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

FG 504 40 MHz FUNCTION GENERATOR

(SN B0400000 & ABOVE)

INSTRUCTION MANUAL

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

070-2655-00
Product Group 75

Serial Number _____

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OPERATORS SAFETY SUMMARY

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

TERMS

In This Manual

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

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

As Marked on Equipment

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

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

SYMBOLS

In This Manual

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

As Marked on Equipment

DANGER — High voltage.

Protective ground (earth) terminal.

ATTENTION — refer to manual.

Power Source

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

Grounding the Product

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

Danger Arising From Loss of Ground

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

Use the Proper Power Cord

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

Use only a power cord that is in good condition.

For detailed information on power cords and connectors, see the power module manual.

Refer cord and connector changes to qualified service personnel.

Use the Proper Fuse

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

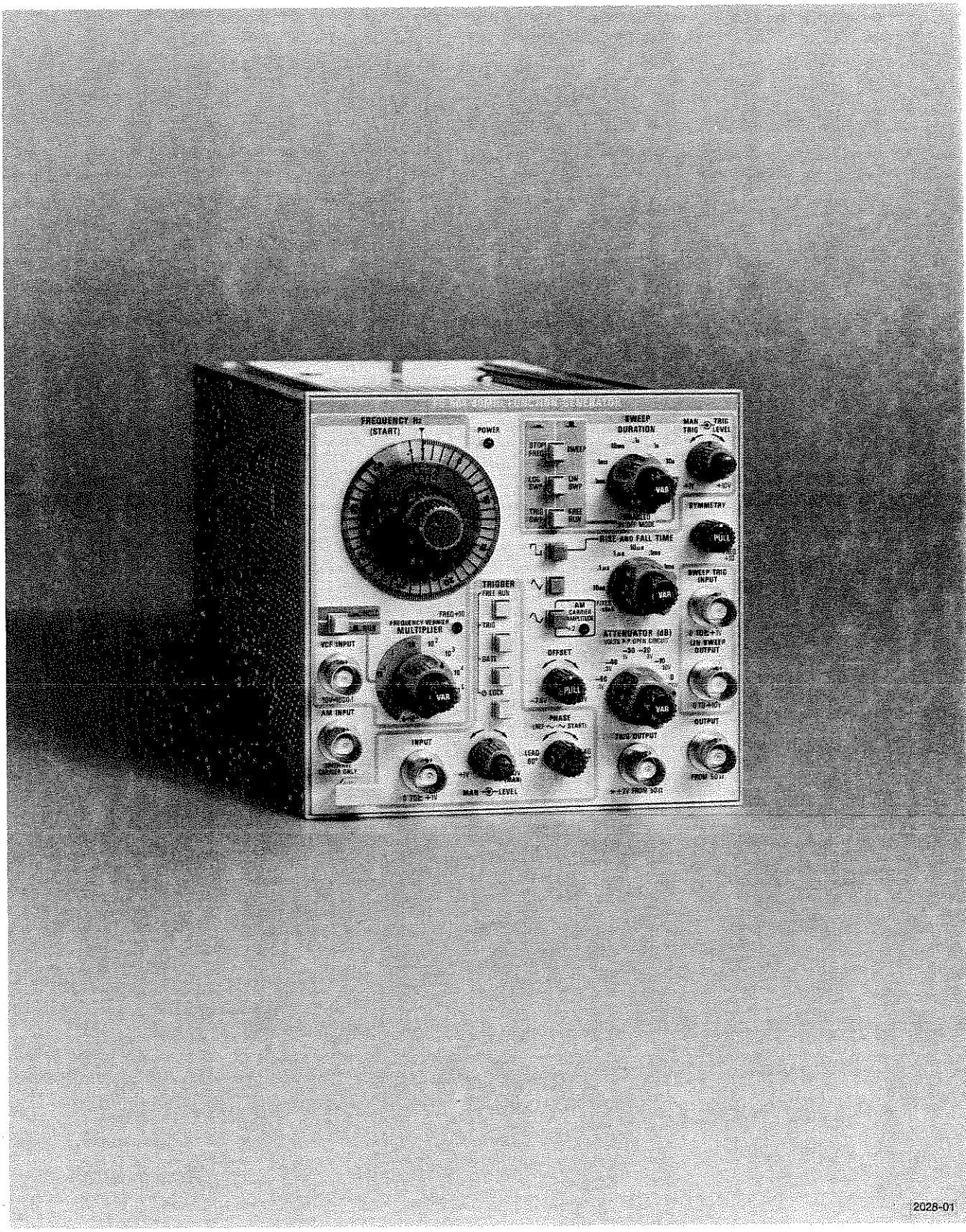
Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

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

Do Not Operate Without Covers

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



The FG 504 Function Generator.

SPECIFICATION

Introduction

The FG 504 Function Generator provides low distortion sine, square, triangle, ramp, and pulse waveforms over the frequencies from 0.001 Hz to 40 MHz in ten decades. A user-definable custom frequency range is also available. The output amplitude is 10 mV to 30 V peak-to-peak into an open circuit and 5 mV to 15 V peak-to-peak into a 50 Ω load. The output impedance is 50 Ω. The FG 504 may be swept between the START and STOP FREQ dial settings with a linear or logarithmic sweep. The output may be phase locked, gated, or triggered for single cycle output. The output waveform may be shifted ±80° from the triggering waveform. The symmetry of the output waveform may also be varied. For the slower frequencies, the output may be held at any level by pushing the front panel button labeled HOLD.

A voltage-controlled frequency (VCF) input controls the output frequency from an external voltage source. The output frequency can be swept above or below the selected frequency, to a maximum of 1000:1, depending on the polarity and amplitude of the VCF input and the selected output frequency. Provision is also made for amplitude modulating the sinewave output from an external source.

The variety of swept and modulated signals available from the FG 504 make it especially useful for such applications as testing amplifier or servo-system response, distortion, and stability. It is useful for fm generation, as a beat frequency oscillator, as a gated triggered or phase-locked logic interface, or as a source for various ramp or pulse waveforms. It is also useful as a source for amplitude modulated signals for various purposes.

SPECIFICATION

Performance Conditions

The following electrical characteristics are valid if the FG 504 is calibrated at an ambient temperature between +20°C and +30°C and is operated at an ambient temperature between 0°C and +50°C, unless otherwise noted. Forced air circulation is required at temperatures above +40°C. Allow a one-hour warm-up period before performing verification tests.

Table 1-1

ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
Frequency		
Range		
Sine-wave, square-wave, and triangle	.001 Hz to 40 MHz calibrated in 10 overlapping steps	
Ramps, pulses, or waveforms waveforms requiring use of variable SYMMETRY control		.001 Hz to nominally 4 MHz.
Duty Cycle		≤7% to ≥93% below 1 MHz ≤20% to ≥80% above 1 MHz
.5 X 10^3 position of MULTIPLIER switch (User selected timing capacitor)		≈400 kHz maximum. A 5 μF capacitor provides a full-scale frequency of ≈400 Hz. The factory-installed capacitor gives a 20 Hz to 20 kHz range for the .5 X 10^3 position of the MULTIPLIER switch.

Table 1-1 (cont)

Characteristic	Performance Requirement	Supplemental Information
Frequency (cont)		
Resolution		1 part in 10^4 of full-scale setting using the FREQUENCY VERNIER control, as measured with a frequency counter.
Stability		Applies to calibrated portion of the FREQUENCY Hz dial only.
Time	≤0.05% for 10 minutes ≤0.1% for 1 hour ≤0.5% for 24 hours	The instrument must be at a constant ambient temperature between 0° C and +50° C and checked after a 1-hour warmup.
Temperature		See Dial Accuracy
Dial Calibration		1 to 40 Hz (X MULTIPLIER setting) calibrated; 0.1 to 1 Hz (X MULTIPLIER setting) uncalibrated.
Dial Accuracy		
FREQUENCY Hz (START) dial	Within 3% of full scale from 0.001 Hz to 4 MHz. Within 6% of full scale from 4 MHz to 40 MHz.	Measurements made at an ambient temperature between +15° CC and +35° C after 1 hour warmup.
STOP FREQuency dial	Within 5% of the difference between the start and stop frequencies plus the FREQUENCY Hz (START) dial error.	STOP FREQuency dial is uncalibrated on the 10^6 MULTIPLIER range.
Maximum Frequency Ranges for Dial, Sweep Frequency, and Voltage Controlled Frequency (VCF) Modes	MULTIPLIER Setting — Maximum to Minimum Frequency Ratios 10^6 — ≥500:1 10^5—10^2 — ≥1000:1 10^1, 1, 10^{-1}, 10^{-2} — ≥100:1 10^{-3} — ≥40:1	
Internal Sweep Accuracy		Linear or Logarithmic. Limited by Start and Stop Frequency Specifications; use external frequency counter if greater accuracy is required.
Sweep Duration		100 s to 0.1 ms in six decades (selected by SWEEP DURATION switch). VARiable control overlaps decades.
Stop Frequency to Swept Stop Frequency Error		Within 2% from 100 s to 1 ms sweep duration. Within 10% from 1 ms to 0.1 ms sweep duration.
LINear SWEEP	0 V to +10 V.	Output impedance 1 kΩ.

