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PLEASE CHECK FOR CHANGE INFORMATION AT THE REAR OF THIS MANUAL.

PFG 5105/PFG 5505

Programmable Pulse/Function Generator

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

070-7331-00
Product Group 76

Serial Number _____

First Printing JAN 1989

INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first number or letter designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B000000	Tektronix, Inc., Beaverton, Oregon, USA
100000	Tektronix Guernsey, Ltd., Channel Islands
200000	Tektronix United Kingdom, Ltd., London
300000	Sony/Tektonix, Japan
700000	Tektronix Holland, NV, Heerenveen, The Netherlands

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WARNING

The following servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing other than that contained in operating instructions unless you are qualified to do so. Refer to Operators Safety Summary prior to performing any service.

LIST OF ILLUSTRATIONS

LIST OF TABLES

OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary.

TERMS

In This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

SYMBOLS

In This Manual

This symbol indicates where applicable cautionary or other information is to be found.

As Marked on Equipment

DANGER—High voltage.

Protective ground (earth) terminal.

ATTENTION—refer to manual.

Power Source

This product is intended to operate from a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Danger Arising from Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

Use the Proper Power Cord (PFG 5505)

Use only the power cord and connector specified for your product.

Use only a power cord that is in good condition.

For detailed information on power cords and connectors, see the Operating Instructions.

Refer cord and connector changes to qualified service pesonnel.

Use the Proper Fuse

To avoid fire hazard, use only the fuse of correct type, voltage rating and current rating as specified in the parts list for your product.

Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere, unless it has been specifically certified for such operation.

Do Not Operate Without Covers

To avoid personal injury, do not operate this product without covers or panels installed. Do not apply power to the plug-in via a plug-in extender.

SERVICE SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY
Refer also to the preceding Operator Safety Summary.

Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

Use Care When Servicing With Power On

Dangerous voltages may exist at several points in this product. To avoid personal injury, do not touch exposed connections and components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

Power Source

This product is intended to operate in a power module connected to a power source (PFG 5105) or from a power source (PFG 5505) that will not apply more than 250 volts rms between the supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Section 1
SPECIFICATION

Introduction

This section of the manual contains a general description of the Tektronix PFG 5105/5505 Programmable Pulse/Function Generator and complete electrical, environmental, and physical specifications. Standard accessories are also listed.

Instrument Description

The PFG 5105/5505 Pulse/Function Generator is a programmable signal source for single pulse, double pulse, sine, triangle, square, and dc output from 0.012 Hz to 12 MHz at 10 mV to 9.99 V p-to-p into 50Ω. Output can be continuous, triggered, gated or burst. The PFG 5105 is a TM 5000 plug-in designed to operate in three compartments of a Tektronix TM 5000-series power module. The PFG 5505 is not a TM 5000 plug-in, but contains its own power module. Parameter values are displayed on the front panel in a 2 x 16 character LCD display.

Both instruments can be manually operated from the front panel or, remotely programmed via the general purpose interface bus (GPIB). Recommended controllers are the Tektronix 4041; or an IBM PC-compatible, such as the Tektronix PEP 301, with the Tektronix GURU software and GPIB interface card. When properly installed, the PFG 5105/5505 is compatible with other devices that meet IEEE Standard 488.1-1987.

Instrument Options

Option 02 adds a frequency lock synthesizer that provides a precise output frequency by locking the output to an internal quartz crystal. This option operates in continuous mode only, from 12.1 Hz to 12 MHz.

Standard Accessories

Instruction Manual
Reference Guide
Instrument Interfacing Guide

Optional Accessories

See Options and Accessories, Section 5.

IEEE 488 (GPIB) Function Capability

The PFG 5105/5505 can be remotely programmed via the digital interface specified in the IEEE Standard 488.1-1987, "Standard Digital Interface for Programmable Instrumentation." In this manual, the interface is called the General Purpose Interface Bus (GPIB).

The IEEE Standard identifies the interface function repertoire of an instrument on the GPIB in terms of interface function subsets. The subsets that apply to the PFG 5105/5505 are listed in Table 1-1.

NOTE

Refer to IEEE Standard 488.1-1987 for more detailed information. The standard is published by the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, New York 10017.

Table 1-1
INTERFACE FUNCTION SUBSETS

Function	Subset	Capability
Source Handshake	SH1	Complete capability.
Acceptor Handshake	AH1	Complete capability.
Basic Talker	T6	Responds to Serial Poll, Untalk if My Listen Address (MLA) is received.
Basic Listener	L4	Unlisten if My Talk Address (MTA) is received.
Service Request	SR1	Complete capability.
Remote-Local	RL1	Complete capability, including Local Lockout.
Parallel Poll	PP0	Does not respond to Parallel Poll.
Device Clear	DC1	Complete capability.
Device Trigger	DT1	Complete capability.
Controller	C0	No controller function.
Electrical Interface	E2	Three-state driver capability.

ELECTRICAL CHARACTERISTICS

Performance Conditions

The following characteristics in this specification are valid with the following conditions:

1. The instrument must have been calibrated at an ambient temperature between +20°C and +30°C.
2. The instrument must be in a non-condensing environment whose limits are described under Environmental.
3. Allow thirty minutes warm-up time for operation to specified accuracy; sixty minutes after exposure to or storage in high humidity (condensing) environment.
4. The instrument must be terminated into a 50 ohm load.
5. Specifications are valid with only those connections to the instrument that are required to verify each specification.

Items listed in the Performance Requirements column of the following tables are verified by completing the Performance Check in the Service manual. Items listed in the Supplemental Information column may not be verified in the manual; they are either explanatory notes or performance characteristics for which no limits are specified.

Table 1-2
WAVEFORMS, OPERATING MODES, AND PARAMETERS

Characteristics	Performance Requirements	Supplemental Information
WAVEFORMS		
Standard Analog Functions:		Sine, square, triangle, single pulse, double pulse, and dc:
OPERATING MODES		
Continuous:	Output continuous at programmed frequency, amplitude, and offset.	
Triggered:	Output quiescent until triggered by an internal, external, GPIB, or manual trigger; then generates one cycle at programmed frequency, amplitude, and offset. See Figure 1-1.	
Gated:	Same as triggered mode except waveform is executed for the duration of the gated signal. The last cycle started is completed.	
Burst:	Same as triggered mode for the programmed number of cycles from 1 to 9999, as set by the N BURST function.	
Sweep:	Internal, programmable start frequency, stop frequency and rate (time per step). Linear sweeps can be continuous, triggered, gated, or burst selected.	

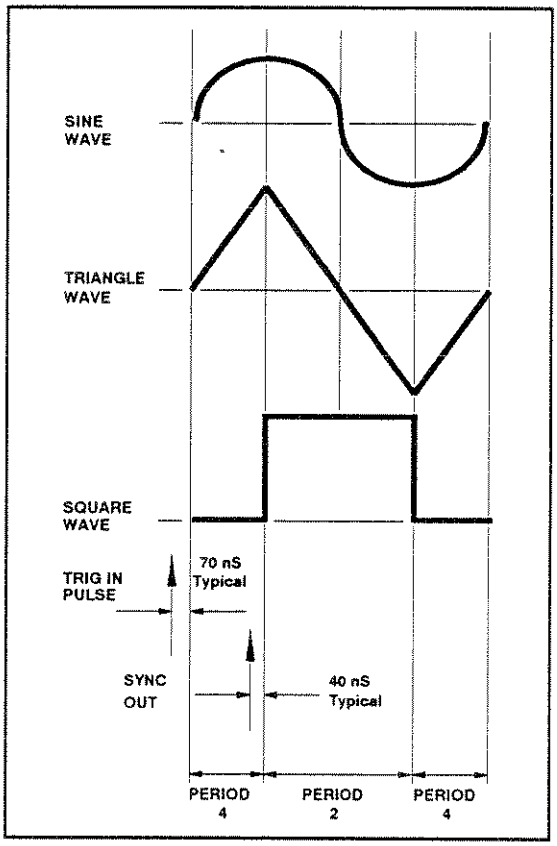


Fig. 1-1. Trigger to timing and phase relationships.

Table 1-2 (Cont)
WAVEFORMS, OPERATING MODES, AND PARAMETERS

Characteristics	Performance Requirements	Supplemental Information
OPERATING MODES (Cont)		
AM Modulation:	Generator can be externally modulated.	For 100% modulation, the AM IN signal amplitude is typically 4.5 Vp-p.
FM Modulation (See Modulation, Section 2):	5 V p-p for a minimum 500 : 1 frequency change.	VCO/FM input resistance (typical): 10 kΩ. Slew rate (typical): 0.1 V/μs. 3dB FM bandwidth (typical): dc to >500 kHz. VCO/FM Linearity (typical): *Conditions—a) Peak deviation ≤5% of maximum range frequency, b) FREQUENCY LOCK "OFF", c) FREQUENCY RANGE LOCK "ON" OR "OFF".* Refer to Special Functions description, page 2-11. 150 kHz to 1 MHz range, <±0.5% (Fig. 1-2A); 1.5 MHz to 10 MHz range <±1.5% (Fig. 1-2B); 15 kHz to 100 kHz range, <±0.5%; 1.5 kHz to 10 kHz range, <±0.5%.

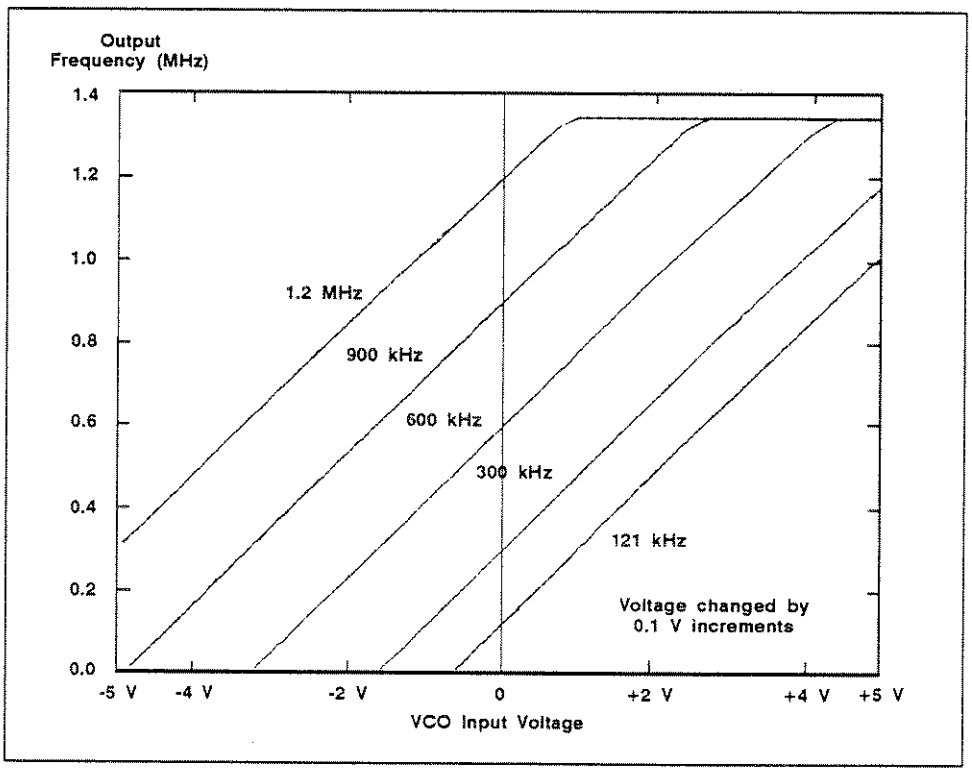


Fig. 1-2A. Typical FM Response of Frequencies 121 kHz, 300 kHz, etc. (Entered by Front Panel or GPIB) to VCO Input Voltages with FREQUENCY RANGE LOCK OFF.

Table 1-2 (Cont)
WAVEFORMS, OPERATING MODES, AND PARAMETERS

Characteristics	Performance Requirements	Supplemental Information
OPERATING MODES (Cont)		

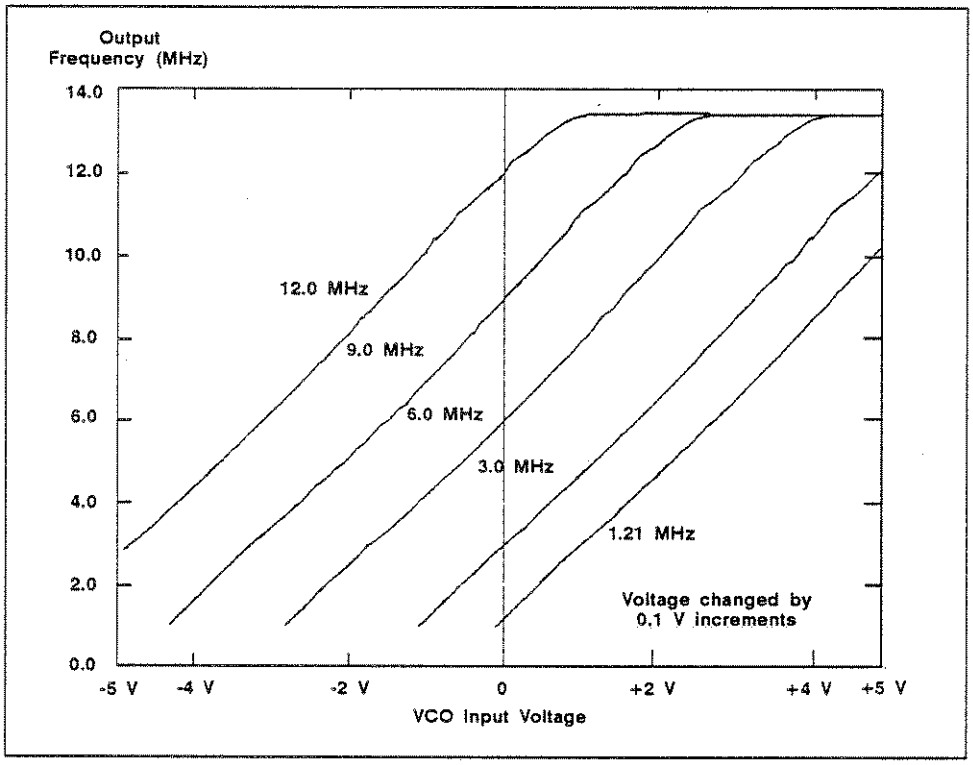


Fig. 1-2B. Typical FM Response of Frequencies 1.21 MHz, 3.0 MHz, etc. (Entered by Front Panel or GPIB) to VCO Input Voltages with FREQUENCY RANGE LOCK OFF.

Synthesizer:	Optional mode. See Table 1-8, Synthesizer.	
Parameters Increment Function:	FREQ, AMPL, OFFSET, RATE, DELAY, WIDTH, DC and NBURST can be manually incremented/decremented by a settable increment delta. Step rate is approximately 2 steps per sec. for the first 3 steps; then 10 steps per sec. for successive steps at one continuous keystroke.	Setting INCR SIZE to 0 sets increment size to the default setting. The default size is the least significant digit of the current range (if the range changes, delta also changes). If increment size is changed via the front panel, it is locked to the new value until it is again set to 0 (default) via the front panel. If increment size is locked to an increment smaller than the LSD of the range, an error is displayed in the front panel if an INCREMENT ⇑ or ⇓ button is pressed. The monotonicity of the increment/decrement function is not guaranteed. If a parameter is incremented, the output could decrement.

Table 1-3
FREQUENCY CHARACTERISTICS (STANDARD ANALOG FUNCTIONS)

Characteristics	Performance Requirements	Supplemental Information
FREQUENCY		
Range:	0.012 Hz to 12.0 MHz.	
Resolution:		3-1/2 digits (1200 counts). Synthesizer mode (Option 02): 12000 counts (4 1/2 digits).
Accuracy:	±0.2% of reading from 121 Hz to 1.2 MHz in continuous mode.	With frequency lock off, accuracy is ±10% from 0.1 Hz to 12 MHz.
	±0.5% of reading from 1.21 MHz to 12 MHz in continuous mode.	In period entry mode, accuracy is decreased by ±0.1% of reading.
	±5% of reading from 0.1 Hz to 120 Hz in continuous mode.	The synthesizer option offers 50 ppm accuracy from 12.1 Hz to 12 MHz.
Jitter:		<0.1% to 5 MHz.
Stability:		±0.2% in continuous mode for all time intervals.
		±0.5% for 24 hours in other modes.
Repeatability:		±1% for 24 hours in other than continuous mode. In continuous locked mode, repeatability is equal to frequency accuracy listed above.
Frequency Lock Mode:		Power-on/default setting is Frequency Lock On. Refer to Special Functions in Section 2.
Settling Time:		Typically less than 2 s.

Table 1-4
GENERAL OUTPUT CHARACTERISTICS (STANDARD ANALOG FUNCTIONS)

Characteristics	Performance Requirements	Supplemental Information
OFFSET		
Range:		Absolute peak amplitude plus offset is limited to a maximum that is dependent on the signal amplitude range. Open circuit values are 2 times the displayed values. See table below.
Resolution:		3 digits. See table above.
Accuracy:	±0.6% ±20 mV into 50Ω.	
Repeatability:		±1% ±20 mV for 24 hours.
OUTPUT		
Resistance:		50Ω.
Protection		The instrument is nondestructively protected against short circuits or accidental voltage of up to 100 V (dc plus peak ac) applied to the main output connector.
LOW SIGNAL AMPLITUDE NOISE:		Total noise and ripple less than 3 mV p-p with 10 mV output amplitude signal.

Offset Range and Resolution

Peak-to-Peak Amplitude Range	Peak Amplitude + Absolute Offset into 50Ω	Resolution into 50Ω
1 V - 9.99 V[1]	4.99 V	10 mV
0.1 V - 0.999 V[2]	0.499 V	1 mV
0.01 V - 0.099 V[3]	0.049 V	1 mV

[1]Maximum offset is ±4.49 V at 1 V amplitude.
[2]Maximum offset is ±0.449 V at 0.1 V amplitude.
[3]Maximum offset is ±0.044 V at 0.01 V amplitude.

Table 1-5
OUTPUT CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
	SINE WAVE	
AMPLITUDE		
Range:	10 mV to 9.99 V p-p from 50Ω, into 50Ω load.	20 mV to 19.98 V p-p from 50Ω into open circuit. Open circuit values are 2 times the displayed values.
Resolution:		**Amplitude Range (Peak-to-Peak)** / **Amplitude Resolution p-p into 50Ω** 1 V - 9.99 V / 10 mV 0.1 V - 0.999 V / 1 mV 10 mV - 99 mV / 1 mV
Accuracy:	±2.0% ±20 mV of programmed value for 1.0 to 9.99 V p-p output at 20 to 30°C. ±2.5% ±20 mV of programmed value for 1.0 to 9.99 V p-p output; 3% ±5 mV for 10 mV to 999 mV p-p output, specified for a sinewave output at 1 kHz over full amplitude and temperature range.	
Sine Distortion:	<0.6% THD (RMS), 121 Hz to 120 kHz at 5 V p-p amplitude at 20 to 30°C.	All harmonics less than –30 dB below fundamental from 121 kHz to 1.0 MHz at 5 V p-p amplitude and 20 to 30°C.
	<1% THD (RMS), 12 Hz to 120 Hz over full temperature and amplitude range.	All harmonics –20 dB below fundamental from 121 kHz to 12 MHz over full amplitude and temperature range.
Repeatability:		±1% for 24 hours.
Flatness (See Fig. 1-3):	0.5 dB from 0.012 Hz to 120 kHz, ±2 dB to 1.2 MHz, ±3 dB to 12 MHz referenced to 1 kHz sinewave.	

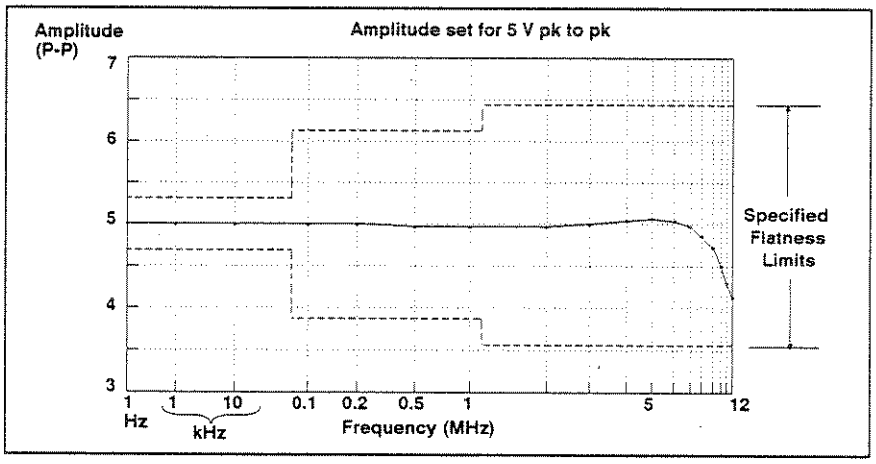


Fig. 1-3. Typical Amplitude Flatness for Sine Wave

Table 1-5 (Cont)
OUTPUT CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
	SQUARE WAVE	
AMPLITUDE		
Range:	10 mV to 9.99 V p-p from 50Ω, into 50Ω load.	20 mV to 19.98 V p-p from 50Ω into open circuit. Open circuit values are 2 times the displayed values.
Resolution:		Amplitude Range (Peak-to-Peak) / Amplitude Resolution p-p into 50Ω 1 V-9.99 V: 10 mV 0.1 V-0.999 V: 1 mV 10 mV-99 mV: 1 mV
Accuracy:	±2.0% ±20 mV of programmed value for 1.0 to 9.99 V p-p output at 20 to 30°C. ±2.5% ±20 mV of programmed value for 1.0 to 9.99 V p-p output; ±3% ±5 mV for 10 mV to 9.99 mV p-p output, specified for a squarewave output at 1 kHz.	
Repeatability:		±1% for 24 hours.
Flatness (See Fig. 1-4):	0.5 dB from 0.012 Hz to 120 kHz, ±2 dB to 1.2 MHz, ±3 dB to 12 MHz referenced to 1 kHz squarewave.	
Time Symmetry:	<0.5%, 121 Hz to 120 Hz; ±1%, 121 Hz to 1.2 MHz; ±5%, 1.2 MHz to 12 MHz.	
Transition Time:	<15 ns 10% to 90% at full output amplitude; elsewhere, <20 ns, 10% to 90%.	
Aberrations:	<8% of p-p amplitude ±20 mV from 3.4 V to 9.99 V p-p output amplitude. <10% of p-p amplitude below 3.34 V p-p output amplitude.	

