Tektronix®
COMMITTED TO EXCELLENCE

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

FG 5010
20 MHz PROGRAMMABLE FUNCTION GENERATOR

INSTRUCTION MANUAL

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

070-3467-01
Product Group 76

Serial Number _____

First Printing OCT 1981
Revised Feb 1988

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/Tektronix, Japan
700000	Tektronix Holland, NV, Heerenveen, The Netherlands

SERVICE SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY

Refer also to the preceding Operators 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.

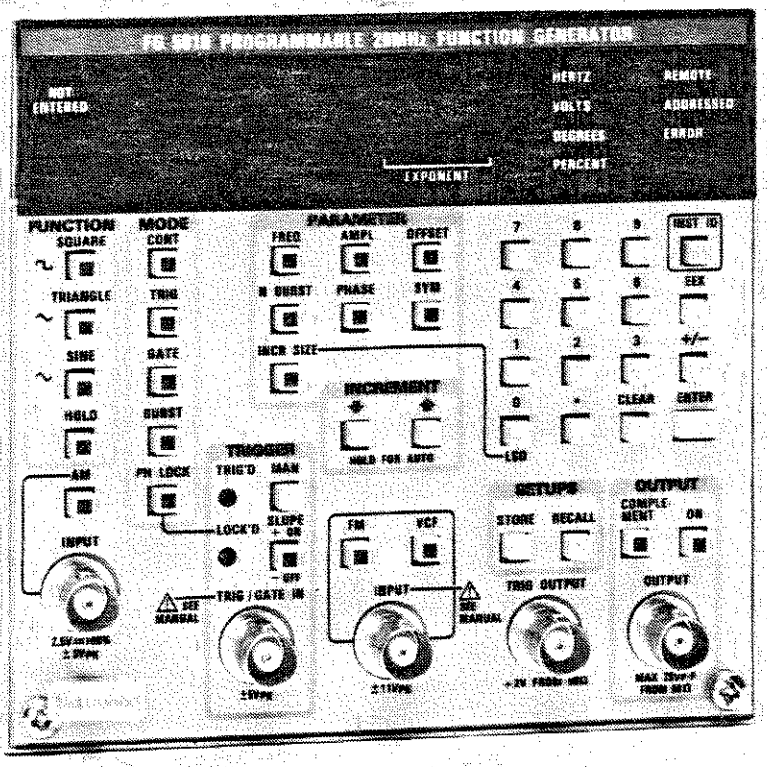
Use Care When Servicing With Power On

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 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.



3467-01

FG 5010 20 MHz Programmable Function Generator

SPECIFICATION

All references to the SA 501 in this manual now apply to the 067-1090-00 Signature Analyzer.

Introduction

This section of the manual contains a general description of the FG 5010 and complete electrical, environmental, and physical specifications. Standard and optional accessories are also listed. Instrument option information is located toward the back of this manual in a separate section.

Instrument Description

The FG 5010 Programmable Function Generator is a signal source for low distortion sinusoidal, square/pulse, and triangle waveforms. The instrument is designed to operate in two compartments of any TM 5000 Series power module. The instrument can be manually programmed from the front panel or, when installed in the proper power module, remotely programmed via the general purpose interface bus (GPIB). When properly installed, the FG 5010 is compatible with other instruments that meet IEEE Standard 488-1978.

The FG 5010 operates within a frequency range of 0.002 Hz to 20 MHz. Output amplitude is from 20 mV to 20 V peak-to-peak, open circuit. Terminated into 50 Ω, output amplitude is from 10 mV to 10 V peak-to-peak. Output circuit dc Offset range is from 0 to ±7.5 V. Waveform symmetry is variable from 10% to 90% duty cycle in 1% steps. Output waveform baseline phase can be shifted from −90° to +90° in 1° increments.

A Voltage Controlled Frequency (VCF) input is provided to control the output frequency from an external voltage source. The output waveform can also be modulated from an external source. Provision is made for both Amplitude Modulation (AM) and Frequency Modulation (FM).

The FG 5010 features a memory capable of storing up to ten complete sets of operating modes and parameters. All modes and parameters of any set can be recalled from the front panel or with a remote program command.

Illuminated pushbuttons provide visual indication that a function is active. Seven-segment LED's display the numerical value and exponent of the selected parameter. The unit of measure of the selected parameter is also displayed in the readout window.

Standard Accessories

The following items are shipped with the FG 5010.

(1) Instruction Manual
(1) Pocket Reference Guide

IEEE 488 (GPIB) Function Capability

The FG 5010 is capable of being remotely programmed via the digital interface specified in IEEE Standard 488-1978, "Standard Digital Interface for Programmable Instrumentation". In this manual, the interface is commonly 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 are defined in the standard. The subsets that apply to the FG 5010 are listed in Table 1-1.

NOTE

Refer to IEEE Standard 488-1978 and the latter part of this manual 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.
Acceptor Handshake	AH1	Complete.
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.
Remote-Local	RL1	Complete.
Parallel Poll	PP0	Does not respond to Parallel Poll.
Device Clear	DC1	Complete.
Device Trigger	DT1	Complete.
Controller	C0	No controller function.
Bus Drivers	E2	Three state drivers.

ELECTRICAL CHARACTERISTICS

Performance Conditions

The electrical characteristics are valid with the following conditions.

1. The instrument must have been adjusted at an ambient temperature between +20°C and +30°C and operating at an ambient temperature between 0°C and +50°C.

2. The instrument must be in a noncondensing environment whose limits are described under Environmental.

3. Allow 20 minutes warm-up time for operation to specified accuracy; 60 minutes after exposure to or storage in a high humidity (condensing) environment.

4. Applicable to front-panel interface only. Due to potential noise and cross talk of the rear interface, the specified electrical characteristics may be degraded.

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

Table 1-2
FREQUENCY

Characteristics	Performance Requirements	Supplemental Information
Frequency		Frequency parameters specified with FM and VCF off.
Selectable Range	.002 Hz to 20 MHz	
Accuracy		Measured at 25°C ±10°C. Operation continues beyond this temperature range, but frequency accuracy degrades and applicable error codes may appear. Verification in GATE mode implies accuracy in TRIG, BURST modes.
CONT	±0.1%	
TRIG,GATE,BURST	f≤200 Hz ±0.1% 200 Hz<f≤2 MHz ±5.0% f>2 MHz with SYMMETRY=50% ±5.0% f>2 MHz with SYMMETRY≠50% ±6.0% increasing linearly to ±8.0% at 10% or 90% SYMMETRY.	
Stability		
1 Hour		Typical Stability: CONT .05% TRIG, GATE, BURST f≤200 Hz .05% f>200 Hz .05%
24 Hours		CONT .05% TRIG, GATE, BURST f≤200 Hz .05% f>200 Hz .10%
Jitter		Typical Jitter: CONT, TRIG, GATE and BURST .05% Ø LOCK 1.0%
Resolution (digits)		CONT 4 digits TRIG, GATE BURST f≤200 Hz 4 digits f>200 Hz $1 \times 10^n \leq freq \leq 2 \times 10^n$ 4 digits where n = 3 to 7 $2 \times 10^m < freq < 10 \times 10^m$ 3 digits where m = 2 to 6 VCF The top of the frequency ranges are 20 MHz, 2 MHz, 200 kHz, 20 kHz, 2 kHz, 200 Hz, 20 Hz, 2 Hz, .2 Hz and .02 Hz. $f_{top} \geq f \geq (f_{top}/2)$ 4 digits $(f_{top}/2) > f \geq (f_{top}/20)$ 3 digits $(f_{top}/20) > f \geq (f_{top}/200)$ 2 1/2 digits $(f_{top}/200) > f \geq (f_{top}/200)$ 1 1/2 digits $(f_{top}/2000) > f \geq 0$ 1 digit

Table 1-3
OUTPUT

Characteristics	Performance Requirements	Supplemental Information
Output Mode Normal/Complement		Output signal is either normal or inverted around the specified offset.
On/Off		Output is disconnected from load.
Amplitude Selectable Range	20 mV to 20 V p-p from 50 Ω into an open circuit.	0 Volts programmed value allowed.
Accuracy		Measured at 25°C ±10°C into 50 Ω load at 50% SYM, COMPL off, for AMPL settings from 20.0 V to 6.34 V p-p.
Triangle Wave	±2% 0.002 Hz ≤ f ≤ 1 kHz ±3.5% 1 kHz < f ≤ 100 kHz ±4% 100 kHz < f ≤ 1 MHz +4%, −5% 1 MHz < f ≤ 5 MHz +4%, −20% 5 MHz < f ≤ 20 MHz	
Square Wave	±2% 0.002 Hz ≤ f ≤ 1 kHz ±3.5% 1 kHz < f ≤ 1 MHz ±5% 1 MHz < f ≤ 10 MHz ±10% 10 MHz < f ≤ 20 MHz	For frequencies ≤ 10 MHz, amplitude is measured ≥ 20 ns after the 90% point of the transition. For frequencies > 10 MHz, abberations continue for a significant portion of the SQWV top level. For these higher frequencies, the settled amplitude is measured and established at 10 MHz, and the total peak-to-peak signal will include the amplitude measured at 10 MHz plus aberrations (±5% +20 mV for each transition). This spec includes peaking effects of aberrations.
Sine Wave	±3% 0.002 Hz ≤ f ≤ 1 kHz ±3.5% 1 kHz < f ≤ 1 MHz ±5% 1 MHz < f ≤ 5 MHz +5%, −10% 5 MHz < f ≤ 20 MHz	
Step Attenuator	AMPL settings 6.32 V to 2.02 V ±0.05 dB 2.000 V to 634 mV ±0.07 dB 632 mV to 202 mV ±0.12 dB 200.0 mV to 63.4 mV ±0.15 dB 63.2 mV to 20.0 mV ±0.20 dB	±0.58% ±0.81% ±1.39% ±1.74% ±2.33%
Resolution		20 mV 2.02 V to 20.00 V p-p 2 mV 202 mV to 2.000 V p-p 0.2 mV 20.0 mV to 200 mV p-p
Offset Selectable Range	−7.5 V to +7.5 V from 50 Ω into an open circuit. Maximum peak signal plus offset cannot exceed ±15 V into an open circuit (±7.5 V into 50 Ω).	

Table 1-3 (cont)

Characteristics	Performance Requirements	Supplemental Information
Accuracy	Measured at 25° ±10°C into 50 Ω load at 50% symmetry, COMPLEMENT Off. All waveforms except SQWV > 2 MHz. < ±(1% of the selected value, +2% of the signal V p-p + 20 mV). SQWV > 2 MHz. < ±(1% of the selected value +5% of the signal V p-p + 20 mV).	Specification includes effects of allowable SQWV aberrations upon measured offset voltage. See "SQWV Amplitude Accuracy" for further details.
Resolution		10 mV Open Circuit; 5 mV into 50 Ω.

Table 1-4
WAVEFORM

Characteristics	Performance Requirements	Supplemental Information
Triangle Linearity		Typically ≤ 1%, 0.002 Hz to 200 Hz Typically ≤ 1%, 200 Hz to 100 kHz Typically ≤ 2%, 100 kHz to 2 MHz Typically ≤ 10%, 2 MHz to 20 MHz Measured from the 10% to the 90% points on the waveform.
Sinewave Distortion	≤ 0.5%, 20.0 Hz to 19.99 kHz ≤ 1.0%, 20.0 kHz to 99.99 kHz Greatest harmonic at least 30 dB down from 100 kHz to 20.0 MHz, Measurement bandwidth limited to approximately 300 kHz. Above measurements taken at +25°C ±10°C ambient with: 0 V offset, 6.32 V set amplitude terminated in 50 Ω. CONT mode, AM, VCF, FM, and COMPL off, SYM at 50%.	THD ≤ 1% 0.002 Hz to 19.99 Hz
Square Wave Output	Measured into 50 Ω.	
Risetime	≤ 10 ns	
Falltime	≤ 10 ns	
Aberrations	≤ ±(5% +20 mV)	

Table 1-4 (cont)

Characteristics	Performance Requirements	Supplemental Information
Symmetry	Square Wave	Sine and triangle waveform symmetry accuracy implied from Square Wave performance.
Accuracy	$\leq \pm 2\%$ Symmetry for freq $\leq$ 2 MHz $\leq \pm[3\% + \text{freq} \times 1\text{ ns} \times 100\%]$ Symmetry for freq $>$ 2 MHz	Measured at 25°C ±10°C, VCF off.
Resolution		2 digits, 1 percent steps
Selectable Range	10% to 90% f $\leq$ 4 MHz For f $>$ 4 MHz, symmetry cannot be adjusted beyond where a triangle transition less than 25 ns is required.	
Output Hold Hold Frequency Range		Output held at instaneous level. .002 Hz to 200 Hz
Drift		D/A Conversion, no S/H decay.
Phase (TRIG, GATE, BURST modes)		
Selectable Range	$\lvert\phi\rvert \leq 90°$ when 0.002 Hz $\leq$ f $\leq$ 1 MHz $\lvert\phi\rvert \leq 80° - \left(\frac{f}{20\text{ MHz}} \times 40°\right)$ when f $>$ 1 MHz	When f $>$ 1 MHz the generator will free run when the phase range is exceeded.
Accuracy	±3° for f $\leq$ 500 kHz $\pm\left[7° + \left(\frac{f}{20\text{ MHz}} \times 28\% \times \lvert\phi\rvert\right)°\right]$ for f $>$ 500 kHz Measured at 25° ±10°C ambient with the output in normal, not COMPLEMENT mode, VCF off, Symmetry = 50%. The baseline must be allowed to settle for at least 4.5 μs before measuring ϕ accuracy.	
Resolution		1 degree 2 digits plus sign for $10° \leq \lvert\phi\rvert \leq 90°$ 1 digit plus sign for $0° \leq \lvert\phi\rvert \leq 9°$
(Phase Lock Mode)	Specifications apply for ambient temperature of 25° ±10°C.	Programmed phase is ϕ difference between the rising edge of the trigger output and the rising edge of the input waveform as it passed through the trigger threshold.
Selectable Range	$\lvert\phi\rvert \leq 90°$ when 20 Hz $\leq$ f $\leq$ 10 MHz $\lvert\phi\rvert \leq 45°$ when f $>$ 10 MHz	Note: Complementing the output will extend the effective ϕ range to ±180°

Table 1-4 (cont)

Characteristics	Performance Requirements	Supplemental Information
Accuracy	±(2° + 5% of selected value) when f ≤ 34 kHz	Internal time delays limit phase accuracy at higher frequencies.
Resolution		1 degree 2 digits plus sign for $10° \leq \lvert\phi\rvert \leq 90°$ 1 digit plus sign for $0° \leq \lvert\phi\rvert \leq 9°$
Time to Acquire Lock		Typical times to ramp through ranges with $\phi = 0°$: Range — Time 20 MHz → 2 MHz 8 msec 2 MHz → 200 kHz 8 msec 200 kHz → 20 kHz 80 msec 20 kHz → 2 kHz 800 msec 2 kHz → 200 Hz 8 sec 200 Hz → below 88 sec Maximum time to acquire lock is the sum of the times required to ramp through the ranges between the last lock and the new lock.

