**OUTPut:POLarity?**

Query the polarity of the waveform. “NORM” or “INV” indicating the polarity will be returned.

**OUTPut:SYNC {OFF|ON}**

Disable or enable the Sync connector on the front-panel. The default is ON.

By disabling the Sync signal, you can reduce the output distortion at lower amplitude. When the Sync signal is disabled, the output level on the Sync connector is a logic “low” level.

- When a waveform is inverted, its Sync signal is not inverted.
- This command is overridden by the setting of the MARK command used with the sweep mode, therefore when the marker frequency is enabled (and the sweep is enabled too), the OUTP:SYNC is ignored.

**OUTPut:SYNC?**

“0” or “1” indicating the enable state of the Sync connector on the front panel will be returned.

### **OUTPut:TRIGger:SLOPe {POSitive|NEGative}**

Specify an edge for the “trigger out” signal. When the trigger out signal is enabled by OUTP:TRIG command, a TTL-compatible square waveform with the specified edge is output from the *Ext Trig* connector on the rear panel at the beginning of the sweep or burst. For a pulse with a rising edge, use Positive and for a pulse with a falling edge, use Negative.

When using the Immediate (internal) trigger source (the TRIG:SOUR IMM command), the waveform generator outputs a square waveform with a 50% duty cycle (the rising edge is the sweep trigger) from the Ext Trig connector on the rear panel. The period is equal to the sweep time.

- When using the External trigger source (the TRIG:SOUR EXT command), the waveform generator disables the “trigger out” signal and the Ext Trig connector is used for sending an externally-triggered sweep.
- When using the Bus (software) trigger source (the TRIG:SOUR BUS command), the waveform generator outputs a pulse (>1 $\mu$ s pulse width) from the Ext Trig connector at the beginning of the sweep.

### **OUTPut:TRIGger:SLOPe?**

“POS” or “NEG” string indicating the edge for the “trigger out” signal will be returned.

### **OUTPut:TRIGger {OFF|ON}**

Disable or enable the trigger out signal. The default is OFF. When the trigger out signal is enabled, a TTL-compatible square waveform with the specified edge is output from the *Ext Trig* connector on the rear panel at the beginning of the sweep or burst.

### **OUTPut:TRIGger?**

“0” or “1” indicating the trigger out signal state will be returned.

-- P to Z --

-- P --

### **PHASe {<angle>|MINimum|MAXimum}**

Adjust the phase offset of the output waveform in degrees or radians as specified by the previous UNIT:ANGL command (not available for pulse and noise). The range is from -360 degrees to 360 degrees or  $-2\pi$  to  $+2\pi$  radians. The default is 0 degrees.

- The specified phase adjustment causes a “bump” or “hop” in the output waveform in order to change the phase relationship to the external signal to which it is currently locked.
- The phase adjustment for phase-lock applications is independent of the burst phase as set by the BURS:PHAS command.

### **PHASe [MINimum|MAXimum]**

Query the phase offset in degree or radians.

## **PHASe:REFeRence**

Set the zero-phase reference point immediately without changing the output. This command changes the phase reference only, and it does not change the phase offset as set with the PHAS command.

## **PHASe:UNLock:ERRor:STATe {OFF|ON}**

Disable or enable the waveform generator to generate an error when the phase-lock is lost. The default is off. When the error is enabled, and the phase-lock is lost, a "Reference phase-lock loop is unlocked" error will be generated. The error setting is cleared after the waveform generator has been turned off.

## **PHASe:UNLock:ERRor:STATe?**

Query the enable state of the lost phase-lock error.

PM:INTernal:FUNCTion {SINusoid|SQUare|RAMP|NRAMP|TRIangle|NOISe|USER}

Specify the shape of the modulating waveform. This applies only when the modulation source is Internal (PM:SOUR INT). Noise can be a modulating waveform, but cannot be used as a carrier waveform, neither do Pulse nor dc. The default modulating waveform is a sine waveform.

- Square waveform has 50% duty cycle.
- Ramp waveform has 100% symmetry
- Triangle waveform has 50% symmetry.
- Negative Ramp waveform has 0% symmetry.
- If an Arbitrary(USER) waveform is chosen to be the modulating waveform, it is automatically limited to 4k points. Extra points are removed using decimation.

## **PM:INTernal:FUNCTion?**

Query the modulating function used in phase modulation. "SIN", "SQU", "RAMP", "NRAMP", "TRI", "NOIS" or "USER" string indicating the modulating function will be returned.

## **PM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}**

Specify the modulating waveform frequency. This applies only the modulation source is internal (PM:SOUR INT). The range is from 2mHz to 20kHz and the default is 10Hz.

## **PM:INTernal:FREQuency? [MINimum|MAXimum]**

Query the internal modulating frequency in Phase modulation. The internal modulating frequency in hertz will be returned.

## **PM:DEVIation {<peak deviation in hertz>|MINimum|MAXimum}**

Specify the phase deviation in degrees. Phase deviation represents the peak variation in phase of the modulated waveform from the carrier waveform. The range is from 0 to 360 degrees and the default is 180 degrees. When an external source is selected, the carrier is modulated with an external waveform. The phase deviation is controlled by the  $\pm 5V$  signal on the rear panel *Modulation In* connector. It means that when you choose to have a deviation of 180 degrees, then a +5V signal level corresponds to a 180 degree phase shift. Lower the external signal level is, less the deviation is.

**PM:DEVIation? [MINimum|MAXimum]**

Query the phase deviation in phase modulation. The phase deviation in degree will be returned.

**PM:SOURce {INTernal|EXTernal}**

Specify the modulating signal source. The default is INTernal. When an external source is selected, the carrier is modulated with an external waveform. The phase deviation is controlled by the  $\pm 5V$  signal on the rear panel Modulation In connector. It means that when you choose to have a deviation of 180 degrees, then a +5V signal level corresponds to a 180 degree phase shift. Lower the external signal level is, less the deviation is.

**PM:SOURce?**

Query the modulating source in phase modulation. "INT" or "EXT" string indicating the modulating source will be returned.

**PM:STATe {OFF|ON}**

Disable or enable Phase Modulation. The default is OFF. To avoid multiple waveform changes, you can enable it after setting up the modulation parameters.

Only one type of modulation can be activated at one time. Also when Phase modulation is activated, sweep or burst mode will be disabled.

**PM:STATe?**

"0" (OFF) or "1" (ON) will be returned.

**PWM:INTernal:FUNCTion {SINusoid|SQUare|RAMP|NRAMP|TRIangle|NOISe|USER}**

Specify the shape of the modulating waveform. The default is sine. This applies when the modulation source is internal (PWM:SOUR INT). The carrier is a pulse wave in PWM.

- Square waveform has 50% duty cycle.
- Ramp waveform has 100% symmetry
- Triangle waveform has 50% symmetry.
- Negative Ramp waveform has 0% symmetry.
- If an Arbitrary(USER) waveform is chosen to be the modulating waveform, it is automatically limited to 4k points. Extra points are removed using decimation.

**PULSe:PERiod {<seconds>|MINimum|MAXimum}**

Specify the pulse period. The range is from 100ns to 2000 seconds. The default is 1ms.

- The specified period must be greater than the sum of the pulse width and the edge time, if not, the waveform generator automatically adjust the edge time first and the pulse width (if needed) to accommodate the period.

$$\text{Period} \geq \text{Pulse Width} + (1.6 \times \text{Edge Time})$$

Or

$$\text{Period} \geq (\text{Period} \times \text{Duty Cycle}/100) + (1.6 \times \text{Edge Time})$$

- The specified period stays when the function changes. If you select pulse waveform and specify the period by PULS:PER command, and then choose another function, the period will be used on the new function.
- If you change to a function whose minimum period is greater than that for a pulse waveform, the period is adjusted to the minimum value allowed for the new function. For example, if you output a pulse waveform with a period of 200 ns and then change to the ramp function, the waveform generator will automatically adjust the period to 5µs (the lower limit for ramps). A “Settings conflict” error will be generated and the period will be adjusted.