Table 1-1 (cont)

Characteristic	Performance Requirement	Supplemental Information
Internal Sweep (cont)		
OUTPUT Amplitude		
Accuracy	Within 5% from 100 s to 1 ms, Within 10% from 1 ms to 0.1 ms.	
SWEEP TRIGger INPUT		
Input sensitivity	1 V p-p.	
Level	1 V through 10 V.	
Maximum Input	+20 V.	
Manual Trigger		Front-panel control.
Voltage-controlled Frequency Input (VCF)		
Nominal Sensitivity (Hz/volt)		=4 X MULTIPLIER setting per volt. A positive-going voltage increases frequency.
Maximum Frequency		=40 X MULTIPLIER setting.
Minimum Frequency		Maximum frequency divided by VCF range (see Maximum Frequency Ranges for Dial, Sweep Frequency, and Voltage Controlled Frequency (VCF) Modes).
Slew Rate		0.3 V/μs maximum.
Input Impedance		10 kΩ.
OUTPUT Signal Amplitude	At least 30 V p-p into an open circuit, at least 15 V into 50 Ω.	
Flatness		
Sine-wave		
0.001 Hz to 40 kHz 40 kHz to 40 MHz	Within $\pm$0.5 dB. Within $\pm$2 dB from 40 kHz to 40 MHz.	Typically within $\pm$0.5 dB to 40 MHz. Reference at 10 kHz.
Triangle		
0.001 Hz to 40 kHz 40 kHz to 40 MHz.	Within $\pm$0.5 dB. Within $\pm$2 dB.	Reference at 10 kHz.
Square-wave		
0.001 Hz to 20 MHz 20 MHz to 40 MHz	Within $\pm$0.5 dB. Within $\pm$2 dB.	Reference at 10 kHz.
Sine-wave, Triangle, and Square-wave Amplitude Match	Within $\pm$1 dB at 10 kHz.	

Table 1-1 (cont)

Characteristic	Performance Requirement	Supplemental Information
Output ATTENUATOR	Attenuator Step / Maximum Open-circuit Output Voltage (p-p) 0 dB — 30 V −10 dB — 9.5 V −20 dB — 3 V −30 dB — 950 mV −40 dB — 300 mV −50 dB — 95 mV	
Accuracy	Within ±0.5 dB/decade.	
VARiable Control	Provides up to −20 dB additional attenuation to reduce the minimum output signal amplitude to 10 mV.	
OFFSET Range		
Into Open Circuit Into 50 Ω	±7.5 V ±3.75 V	Maximum signal plus offset peak output amplitude of ±20 V into an open circuit and ±11.25 V into 50 Ω. Offset defeatable by front-panel control.
Output Waveforms		
Without Use of SYMMETRY (variable) control		Sine, Triangle, and Square
With SYMMETRY (variable) Control		Ramps and Pulses. Duty cycle range is ⩽7% to ⩾93% for all variable symmetry waveforms below 1 MHz; limited to ≈20% to ≈80% for triangle and sine-waveforms above 1 MHz. Actuation of SYMMETRY control divides output frequency by approximately 10.
Triangle		
Symmetry		Typically within 2% from 0.001 Hz to 10 Hz.
10 Hz to 400 kHz 400 kHz to 40 MHz	Within 1%. Within 5%.	On calibrated portion of FREQUENCY Hz dial.
Linearity		Measured from the 20% point to the 80% point of the waveform. Typically within 2% from 0.001 Hz to 10 Hz.
10 Hz to 400 kHz 400 kHz to 4 MHz 4 MHz to 40 MHz		Within 1%. Within 2%. Within 10%.

Table 1-1 (cont)

Characteristic	Performance Requirement	Supplemental Information
Output Waveforms (cont)		
Sine-Wave		
Total Harmonic Distortion		Typically ≤1% from 0.001 Hz to 20 Hz, measured under the following conditions: Temperature +10° C to +35° C ambient terminated into 50 Ω; zero offset; ≤30 dB attenuation, and with FREQUENCY Hz (START) dial set between 4 and 40.
20 Hz to 40 kHz	≤0.5%.	
40 kHz to 1 MHz	Greatest harmonic at least 30 dB down.	
1 MHz to 40 MHz	Greatest harmonic at least 20 dB down.	
Square-wave		
RISE AND FALL TIMES FIXED	≤6 ns 10 ns to 100 ms in 7 steps measured from 10% to 90%	Applies to pulse waveforms also.
Aberrations	≤5% p-p plus 30 mV into 50 Ω load.	
VARiable	10 ns to 100 ms in 7 steps. Measured between the 10% and 90% points of Amplitude; accuracy within 30%. VARiable control has ≥10X range.	Period of waveform must exceed combined rise and fall times by ≥20%.
AM INPUT		
Dc to 4 MHz	5 V p-p signal produces 100% modulation of a sine-wave carrier with ≤5% distortion at 70% modulation.	When driven from a source impedance ≤600 Ω.
4 MHz to 40 MHz	≤10% distortion at 65% modulation.	Modulating frequencies from 20 Hz to 20 kHz. Modulation frequency bandwidth is dc to 100 kHz. A modulating source impedance of ≤10 kΩ ensures proper modulation and divides the output amplitude by 2.
Input Impedance		≥1 MΩ.
External TRIG/GATE/ Φ LOCK Input		
Input Impedance		≥10 kΩ.
Sensitivity	≤1 V p-p.	
Maximum Input Amplitude		+20 V.
TRIG		
LEVEL	−1 V to +10 V.	For triggering a single cycle of generator waveform.
Minimum Period		75 ns.

Table 1-1 (cont)

Characteristic	Performance Requirement	Supplemental Information
External TRIG/GATE/ Φ LOCK Input (cont)		
Maximum Trigger Frequency	≥20 MHz.	
GATE		
Minimum Period		75 ns.
Maximum Gated Frequency	≥20 MHz.	For gating multiple-cycle burst of generator waveform.
Φ LOCK	100 Hz to 40 MHz. Adjust range ±80° from 0 100 Hz to 4 MHz.	Capture range: ±10 major dial divisions from 100 Hz to 4 MHz; ±8 major dial divisions from 4 MHz to 40 MHz (40 MHz may not capture, but will track.)
4 MHz to 40 MHz	±8 major dial divisions.	
Lock Range		Generator will lock to a changing external signal, without readjusting the PHASE control, within ±10 major dial divisions from 100 Hz to 4 MHz and within ±1 MHz from 4 MHz to 40 MHz.
PHASE		
Phase Adjustment Range		±80° from 0.001 Hz to 4 MHz.
MAN		Manual Trigger/Gate front-panel pushbutton.
TRIG OUTPUT	0 V to +2 V from 50 Ω.	
HOLD		
Drift		10% of p-p output amplitude/hour.
Range	0.001 Hz to 400 Hz.	

Table 1-2

ENVIRONMENTAL CHARACTERISTICS

Characteristics	Description
Temperature	
Operating	0° C to +40° C (+40° C to +50° C; forced air required).
Storage	−40° C to +75° C.
Altitude	
Operating	To 15,000 feet (4,570 meters).
Storage	To 50,000 feet (15,250 meters).
Vibration	
Operating and non-operating	0.64 mm (0.025") displacement, 10-50-10 Hz sinewave, 54 minutes.
Shock	
Operating and non-operating	50 g's (half sine), 11 ms, 12 shocks.
Transportation	Qualified under National Safe Transit Association Test, Procedure 1A Category II.

Table 1-3

PHYSICAL CHARACTERISTICS

Characteristics	Description
Finish	Anodized aluminum panel and chassis.
Weight	3.75 pounds (1.7 kg).
Overall Dimensions	Width 5.312" (13.49 cm), Length 12.125" (30.8 cm), Height 5.0" (12.7 cm).