Table 1-5
AUXILIARY INPUT/OUTPUT

Characteristics	Performance Requirements	Supplemental Information
TRIG, GATE, BURST and PH LOCK input		
Trigger		Midpoint of Hysteresis internally selectable: 0.0 V or +0.5 V (both typically ±100 mV)
Input Impedance		Internally selectable. 50 Ω ±5%, or (1 MΩ + 20 pF) ±5%.
Slope	Plus or minus, only plus available in PH LOCK.	
Sensitivity	≤ 0.25 V p-p	
Maximum Input Amplitude		±5 V pk in 50 Ω ±20 V pk in 1 MΩ
Minimum Pulse Width	25 nsec	
Minimum Time between bursts		100 nsec typical
Maximum Trigger Frequency	20 MHz	
Burst range	1 to 9999 cycles	

Table 1-5 (cont)

Characteristics	Performance Requirements	Supplemental Information
PH LOCK frequency range	20 Hz to 20 MHz for SYM = 50%. Upper frequency limit is identical to that specified under "Symmetry Selectable Range" for SYM not equal to 50%.	Frequency Out = Frequency In
PH LOCK capture range	Auto capture over 20 Hz to 20 MHz	
Modulation Input		
AM Input		
Input Impedance		10 kΩ ± 5% when AM is selected.
Sensitivity	5 V p-p produces ≥ 100% modulation.	0 to +2.5 V signal increases carrier output. 0 to −2.5 V signal decreases carrier output.
Distortion		< 2% for 10 f_{mod} ≤ f ≤ 2 MHz, with 70% modulation < 4% for 10 f_{mod} ≤ f ≤ 20 MHz, with 70% modulation
Bandwidth (3 dB)		Dc to ≥ 100 kHz. When AM is turned on, carrier amplitude is reduced to one-half the displayed value. The displayed amplitude becomes the maximum p-p output that can be generated at 100% modulation.
Maximum Input Amplitude		±20 V pk
FM Input		
Input Impedance		10 kΩ ±5%.
Sensitivity	0 to ±1 V modulates to ≥ ±1% deviation from center frequency.	
Dynamic range	±3.5 V pk	+10.0 V pk to −3.5 V pk available
Bandwidth (3 dB)		Typically dc to ≥ 70 kHz
Distortion		Typically ≤ 2%.
Maximum Input Amplitude		±20 V pk
VCF Input		
Input Impedance		10 kΩ ±5%.
Sensitivity	0 V to 10.0 V produces ≥1:1000 frequency change when programmed VCF start frequency = 0 Hz. VCF range will be limited above 4 MHz when SYM ≠ 50%. See "Symmetry Selectable Range" for limits.	VCF mode prevents further frequency range switching and allows selection of f = 0 Hz. The top of the frequency ranges are: 20 MHz, 2 MHz, 200 kHz, 20 kHz, 2 kHz, 200 Hz, 20 Hz, 2 Hz, 2 Hz, and .02 Hz. Positive going voltage increases frequency.

Table 1-5 (cont)

Characteristics	Performance Requirements	Supplemental Information
Input Level	$-3.5\ V \leq V_{in} \leq +10\ V$	
Bandwidth (3 dB)		Typically dc to ≥ 70 kHz
Slew Rate		Typically 0.063 V/μs maximum
Max Input Amplitude		± 20 V pk
Trigger Output	0 ±100 mV to ≥ 2 V from 50 Ω into an open circuit.	
Setup Capacity	10 sets of descriptions for parameters, modes, and input/output controls plus one for existing operating state.	
Storage		Stored settings remain only while power module power is on.

Table 1-6
GPIB

Characteristics	Performance Requirements	Supplemental Information
Settling Times		NOTE: Multiple setting changes will typically be less than sum of individual settling times.
Frequency change		<35 ms
Frequency with range change		< 50 ms. Range boundaries at 2 MHz, 200 kHz, 20 kHz, 2 kHz, 200 Hz, 20 Hz, 2 Hz, 0.2 Hz and 0.02 Hz.
Amplitude change		<20 ms
Amplitude with range change		<27 ms. Range boundaries at 6.32 V, 2.00 V, 0.632 V, 0.200 V, and 0.063 V.
Symmetry change		<27ms
Symmetry with range change		<27 ms. Range change occurs when switching to or from 50% symmetry.
Offset change		<15 ms
Phase change		
TRIG, GATE, BURST		<16 ms
ϕ LOCK		<16 ms
Recall settings		<58 ms

Table 1-6 (cont)

Characteristics	Performance Requirements	Supplemental Information
Mode Change Times		
Output ON/OFF		<8 ms
Normal/Complement		<15 ms
Other modes		<16 ms
Function Change Times		
Waveform change		<12 ms
Modulation change		<8 ms

Table 1-7
MISCELLANEOUS

Characteristics	Description	
Fuse Data		
25 Vac input from power module (2)	3 A, fast blow	All in Output Amplifier Board
+26 V supply (1)	3 A, fast blow	
−26 V supply (1)	3 A, fast blow	
+8 V supply (1)	5 A, fast blow	
+12 V supply (1)	3 A, fast blow	All in Sine Shaper Board
−12 V supply (1)	3 A, fast blow	
Power Consumption	60 W (Includes power dissipated in power module components).	
Power Dissipation	40 W (Includes only power dissipated within the plug-in).	
Recommended Adjustment Interval	1000 hours or 6 months, whichever occurs first.	
Warm-up Time	20 minutes.	

ENVIRONMENTAL CHARACTERISTICS

Table 1-8
ENVIRONMENTAL[a]

Characteristics	Description	
Temperature		Meets MIL-T-28800B, class 5.
Operating	0°C to +50°C	
Non-operating	−55°C to +75°C	
Humidity	95% RH, 0°C to 30°C 75% RH to 40°C 45% RH to 50°C	Exceeds MIL-T-28800B, class 5.
Altitude		Exceeds MIL-T-28800B, class 5.
Operating	4.6 km (15,000 ft)	
Non-operating	15 km (50,000 ft)	
Vibration[b]	0.38 mm (0.015") peak to peak, 5 Hz to 55 Hz, 75 minutes.	Meets MIL-T-28800B, class 5, when installed in qualified power modules.
Shock[b]	30 g's (1/2 sine) 11 ms duration 3 shocks in each direction along 3 major axes, 18 total shocks.	Meets MIL-T-28800B, class 5, when installed in qualified power modules[c].
Bench Handling[d]	12 drops from 45°, 4" or equilibrium, whichever occurs first.	Meets MIL-T-28800B, class 5, when installed in qualified power modules[c].
Transportation[d]	Qualiified under National Safe Transit Association Preshipment Test Procedures 1A-B-1 and 1A-B-2.	
EMC[e]	Within limits of F.C.C. Regulations, Part 15, Subpart J, Class A; VDE 0871 Class B, and MIL-461B/462 tests RE01, CE01, CE03, RS01, RS03, CS01, CS02, CS06 and RE02 Part 7.	
Electrical Discharge	20 kV maximum charge applied to instrument case.	

[a] With power module.
[b] Requires retainer clip.
[c] Refer to TM 500/5000 power module specifications.
[d] Without power module.
[e] System performance subject to exceptions of power module or other individual plug-ins.

PHYSICAL CHARACTERISTICS

Table 1-9
MECHANICAL

Characteristics	Description
Finish	Plastic laminate front panel. Anodized aluminum chassis.
Net Weight	Approximately 6.2 lbs.
Overall Dimensions	Height 5.0 in. (12.7 cm) Width 5.3 in. (13.5 cm) Length 12.2 in. (31 cm)
Enclosure Type and Style per MIL-T-28800B FG 5010 Type Style	 III E (with 040 kit style F)

OPERATING INSTRUCTIONS

Introduction

This section of the manual provides operating information required to obtain the most effective performance from the FG 5010. Also included are installation and removal instructions and a functional description of front panel controls and connectors. Operating modes are also discussed. Remote operation and programming instructions are contained in a separate section.

Installation and Removal

The FG 5010 is calibrated and ready for use when received. It operates in two 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 FG 5010, 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 FG 5010 circuit board edge connectors. If they do not match, do not insert the instrument until the reason is determined. When the units are properly matched, align the FG 5010 chassis with the upper and lower guides of the selected compartments (see Fig. 2-1). Insert the FG 5010 into the power module and press firmly to seat the circuit board edge connectors in the power module interconnecting jacks. Apply power to the FG 5010 by actuating the power switch on the power module.

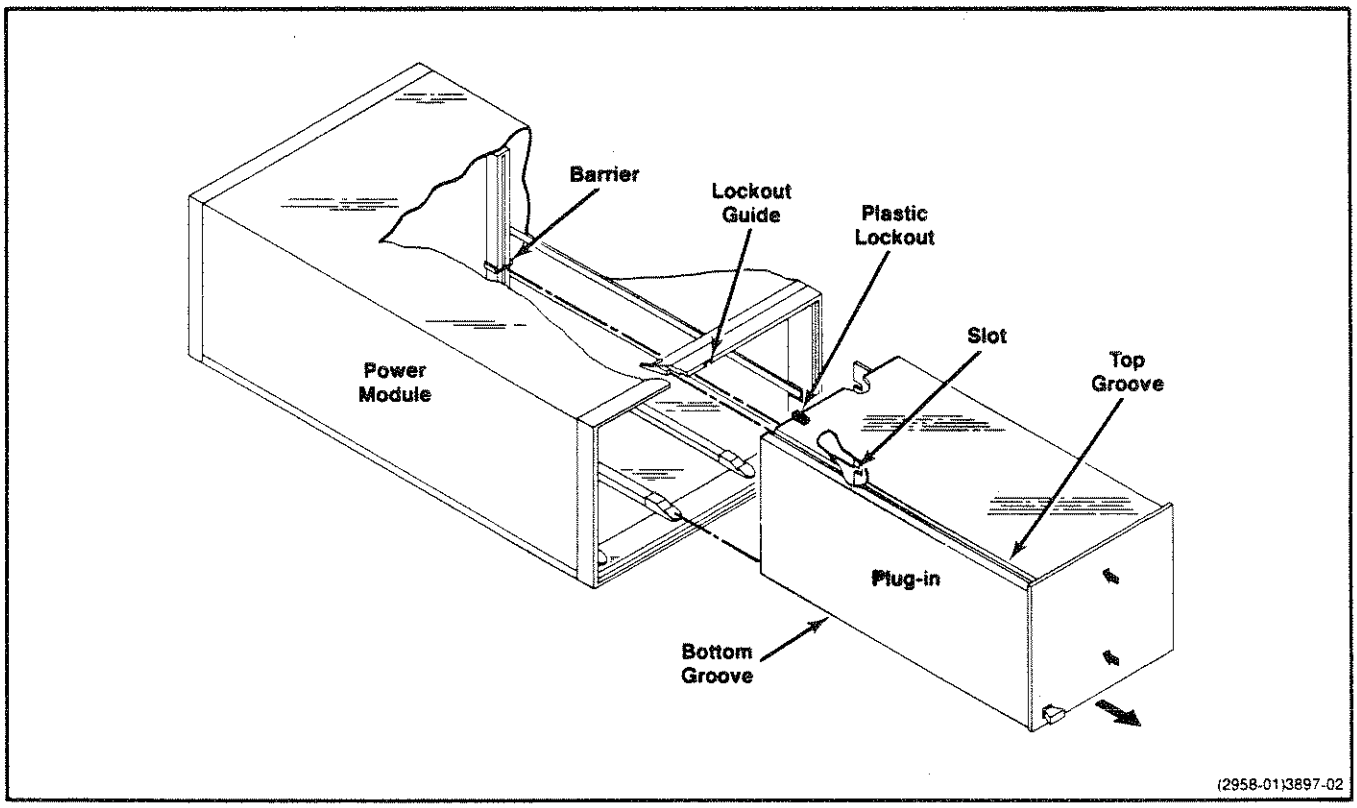


Fig. 2-1. Installation and Removal.

To remove the FG 5010 from the power module, pull the release latch (located in the lower left corner) until the interconnecting jack disengages. The instrument will now slide straight out.

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 not fit for use or not available, repackage the instrument as follows.

Surround 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 an industrial stapler.

The carton test strength for your instrument is 200 lbs.

CONTROLS, CONNECTORS, AND DISPLAY

Although the FG 5010 is calibrated and ready to use, the functions and actions of the controls and connectors should be reviewed before attempting to use it. All controls necessary for local operation of the instrument are located on the front panel. Illuminated pushbutton switches provide visual indication that a funciton is active. A brief description of these controls follows. Refer to Fig. 2-2.

READOUT DISPLAY

The FG 5010 employs seven-segment LED's to display a numerical value (up to four digits) and associated exponent of the selected parameter. The following LED indicators are also displayed in the readout window.

PARAMETER UNITS OF MEASURE

HERTZ – Illuminated when FREQ (frequency) is selected.

VOLTS – luminated when AMPL (amplitude) or OFFSET is selected.

DEGREES – Illuminated when PHASE is selected.

PERCENT – Illuminated when SYM (symmetry) is selected.

GPIB INDICATORS

REMOTE – Illuminated when the FG 5010 is operating under remote program control via the GPIB.

ADDRESSED – Illuminated when the FG 5010 is either "listening" or "talking" over the GPIB.

ERROR INDICATORS

ERROR – Illuminated when an attempt is made to enter an invalid setup (front panel only), or when CPU fails to maintain programmed frequency.

NOT ENTERED – Begins to flash when a parameter entry is started, and continues to flash until the entry has been accepted as valid.

CONTROLS AND CONNECTORS

All controls, except trigger input impedance and trigger level, necessary to operate the FG 5010 are located on the front panel. Refer setting of these internal controls to qualified service personnel.

(1) INST ID

Causes the FG 5010 to display its bus address and generate a service request (SRQ) over the GPIB.

(2) FUNCTION

The buttons in this group are illuminated when the associated function is active. These functions, except HOLD, are mutually exclusive.

SQUARE (⊓⊔) – Square waveforms will be generated at the output connector.

TRIANGLE (∿) – Triangle waveforms will be generated at the output connector.

SINE (∿) – Sinusoidal waveforms will be generated at the output connector.

HOLD - The output waveform (below 200 Hz) is held at its instantaneous level.

(3) MODE

The buttons in this group are illuminated when the associated mode is active. These functions are mutually exclusive.

CONT – The waveform, at the programmed frequency, is continuously generated.

TRIG – One complete cycle of the selected waveform will be generated for each trigger signal at the TRIG/GATE IN connector or each time the MAN button is pressed.

GATE – The selected waveform is generated continuously for the duration of the gating signal at the TRIG/GATE IN connector or for as long as the MAN button is held in.

BURST – A pre-programmed number of cycles of the selected waveform is generated for each trigger or gate signal at the TRIG/GATE IN connector or each time the MAN button is pressed.

PH LOCK – The waveform generated is phase-locked to the input trigger signal.

(4) PARAMETER

The buttons in this group are illuminated when the associated parameter is selected. These functions are mutually exclusive.

FREQ – Allows the operator, via the keyboard, to set or observe the frequency of the output waveform.

AMPL – Allows the operator, via the keyboard, to set or observe the amplitude of the output waveform.

OFFSET – Allows the operator, via the keyboard, to set or observe the dc offset voltage.