**PULSe:PERiod? [MINimum|MAXimum]**

The period of the pulse waveform will be returned in seconds.

**PWM:INTernal:FUNCtion?**

Query the modulating function used in PWM. “SIN”, “SQU”, “RAMP”, “NRAM”, “TRI”, “NOIS” or “USER” string indicating the modulating function will be returned.

**PWM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}**

Specify the modulating waveform frequency. This applies only when the modulation source is internal (PWM:SOUR INT). The range is from 2mHz to 20kHz and the default is 10Hz.

**PWM:INTernal:FREQuency? [MINimum|MAXimum]**

Query the internal modulating frequency in PWM. The internal modulating frequency in hertz will be returned.

**PWM:DEVIation {< deviation in seconds>|MINimum|MAXimum}**

Specify the pulse width deviation in seconds. Pulse width deviation represents the variation in seconds from the pulse width of the carrier pulse width. The range is from 0 to 1000 seconds and the default is 10µs. The pulse width deviation cannot exceed the current pulse width. The minimum value is 0 seconds and the maximum value is determined by period, minimum pulse width and edge time. Here's the constraints pulse width deviation has to conform:

$$\text{Width Deviation} \leq \text{Pulse Width} - W_{\text{min}}$$

And

$$\text{Width Deviation} \leq \text{Period} - \text{Pulse Width} - W_{\text{min}}$$

Where:

$$W_{\text{min}} = 200\text{ns for period} \leq 10\text{s.}$$

$$W_{\text{min}} = 200\text{ns for period} > 10\text{s, but} \leq 100\text{s.}$$

$$W_{\text{min}} = 2\mu\text{s for period} > 100\text{s, but} \leq 1000\text{s.}$$

$$W_{\text{min}} = 20\mu\text{s for period} > 1000\text{s.}$$

Also

$$\text{Width Deviation} \leq \text{Pulse width} - (1.6 \times \text{Edge time})$$

And

$$\text{Width Deviation} \leq \text{Period} - \text{Pulse width} - (1.6 \times \text{Edge time})$$

When you choose an external source (PWM:SOUR EXT), the width deviation is controlled by the ±5V signal level shown on the Modulation In connector on the rear panel. It means that when the modulating signal is at +5V, the output will be at its maximum width deviation, and when the modulating signal is at -5V, the output will be at its minimum duty cycle. Lower external signal levels produce less deviation, and negative signal levels produce negative deviation.

**Note**

The operation of this command is affected by FUNC:PULS:HOLD command. FUNC:PULS:HOLD command decides if the pulse width or the duty cycles are to be held constant as the period varies. If the pulse width is held constant, so is the pulse width deviation; If the duty cycle is held constant, so is the duty cycle deviation. If one is held constant, the other specified in the command will be automatically converted to the equivalent value.

**PWM:DEVIation? [MINimum|MAXimum]**

Query the pulse width deviation. The pulse width deviation in seconds will be returned.

**PWM:DEVIation:DCYCLE {< deviation in percent>|MINimum|MAXimum}**

Specify the duty cycle deviation in percent. This value represents the duty cycle variation in the modulated waveform from the duty cycle in the original pulse waveform, and it is in the form of a percentage of the period.

The default duty cycle deviation is 1%, and the range is from 0% to 100%. The minimum value is 0% and the maximum value is approximately 100% (limited by the period, minimum pulse width, and edge time). More over, it must not be greater than the pulse duty cycle and is under the following constraints:

$$\text{Duty Cycle Deviation} \leq \text{Duty Cycle} - 100 \times \text{Minimum Width/Period}$$

And

$$\text{Duty Cycle Deviation} \leq 100 - \text{Duty Cycle} - 100 \times \text{Minimum Width/Period}$$

Where

$$W_{\min} = 200\text{ns for period} \leq 10\text{s.}$$

$$W_{\min} = 200\text{ns for period} > 10\text{s, but} \leq 100\text{s.}$$

$$W_{\min} = 2\mu\text{s for period} > 100\text{s, but} \leq 1000\text{s.}$$

$$W_{\min} = 20\mu\text{s for period} > 1000\text{s.}$$

The duty cycle deviation also needs to conform with the following rules:

$$\text{Duty Cycle Deviation} \leq \text{Duty Cycle} - (160 \times \text{Edge Time})/\text{Period}$$

And

$$\text{Duty Cycle Deviation} \leq 100 - \text{Duty Cycle} - (160 \times \text{Edge Time})/\text{Period}$$

When you choose an external source (PWM:SOUR EXT), the duty cycle deviation is controlled by the  $\pm 5\text{V}$  signal level shown on the Modulation In connector on the rear panel. It means that when the modulating signal is at +5V, the output will be at its maximum width deviation, and when the modulating signal is at -5V, the output will be at its minimum duty cycle. Lower external signal levels produce less deviation, and negative signal levels produce negative deviation.

**Note**

The operation of this command is affected by FUNC:PULS:HOLD command. FUNC:PULS:HOLD command decides if the pulse width or the duty cycles are to be held constant as the period varies. If the pulse width is held constant, so is the pulse width deviation; If the duty cycle is held constant, so is the duty cycle deviation. If one is held constant, the other specified in the command will be automatically converted to the equivalent value.

**PWM:DEVIation:DCYCLes? [MINimum|MAXimum]**

Query the duty cycle deviation in PWM. The duty cycle deviation in percent will be returned.

**PWM:SOURce {INTernal|EXTernal}**

Specify the modulating signal source. The waveform generator takes either an internal or an external source. The default is internal. When choosing an external source, the pulse waveform is modulated with an external waveform. The width/duty cycle deviation is controlled by the  $\pm 5V$  signal level shown on the Modulation In connector on the rear panel. It means that when the modulating signal is at +5V, the output will be at its maximum duty cycle, and when the modulating signal is at -5V, the output will be at its minimum duty cycle.

**PWM:SOURce?**

Query the modulating source in PWM. "INT" or "EXT" string indicating modulating source will be returned.

**PWM:STATe {OFF|ON}**

Disable or enable PWM. The default is OFF. To avoid multiple waveform changes, you can enable it after setting up the modulation parameters.

Only one type of modulation can be activated at one time. Also when PWM is activated, sweep or burst mode will be disabled. PWM is allowed only when pulse is used.

**PWM:STATe?**

Query the PWM state. "0" (OFF) or "1" (ON) will be returned.

-- R --

**\*RCL {0|1|2|3|4}**

Recall the instrument to the state previously stored in the non-volatile storage location.

- Storage location 0 stores the waveform generator's power-on state and storage location 1 to 4 are empty when the instrument is shipped out from the factory.
- You can not recall a state from a storage location which is empty.

**\*RST**

Reset the waveform generator to its factory default, independent of the MEM:STAT:REC:AUTO command setting. This command does not affect any stored instrument states, arbitrary waveforms, or the I/O settings. It also enables the front-panel display if it has been turned off. This command will abort a sweep or burst in progress.

-- S --

**\*SAV {1|2|3|4}**

Store the current instrument state to the specified non-volatile storage location.

- If there is any instrument state stored in the specified location, it will be overwritten.
- If you store the instrument state for an arbitrary waveform and then delete it later, the waveform data is lost and the waveform generator is not able to output the waveform.
- When you store an instrument state, the selected function, frequency, amplitude, dc offset, duty cycle, symmetry, as well as any modulation parameters are saved also.

**SWEep:SPACing {LINear|LOGarithmic|USER}**

Specify the spacing for the sweep. The default sweep mode is Linear, which waveform generator sweeps the frequency with spacing calculated in a linear function. In logarithmic sweep mode, the waveform generator sweeps with spacing calculated in a logarithmic function. In Arbitrary sweep mode, the waveform generator sweeps with spacing calculated in a wave pattern depending on chosen arbitrary waveform.

**SWEep:SPACing?**

Query the spacing used in sweeps. "LIN" or "LOG" or "USER" string indicating the spacing will be returned.