OPERATING INSTRUCTIONS

INSTALLATION AND REMOVAL INSTRUCTIONS

The FG 504 is calibrated and ready to use when received. It operates in any two compartments of the TM 500 series power modules except the TM 501. Refer to the power module instruction manual for line voltage requirements and power module operation. Forced air cooling is required for operation between 40 and 50 degrees centigrade.

CAUTION

Turn the power module off before inserting or removing the FG 504; otherwise, arcing may occur at the rear interface connectors. Arcing reduces the useful life of the connectors and damage may be done to the plug-in circuitry.

Check for plastic barriers on the interconnecting jacks of the power module in the selected compartments. If there are barriers present and they do not match the cut-outs in the FG 504 circuit board edge connectors, they may indicate special rear interface connections for another type of instrument. Do not insert the plug-in until this has been verified by qualified service personnel.

When the units are properly matched, align the FG 504 with the upper and lower guides (see Fig. 2-1) of the selected compartments. Insert the FG 504 into the compartment and press firmly to seat the circuit boards in the interconnecting jacks. The POWER light should be illuminated when the power module switch is turned on.

To remove the FG 504, pull the release latch, which is located on the lower left corner, until the circuit board edge connectors disconnect from the power module jacks. The FG 504 will now slide out of the power module.

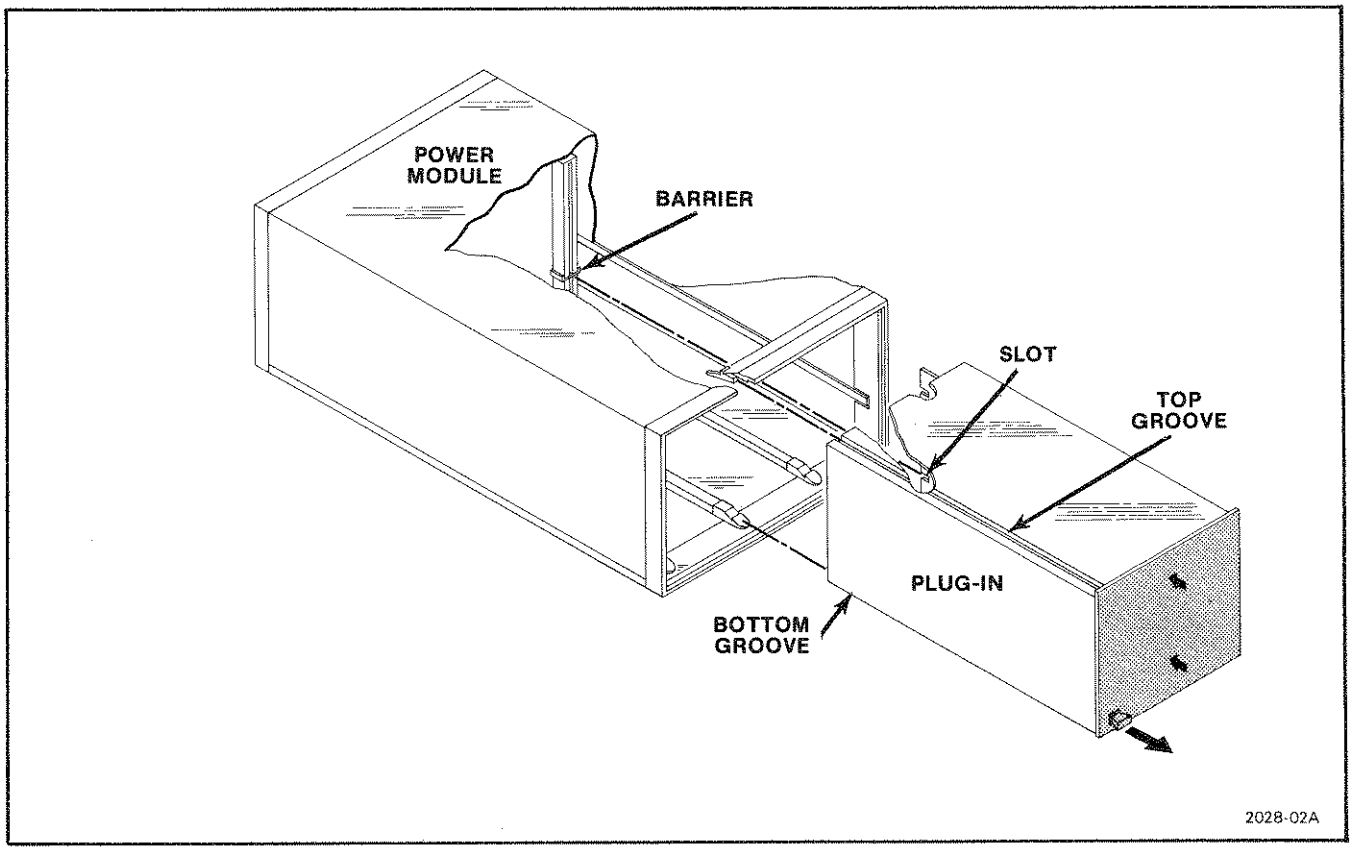


Fig. 2-1. FG 504 Installation and Removal.

OPERATING CONSIDERATIONS

Output Connections

The output of the FG 504 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 excessive aberrations on the output waveform (see Impedance Matching discussion). 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 triangle waveforms). To ensure waveform purity, observe the following precautions:

1. Use good quality 50 Ω coaxial cables 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 cable (6 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.

NOTE

If the FG 504 is used in early models of the TM 500 Series Power Modules, ripple on the output waveform can be excessive in some cases. The ripple results from Power Module transformer phasing that is incompatible with FG 504 operation; however, the problem is easily cured. Refer to qualified service personnel for checking transformer phasing.

CONTROLS AND CONNECTORS

(1) **FREQUENCY (Hz):** Selects frequency of operation, or lowest frequency in sweep mode.

(2) **STOP FREQUENCY (Hz):** Selects highest frequency in sweep mode.

(3) **FREQ ÷10:** Lamp indicates when SYMMETRY knob is pulled out.

(4) **RUN:** (Button out) for normal operation.

HOLD: (Button in) Disables the generator and provides an output dc level equal to the level of the signal when the button was pushed. (5 lower frequency ranges only.)

(5) **VCF INPUT:** Externally applied voltage varies output frequency.

(6) **FREQUENCY VERNIER:** For fine frequency variations.

(7) **MULTIPLIER:**Determines range of FREQUENCY dial.

(8) **AM INPUT:** Externally applied signal modulates sine wave output.

(9) **LATCH:** Pull to remove the plug-in.

(10) **INPUT:** Apply external gating, triggering, or phase-locking signals to this connector.

(11) **MAN:** Provides a manual trigger in TRIG operation or manual gate in GATE operation to control the output waveform.

(12) **LEVEL:** Selects the beginning voltage level on INPUT waveform for triggered, gated, or phase-locked operation.

(13) **Φ LOCK:** Button in locks output waveform frequency to signal applied to INPUT connector.

(14) **GATE:** Button in causes generator to produce a waveform during a high level at the INPUT connector.

(15) **TRIG:** Button in causes generator to produce one cycle of output waveform for each positive-going INPUT signal.

(16) **FREE RUN:** Button in causes continuous output waveform.

(17) **PHASE:** Selects phase lead or lag up to ±80 degrees from selected triggering level on INPUT sine or ramp waveforms.

(18) **TRIG OUTPUT:** Produces one positive pulse for each positive cycle of selected waveform. (Except square wave output corresponds to negative cycle.)

(19) **OUTPUT:** Connector for generator OUTPUT waveform.

(20) **VAR:** Varies OUTPUT amplitude between steps of ATTENUATOR switch.

(21) **ATTENUATOR (dB):** Varies amplitude of OUTPUT waveform in steps of 10 dB.

(22) **LIN SWEEP OUTPUT:** Provides a 0—10 V linear sweep output whenever the sweep is running.

(23) **SWEEP TRIG INPUT:** Apply a trigger waveform here to start the sweep when using the TRIG SWP.

(24) **VAR:** Varies the rise and fall times of the square wave.

(25) **RISE and FALL TIME:** Varies rise and fall time of square wave in steps.

(26) **SYMMETRY:** Pull and turn to adjust waveform symmetry. Divides output frequency by ten and lights ÷10 light. (Call-out 3.)

(27) **VAR:** Varies sweep time between steps of SWEEP DURATION control.