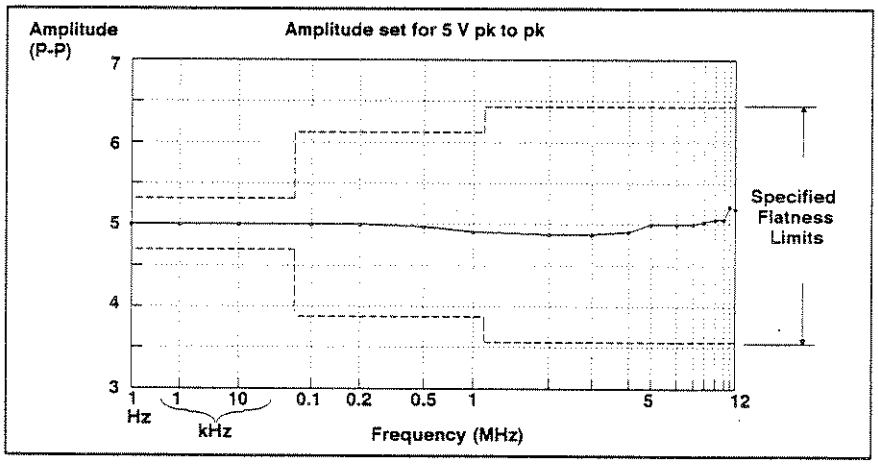


Fig. 1-4. Typical Amplitude Flatness for Square Wave

Table 1-5 (Cont)
OUTPUT CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
	TRIANGLE WAVE	
AMPLITUDE		
Range:	10 mV to 9.99 V p-p from 50Ω, into 50Ω load.	20 mV to 19.98 V p-p from 50Ω into open circuit. Open circuit values are 2 times the displayed values.
Resolution:		**Amplitude Range (Peak-to-Peak)** / **Amplitude Resolution p-p into 50Ω** 1 V-9.99 V — 10 mV 0.1 V-0.999 V — 1 mV 10 mV-99 mV — 1 mV
Accuracy:	±2.0% ±20 mV of programmed value for 1.0 to 9.99 V p-p output at 20 to 30°C. ±2.5% ±20 mV of programmed value for 1.0 to 9.99 V p-p output; ±3% ±5 mV for 10 mV to 9.99 mV p-p output, specified for a triangle wave output at 1 kHz.	
Triangle Linearity:		98% to 100 kHz measured from 10% to 90% on waveform.
Repeatability:		±1% for 24 hours.
Flatness (See Fig. 1-5):	0.5 dB from 0.012 Hz to 120 kHz, ±2 dB to 1.2 MHz, ±3 dB to 12 MHz referenced to 1 kHz triangle wave.	

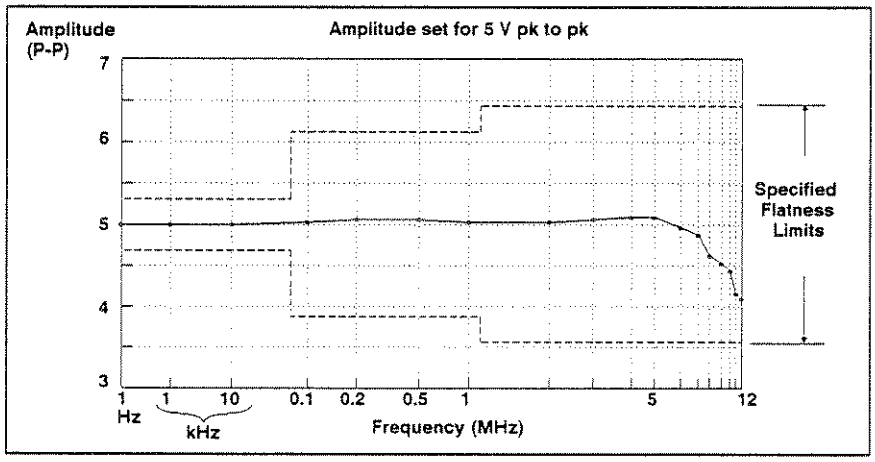
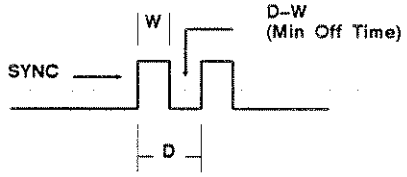


Fig. 1-5. Typical Amplitude Flatness for Triangle Wave

Table 1-5 (Cont)
OUTPUT CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
	PULSE	
PULSE WIDTH	40 ns to 99.9 ms.	Measured from 50% of leading edge to 50% of trailing edge.
Resolution:		3 digits, 1.0 ns maximum.
Accuracy:	±5% of programmed value, ±10 ns.	
Repeatability:		±1%, ±5 ns.
DELAY	40 ns to 99.9 ms.	
Resolution:		3 digits, 1.0 ns maximum.
Accuracy:	±5% of programmed value, ±10 ns.	
Repeatability:		±1%, ±5 ns.
DUTY CYCLE	Delay + width may be up to 85% of period.	
DOUBLE (PAIRED) PULSE	2 pulses of selected width up to 6 MHz separated by selected delay period.	

WIDTH	Min Off Time D–W
0.040 - 0.099 μs	>40 ns
0.100 - 0.999 μs	>50 ns
1.000 - 9.99 μs	>200 ns
10.0 - 99.9 μs	>2 μs
100 - 999 μs	>20 μs
1.00 - 9.99 ms	>200 μs
10.0 - 99.9 ms	>2 ms



AMPLITUDE

Range: 10 mV to 9.99 V p-p from 50Ω into 50Ω load. 20 mV to 19.98 V p-p from 50Ω into open circuit. Open circuit values are 2 times the displayed values.

Resolution:

Amplitude Range (Peak-to-Peak)	Amplitude Resolution p-p into 50Ω
1 V-9.99 V	10 mV
0.1 V-0.999 V	1 mV
10 mV-999 mV	1 mV

Table 1-5 (Cont)
OUTPUT CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
	PULSE (Cont)	
AMPLITUDE (Cont)		
Accuracy:	±2.5% ±20 mV of programmed value for 1.0 to 9.99 V p-p output; ±3% ±5 mV for 10 mV to 999 mV p-p output, specified for a squarewave output at 1 kHz.	
Repeatability:		±1% for 24 hours.
Transition Time:	<15 ns 10% to 90% at full output amplitude; elsewhere, <20 ns, 10% to 90%.	
Aberrations:	<8% of p-p amplitude ±20 mV from 3.4 V output amplitude to 9.99 V p-p amplitude. <10% of p-p amplitude below 3.34 V p-p output amplitude.	
Flatness (See Fig. 1-6):	0.5 dB from 0.012 Hz to 120 kHz, ±2 dB from 121 kHz to 1.2 MHz, ±3 dB from 1.21 MHz to 12 MHz, referenced to 1 kHz pulse waveform.	

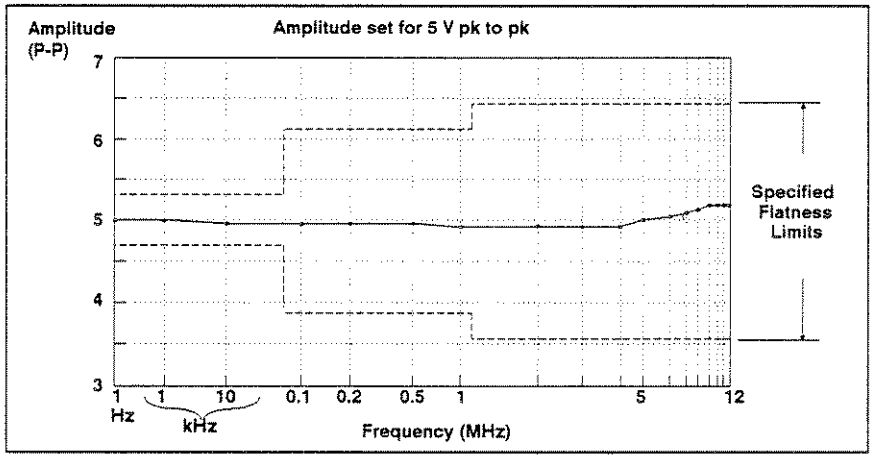


Fig. 1-6. Typical Amplitude Flatness for Pulse.

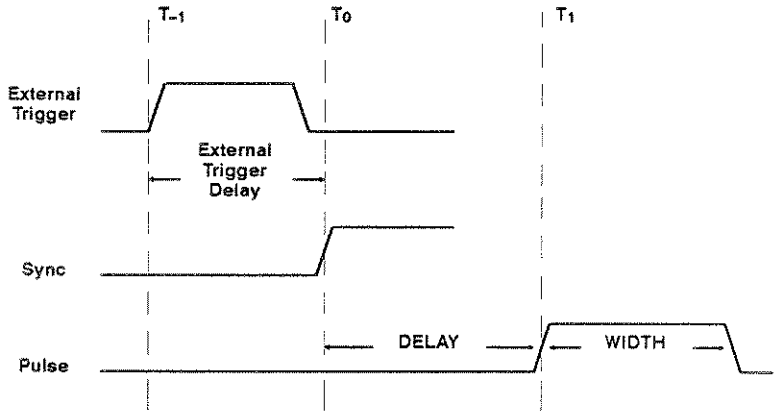
	DC	
AMPLITUDE		
Range:	±4.99 Vdc from 50Ω into 50Ω load.	±9.98 Vdc from 50Ω into open circuit. Open circuit values are 2 times the displayed values.
Resolution:		10 mV
Accuracy:	±0.6% ±20 mV into 50Ω.	
Repeatability:		±1% for 24 hours.

Table 1-6
INTERNAL TRIGGER

Characteristics	Performance Requirements	Supplemental Information
Range:	Repetition rate 0.1 μs to 999.9 s.	
Resolution:	4 digits.	0.1 μs maximum resolution.
Accuracy:	0.01%.	

Table 1-7
EXTERNAL TRIGGER

Characteristics	Performance Requirements	Supplemental Information
Delay: T_{-1} $-T_0$		Trigger mode <150 ns Burst mode $< \left(\frac{1}{\text{frequency} \times 4} \right) + 65$ ns Gate mode $< \left(\frac{1}{\text{frequency} \times 4} \right) + 65$ ns



Jitter:		
Trigger		Sync/Output
$T_{-1} - T_0$		<1 ns
$T_0 - T_1$		<1 ns

Table 1-8
SYNTHESIZER (OPTION 02)

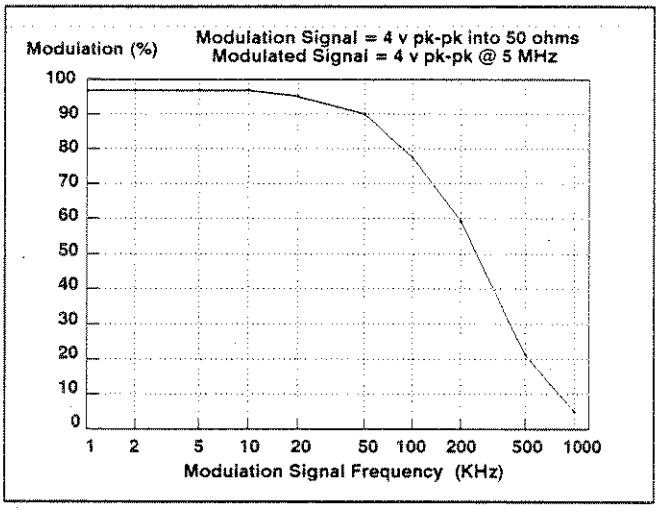
Characteristics	Performance Requirements	Supplemental Information
Range:	12.1 Hz to 12 MHz.	
Resolution:	Frequency resolution (LSD of display) is 10 mHz on lowest range and 1 kHz on highest frequency range (4.5 digits, or 12000 counts).	
Accuracy:	±50 ppm averaged measurement.	
Stability:		±10 ppm/°C or better.
Settling Time:		Typically less than 2 s plus 100 cycles.
Jitter		<0.1% from 12.1 Hz to 12 MHz.

Table 1-9
FREQUENCY SWEEP

Characteristics	Performance Requirements	Supplemental Information
Sweep Type:	Linear.	
Sweep Time:	100 ns to 999.9 s per point. 0.1 μs (4 digit) maximum resolution. 1 sweep equals 256 points for the time base.	STOP frequency must be greater than the START frequency.
Sweep Width:	1200:1 maximum; start frequency and stop frequency must be in the same range. See sweep ranges specification.	If the highest frequency is less than the top of the range, the ratio is less than 1200:1.
Sweep Ranges:	10 kHz to 12 MHz 1 kHz to 1.2 MHz 100 Hz to 120 kHz 10 Hz to 12 kHz 1 Hz to 1.2 kHz 0.1 Hz to 120 Hz 0.012 Hz to 12 Hz	The STOP frequency determines the sweep range.
Accuracy of START/ STOP Frequencies:		±5% of highest frequency of range, typical.

Table 1-10
INPUTS AND OUTPUTS

Characteristics	Performance Requirements	Supplemental Information
VCO/FM INPUT:	5 V p-p for a 500:1 minimum frequency change.	Input resistance: 10 kΩ nominal. Slew rate: 0.1 V per microsecond. Bandwidth: dc to >500 kHz.
TRIGGER IN:	TTL compatible.	Nominal impedance: 10 kΩ. Maximum rate: 12 MHz. Minimum width: 20 ns.
AM INPUT:		Input resistance: 10 kΩ nominal. Bandwidth: dc to ≈150 kHz, 4.5 V p-p for 100% modulation, typical, within allowable amplitude ranges. AM % modulation ≤30% from 10 V p-p to 8 V p-p output amplitude setting. AM % modulation to 100% over limited output amplitude ranges: 10 mV to 23 mV p-p 34 mV to 45 mV p-p 100 mV to 230 mV p-p 334 mV to 450 mV p-p 1.00 V to 2.3 V p-p 3.34 V to 4.5 V p-p.
INPUT PROTECTION:	All inputs protected against up to ±42 V (dc plus peak ac) accidental input.	
SYNC OUTPUT:	TTL level squarewave at programmed frequency.	Output protected against short circuit and up to ±15 V accidental input (for less than 1 minute).
SWEEP OUTPUT:	Source resistance is 600Ω; a positive linear ramp. Amplitude is dependent on start and stop frequency and a 5 V limit.	



AM Modulation Bandwidth

Table 1-11
GPIB CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
INTERFACE:	Conforms to IEEE-488.1 1987. See Table 1-1 for information on the supported subsets.	

Table 1-12
MISCELLANEOUS ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
Fuse Data:		1 fuse: 2A, 125V slow blow. (U.L. listed component.) 2 fuses: 1 A, 125 V slow blow. (U.L. listed component.)
Power Consumption:	50 VA maximum, limited by internal fuse.	
Power Dissipation:	30 W.	
Recommended Adjustment Interval:	1000 hours or 6 months, whichever occurs first.	
Warm-up Time:	30 minutes.	
Mean Time to Repair (MTTR) (estimated):	2.0 hours.	
Mean Time Between Failures (MTBF) (calculated):	5000 hours.	
Memory Backup Battery Life:		5 years, typical.

Table 1-13
SOURCE POWER REQUIREMENTS (PFG 5505 only)

Characteristics	Performance Requirements	Supplemental Information
Voltage Ranges:		Selectable 100 V, 120 V, 220 V, and 240 V nominal line ±10%.
Line Frequency:		50-60 Hz.
Maximum Power Consumption:		Approximately 90 W.
Fuse Data:		
100 V, 120 V Ranges:		1.0 A, 3 AG, slow blow, 250 V.
220 V, 240 V Ranges:		0.5 A, 3 AG, slow blow, 250 V.

PHYSICAL CHARACTERISTICS

Table 1-14
ENVIRONMENTAL[1]

Characteristics	Description
TEMPERATURE	Meets MIL-T-28800D, class 5.
Operating:	0°C to +50°C
Non-Operating:	–20°C to +60°C
	Class 5 non-operating temperature exception due to internal keep-alive battery and LCD display.
HUMIDITY:	95% RH, 0°C to 30°C
	75% RH to 40°C
	45% RH to 50°C
	Exceeds MIL-T-28800D, class 5, non-condensing.
ALTITUDE:	Exceeds MIL-T-28800D, class 5.
Operating:	4.6 km (15,000 ft.)
Non-Operating:	15 km (50,000 ft.)
VIBRATION[2]	0.38 mm (0.015") peak-to-peak, 5 Hz to 55 Hz, 75 minutes.
	Meets MIL-T-28800D, class 5, when installed in qualified power modules.[3]
SHOCK[2]	30 g's (1/2 sine) 11 ms duration, 3 shocks in each direction along 3 major axes, 18 total shocks.
	Meets MIL-T-28800D, class 5 when installed in qualified power modules.[3]
BENCH HANDLING[4]	12 drops from 45°, 4" or equilibrium, whichever occurs first.
	Meets MIL-T-28800D, class 5, when installed in qualified power modules.[3]
TRANSPORTATION[4]	Qualified under National Safe Transit Association Preshipment Test Procedures 1A-B-1 and 1A-B-2.
EMC[5]	Within limits of F.C.C Regulations Part 15, Subpart J, Class A; MIL-461B (1980) for RE01, RE02, RS01, RS03, CS01, CS02, and CS06.
ELECTRICAL DISHARGE	
Operating Maximum Test Voltage:	15 kV, 150 pF through 150Ω.
Non-Operating Max. Test Voltage:	20 kV, 150 pF through 150Ω.
SAFETY SPECIFICATIONS:	Shall meet the following safety standards:
U.S.A.:	UL1244 (Electrical and Electronic measuring and test equipment).
Canada:	CSA 556B (Electrical Bulletin).
International:	IEC 348 (Electronic measuring apparatus).

1 With power module.
2 Requires retainer clip.
3 Refer to TM 500/5000 power module specifications.
4 Without power module.
5 System performance subject to exceptions of power module and/or other plug-ins.

Table 1-15
MECHANICAL

Characteristics	Description
FINISH:	
Front Panel:	Polycarbonate.
Chassis (PFG 5105):	Chromate conversion-coated aluminum.
NET WEIGHT:	
PFG 5105	4.6 lbs (1.7 kg)
PFG 5505	14.3 lbs (5.3 kg)
OVERALL DIMENSIONS:	
PFG 5105	
Height:	5.0 in. (12.7 cm)
Width:	5.3 in. (xx.x cm)
Length:	12.2 in. (31 cm)
PFG 5505	
Height:	5.5 in. (14.0 cm)
Width:	9.2 in. (23.4 cm)
Length:	17.0 in. (43.2 cm)
ENCLOSURE TYPE & STYLE PER MIL-T-28800D (PFG 5105 in TM 5000 Series power module)	
Type:	III
Style:	E (Style F with rackmount kit)

Section 2
OPERATING INSTRUCTIONS

Introduction

This section of the manual provides installation and removal instructions and describes the functions of the PFG 5105/5505 front-panel controls and connectors. This information is provided as an aid in understanding how to operate the PFG 5105/5505 under local (manual) control only. The information in this section assumes the instrument is not connected to the GPIB. Complete information for programming the PFG 5105/5505 via the GPIB (General Purpose Interface Bus) is found in the Programming section of this manual.

PREPARATION FOR USE

Installation and Removal—PFG 5105 Only

NOTE

The PFG 5105 is designed to operate only in a TM 5000-Series power module. Refer to the power module instruction manual before installing the PFG 5105.

The PFG 5105 is calibrated and ready for use when received. It operates in three compartments of any TM 5000-Series GPIB compatible power module. Refer to the power module instruction manual for line voltage requirements and power module operation.

CAUTION

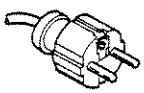
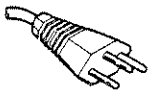
To prevent damage to the PFG 5105, turn the power module off before installation or removal. Do not use excessive force to install or remove.

Check to see that the plastic barriers on the interconnecting jacks of the selected power module compartments match the cutouts in the PFG 5105 circuit board edge connectors. If these do not match, do not insert the instrument until the reason is determined. When the units are properly matched, align the PFG 5105 chassis with the upper and lower guides of the selected compartments. Insert the PFG 5105 into the power module and press firmly to seat the circuit board edge connectors in the power module interconnecting jacks. Apply power to the PFG 5105 by actuating the power switch on the power module.

To remove the PFG 5105 from the power module, pull both release latches on the front panel until the interconnecting jack disengages. The instrument will then slide straight out.

Power Cords—PFG 5505 Only

The PFG 5505 is shipped with the power cord option as ordered by the customer (see Fig. 2-1). Verify that the instrument power cord is the proper cord for use with the available power.