**SWEep:TIME {<seconds>|MINimum|MAXimum}**

Specify the time duration in seconds to sweep from the start frequency to the stop frequency. The range is from 1ms to 500 seconds and the default is 1 second.

The number of discrete frequency points in the sweep will be calculated according to the specified sweep time.

**SWEepe:TIME?**

Query the sweep time. The sweep time in seconds will be returned.

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

Disable or enable the sweep mode. The default is OFF. To avoid multiple waveform changes, you can enable it after setting up the modulation parameters.

Only one type of modulation can be activated at one time. Also when Sweep is activated, modulation or burst mode will be disabled.

**SWEep:STATe?**

Query the sweep state. "0" (OFF) or "1" (ON) will be returned.

### **SYSTem:ERRor?**

Query and clear one error from the waveform generator's error queue. Up to 20 errors can be stored in the queue. Errors are retrieved in first-in-first-out (FIFO) order. Each error string may contain up to 255 characters. The waveform generator beeps every time it detects an error unless the beeper is turned off. Errors are cleared once you read them.

If more than 20 errors are detected, "too many Errors" show up in the last place of the error queue. Unless user read the errors in the queue, the additional errors will not be stored. If there is no error in the error queue when you read it, "No error" string will be displayed.

### **SYSTem:BEEPer**

Issue a single beeping tone.

### **SYSTem:BEEPer:STAtE {OFF|ON}**

Disable or enable the beeper.

### **SYSTem:BEEPer:STAtE?**

Query the beeper state. Return "0" (OFF) or "1" (ON).

**SYSTem:COMMunicate:RLStAtE {LOCAl|REMOte|RWLOCK}**

Set the remote/local state of the waveform generator over the LAN interface from a Telnet or socket session. Provides control analogous to the IEEE-488.2 commands such as GTL (Go To Local) over the GP-IB and USB interfaces. The default is Local which sets the instrument state to local and removes any annunciator and locks the front-panel keyboard. The Remote parameter sets the instrument state to remote, display the annunciators and locks the keyboard. The RWLock parameter sets the instrument state to remote with lock and display the rwl annunciator and locks the keyboard.

### **SYSTem:VERSIon?**

Query the waveform generator's current SCPI version. A string in the form of "YYYY.V" will be returned. "YYYY" represents the year of the version and "V" represents the version number.

### **SYSTem:KLOCK[:STAtE] {OFF|ON}**

Disable or enable the front panel keyboard lock. The default is OFF (meaning the lock is off). When the lock is on, the front panel keyboard is locked. You can exclude "local" key when locking the front panel keyboard by using SYST:KLOC:EXCL LOC before you lock the keyboard.

### **SYSTem:KLOCK:EXCLude {NONE|LOCAl}**

Specify if locking the front panel keyboard including the "local" key or excluding the "local" key.

### **SYSTem:KLOCK:EXCLude?**

Query which key is excluded when locking the front panel keyboard.

## **SYSTem:SECurity:IMMediate**

Clears all instrument memory except for the boot parameters and calibration constants. Reset all instrument setting to their \*RST values. This command clears all user-defined state information, user-defined arbitrary waveforms, and user-defined I/O settings. This command is usually used to clear all memory for security purpose, therefore it is not recommended for use in routine applications because of the possible unintended loss of data.

-- T --

## **TRIGger**

Issue an immediate trigger from the remote interface. This command can trigger a sweep or burst with any available trigger source (TRIG:SOUR command).

### **TRIGger:SOURce {IMMediate|EXTernal|BUS}**

Specify a trigger source for the triggered burst mode only. The waveform generator accepts a software (BUS) trigger, an immediate (internal) trigger, or a hardware trigger from the rear-panel EXT TRIG connector. The default is IMM.

- When using the immediate (internal) source, the frequency at which the burst is generated is determined by the burst period.
- When using the External source, the waveform generator takes hardware trigger from the Trig In connector on the rear panel.
- When using the Bus (software) trigger source, the waveform generator outputs one burst each time it receives a bus trigger command. Use \*TRG to trigger from the remote interface. The Trigger button is lit when the waveform generator is waiting for a trigger.
- The APPLY automatically sets the trigger source to be Immediate.
- When the External or the Bus source is selected, the burst count and the burst phase remain in effect, but the burst period is ignored.
- To ensure synchronization when the Bus source is selected, send the \*WAI (wait) command. When the \*WAI command is executed, the waveform generator waits for all pending operations to complete before executing any additional commands. For example, the following command string guarantees that the first trigger is accepted and the operation is executed before the second trigger is recognized.

### **TRIG:SOUR BUS;\*TRG;\*WAI;\*TRG;\*WAI**

- You can use the \*OPC? (operation complete query) command or the \*OPC (operation complete) command to 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 when the burst is complete.

### **TRIGger:SOURce?**

Query the trigger source. "IMM" or "BUS" or "EXT" string indicating the trigger source will be returned.

### **TRIGger:SLOPe {POSitive|NEGative}**

Specify whether the rising (positive) or falling (negative) edge of the trigger signal is to be used for an externally-triggered sweep. The default is POS.

### **TRIGger:SLOPe?**

Query the trigger slope. "POS" or "NEG" string indicating the trigger slope will be returned.

### **\*TST?**

Order a complete self-test of the waveform generator. Returns "0" when the test runs successfully, or "1" when the test fails.

-- U --

### **UNIT:ANGLE {DEGree|RADian}**

Specify the unit of the starting phase for the burst with the BURS:PHAS command. The default is DEG. Radians are not available from the front panel, so if switching to the front panel operation after using radians on the remote interface operation, the waveform generator automatically converts the unit back to degrees for you.

### **UNIT:ANGLE?**

"DEG" or "RAD" indicating the unit of the starting phase for the burst will be returned.

-- V --

### **VOLTage {<amplitude>|MINimum|MAXimum}**

Specify the output amplitude. The minimum value is 10mVp-p into 50Ω and the maximum value is the largest amplitude for the chosen function (at most 10Vp-p into 50Ω depending on the chosen function and the offset voltage).

- The output amplitude and offset voltage are related to Vmax as shown below:

$$|\text{Voffset}| + V_{p-p} / 2 \leq V_{\text{max}}$$

Where Vmax is the maximum peak voltage for the selected output termination (5V for a 50Ω load or 10V for a high-impedance load), the function generator will take the new specified output amplitude, but the offset voltage may be reduced accordingly, and a "Settings conflict" error is generated.

- Output Termination Limits: When the Output Termination Setting is changed, the Output Amplitude is automatically adjusted. For instance, when you change the output termination from 50Ω to "high impedance", your offset voltage doubles, thus it affects your output amplitude, and when Output Termination has been changed from "high impedance" to 50Ω, the offset voltage decreases in half.
- Output amplitude in dBm is not available when the output termination is set to "high impedance". The units will be Vp-p.
- For arbitrary waveforms, if the waveform data points do not span the full range of output DAC (Digital-to-Analog Converter), the maximum offset and amplitude will be limited.

- Setting a high level and low level is another way to specify the output amplitude. For instance, you will have an amplitude of 5Vp-p (with an associated offset voltage of -500mV) when you set your high level to +2Vp-p and low level to -3Vp-p.
- While changing amplitude, you may notice a momentary disruption in the output waveform at certain voltages due to switching of the output attenuators. The amplitude is controlled, however, the output voltage will never exceed the current setting while switching ranges. You may use the VOLT:RANG:AUTO command to disable the voltage autoranging to prevent this output disruption.
- To output a dc voltage level, select the dc voltage function using the FUNC DC command and then set the offset voltage level using the VOLT:OFFS command. You can set the dc level to any value between  $\pm 5\text{Vdc}$  into  $50\Omega$  or  $\pm 10\text{Vdc}$  into an open circuit.

### **VOLTage? [MINimum|MAXimum]**

Query the output amplitude for the current function. The value is returned in the unit chosen by the VOLT:UNIT command.