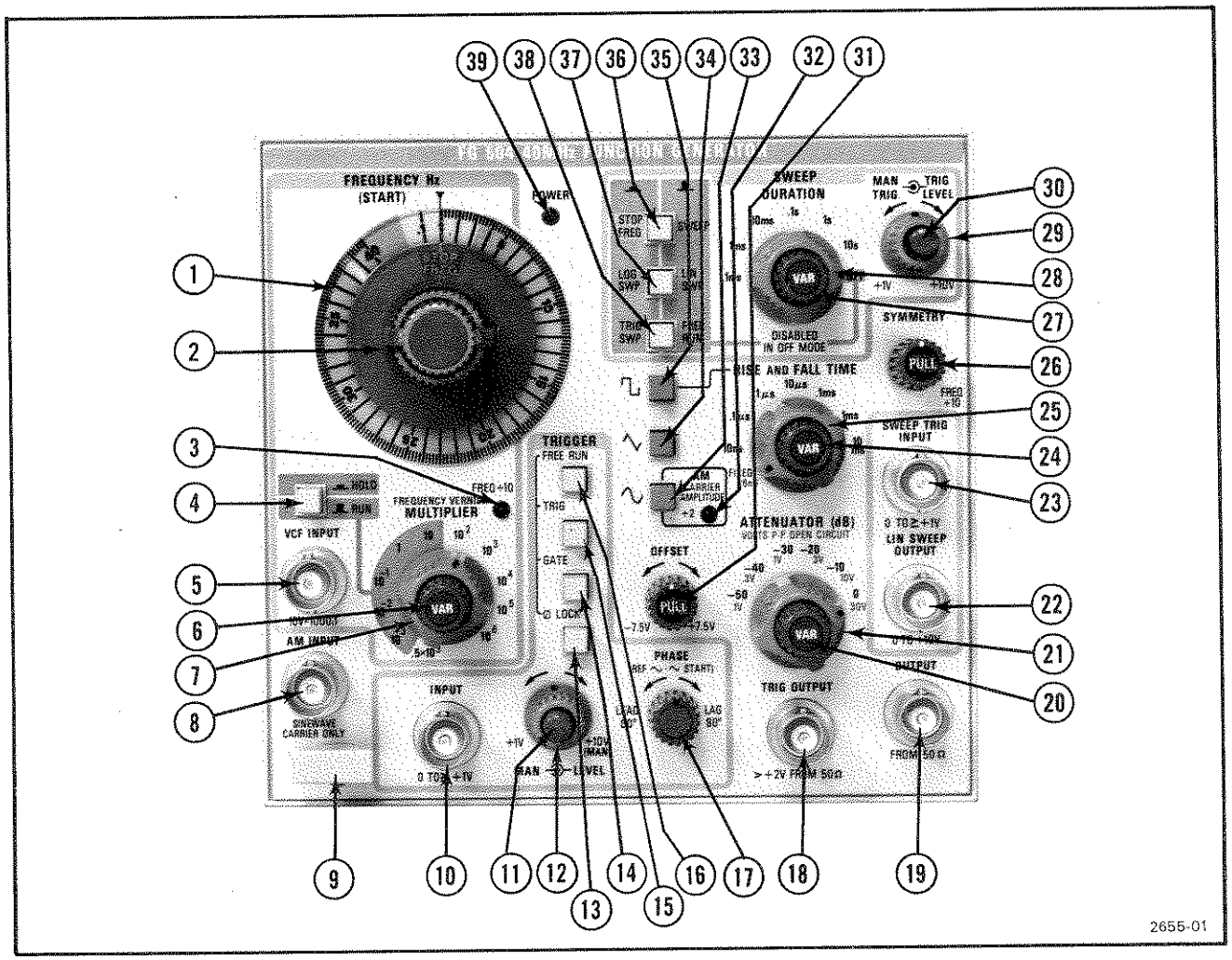


Fig. 2-2. FRONT Panel Controls and Connectors.

(28) **SWEEP DURATION:** Selects duration of frequency sweeping ramp.

(29) **TRIG LEVEL:** Selects level on SWEEP TRIG INPUT that starts sweep ramp.

(30) **MAN TRIG:** Provides manual sweep waveform start when pressed in.

(31) **OFFSET:** Pull and rotate to offset the OUTPUT waveform from 0 V at the OUTPUT connector.

(32) **AM CARRIER AMPLITUDE ÷2:** Lamp lights when impedance at AM INPUT ≤10 kΩ.

(33) **(SINE WAVE):** Button in selects sine wave output.

(34) **(TRIANGLE WAVE):** Button in selects triangle wave output.

(35) **(SQUARE WAVE):** Button in selects square wave output.

(36) **STOP FREQ:** Button in stops frequency sweep at highest (STOP) frequency. Button out sweeps frequency from START to STOP settings on FREQUENCY dial.

(37) **LOG SWP/LIN SWP:** Button in produces logarithmic sweep. Button out produces a linear sweep.

(38) **TRIG SWP/FREE RUN:** Button in causes sweep to start with trigger. Button out causes the sweep to free run.

(39) **POWER:** Indicates when power is applied to FG 504.

FIRST TIME OPERATION

The Controls and Connectors pages give a description of the front panel controls and connectors. The frequency determining controls are outlined in blue, the trigger function controls and inputs are outlined in green, and the internal sweep function controls and inputs are outlined in orange on the FG 504 front panel.

For first time operation, preset the controls as follows:

Blue section:

FREQUENCY Hz (Main Dial)	10
STOP	40
MULTIPLIER	10^2
HOLD/RUN	RUN (out)
VAR	Fully cw

Green section:

FREE RUN	In

Orange section:

SWEEP DURATION	OFF

Unmarked section:

Sine Wave	In
RISE and FALL TIME	FIXED
ATTENUATOR	−10
VAR	Fully cw

Connect a 50 Ω bnc cable terminated in 50 Ω to the vertical input of an oscilloscope. Set the oscilloscope to:

Vertical	1 V/Div DC coupled
Horizontal time base	1 millisecond/Div

Adjust the oscilloscope to display at least five full cycles of the sine wave. Now alternately push in the square wave, sine wave, and the triangle wave buttons in the unmarked section and observe the different waveshapes. Rotate the ATTENUATOR and VAR controls to verify that the output amplitude changes. Return them to the preset conditions. Pull out the OFFSET knob and rotate it. Notice the change in dc level of the output waveform. Return the OFFSET knob to the in position.

Press the square wave button in. Rotate the RISE and FALL TIME switch through its range. Note the change of square wave shape. Return the RISE and FALL TIME switch to the PRESET position. Pull the SYMMETRY knob to its out position and rotate it through its range. Note the change of waveshape for the square wave, the triangle wave, and the sine wave with the appropriate buttons pushed in. Return the SYMMETRY knob to its in position.

With the three buttons in the orange section in the out position, switch the SWEEP DURATION switch to 1 s. Note that the output frequency changes from a low frequency to a higher frequency once a second. Press the LOG SWP button in and note that the frequency change is slow at first and then more rapid. Press the STOP FREQ button and note that the sweep stops at the highest frequency of the sweep range. Rotate the STOP FREQ knob on the main dial in the blue seciton of the panel. Note

that the STOP FREQ is set by the STOP FREQ dial. Release the STOP FREQ button and press the TRIG SWP button. Note that the frequency no longer changes. Press the MAN TRIG button and note that the frequency changes once. Return the SWEEP DURATION knob to the OFF position.

Press the TRIG button in the green section of the panel in. Note that the OUTPUT signal stops. Press the MAN button in the green section in and note that there is one complete output cycle for each time the MAN switch is pressed. Press the GATE button in. Now press the MAN button. Note that the output waveform is continuous while the MAN button is pressed. Press the FREE RUN button in again for continuous output.

The output frequency controls are outlined in blue. Vary the FREQUENCY control to see the effect on the output frequency. The output frequency MULTIPLIER Knob selects the frequency range covered by the main dial. Switch the MULTIPLIER knob to the 10^{-2} range. As the signal amplitude slowly varies on the oscilloscope, push the HOLD/RUN button in and release it several times to see that the oscillator stops at one point on the waveform and then begins at the same point when the button is released.

This completes the first time operation of the instrument.

Risetime and Falltime

If the output pulse from the FG 504 is used to measure the rise or falltime of a device, consider the risetime characteristics of the associated equipment used. If the risetime of the device under test is at least ten times longer than the combined risetimes of the FG 504 plus the monitoring oscilloscope and associated cables, the error introduced will not exceed 1%. This error can generally be ignored. When the rise or falltime of the test device is less than ten times as long as the combined risetimes of the testing system, the actual risetime of the system must be determined. This is found from the risetime of each component making up the system. The total risetime equals the square root of the sum of the squares of the individual risetimes, or:

$$R_t = \sqrt{(R_1)^2 + (R_2)^2 + \ldots}$$

Once the risetime of the system is known, the risetime of the device under test can be found by using the preceding method.