SYM – Allows the operator, via the keyboard, to adjust or observe the symmetry of the output waveform.

PHASE – Allows the operator, via the keyboard, to set or observe the baseline of the output waveform, with respect to a ramp-up zero-crossing of the triangle, for TRIG, GATE, and BURST modes. Also allows the operator, via the keyboard, to set the phase relationship of the trigger output waveform relative to the input trigger signal for PH LOCK mode.

N BURST – Allows the operator, via the keyboard, to set or observe the number of cycles that will be generated when operating in the BURST mode.

INCR SIZE – Allows the operator, via the keyboard, to set or observe the size of the increment/decrement step for the parameter selected. If no value is set, the step size will default to the least significant digit (LSD) displayed. Keyboard zero (0) is used to return the step size back to LSD.

(5) INCREMENT

These two buttons incrementally vary the parameter up (↑) or down (↓). When the button is pressed and released, the parameter will be stepped one unit of the defined increment size. When the button is in the HOLD FOR AUTO (press and hold) position, the parameter will be stepped in units of the defined increment size, but will accelerate to a rapid rate, until the button is released or the parameter limit is reached.

(6) NUMERIC KEYBOARD

These fifteen non-illuminated keys are used to establish the numerical value of the selected parameter and associated exponent. The function of the 0-9 keys should be self-explanatory. The other four keys are briefly described below.

EEX – Followed by the +/– key and one or more digits, sets the exponent to be applied to the numerical value of the selected parameter.

+/− – Changes the sign of the phase and offset voltages and the exponent. A plus (+) sign will be assumed unless the button is pressed to set a minus (−). Pressing the button when minus (−) is displayed changes the sign back to plus (+).

CLEAR – Clears the entry being attempted and re-displays the current value of the selected parameter.

NOTE

The CLEAR key is the only key that will clear an error in numeric entry.

ENTER – Enters a valid parameter into the current operating setup.

(7) SETUPS

These two non-illuminated keys access the ten available memory locations.

STORE – This key followed by one digit (0-9) stores the last valid setup, except increment size and GPIB flags, in its entirety, in the desired memory location.

RECALL – Recalls and activates the entire setup stored in the selected memory location. The contents of all undefined memory locations default to power-on settings.

NOTE

Should the power to the FG 5010 be interrupted for any reason, all setups stored in the memory will be lost.

(8) ⚠ TRIG/GATE IN

Connector for coupling the external trigger or gate signal to the FG 5010.

NOTE

Input voltage limited to ±5 V peak.

SLOPE – Selects the slope (+ or −) of the input signal upon which the output waveform will be triggered. Button is illuminated when + slope is selected.

MAN – Manual trigger control. With no signal applied to the TRIG/GATE IN connector, provides one output cycle in the TRIG mode, a burst of n cycles in the BURST mode, or continuous output until the button is released in GATE mode.

TRIG'D – This indicator is active in TRIG, GATE, BURST and PH LOCK modes. It will be in one of the following three states.

FLASHING – Input triggered at greater than approximately a 10 Hz repetition rate or following the input signal at slower repetition rates.

ON – Input potential above threshold level with + SLOPE selected or below threshold level with − SLOPE selected. Output determined by mode selected.

OFF – Input potential below threshold level with + SLOPE selected or above threshold level with − SLOPE selected. No output.

LOCK'D – Illuminated when the phase of the output waveform is locked to the input trigger signal (PH LOCK mode only).

(9) AM INPUT

With a modulating signal applied to this connector, activation of the AM function causes the output waveform to be amplitude modulated. With no signal applied, activation of this function reduces output amplitude by 50%. This button is illuminated when the function is active.

(10) ⚠ FM/VCF INPUT

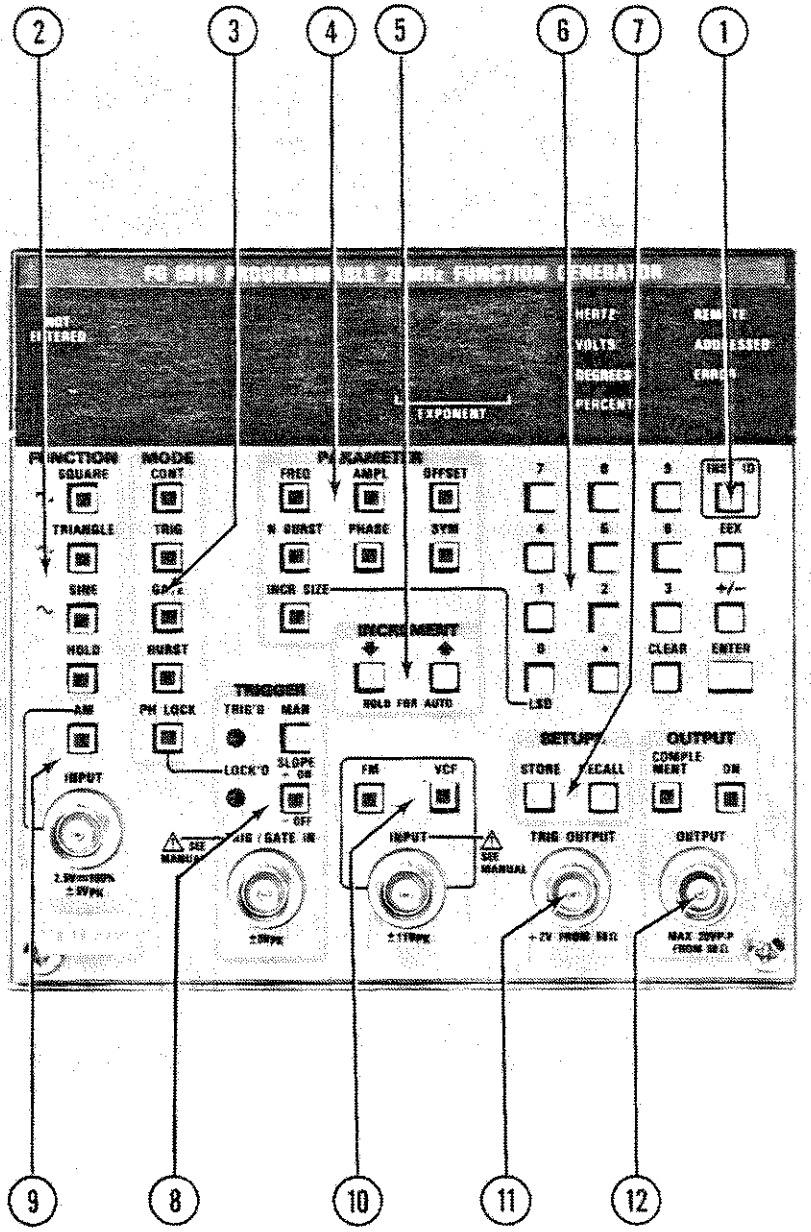
These two buttons are illuminated when the respective function is active. These functions are mutually exclusive.

NOTE

Input voltage limited to ±11 V peak.

FM – With a modulating signal applied to the INPUT connector, activation of this function causes the output waveform to be frequency modulated.

VCF – With a voltage source applied to the INPUT connector, activation of this function causes the frequency of the output waveform to be voltage controlled. A positive going voltage will increase the frequency of the output signal.



3467-03

Fig. 2-2. Controls and Connectors.

(11) TRIG OUTPUT

One trigger pulse is generated at this connector for each cycle of the output waveform. The trigger output remains positive during the off time of the TRIG, GATE, and BURST modes.

(12) OUTPUT

This connector is the main output for all waveforms generated by the FG 5010.

ON – When this button is illuminated, the output is as defined by the programmed parameters. When the button is extinguished, generated signals are disconnected from the connector.

COMPLEMENT – When this button is illuminated, the output waveform is complemented. Offset remains the same.

OPERATING CONSIDERATIONS

Output Connections

The output of the FG 5010 is designed to operate as a 50 Ω voltage source working into a 50 Ω load. At higher frequencies, an unterminated or improperly terminated output will cause aberrations on the output waveform. Loads less than 50 Ω will reduce the waveform amplitude.

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

1. Use good quality 50 Ω coaxial cable and connectors.

2. Make all connections tight and as short as possible.

3. Use good quality attenuators if it is necessary to reduce waveform amplitude 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 FG 5010 is driving a high impedance such as the 1 MΩ input impedance (paralleled by a stated capacitance) of the vertical input of an oscilloscope, connect the transmission line to a 50 Ω attenuator, 50 Ω termination, and then the oscilloscope input. The attenuator isolates the input capacitance of the device, and the FG 5010 is properly terminated.

First Time Operation

The controls and connectors pages give a description of the front panel controls. The function and mode selection controls are outlined in blue. The parameter selection, memory, and output controls are outlined in gray. The trigger controls and input are outlined in green.

The following exercise will familiarize the operator with most functions of the FG 5010.

NOTE

If any discrepancies are encountered during the exercise, refer the condition to qualified service personnel.

Connect the FG 5010 OUTPUT to the vertical input of an oscilloscope. Use a suitable length of 50 Ω coaxial cable and a 50 Ω termination. Apply power to the oscilloscope and the FG 5010 power module.

When powered up, the FG 5010 performs a diagnostic self-test to check the functionality of the ROM and RAM. If an error is found, an error code will be displayed in the readout window. Error code definitions are listed in Table 2-1. The FG 5010 will not respond to input until the error is cleared.

Table 2-1
FRONT PANEL ERROR CODES

Code	Error
301	Interrupt fault
302	System error
311	Period measurement failed to complete
312	Period measurement overflow occurred
313	Shift register (in VIA) failed to function
314	Mag-latch relay strobe interrupt failed to occur
315	Phase lock status over and under range at the same time
316	Automatic frequency correction range exceeded
320	VIA fault on CPU board
321	Trig/Gate control error on CPU board
322	4 MHz reference frequency clock or counter fault
323	Frequency control logic fault on Loop 2 board
324	Loop cycle counter fault on Loop 2 board
325	Frequency prescaler fault on Loop 2 board
326	Low freq generator fault
327	No signal detected from Loop 1 board
328	Inadequate freq range - 2 kHz range
329	Inadequate freq range - 20 kHz range
330	Inadequate freq range - 200 kHz range
331	Inadequate freq range - 2 MHz range
332	Inadequate freq range - 20 MHz range
333	Burst counter fault
334	Offset generator fault
335	Amplitude DAC error
336	Amplitude attenuator error
337	Waveform shaping error
338	Normal/complement error
339	Low freq generator DAC error
340	Faulty RAM found (U1400)
341	Faulty RAM found (U1500)
350	Faulty RAM found in MPU chip
370	ROM placement error at address A000
372	ROM placement error at address C000
374	ROM placement error at address E000
390	ROM checksum error at address A000
392	ROM checksum error at address C000
394	ROM checksum error at address E000

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

The display will read 1.000 +3 and the HERTZ indicator will be illuminated.

Verify that the listed conditions have been set.

Table 2-2
POWER-UP CONDITIONS

Pushbuttons marked with an asterisk (*) will be illuminated.

Function	Condition
*FREQ	1.000 kHz
AMPL	0.5 volts
OFFSET	0.0 volts
PHASE	0 Deg
SYM	50%
N BURST	10
FUNCTION	*SINE
MODE	*CONT
HOLD	Off
*SLOPE	POSITIVE (+)
GATE	Off
OUTPUT	Off
COMPLEMENT	Off
AM	Off
FM	Off
VCF	Off

Press the AMPL button. The button will light, the display will read 500 −3, and the VOLTS indicator will be on.

Press the OFFSET button. The button will light, the display will read 0.00, and the VOLTS indicator will be on.

Press the SYM button. The button will light, the display will read 50, and the PERCENT indicator will be on.

Press the PHASE button. The button will light, the display will read 0, and the DEGREES indicator will be on.

Press the N BURST button. The button will light, the display will read 10, and all parameter indicators will be off.

Press the FREQ button.

Set the oscilloscope controls to:
Vertical — .2 V/Div
Horizontal — 1 ms/Div

Turn the FG 5010 OUTPUT on - the button will be illuminated.

The oscilloscope will display one complete cycle of the sine wave per division across the graticule. The waveform amplitude will be two and one half vertical divisions.

Alternately press the SINE, SQUARE, and TRIANGLE buttons and observe the various waveforms on the oscilloscope. The button will be illuminated when a particular waveform is being displayed.

With no input signal applied to the TRIG/GATE IN connector, modes other than CONT can be observed using the manual trigger button.

Press the TRIG button. The button will light and the oscilloscope will display a dc level. Press the MAN button repeatedly and observe that the TRIG'D indicator blinks each time the button is pressed. Also observe that one cycle of the selected waveform will be generated.

Press the GATE button. The button will light and the oscilloscope will display a dc level. Press the MAN button several times. Observe that the TRIG'D indicator will be illuminated and the selected waveform will be displayed as long as the button is held in.

Press the BURST button. The button will be illuminated and the oscilloscope will display a dc level. Press the MAN button repeatedly. Observe that the TRIG'D indicator will blink each time the button is pressed. Also observe that, depending on where along the oscilloscope sweep the trigger pulse occurs, ten cycles of the selected waveform will be generated.

The PH LOCK mode cannot be observed without the application of an external trigger signal.

Keyboard

The function of the numeric keyboard is to set parameter values and polarity, select increment size, and access the memory. The following will familiarize the operator with the keyboard.

Press the FREQ button. The button will be illuminated, the display will read 1.000 +3 (1 kHz), and the HERTZ indicator will be on.

On the keyboard, press key 2 and ENTER. The display will read 2.000 (2 Hz) and the HERTZ indicator will be on. Observe that when key 2 was pressed, the NOT ENTERED indicator started blinking, and continued to blink until the ENTER key was pressed, completing a valid entry. Also observe that the frequency of the displayed waveform changed accordingly.

Press the INCREMENT ↓ (down) button. The display will read 1.999 (Hz). Press the INCREMENT ↑ (up) button twice. The display now reads 2.001 (Hz). Press the INCREMENT ↓ (down) button again. The display now reads 2.000(Hz). Notice that there is an audible relay click when the display changes from 2.000 to 2.001 and again when it changes back to 2.000. This relay click is the change in range. The FG 5010 changes frequency ranges at 2 in decade steps. Increase the frequency several ranges, one at a time, and observe the range changes. Notice that when at attempt is made to enter 2 EEX 8, which exceeds the limit of the FG 5010 frequency range, the NOT ENTERED and ERROR indicators will blink. To relieve this condition press the CLEAR key. The last valid entry will now be displayed.

Value changes to the other paramters are accomplished in the same manner discussed above. Select the parameter; set the numeric value, decimal point, and exponent (EEX) as desired; press ENTER.

Notice that the FG 5010 will ignore a command to increment a step size large enough to set the selected parameter beyond specified limits.

The remaining functions (AM, FM, and VCF) cannot be observed without external signals.

This completes the operators front panel familiarization exercise.

OPERATING MODES

This part of the manual discusses local front panel operation only. Refer to the Programming section for remote operation and programming details.

Continuous (free-running) Output

The following procedure will provide continuous output from the FG 5010.