### **VOLTage:OFFSet {<offset>|MINimum|MAXimum}**

Specify the dc offset voltage. The default is 0V. The minimum value is the most negative dc offset for the chosen function and amplitude and the maximum value is the largest dc offset for the chosen function and amplitude.

- The output amplitude and offset voltage are related to  $V_{\text{max}}$  as shown below:

$$|\text{Voffset}| + V_{\text{p-p}} / 2 \leq V_{\text{max}}$$

Where  $V_{\text{max}}$  is the maximum peak voltage for the selected output termination (5V for a  $50\Omega$  load or 10V for a high-impedance load). The function generator will take the new specified output amplitude, but the offset voltage may be reduced accordingly, and a “Settings conflict” error is generated.

- When the Output Termination Setting is changed, the offset limits are automatically adjusted. For instance, when you change the output termination from  $50\Omega$  to “high impedance”, your offset voltage doubles, thus it affects your output amplitude, and when Output Termination has been changed from “high impedance” to  $50\Omega$ , the offset voltage decreases in half.
- For arbitrary waveforms, if the waveform data points do not span the full range of output DAC (Digital-to-Analog Converter), the maximum offset and amplitude will be limited.
- Setting a high level and low level is another way to specify the offset. For instance, you will have an amplitude of 5Vp-p (with an associated offset voltage of -500mV) when you set your high level to +2Vp-p and low level to -3Vp-p.

### **VOLTage:OFFSet? [MINimum|MAXimum]**

Query the dc offset voltage for the current function.

### **VOLTage:HIGh {<voltage>|MINimum|MAXimum}**

Specify the high voltage level. The default high level for all functions is +50mV. The minimum value is the most negative voltage level and the maximum value is the largest voltage level for the chosen function.

- The high and low voltage level must conform the following restriction:

$$V_{\text{high}} - V_{\text{low}} \leq V_{\text{p-p}} (\text{max}) \quad \text{and} \quad V_{\text{high}}, V_{\text{low}} \leq V_{\text{p-p}} (\text{max}) / 2$$

Where  $V_{\text{p-p}} (\text{max})$  is the maximum peak-to-peak amplitude for the chosen output termination (10 Vp-p for a 50Ω load or 20Vp-p for a high-impedance load). If you specify an invalid voltage level, the waveform generator will adjust it automatically to the highest allowed value and “Data out of range” error is generated.

- The high voltage level should always be greater than the low level. If not, a “Setting conflict” error is generated and the waveform generator automatically sets the high level to 1mV larger than the specified low level.
- specifying a high level and low level also sets the offset. For instance, you will have an amplitude of 5Vp-p (with an associated offset voltage of -500mV) when you set your high level to +2Vp-p and low level to -3Vp-p.
- When the Output Termination Setting is changed, the voltage levels are automatically adjusted. For instance, when you change the output termination from 50Ω to “high impedance”, your voltage shown on the display doubles, and when Output Termination has been changed from “high impedance” to 50Ω, the voltage decreases in half.
- To invert the waveform relative to the offset voltage, you can use the OUPt:POL command.

### **VOLTage:HIGh? [MINimum|MAXimum]**

Query the high voltage level.

### **VOLTage:LOW {<voltage>|MINimum|MAXimum}**

Specify the low voltage level. The default low level for all functions is -50mV. The minimum value is the most negative voltage level and the maximum value is the largest voltage level for the chosen function.

- The high and low voltage level must conform the following restriction:

$$V_{\text{high}} - V_{\text{low}} \leq V_{\text{p-p}} (\text{max}) \quad \text{and} \quad V_{\text{high}}, V_{\text{low}} \leq V_{\text{p-p}} (\text{max}) / 2$$

Where  $V_{\text{p-p}} (\text{max})$  is the maximum peak-to-peak amplitude for the chosen output termination (10Vp-p for a 50Ω load or 20Vp-p for a high-impedance load). If you specify an invalid voltage level, the waveform generator will adjust it automatically to the highest allowed value and “Data out of range” error is generated.

- The high voltage level should always be greater than the low level. If not, a “Setting conflict” error is generated and the waveform generator automatically sets the high level to 1 mV larger than the specified low level.
- specifying a high level and low level also sets the offset. For instance, you will have an amplitude of 5Vp-p (with an associated offset voltage of -500mV) when you set your high level to +2Vp-p and low level to -3Vp-p.
- When the Output Termination Setting is changed, the voltage levels are automatically adjusted. For instance, when you change the output termination from 50Ω to “high impedance”, your voltage shown on the display doubles, and when Output Termination has been changed from “high impedance” to 50Ω, the voltage decreases in half.
- To invert the waveform relative to the offset voltage, you can use the OUTP:POL command.

### **VOLTage:LOW? [MINimum|MAXimum]**

Query the low voltage level.

### **VOLTage: RANGE:auto{OFF|ON|ONCE}**

Disable or enable the voltage auto-ranging. The default is “On” where the waveform generator selects an optimal setting for the output amplifier and attenuators. When the auto-ranging is “Off”, the current setting is used.

- The “ONCE” parameter enables the auto-ranging, selects an optimal setting and then disables it.
- The APPLY command overrides this command and turns the auto-ranging on.
- Disabling the auto-ranging can avoid momentary disruption caused by attenuators switching while changing amplitudes. However, the amplitude and offset accuracy may be adversely affected when reducing the amplitude below the expected range change.

### **VOLTage: RANGE:auto?**

“0” (off) or “1” (on) indicating the auto-ranging enable state is returned.

### **VOLTage:UNIT {VPP|VRMS|DBM}**

Select the unit of the output amplitude. The default is VPP. The waveform generator used the same unit for front panel and the remote interface, so the front panel display in the unit that you select from remote interface.

If you don’t specify the unit in the APPLY or VOLT commands, the function generation uses the unit specified in this command.

When the output termination is set to “high impedance”, you cannot specify the output amplitude in dBm. The unit will be automatically converted to Vp-p.

### **VOLTage:UNIT?**

Query the unit of the output amplitude. “VPP”, “VRMS” or “DBM” will be returned.

-- W --

**\*WAI**

Wait for all pending operation to complete before executing any additional commands over the interface.

**B-4. IEEE-488 Compliance Information**

The SCPI commands used in FGX-295 are in conformance with the SCPI standard Version 1992.0. The common commands are listed below:

\*CLS  
\*ESE<NRf>  
\*ESE?  
\*ESR?  
\*IDN?  
\*LRN?  
\*OPC  
\*OPC?  
\*PSC {0|1}  
\*PSC?  
\*RCL<0|1|2|3|4>  
\*RST  
\*SAV<0|1|2|3|4>  
\*SRE<NRf>  
\*SRE?  
\*STB?  
\*TRG  
\*TST?  
\*WAI

**B-5. Using device clear to halt measurements**

Device Clear is a special IEEE-488 low-level bus message. It is designed to be used to return the waveform generator to a responsive state. Different programming languages and IEEE-488 interface cards provide their own special commands to perform this function. The status registers, the error queue, and all configuration states are left intact when a device clear is performed. In particular, device clear performs the following actions:

- The input and output buffers are cleared.
- An overlapped command, if any, will be terminated without “Operation Complete” indication (applies to the \*TRG command).
- Any sweep or burst in progress will be immediately aborted.
- Get the waveform generator ready to accept a new command string.

## Appendix C: Application programs Various operation by remote interface

Various operation of FGX-295 is possible using several interfaces.

There are two methods for controlling from the interface, one is to issue directly a command and the other is to use private application. The detail of each is described below.

### C-1. Communication issuing directly a command

The front panel operation is possible by issuing a various command from the PC via each interface. However, the data of an arbitrary waveform which is custom made by users may not be transferred. Depending on the way of communication, following drivers will be needed.

[Communication method using each interface and comand]

Interface	Communication method	Required driver
USB	Communication via NI-VISA	NI-VISA
GPIB	Communiaction via NI-VISA	NI-VISA
	Direct communication	Not required
LAN	Communication via NI-VISA	NI-VISA

※ NI-VISA is included in the attached CD

### C-2. Communication by private application

Front panel operation or transfer of the arbitrary waveform data made by users may be transferred by using the private application. The relation between the private application and the interface will be as following.