The physical and electrical characteristics of the pulse transmitting cable determine the characteristic impedance, velocity of propagation, and amount of signal loss. Signal loss is related to frequency. A few feet of cable can attenuate high frequency information in a fast-rise pulse. It is therefore important to keep these cables as short as practical.

When signal comparison measurements or time difference determinations are made, the two signals from the test device should travel through coaxial cables with identical loss and time delay characteristics.

Impedance Matching

As a pulse travels down a transmission line, each time it encounters a mismatch (or an impedance different than that of the transmission line), a reflection is generated and sent back along the line to the source. The amplitude and polarity of the reflections are determined by the impedance mismatch encountered. If the impedance mismatch is a higher value than the line impedance, the reflection will be of the same polarity as the applied signal. If it is a lower value than the line impedance, the reflection will be of opposite polarity.

If the reflected signal returns before the pulse is ended, it adds to or subtracts from the amplitude of the pulse. This distorts the pulse shape and amplitude.

If the FG 504 is driving a high impedance such as the 1 MΩ input impedance (paralleled by a stated capacitance) of the vertical input to 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 504 is properly terminated.

Free Running Output

Select the desired waveform (square, triangle, or sine) by pushing the appropriate button marked with SQUAREWAVE, TRIANGLE, or SINEWAVE symbols. Push the FREE RUN button. Make certain the SWEEP DURATION switch is in the OFF position. Select the desired frequency with the MULTIPLIER and FREQUENCY Hz (START) dials. The FREQUENCY VERNIER control permits fine frequency adjustments. Connect the load to the OUTPUT terminal. Make certain the HOLD button is out. Set the ATTENUATOR control for the desired peak-to-peak output amplitude. Use the VAR knob to vary the amplitude between the steps.

The waveforms without offset center around 0 V. To offset the waveforms, pull and rotate the OFFSET control for the desired offset. If a square-wave output is selected, adjust the RISE and FALLTIME control for the desired values. The VAR knob varies these times between the

control steps. A trigger signal, one for each cycle of the selected waveform, is available at the TRIG OUTPUT connector.

When using the sine or triangle waveform output with the MULTIPLIER in the slowest five positions, the waveform output may be stopped by pushing the HOLD button. The waveform generator stops and the FG 504 outputs a dc voltage equal to the voltage the triangle or sine waveform reached when the button was pushed. This feature does not operate on the square waveform.

When pulled out, the SYMMETRY control divides the output frequency (FREQ ÷10 indicator lit) by ten, and varies the time based symmetry of the selected waveform. Pull this control and turn for the desired symmetry using any of the three basic waveforms.

Triggered or Gated Operation

With the FG 504 set for free running operation as described in the previous paragraphs, apply the triggering or gating signal to the INPUT connector. If only one cycle of the output waveform per trigger is desired, push the TRIG button and set the LEVEL control for the level on the triggering waveform at which the output waveform is to begin. If more than one cycle of the output waveform is desired, press the GATE pushbutton. The FG 504 output now begins at the triggering level and continues until the waveform at the input connector drops below the triggering level. The output duration is now the duration of the gating waveform. The number of cycles per burst may be approximated by dividing the gating signal duration by the period of the FG 504 output frequency. In the gated mode of operation, the FG 504 always completes the last cycle. If, at the termination of the gating waveform, less than approximately 270° of the last cycle remains, an additional cycle is completed.

In triggered or gated operation the PHASE control varies the start of the triangle or sine output waveform by ±80°. This phase change is measured from the 0 V, 0° point on the output waveform.

To manually trigger or gate the FG 504, turn the LEVEL control fully clockwise and push the TRIG or GATE button as desired. In the TRIG mode, pushing the MAN button triggers one cycle of the output waveforms. In the GATE mode, the selected output waveform continues as long as the MAN button is pressed in.

Voltage Controlled Frequency Operation

The output frequency of the FG 504 can be swept over a frequency range of 1000:1, depending on the MULTIPLIER setting, by applying a 0 V to 10 V signal to the VCF INPUT connector. See Figure 2-3 for the maximum vcf range for each MULTIPLIER setting. It may be necessary to vary the FREQUENCY VERNIER control to obtain the full 1000:1 swept range or the lowest swept frequency desired.

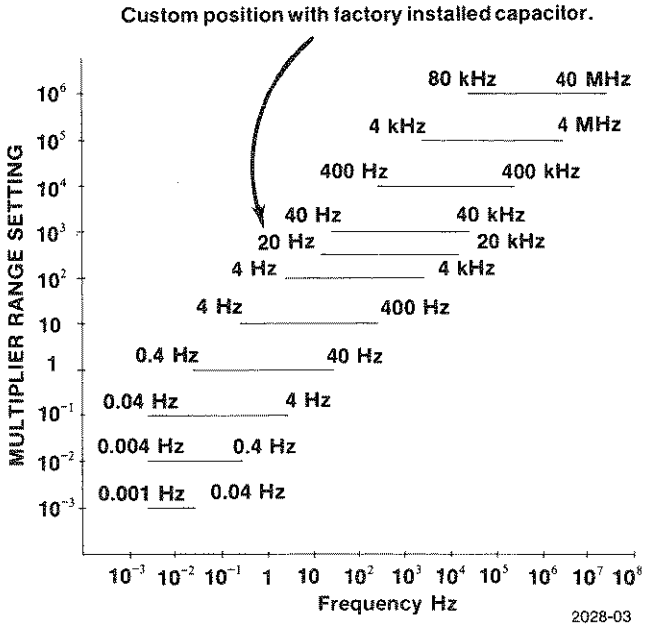


Fig. 2-3. Graph showing range of frequencies for each MULTIPLIER setting that can be swept with a 0 to 10 V signal applied to the VCF INPUT.

The polarity of the vcf input signal determines the direction the output frequency is swept from the frequency set by the MULTIPLIER, FREQUENCY Hz (START), and FREQUENCY VERNIER controls. A positive-going voltage raises the frequency while a negative-going voltage lowers the frequency. A voltage that varies symmetrically about 0 V sweeps the output frequency symmetrically about the center frequency determined by the frequency controls (see Figure 2-3).

Since the vcf input amplitude versus frequency is a linear relationship, the frequency output may be determined from the vcf input amplitude and the FREQUENCY Hz dial position. VCF sensitivity is the highest possible dial setting (40) times the MULTIPLIER range divided by the maximum VCF input voltage (10 V). In the FG 504, this is a nominal sensitivity (Hz per V), of 4 times the MULTIPLIER setting. For example, with a 10^3 MULTIPLIER setting, a two-volt change at the VCF INPUT will change the output frequency 8 kHz.

Custom Timing Range

This feature permits the user to install a custom swept frequency range. The .5 X 10^3 position of the MUL-

TIPLIER switch is used for the custom range. The factory-installed capacitor (C248) for this position of the MULTIPLIER switch provides a swept range from 20 Hz to 20 kHz.

Phase Locked Operation

The frequency of the output waveform may be synchronized with an externally-applied reference signal. The output frequency of the FG 504 must be set to within ±10 major dial divisions of the frequency of the externally applied signal (the "1" on the dial is the lowest major dial division). Connect the reference signal to the INPUT connector and push the ΦLOCK pushbutton. The PHASE control varies the phase of the output waveform ±80° with respect to the reference signal waveform. The LEVEL control adjusts the triggering point on the reference waveform.