1. Select the desired waveform and press the CONT button.

2. Press FREQ and, via the keyboard, enter the desired frequency.

3. Press AMPL and, via the keyboard, enter the waveform amplitude.

4. Connect the load to the FG 5010 OUTPUT connector using suitable cable, attenuators terminators, etc.

5. Press the OUTPUT ON button.

When operating in the continuous mode, the output waveform and any applicable parameter can be changed at any time. To monitor the value of a given parameter, simply press the appropriate button; the value will be displayed with no affect on the output.

The HOLD function can be activated in this mode when the frequency of the output waveform is 200 Hz or less. The output will be held at its level until the HOLD button is pressed again.

Triggered, Gated, and Burst Output

These modes require application of an external trigger signal or manipulation of the manual trigger button. The output can also be triggered remotely over the GPIB; refer to the Programming Section for details.

NOTE

Frequency accuracy changes in these modes (see specifications). Frequency accuracy can be improved (≈0.1%) by setting up for CONT operation then switching to one of the triggered modes.

The trigger input impedance and trigger threshold level are selectable. The FG 5010 is shipped from the factory with the trigger input impedance set at 1 MΩ, which can be changed to 50 Ω. The trigger threshold level is set at 0.5 V and can be changed to 0 volts. These parameters are changed by relocating internal jumpers.

WARNING

Refer qualified service personnel to the Maintenance section of this manual for jumper locations.

When operating in these modes, the TRIG'D light functions as a trigger level indicator. With +SLOPE selected, when the input signal is above the threshold level the TRIG'D light will be continuously on. When the input signal is below the threshold level, the TRIG'D light is continuously off. A flashing light means the input signal is transitioning the threshold and toggling the input. When −SLOPE is selected, the TRIG'D light functions but the polarities are reversed.

It should be noted that the generator can be triggered manually only on + SLOPE when operating in these modes.

Under some operating conditions (particularly with low-amplitude input signals approaching 20 MHz) the TRIG'D light may disagree with the actual operating state of the FG 5010. Should this be the case, a slight increase in input signal amplitude will correct the disagreement.

Triggered Output

In this mode, one cycle of the selected waveform is generated for each trigger signal at the TRIG/GATE IN connector. Set up is as described under Continuous Output. Unless the SLOPE button is extinguished to select − SLOPE, + SLOPE will be assumed.

Gated Output

In this mode, the selected waveform is generated continuously for the duration of the gating pulse applied to the TRIG/GATE IN connector. If triggered manually, output will be continuous until the MAN button is released. As in triggered mode, + SLOPE will be assumed unless the SLOPE button is extinguished to select − SLOPE.

Burst Output

In this mode, a pre-determined number of cycles of the selected waveform is generated each time the generator is triggered. The number of cycles per burst is selectable via the keyboard from 1 to 9999. The first pulse edge to pass through the threshold level will trigger the generator. All subsequent pulses will be ignored until the selected burst is complete. The next pulse after the burst is complete will restart the generator and repeat the burst. If desired, the burst can be triggered with the manual trigger button.

Phase Locked Output

The FG 5010 utilizes Auto Scanning Phase Lock for this mode of operation. The control circuit automatically changes frequency ranges until the input signal is within capture range and phase lock can occur. The instrument will automatically lock on any toggling input of sufficient amplitude within the 20 Hz to 20 MHz range. When phase lock has occurred, the LOCK'D indicator will be illuminated.

Modulated and Voltage Controlled Output

The FG 5010 output can be amplitude modulated (AM), frequency modulated (FM), or swept with a voltage applied to the input connector (VCF).

Amplitude Modulation (AM) - A modulating signal of approximately 5 V peak to peak applied to the AM INPUT connector will provide 100% modulation of the output. It should be noted that when AM is selected, with no input signal applied, the amplitude of the output waveform is reduced by 50%. This is done so that at 100% modulation, the peak-to-peak amplitude of the output will be as selected by the operator.

Frequency Modulation (FM) - When this function is activated, the output signal becomes the FM carrier. A modulating signal applied to the input connector will deviate the output approximately 1% per volt.

Voltage Controlled Frequency (VCF) - The frequency of any selected waveform can be swept within a range of 1000:1 by connecting a voltage source to the FM/VCF INPUT connector. The polarity of the VCF input signal determines which direction the output will deviate from the selected frequency. A positive going voltage increases the frequency, while a negative going voltage decreases the frequency. The amplitude and polarity of the input voltage can be selected within a range of +10 V to −3 V depending on the output frequency selected.

It should be noted that, although the FG 5010 is capable of three decades of sweep, the full 1000:1 frequency variation may not be possible. The generator can only be swept to the top of its normal frequency ranges. The FG 5010 frequency ranges change at 2 in decade steps from .02 Hz through 20 MHz.

When the VCF function is activated, the range within which the selected output frequency falls is locked, which sets the upper sweep limit. If for instance, 10 kHz (which falls within the 2 kHz to 20 kHz range) is selected as the output frequency, the generator can only be swept up to 20 kHz. If a second, or start, frequency is not selected after activating VCF, 10 kHz will be the assumed start frequency. With sufficient positive voltage applied to the input connector, the output will sweep between 10 kHz and 20 kHz. It will take significantly less than 10 volts to accomplish this, resulting in considerably less than a 1000:1 sweep. The output can also be swept downward as far as a negative 3 volt signal will take it.

A second, or start, frequency can be selected after activating the VCF function. Provided the two frequencies are not more than three ranges apart, the output can be swept between them. For example; select 10 kHz (20 kHz is top of range), activate VCF, and select 20 Hz. Under these conditions, with adequate positive voltage applied, the output will sweep between 20 Hz and 20 kHz, a full three decades.

Since zero frequency can be selected, total external control of the frequency capabilities of the FG 15010 is possible. The generator can be swept between 0 and 2 Hz (1000:1) with a positive 10 volt input signal.

MISCELLANEOUS OPERATING CONSIDERATIONS

Memory

Up to ten complete instrument setups can be stored in the FG 5010 memory. All operating functions except increment size are stored. Once a setup has been stored, it remains in memory until changed or power is removed. Recalling a setup does not erase it from memory.

NOTE

If power is interrupted for any reason, all memory is lost and will revert to power up conditions when power is restored.

At power up, the initial settings described under First Time Operation are all stored in each of the ten memory locations. To store a setup, it is necessary to enter into memory only those functions that differ from the power up setting. Once a setup has been defined, a STORE command followed by a 0 to 9 digit and ENTER places the setup in the selected memory location. A RECALL command followed by a 0 to 9 digit and ENTER will retrieve the data in the specified location. To change part or all of a setup in memory, call up the desired function(s), set the new value(s), and enter a STORE command for the location that contains that setup; the new information is written over the old.

Increment

The INCREMENT buttons allow the numeric value of the function parameters to be increased or decreased in selectable step size. At power up, the increment size for all parameters defaults to the least significant digit (LSD) displayed. The increment size for any parameter can be set to any value within specified limits.

To set increment size:

1) Call up the desired parameter;
2) press the INCR SIZE button;
3) enter the numeric value on the keyboard; and
4) press ENTER.

Notice that the INCR SIZE button is illuminated during this operation. When the entry has been accepted as valid, but button is extinguished. The next parameter may now be called up.

A single depression of the desired increment button will change the value of the selected parameter by one step. When the button is held in the HOLD FOR AUTO position, the parameter value will increment automatically up or down until the button is released or the parameter limit is reached. When in AUTO increment, the rate of change is slow at start and accelerates to a very rapid, finite rate. To revert to the LSD condition, select INCR SIZE, press 0 (LSD) on the keyboard, and ENTER.

It should be noted that an attempt to increment a parameter beyond specified limits will be ignored. No error conditions results.

Errors

When an attempt is made to enter an invalid or out of range number from the keyboard, the ERROR and NOT ENTERED indicators will blink. All further instructions will be ignored until the error is cleared. Depressing the CLEAR button returns the instrument to the condition it was in just prior to the start of the invalid entry.

If any key other than the numeric keyboard generates a conflict, only the ERROR indicator will blink. Errors of this nature are cleared by depressing any key except INST ID and the key that caused the error.

Errors caused by front panel entries do not generate a service request (SRQ). Erroneous commands received over the GPIB generate a service request, but do not display an error code on the front panel. Refer to the Programming Section.

CENTER WAVEFORM TIME RELATIONSHIPS

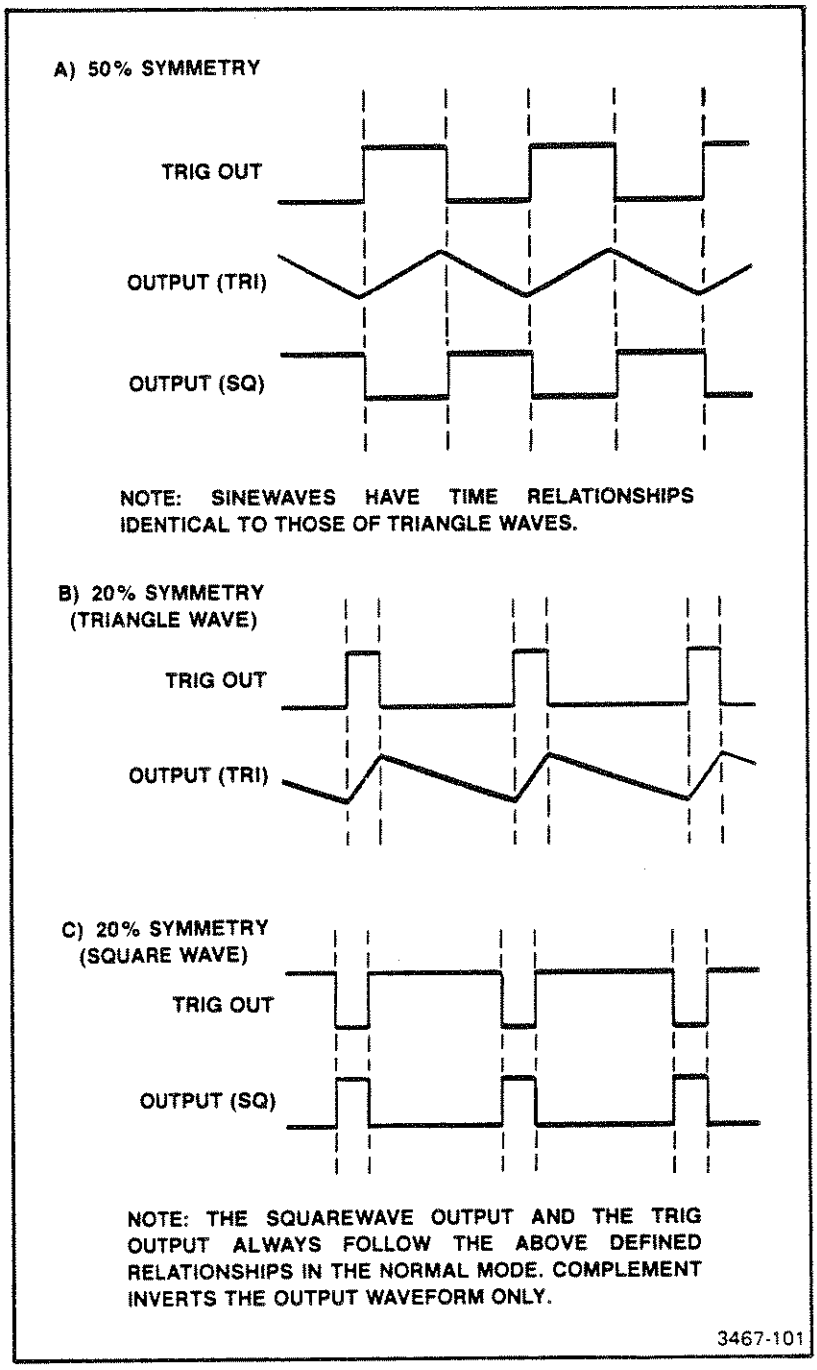


Fig. 2-3. Continuous Mode Waveforms

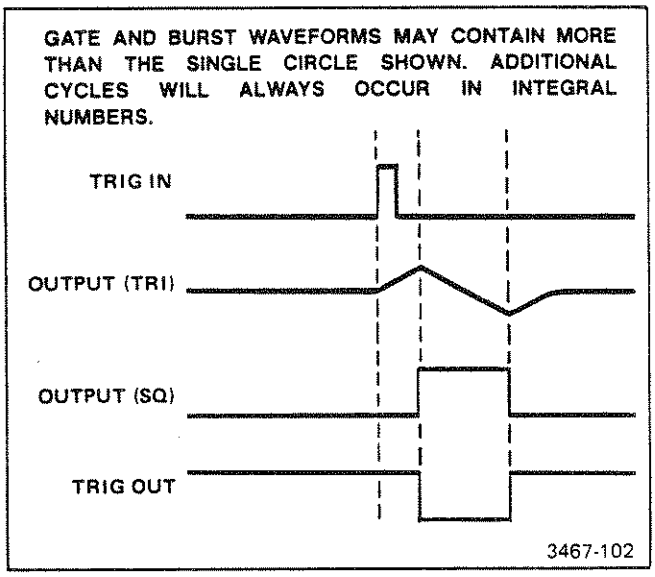


Fig. 2-4. Trig. Gate and Burst Waveforms

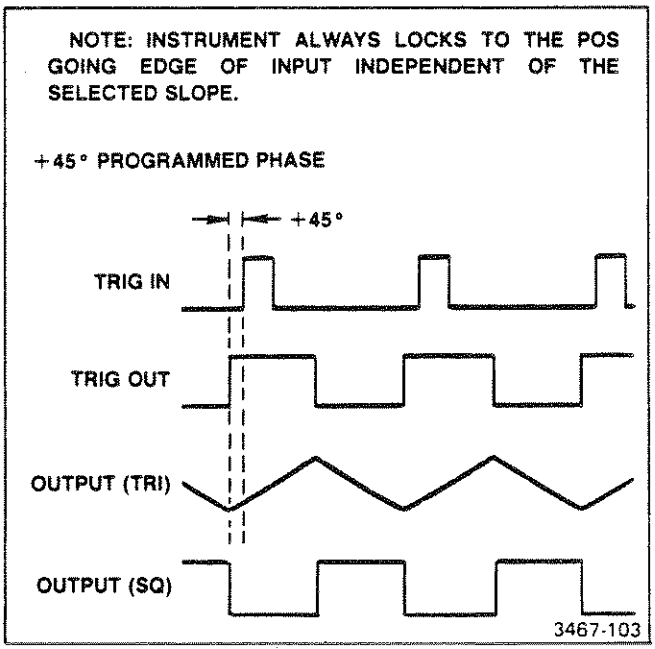


Fig. 2-5. Ø—Lock Mode Waveforms

PROGRAMMING

INTRODUCTION

This manual section provides the information required for programming the FG 5010 Programmable 20 MHz Function Generator via the IEEE-488 bus. This information assumes that the reader is knowledgeable in IEEE-488 bus communication and has had some experience in programming the system that acts as the controller for the FG 5010. Communication via the IEEE-488 bus is specified and described in IEEE-Standard 488-1978, Standard Digital Interface for Programmable Instrumentation[1]. 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.

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 the power-up states.

Commands are presented in three formats:

- Command Functional Groups—A command list divided into functional groups with brief descriptions of commands.
- Control/Command Associations—A front panel illustration showing command relationships to front panel operation and internal parameters.
- Detailed Command Descriptions—An alphabetically arranged presentation of all commands with complete detailed descriptions.