PLUG CONFIGURATION	USAGE	LINE VOLTAGE	REFERENCE STANDARDS	OPTION NUMBER
	North American 120/15A	120V	ANSI C73.11 NENA 5-15-P IEC 83	
	Universal Euro 240V/ 10-16A	240V	CEE (7),II,IV,VII IEC 83	A1
	UK 240V/ 13A	240V	BS 1363 IEC 83	A2
	Australian 240V/ 10A	240V	AS C112	A3
	North American 240V/ 15A	240V	ANSI C73.20 NEMA 6-15-P IEC 83	A4
	Switzerland 220V/ 6A	220V	SEV	A5

6759-13

Fig. 2-1. Power Cords.

Line Voltage Selection/Fuse Replacement – PFG 5505 Only

NOTE

The PFG 5505 contains fuses in the voltage selector/fuse holder assembly located on the rear panel. The instrument also contains internal fuses; refer qualified service personnel to the Maintenance section of this manual for information on internal fuse replacement.

The line voltage selector is part of the line cord plug assembly, located on the rear of the power module. Verify that the voltage shown in the selector window is correct for the line voltage available.

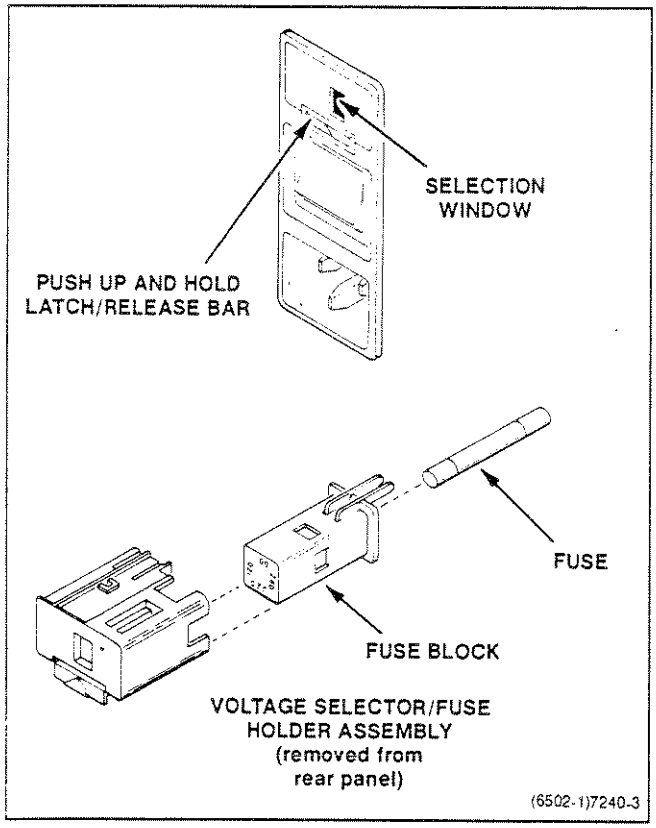


Fig. 2-2. Line Voltage Selection/Fuse Replacement.

If the displayed voltage selection is incorrect or the fuse needs replacement, perform the following procedure. Refer to Fig. 2-2.

1. Make certain that the power switch (on rear of unit) is turned off and the line cord is not plugged into the line voltage connector.

2. Remove the voltage selector/fuse holder by pushing the latch/release bar toward the selection window. The selector/fuse holder should release and move slightly out of the socket. Remove the voltage selector/fuse holder from the assembly.

3. Pull the fuse block and fuse from the voltage selector/fuse holder. Remove the fuse from the fuse block. Make certain a replacement fuse has the proper ratings for the selected line voltage (refer to Specifications for fuse rating). Insert fuse into fuse block.

4. The line voltage selections are printed on the end of the fuse box. Rotate the fuse box and reinstall it so that the proper line voltage selection is visible through the selection window.

5. Reinstall the voltage selector/fuse holder.

6. Verify that the correct line voltage is visible through the line voltage selector window.

Turn-On Procedure

After completing the appropriate Preparation For Use instructions, install the power cord and connect it to the proper power outlet. Turn on the power switch on the instrument rear panel.

IEEE 488 (GPIB) Connector – PFG 5505 Only

Figure 2-3 shows the pin assignments for the rear panel GPIB connector.

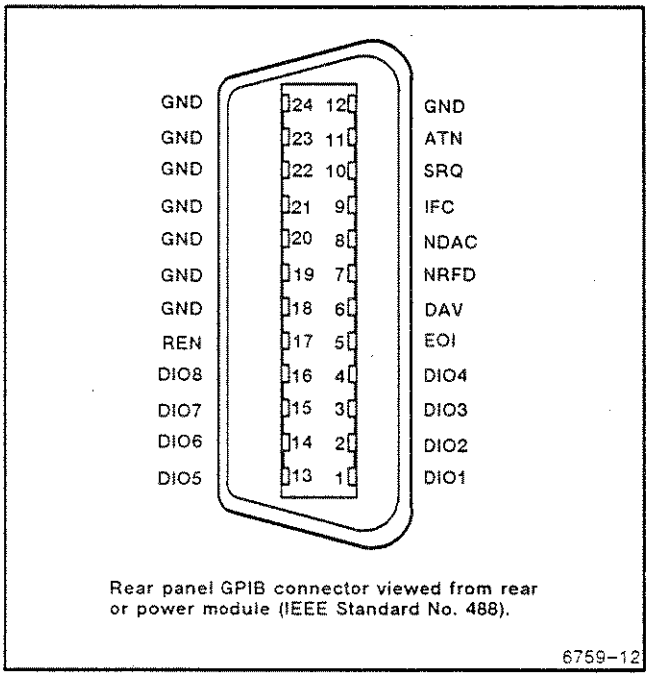


Fig. 2-3. Rear Panel GPIB Connector.

Repackaging For Shipment

If the instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing: owner (with address) and the name of an individual at your firm that can be contacted. Include complete instrument serial number and a description of the service required.

If the original package is unfit for reuse or unavailable, repackage the instrument as follows:

Wrap the instrument with polyethylene sheeting or other suitable material to protect the exterior finish. Obtain a carton of corrugated cardboard of adequate strength and having inside dimensions no less than six inches more than the dimensions of the instrument. Cushion the instrument by tightly packing dunnage or urethane foam between the carton and instrument, on all sides. Seal the carton with shipping tape or use an industrial stapler.

The carton test strength for your instrument is:

PFG 5105: 200 pounds per square inch

PFG 5505: 275 pounds per square inch

CONTROLS, CONNECTORS, AND DISPLAY

General Information

All controls and connectors used for local (manual) operation of the PFG 5105/5505 are located on the front panel. The exception is the ON/OFF switch for the PFG 5505 only, which is located on the rear panel. The front panel keys are used to select a parameter, or function for the waveform output; to display the current value of the parameter, or function; and to change its value, if desired. Other keys select the trigger source and mode. The DATA keypad is used to enter a different value for the selected key function. Some keys have built-in LEDs that illuminate to indicate that the associated function is active. On all keys that include LEDs, the indicators light only while a parameter or function is selected, or is active.

Display Window, Changing Settings

The PFG 5105/5505 has a two-row LCD in the display window that can show up to 16 characters per row. When the PFG 5105/5505 is on, each row displays a function, parameter, etc., and its current setting. For example, the default display shows the current setting for frequency and amplitude. Depending on the key function, selection allows the user to:

- Display the current setting of a key function. For example, if frequency and amplitude are displayed, press N BURST to see its current setting.
- Change the current setting of a key function. For example, press N BURST, press a DATA numeric key such as 6, press ENTER.
- Turn on, or enable the selected key function, without changing its current setting. For example, if DC was previously set to 1 V, but is now off (LED off), turn on the DC function by pressing DC, ENTER.
- Display the current setting of a key function, change that setting using the DATA keypad (numeric and units of measure keys), and turn on or enable the function, etc., with the new setting. For example, press SWEEP, DATA key 4, ENTER. The output at the SWEEP OUT connector is a logarithmic sweep.

(The other displayed characteristic or one that is not displayed can be selected by pressing its front panel key.)

A right caret in the left display area indicates which of the two displayed items is "selected", or "can be acted upon" using the front panel keys. Refer to Fig. 2-4, part A.

An asterisk is displayed in place of the right caret when a DATA key is pressed (to change the displayed numeric setting). Refer to Fig. 2-4, part B. The DATA keys are used to change the displayed numeric setting; some DATA keys also can change the units of measure (units are function key dependent). The asterisk indicates that the settings change is incomplete and must be concluded by pressing the ENTER key. Refer to Fig. 2-4, part C.

A numeric settings change in process can be aborted by pressing any key other than DATA and INST ID keys; also a timeout of about 9 seconds will abort the incomplete change. When a settings change is completed, the asterisk reverts to a right caret.

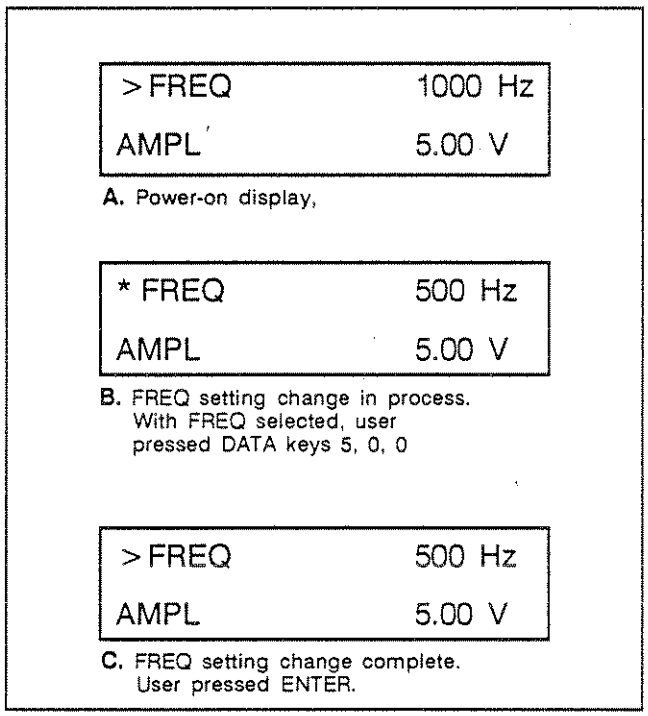


Fig. 2-4. Front Panel Numeric Setting Change.

Power-On/Initial Conditions

When powered on, the PFG 5105/5505 microprocessor performs a diagnostic routine (self test) to check the functionality of the ROM and RAM. If no ROM or RAM error is found, the microprocessor goes on to check the functionality of the other instrument hardware. When the self test is finished, the instrument enters the local state (LOCS) with the following default settings:

Table 2-1
POWER-ON DEFAULT SETTINGS

AM	OFF
AMPLITUDE	5 V
DC	0 V
DCYCLE	0
DELAY	0
DT	OFF
FM	OFF
FRQLCK	ON
FRQSTART	1 Hz
FRQSTOP	1200 Hz
FREQUENCY	1 kHz
FUNCTION	SINE
MODE	CONT
NBURST	2
OFFSET	0 V
OUTPUT	OFF
PERIOD	1 ms
RATE	10 μs
RNGLCK	OFF
RQS	ON
SWEEP	OFF
TRIG	MAN
USEREQ	OFF
WIDTH	0.5 ms

The GPIB address and termination are factory-set to 8 and LF with EOI, respectively. New values for these parameters can be entered and stored using SPCL 240 and 241. See Special Functions. later in this section, for more information.

The SRQ line on the GPIB is also asserted unless the GPIB address is set to 31 (ignore GPIB commands). If the instrument is polled by the controller, the status byte returned will be "0100 0001" (65 decimal; power-on SRQ).

If a ROM or RAM error is found, an error code is displayed in the front-panel display. The instrument will not respond to input from the front panel or the GPIB interface. Internal errors detected after the ROM and RAM tests have passed will be reported to both the front panel and the GPIB. The instrument will respond to input and attempt to function in spite of the internal error. An error code may be removed from the display by pressing the INST ID key, by starting a numeric entry, by incrementing the selected parameter, by pressing the clear key, or by a transition into the remote state (REMS).

GPIB Indicators

ADRS — Illuminates when the PFG 5105/5505 is addressed as a listener or as a talker over the GPIB.

REMOTE — Illuminates when the PFG 5105/5505 is operating under remote program control via the GPIB.

CONTROLS AND CONNECTORS

The following description explains the function of each front panel control and connector. The number associated with each description pinpoints the location of the key or connector on the front panel in Fig. 2-5.

(1) PARAMETER KEYS

The PARAMETER keys are used to select a parameter for the waveform selected for output from the PFG 5105/5505; to display the current value of the parameter; and to change its value and/or units of measure using the DATA keypad. The PARAMETER keys are mutually exclusive in operation.

FREQ — Selects the FREQuency parameter and displays the current frequency of the output function and its current amplitude. Frequency can be changed via front panel keys. Becomes period entry and display when SPCL 210 is used.

AMPL — Selects the AMPLitude parameter and displays the current amplitude of the output function. The amplitude can be changed via front panel keys. Amplitude and offset are both displayed when either parameter is selected.

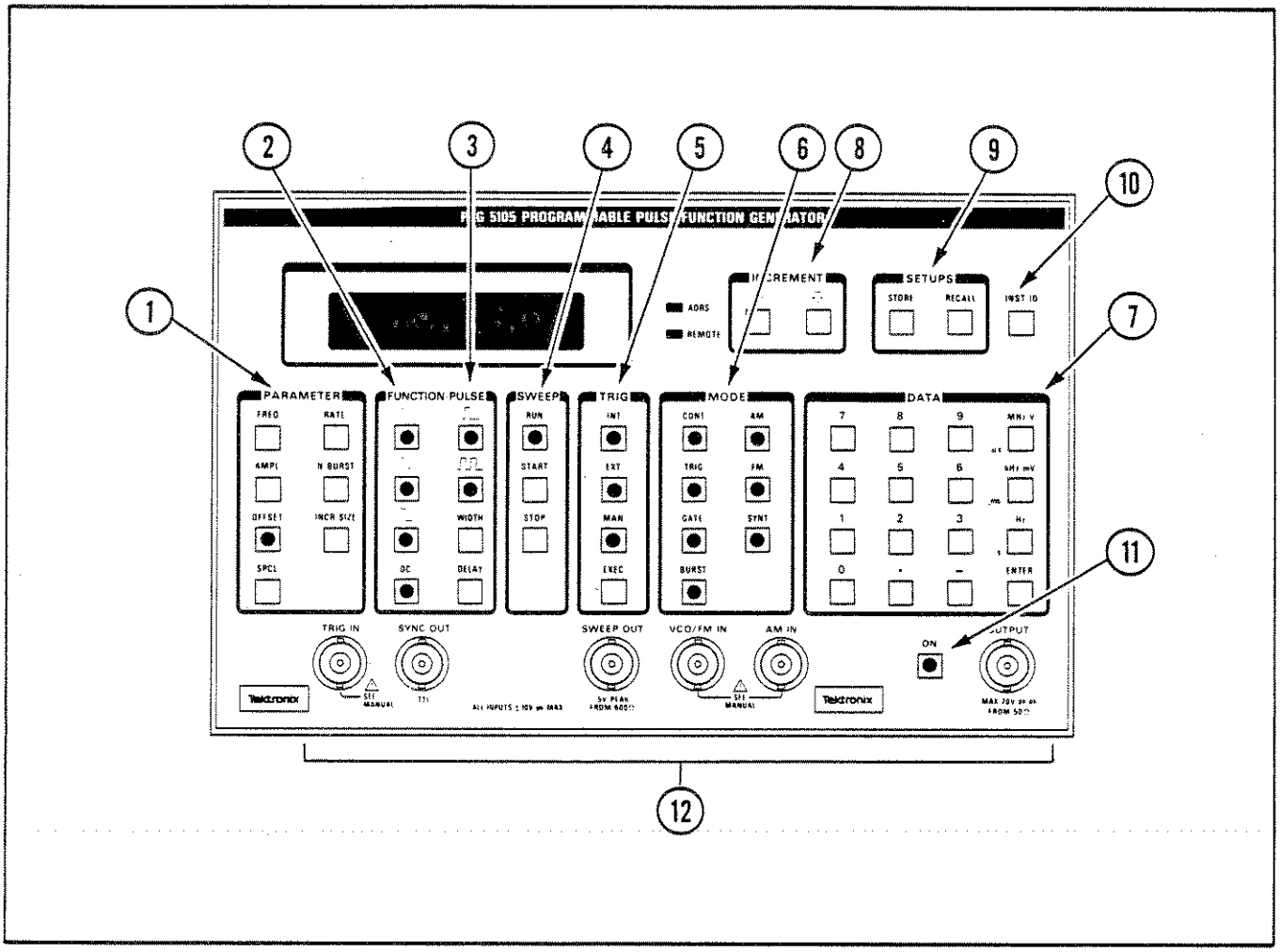


Fig. 2-5. Controls and Connectors.

OFFSET — Illuminates if the output OFFSET voltage is not zero. The value can be changed via the front panel keys. Amplitude and offset are both displayed when either parameter is selected. Setting OFFSET to 0 turns the offset function off.

SPCL — Selects a special function or mode using the sequence: press SPCL key (display shows the SPCL function code and description for the last used SPCL function, or the SPCL function with the lowest code), press the up- or down-arrow key to page through a list of SPCL codes until the desired function is displayed; press ENTER; perform the required operation to use the function while its code is displayed; exit the SPCL function menu by pressing any parameter or function key. Refer to Special Functions, later in this section, for more information.

RATE — Selects the RATE parameter and displays the current rate. The RATE setting controls the sweep rate and internal trigger rate. RATE can be changed via the front panel keys.

N BURST — Selects the N BURST parameter and displays the current N BURST setting—the number of cycles that will be generated in BURST mode. The number of cycles can be changed via front panel keys.

INCR SIZE — Selects the INCR SIZE parameter and displays the current step size of the INCREMENT key function (used for incrementing and decrementing a selected parameter). INCR SIZE can be changed via the DATA keypad. The INCR SIZE setting defaults to the least significant digit of the range for the currently selected parameter: N BURST, DC, FREQ, AMPL, OFFSET, WIDTH, DELAY and RATE. (INCR SIZE changes when either the range or the parameter is changed.) When the value of INCR SIZE is changed by the user, INCR SIZE is locked to the new value, until the user changes INCR SIZE to 0. If INCR SIZE is locked to a value that is less than the least significant digit of the range, then the PFG 5105/5505 generates an error. Both amplitude and offset are displayed. INCR SIZE is not saved by the STORE function.

(2) FUNCTION KEYS

SINE — Selects a sine wave output (LED on).

TRIANGLE — Selects a triangle wave output (LED on).

SQUARE — Selects a square wave output (LED on).

DC — Selects a dc voltage function (LED on) at the selected voltage. User must press ENTER after selecting this function (and optionally selecting a voltage level) to start signal output.

(3) PULSE KEYS

These keys select single or double pulse waveforms. Pulse width and delay can also be set with these keys.

PULSE — Selects a pulse waveform output (LED on).

DOUBLE PULSE — Changes single pulse output to a double pulse.

WIDTH — Selects width of output pulse.

DELAY — Selects delay to start of pulse.

(4) SWEEP KEYS

RUN
START
STOP — The RUN key is used with the START and STOP keys (to select the START and STOP frequencies over which the output waveform is swept) and the DATA keypad (to select the sweep type). To select sweep function, first set the START and STOP frequencies; then press RUN.

(5) TRIG KEYS

This section of keys selects the trigger source used by the TRIG, GATE, and BURST modes.

INT — Selects internal trigger source. The rate of the trigger source is the last entered RATE parameter. The key LED is on while INT is selected.

EXT — Selects the external trigger signal applied to the front panel TRIG IN BNC connector. The key LED is on while EXT is selected. When the trigger mode/source is EXT TRIG, the delay between the trigger input and the sync pulse output will be a fixed value of about 200 ns. The GATE and BURST modes will have a delay between the external trigger and the first sync pulse output of 1/(frequency setting x 4) + 20E–9 or (period setting/4) + 20E–9.

MAN — Selects a manual trigger/gate as the trigger source. With MAN selected, and either the TRIG, GATE, or BURST modes selected, a trigger can be initiated by pressing the EXEC key. The key LED is on while MAN is selected.

EXEC — If MAN trigger is selected, pressing EXEC generates one trigger. If the instrument is in TRIG mode, pressing EXEC triggers a signal of one cycle in length. If the instrument is in GATE mode, the output is enabled as long as the EXEC button is pressed. If the instrument is in BURST mode, pressing EXEC triggers a waveform that is N BURST cycles in length.

(6) MODE KEYS

These buttons select the output mode. The CONT, TRIG, GATE, BURST and SYNT modes are mutually exclusive; the key LED lights to indicate the selected mode.

CONT — Generates a continuous output.

TRIG — Generates one cycle of the selected waveform for each trigger received. Refer to the TRIG KEYS description.

GATE — When this key is pressed, the instrument outputs complete cycles as long as the trigger source is asserted.

BURST — When this key is pressed, the instrument outputs the number of cycles selected by N BURST, for each trigger received.

AM — Uses the signal connected to the AM IN connector to amplitude-modulate the output signal.

FM — Uses a signal applied to the VCO/FM IN connector to control the output frequency, allowing FM modulation. FM cannot be used with the SYNT mode.

SYNT — For Option 02 instruments only. When this key is pressed, the instrument outputs a continuous waveform that is frequency-locked to an internal quartz crystal. Display allows 4.5 digit resolution.

(7) DATA KEYS

The DATA keypad is used to enter numeric data. Some keys are dual function (refer to the SWEEP key description). Using the MHz/V-μs key, the kHz/mV-ms key, or the Hz-s key allows the user to scale the input. A decimal point key and minus key are also included. The ENTER key is used to terminate an entry.

NOTE

If the function or parameter is selected, and no data is entered, the ENTER key will terminate the selection with no change to the value of the function or parameter.