[Private application and interface]

Private application	Adaptable interface	Required driver	Function
Wavepatt (Included with attached CD)	USB、GPIB	NI-VISA	<ul style="list-style-type: none"> <li>▪ Panel operation by command issue</li> <li>▪ Arbitrary waveform data create and transfer</li> </ul>
Control by internal software of FGX (Refer next close)	LAN	Not required	Panel operation and various data display by HTML window

※ Please refer application manual included in the CD for Wavepatt.

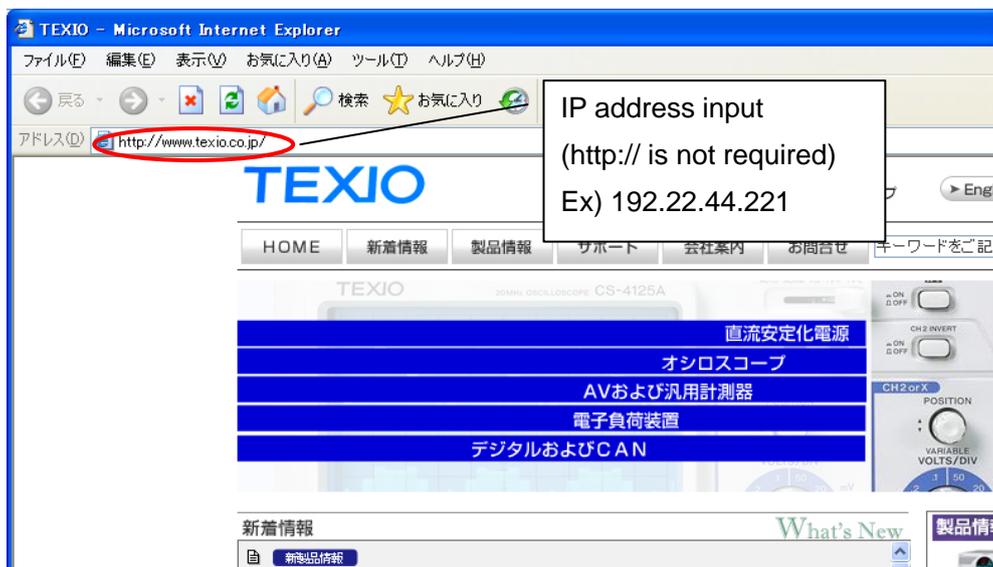
### C-3. LAN communication by internal software of FGX-295 (LXI communication)

By internal software of FGX-295, panel operation or display of various data may be done via LAN.

Keeping the LAN connection with the product, the internal software of FGX-295 will be displayed while input of the product IP as address into the Internet Browser. Refer 5.1.3 for product IP address.

Clicking the upper left button of HTML window, the panel operation window or a diverse information display window may be selected.

#### Setup for IP address



#### Display window

TEXIO

50MHz ARBITRARY FUNCTION GENERATOR

### Welcome to use FGX-295

Information about this Web-Enabled Instrument

- Welcome Page
- Browser Web Control
- View & Modify Configuration
- System Status
- Print Display
- Help with this Page

Information related to communication	FGX-295 50MHz ARBITRARY FUNCTION GENERATOR
Panel operation	TEXIO
LAN setup change	TW00009235
System information display	TEXIO-FGX-295 (TW00009235)
Printout display window	C
Help	1.2.01
Ethernet (MAC) Address:	192.168.0.1
TCP/IP Address:	00-19-7B-00-24-13
Firmware Revision:	192.168.0.1
	0.01-0B0-1B-02-02

Advanced information

Instrument Address String:	TCP/IP:: 192.168.0.1 ::INSTR TCP/IP:: 192.168.0.1 ::5025::SOCKET USB::2447::295::TW00009235::INSTR GPIB::1::INSTR
SCPI TCP/IP Socket Port:	5025
SCPI Telnet Port:	5024
GPIB Address:	1

## Front panel operation window

Clicking the button on the operation panel, the entire operation of FGX-295 is possible. Also, the display of FGX-295 will also synchronize along with the remote operation.

Left click then setup value falls, rises with right click.

Display contents is renewed each time of click.

Click each button to synchronize with real button.

Renew the display contents.

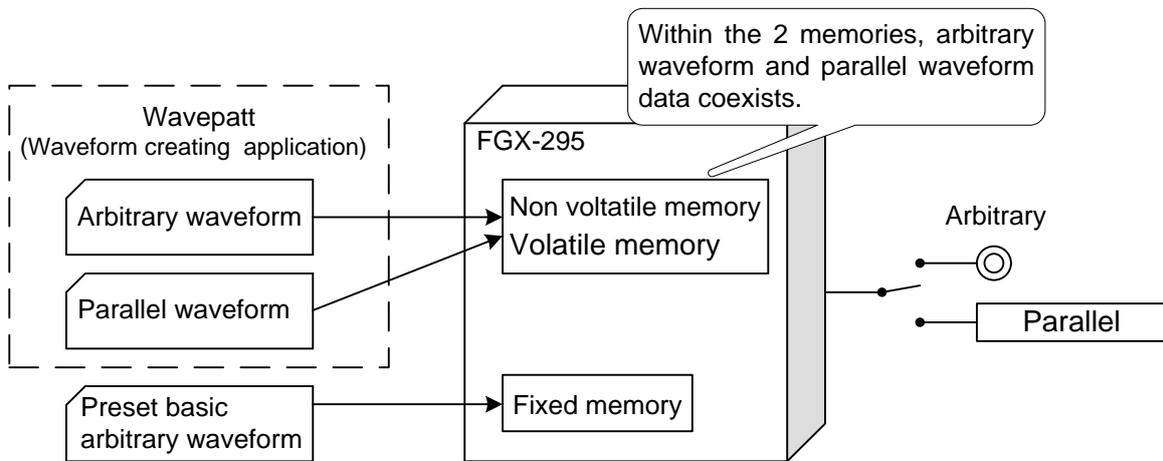
Update Display

## Appendix D: Arbitrary waveform and parallel output waveform data

FGX-295 is capable to save both user customized arbitrary waveform as well as parallel waveform. These two kinds of data will be created by the attached application software “Wavepatt” and will be saved into the following two kinds of memory inside of FGX-295.

- Non volatile memory (May save up to 4 data and data will not disappears even power OFF)
- Volatile memory (May save one data and disappears when power OFF)

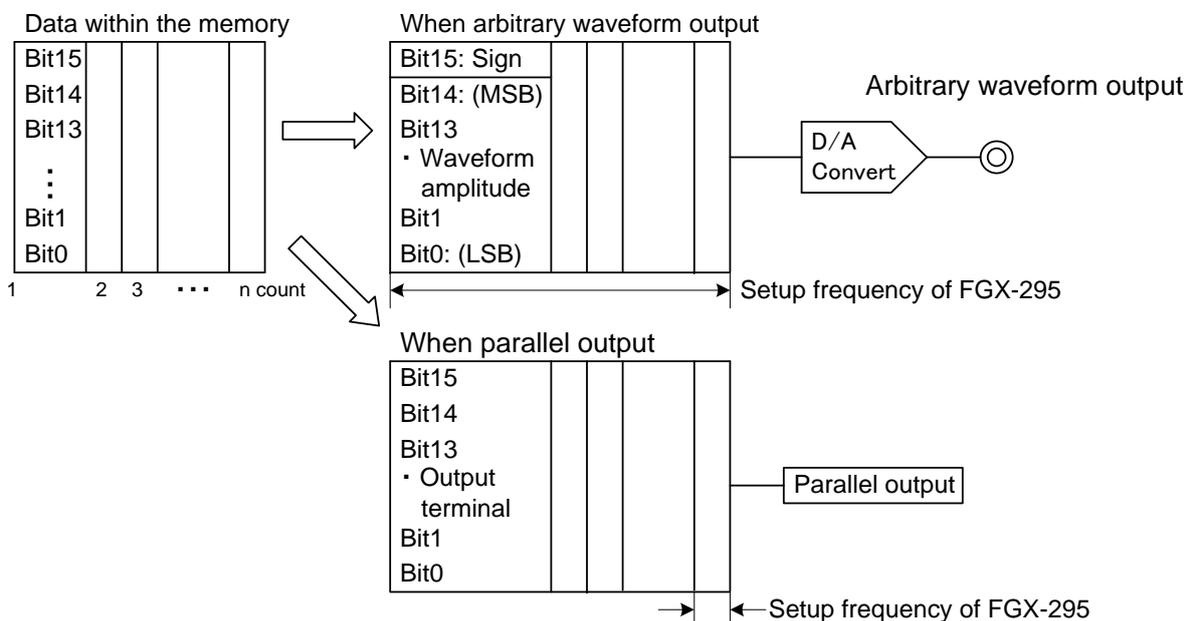
Besides, a basic arbitrary waveform pre-set inside of FGX (Exponential rise, Exponential fall, Negative ramp wave, Sync wave, Cardio wave) exists within the fixed memory so a basic 3 kinds of output waveform such as arbitrary waveform, parallel waveform will be output.