TM 5000 programmable instruments connect to the IEEE-488 bus through a TM 5000 power module. (Refer to the Operating Instructions section of this manual for information on installing the FG 5010 in the power module. Also, it would be advantageous to reveiw that section to become familiar with front panel and internally selectable instrument functions. The IEEE-488 bus primary address for the FG 5010 is selectable from the back of the insrument when it is removed from the power module. The FG 5010 is shipped with the address set to decimal 24. The message terminator is also selectable from the back of the instrument when it is removed from the power module. (Message terminators are described in this section, in the portion entitled Messages and Communications Protocol.) TM 5000 instruments are shipped with this terminator set to EOI only. Pressing the INST ID push button causes the FG 5010 to display its selected IEEE-488 bus primary address; the right-hand decimal point lights if the selected message terminator is LF/EOI.

[1]Published by the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, N.Y. 10017.

COMMANDS

The FG 5010 is controlled either by front panel controls or through commands received from the controller. These commands are of three types:

Setting—control instrument settings.
Query/Output—request data.
Operational—cause a particular action.

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

Command Functional Groups

The following list of commands is arranged by functional group; the instrument commands group is in turn divided into sub-groups by classification.

Instrument Commands

Function Selection

FUNC SINE—Selects sine waveform for output.

FUNC SQUARE—Selects square waveform for output.

FUNC TRIANGLE—Selects triangular waveform for output.

FUNC?—Returns output waveform selection status.

HOLD ON—Causes output voltage to be held at current value.

HOLD OFF—Causes resumption or continuance of selected output waveform.

HOLD?—Returns hold status, on or off.

SINE—Selects sine waveform output.

SQUARE—Selects square waveform output.

TRIANGLE—Selects triangular waveform output.

Mode Control

MODE CONT—Selects continuous output mode.

MODE TRIG—Selects triggered output mode.

MODE GATE—Selects gated output mode.

MODE BURST—Selects burst output mode.

MODE LOCK—Selects phase locked output mode.

MODE PHLOCK—Selects phase locked output mode.

MODE?—Returns mode status.

Trigger Control

GATE ON—Causes gated output to be enabled.

GATE OFF—Causes gated output to be disabled.

GATE?—Returns gate status, on or off.

LOCK?—Returns phase lock status.

MANUAL—Causes finite duration output, with duration dependent upon mode.

MTRIG—Causes finite duration output, with duration dependent upon mode.

SLOPE POS—Selects low to high trigger transition.

SLOPE NEG—Selects high to low trigger transition.

SLOPE?—Returns selected transition status.

TRIG?—Returns state of trigger/gate input signal.

Parameter Settings

AMPL—Selects peak-to-peak output amplitude.

AMPL?—Returns selected output amplitude.

FREQ—Selects output frequency.

FREQ?—Returns selected output frequency.

NBUR—Sets number of cycles in each burst in burst mode.

NBUR?—Returns selected burst number.

OFFS—Sets output offset voltage.

OFFS?—Returns selected offset voltage.

PHAS—Selects relationship of output signal phase to trigger/gate signal phase.

PHAS?—Returns selected phase angle.

SYM—Selects output signal duty cycle.

SYM?—Returns selected duty cycle.

Modulation Control

AM ON—Causes amplitude modulation to be enabled.

AM OFF—Causes amplitude modulation to be disabled.

AM?—Returns amplitude modulation status, on or off.

FM ON—Causes frequency modulation to be enabled.

FM OFF—Causes frequency modulation to be disabled.

FM?—Returns frequency modulation status.

VCF ON—Causes voltage controlled frequency to be enabled.

VCF OFF—Causes voltage controlled frequency to be disabled.

VCF?—Returns voltage controlled frequency status.

Stored Settings

LLSET—Causes instrument to assume settings contained in binary block argument.

REC—Reinstitutes settings that were previously stored.

SEND—Selects stored settings data for output.

STOR—Stores current settings for later use.

Display Selection

DISP FREQ—Causes display of programmed output frequency.

DISP AMPL—Causes display of programmed output amplitude.

DISP OFFS—Causes display of programmed output offset voltage.

DISP NBURST—Causes display of programmed output burst length.

DISP PHASE—Causes display of programmed output phase angle.

DISP SYM—Causes display of programmed output duty cycle.

Input/Output Control Commands

COMP ON—Selects complemented output signal.

COMP OFF—Selects uncomplemented output signal.

COMP?—Returns output signal status, complemented or uncomplemented.

OUT ON—Causes output signal to be supplied from front panel connector via relay contact closure.

OUT OFF—Causes output signal to be disconnected from front panel connector via relay contact opening.

OUT?—Returns output signal status, on or off.

System Commands

DT SET—Causes instrument to wait for <GET> before updating settings.

DT TRIG—Causes instrument to trigger on <GET> with output dependent upon mode.

DT GATE—Causes gate signal to toggle on <GET> in gate mode.

DT OFF—Disables <GET> function.

DT?—Returns device trigger status.

ERR?—Returns code of last error reported by serial poll.

ID?—Returns instrument identification information.

INIT—Causes initialization of instrument parameter settings.

SET?—Returns information on current instrument settings.

TEST—Causes instrument to suspend signal output and perform self tests.

Status Commands

PLI ON—Causes phase lock interrupt to be enabled.

PLI OFF—Causes phase lock interrupt to be disabled.

PLI?—Returns phase lock status, on or off.

RQS ON—Enables service request generation.

RQS OFF—Disables service request generation.

RQS?—Returns service request generation status, on or off.

USER ON—Enables service request generation upon user's pressing front panel INST ID pushbutton.

USER OFF—Disables service request generation by user.

USER?—Returns user SRQ generation status, on or off.

Control/Command Associations

Figure 3-1 shows the FG 5010 front panel and its control relationships to associated commands.

Detailed Command Descriptions

Each FG 5010 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 FG 5010 and the controller.

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

<NUM> —A number that can be transmitted or accepted by the FG 5010. Numbers may be in NR1 (integer), NR2 (decimal), and NR3 (with exponent) formats. (See ANSI Standard X3.42.)

<BINBLK> —A Binary Block of data in the format specified in Tektronix Codes and Formats (V79.1). The binary block consists of the percent sign (%, decimal 37) followed by a two-byte binary count and the data bytes, and ends with a checksum. 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.

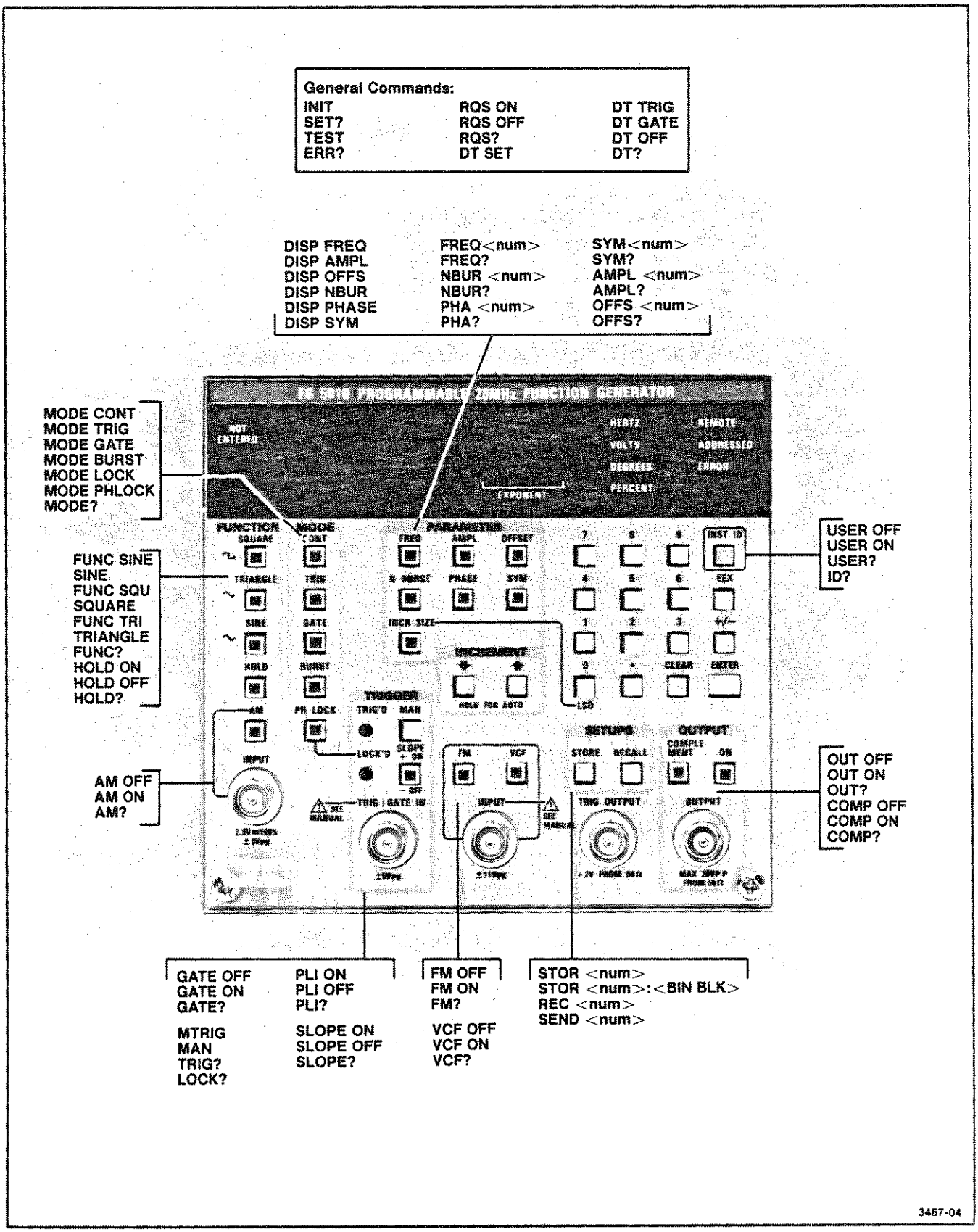


Fig. 3-1. Command associations to controls.

AM (Amplitude Modulation)

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 AM command enables or disables the FG 5010 amplitude modulation function. When enabled, the signal applied to the AM input connector modulates the output signal amplitude. When amplitude modulation is selected, the open-circuit output amplitude is reduced to half the programmed value with no modulating signal applied. At 100-percent modulation, the open-circuit peak-to-peak output amplitude is equal to the programmed amplitude. Valid arguments are:

ON—Enables the amplitude modulation function.

OFF—Disables the amplitude modulation function.

The power-on settings is AM OFF. An AM query returns the function status.

AMPL (Amplitude)

Type:
Setting or Query

Setting Syntax:
AMPL <NUM>

Examples:
AMPL 1000E-3
AMPL 1
AMPL 0.5

Query Syntax:
AMPL?

Query Response:
AMPL <NUM>;

Discussion:

The AMPL command sets the FG 5010 output peak-to-peak open-circuit amplitude to the value specified by the argument. The argument is specified in volts. The power-on setting is 0.5 volt ("500.0E-3"). An AMPL query returns the amplitude.

The argument range is 0.0 to 20.0 V; the argument resolution is as follows:

20 mV from 2.0 V to 20.0 V
2 mV from 0.2 V to 2.0 V
0.2 mV from 0.02 V to 0.2 V

There is only one valid setting below 0.02 V; it is 0.0 V. The peak amplitude (half of the programmed value) plus the offset must be 15.0 V or less.

COMP (Complement)

Type:
Setting or Query

Setting Syntax:
COMP { ON / OFF

Examples:
COMP ON
COMP OFF

Query Syntax:
COMP?

Query Response:
COMP ON;
COMP OFF;

Discussion:

The COMP command controls the complementing of the FG 5010 output waveform. The offset voltage remains unchanged. Valid arguments are:

ON—Causes the output waveform to be inverted.

OFF—Causes the output waveform to be not inverted.

The power-on setting is COMP OFF. A COMP query returns the output waveform status.

DISP (Display)

Type:
Operational

Syntax:
DISP { FREQ / AMPL / OFFS / NBURST / PHASE / SYM

Examples:
DISP FREQ
DISP AMPL
etc.

Discussion:

The DISP command selects the FG 5010 output signal parameter to be displayed. Valid arguments are:

FREQ—Causes the programmed output frequency to be displayed.

AMPL—Causes the programmed output amplitude to be displayed.

OFFS—Causes the programmed output offset voltage to be displayed.

NBURST—Causes the programmed output burst length to be displayed.

PHASE—Causes the programmed output phase value to be displayed.

SYM—Causes the programmed output symmetry value to be displayed.

The FREQ parameter is displayed at power-on.

DT (Device Trigger)

Type:
Setting or Query

Setting Syntax:
DT { SET | TRIG | GATE | OFF }

Examples:
DT SET
DT TRIG
DT GATE
DT OFF

Query Syntax:
DT?

Query Response:
DT SET;
DT TRIG;
DT GATE;
DT OFF;

Discussion:

The DT command controls the FG 5010 response to <GET>.

Valid arguments are:

SET—Causes the FG 5010 to wait for <GET> before updating the settings.

TRIG—Causes the FG 5010 to trigger on <GET> and produce a single cycle of output in TRIG mode or a burst of cycles in NBURST mode. (The number of cycles is set by the NBURST command.) This signal may be blocked by an external trigger input that remains continuously above the trigger threshold (SLOPE = +), or below the trigger threshold (SLOPE = −). This condition is indicated by a steadily lighted TRIG'D indicator.

GATE—Causes the FG 5010 internal gate setting to toggle on <GET> when in GATE mode. (This signal may be overridden by an external gate input.)

OFF—Disables the FG 5010 response to <GET>.

A DT query causes return of DT SET;, DT TRIG;, DT GATE;, or DT OFF;, as appropriate.

The power-on setting is DT OFF.

ERR (Error)

Type:
Query only

Query Syntax:
ERR?

Query Response:
ERR <NUM>;

Discussion:

The ERROR query causes the FG 5010 to respond with status information. If RQS is on, the ERR query returns an event code number that describes why the RQS bit was set in the last status byte reported by the FG 5010. The event is then cleared. (The event codes are listed in Table 3-1 at the end of this section.) If RQS is off, the ERR query returns an event code number that describes the highest priority condition currently pending in the FG 5010. This event is then cleared; another ERR query will return the event code for the next highest priority condition pending.

FM (Frequency Modulation)

Type:
Setting or Query

Setting Syntax:
FM { ON / OFF

Examples:
FM ON
FM OFF

Query Syntax:
FM?

Query Response:
FM ON;
FM OFF;

Discussion:

The FM command enables or disables the FG 5010 frequency modulation function. When enabled the signal applied to the FM/VCF INPUT connector modulates the output frequency about the center frequency selected by the frequency setting. Valid arguments are:

ON—Enables the frequency modulation function.

OFF—Disables the frequency modulation function.

The power-on setting is FM OFF. An FM query returns the function status.

The VCF function is automatically disabled when the FM ON command is executed. The FM function may not be enabled while the FG 5010 is in the PHLOCK mode.

FREQ (Frequency)

Type:
Setting or Query

Setting Syntax:
FREQ <NUM>

Example:
FREQ 1960
FREQ 3E+5

Query Syntax:
FREQ?