(8) INCREMENT KEYS

Increments (up-arrow key) or decrements (down-arrow key) the value of the selected parameter. Step size is set by the INCR SIZE parameter key. To use these keys to change a parameter value, press the parameter key and the INCREMENT up- or down-arrow key.

NOTE

The PFG 5105/5505 is a digitally controlled analog pulse/function generator. Monotonicity of the increment/decrement function is not guaranteed, and in fact, an increment of a parameter can cause a decrement in the output. Example: DELAY is decremented from 84 ns to 83 ns and the actual delay is increased from 84 ns to 84.5 ns. The accuracy of the parameter will always be in spec.

(9) SETUP KEYS

These keys are used to save or recall front panel settings.

STORE — Used with the DATA keypad to store the present front panel settings in the settings memory, except for INCR SIZE. The current settings for the SPCL functions Range Lock and Frequency Lock are stored. To store the present settings, press STORE, enter the number of the settings buffer (1-99) that you want to store the settings in, and press ENTER. Settings buffer number 0 contains the power-up front panel settings; the settings in this buffer cannot be changed. Refer to Table 2-1 for a list of the power-on settings.

NOTE

INCR SIZE and partially entered functions or parameters are not stored by the STORE function.

RECALL — Used with the DATA keypad to recall previously stored front panel settings. To recall stored settings, press RECALL, enter the number of the desired settings buffer, press ENTER.

(10) INST ID KEY

Causes the PFG 5105/5505 to display its GPIB address, EOI/LF terminator and, if enabled, to generate a service request (SRQ) over the GPIB. To display the GPIB address or terminator, press INST ID. To change the address, enter SPCL function code 240, and press ENTER; press the INCREMENT up- or down-arrow key to change the displayed address to the new address, or enter the new address using the DATA keys; press ENTER. To change the terminator, enter SPCL function code 241 and press ENTER; use the INCREMENT up- and down-arrow keys to change the displayed terminator selection, press ENTER to set the selection.

(11) OUTPUT ON KEY

Turns the main output of the instrument on (LED on) or off.

(12) CONNECTORS

Refer to the specifications in Section 1 for input/output characteristics and limits.

TRIG IN	The input connector for external TTL-level trigger and gate functions.
SYNC OUT	The output depends on the function set. In the standard modes, the output is a TTL square wave in phase with the main output and at the same frequency as the main output.
SWEEP OUT	Outputs a sweep control voltage for use with an xy oscilloscope or plotter.
VCO/FM IN	The input connector for the FM modulation signal or the VCO input voltage.
AM IN	The input connector for the AM modulation signal.
OUTPUT	The output connector for the main generator signal.

OPERATING CONSIDERATIONS

General Operating Information

Allow 30 minutes warmup time for operation to specified accuracy.

CAUTION

Observe the specified maximum input voltage ratings listed in the Electrical Specifications, in this manual. Instrument damage may occur if the maximum input ratings are exceeded.

Output Connections

The PFG 5105/5505 output circuits are designed to operate as a 50 ohm voltage source working into a 50 ohm load. At higher frequencies, an unterminated or improperly terminated output will cause aberrations on the output waveform. Loads less than 50 ohms will reduce the waveform amplitude; loads more than 50 ohms will increase waveform amplitude.

Excessive distortion or aberrations, due to improper termination, are less noticeable at lower frequencies (especially with sine and square waveforms). To ensure waveform purity, observe the following precautions.

1. Use good quality 50 ohm coaxial cable and connectors.
2. Make all connections tight and short as possible.
3. Use good quality attenuators if it is necessary to reduce waveform amplitudes applied to sensitive circuits.
4. Use terminations or impedance-matching devices to avoid reflections when using long cables (six feet or more).
5. Ensure that attenuators, terminations, etc., have adequate power handling capabilities for the output waveform.

If there is a dc voltage across the output load, use a coupling capacitor in series with the load. The time constant of the coupling capacitor and load must be long enough to maintain pulse flatness.

Impedance Matching

If the PFG 5105/5505 is driving a high impedance such as the 1 Meg-ohm input impedance (paralleled by a stated capacitance) of an oscilloscope vertical input, connect the transmission line to a 50-ohm attenuator, a 50-ohm termination, and then the oscilloscope input. The attenuator isolates the input capacitance of the device, and the PFG 5105/5505 is properly terminated.

Displayed Errors

When powered up, the PFG 5105/5505 performs a diagnostic self-test to check its functionality. If an error is found, an error code and text will be displayed in the display window. Other errors occur when the user attempts to make an invalid front panel setting. In this event, an error code and descriptive phrase are shown in the display window; the error can be cleared by pressing any key except INST ID. The PFG 5105/5505 automatically clears front panel errors after a timeout of about 9 seconds. Error code definitions are listed in Table 2-2.

Table 2-2
FRONT PANEL ERROR CODES

Error	Description
010	Incorrect syntax
011	Increment step error
012	Increment limit
013	Decrement limit
014	Increment/decrement error
015	SPCL Function/Mode does not exist
016	Mode conflict
020	Not implemented
204	Settings conflict
205	Out of range
250	AMPL OFST conflict
255	Illegal settings
261	Sweep operation error
262	Synthesizer not installed
271	RATE out of range.
273	FREQ out of range
274	AMPL out of range.
275	OFFSET out of range
280	DC out of range
281	Width out of range
282	Delay out of range
283	Pulse mode. Width + delay > (0.85 x period)

(continued on next page)

Table 2-2 (Cont)
FRONT PANEL ERROR CODES

Error	Description
284	Pulse mode. Period–(width + delay) < = 40 ns
285	Double pulse. Delay ≤width
286	Double pulse. Delay ≤(width + Nl)
290	Synt illegal data
302	System error
350	Synthesizer out of lock
650	Low battery
660	Output overload

If no error is found during self test, the instrument enters the local state with the settings listed in Table 2-1.

Store/Recall Settings

The PFG 5105/5505 can store 99 front-panel setups in non-volatile memory; the stored setups can be recalled (front panel settings are changed to match the stored setup).

To store the current front panel settings in a settings buffer, press STORE, a settings buffer number (using the DATA keypad), then press ENTER. Settings buffers are numbered 0 through 99; settings buffer number 0 is a read-only buffer that contains the power-on settings listed in Table 2-1. (At shipment, all buffers contain the power-on settings.)

The following settings are not stored in settings buffers by the STORE function, but are retained in non-volatile memory and used at power-on:

Display intensity/backlight (SPCL function 220)

GPIB address (SPCL function 240)

GPIB message terminator (SPCL function 241)

To recall a stored setup, press RECALL, the number of the buffer that contains the desired setup, and press ENTER.

Special Functions

The PFG 5105/5505 has a series of special functions that allow the user to change additional instrument settings. These functions are listed in Table 2-3.

To invoke a SPCL function, press SPCL. Then, enter the three-digit SPCL code and press ENTER, or press the INCREMENT up- or down- arrow keys to page through a menu in the display of the SPCL functions (both the code and a the function name are displayed). Use the keys indicated in the SPCL function description following to modify the function; then press any FUNCTION key to exit the SPCL function and restore the display.

Table 2-3
SPECIAL FUNCTIONS

Code	Description
100	Identifies the product type and displays the product version number, the firmware version number, and option number: TEK PFG 5105 V81.1 F1.0 OPT02. OPT02 indicates that the Option 02 synthesizer is installed; instruments without the option do not return an option statement.
210	Enters the pulse generator frequency as a period or returns to frequency entry. Use the increment/decrement keys to toggle between frequency or period entry. When using period entry, there will be only 3 1/2 digits resolution in SYNT mode.
220	Changes the intensity and back-lighting level; use the INCREMENT up and down arrow keys to increase or decrease the intensity of the characters; backlighting automatically toggles between ON and OFF when the user presses ENTER.
230	Frequency lock mode selection. Press either INCREMENT key to toggle the frequency lock status between ON and OFF.
240	This function allows the user to change the GPIB address from the front panel. Use the INCREMENT keys to increment or decrement the displayed address.
241	This function allows the user to change the GPIB termination from the front panel. Use the INCREMENT up and down arrow keys to toggle between terminators.
260	Range lock (enables external wide sweep). Press either INCREMENT key to toggle range lock on or off. Refer to Frequency Modulation in this section.
270	Downloads demo setting into settings buffers 90-99. See Table 2-4. This will write over any setting in these buffers.

(continued on next page)

Table 2-3 (Cont)
SPECIAL FUNCTIONS

Code	Description
410	Enters duty cycle mode. When a duty cycle of 10-85% is entered, the PFG 5105/5505 will change width to maintain the duty cycle as the period changes. A width entry removes the instrument from duty cycle mode.
420	Allows a predefined output level to be set. Use the INCREMENT up and down arrow keys to select one of the following: TTL, (0-3 V); CMOS (0-4.99 V); ECL (–0.8 V to –1.8 V). The amplitude/offset value can be used to modify the predefined level.
Calibration	
510	Calibration routines. For use by qualified service personnel only.

Stepping a Parameter Level

The PFG 5105/5505 allows the user to step the level of the following parameters/functions, while the output waveform is being generated. Stepping is done by selecting the parameter/function, and pressing the INCREMENT up- or down-arrow key. The step size is determined by the INCR SIZE setting for the selected parameter.

FREQ steps the waveform frequency

AMPL steps the waveform amplitude

WIDTH steps pulse width

DELAY steps pulse delay

OFFSET steps the offset voltage

RATE steps the value used by RATE to control the sweep rate and the internal trigger rate.

N BURST steps the number-in-burst value that controls the number of cycles generated in BURST mode.

DC steps the output voltage of the DC function.

The direction of step change is determined by the user: pressing the INCREMENT up-arrow key steps in a positive direction; the down-arrow key in a negative direction.

INCR SIZE operates in two modes. In the default mode, the PFG 5105/5505 automatically sets the value of INCR SIZE to the least significant digit of the range for the currently selected parameter. When parameter selection changes, the value of INCR SIZE automatically changes accordingly.

In the non-default mode, the value of INCR SIZE is set by the user as follows: with the parameter to be stepped selected, press INCR SIZE, enter a step size using the DATA keypad, press ENTER. In this mode, step size is locked to the user-selected value until the user resets the step size to 0. Note that setting INCR SIZE to a value that is less than the least significant digit for the currently selected parameter range generates an error when the INCREMENT key is pressed.

Table 2-4
DEMO SETUPS[1]

DEMO	SETUPS[1]	PARAMETER					FUNCTION-PULSE			SWEEP		TRIG	MODE	OUT
	RECALL	FREQ	RATE	AMPL	OFFSET	NBURST	FUNCTION	WIDTH	DELAY	START	STOP			
Basic Sinewave	90	1 MHz	—	1 V	0 V	—	∿	—	—	—	—	INT	CONT	ON
	91	1 MHz	100 µs	1 V	0 V	10	∿	—	—	—	—	INT	BURST	ON
	92	—	100 µs	1 V	0 V	—	⎍	1 µs	10 µs	—	—	INT	TRIG	ON
	93	—	1 µs	3 V	1.5 V	—	⎍	100 ns	0 µs	—	—	INT	TRIG	ON
	94	1 MHz	—	2 V	2 V	—	⩘	—	—	—	—	INT	CONT	ON
Slow Sweep (1 kHz to 10 kHz)	95	—	5 ms[2]	1 V	0 V	—	∿	—	—	1 kHz	10 kHz[3]	INT	CONT	ON
Fast Sweep (100 kHz to 10 MHz)	96	—	20 µs[4]	1 V	0 V	—	⎍	—	—	100 kHz	10 MHz[3]	INT	CONT	ON
Setups Requiring External Signal Source														
VCO (FM)	97	10 MHz[5]	—	1 V	0 V	—	⎍	—	—	—	—	INT	CONT FM	ON
Delayed Pulse	98	—[6]	—	1 V	0 V	—	⎍	40 ns	1 µs	—	—	EXT	TRIG	ON
Amplitude Modulation	99	1 MHz[7]	—	1 V	0 V	—	∿	—	—	—	—	EXT	CONT FM	ON

1 Demo setups loaded by pressing [SPCL] [2] [7] [0] [ENTER]
2 1.28 seconds per sweep
3 Press [RUN] to start sweep
4 5.12 ms per sweep
5 A 0-5 volt input at the VCO/FM IN connector effects a 10 kHz-12 MHz frequency range. For VCO mode, RANGE LOCK (accessed thru SPCL 260) is turned OFF
6 With 1 msec delay, external trigger (TTL levels) rate to TRIG IN connector should not exceed about 800 kHz.
7 A 5 volt p-p (–2.5 V to +2.5 V) input to the AM IN connector effects 100% modulation (output ranges from 0 V to 2 V)

GENERATING AN OUTPUT FUNCTION

The PFG 5105/5505 provides the following output functions: single pulse, double pulse, sine-wave, triangle-wave, square-wave, and dc. To output a function requires selecting the front-panel functions, parameters, modes, etc., and their values, that define the waveshape of the output signal. These selections are presented in Tables 2-5 and 2-6 by general characteristic. The list is a guide to setting the controls to define the output; additional settings are then described that add capabilities useful for special applications.

Table 2-5
GENERATING SINE, TRIANGLE, SQUARE AND DC FUNCTIONS

Purpose	Step 1	Step 2
Select Output Function: (Press one)	SINE, TRIANGLE, SQUARE, DC	If DC output is selected, enter dc voltage: (DATA numeric, units keys); press ENTER.
Select Output Frequency:	FREQ	Enter frequency: (DATA numeric, units keys); press ENTER.
Select Output Amplitude:	AMPL	Enter amplitude: (DATA numeric, units keys); press ENTER.
Select Trigger Source: (Press one)	INT, MAN, EXT	If INT is selected, set internal trigger rate: (RATE, DATA numeric, units keys), press ENTER.
Select Output Mode: (Press one)	CONT, TRIG, GATED, SYNT, BURST	If BURST is selected, set number in burst: (N BURST, DATA numeric, units keys), press ENTER.
Turn Output On:	OUTPUT (LED on)	

Table 2-6
GENERATING PULSE FUNCTIONS

Purpose	Step 1	Step 2
Set to Period Input Mode:	SPCL	Enter 210. Press ENTER. Change to Period with INCREMENT key.
Set Period:	FREQ (PERIOD displayed)	Enter period: (DATA numeric, units keys); press ENTER. Period is displayed instead of frequency.
Set Delay:	DELAY	Enter delay: (DATA numeric, units keys); press ENTER. Delay must be less than the width.
Set Width:	WIDTH	Enter width: (DATA numeric, units keys); press ENTER. Width must be greater than delay in double pulse.
Select Trigger Source:	INT, MAN, or EXT	If INT is selected, set trigger rate: (DATA numeric, units keys); press ENTER.
Select Output Mode:	CONT, TRIG, GATED, SYNT, or BURST	If BURST is selected, set number in burst: (N BURST, DATA numeric, units keys), press ENTER.
Select Pulse Output:	SPULSE, DPULSE	If error occurs, check period, delay, and width for illegal combinations (see Width, Delay and Period Relationships later in this section).
Turn Output On:	OUTPUT (LED on)	(NOTE: SPCL 210 returns period mode to frequency mode.)

MODULATION

Two kinds of modulation can be used to alter the output waveform: frequency modulation, and amplitude modulation. For each, the appropriate external signal is applied to a special connector on the front panel. Refer to Specifications section regarding limitations on external signals applied to the AM IN and VCO/FM connectors.

Frequency Modulation

A signal applied to the VCO/ FM IN connector can modulate the frequency of the output waveform; the output signal becomes the FM carrier or a voltage-controlled frequency signal (VCF). The polarity of the external input signal determines the direction in which the output will deviate in frequency: a positive-going input signal increases output signal frequency. The amplitude of the external input signal determines the percent of frequency change in the output signal.

Range Lock. Special function 260 controls Range Lock ON or OFF (either INCREMENT key toggles ON or OFF). For either Range Lock setting, the output frequency of the triangle generator (the PFG oscillator) can be changed by a signal at the FM/VCO input. The Range Lock should be OFF for frequency modulation operation; or ON for operation as an externally swept frequency generator. To enable either frequency modulation or externally swept output, set Range Lock appropriately and press the FM key (LED on). Entering a frequency parameter will have no effect on output frequency unless Range Lock is turned OFF.

The selected output frequency (FREQ key setting) is the "center" frequency above and below which frequency modulation swings. The PFG 5105/5505 is capable of 3 decades of sweep within each frequency range. Frequency ranges change at 12 in decade steps.

NOTE

The allowable maximum deviation from the center frequency is dependent upon the location of center frequency within the frequency range. If center frequency is close to the upper end of the range, only a small increase in frequency can be achieved before the maximum range frequency is reached.

As an example, it is OK to set carrier signal frequency to 110 kHz and modulating signal amplitude to produce 20 kHz deviation. However, if the modulating signal amplitude is increased to produce 40 kHz deviation, distortion will occur since the carrier signal cannot go higher than about 140 kHz in this frequency range. Frequency modulation or FM/VCO input sweep operation cannot drive output frequency from one frequency range to another. Frequency modulation can however drive the output frequency about 10% higher than the top of the range, as explained below.

With Range Lock ON, the frequency control DAC of Fig. 2-6 is turned off and only the VCO/FM input voltage controls the VCO triangle generator. With 0 volts VCO/FM input, output frequency is at its lowest of the selected range. To move the output frequency to the top of the range, apply approximately 7 volts.

With Range Lock OFF (default setting), the DAC output supplies a DC voltage to set output frequency. The amplitude of a signal applied to the VCO/FM input when in FM mode will be added to the DAC DC output at the summing junction and applied to the VCO triangle generator. Approximately 7 volts is still required to move the output frequency to the top of the range, but it can consist of the sum of the DAC DC output voltage and the peak amplitude of the FM/VCO signal input. Thus, to frequency modulate an output frequency, Range Lock should be OFF, center frequency should be entered by depressing FREQ parameter and value, and FM mode selected. Then a sinusoidal input signal centered around 0 volts to the FM/VCO port will deviate the output equally UP and DOWN in frequency.

When in FM mode, output frequency can actually be driven above the nominal range limit, by approximately 10%. When not in FM mode, range frequency is precisely defined by a firmware controlled DAC output voltage. For example, if an output frequency of 1.21 MHz (0.1 MHz above the 0.12 MHz to 1.2 MHz range) is selected, the DAC output voltage would produce an output frequency close to the bottom of the next higher frequency range 1.21 MHz to 12 MHz.

In the FM mode, the voltage to the triangle generator is not limited to the DAC dc output, but can be changed by the amplitude of the modulating signal. The triangle generator can be driven harder into limiting as shown by the flattening of the upper frequencies in Figures 1-2A and 1-2B.

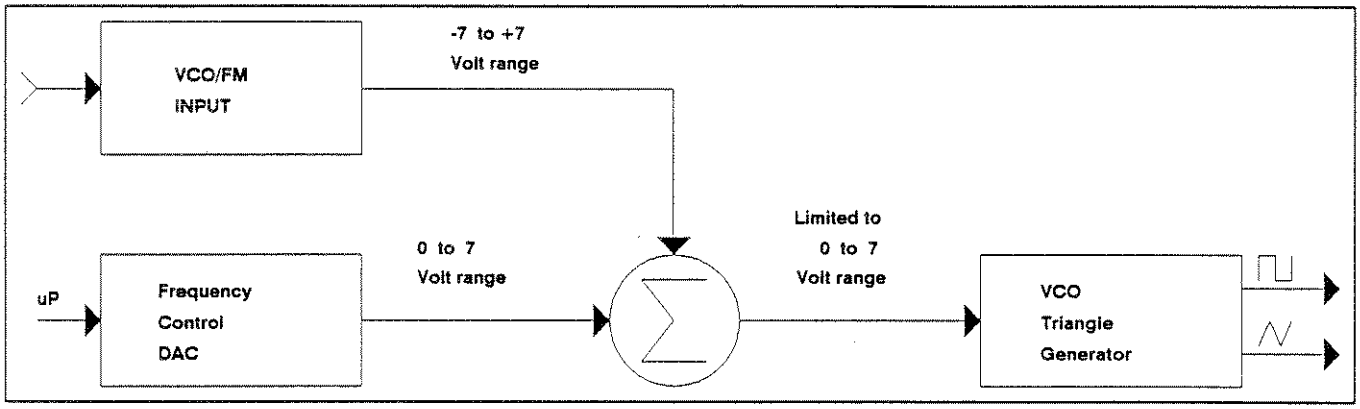


Fig. 2-6. Triangle generator architecture.

External VCO Example:
To get a swept output from approximately 1 to 5 kHz:

- Set Frequency to 11 kHz.
- Set Range Lock ON and FM mode ON.
- Set a ramp generator to start a 1 V and end at 3 V.

This setup will provide a linear sweep of output frequency from about 1 kHz to 5 kHz.

Frequency Lock. With frequency lock on, internal circuitry improves the generator's frequency accuracy. For operation to specified frequency accuracy, frequency lock should be on. The default setting is frequency lock on. Frequency lock is disabled when FM mode is selected. Frequency lock can be turned off by using a SPCL function. Refer to Special Functions in this section of the manual.

Amplitude Modulation

A signal applied to the AM IN connector modulates the amplitude of the output waveform. Amplitude modulation effectively multiplies the amplitudes of the generator and the external signal applied to the AM IN connector.

A modulating signal of approximately 4.5 volts peak-to-peak will cause 100-percent modulation of the output if the output amplitude is set to 5 V peak-to-peak; if the output amplitude is greater than 5 V peak-to-peak, a 4.5 V modulating signal will cause clipping of the output signal. Refer to Table 1-10, AM INPUT, in the Specifications section.