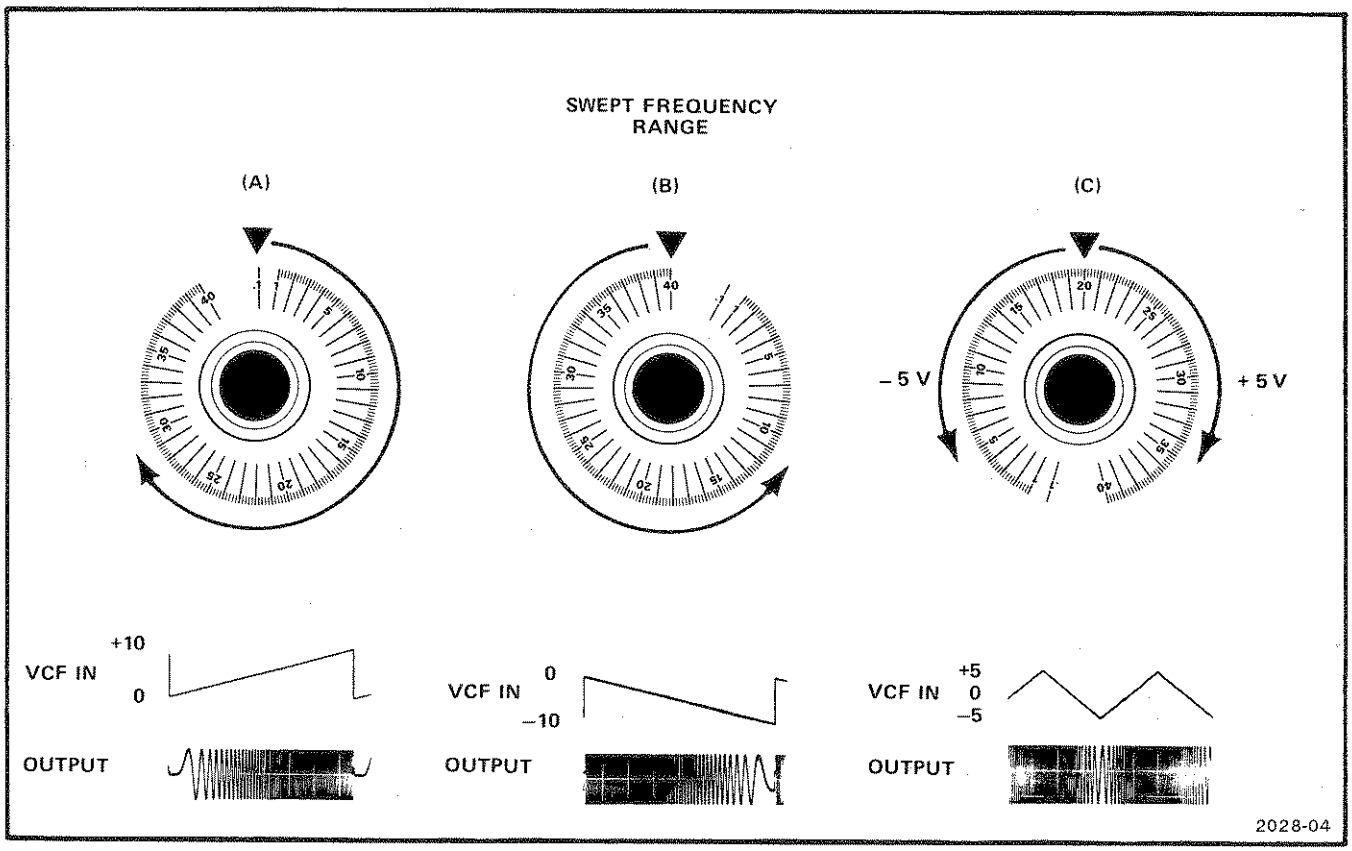


Fig. 2-4. Swept frequency range with 10 V signal applied to VCF IN connector.

Proper adjustment of the LEVEL and PHASE controls is easier if they are adjusted first in the TRIG mode. Set the FREE RUN frequency of the FG 504 somewhat higher than the frequency of the reference signal applied to the INPUT connector, and then select the TRIG mode. Adjust the LEVEL control for stable triggering and (if viewing on an oscilloscope) adjust the output frequency of the FG 504 until it is nearly the same as the frequency of the signal applied to the INPUT connector. Set the PHASE control at 12 o'clock (for 0° with sine wave selected) and press ΦLOCK. Readjust the PHASE control, if necessary, to obtain a stable output at the desired phase. The PHASE control range decreases above 4 MHz.

A jumper allows the VCF INPUT to function as a phase modulating input when the FG 504 is operated in the PHASE LOCK mode. The phase modulating input voltage limits are ±2.5 V, with an upper frequency limit of 1 kHz. When phase locked, the phase modulating voltage varies the output phase by approximately 5°/V.

Amplitude Modulating Input

To amplitude modulate the output waveform, connect the modulating signal to the AM INPUT connector. Push the SINEWAVE pushbutton and set the FREQUENCY Hz dial for the desired carrier frequency. Refer to the Amplitude Modulating Input specification for more information about this mode of operation.

Internal Sweep Operation

Select the time for one complete sweep with the SWEEP DURATION control. Use the VAR knob to obtain sweep times between steps. Set the FREQUENCY Hz (START), STOP FREQ, and MULTIPLIER dials for the desired swept frequencies. Select either a logarithmic or linear sweep rate by pushing or releasing the LOG/LIN SWP pushbutton. Release the STOP FREQ pushbutton. Use the FREQUENCY VERNIER control to set the START frequency when sweeping from frequencies lower than the "1" calibration figure on the dial. If a triggered sweep is desired, push the TRIG SWP pushbutton and connect the trigger signal to the SWEEP TRIG INPUT connector. Adjust the LEVEL control so the sweep starts at the desired level on the triggering waveform. If free running operation is desired, release the TRIG SWP pushbutton. The sweep may be stopped and the output frequency held at any time by pushing the STOP FREQ pushbutton. The linear sweep voltage is available at the SWEEP OUTPUT connector.

External Input Signals for Trigger, Gate, Phase Lock, and Sweep Trig Modes

External input signals for these modes must be at least 1 V p-p around the dc voltage set by the LEVEL control (+1 V to +10 V). With the LEVEL control at or near minimum, the external signal must, at least, pass through +0.5 V and +1.5 V. For example, an external signal whose amplitude is symmetrical about 0 V (such as a sine wave) must be at least 3 V p-p (+1.5 V to −1.5 V). Typical input signals are as shown in Figure 2-5.

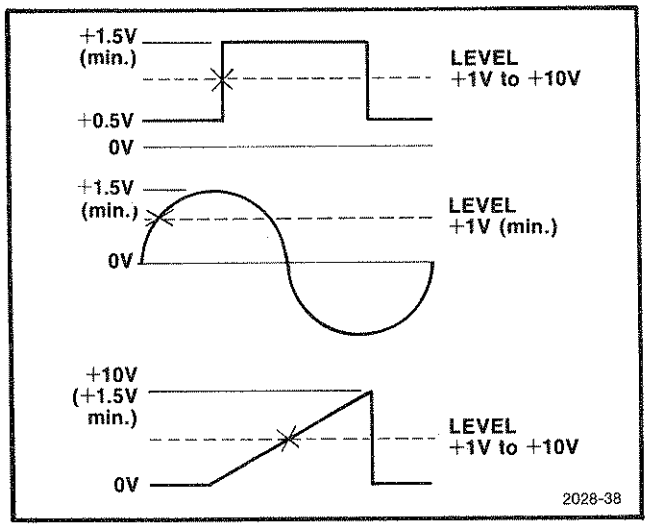


Fig. 2-5. Trigger Signal amplitude requirements and triggering points.

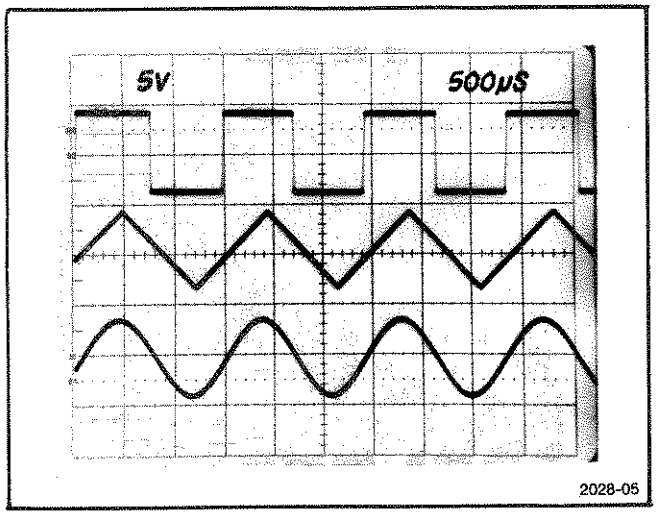


Fig. 2-7. BASIC FUNCTIONS. Square, triangle, and sine waveforms selected by front panel pushbuttons.