Query Response:
FREQ <NUM>;

Discussion:

The FREQ command sets the FG 5010 output frequency to the value specified by the argument. The argument is specified in hertz. The power-on setting is 1 kHz. A FREQ query returns the programmed frequency.

The argument range is 0.002 Hz to 20.0 MHz. In VCF mode, the frequency may be set to 0.0 Hz. The argument resolution is ordinarily four digits, but is three digits under the following conditions:

VCF function enabled; or
FM function enabled; or
MODE is TRIG, GATE, or BURST and FREQ is greater than 200.0 Hz.

Limits are as follows: The frequency may not be set higher than 200.0 Hz when the hold function is enabled; the frequency may not be set higher than that frequency which, in conjunction with the symmetry setting, requires a triangle ramp time of less than 25 ns.

FUNC (Function)

Type:
Setting or Query

Setting Syntax:
FUNC { SINE / SQUARE / TRIANGLE }

Examples:
FUNC SINE
FUNC SQUARE
FUNC TRIANGLE

Query Syntax:
FUNC?

Query Response:
FUNC SINE;
FUNC SQUARE;
FUNC TRIANGLE;

Discussion:

The FUNC command causes the FG 5010 to select the specified waveform type for output. A FUNC query response will indicate that the output is a sine wave, a square wave, or a triangular wave. The power-on setting is the sine-wave output. The header "FUNCTION" or "FUNC" is optional; that is, the commands FUNC SINE and SINE are equivalent.

GATE

Type:
Setting or Query

Setting Syntax:
GATE ON / OFF

Examples:
GATE ON
GATE OFF

Query Syntax:
GATE?

Query Response:
GATE ON;
GATE OFF;

Discussion:

The GATE command controls the state of the FG 5010 output gate. In the GATE mode, an output signal is supplied only when the gate is on. Valid arguments are:

ON—Enables the output waveform.

OFF—Disables the output waveform at end of next complete cycle.

The power-on setting is GATE OFF. A GATE query will return the gate status.

The gate may be set to the "on" state only if the FG 5010 is in the gated mode, and the gate setting will be turned off automatically if any other mode is selected. (Refer to the DT command description for control of gate setting via <GET>.) The GATE OFF command may be overridden by an external gate input.

HOLD

Type:
Setting or Query

Setting Syntax:
HOLD { ON
OFF

Examples:
HOLD ON
HOLD OFF

Query Syntax:
HOLD?

Query Response:
HOLD ON;
HOLD OFF;

Discussion:

The HOLD command causes the FG 5010 output voltage to be held at the value current when the command is executed. For the HOLD command to be operable, the frequency setting must be 200 Hz or less and the mode must not be PH LOCK. Valid arguments are:

ON—Causes the output waveform to be held at the voltage value that was being generated upon execution of the HOLD ON command.

OFF—Causes the FG 5010 to resume the output waveform that was being generated before execution of the HOLD ON command.

The power-on setting is HOLD OFF. A HOLD query will return the hold status as shown.

ID (Identify)

Type:
Query only

Query Syntax:
ID?

Query Response:
ID TEK/FG5010,V79.1,Fxx;

Discussion:

The ID command causes the FG 5010 to respond with instrument identification information. This information includes:

ID TEK/FG 5010—indicates the instrument type.

V79.1—indicates the codes and formats version.

Fxx—indicates the firmware version number.

INIT (Initialize)

Type:
Operational

Syntax:
INIT

Discussion:

The INIT command performs an initialization of the FG 5010 parameter settings as in the power-on sequence. All settings except the step size and stored settings are initialized. However, the INIT command does not cause the FG 5010 to generate a power-on SRQ or to revert to local mode as does the power-on sequence.

LLSET (Low Level Settings)

Type:
Setting or Query

Setting Syntax:
LLSET <BINBLK>

Example:
LLSET %<byte count><data bytes><checksum>;

Query Syntax:
LLSET?

Query Response:
LLSET <BINBLK>;

Discussion:

CAUTION

Binary settings data must not be modified or generated by the user. The FG 5010 must be sent only binary settings data that have been generated by an FG 5010.

The LLSET command programs the FG 5010 to the settings represented in the binary block argument, and is used for rapid transfer of settings. The binary block is generated by the FG 5010 and is not intended to be modified by the user.

An LLSET query returns all FG 5010 settings in low-level (binary) format.

LOCK

Type:
Query only

Query Syntax:
LOCK?

Query Response:
LOCK −1;
LOCK 0;
LOCK 1;

Discussion:

The LOCK query causes the FG 5010 to respond with an indication of the phase lock status. Valid responses are:

−1—Phase lock mode not selected.

0—Phase lock mode selected, but not currently locked.

1—Phase lock mode selected, currently locked.

MAN (Manual)

(See MTRIG command.)

MODE

Type:
Setting or Query

Setting Syntax:
MODE { CONT | TRIG | GATE | BURST | LOCK | PHLOCK }

Examples:
MODE CONT
MODE TRIG
etc.

Query Syntax:
MODE?

Query Response:
MODE CONT;
MODE TRIG;
MODE GATE;
MODE BURST;
MODE LOCK;

Discussion:

The MODE command selects the FG 5010 operating mode. Valid arguments are:

CONT—Causes the FG 5010 to produce a continuous output. Trigger events are ignored.

TRIG—Causes the FG 5010 to produce one cycle of the selected output waveform each time a trigger is received.

GATE—Causes the FG 5010 to produce an output signal only during the time when the gate is enabled. The gate is defined as enabled when: 1) the front panel MAN trigger pushbutton is pressed and held; 2) the GATE ON command has been received; or 3) the trigger/gate input signal is true.

BURST—Causes the FG 5010 to produce a burst N cycles in length when a trigger is received, with the number of cycles (N) specified by the burst number setting (NBURST). Trigger events received during an active burst are ignored.

LOCK or PHLOCK—Causes the FG 5010 to produce an output signal frequency and phase adjusted to match that of the signal on the trigger/gate input. When an input is present at the trigger/gate input in the range of 20 Hz to 20 MHz, the FG 5010 will initiate an automatic scan to acquire lock.

The phase lock mode may not be selected when the FM function, the VCF function, or the HOLD function is enabled.

The power-on setting is CONT mode. A MODE query returns the mode status as shown.

MTRIG (Manual Trigger)

Type:
Operational

Syntax:
MTRIG

Discussion:

The MTRIG command causes the FG 5010 to produce one output cycle in triggered mode or N cycles in burst mode. (The trigger/gate input must be false or triggering will not be possible.) The MAN command may also be used for this function.

NBUR (NBurst)

Type:
Setting or Query

Setting Syntax:
NBUR <NUM>

Example:
NBUR 80

Query Syntax:
NBUR?

Query Response:
NBUR <NUM>;

Discussion:

The NBUR command selects the number of cycles in each burst when the FG 5010 is operating in burst mode. The number of cycles is specified by the argument, with the argument range from 1 through 9999 and the argument resolution of 1.

The power-on setting is 10. An NBUR query returns the programmed value.

OFFS (Offset)

Type:
Setting or Query

Setting Syntax:
OFFS <NUM>

Example:
OFFS 4.5

Query Syntax:
OFFS?

Query Response:
OFFS <NUM>;

Discussion:

The OFFS command sets the FG 5010 open-circuit output offset voltage to the value specified in the argument. The offset value is specified in volts, with the argument range from 0.0 V to ±7.5 V and the argument resolutin of 0.01 V. Note that the offset plus the peak amplitude (half of the programmed value) must be 15.0 V or less.

The power-on setting is 0. An OFFS query returns the programmed offset value.

OUT (Output)

Type:
Setting or Query

Setting Syntax:
OUT { ON / OFF

Examples:
OUT ON
OUT OFF

Query Syntax:
OUT?

Query Response:
OUT ON;
OUT OFF;

Discussion:

The OUT command controls connection of the FG 5010 output signal to the output connector. The form of the output is as selected by the other parameters. Valid arguments are:

ON—Causes the output relay to close, connecting the output signal connector.

OFF—Causes the output relay to open, disconnecting the output signal connector.

The power-on setting is OUT OFF. An OUT query returns the status of the output connection.

PHAS (Phase)

Type:
Setting or Query

Setting Syntax:
PHAS <NUM>

Example:
PHAS 60

Query Syntax:
PHAS?

Query Response:
PHAS <NUM>

Discussion:

In phase lock mode, the PHAS command sets the FG 5010 output signal phase, relative to the phase of the trigger/gate input signal, to the value specified in the argument. The argument is specified in degrees. In triggered, gated, or burst modes the phase number specifies the point on the triangle waveform at which the FG 5010 starts its initial cycle when triggered.

The power-on setting is 0. A PHAS query returns the programmed phase.

PLI (Phase Lock Interrupt)

Type:
Setting or Query

Setting Syntax:
PLI { ON
OFF

Examples:
PLI ON
PLI OFF

Query Syntax:
PLI?

Query Response:
PLI ON;
PLI OFF;

Discussion:

The PLI command controls enabling of the FG 5010 phase lock interrupt. If RQS is ON, a service request will be generated when the FG 5010 makes a transition into or out of the phase locked state. If RQS is OFF, the event can be detected via the ERR query. (PLI applies only in phase lock mode.) Valid arguments are:

ON—Causes the phase lock interrupt to be enabled.

OFF—Causes the phase lock interrupt to be disabled.

The power-on setting is PLI OFF. A PLI query returns the interrupt status.

REC (Recall)

Type:
Operational

Syntax:
REC <NUM>

Example:
REC 8

Discussion:

The REC command causes the FG 5010 settings to be restored to those values stored in the location specified by the argument. DT, PLI, RQS, and USER settings remain unchanged. Recall of locations that have not been stored into, since power on, return to the power-on settings. The argument range is 0 through 9. The step size parameters current upon receipt of the command remain unchanged.

RQS (Request for Service)

Type:
Setting or Query

Setting Syntax:
RQS { ON
    { OFF

Examples:
RQS ON
RQS OFF

Query Syntax:
RQS?

Query Response:
RQS ON;
RQS OFF;

Discussion:

The RQS command controls the FG 5010 service request generation. Valid arguments are:

ON—Allows the FG 5010 to generate an SRQ.

OFF—Prevents the FG 5010 from generating an SRQ.

An RQS query returns the current status. The ERR query can be used while RQS is off to ascertain if any SRQ conditions have occurred. An SRQ will be generated for any previously unreported SRQ events when RQS is turned on after having been off.

The power-on setting is RQS ON.

SEND

Type:
Output

Syntax:
SEND<NUM>,.....,<NUM>

Example:
SEND 9
SEND 5, 2, 9

Response:
STORE <NUM>:<BINBLK>;
STORE <NUM>:<BINBLK>,<NUM>:<BINBLK>,
<NUM>:<BINBLK>;

Discussion:

CAUTION

Binary settings data must not be modified or generated by the user. The FG 5010 must be sent only binary settings data that have been generated by an FG 5010.

The SEND command causes the FG 5010 to supply as output the contents of the stored settings location(s) specified by the argument(s). The argument range is from 0 through 9.

Returned values will be formatted as shown where the number (NUM) is the storage location and the binary data (BINBLK) contain binary settings data.

SET

Type:
Query only

Query Syntax:
SET?

Query Response:
FREQ 1.0E+3;AMPL 500.0E−3;OFFS 0.0;SYM 50;
PHASE 0;NBUR 10;
FUNC SINE;MODE CONT;SLOPE POS;OUT
OFF;COMP OFF;AM OFF;
FM OFF;VCF OFF;HOLD OFF;GATE OFF;PLI OFF;DT
OFF;USER OFF;RQS ON;

Discussion:

The SET query causes the FG 5010 to respond with information on all current instrument settings that can be queried. This response information may then be used at a later time to return the FG 5010 to those settings.

SINE

Type:
Setting only

Syntax:
SINE

Discussion:

the SINE command causes the FG 5010 output to be in sinewave form. Selection of sinewave output cancels any previous selection. This command is a special case of the FUNC command. The header (FUNC) is optional, but the argument (SINE) is not.

SLOPE

Type:
Setting or Query

Setting Syntax:
SLOPE { POS
{ NEG

Examples:
SLOPE POS
SLOPE NEG

Query Syntax:
SLOPE?

Query Response:
SLOPE POS;
SLOPE NEG;

Discussion:

The SLOPE command controls the setting of the FG 5010 trigger/gate active edge/state. Valid arguments are:

POS—A low to high transition causes a trigger to occur in triggered modes; a high state causes the gate to be on in gated mode.

NEG—A high to low transition causes a trigger to occur in triggered modes; a low state causes the gate to be on in gated mode.

The power-on setting is POS. (The FG 5010 always triggers on the positive slope in the phase lock mode.)

SQUARE

Type:
Setting only

Syntax:
SQUARE

Discussion:

The SQUARE command causes the FG 5010 output to be in squarewave form. Selection of squarewave output cancels any previous selection. This command is a special case of the FUNC command. The header (FUNC) is optional, but the argument (SQUARE) is not.

STOR (Store)

Type:
Operational

Syntax:
STOR <NUM>:<BINBLK>,.....,<NUM><BINBLK>

Example:
STOR 7
STOR 7, 8
STOR 5:<BINBLK>,6:<BINBLK>,7, 2

Discussion:

The STOR command causes the FG 5010 to store the current settings in the location(s) specified by the argument(s). Multiple arguments are allowed if separated by a comma or a space. The argument range is 0 through 9. The STEP SIZE, DT, PLI, RQS, and USER settings are not stored.

CAUTION

Binary settings data must not be modified or generated by the user. The FG 5010 must be sent only binary settings data that have been generated by an FG 5010.

The STOR command may also be used to fill a storage location with settings data specified in a binary block argument. In this case, the storage location number must be followed by a colon, which is then followed by the binary settings, in binary block format. To obtain storage location contents in binary forms, refer to the SEND command.

SYM (Symmetry)

Type:
Setting or Query

Setting Syntax:
SYM <NUM>

Example:
SYM 85

Query Syntax:
SYM?

Query Response:
SYM <NUM>;

Discussion:

The SYM command sets the duty cycle of the FG 5010 output signal to the percentage value specified in the argument. The argument range is 10 through 90 percent, with a resolution of 1 percent. Signal symmetry may not be set to a value that, in conjunction with the frequency setting, requires a triangle ramp time less than 25 ns. Refer to Fig. 3-2.

The power-on setting is 50 percent. A SYM query returns the duty cycle number that was last specified.