The PFG 5105/5505 output amplifier cuts off at ≈10.2 volts peak to peak. Any modulation that causes a peak-to-peak voltage near this limit will distort the output. The maximum output voltage that can have 100% modulation is 5.1 volts peak to peak.

See Fig 2-7 for an example of how an output of 9 volts peak-to-peak is distorted with a 0.8 volt modulating signal but not with a 0.6 volt modulating signal.

To enable amplitude modulation, press the AM key (LED on).

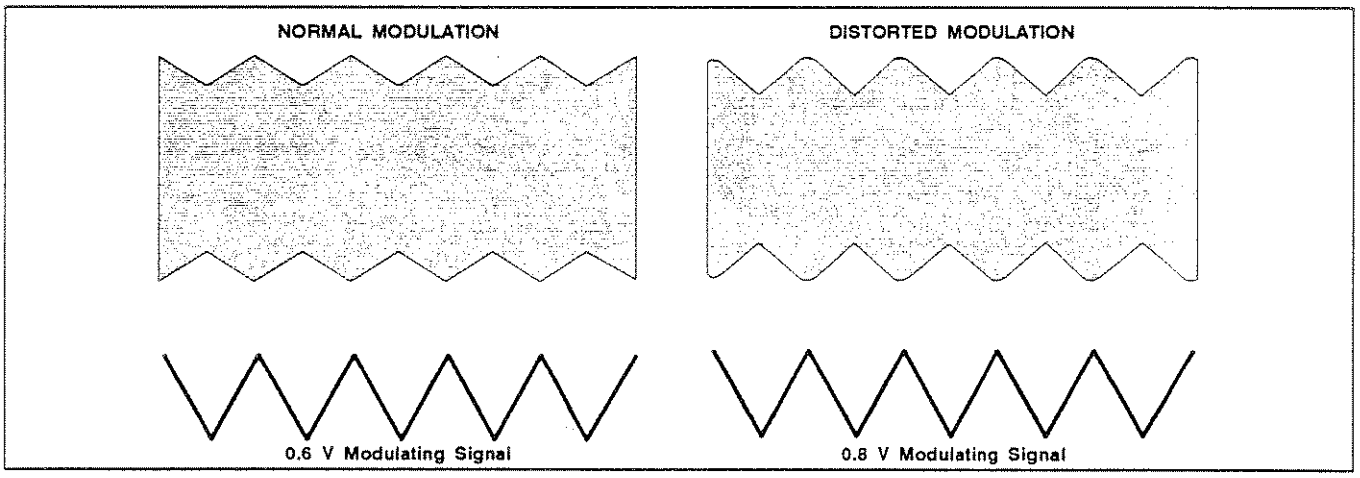


Fig. 2-7. AM Distortion.

Offset

The offset parameter can add a positive or negative dc level to the output waveform. Refer to the Electrical Specifications for combined output/offset level limitations.

To use OFFSET, press the OFFSET key, enter the offset voltage level, select units if appropriate, press ENTER. The OFFSET key LED is on while the offset level is not 0. To turn the offset off, repeat the process described above, setting the offset level to 0 (LED off). If an illegal offset combination is entered, an error will be generated.

Width, Delay and Period Relationships

The PFG 5105/5505 has automatic lockout of illegal width, delay and period combinations in Pulse Mode. Settings that do not meet the criteria will cause an error message to be returned. See Fig. 2-8 for the correct relationship between width, delay and period.

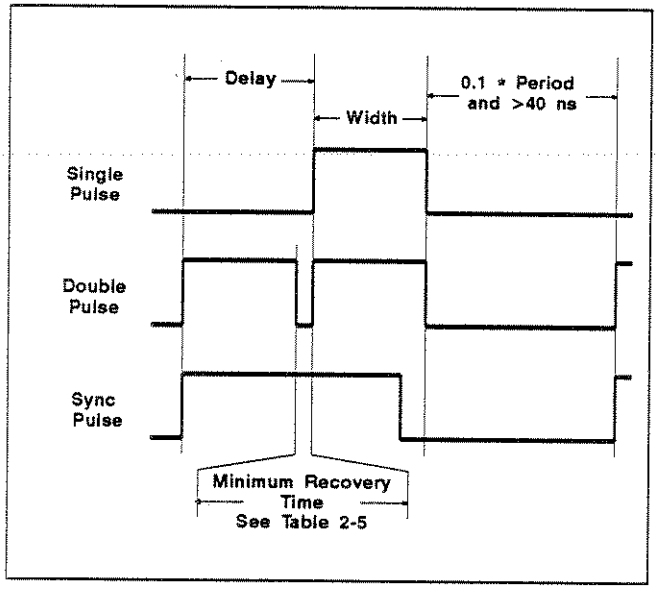


Fig. 2-8. Relationship Between Width, Delay and Period.

Single Pulse Mode

Two equations describe the allowable combinations of width, delay and period.

Equation One:

delay + width $\leq$ period * 0.85

Equation Two:

period − (delay + width) $>$ 40 ns

Using these equations, the following settings can be shown to be legal:

delay = 0
width = 359 ns
period = 400 ns ($1/2.5^6$)

Substituting these settings into Equation One

$0 + 359^{-9} \leq 400 \text{ ns} * 0.85$

$359^{-9} \leq 360^{-9}$

The equation is true, so the settings are legal.

The equation is also true when the settings are substituted into Equation Two:

$400^{-9} - (359^{-9} + 0) \geq 40^{-9}$

$41^{-9} \geq 40^{-9}$

Settings may be illegal even if only one equation is false. For instance, the following settings are illegal because they will return a period − (width + delay) = 40 ns (Equation Two):

delay = 0
width = 360 ns
period = 400 ns ($1/2.5^6$)

And, because they give a false return on Equation One, the following settings are illegal:

delay = 0
width = 451 ns
period = 500 ns ($1/2.00^6$)

Double Pulse Mode

When in double pulse mode, two other factors (Equations Three and Four) affect legal settings:

Equation Three:

delay > width

Equation Four:

delay > width + recovery time

Recovery time is determined by pulse range as shown in Table 2-7.

EXAMPLES:

If width = 400 ns and delay = 390 ns, a delay ≤ width error will be returned.

If width = 400 ns and delay = 410 ns, then delay – width 10 ns. This is less than the recovery time for a width of 400 ns listed in Table 2-7. Therefore, a delay ≤ width + recovery time error will be returned.

Table 2-7
MINIMUM RECOVERY TIME

Width Range	Recovery Time
0.04 - 0.099 μs	40 ns
0.100 - 0.999 μs	50 ns
1.00 - 9.99 μs	200 ns
10.0 - 99.9 μs	2.0 μs
100 - 999 μs	20 μs
1.00 - 9.99 ms	200 μs
10.0 - 99.9 ms	2.0 ms

Synthesizer

The synthesizer mode is available only on instruments that include Option 02. The synthesizer outputs a continuous waveform that is frequency-locked to an internal quartz crystal. The display allows 4.5 digit resolution.

USING THE SWEEP GENERATOR

The PFG 5105/5505 also provides a sweep generator function that outputs the selected sweep waveform at the SWEEP OUT connector. Sweep type is linear.

The sweep time is controlled by the RATE setting; sweep width is controlled by the START and STOP frequency settings. The PFG 5105/5505 calculates the waveshape with a 256-point length, between the current START and STOP frequencies. The 256-point waveshape constitutes one sweep cycle; each point of the 256 points in the cycle's waveshape is output at the rate set by the RATE function.

For example, a linear sweep with a START frequency of 10 kHz, a STOP frequency of 11 kHz, and a RATE of 3.9 millisecond will generate a linear sweep between 10 and 11 kHz with a cycle of 1 second.

The START and STOP frequencies must be in the same sweep range; refer to sweep specifications in Section 1 for ranges. If START and STOP frequencies are not in the same sweep range, an error (261) is generated. Valid START/STOP ranges are shown in Table 2-8.

EXAMPLE:

If the stop frequency is set to 1.2 MHz, the frequency range will be set from 120.1 kHz to 1.20 MHz. This allows you to set the start frequency to a minimum of 1 kHz, a 1200:1 ratio.

However, if the stop frequency is set to 1.21 kHz, the frequency range will be set to 1.21 to 12 MHz. This changes the minimum start frequency to 10 kHz, only a 121:1 ratio. This must be taken into account when figuring sweep frequencies.

To turn sweep on, set the START and STOP frequencies, then press RUN.

To turn off the sweep generator, press RUN again.

Table 2-9 lists the items that must be set to generate a sweep.

Table 2-8
VALID START/STOP RANGES

Stop Frequency Range	Sweep Frequency Range
1.21 MHz - 12 MHz	10 kHz - 12 MHz
120.1 kHz - 1.2 MHz	1 kHz - 1.2 MHz
12.1 kHz - 120 kHz	100 Hz - 120 kHz
1.21 kHz - 12 kHz	10 Hz - 12 kHz
120.1 Hz - 1.2 kHz	1 Hz - 1.2 kHz
12.1 Hz - 120 Hz	0.1 Hz - 120 Hz
0.012 Hz - 12 Hz	0.012 Hz - 12 Hz

Table 2-9
USING THE SWEEP GENERATOR

Purpose	Step 1	Step 2
Select sweep starting frequency:	START	Enter frequency at which sweep will start (DATA numeric, units keys), press ENTER. See table and example above for sweep start and stop frequency ratios.
Select sweep stopping frequency:	STOP	Enter frequency at which sweep will stop (DATA numeric, units keys), press ENTER.
Select sweep rate:	RATE	Input rate value (DATA numeric, units keys); press ENTER
Select SWEEP mode:	RUN	(RUN toggles the sweep on and off.)

Section 3
PROGRAMMING

Introduction

This manual section provides the information required for programming the TEKTRONIX PFG 5105/5505 Programmable Pulse Function Generator via the IEEE-488 bus. The IEEE-488 interface function subsets for the PFG 5105/5505 are listed in Section 1. In this manual, the IEEE-488 digital interface is called the General Purpose Interface Bus (GPIB). Message protocol over the GPIB is specified and described in the IEEE-Standard 488.1-1987, *Standard Digital Interface for Programmable Instrumentation.*

The information in this section assumes that the reader is knowledgeable in GPIB bus communication and has some experience in programming the system.

Tektronix Codes and Formats (V81.1) is the standard used in programming the PFG 5105/5505. TM 5000 instruments are designed to communicate with any bus-compatible controller that can send and receive ASCII messages (commands) over the IEEE-488 bus. These commands program the instruments or request information from the instruments.

Recommended controllers for use in programming the PFG 5105/5505 are the Tektronix 4041; or an IBM PC-compatible, such as the Tektronix PEP 301, with the Tektronix GURU (GPIB User's Resource Utility for the IBM P.C.) software and GPIB interface card.

Commands for TM 5000 programmable instruments are designed for compatibility among instrument types. The same commands are used in different instruments to control similar functions. In addition, commands are specified in mnemonics that are related to the functions implemented. For example, the INIT command initializes instrument settings to their power-on states.

Instrument commands are presented in this manual section in three formats:

- A front panel illustration—showing command relationships to front panel operation. See Fig. 3-1.
- Functional Command List—a list divided into functional groups with brief descriptions.
- Detailed Command List—an alphabetical listing of commands with complete descriptions.

NOTE

The PFG 5105 and PFG 5505 each respond to all commands as a PFG 5105. No distinction is made between the two instruments over the GPIB bus.

TM 5000 programmable instruments connect to the GPIB through a TM 5000 power module. Refer to the Operating Instructions section of this manual for information on installing the instrument in the power module. Also review this section for instrument caution and warning statements and to become familiar with front panel instrument functions.

The PFG 5105/5505 is shipped with the primary GPIB address set to 8. TM 5000 instruments are shipped with the message terminator set to LF with EOI. (Message terminators are described in Messages and Communications Protocol in this section.) The address and terminator settings are stored in non-volatile RAM. To display the current address and terminator, press the INST ID key. The GPIB primary address and message terminator can be changed using SPCL Functions (SPCL Functions are front panel key operations). For information, refer to SPCL Functions in the Operating Instructions section in this manual.

COMMANDS

The instrument is controlled by the front panel keys or via commands received from the controller. These commands are of three types:

- Setting commands—control instrument settings.
- Query/Operational—request data.
- Operational—cause a particular action as soon as the message unit is received over the GPIB interface.

When the instrument is in the remote state, it provides a response or executes all commands as appropriate. In the local state, only query/operational commands are executed; setting and operational commands generate error responses, since instrument functions are under front panel control.

NOTE

The PFG 5105 and PFG 5505 each respond to all commands as a PFG 5105. No distinction is made between the two instruments over the GPIB bus.

Command Functional Groups

The following list of commands is arranged by functional group; some functional group lists are also divided into sub-groups.

INPUT/OUTPUT CONTROL COMMANDS

AM ON|OFF
Enables/disables use of the signal applied to the AM IN connector to amplitude-modulate the main output signal.

AM?
Returns the amplitude modulation mode status. Response: AM ON;, or AM OFF;

FM ON|OFF
Enables/disables the use of a signal applied to the VCO/FM IN connector to modulate the frequency of the main output signal.

FM?
Returns the frequency modulation mode status. Response: FM ON;, or FM OFF;

OUTput ON|OFF
Connects/disconnects the main output signal to the front-panel OUTPUT connector.

OUTput FLOAT
Disconnects the main output signal from the front panel OUTPUT connector and terminates it into a high impedance (floating).

OUTput?
Returns the output signal status (OUT ON;, OUT OFF;, or OUT FLOAT;).

INSTRUMENT COMMANDS

Store/Recall

RECall <bufnum>
Changes the instrument front panel settings to those recalled from the specified settings buffer (*bufnum*). Buffer 0 is a read-only buffer that contains the power-on settings. Buffer numbers: 0 - 99.

SEND? <bufnum>[,<bufnum>]...
Returns the stored settings from the specified buffer(s). Query response: STORE<num>:<binblk>[,<num>:<binblk>]...;

SEND? ALL
Returns the contents of all stored setting locations, beginning with buffer 1. Response: STORE ALL:<binblk>...<binblk>;

STORe <bufnum>[:<binblk>[,<bufnum>:<binblk>]]...
Saves the current front panel settings in a specified buffer(s) (<*bufnum*>) for later recall. Buffer 0 is a read-only buffer that contains the power-on settings; attempting to store settings in buffer 0 generates an error. Optionally stores the settings data defined in *binblk* in the specified buffer. <bufnum>: 1-99.

STORe ALL:<binblk>...<binblk>
Sequentially stores each front panel setup defined in *binblk* in a settings buffer, beginning with buffer 1.

Function

FUNCtion SINE
Selects the sine waveform for output.

FUNCtion SQUare
Selects the square waveform for output.

FUNCtion TRIAngle
Selects the triangle waveform for output.

FUNCtion DC
Selects dc output at the current value of the DC parameter.

FUNCtion SPULSE
Selects the single pulse mode.

FUNCtion DPULSE
Selects the double pulse mode.

FUNC?
Returns the output waveform selection status. Response: FUNC SINE;, FUNC SQUARE;, FUNC TRIANGLE;, FUNC DC;, FUNC SPULSE; or FUNC DPULSE;.

DC [<volts>]
Selects dc output at the current value of the DC parameter, or at the level specified by the optional argument.

DC?
Returns the current setting of the DC output function. Response: DC <volts>;

Parameter

AMPLitude <volts>
Sets the peak-to-peak output voltage (into 50 ohms) to the value specified by the argument.

AMPL?
Returns the current output amplitude. Response: AMPL <volts>;

DISPlay <parameter>
Changes the display to show the parameter specified in the argument and its current value. Parameters: FREQuency, AMPLitude, OFFSet, WIDth, FRQSTART, DELay, FRQSTOP, NBURst, or RATE.

DISPlay?
Returns the parameter that is currently shown in the display window. Response: FREQ;, AMPL;, OFFS;, WID;, FRQSTART;, DELAY;, FRQSTOP;, NBUR;, or RATE;

FREQuency <freq>[:<units>]
Sets the output frequency to the argument value.

FREQ?
Returns the current output frequency. Response: FREQ <freq>;

NBURst [<# cycles>]
Sets the number of cycles for output in burst mode.

NBURst?
Returns the current number of cycles set for the N BURST command. Response: NBURST <# cycles>;

OFFSet <volts>
Sets the open-circuit offset voltage to the argument value in volts. Argument 0 turns the offset off.

OFFSet?
Returns the current offset setting. Response: OFFS <volts>;

PERIOD <period>[:<units>]
Changes the period of the output waveform. It is an alias for the frequency parameter.

PERIOD?
Returns the current period setting. Response: PERIOD <period>; or PERIOD 0; (Period mode off).

PRELEVEL <TTL|CMOS|ECL>
Sets predetermined output levels for TTL, CMOS, or ECL.

RATE <rate>[:<units>]
Sets the internal trigger interval. Units: S, MS, US.

RATE?
Returns the current internal trigger interval. Response: RATE <rate>;

Trigger Mode

FRQLck ON|OFF
Enables/disables internal software control of the output frequency.

FRQLck?
Returns the status of the frequency lock mode. Response: FRQL ON;, or FRQL OFF;

MODE CONT
Selects continuous output mode.

MODE TRIG
Selects triggered output mode.

MODE BURST
Selects the burst trigger mode.

MODE GATED
Selects the gated trigger mode. Sending <GET> toggles the gate on or off.

MODE SYNT
Selects the frequency lock mode (Option 02), with continuous output only.

MODE?
Returns mode status. Response: MODE CONT;, MODE TRIG;, MODE BURST;, MODE SYNT;, or MODE GATE;

Trigger Source

TRIG INT
Selects the internal trigger as trigger source.

TRIG EXT
Selects the external trigger as trigger source.

TRIG MANual
Selects the manual trigger function as the trigger source.

TRIG?
Returns the trigger source setting. Response: TRIG INT;, TRIG EXT; or TRIG MAN;

Sweep Function

FRQSTART <freq>[:<units>]
Sets the sweep start frequency. Default units: Hz.

FRQSTART?
Returns the sweep start frequency setting in Hz. Response: FRQSTART <freq>;.

FRQSTOP <freq>[:<units>]
Sets the sweep stop frequency in Hz.

FRQSTOP?
Returns the stop frequency in Hz. Response: FRQSTOP <freq>;.

RNGLCK ON|OFF
Locks or unlocks the frequency range. When RNGLCK ON is executed, the frequency range is locked to the current range and the internal output frequency is set to 0 Hz (or the lowest frequency). Only RNGLCK OFF releases the range lock.

RNGLCK?
Returns the range lock status. Response: RNGLCK ON;, or RNGLCK OFF;

SWEEP ON|OFF
Turns the sweep on. The power-on setting is SWEEP OFF, which disables the sweep operation.

SWEEP?
Returns the sweep output status. Response: SWEEP ON;, or SWEEP OFF;

PULSE COMMANDS

DCYCLE <% duty cycle>|0
Enters duty cycle mode. When a duty cycle of 10-85% is entered, the PFG 5105/5505 will change width to maintain the duty cycle as the period varies. Entering a new width parameter or sending DCYCLE 0 causes the instrument to exit the duty cycle mode.

DCYCLE?
Returns the duty cycle mode status. Response: DCYCLE <% duty cycle>; or DCYCLE 0; (off).

DELAY <delay>[:<units>]
Sets the delay time from the trigger point to the first pulse, if the instrument is in single pulse mode; or sets the delay time between the first pulse and the second pulse, in double pulse mode.

DELAY?
Returns the value of the delay in seconds. Response: DELAY <delay>;

WIDTH <width>[:<units>]
Sets the width of the output pulses. Width value is calculated and set automatically in the duty cycle mode. Setting a new width value terminates the duty cycle mode.

WIDTH?
Returns the value of the width in seconds. Response: WID <width>;

SYSTEM COMMANDS

DT TRIG
On receipt of a <GET> interface message, triggers the instrument to output a one-cycle waveform if in TRIG mode, or a burst of cycles if in BURST mode.

DT GATE
Toggles the gate setting on or off on receipt of a <GET> interface message when in the MODE GATE trigger mode.

DT SET
Causes the instrument to wait for a <GET> interface message before updating the instrument settings.

DT OFF
Disables Trigger and Gate <GET> function; no response to <GET>; allows the instrument to update its settings without waiting for <GET>.

DT?
Queries the device trigger status. Response: DT GATE;, DT SET;, DT TRIG;, or DT OFF;

ERRor? or EVENT?
Returns an error code that matches the last SRQ that was polled with RQS ON, or the oldest error in the error queue if RQS is OFF. ERR 0 (nothing to report) indicates that there are no errors in the error queue. Response: ERR <num>; or EVENT <num>;

ERRM?
Returns the error code and the associated text shown in the front panel window that describes the current error. The returned code and text matches the last SRQ that was polled with RQS ON, or the oldest error in the error queue if RQS is OFF. ERR 0 is returned if there are no errors in the error queue. Response: ERRM <error #>, <error message>;

HELP?
Returns all PFG 5105/5505 commands.

ID?
Returns the identification of the instrument in the form: ID TEK/<model number>,<Tek Codes and Format version>,<firmware version>,<installed options>;

INIT
Returns all settings to the power-on state, except stored settings.

SET?
Returns all instrument settings that can be set and queried except stored front panel settings.

TEST?
Executes internal checkout routines. Failure produces an error code in the response. A response of 0 indicates that the test was successful; 1 indicates a failure. Response: TEST <num>;

STATUS COMMANDS

RQS ON|OFF
Enables/disables service request operation. If RQS is ON, errors are reported using SRQ at the end of command execution; if OFF, errors are queued until an error query is sent or until RQS is turned back on.

RQS?
Returns the RQS status. Response: RQS ON;, or RQS OFF;

USEReq ON|OFF
Enables/disables SRQ when the INST ID front panel key is pressed.