### D-1. The difference about waveform data for each memory and the output format

The 3 kinds of waveform data are all digital data having 16 bits length and each memory registers the file containing waveform points for few minutes as one data.

The meaning of setup frequency of FGX-295 and data of each bit of output will differs as following when output this data from arbitrary waveform output and parallel output

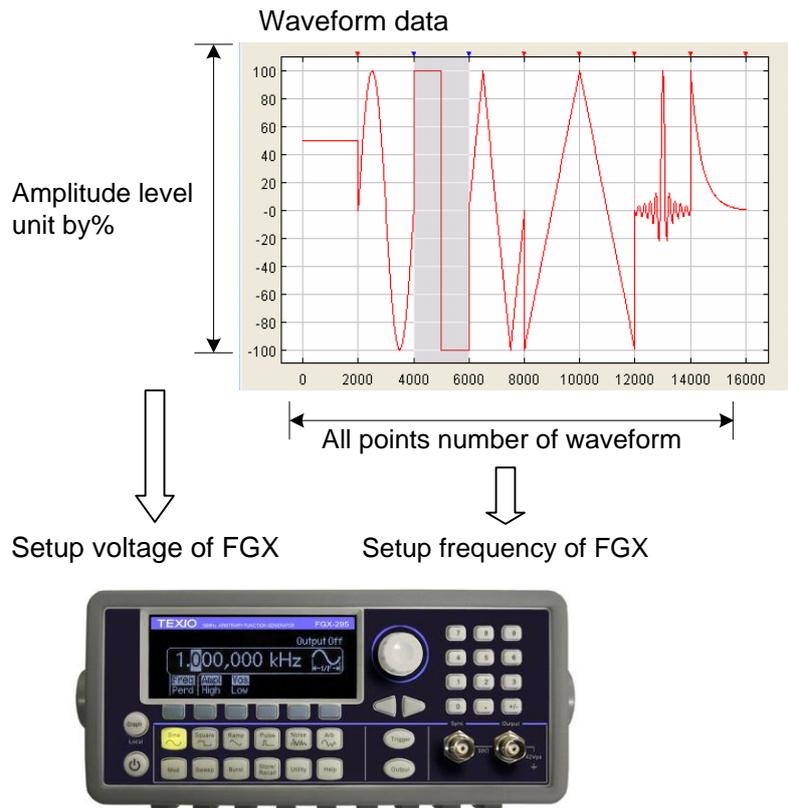


## Appendix E: Frequency output for arbitrary waveform

### E-1. Relation between the data of an arbitrary waveform and FGX-295

FGX-295 is capable of arbitrary waveform output that is created by Wavepatt. The output of arbitrary waveform will be made from the registered memory of the product but the time parameter (X direction) and the amplitude parameter (Y direction) of the registered data will be the amplitude level when maximum amplitude is  $\pm 100\%$  and the total point numbers of the registered waveform data.

The voltage and the frequency may be setup when output the arbitrary waveform from FGX-295, but the setup frequency corresponds to the total point number of the time axis parameter and setup voltage(Vp-p) corresponds to  $\pm 100\%$  of the amplitude parameter.



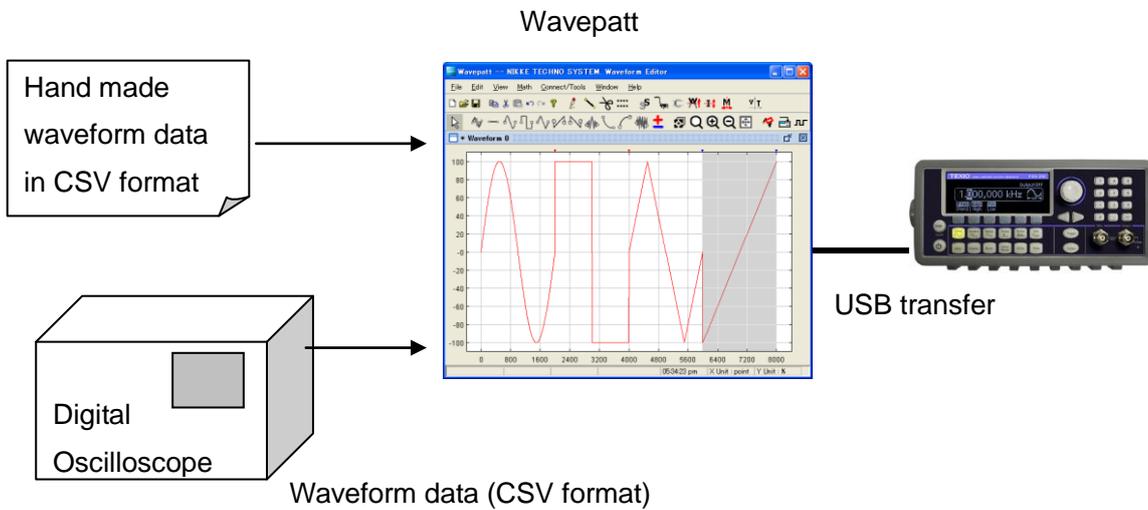
### E-2. Limitation of signal speed for arbitrary waveform

The output of arbitrary waveform from FGX-295 will be decided by the setup frequency and the speed for reading out the waveform data of one point from all the points. The sampling rate of FGX-295 is 125MS/Sec for its maximum and if the value of output signal is over this speed by calculation, a correct output may not be done. Also, when sampling frequency is below 125MS/Sec or the frequency of output signal is over 10MHz, a correct output may not be done.

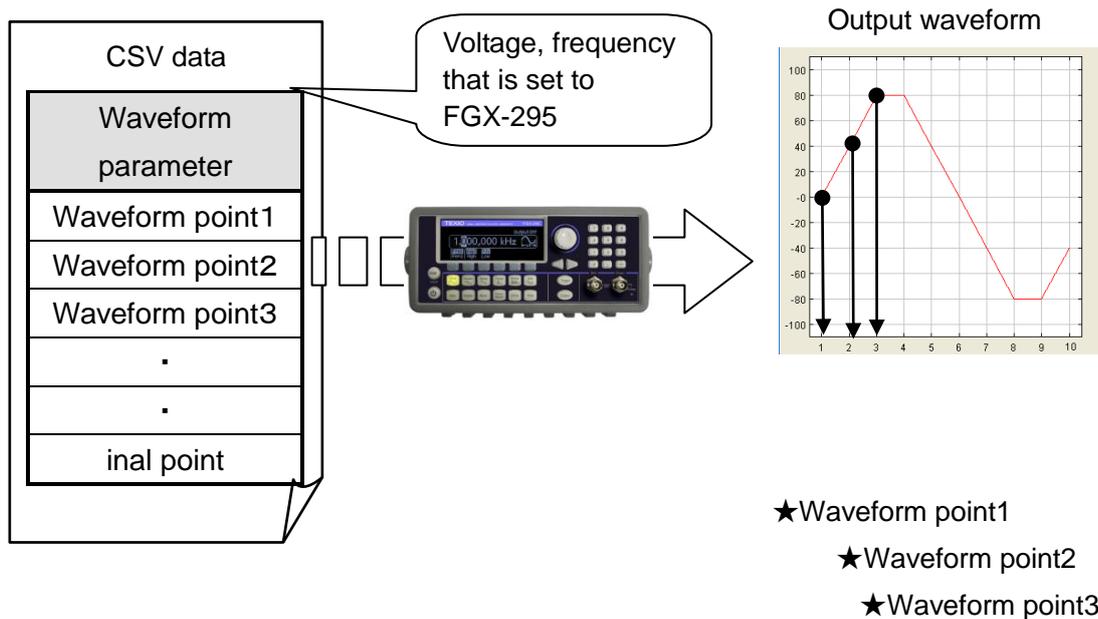
$$\begin{aligned} (\text{Setup frequency of FGX-295}) \times (\text{Point number of arbitrary waveform data}) &\leq 125\text{MS/Sec} \\ (\text{Output signal frequency}) &\leq 10\text{MHz} \end{aligned}$$