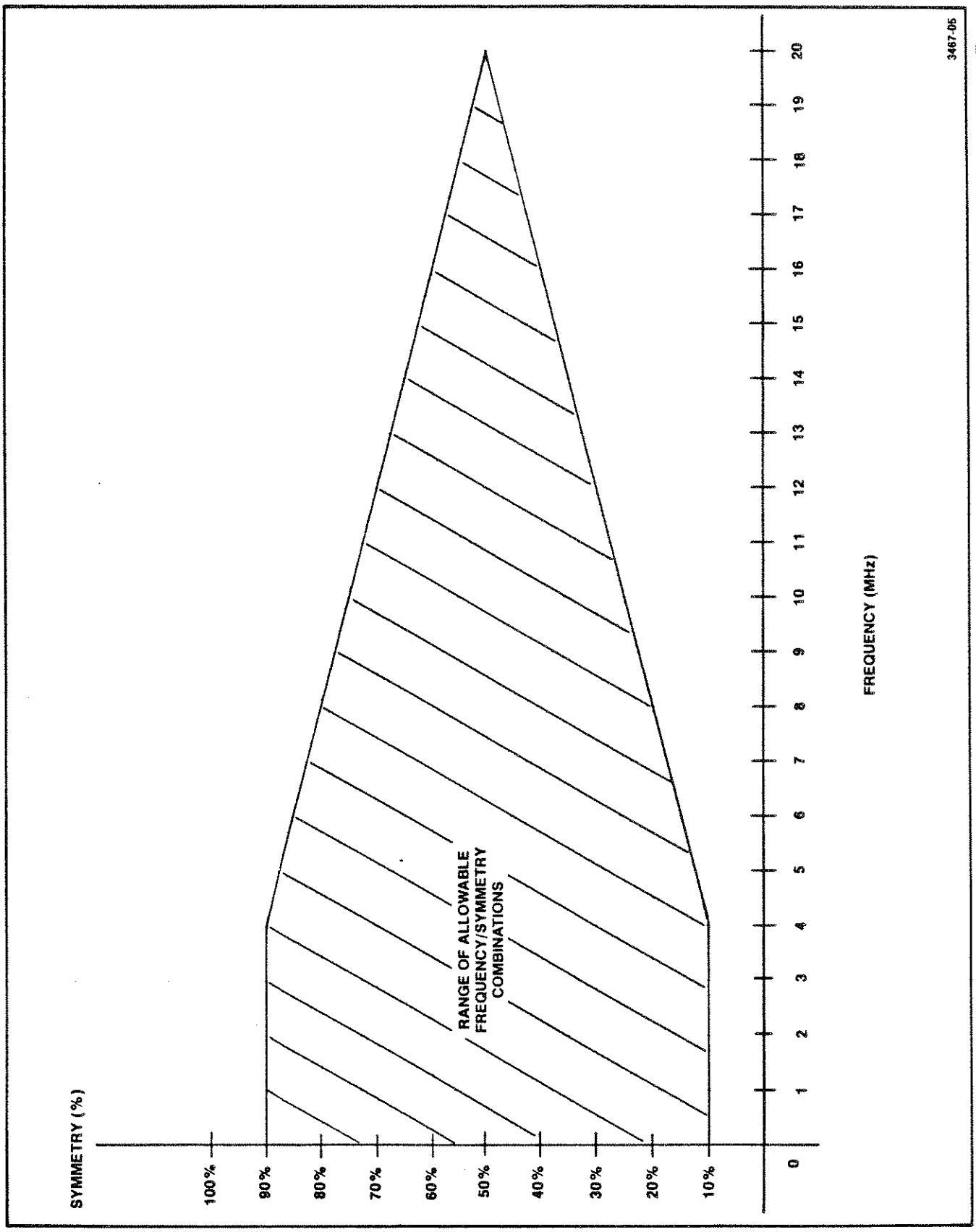


Fig. 3-2. Frequency/Symmetry combinations.

TEST

Type:
Output

Syntax:
TEST

Response:
TEST <NUM>;

Discussion:

The TEST command causes the FG 5010 to perform self tests. Those performed are the ROM tests, the serial I/O hardware tests, and the AFC hardware integrity test; and are the same as the tests performed during the power-on self-test sequence, except for the RAM tests. RAM tests are performed only at power-on.

Signal output from the FG 5010 is disabled during test execution. Previous settings are restored at completion of testing. Test results are supplied as an output from the FG 5010. A result of 0 indicates that no failures were detected. A detected failure causes an error code output that is the same as that of power-on self-test failures. Refer to Table 3-1 near the end of this section for event codes.

TRIANGLE

Type:
Setting only

Syntax:
TRIANGLE

Discussion:

The TRIANGLE command causes the FG 5010 output to be in triangular waveform. Selection of triangle waveform output cancels any previous selection. This command is a special case of the FUNC command. The header (FUNC) is optional, but the argument (TRIANGLE) is not.

TRIGGER

Type:
Query only

Query Syntax:
TRIG?

Query Response:
TRIG 0;
TRIG 1;
TRIG 2;
TRIG 3;

Discussion:

The TRIGGER query causes the FG 5010 to respond with an indication of the state of the trigger/gate input signal. Valid responses are:

0—Trigger status not available.

1—Input level below threshold.

2—Input level toggling faster than 3 Hz.

3—Input level above threshold

USER (User Request)

Type:
Setting or Query

Setting Syntax:
USER { ON
{ OFF

Examples:
USER ON
USER OFF

Query Syntax:
USER?

Query Response:
USER ON;
USER OFF;

Discussion:

The USER command enables the FG 5010 to generate a service request to the controller when the user presses the front panel INST ID pushbutton. This provides a means of communication between the user and the controller through the FG 5010 for coordination of FG 5010 operations. Valid arguments are:

ON—If RQS is ON, allows the FG 5010 to generate an SRQ when the user presses the INST ID pushbutton. The SRQ remains asserted until the status is read by a serial poll or until a device clear is performed. The USER is indicated by a status byte of 67 or 83 and an error query response of ERR 403. If RQS is OFF, the event can be detected via the ERR query.

OFF—Prevents the FG 5010 from generating an SRQ when the user presses the INST ID pushbutton.

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

VCF (Voltage Controlled Frequency)

Type:
Setting or Query

Setting Syntax:
VCF { ON
OFF

Examples:
VCF ON
VCF OFF

Query Syntax:
VCF?

Query Response:
VCF ON;
VCF OFF;

Discussion:

The VCF command enables or disables the FG 5010 voltage controlled frequency function. The frequency modulation function is automatically disabled when the VCF ON command is executed. The internal frequency control digital-to-analog converters are not changed. The VCF start frequency is selected by the frequency setting; the VCF stop frequency is the top of the range in which the FG 5010 was operating when the VCF ON command was received. Once in VCF mode, the start frequency may be changed within the range by the FREQ command. FREQ 0 is allowed in VCF. Valid arguments are:

ON—Causes the voltage controlled frequency function to be enabled.

OFF—Causes the voltage controlled frequency function to be disabled. When the VCF function is disabled, the FG 5010 will return to the frequency that was being generaged before VCF was enabled.

The power-up setting is VCF OFF. No frequency range switching is allowed in VCF mode.

The VCF function may not be enabled when the FG 5010 is in the phase-lock mode. A VCF query returns the current status.

MESSAGES AND COMMUNICATION 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;
```

Message Terminator

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 message. 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.

A set of six address and message terminator switches is located on the CPU board and is accessible through a cutout in the rear panel of the FG 5010. (Simply remove the instrument from Power Module for access.) Five of the switches are user set to select the primary address of the FG 5010. One switch is user set for the instrument to respond to one of two possible message delimiters (LF/EOI, or EOI) that may be sent over the bus by various controllers. Selection of the primary address bits and message terminator is accomplished as shown in Fig. 3-3. (Switches 1 through 5 can be set to any address between 0 and 31. All FG 5010 instruments are shipped with EOI only selected.).

Formatting A Message

Commands sent to TM 5000 instruments must have the proper format (syntx) 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. 3-4).

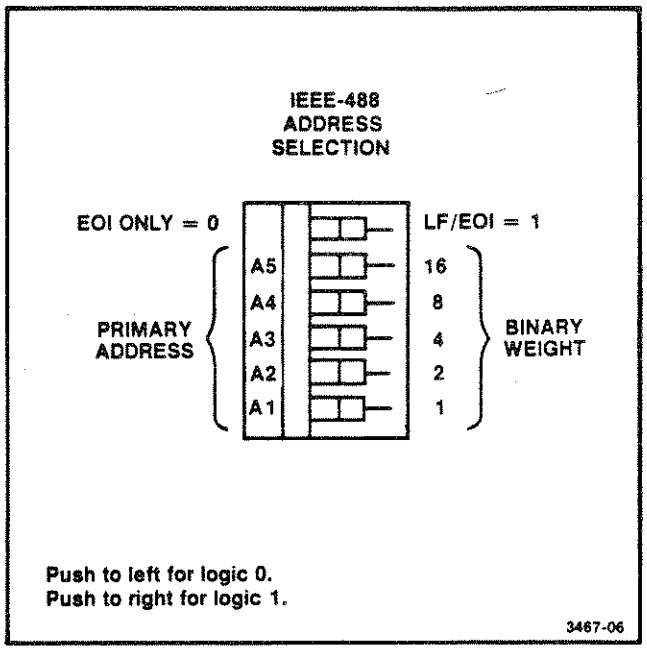


Fig. 3-3. Address and message terminator switches.

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 charcters 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

$_{SP}RQS_{SP}ON;_{CR\ LF}$

$_{SP}USER_{SP}OFF$

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 abbreviated version must be those given in the full-length version. For documentation of

ASCII & IEEE 488 (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	
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)	1 7 RUBOUT (DEL) 7F (127)

ADDRESSED COMMANDS

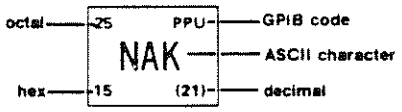
UNIVERSAL COMMANDS

LISTEN ADDRESSES

TALK ADDRESSES

SECONDARY ADDRESSES OR COMMANDS

KEY TO CHART



3391-13

Fig. 3-4. ASCII and IEEE 488 (GPIB) Code Chart.

programs, the user may add alpha characters to the full-length version. Alpha charcters may also be added to a query header, provided the question mark is at the end.

USER?
USERE?
USEREQ?
USEREQUEST?

Multiple arguments are separated by a comma; however, the instrument will also accept a space or spaces as a delimiter.

2,3
$2_{SP}3$
$2,_{SP}3$

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.

- Signed or unsigned integers (including +0 and −0). Unsigned integers are interpreted as positive.

  Examples: +1, 2, −1, −10.

- Signed or unsigned decimal numbers. Unsigned decimal numbers are interpreted as positive.

  Examples: −3.2, +5.0, 1.2

- Floating point numbers expressed in scientific notation.

  Examples: +1.0E−2, 1.0E−2, 1.E−2, 0.01E+0

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, a *query-output command*, or an *operational command* in a message. The normal execution of settings is modified by the DT *setting commands*.

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. Howver, 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 oc-

curs, 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 controllers 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 delets 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 488-1978. Abbreviations from the standard are used in this discussion, which describes the effects of interface messages on instrument operation.

UNL—Unlisten (WBYTE @63:)
UNT—Untalk (WBYTE @95:)

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 (WBYTE @20:)

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 (WBYTE @A,4:)

This message performs the same function as DCL; however, only instruments that are addressed respond to SDC.

GET—Group Execute Trigger (WBYTE @A,8:)

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 (WBYTE @24:)

The SPE message enables the instrument to supply output serial poll status bytes when it is talk addressed.

SPD—Serial Poll Disable (WBYTE @25:)

The SPD message switches the instrument back to its normal operation of sending the data from the Output Buffer.

MLA—My Listen Address (WBYTE @A:)
MTA—My Talk Address (WBYTE @B:)

The primary listen and talk addresses are established by the instrument IEEE-488 bus address (set by switches that are accessible from the back of the FG 5010 when it is removed from the Power Module). The current setting of the bus address is displayed on the front panel when the INST ID button is pressed. When the instrument is addressed to talk or listen, the front panel ADDRESSED indicator is lighted. (A = bus address +32; B = bus address +64.)

LLO—Local Lockout (WBYTE @17:)

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 transition 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 (WBYTE @A,1:)

Only instrurnents 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 unasserte after the execution of the settings. Since *rtl* prevents transition to REMS, the instrument unasserts *rtl* if a multiple button 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 caused 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 pushbuttons. 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 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. 3-5. 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 that it cannot understand.

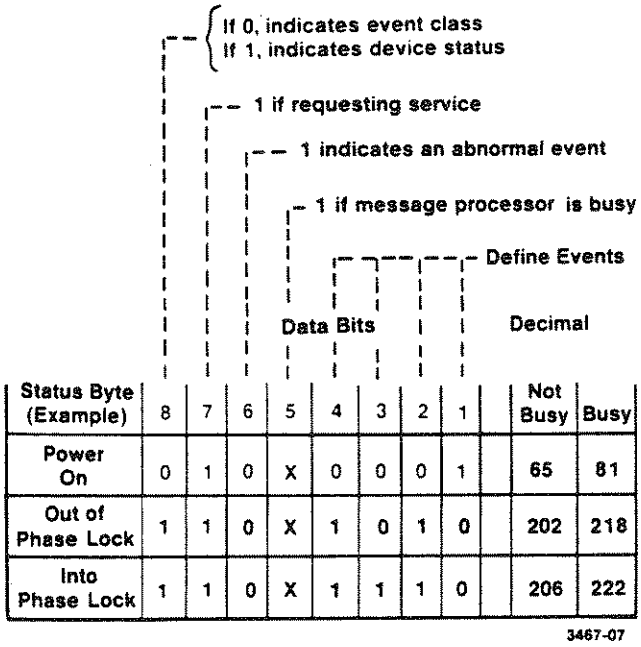
EXECUTION ERROR —Indicates tha the instrument has received a command that it cannot execute. (This is caused by out of range arguments or settings that conflict.)

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.).

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 cali-



Status Byte (Example)	8	7	6	5	4	3	2	1		Not Busy	Busy
Power On	0	1	0	X	0	0	0	1		65	81
Out of Phase Lock	1	1	0	X	1	0	1	0		202	218
Into Phase Lock	1	1	0	X	1	1	1	0		206	222

3467-07

Fig. 3-5. Definition of Status Byte Bits.

bration). (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 ERR query (ERR?). In response, the instrument returns a code that defines the event. These codes are described in Table 3-1.

Table 3-1
ERROR QUERY AND STATUS INFORMATION

Abnormal Event	Error Query Response	Serial Poll Response[a]
Command Errors (100 series)		
Invalid command header	101	97
Header delimiter error	102	97
Argument error	103	97
Argument delimiter error	104	97
Missing argument	106	97
Invalid message unit delimiter	107	97
Binary block checksum error	108	97
Binary block byte-count error	109	97

Table 3-1 (cont)

Abnormal Event	Error Query Response	Serial Poll Response[a]
Execution Errors (200 series)		
Not executable in local state	201	98
Settings lost because of rtl	202	98
Input and output buffers full (capacities exceeded, output dumped to avoid dead-lock)	203	98
Arument out of range	205	98
<GET> ignored	206	98
Frequency-symmetry conflict error	251	98
Amplitude-offset conflict error	252	98
Hold-phase lock mode conflict error	254	98
Frequency-hold mode conflict error	255	98
FM-phase lock mode conflict error	256	98
VCF-phase lock mode conflict error	257	98
Gate-mode conflict error	258	98
Internal Errors (300 series)		
Interrupt fault	301	99
System error	302	99
Period measurement failed to complete	311	99
Period measurement overflow occurred	312	99
Shift register (in VIA) failed to function	313	99
Mag-latch relay strobe interrupt failed to occur	314	99
Phase lock status over and underrange at the same time	315	99
Automatic frequency correction range exceeded	316	99
VIA fault on CPU board	320	99
Trig/gate control error on CPU board	321	99
4 MHz reference frequency clock or counter fault	322	99
Frequency control logic fault on Loop 2 board	323	99
Loop cycle counter fault on Loop 2 board	324	99
Frequency precaler fault on Loop 2 board	325	99
Low-frequency generator fault	326	99

Table 3-1 (cont)

Abnormal Event	Error Query Response	Serial Poll Response[a]
Internal Errors (300 series) (cont)		
No signal detected from Loop 1 board	327	99
Inadequate frequency range (2 kHz range)	328	99
Inadequate frequency range (20 kHz range)	329	99
Inadequate frequency range (200 kHz range)	330	99
Inadequate frequency range (2 MHz range)	331	99
Inadequate frequency range (20 MHz range)	332	99
Burst counter fault	333	99
Faulty RAM found (U1400)	340[b]	
Faulty RAM found (U1500)	341[b]	
Faulty RAM found in MPU chip	350[b]	
ROM placement error at address A000	370[b]	
ROM placement error at address C000	372[b]	
ROM placement error at address E000	374[b]	
ROM checksum error at address A000	390[b]	
ROM checksum error at address C000	392[b]	
ROM checksum error at address E000	394[b]	
System Events (400 series)		
Power on	401	65
User request (via front panel INST ID button)	403	67
Device Dependent Events (700 series)		
Generator went out of phase lock	731	202
Generator went into phase lock	732	206

[a]If the FG 5010 is busy, it returns a decimal number that is 16 higher than the listed number.

[b]Front panel display only.

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 button 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 zero (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.

Sending Interface Control Messages

Interface messages and the effects of those messages on the FG 5010 interface functions are defined in IEEE Standard 488-1978. Abbreviations from that standard are used in this description of the effects on instrument operation.

NOTE

These commands are for TEKTRONIX 4050-Series controllers, but are representative of those for other controllers.

Bus interface control messages are sent as low-level commands through the use of WBYTE controller commands. Refer to 070-2056-01 4050-Series Graphic System Reference Manual for RBYTE controller commands. Higher level commands are also available for the user. For the following commands, A = 32 plus the instrument address and B = 64 plus the address.

Listen (MLA)	WBYTE @ A:
Unlisten (UNL)	WBYTE @ 63:
Talk (MTA)	WBYTE @ B:
Untalk	WBYTE @ 95:
Untalk-Unlisten	WBYTE @ 63, 95:
Device Clear (DCL)	WBYTE @ 20:
Selective Device Clear (SDC)	WBYTE @ A, 4:
Go To Local (GTL)	WBYTE @ A, 1:
Remote with Lockout (RWLS)	WBYTE @ A, 17, 63:
Local Lockout (LLO)	WBYTE @ 17:
Group Execute Trigger <GET>	WBYTE @ A, 8:
Serial Poll Enable (SPE)	WBYTE @ 24:
Serial Poll Disable (SPD)	WBYTE @ 25:

POWER-ON SEQUENCES AND DEFAULT SETTINGS

Each time power is applied to the FG 5010, 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. Functional groups of circuits checked include the following:

Trigger/Gate Control Logic
Period Measurement Counters and Logic
Low Frequency Generator Counters
Frequency Range Control
Burst Counters

If a RAM or ROM error is found, an error code will be displayed on the front panel readout. In this error state, the FG 5010 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 FG 5010 will respond to input and will attempt to operate despite the error. An error code may be removed from the display by pressing the front panel INST ID button, by starting a numeric entry, by incrementing the selected parameter, by pressing the CLEAR button, or by a transition into the remote state (REMS).

When the self-test has been completed, the FG 5010 enters the local state (LOCS) and assumes the following default settings:

Header	Argument
FREQ	1.000 kHz
AMPL	0.5 V
OFFS	0.0 V
PHAS	0°
SYM	50%
NBUR	10
FUNC	SINE
MODE	CONT
HOLD	OFF
SLOPE	POS
GATE	OFF
OUT	OFF
COMP	OFF
AM	OFF
FM	OFF
VCF	OFF
PLI	OFF
DT	OFF
USER	OFF
RQS	ON

The SRQ line on the IEEE-488 bus is also asserted unless the bus address switch is set to 31 (Ignore Bus Commands). If the FG 5010 is polled by the controller, the status byte returned will be 65 (Power-On SRQ) if the busy bit is false, or 81 (65 + 16) if the busy bit is true.

APPLICATIONS

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 4050-Series Controllers