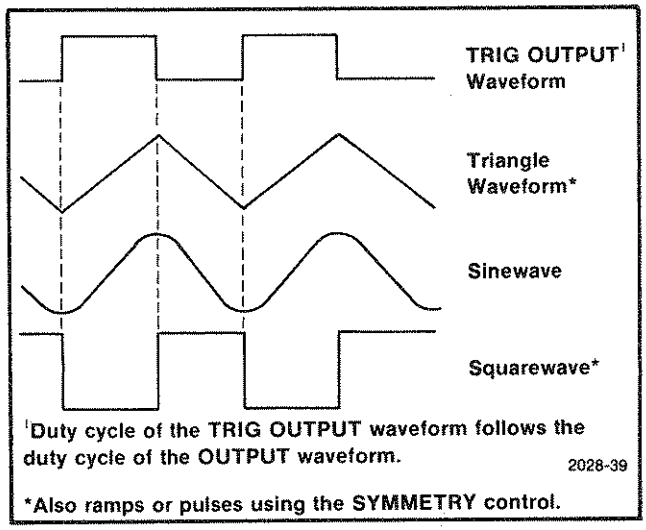


Fig. 2-6. Phase relationships between OUTPUT waveforms and the TRIG OUT waveform.

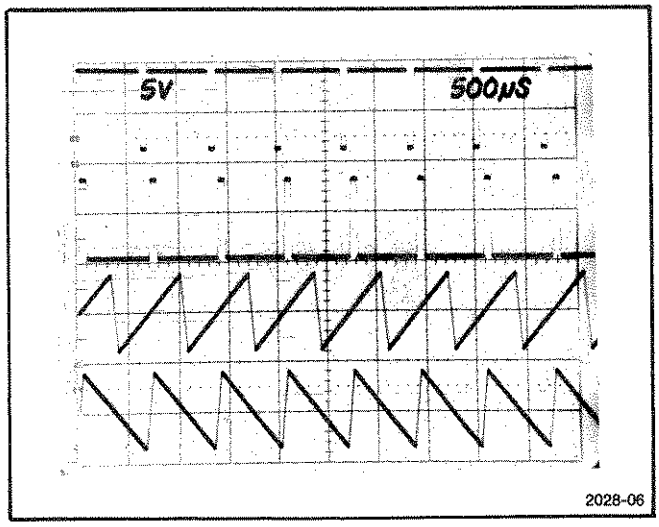


Fig. 2-8. RAMPS AND PULSES. These are obtained from the basic waveforms by using the SYMMETRY control.

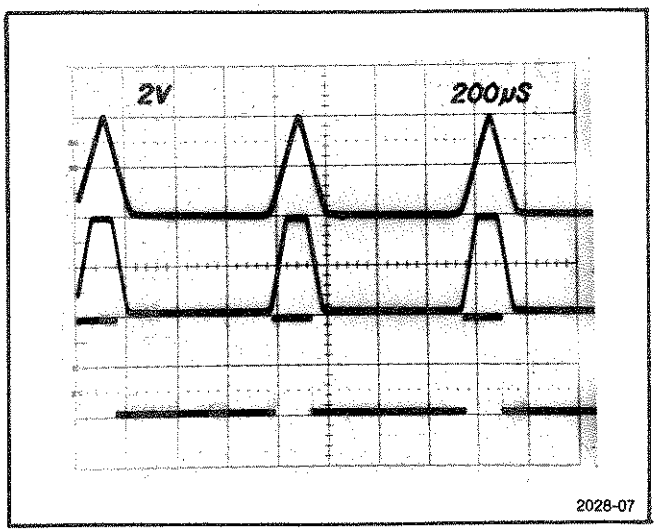


Fig. 2-9. VARIABLE RISE AND FALL TIMES. By varying the rise and fall times in the square wave mode various pulse shapes are formed.

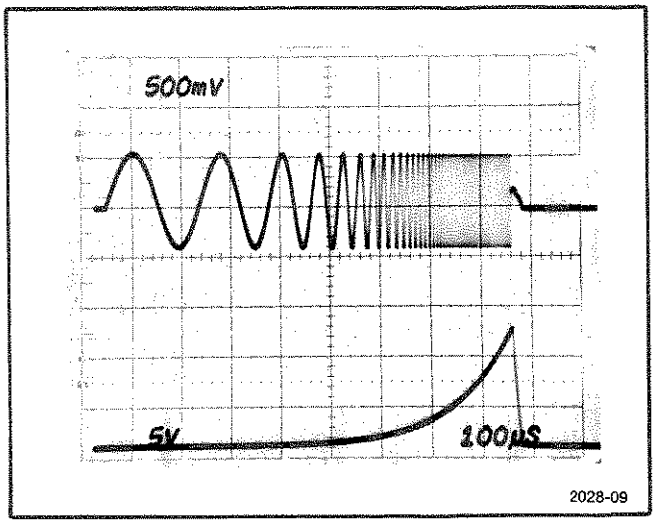


Fig. 2-11. LOGARITHMIC SWEEP. Use the same setup as in Fig. 2-10. Select the logarithmic ramp. The frequency is swept at a logarithmic rate. The logarithmic ramp voltage is not externally available.

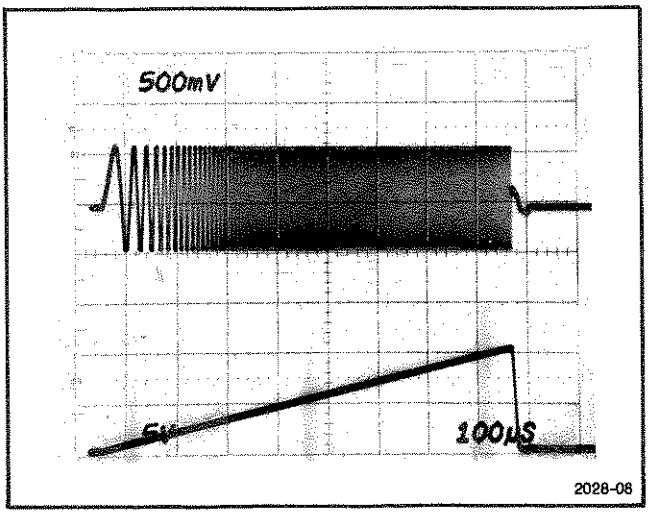


Fig. 2-10. LINEAR SWEEP. Select the start and stop frequencies and the internal linear ramp for a swept output from the start to stop frequencies in the selected time.

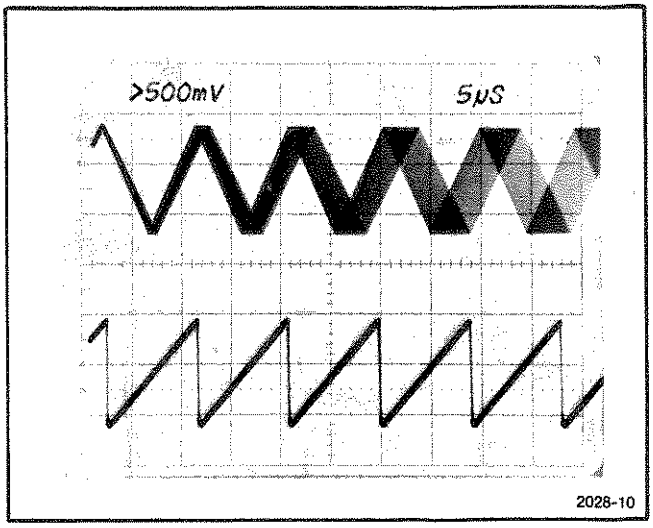


Fig. 2-12. NARROW BAND SWEEP. The top trace shows the triangle waveform swept by a linear ramp. The start frequency is 9.52 kHz and the stop frequency is 10.52 kHz. This function is useful for narrow band sweep testing. The bottom trace is the sweeping ramp.

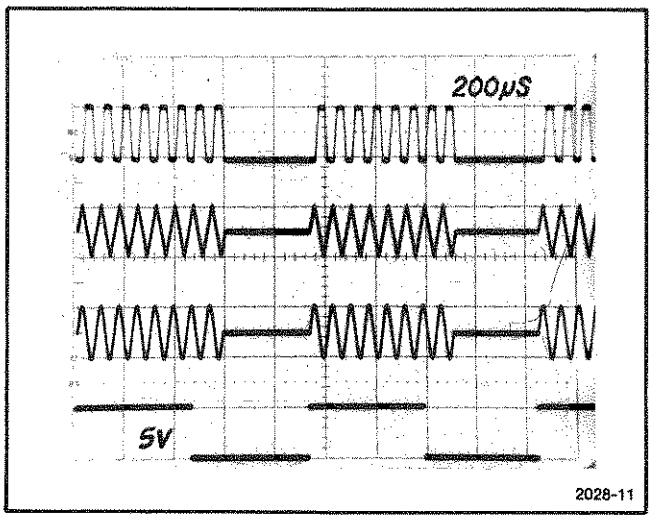


Fig. 2-13. GATED OPERATION. The top three traces are various output waveforms and the bottom trace is the gating waveform applied to the trigger INPUT connector with the GATE pushbutton pressed in. Note the additional cycle completed after the waveforms are gated off.