USER?
Returns the status of the USER REQUEST setting. Response: USER ON;, or USER OFF;

Control/Command Associations

Figure 3-1 shows the PFG 5105/5505 front panel key and command relationships.

Detailed Command Descriptions

Each PFG 5105/5505 command, like those in all TM 5000 instruments, begins with a header, which is a word or acronym that describes the function implemented. Following the header, many commands require an argument, which is a word or number that specifies the desired state for the function. The commands are presented alphabetically on the following pages. In this presentation, the following notations are used to represent elements of the IEEE-488 bus communications between the PFG 5105/5505 and the controller.

<GET>[1] — The Group Execute Trigger interface message (decimal code 8 transmitted with attention asserted). Only addressed listeners respond to <GET>[1].

<num>[1] — A number that can be transmitted or accepted by the PFG 5105/5505. Numbers may be NR1 (integer), NR2 (decimal), and NR3 (with exponent) formats. (See ANSI Standard X3.42.)

: (colon) — Command argument link data. Data that is linked to the previous argument uses the colon (:) as the delimiter.
Example:
STOR 3:<binblk>[1]
The buffer number 3 is linked to the buffer data (<binblk>[1]).

<binblk>[1] — A Binary Block of data in the format specified in Tektronix Codes and Formats (V81.1). The binary block consists of the percent sign (%, decimal 37) followed by a two-byte binary count, the data bytes, and then ends with a checksum byte. The two-byte binary count (integer, most significant byte first) specifies the number of data bytes plus the checksum byte. The checksum is the two's complement of the modulo-256 sum of the preceding binary data bytes and the binary count bytes, but does not include the percent sign. The format for the data points is 2 bytes per point – high byte followed by low byte.

NOTE

Because a binary block argument can have any byte in it (including LF), the controller and instrument must be in EOI ONLY mode.

| — A vertical line is used in a series of two or more units, to separate the units; any one unit must be selected and sent as part of the command message. Do not include the line in the message.

[and] — Square brackets enclose an optional message part. Do not include the square brackets in the message.

1 Carets are not part of the format; they are used in this manual to enclose an element for which the user must substitute the appropriate characters.

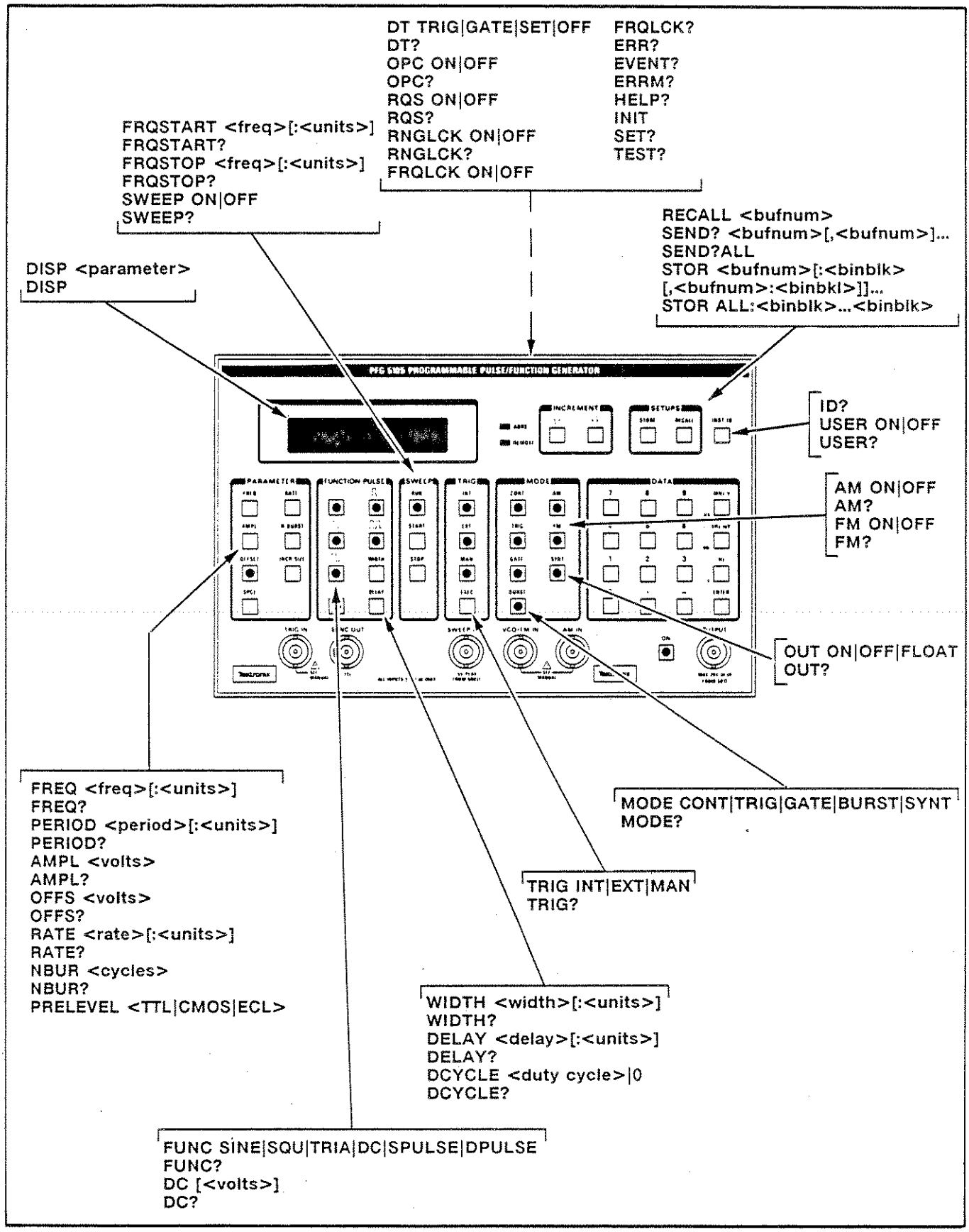


Fig. 3-1. Command Associations to Controls.

DETAILED COMMAND LIST

AM (Amplitude Modulation)

Command Type:
Setting or query

Setting Syntax:
AM ON|OFF

Examples:
AM ON
AM OFF

Query Syntax:
AM?

Query Response:
AM ON;
AM OFF;

Discussion:

The *on* argument causes the instrument to use the signal at the AM IN connector to amplitude-modulate the main output signal. Amplitude modulation effectively controls the peak-to-peak amplitude of the main output using the external signal applied to the AM IN connector.

A modulating signal of approximately 4.5 volts peak-to-peak will cause 100-percent modulation of a 5 V p-p output signal; an external input signal over 4.5 volts peak-to-peak will distort the main output. Refer to Electrical Specifications for limitations on amplitude modulation and the modulating signal.

The *off* argument turns off amplitude modulation.

The query returns the status of amplitude modulation.

AMPL (Amplitude)

Command Type:
Setting or query

Setting Syntax:
AMPLitude <volts>

Examples:
AMPLITUDE 8
AMPL 2.5

Query Syntax:
AMPL?

Query Response:
AMPL <volts>;

Discussion:

The AMPL command sets the peak-to-peak output voltage into 50 ohms to the value specified by the argument. The argument is specified in volts. The power-on setting is 5 V.

The argument range is 10 mV to 9.99 V p-p into 50 ohms. The argument resolution is 1 mV when the amplitude is less than 1.0 V, and 10 mV when the amplitude is greater than or equal to 1 V.

Refer to the discussion on the OFFSET command for a more complete description of the relationship between amplitude and offset commands.

DC

Command Type:
Setting or query

Setting Syntax:
DC [<volts>]

Examples:
DC
DC 3.45
DC 5E-2
DC 699E-2

Query Syntax:
DC?

Query Response:
DC <volts>;

Discussion:

This command selects a dc output. If the argument is omitted, the output level is the current level set for the DC parameter.

The response is returned in NR2 format.

DCYCLE

Command Type:
Setting or query

Setting Syntax:
DCYCLE <% duty cycle>

Examples:
DCYCLE 20
DCYCLE 0

Query Syntax:
DCYCLE?

Query Response:
DCYCLE <% duty cycle>
DCYCLE 0

Discussion:

This command enters the duty cycle mode when a duty cycle between 10% and 85% is sent. The argument must be a whole number. The function generator changes width to maintain the duty cycle as the period changes. Sending DCYCLE 0 turns off the duty cycle mode. Entering a new width value will also turn off duty cycle mode.

DELAY

Command Type:
Setting

Setting Syntax:
DELAY <delay>[:<units>]

Examples:
DELAY 40:ns
DELAY 90:ms
DELAY 100E-9

Query Syntax:
DELAY?

Query Response: (one of the following)
DELAY <delay>;
DELAY 0.04E-6;

Discussion:

This command sets the delay time from the trigger point to the first pulse, if the instrument is in single pulse mode; or sets the delay time between the first pulse and the second pulse if the instrument is in double pulse mode. If no time unit is specified, the default unit is seconds. The power-on default is 0 seconds. The range of the delay time is 40 ns to 99.9 ms.

DISPLAY

Command Type:
Setting or query

Setting Syntax:
DISPlay <parameter>

Examples:
DISP AMPL
DISPL FREQUENCY
DISPLA OFFSET
DISP WID
DISP FRQSTART
DISP DELAY
DISP DC
DISP FRQSTOP
DISP NBURST
DISPLAY RATE

Query Syntax:
DISPlay?

Query Example:
DISPL?
DISPLA?
DISPLAY?

Query Response: (one of the following)
DISPL FREQ;
DISPL AMPL;
DISPL OFFS;
DISPL WID
DISPL FRQSTART
DISPL DELAY
DISP DC
DISPL FRQSTOP
DISPL NBUR;
DISPL RATE;

Discussion:

The DISPL command changes the display window to show the parameter specified in the argument. The argument is limited to the following:

FREQuency
AMPLitude
OFFSet
WIDth
FRQSTART
DELAY
DC
FRQSTOP
NBURst
RATE

The query command returns the name of the parameter that is currently shown in the display window.

DT (Device Trigger)

Command Type:
Setting or query

Setting Syntax:
DT TRIG
DT GATE
DT SET
DT OFF

Query Syntax:
DT?

Query Response (one of the following):
DT TRIG;
DT GATE;
DT SET;
DT OFF;

Discussion:

This command controls the instrument's response to the Group Execute Trigger <GET> interface message.

When a <GET> interface message is received and the DT TRIG mode is set, the instrument produces one cycle of signal if it is in TRIG mode, or it produces a burst of cycles if it is in BURST mode.

If the trigger mode is set to GATE and <GET> is received, the output is turned on until <GET> is received again.

The SET argument causes the instrument to wait for a <GET> interface message before updating its settings.

The power-on setting is DT OFF; the instrument updates its settings without waiting for <GET>.

If DT is off and <GET> is sent, the error message: 206, "GET IGNORED"; will be returned.

ERROR? or EVENT?

Command Type:
Query

Query Syntax:
ERRor?
EVENT?

Examples:
ERR?
ERROR?
EVENT?

Query Response: (depends on query sent)
ERR <num>;
EVENT <num>;

Discussion:

This query returns the error code for the last SRQ that was polled (with RQS ON), or it returns the error code for the oldest error in the error queue if RQS is OFF. Error code 0 (nothing to report) is returned if the error queue is empty.

ERRM? (Error Message)

Command Type:
Query

Query Syntax:
ERRM?

Query Response:
ERRM <error#>,<error message>;
ERRM 206, "GET IGNORED";

Discussion:

This query returns the error code and text that is displayed in the front panel window. The query returns error information matching the last SRQ that was polled with RQS ON, or the oldest error in the error queue if RQS was OFF. ERR 0 (Nothing to Report) is returned if there are no errors in the error queue.

FM (Frequency Modulation)

Command Type:
Setting or Query

Setting Syntax:
FM ON|OFF

Query Syntax:
FM?

Examples:
FM ON
FM OFF

Query Response:
FM ON;
FM OFF;

Discussion:

The *on* argument causes the instrument to use the signal applied to the VCO/FM IN connector to modulate the frequency of the main output signal. The polarity of the external input signal determines the direction in which the output will deviate in frequency: a positive-going input signal increases output signal frequency. The amplitude of the external input signal determines the percent of frequency change in the main output signal.

The *off* argument terminates frequency modulation.

The query returns the status of the FM command.

FREQUENCY

Command Type:
Setting or query

Setting Syntax:
FREQuency <freq>[:<units>]

Examples:
FREQ 60
FREQ 11.99:MHZ
FREQ 11.99:kHz
FREQ 11E6
FREQ 60E2:HZ

Query Syntax:
FREQ?

Query Response:
FREQ<freq>;
FREQ 11.99E3;

Discussion:

This command sets the output frequency to the value specified by the argument. The programmed value is rounded to the nearest increment of the frequency generator.

The default unit of measure is Hz; choices are Hz, kHz, MHz.

The power-on setting is FREQ 1 kHz.

Frequency can be specified to 4 digits in normal mode; 5 digits in synthesizer mode.

The query returns the current frequency setting in Hz.

RANGE IS 0.012 Hz to 12 MHz

FRQLCK (Frequency Lock)

Command Type:
Setting or query

Setting Syntax:
FRQLck ON
FRQLck OFF

Examples:
FRQL ON
FRQLCK OFF

Query Syntax:
FRQLck?

Query Response: (one of the following)
FRQL ON;
FRQL OFF;

Discussion:

With FRQL ON, internal circuitry and software improve the generator's frequency accuracy. For operation to frequency accuracy (listed under Electrical Specifications) FRQL must be *on.*

The power-on setting is FRQL ON.

FRQSTART (Frequency Start)

Command Type:
Setting or query

Setting Syntax:
FRQSTART <freq>[:<units>]

Examples:
FRQSTART 59.99
FRQSTART 9.99:MHZ

Query Syntax:
FRQSTART?

Query Response:
FRQSTART <freq>;
FRQSTART 1.0E+6;

Discussion:

This command sets the frequency at which a sweep will begin. Start frequency must be greater than stop frequency. Resolution is 4 digits; default unit of measure is Hz.

The power-on setting is FRQSTART 1 Hz.

Units of measure can be Hz, kHz, or MHz.

FRQSTART and FRQSTOP are not checked for illegal setting and are not updated until SWEEP ON is sent.

FRQSTOP (Frequency Stop)

Command Type:
Setting or query

Setting Syntax:
FRQSTOP <freq>[:<units>]

Examples:
FRQSTOP 4700
FRQSTOP 11:MHZ
FRQSTOP 1E6

Query Syntax:
FRQSTOP?

Query Response:
FRQSTOP <freq>;
FRQSTOP 1.0E+6;

Discussion:

This command sets the frequency at which a sweep will end. Start frequency must be greater than stop frequency.

The resolution is 4 digits; the default unit of measure is Hz. Units of measure can be Hz, kHz, or MHz.

The power-on setting is FRQSTOP 1200 Hz.

FUNCTION

Command Type:
Setting or query

Setting Syntax:
FUNCtion SINE
FUNCtion SQUare
FUNCtion TRIAngle
FUNCtion DC
FUNCtion SPULSE
FUNCtion DPULSE

Examples:
FUNC SINE
FUNCT SQUARE
FUNCTION DC
FUNCT TRIANG
FUNC SPULSE
FUNC DPULSE

Query Syntax:
FUNC?

Query Response (one of the following):
FUNC SINE;
FUNC SQUARE;
FUNC TRIANGLE;
FUNC DC;
FUNC SPULSE;
FUNC DPULSE;

Discussion:

This command selects the type of waveform for output. FUNC SINE is the power-on setting.

When any of the standard waveform commands (SINE, SQU, TRIA, SPULSE, DPULSE) is sent, the level of the output is the current amplitude level. The DC level is set by the DC function.

HELP?

Command Type:
Query

Query Syntax:
HELP?

Query Response:
<a string containing all PFG 5105/5505 commands>;

Discussion:

The HELP query command returns a string that is a list of all PFG 5105/5505 commands. The string consists of the following:

HELP AM, AMPL, DC, DCYCLE, DELAY, DISP, DT, ERR, ERRM, EVENT, FM, FREQ, FRQL, FRQSTART, FRQSTOP, FUNC, HELP, ID, INIT, MODE, NBUR, OFFS, OUT, PERIOD, PRELEVEL, RATE, REC, RNGLCK, RQS, SEND, SET, SINE, SQU, STOR, SWEEP, TEST, TRIA, TRIG, USER, WIDTH;

ID? (Identify)

Command Type:
Query

Query Syntax:
ID?

Query Response:
ID TEK/<model number>,<Tek Codes and Format version>,<firmware version>,<options, if installed>;

Query Response Example:
TEK/PFG5105,V81.1,F1.0,OPT02;

Discussion:

The ID? query command returns identification information about the instrument. If the instrument has no options, option information is omitted.

INIT (Initialize)

Command Type:
Setting

Setting Syntax:
INIT

Discussion:

The INIT command restores all front panel settings to the power-on states, except stored settings.

MODE

Command Type:
Setting or query

Setting Syntax:
MODE CONT MODE TRIG
MODE BURST MODE GATE MODE SYNT

Examples:
MODE CONT MODE TRIG
MODE BURST MODE GATE MODE SYNT

Query Syntax:
MODE?

Query Response (one of the following):
MODE CONT; MODE TRIG;
MODE BURST; MODE GATE; MODE SYNT;

Discussion:

This command sets the trigger mode to the mode specified by the argument.

CONT — Sets the PFG 5105/5505 to generate a continuous output signal. Trigger events are ignored. CONT is the power-on setting.

TRIG — Sets the PFG 5105/5505 to the triggered output mode. One cycle of the output signal is generated for each trigger event. Trigger sources include an external trigger, internal trigger, manual trigger, or Group Execute Trigger <GET> over the GPIB. See also the TRIG and DT command descriptions.

BURST — Sets the PFG 5105/5505 to the burst mode. When a trigger occurs, the instrument produces a burst of the programmed output signal; the number of cycles is determined by the N BURST parameter. All trigger sources apply.

GATE — Sets the PFG 5105/5505 to the gated mode. Output is generated while the MAN key is pressed or the trigger/gate input is enabled. If the gate signal on the trigger input is removed in the middle of a cycle, the cycle is completed. <GET> toggles the gate on or off when DT is set to GATE.

SYNT — This mode is available only on an Option 02 instrument. It sets the PFG 5105/5505 to the synthesizer mode. If this mode is selected and the instrument does not have the option installed, an execution error is reported.

NBURST (Number of Burst Cycles)

Command Type:
Setting or query

Setting Syntax:
NBURST <# cycles>

Examples:
NBURST 9999
NBURST 10

Query Syntax:
NBURST?

Query Response:
NBURST <# cycles>;

Discussion:

This command sets the number of cycles that will be output in burst mode. The argument must be a whole number. The power-on setting is 2 cycles; the range is 1 to 9999.

OFFSET

Command Type:
Setting or query

Setting Syntax:
OFFSet <volts>

Examples:
OFFS 5
OFFSET 0.1

Query Syntax:
OFFS?

Query Response:
OFFS <volts>;
OFFS 0.1;

Discussion:

This command sets the offset voltage of the output signal to the value specified by the argument. The argument is specified in volts. The absolute peak amplitude plus offset is limited to a maximum that is dependent on the signal amplitude range, as follows:

Amplitude Range	Peak Amplitude + Absolute Offset into 50 ohms	Resolution into 50 ohms
1 V - 9.99 V	4.99 V	10 mV
0.1 V - 0.999 V	0.499 V	1 mV
0.01 V - 0.099 V	0.049 V	1 mV

This formula describes the relationship between amplitude and offset:

$$\frac{\text{Dspld Amp.}}{2} + \text{Displayed Offset} = \text{Absolute peak amplitude into 50 ohms, for range} + \text{offset}$$

The power-on setting is 0 V (offset is disabled). An OFFS query returns the programmed offset value in volts.

OUTPUT

Command Type:
Setting or query

Setting Syntax:
OUTput ON
OUTput OFF
OUTput FLOAT

Examples:
OUT ON
OUTP FLOAT
OUTPUT OFF

Query Syntax:
OUTput?

Query Response (one of the following):
OUT ON;
OUT OFF;
OUT FLOAT;

Discussion:

The OUTPUT command controls the PFG 5105/5505 output signal at the main OUTPUT connector.

ON — Connects the PFG 5105/5505 output signal to the main OUTPUT connector.

FLOAT — Disconnects the PFG 5105/5505 output signal from the main OUTPUT connector and terminates it into a high (floating) impedance.

OFF — Disconnects the PFG 5105/5505 output signal from the main OUTPUT connector. Output is terminated into 50 ohms.

The power-on setting is OUTPUT OFF.

PERIOD

Command Type:
Setting or query

Setting Syntax:
PERIOD <period>[:<units>]

Examples:
PERIOD 10
PERIOD 5:MS
PERIOD 5E–3

Query Syntax:
PERIOD?

Query Response (one of the following):
PERIOD <period>;
PERIOD 10;
PERIOD 5E–3;

Discussion:

The PERIOD command sets the period of the output waveform. It also affects the FREQuency parameter. (Changing the PERIOD parameter will change the FREQuency parameter.) The power-on setting is 1 ms.

Units can be S, mS, uS.

With synthesizer card installed, PERIOD is only 3 1/2 digits resolution rather than the usual 4 1/2 digits.

PRELEVEL

Command Type:
Setting or query

Setting Syntax:
PRELEVEL TTL
PRELEVEL CMOS
PRELEVEL ECL

Examples:
PRELEVEL TTL
PRELEVEL CMOS
PRELEVEL ECL

Discussion:

This command selects predefined output levels as specified by the argument.