## Appendix F: Arbitrary waveform structure on CSV format

The arbitrary waveform data created by Wavepatt may be saved or read to the PC by CSV format. Using this function, create an arbitrary waveform assigned by a numeric value for each points of the waveform or transfer to FGX-295 the waveform data in arranged CSV format from the digital oscilloscope will be possible.



F-1. Relation between the structure of an arbitrary waveform data in CSV format and waveform output



Arbitrary waveform in CSV format is constituted by waveform parameter and the data of amplitude level of each point.

The arbitrary waveform data is the consecution of the level of each points by its order, so that the real output amplitude will be decided by the voltage setup of FGX-295 and the level of  $\pm 1.0$  will be the setup voltage. Besides, the frequency will be the output frequency when the setup frequency of FGX-295 has terminated output of all points. (Refer Appendix E-1 for detail)

Waveform parameter will be constituted by voltage set to FGX-295 and offset voltage only when waveform name, waveform point number, waveform are transferred to FGX-295. Waveform name or point number will be saved to the memory as the parameter of the waveform data but please be careful that other parameter will only be set to FGX-295 when data transfer and not be saved to the memory.

F-2. Detail of arbitrary waveform data structure in CSV format

**Waveform parameter**

At first line of waveform parameter, there is a title of each setup value and delimit by the comma in the order of each setup at second line then input return at the end. The setup value should be input by alphanumeric of normal-width and the space will be invalid.

```

                CSV data
Data,Name,Freq(kHz),Ampl(VPP),Offset(VDC),Points
3,FGX_DATA,1000,0.1,0,500
(Waveform point data after second point will continue)
.
.
.
    
```

The detail of each setup value at second line is as below:

Order	Title	Contents
1	Data	Waveform data at first point
2	Name	Waveform name indicated on FGX-295 (Alphanumeric small letter within 12 characters) ※When no input, waveform name will be ARB_EX
3	Freq (kHz)	Frequency that is set while data transfer to FGX-295
4	Ampl (Vp-p)	Amplitude voltage that is set while data transfer to FGX-295
5	Offset (Vdc)	Offset voltage that is set while data transfer to FGX-295
6	Points	All point number of one waveform (Setup may be 0 since data number will be written while data is read by Wavepatt)

**Waveform point data**

Set the level of each point by number of small letter and normal width period ( . ).

The waveform data at first point will enter to the second line at CSV data, so the data after second point should be input from 3<sup>rd</sup> line by its output order. The delimitation of individual setup value should be made by putting comma ( , ) + return.

```

                CSV data (Example of input)
0.775,
0.77,
0.775,
0.77,
0.77,
0.77,
0.77,
0.78,
    
```

**File name of CSV**

Japanese may be used as file name but extension must be as csv in alphanumeric small letter.

F-3. To edit arbitrary waveform data in CSV format by Microsoft Excel.

When you process the data reading the created CSV data by Excel, Wavepatt may not be able to read it since it converts and saves automatically into the following format.

```

Data,Name,Freq(kHz),Ampl(VPP),Offset(VDC),Points
0,,1000,0.1,0,0
0.58778524,,,,,
0.95105654,,,,,
0.9510565,,,,,
0.5877852,,,,,
-8.74E-08,,,,,
-0.58778554,,,,,
-0.9510565,,,,,
-0.9510565,,,,,
-0.5877853,,,,,
1,,,,,
1,,,,,
1,,,,,
1,,,,,
1,,,,,
-1
-1
-1
-1
-1
    
```

5 comma (,,,,,)is automatically added.

Comma is deleted after 17th line.

The method is to input half angle space in right cell of all the waveform data.

When reading CSV data with Wavepatt, more than one comma behind the waveform data may be disregarded but if there is no comma, it will be error and could not be read.

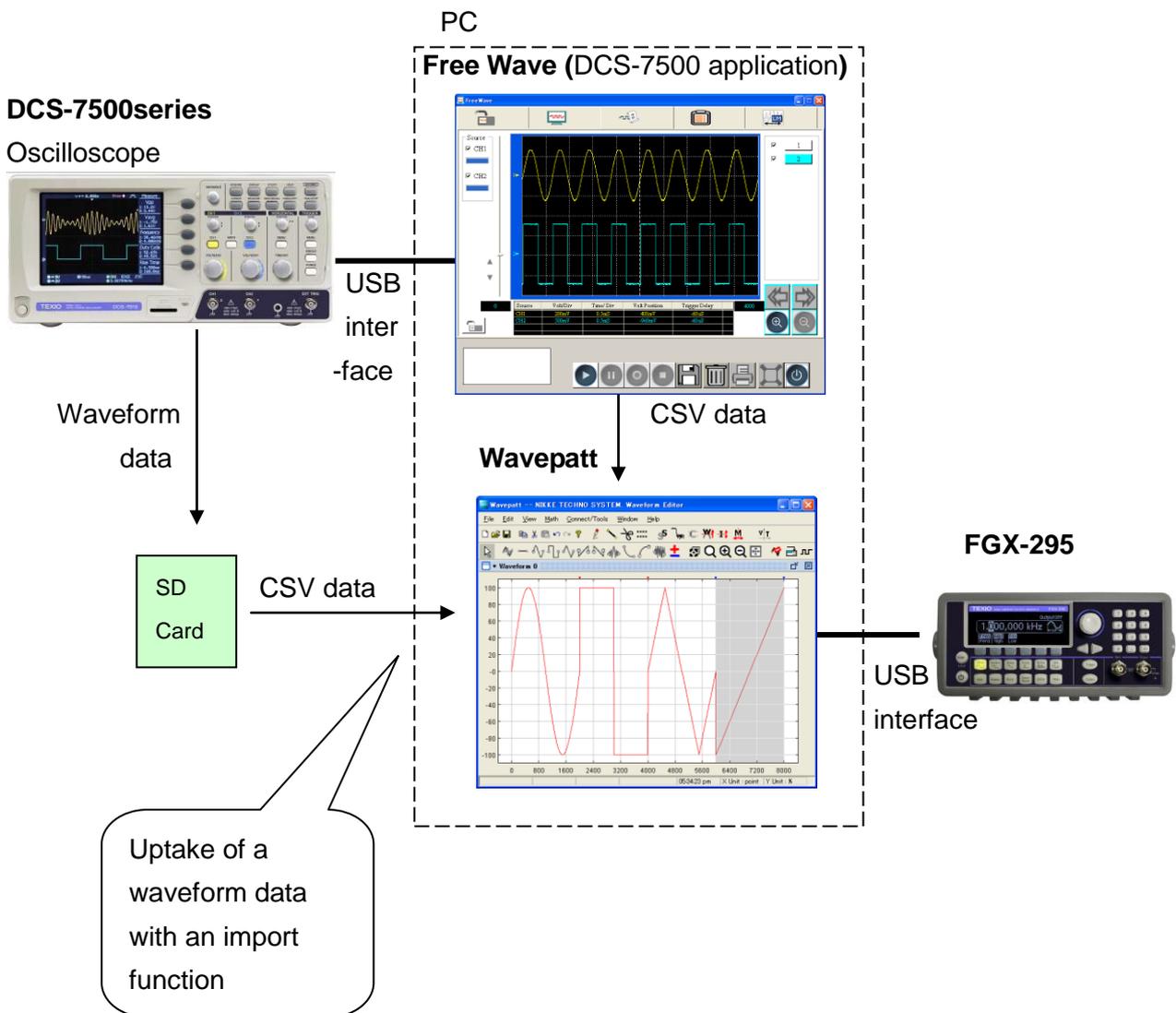
	A	B	C	D	E	F
1	Data	Name	Freq(kHz)	Ampl(VPP)	Offset(VDC)	Points
2	0		1000	0.1	0	500
3	0.775					
4	0.77					
5	0.775					
6	0.77					
7	0.77					
8	0.77					
9	0.78					
10	0.775					
11	0.775					
12	0.785					
13	0.77					
14	0.775					
15	0.77					