```
100 REM  FG5010 TALKER/LISTENER PROGRAM
110 REM  FG5010 BUS ADDRESS = 24
120 INIT
130 W=24
140 ON SRQ THEN 290
150 DIM R$(380)
160 PRINT "ENTER COMMAND(S), MESSAGE(S):";
170 INPUT A$
180 PRINT @W:A$
190 REM  CHECK FOR QUERIES
200 IF POS(A$,"?",1)<>0 THEN 260
210 REM  CHECK FOR SEND
220 IF POS(A$,"SEND",1)<>0 THEN 260
230 REM  CHECK FOR TEST
240 IF POS(A$,"TEST",1)=0 THEN 260
250 GO TO 160
260 INPUT @W:R$
270 PRINT R$
280 GO TO 160
290 REM  THIS PROGRAM FOR ONE ADDRESS ONLY
300 REM  (SRQ INTERRUPT HANDLER)
310 POLL D,S;W
320 PRINT @W:"ERR?;"
330 INPUT @W:E$
340 PRINT "SRQ OCCURRED - STATUS =";S
350 PRINT S;" ";E$
360 RETURN
```

Talker Listener Program For 4040-Series Controllers

```
100 Rem FG5010 TALKER/LISTENER PROGRAM
110 Rem       PRIMARY ADDRESS = 24
120 Init all
130 On srq then gosub srqhdl
140 Enable srq
150 Dim respons$ to 200
160 Input prompt "ENTER MESSAGE(S): ":message$
170 Print #24:message$
180 Rem CHECK FOR QUERIES
190 If pos(message$,"?",1) then goto 290
200 Rem CHECK FOR 'SEND' COMMAND
210 If pos(message$,"SEND",1) then goto 290
220 Rem CHECK FOR 'TEST' COMMAND
230 If pos(message$,"TEST",1) then goto 290
240 Goto 160
250 Rem INPUT DATA FROM DEVICE #24
260 Rem    The 'SEND n' command and 'LLSET?'
270 Rem    send non-printable ASCII data in
280 Rem    binary block format.
290 Input #24:respons$
300 Print "RESPONSE: ";respons$
310 Goto 160
320 Rem SERIAL POLL ROUTINE
330 Srqhdl: poll stb,pri
340 Print "STATUS BYTE: ";stb
350 Resume
360 End
```

Example Programs

The following FG 5010 programming information is useful in various applications. The examples shown are given in 4050-Series BASIC. The implementation details vary from controller to controller.

How To Handle Service Requests (SRQ)

Several methods are available when using SRQ:

1. Write an SRQ interrupt handler.

```
100 REM ***EXAMPLE OF SRQ HANDLING***
105 W=24
110 ON SRQ THEN 150
115 REM  LINES OF PROGRAM CODE EXECUTING
120 REM              *
125 REM              *
130 REM              *
135 REM              *
140 REM              *
145 REM              *
147 GO TO 147
148 REM  LINE 147 SIMULATES USER PROGRAM
150 REM  SRQ HANDLING ROUTINE
155 POLL D,S;W
160 PRINT 'SRQ STATUS = ';S
165 RETURN
```

A = instrument address
D = device number in the address list
S = instrument status

2. Instruct the FG 5010 not to assert SRQ. In this mode, errors may be detected using the error query (ERR?).

```
200 REM  ***EXAMPLE OF SUPPRESSING SRQ
205 REM     ASSERTION FROM THE FG5010***
210 W=24
215 PRINT @W:'RQS OFF;'
220 REM  PROGRAM CODE RUNNING HERE.
225 REM              *
230 REM              *
235 REM  CHECK FG5010 FOR ANY ERRORS.
240 GOSUB 270
245 REM  CONTINUE PROGRAM EXECUTION
250 REM              *
255 REM              *
260 REM              *
265 REM              *
270 REM  ROUTINE TO QUERY FG5010 ERRORS.
275 PRINT @W:'ERR?;'
280 INPUT @W:E
285 IF E=0 THEN 295
290 PRINT 'ERROR ';E;' DETECTED.'
295 RETURN
```

3. Instruct the controller to ignore SRQ. This is a controller-dependent function. Refer to the particular controller reference manual.

How To Use Low-Level Settings

This program example reads low-level settings data into numeric array L and untalks the instrument.

```
700 REM  *** READ LOW LEVEL SETTINGS
705 REM      FROM FG5010 ***
710 Z=24
715 DIM L(50)
720 PRINT @Z:'LLSET?;'
725 WBYTE @64+Z:
730 RBYTE L
735 WBYTE @95:
```

This program example makes the instrument at address A a listener, sends the low-level settings data in numeric array L, and unlistens the instrument.

```
800 REM  *** SEND LOW LEVEL SETTINGS
805 REM      TO FG5010 ***
810 W=24
815 REM  ARRAY L CONTAINS LOW LEVEL
820 REM  SETTINGS VALUES.
825 WBYTE @32+W:L
830 WBYTE @63:
```

How To Synchronize Settings Changes

Given two (or more) instruments in a system; one at address A, the other at address B, etc.

```
900 REM  *** USING DT SET ***
905 W=24
910 V=25
915 PRINT @W:"DT SET;"
920 PRINT @V:"DT SET;"
925 PRINT @W:"FREQ 100;AMPL 2.5;"
930 PRINT @W:"OFFS 3.5;FUNC TRI;OUT ON"
935 PRINT @V:"AMPL 5.6;OFFS -2.8;OUT ON"
940 REM  WAIT UNTIL INSTRUMENTS ARE
945 REM  READY FOR TRIGGER.  WHEN FG5010S
950 REM  ARE READY TO RECEIVE TRIGGER,
955 REM  THEY WILL BE ABLE TO ANSWER
960 REM  THE DT? QUERY.
965 PRINT @W:"DT?;"
970 INPUT @W:A$
975 PRINT @V:"DT?;"
980 INPUT @V:A$
985 REM  SEND <GET> (GROUP EXECUTE
990 REM  TRIGGER) TO BOTH INSTRUMENTS.
995 WBYTE @32+W,32+V,8,63:
```

How To Synchronize Trigger Events

Given two (or more) instruments in a system; one at address A, the other at address B, etc.

```
1000 REM  ***USING DT TRIG ***
1005 W=24
1010 V=25
1015 PRINT @W:"MODE BURST;FREQ 1000;"
1020 PRINT @W:"NBUR 10;DT TRIG;"
1025 PRINT @V:"FREQ 1.0E+4;NBUR 100;"
1030 PRINT @V:"MODE BURST;DT TRIG;"
1040 REM  READY FOR TRIGGER.  WHEN
1045 REM  FG5010S ARE READY TO RECEIVE
1050 REM  TRIGGER, THEY WILL BE ABLE TO
1055 REM  ANSWER THE DT? QUERY.
1060 PRINT @W:"DT?;"
1065 INPUT @W:A$
1070 PRINT @V:"DT?;"
1075 INPUT @V:A$
1080 REM  SEND <GET> (GROUP EXECUTE
1085 REM  TRIGGER), UNLISTEN BUS.
1090 WBYTE @32+W,32+V,8,63:
```

How To Detect the Phase-Locked State

1. Lock query

```
1100 REM  *** DETECTING PHASE LOCK
1105 REM  USING PHASE LOCK QUERY ***
1110 W=24
1115 PRINT @W:"MODE LOCK;"
1120 PRINT @W:"LOCK?;"
1125 INPUT @W:L
1130 IF L<>1 THEN 1140
1135 PRINT "PHASE-LOCK DETECTED."
1140 REM  REST OF PROGRAM
1145 REM        '
1150 REM        '
```

2. Phase-lock interrupt

```
1200 REM  *** DETECTING PHASE LOCK
1205 REM  USING PHASE LOCK INTERRUPT ***
1210 W=24
1215 F1=0
1220 ON SRQ THEN 1265
1222 PRINT @W:"RQS ON;"
1225 PRINT @W:"MODE LOCK;PLI ON;"
1230 REM  WAIT FOR PLI INTERRUPT
1235 WAIT
1240 IF F1=0 THEN 1235
1245 REM  CONTINUE PROGRAM EXECUTION
1250 REM           '
1255 REM           '
1260 REM           '
1263 END
1265 REM  SRQ HANDLING ROUTINE
1270 POLL D,S,W
1275 REM  TEST STATUS BYTE TO DETERMINE
1280 REM  IF PHASE LOCK STATE IS BEING
1285 REM  REPORTED.
1290 REM  206 IF "BUSY BIT" = 0,
1295 REM  222 IF "BUSY BIT" = 1.
1300 IF S<>206 AND S<>222 THEN 1315
1305 PRINT "PHASE-LOCK DETECTED."
1310 F1=1
1315 RETURN
```

A = instrument address
D = device number in the address list
S = instrument status

3. Device dependent status byte

```
1400 REM  *** DETECTING PHASE LOCK
1405 REM      USING STATUS BYTE ***
1410 W=24
1415 PRINT @W;"MODE LOCK;PLI OFF;"
1420 REM  SEND SERIAL POLL ENABLE AND
1425 REM  FG5010 TALK ADDRESS, READ THE
1430 REM  STATUS BYTE, UNTALK THE FG5010
1435 REM  AND SEND SERIAL POLL DISABLE.
1440 WBYTE @24,64+W;
1445 RBYTE S
1450 WBYTE @95,25;
1455 REM  TEST STATUS BYTE TO DETERMINE
1460 REM  IF PHASE-LOCK STATE IS BEING
1465 REM  REPORTED.
1470 REM  "IN-LOCK" STATUS IS;
1475 REM  142 IF "BUSY BIT" =0,
1480 REM  158 IF "BUSY BIT" =1.
1485 IF S<>142 AND S<>158 THEN 1495
1490 PRINT "PHASE-LOCK STATE DETECTED."
1495 REM  CONTINUE PROGRAM EXECUTION
1500 REM              "
1505 REM              "
1510 REM              "
```

Additional assistance in developing specific application oriented software is avaliable in the following Tektronix manuals.

1. 070-3985-00 GPIB Programming Guide. This manual is specifically written for apllications of this instrument in IEEE-488 systems. It contains programming instructions, tips, and some specific example programs.
2. 070-2270-00 4051 GPIB Hardware Support Manual. This manual gives an indepth discussion of IEEE-488 bus operation, explanations of bus timing details and early bus interface circuitry.
3. 070-2058-01 Programming in BASIC
4. 070-2059-01 Graphic programming in BASIC
5. 062-5971-01 4050-Series programming aids, T1 (includes software)
6. 062-5972-01 4050-Series programming aids, T2 (includes software)
7. 070-2380-01 4907 File Manager operators manual
8. 070-2128-00 4924 Users manual
9. 070-1940-01 4050-Series graphic system operators manual
10. 070-2056-01 4050-Series graphic system reference manual
11. 070-3918-00 4041 operators manual
12. 061-2546-00 4041 Programming reference manual