TTL	0 V to 3 V
CMOS	0 V to 4.99 V
ECL	–0.8 V to –1.8 V

When this command is sent the amplitude and offset are set to meet indicated levels. Amplitude and offset can then be changed.

RATE

Command Type:
Setting or query

Setting Syntax:
RATE <rate>[:<units>]

Examples:
RATE 999.9
RATE 100:NS

Query Syntax:
RATE?

Query Response:
RATE <rate>;
RATE 10E–6:S;

Discussion:

This command sets the internal trigger interval. The power-on setting is 10 microseconds; the power-on units of measure is seconds. Units can be specified in S, mS, uS.

The rate generator is used for internal trigger and sweep rate.

RECALL

Command Type:
Operational

Syntax:
RECall <num>

Examples:
REC 3
RECALL 8

Discussion:

This command changes the PFG 5105/5505 settings to those stored in the settings buffer specified in the argument, except for the following settings which are not stored in settings buffers and therefore remain unchanged:

RQS

USER

Increment Size

SPCL function 220—Display intensity/backlight

SPCL function 240—GPIB address

SPCL function 241—GPIB message terminator

The argument range is 0 to 99. Buffer 0 is a read-only buffer that contains the power-on settings. (All other settings buffers contain the power-on settings until they are changed by the user.)

RNGLCK (Range Lock)

Command Type:
Setting or query

Setting Syntax:
RNGLCK ON
RNGLCK OFF

Examples:
RNGLCK ON
RNGLCK OFF

Query Syntax:
RNGLCK?

Query Response (one of the following):
RNGLCK ON;
RNGLCK OFF;

Discussion:

The *on* argument turns on the range lock function. This function limits the generator's frequency output range to the limits of the frequency range currently in use (determined by FREQ setting).

When RNGLCK is set *on*, the frequency change is locked and the output frequency is set to its lowest value. Changing the frequency parameter will not affect the range or output frequency. When RNGLCK is set *on*, the maximum allowable sweep range is allowed using an external sweep.

The power-on setting is RNGLCK OFF.

For more information, see the discussion of Range Lock in the Operating Instructions section.

RQS (Request for Service)

Command Type:
Setting or query

Setting Syntax:
RQS ON
RQS OFF

Examples:
RQS ON
RQS OFF

Query Syntax:
RQS?

Query Response (one of the following):
RQS ON;
RQS OFF;

Discussion:

The RQS command controls the PFG 5105/5505 service request operation. Valid arguments are:

ON	Allows the PFG 5105/5505 to generate an SRQ to report an event or error.
OFF	Prevents the PFG 5105/5505 from generating an SRQ to report an event or error.

An RQS query returns the current request-for-service status. The ERR query can be used while RQS is off to determine if any SRQ conditions have occurred. See Status and Error Reporting in this section for more information.

The power-on setting is RQS ON.

SEND

Command Type:
Query

Query Syntax:
SEND? <bufnum>[,<bufnum>]...
SEND? ALL

Examples:
SEND? 3,5
SEND? 80
SEND? ALL

Query Response:
STOR<bufnum>:<binblk>[,<bufnum>:<binblk>]...;
or

STOR ALL:<binblk>...<binblk>; (99 settings)

Discussion:

In response to this command, the PFG 5105/5505 transmits over the GPIB, the contents of the stored settings buffer(s) identified in the argument. Argument range is 1 to 99. The settings data is sent in binary block format.

SET?

Command Type:
Query

Query Syntax:
SET?

Query Response Example:
FREQ 1.0E+3; AMPL 5.0; OFFS 0; DC 0; RATE 10.0E-6:S; NBUR 2; FRQSTART 1.0; FRQSTOP 1.2E+3; SWEEP OFF; FUNC SINE; MODE CONT; TRIG MANUAL; AM OFF; FM OFF; OUT OFF; FRQL ON; RNGLCK OFF; DT OFF; RQS ON; USER OFF; DELAY 100E-9; DCYCLE 0; PRELEVEL ECL; DISP FREQUENCY; WIDTH 0.04E-6;

Discussion:

This command returns the status of all instrument settings that can be set and that respond to a query command with the following exception:

stored front panel settings

STORE

Command Type:
Operational

Syntax:
STORe <num>[:<binblk>[,<num>:<binblk>]]...
STORe ALL:<binblk>...<binblk>

Discussion:

The current settings of the instrument are saved in the settings buffer specified by the argument <num>. If the optional <binblk> argument is included, the data stored in the specified settings buffer is the data in the argument; if the <binblk> argument is omitted, the data stored in the settings buffer is the current front panel settings data. Multiple arguments are allowed if connected by a comma.

The following settings are not stored by the STORE command:

RQS

USER

Increment Size

SPCL function 220—Display intensity/backlight

SPCL function 240—GPIB address

SPCL function 241—GPIB message terminator

The STORE ALL command stores each binary block settings packet received over the GPIB in a settings buffer. The first binary block packet is stored in settings buffer 1, the second packet in settings buffer 2, and so on to 99. All buffers must be present.

If a binary block packet is longer or shorter than required, the instrument reports an execution error. If a binary block packet has a bad checksum byte, the instrument reports an execution error. If one packet in the argument is in error, then an error is generated and that packet and all succeeding packets are discarded; all packets up to the discarded packet are stored. The error number returned reflects the number of the bad packet.

Settings buffer 0 is a read-only buffer that contains the power-on settings. This buffer cannot be stored into.

SWEEP

Command Type:
Operational or query

Syntax:
SWEEP ON
SWEEP OFF

Query Syntax:
SWEEP?

Query Response (one of the following):
SWEEP ON;
SWEEP OFF;

Discussion:

This command sets the sweep to the shape specified by the argument.

ON Enables the sweep operation.

OFF Disables the sweep operation.

The power-on setting is SWEEP OFF.

The FRQSTART and FRQSTOP parameters are not checked or executed until SWEEP ON is sent.

TEST?

Command Type:
Query

Query Syntax:
TEST?

Query Response:
TEST <num>;

Discussion:

This command causes the instrument to execute internal checkout routines. A code in the response indicates the test results. If the instrument successfully passes the test, the code number is 0; a failure is defined by the error code number returned, as follows:

0 - No error detected.

1 - An error was detected.

During the test, output is turned off and the GPIB port remains active; output is resumed following test completion.

TRIG

Command Type:
Setting or query

Setting Syntax:
TRIG INT
TRIG EXT
TRIG MANual

Examples:
TRIG INT
TRIG EXT
TRIG MAN

Query Syntax:
TRIG?

Query Response (one of the following):
TRIG IN;
TRIG EXT;
TRIG MAN;

Discussion:

This command selects the trigger source as specified by the argument.

INT	Selects an internal trigger. This trigger can not be used in arbitrary and sweep modes.
EXT	Selects an external trigger. The source is the signal applied to the TRIG IN connector.
MAN	Selects the manual trigger source. Pressing the MAN button generates a trigger.

The query returns the current trigger source selection.

The power-on setting is TRIG MAN.

USEREQ

Command Type:
Setting or query

Setting Syntax:
USEReq ON
USEReq OFF

Examples:
USEREQ ON
USER OFF

Query Syntax:
USER?

Query Response (one of the following):
USER ON;
USER OFF;

Discussion:

The USER command enables the PFG 5105/5505 to assert SRQ when the user presses the front panel INST ID key. This provides a means of communication between the user and the controller through the PFG 5105/5505 for coordination of PFG 5105/5505 operations. Valid arguments are:

ON — If RQS is ON, the PFG 5105/5505 asserts SRQ when the user presses the INST ID key. SRQ remains asserted until the status is read by a serial poll, or until a Device Clear (DCL) is performed by the controller. The USER SRQ is indicated by a status byte of 67 or 83, and an error query response of 403. If RQS is OFF, the event can be detected via the ERR query.

OFF — Disables the USEREQ function. SRQ assertion is disabled and no errors will be reported.

A USER query returns the current status. The power-on setting is USER OFF.

WIDTH

Command Type:
Setting

Setting Syntax:
WIDTH <width>[:<units>]

Examples:
WIDTH 40:ns
WIDTH 90:ms
WIDTH 0.04E-6

Query Syntax:
WIDTH?

Query Response (one of the following):
WID <width);
WID 0.04E-6;

Discussion:

Sets the width of the output pulses. If the units parameter is omitted, then the default unit is seconds. The range of the width time argument is 40 ns to 99.9 ms. See Figure 3-2.

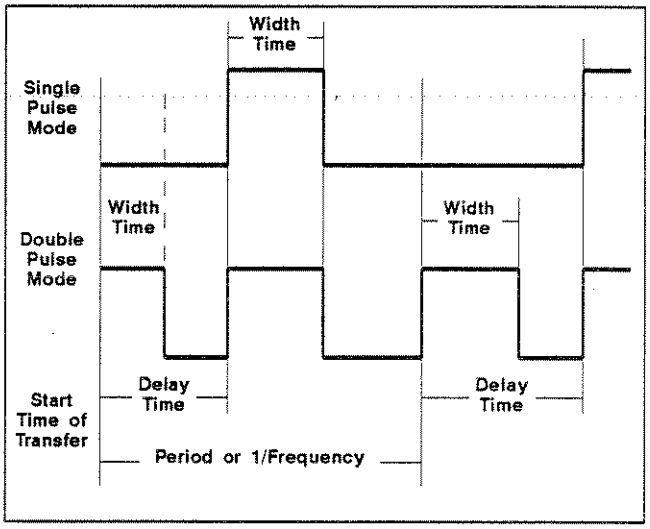


Fig. 3-2. Pulse and Width Relationships.

MESSAGES AND COMMUNCIATION PROTOCOL

Command Separator

A message consists of one command or a series of commands, followed by a message terminator. Commands in multiple command messages must be separated by semicolons. A semicolon at the end of a message is optional. For example, each line below is a message.

INIT

TEST?;INIT;RQS ON;USER OFF;ID?;SET?

TEST?;

Address and Message Terminator Selection

Messages may be terminated with EOI or the ASCII line feed (LF) character. Some controllers assert EOI concurrently with the last data byte; others use only the LF character as a terminator. The instrument can be set to accept either terminator. With EOI only selected as the terminator, the instrument interprets a data byte received with EOI asserted, as the end of the input message; it also asserts EOI concurrently with the last byte of the output messages. With the LF/EOI setting, the instrument interprets the LF character without EOI asserted (or any data byte received with EOI asserted) as the end of an input message; it transmits carriage return (CR) followed by line feed (the LF with EOI asserted) to terminate output messages.

NOTE

Do not use LF mode when transmitting or receiving Binary Block data. See SEND?, STOR.

The PFG 5105/5505 is shipped from the factory with a GPIB address of 8; the terminator is LF with EOI.

Both the GPIB primary address and the message terminator are selected using front panel keys. These selections are stored in non-volatile RAM. The following steps outline the selection process:

1. Press the INST ID key. The current GPIB address and terminator are indicated in the display window (while the key is pressed).

2. To change the GPIB address, press the SPCL key; press keypad numbers 240; press ENTER.

   Press the keypad numbers for the new GPIB address; press ENTER. The new address should be shown in the display window.

   The legal values are 0 to 31. Using address 31 disconnects the PFG 5105/5505 from bus communication.

3. To change the terminator selection, press the SPCL key; press keypad numbers 241; press ENTER; press the INCREMENT up- or down-arrow key to change the terminator selection. The new terminator selection should be indicated in the display window.

Formatting a Message

Commands sent to TM 5000 instruments must have the proper format (syntax) to be understood; however, this format is flexible in that many variations are acceptable. The following describes the format and the acceptable variations.

The instruments expect all commands to be encoded in ASCII, with either upper or lower case ASCII characters acceptable. All data output is in upper case (see Fig. 3-3). As previously discussed, a command consists of a header, followed if necessary, by arguments. A command with arguments must have a header delimiter, which is the space character (SP) between the header and the argument. The space character (SP), carriage return (CR), and line feed (LF) are shown as subscript in the following examples.

RQS$_{SP}$ON

If extra formatting characters SP, CR, and LF (the LF cannot be used for format in the LF/EOI terminator mode) are added between the header delimiter and the argument, those characters are ignored by the instrument.

Example 1: RQS$_{SP}$ON;

Example 2: RQS$_{SP}$ $_{SP}$ON;

Example 3: RQS$_{SP}$ $_{CR}$ $_{LF}$

$_{SP}$ $_{SP}$ON

In general, these formatting characters are ignored after any delimiter and at the beginning and end of a message. For example:

$_{SP}$RQS$_{SP}$ON$_{CR}$ $_{LF}$

$_{SP}$USER$_{SP}$OFF

In the command list, some headers and arguments are listed in two forms, a full-length version and an abbreviated version. The instrument accepts any header or argument containing at least the characters listed in the short form; any characters added to the

ASCII & GPIB CODE CHART

B7 B6 B5 / BITS / B4 B3 B2 B1	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
	CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER CASE	
0 0 0 0	0 NUL 0 0	20 DLE 10 16	40 SP 20 32	60 0 30 48	100 @ 40 64	120 P 50 80	140 ` 60 96	160 p 70 112
0 0 0 1	1 GTL SOH 1 1	21 LLO DC1 11 17	41 ! 21 33	61 1 31 49	101 A 41 65	121 Q 51 81	141 a 61 97	161 q 71 113
0 0 1 0	2 STX 2 2	22 DC2 12 18	42 " 22 34	62 2 32 50	102 B 42 66	122 R 52 82	142 b 62 98	162 r 72 114
0 0 1 1	3 ETX 3 3	23 DC3 13 19	43 # 23 35	63 3 33 51	103 C 43 67	123 S 53 83	143 c 63 99	163 s 73 115
0 1 0 0	4 SDC EOT 4 4	24 DCL DC4 14 20	44 $ 24 36	64 4 34 52	104 D 44 68	124 T 54 84	144 d 64 100	164 t 74 116
0 1 0 1	5 PPC ENQ 5 5	25 PPU NAK 15 21	45 % 25 37	65 5 35 53	105 E 45 69	125 U 55 85	145 e 65 101	165 u 75 117
0 1 1 0	6 ACK 6 6	26 SYN 16 22	46 & 26 38	66 6 36 54	106 F 46 70	126 V 56 86	146 f 66 102	166 v 76 118
0 1 1 1	7 BEL 7 7	27 ETB 17 23	47 ' 27 39	67 7 37 55	107 G 47 71	127 W 57 87	147 g 67 103	167 w 77 119
1 0 0 0	10 GET BS 8 8	30 SPE CAN 18 24	50 (28 40	70 8 38 56	110 H 48 72	130 X 58 88	150 h 68 104	170 x 78 120
1 0 0 1	11 TCT HT 9 9	31 SPD EM 19 25	51) 29 41	71 9 39 57	111 I 49 73	131 Y 59 89	151 i 69 105	171 y 79 121
1 0 1 0	12 LF A 10	32 SUB 1A 26	52 * 2A 42	72 : 3A 58	112 J 4A 74	132 Z 5A 90	152 j 6A 106	172 z 7A 122
1 0 1 1	13 VT B 11	33 ESC 1B 27	53 + 2B 43	73 ; 3B 59	113 K 4B 75	133 [5B 91	153 k 6B 107	173 { 7B 123
1 1 0 0	14 FF C 12	34 FS 1C 28	54 , 2C 44	74 < 3C 60	114 L 4C 76	134 \ 5C 92	154 l 6C 108	174 | * 7C 124
1 1 0 1	15 CR D 13	35 GS 1D 29	55 - 2D 45	75 = 3D 61	115 M 4D 77	135] 5D 93	155 m 6D 109	175 } 7D 125
1 1 1 0	16 SO E 14	36 RS 1E 30	56 . 2E 46	76 > 3E 62	116 N 4E 78	136 ^ 5E 94	156 n 6E 110	176 ~ 7E 126
1 1 1 1	17 SI F 15	37 US 1F 31	57 / 2F 47	77 UNL ? 3F 63	117 O 4F 79	137 UNT 5F _ 95	157 o 6F 111	177 DEL (RUBOUT) 7F 127
	ADDRESSED COMMANDS	UNIVERSAL COMMANDS	LISTEN ADDRESSES		TALK ADDRESSES		SECONDARY ADDRESSES OR COMMANDS (PPE)	(PPD)

*| | on some keyboards or systems

KEY

octal 25 PPU — GPIB code
NAK — ASCII character
hex 15 21 — decimal

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REF: ANSI STD X3. 4-1977
IEEE STD 488.1-1987
ISO STD 646-1973

Fig. 3-3. ASCII and IEEE (GPIB) Code Chart.

abbreviated version must be those given in the full-length version. For documentation of programs, the user may add alpha characters to the full-length version. Alpha characters may also be added to a query header, provided the question mark is at the end.

USER?

USERE?

USEREQ?

Multiple arguments are separated by a comma.

2,3

2,SP3

NOTE

In the last example, the space is treated as a format character because it follows the comma (the argument delimiter).

Number Formats

The instrument accepts the following kinds of numbers for any of the numeric arguments.

NR1 Signed or unsigned integers (including +0 and –0). Unsigned integers are interpreted as positive.
Examples: +1, 2, –1, –10.

NR2 Signed or unsigned decimal numbers. Unsigned decimal numbers are interpreted as positive.
Examples: –3.2, +5.0, 1.2

NR3 Floating point numbers expressed in scientific notation.
Examples: +1.0E-2, 1.0E2, 1.E-2, 0.01E+0

Link arguments can be used in place of scientific notation.
Examples: +10:MHZ, –.25:V, 2:KHZ.

Rounding of Numeric Arguments

The instrument rounds numeric arguments to the nearest unit of resolution and then checks for out-of-range conditions.

Message Protocol

Upon receipt by the instrument, a message is stored in the Input Buffer, then processed, and executed. Processing a message consists of decoding commands, detecting delimiters, and checking syntax. For *setting commands,* the instrument then stores the indicated changes in the Pending Settings Buffer. If an error is detected during processing, the instrument asserts SRQ, ignores the remainder of the message, and resets the Pending Settings Buffer. Resetting the Pending Settings Buffer avoids undesirable states that could occur if some setting commands are executed while others in the same message are not.

Executing a message consists of performing the actions specified by its command(s). For *setting commands,* this involves updating the instrument settings and recording these updates in the Current Settings Buffer. The *setting commands* are executed in groups —that is, a series of *setting commands* is processed and recorded in the Pending Settings Buffer before execution takes place. This allows the user to specify a new instrument state without having to consider whether a particular sequence would be valid. Normally, execution of the settings occurs when the instrument processes the message terminator, *query-output command,* or an *operational command* in a message. The normal execution of settings is modified by the Device Trigger (DT) setting command.

When the instrument processes a *query-output* command in a message, it executes any preceding *setting commands* to update the state of the instrument. It then executes the *query-output command* by retrieving the appropriate information and putting it in the Output Buffer. Processing and execution then continue for the remainder of the message. The data are sent to the controller when the instrument is made a talker.

When the instrument processes an *operational command* in a message, it executes any preceding *setting commands* before executing the operational command.

Multiple Messages

The Input Buffer has finite capacity and thus a single message may be long enough to fill it. In this case, a portion of the message is processed before the instrument accepts additional input. During command processing, the instrument holds off additional data (by asserting NRFD) until space is available in the buffer. When space is available, the instrument can accept a second message before the first has been processed. However, it holds off additional messages with NRFD until it completes processing the first.

After the instrument executes a *query-output command* in a message, it holds the response in its Output Buffer until the controller makes the instrument a talker. If the instrument receives a new message before all of the output from the previous message is read, it clears the Output Buffer before executing the new message. This prevents the controller from getting unwanted data from old messages.

One other situation may cause the instrument to delete output. The execution of a long message might cause both the Input and Output Buffers to become full. When this occurs, the instrument cannot finish executing the message because it is waiting for the controller to read the data it has generated; but the controller cannot read the data because it is waiting to finish sending its message. Because the instrument Input Buffer is full and it is holding off the rest of the controller's message with NRFD, the system is hung up with the controller and instrument waiting for each other. When the instrument detects this condition, it generates an error, asserts SRQ and deletes the data in the Output Buffer. This action allows the controller to transmit the rest of the message, and informs the controller that the message was executed and that the output was deleted.

A TM 5000 instrument can be made a talker without having received a message that specifies the output. In this case, an acquisition instrument (a counter or a multimeter) returns a measurement if one is ready. If no measurement is ready, it returns a single byte message with all bits equal to 1 (with message terminator). Non-acquisition TM 5000 instruments will return only this message.

Instrument Response to IEEE-488 Interface Messages

Interface messages and the effects of those messages on the instrument interface functions are defined in IEEE Standard 488.1-1987. Abbreviations from the standard are used in this discussion, which describes the effects of interface messages on instrument operation. Where appropriate, the GPIB code is listed, in decimal.

UNL—Unlisten (63 with ATN))
UNT—Untalk (95 with ATN)
When the UNL command is received, the instrument listener function goes to its idle state (unaddressed). In the idle state, the instrument will not accept instrument commands from the IEEE-488 bus.

The talker function goes to its idle state when the instrument receives the UNT command. In this state, the instrument cannot supply output data via the bus.

The addressed indicator is off when both the talker and listener functions are idle. If the instrument is either talk-addressed or listen-addressed, the indicator is on.

IFC—Interface Clear (Bus pin 9)
This uniline message has the same effect as both the UNT and UNL messages. The front panel ADDRESSED indicator is off.

DCL—Device Clear (20 with ATN)
The Device Clear message reinitializes communication between the instrument and controller. In response to DCL, the instrument clears any input and output messages and any unexecuted settings in the Pending Settings Buffer. Also cleared are any errors or events waiting to be reported, except the power-on event. If the SRQ line is asserted for any reason other than power-on when DCL is received, SRQ is unasserted.