Input half angle space in right cell of all the waveform data

Appendix G: To add arbitrary waveform data into FGX-295 from TEXIO DCS-7500 series. Using the Wavepatt, a waveform data of TEXIO digital oscilloscope DCS-7500 can be added into FGX-295 easily.

A waveform data of DCS -7500 is saved in a PC via USB or SD memory as one CSV data for a channel. If these data are imported to the Wavepatt with the import function, the wavepatt convert it into a waveform data which are most suitable for FGX-295. The 1M or 2M points waveform data of DCS -7500 are converted into 250k points automatically within the size that FGX-295 can treat, and the amplitude value of each point is converted into the maximum in FGX-295, in that way the data are taken in the Wavepatt. Therefore the waveform data of the oscilloscope can be added to FGX-295 as an arbitrary waveform data, by only pushing one button.

Please refer to the the application manual attached CD for the details of the import function in the Wavepatt.



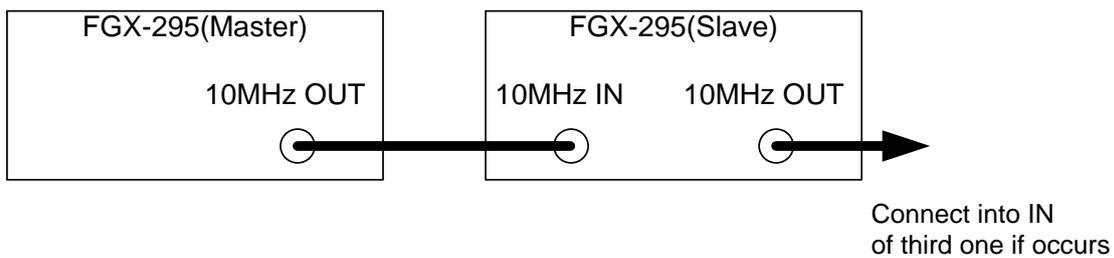
## Appendix H: Synchronized output using several FGX-295

A synchronized signal may be output by synchronizing several FGX-295.

The two FGX-295 will make synchronized operation by output a referenced signal from 10MHz Out terminal at rear panel then input it into the 10MHz In terminal of other FGX-295.

To output the referenced signal, press key of the front panel by the order of Utility  $\Rightarrow$  Output Setup  $\Rightarrow$  10M Out, then switch output to ON status. Input side will automatically synchronized operate by input of referenced signal.

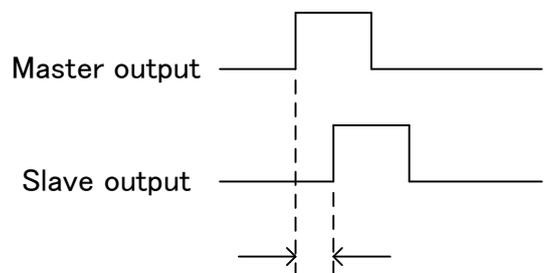
Also, to synchronize more than two sets, repeat connection of the second output with the following way.



At that time, a synchronized two waveforms will be output by making output of the arbitrary waveform with same data number and frequency. Also, using the phase adjusting function, the shifting of both signals may be rectified. Therefore a synchronized output is possible as well.

To make a phase adjustment press key of the front panel by the order of Utility  $\Rightarrow$  Output Setup  $\Rightarrow$  Adj Phase.

The shifting may be adjusted by adjusting either master of slave side.



Adjust with phase adjusting function

## Appendix I: Application programs

This chapter contains several remote interface example programs to help you develop programs for your own application. “Remote Interface Reference” starting lists the syntax for the SCPI (Standard Commands for Programmable Instruments) commands available to program the function generator.

### Introduction

Five example programs are included in this chapter to demonstrate controlling the TEXIO FGX-295 using SCPI commands. All of these programs are written in Microsoft® Visual C++ and use the NI-VISA.

If you want to modify the example programs, or write your own programs and compile them, you will need to install the NI-VISA.

- If you are using GP-IB. The software should have been loaded when you installed your GP-IB interface card in your PC.
- If you are using USB or LAN. You must have NI-VISA version to support USB and LAN.

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All of the sample application programs in this chapter are example programs intended for use with Microsoft Visual C++ and the NI-VISA by USB.

To use VISA in another Visual C++ project, you have to set the environmental variable in Microsoft Visual C++. The procedures are in the following.

- In the VC++, after the path Tools\Options\Directories\include has been entered, you have to add an “Include” path offered by NI-VISA, such as C:\VXIIPNP\WinNT\include.
- Add C:\VXIIPNP\WinNT\lib\msc\visa32.lib to Project folder.

The command for USB interface in the following or others will be different on other unit. If you have to check the right information, please do the procedure of Utility/IO/Show USB Id (for USB interface) to get it.

```
char instrDesc[]="USB0::2447::0295::XXXXXXXX::INSTR";
```

If the communication is via GP-IB or LAN interface, you have to revise the following USB command 1). to be GP-IB 2). or LAN 3). one.

```
(1) char instrDesc[]="USB0::2447::0295::XXXXXXXX::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 Listings

### Example 1 : Simple sine waveform

This program (found in the "Examples\Sine" subdirectory on the CDROM) selects the function as "sine," 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:: 2447::0295::XXXXXXXX::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 Vp-p.
    //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);
}
```

## Example 2 : Amplitude modulation

This program (found in the "Examples\AM" subdirectory on the CDROM) configures a waveform with amplitude modulation using lower-level SCPI commands. It also shows how to use the \*SAV command to store the instrument configuration in the function generator's internal memory.

```
//Amplitude Modulation
#include <visa.h>
#include <stdio.h>
void main (int argc,char *argv[])
{
    ViSession defaultRM,vi=0;
    ViStatus status;
    char instrDesc[]="USB0::2447::0295::XXXXXXXXX::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 Vp-p

    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:DEPTTh 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);
}
```

### Example 3 : Linear Sweep

This program (found in the "Examples\Linear\_Sweep" subdirectory on the CDROM) creates a linear sweep for a sine wave. It sets the start and stop frequencies, and 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::2447::0295::XXXXXXXX::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 Vp-p.
    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);
}
```

#### Example 4 : A Pulse Waveform

This program (found in the "Examples\Pulse" subdirectory on the CD-ROM) configures a pulse waveform, setting pulse width, period, and high/low levels. The edge time is then incremented.

```
//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:: 2447::0295::XXXXXXXX::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);
}
```

### Example 5 : Pulse Width Modulation (PWM)

This program (found in the “Examples\PWM” subdirectory on the CD-ROM) configures a pulse waveform with duty cycle, which is then slowly modulated by 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::2447::0295::XXXXXXXXX::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 generator 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\r\n");           //Turn PWM modulation on
viPrintf(vi,"OUTPut ON\r\n");             //Turn on the instrument output

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



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