SDC—Selected Device Clear (4 with ATN)
This message performs the same function as DCL; however, only instruments that are listen-addressed respond to SDC.

GET—Group Execute Trigger (8 with ATN)
The instrument responds to <GET> only if it is listen-addressed and the instrument device trigger function has been enabled by the Device Trigger command (DT). The <GET> message is ignored and an SRQ generated if the DT function is disabled (DT OFF), the instrument is in the local state, or if a message is being processed when <GET> is received.

SPE – Serial Poll Enable (24 with ATN)
The SPE message enables the instrument to supply output serial poll status bytes when it is talk addressed.

SPD – Serial Poll Disable (25 with ATN)
The SPD message switches the instrument back to its normal operation of sending the data from the Output Buffer.

MLA – My Listen Address (Address + 32)
MTA – My Talk Address (Address + 64)
The primary listen and talk addresses are established by the instrument IEEE-488 bus address (set by front-panel key sequence). The current setting of the bus address ID displayed on the front panel when the INST ID key is pressed. When the instrument is addressed to talk or listen, the front panel ADDRESSED indicator is lighted.

LLO – Local Lockout (17 with ATN)
In response to LLO, the instrument changes to a lockout state – from LOCS to LWLS or from REMS to RWLS.

REN – Remote Enable (GPIB pin 17)
If REN is true, the instrument may change to a remote state (from LOCS to REMS if the internal message return-to-local (rtl) is false, or from LWLS to RWLS) when its listen address is received. REN false causes a transition from any state to LOCS; the instrument stays in LOCS as long as REN is false.

A REN transiton may occur after message processing has begun. In this case, execution of the message being processed is not affected by a transition.

GTL – Go To Local (1 with ATN)
Only instruments that are listen-addressed respond to GTL by changing to a local state. Remote-to-local transitions caused by GTL do not affect the execution of the message being processed when GTL was received.

Remote-Local Operation

The preceding discussion of interface messages describes the state transitions caused by GTL and REN. Most front panel controls cause a transition from REMS to LOCS by asserting a message called return-to-local (rtl). This transition may occur during message execution; but, in contrast to GTL and REN transitions, a transition initiated by rtl does affect message execution. In this case, the instrument generates an error if there are any unexecuted *setting* or *operational commands.* Front panel controls that change only the display (such as INST ID) do not affect the remote-local states – only front panel controls that change settings assert rtl. The rtl message remains asserted while multiple keystroke settings are entered, and it is unasserted after the execution of the settings. Since rtl prevents transition to REMS, the instrument unasserts rtl if a multiple key sequence is not completed in a reasonable length of time (approximately 5 to 10 seconds).

The instrument maintains a record of its settings in the Current Settings Buffer and new settings from the front panel or the controller update these recorded settings. In addition, the front panel is updated to reflect setting changes causes by commands. Instrument settings are unaffected by transitions among the four remote-local states. The REMOTE indicator is lighted when the instrument is in REMS or RWLS.

Local State (LOCS)

In LOCS, instrument settings are controlled by the operator via front panel keys. When in LOCS, only bus commands that do not change instrument settings are executed (*query-output commands.)* All other bus commands (*setting* and *operational*) generate an error since those functions are under front panel control.

Local Without Lockout State (LWLS)

The instrument operates the same as it does in LOCS, except that rtl will not inhibit a transition to remote.

Remote State (REMS)

In this state, the instrument executes all instrument commands. For commands having associated front panel indicators, the front panel is updated when the commands are executed.

Remote With Lockout State (RWLS)

Instrument operation is similar to REMS operation except that the rtl message is ignored. (The front panel is locked out.)

STATUS AND ERROR REPORTING

Through the Service Request function (defined in the IEEE-488.1 Standard), the instrument may alert the controller that it requires service. This service request is also a means of indicating that an event (a change in status or an error) has occurred. To service a request, the controller performs a Serial Poll. In response, the instrument returns a Status Byte (STB), which indicates whether it was requesting service or not. The STB can also provide a limited amount of information about the request. The format of the information encoded in the STB is given in Fig. 3-4. Note that, when data bit 8 is set, the STB conveys Device Status information, which is contained in bits 1 through 4.

Because the STB conveys limited information about an event, the events are divided into classes; the Status Byte reports the class. The classes of events are defined as follows:

Command Error—Indicates that the instrument has received a command which it cannot understand or implement under any circumstances. The command will not affect the state of the instrument.

Execution Error—Indicates that the instrument has received a command that is cannot execute. (This is caused by out-of-range arguments or settings that conflict.)

Internal Error—Indicates that the instrument has detected a hardware condition or firmware problem that prevents operation.

System Events—Events that are common to instruments in a system (e.g., Power On, User Request, etc.).

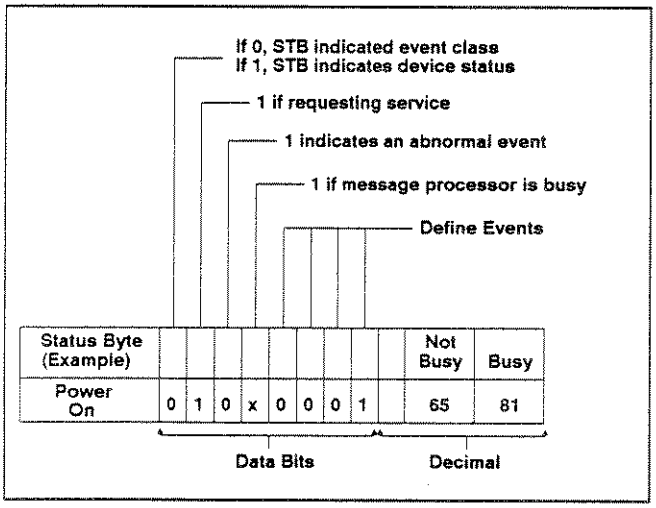

Fig. 3-4. Definition of STB Bits.

Execution Warning—Indicates that the instrument is operating, but that the user should be aware of potential problems.

Internal Warning—Indicates that the instrument has detected a problem (e.g., out of calibration). (The instrument remains operational, but the problem should be corrected.)

Device Status—Device dependent events. The instrument can provide additional information about many of the events, particularly the errors reported in the Status Byte. After determining that the instrument requested service (by examining the STB), the controller may request the additional information by sending an ERROR query (ERR?). In response, the instrument returns a code that defines the event. These codes are described in Table 3-1. Note that some errors are also shown in the front panel display window. (Refer to Table 3-2 for a list of errors that are reported only on the front panel display.)

If there is more than one event to be reported, the instrument continues to assert SRQ until it reports all events. (SRQ "stacking" consists of reporting only the latest event of each priority level.) Each event is automatically cleared when it is reported via Serial Poll. The Device Clear (DCL) interface message may be used to clear all events except Power-On.

Commands are provided to control the reporting of some individual events and to disable all service requests. For example, the User Request command (USER) provides individual control over the reporting of the user request event that occurs when the front panel INST ID key is pressed. The Request for Service command (RQS) controls whether the instrument reports any events with SRQ.

RQS OFF inhibits all SRQ's. When RQS is OFF, the ERR query allows the controller to find out about events without first performing a Serial Poll. With RQS OFF, the controller may send the ERR query at any time and the instrument will return an event waiting to be reported. The controller can clear all events by sending the ERR query until a ERR 0 code is returned, or clear all events except Power-On through the DCL interface message.

With RQS OFF, the controller may perform a Serial Poll, but the Status Byte contains only Device Dependent Status information. With RQS ON, the STB contains the class of the event and a subsequent error query returns additional information about the previous event reported in the STB.

Table 3-1
ERROR QUERY AND STATUS INFORMATION
(Bus Reportable)

NOTHING TO REPORT
STB byte = 128

Error	Error Type/Message	Priority	Description
0	Nothing to report	15	Returned if nothing to report.

COMMAND ERRORS (100)
SRQ byte = 97 decimal or 113 decimal (busy bit set)

Error	Error Type/Message	Priority	Description
101	Command header error	01	The keyword of a command is unknown or misspelled. (Incorrect syntax.)
102	Header delimiter error	01	The delimiter between the header and the argument is missing or the wrong character. (Incorrect syntax.)
103	Command argument error	01	The syntax of the argument is wrong. (Incorrect syntax.)
104	Argument delimiter error	01	The delimiter between arguments is the wrong character. (Incorrect syntax.)
106	Missing argument	01	A command is missing one of its arguments.
107	Invalid message unit delimiter	01	The delimiter between commands is missing or the wrong character.
108	Checksum error	01	A binary block argument's calculated checksum does not match the byte count sent with the argument.
109	Bytecount error	01	The number of bytes in a binary block argument does not match the byte count sent with the argument (terminator is received before the number of bytes in the byte count is received).

EXECUTION ERRORS (200)
SRQ byte 98 or 114 (Busy bit set)

Error	Error Type/Message	Priority	Description
201	Command not executable in local	02	Command cannot be executed while the instrument is under local control. This includes all of the commands that control the settings of the instrument. It does not include queries, rqs on, user on.
202	Settings lost due to rtl	02	The local button is pressed while a command is being set or executed.
203	Output buffer full		When the output buffer and input buffer are full, this error is returned and the output buffer is purged.
204	Settings conflict	03	This error occurs if you try to execute a command that conflicts with the current mode of operation. Example: trying to run FM with sweep. This error replaces the System mode error.

Table 3-1 (cont)
ERROR QUERY AND STATUS INFORMATION
(Bus Reportable)

EXECUTION ERRORS (200) (cont)

Error	Error Type/Message	Priority	Description
205	Argument out of range	03	This error is returned if a numerical argument is out of the range of the instrument.
206	<GET> ignored	03	If GET (group Execute Trigger) is sent and DT is off, this error is returned.
250	AMPL OFST conflict	03	If the output voltage plus the offset voltage is greater than 5 volts, this error will occur. The execution error SRQ byte will be returned.
255	Bad set buffer	03	If a stored buffer <1 >99 is accessed, this error is returned. An execution error is returned by a serial poll.
261	Sweep operation error	03	If one of the sweep parameters is out of range or cannot be executed, this error is returned. This is a general error.
262	Synthesizer option not installed	03	This error will be returned if the user tries to use the synthesizer mode when it is not installed. An execution error is returned by a serial poll.
263	Pulse error	03	If one of the pulse parameters is out of range, this error is returned.
270	NBURST count out of range	03	If the number of cycles in a burst is out of range, this error will be returned.
271	RATE out of range	03	If the RATE command is out of range, this error will be returned.
273	Frequency out of range	03	If the frequency is set out of the range of the instrument, this error will be returned.
274	Amplitude out of range	03	If the amplitude is set greater than 9.9 V, this error will be returned.
275	Offset out of range	03	If offset is set out of range, this error will be returned.
276	START out of range	03	Sweep start frequency out of range of the instrument.
277	STOP out of range	03	Sweep stop frequency out of range of the instrument.
280	DC out of range	03	This error will be returned if the dc is out of range.
281	Width out of range	03	This error will be returned if the width is set greater than the period.

Table 3-1 (cont)
ERROR QUERY AND STATUS INFORMATION
(Bus Reportable)

EXECUTION ERRORS (200) (cont)

Error	Error Type/Message	Priority	Description
282	Delay out of range	03	This error will be returned if the delay is set greater than the period and the mode is set to continuous or burst mode.
283	W + D > 0.85 P	03	This error is returned if width + delay > 0.85 x period (single or double pulse).
284	P – (W + D) < = 40 ns	03	This error is returned if period > width + delay + 40 ns (single or double pulse).
285	D < = W	03	This error is returned if delay ≤width (double pulse only).
286	D < = W + NI	03	This error is returned if delay ≤width + NI (double pulse only).

Width Range	D–W > NI
0.40 – 0.099 μs	40 ns
0..100 –0.999 μs	50 ns
1.00 – 9.99 μs	200 ns
10.0 – 99.9 μs	2.0 μs
100 – 999 μs	20 μs
1.00 – 9.99 ms	200 μs
10.0 – 99.9 ms	2.0 ms

290	Synt illegal data	03	Frequency out of range of the synthesizer.

INTERNAL ERRORS (300)
SRQ byte 99 or 115 (busy bit set)

Error	Error Type/Message	Priority	Description
340	Save RAM failure	05	If the checksum of the Save RAM is bad, this error will be returned.
350	Synthesizer out of lock	05	This error will be returned if the synthesizer is not locked. An internal error is returned by a serial poll.

Table 3-1 (cont)
ERROR QUERY AND STATUS INFORMATION
(Bus Reportable)

SYSTEM EVENTS (400)

Error	Error Type/Message	Priority	STB	Description
401	Power on	00	65	This will be returned if the instrument has just powered on. This event cannot be masked.
402	Operation Complete	14	66	If the instrument has OPC set ON and a pending operation has completed, this event code will be returned. When the instrument is polled, the OPC SRQ byte is returned (66 or 82 [busy bit on]).
403	User Request	14	67	If USER ON is set and the front panel ID button is pushed, SRQ is asserted and after the instrument is polled, this event code will be returned. The SRQ byte returned by the poll is 67 or 83 (busy bit on).

INTERNAL WARNINGS (600)

Error	Error Type/Message	Priority	Description
650	Low battery condition	13	This error will be returned if the battery gets low. An internal warning will be returned at power-on, after the power-on SRQ byte is returned.
660	Output overload	13	If the output is in an overload condition, this error will be returned.

STORED BUFFER ERRORS (800)

Error	Error Type/Message	Priority	Description
801-899		03	Returned if an error exists in a binary block packet used to send binary block data to a stored settings buffer. The buffer number at which the error occurs is equal to the error number minus 800.

Table 3-2
FRONT PANEL ERROR CODES
(Non-Bus Reportable)

Error	Description
010	Incorrect syntax
011	Increment step error
012	Increment limit
013	Decrement limit
014	INCR/DECR error
015	SPCL Function/Mode does not exist
016	Mode conflict
020	Not implemented
204	Settings conflict
205	Out of range
250	AMPL OFST conflict
255	Illegal settings
261	Sweep operation error
262	Synthesizer not installed
271	RATE out of range
273	FREQ out of range
274	AMPL out of range
275	OFFSET out of range
280	DC out of range
281	Width out of range
282	Delay out of range
283	W+D>0.85 P
284	P-(W+D)<=40 ns
285	D<=W
286	D<=W+NI
290	Synt illegal data
302	System error
350	Synthesizer out of lock
650	Low battery
660	Output overload

Sending Interface Control Messages

Interface messages and the effects of those messages on the PFG 5105/5505 interface functions are defined in IEEE Standard 488.1-1987. Abbreviations from that standard are used in this description of the effects on instrument operation.

Bus interface control messages are sent as low-level commands through the use of WBYTE controller commands. Higher level commands are also available for the user. For the following commands, A is 32 plus the instrument's GPIB address, B is 64 plus the address, and C is the instrument's GPIB address.

Listen (MLA)	wbyte atn(A)
Unlisten (UNL)	wbyte atn(unl)
Talk (MTA)	wbyte atn(B)
Untalk	wbyte atn(unt)
Untalk-Unlisten	wbyte atn(unl,unt)
Device Clear (DCL)	wbyte dcl
Selective Device Clear(SDC)	wbyte sdc(C)
Go To Local (GTL)	wbyte gtl(C)
Remote with Lockout (RWLS)	wbyte atn(A), llo,atn(unl)
Local Lockout (LLO)	wbyte llo
Group Execute Trigger (GET)	wbyte get(C)

These commands are for the Tektronix 4041 controller and may be representative for some other controllers.

POWER-ON SEQUENCES AND DEFAULT SETTINGS

Each time power is applied to the PFG 5105/5505, the internal microprocessor performs a self-test diagnostic routine to check the instrument RAM and ROM functionality. If no RAM or ROM error is found, the microprocessor performs further routines that check the functionality of other instrument hardware.

If a RAM or ROM error is found, an error code will be displayed on the front panel readout. In this error state, the PFG 5105/5505 will not respond to input from the front panel or the IEEE-488 bus interface. Internal errors detected after the RAM and ROM tests have been completed successfully will be reported at the front panel and over the IEEE-488 bus. In this error state, the PFG 5105/5505 will respond to input and will attempt to operate despite the error. An error code may be removed from the display be pressing the front panel INST ID button, by starting a numeric entry, by incrementing the selected parameter, by pressing the CLEAR key, or by a transition into the remote state (REMS).

When the self-test has been completed, the PFG 5105/5505 enters the local state (LOCS) and assumes the following default settings:

The SRQ line on the GPIB is also asserted unless the GPIB address is set to 31 (ignore GPIB commands). If the instrument is polled by the controller, the status byte returned will be 0100 0001 (65 decimal; power-on SRQ).

Table 3-3
POWER-ON DEFAULT SETTINGS

AM	OFF
AMPLITUDE	5 V
DC	0 V
DCYCLE	0
DELAY	0
DT	OFF
FM	OFF
FRQLCK	ON
FRQSTART	1 Hz
FRQSTOP	1200 Hz
FREQUENCY	1 kHz
FUNCTION	SINE
MODE	CONT
NBURST	2
OFFSET	0 V
OUTPUT	OFF
PERIOD	1 ms
RATE	10 μs
RNGLCK	OFF
RQS	ON
SWEEP	OFF
TRIG	MAN
USEREQ	OFF
WIDTH	0.5 ms

TALKER LISTENER PROGRAMS

The following sample programs allow a user to send any of the commands listed in the Functional Command List and to receive the data generated.

Talker Listener Program For Tektronix 4041 Controllers

```
100     Rem  PFG  5105/5505  TALKER/LISTENER
110     Rem  PFG  5105/5505  PRIMARY  ADDRESS  8
120        Init  all
130        On  srq  then  gosub  srqhdl
140        Enable  srq
150        Dim  respons$  to  300
160        Input  prompt  "ENTER  MESSAGE(S):  ":message$
170        Print  #16:message$
180     Rem  input  from  device
190        Input  #16:respons$
200        Print  "RESPONSE:  ";respons$
210        Goto  160
220     Rem    SERIAL  POOL  ROUTINE
230  Srqhdl:         poll  stb,pri
240        Resume
250        End
```

Quick Basic Talker Listener Program For Tektronix PEP 301 Controllers

```
'  ********************************************************************************
'  ******************** PFG 5105/5505 TALKER/LISTENER PROGRAM *********************
'  ********************************************************************************
'  THIS PROGRAM REQUIRES THAT THE PFG 5105 ADDRESS TO BE SET
'  TO THE FACTORY DEFAULT OF 8
COMMON SHARED IBSTA%, IBERR%, IBCNT%
ID$ = "TEKDEV1"
CALL IBFIND(ID$, BD%)
PFG% = 8
CALL IBPAD(BD%, PFG%)
ID$ = "GPIB0"
CALL IBFIND(ID$, GP%)
REMOTE% = 1
CALL IBSRE(GP%, REMOTE%)
CLS
DOOVER:
PRINT "********************************************************************************"
PRINT "******************** PFG 5105/5505 TALKER LISTENER PROGRAM *********************"
PRINT "********************************************************************************"
PRINT "RETURN TO EXIT: "
INPUT "ENTER MESSAGE(S)"; WRT$
CALL IBWRT(BD%, WRT$)
GOSUB CHECKGPIB
IF WRT$ = "" THEN GOTO TERMINATE
'  ***************************** INPUT FROM DEVICE *********************************
REPLY$ = SPACE$(255)
CALL IBRD(BD%, REPLY$)
GOSUB CHECKGPIB
GOSUB CHECKDM
PRINT : PRINT "INSTRUMENT REPLY "; REPLY$
PRINT : PRINT "Returned status byte:"; SPR%,
PRINT : PRINT ERRM$
GOTO DOOVER
'  ********************************* ERROR ROUTINES ********************************
CHECKDM:
ERRM$ = SPACE$(50)
CALL IBRSP(BD%, SPR%)
CALL IBWRT(BD%, "ERRM?")
CALL IBRD(BD%, ERRM$)
RETURN
CHECKGPIB:
IF IBSTA% >= 0 AND BD% >= 0 AND IBSTA% < &H4000 AND IBERR% <> 6 THEN RETURN
'no error to report
IF BD% < 0 THEN PRINT "device not installed - use IBCONF then reboot"
IF IBSTA% > 0 AND IBSTA% >= &H4000 THEN PRINT "timeout"
IF IBERR% = 6 THEN PRINT "timeout"
PRINT "gpib error "; IBERR%
IF IBERR% = 0 THEN PRINT "DOS error device not installed"
IF IBERR% = 1 THEN PRINT "function requires GPIB-PC to be CIC"
IF IBERR% = 2 THEN PRINT "no. listener on write function"
IF IBERR% = 3 THEN PRINT "GPIB-PC not addressed correctly"
IF IBERR% = 4 THEN PRINT "invalid argument to function call"
IF IBERR% = 5 THEN PRINT "GPIB-PC not system controller as required"
IF IBERR% = 6 THEN PRINT "I/O operation aborted"
IF IBERR% = 7 THEN PRINT "non-existent GPIB-PC board"
IF IBERR% = 10 THEN PRINT "I/O started before previous operation completed"
IF IBERR% = 11 THEN PRINT "no capability for operation"
IF IBERR% = 12 THEN PRINT "file system error"
IF IBERR% = 14 THEN PRINT "command error during device call"
IF IBERR% = 15 THEN PRINT "serial poll status byte lost"
IF IBERR% = 16 THEN PRINT "SRQ stuck in on position"
INPUT "[ENTER] TO CONTINUE"; A$' if help$ then
RETURN
'  ****************************** TERMINATE PROGRAM ********************************
TERMINATE:
REMOTE% = 0
CALL IBSRE(GP%, REMOTE%)
PRINT "PROGRAM TERMINATED."
END
```