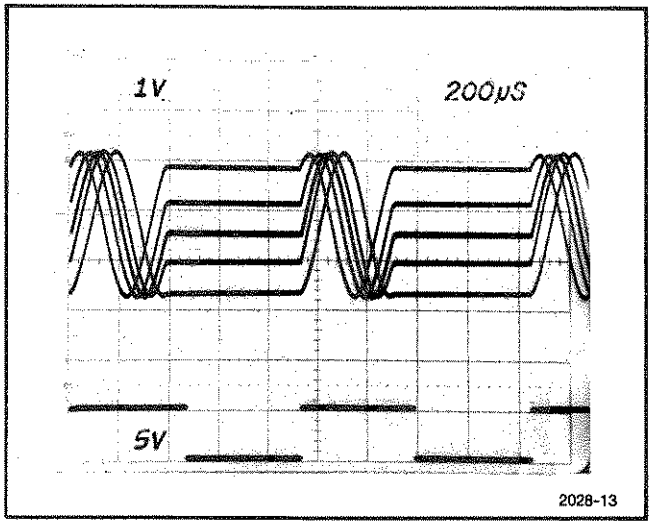


Fig. 2-15. PHASE CONTROL OPERATION. This photograph illustrates PHASE control usage in the triggered mode. The five super-imposed traces illustrate the effect of the phase control. This control provides approximately ±80° of shift. The bottom trace is the triggering waveform.

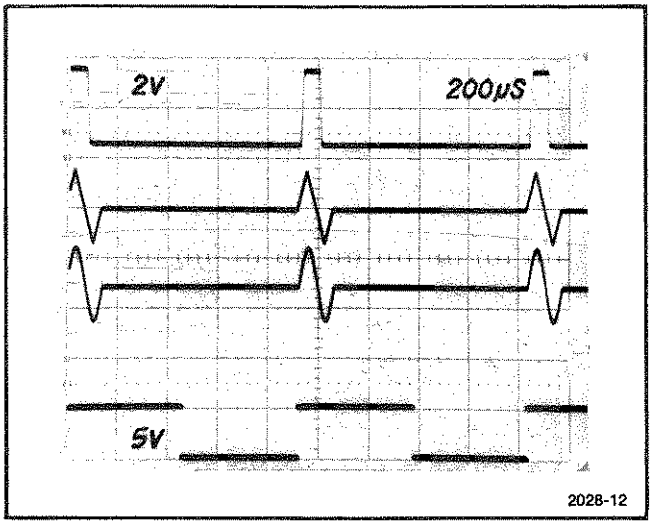


Fig. 2-14. TRIGGERED OPERATION. The top three traces are the various output traces selected. The bottom trace is the triggering waveform applied to the trigger INPUT connector with the TRIG mode selected. Note that only one cycle of the output waveforms is completed.

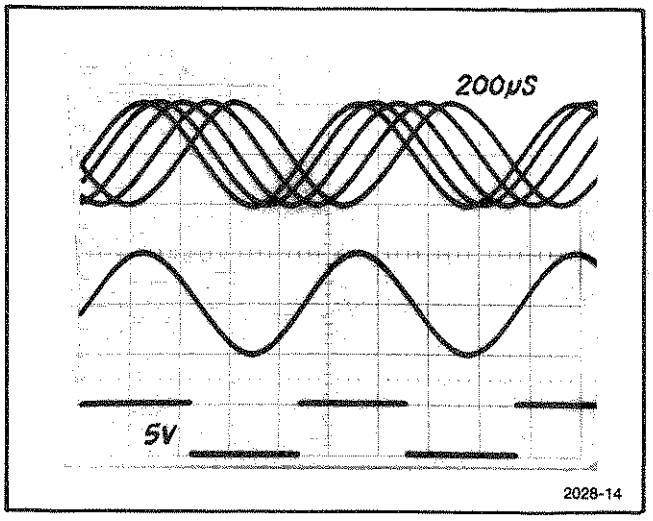


Fig. 2-16. PHASE LOCKED LOOP. The bottom trace is the signal applied to the INPUT connector in the Φ LOCK mode of operation. The middle trace is the output phase locked to the input signal. The top traces show the effect of the PHASE control.

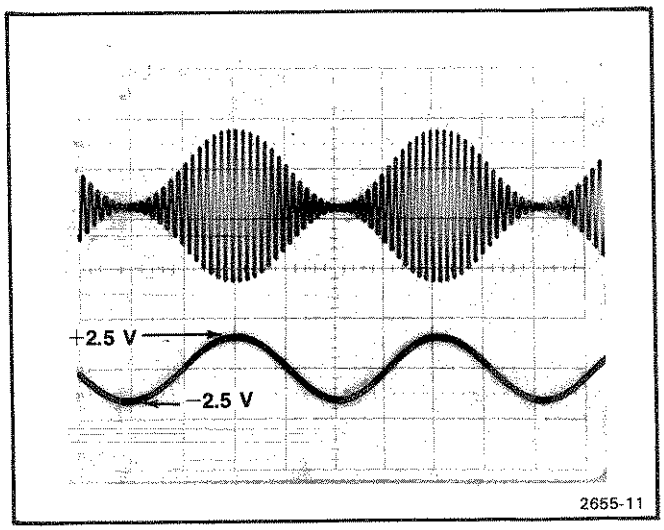


Fig. 2-17. AMPLITUDE MODULATION. The top trace shows the 100% modulated envelope and the bottom trace the modulating signal. ±2.5 volts modulates the output 100%. (5 V P-P centered around 0 V).

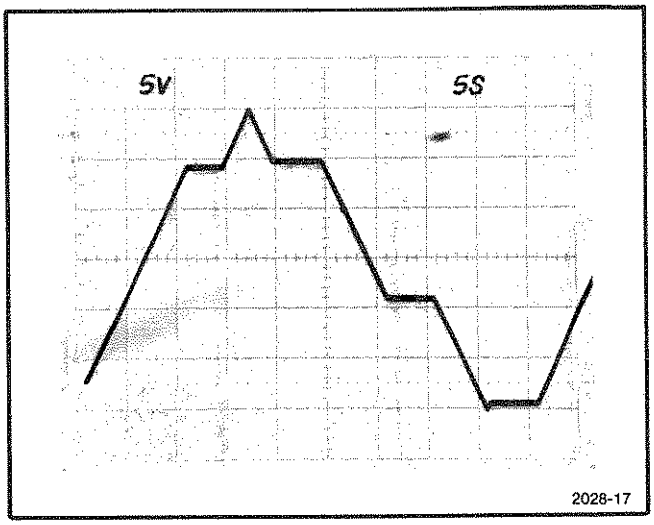


Fig. 2-19. LOW FREQUENCY HOLD. The output of the FG 504 in the lowest five MULTIPLIER settings can be held at any level by pushing the HOLD button. The steps on this time exposure were obtained in this manner.

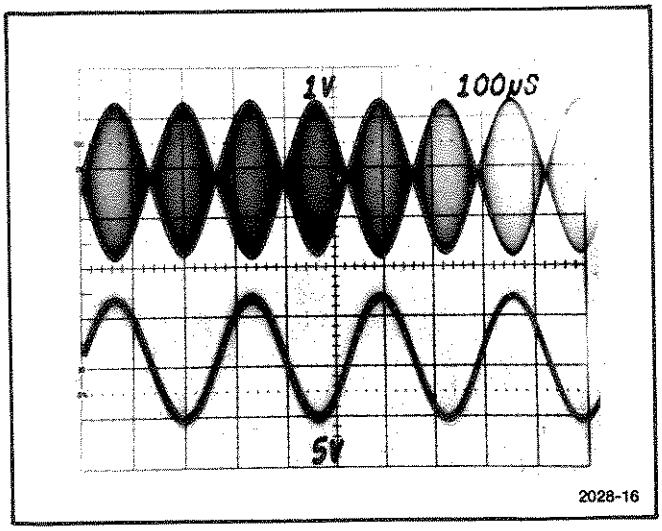


Fig. 2-18. SUPPRESSED CARRIER MODULATION. The top trace shows a double sideband suppressed carrier modulation envelope while the bottom trace displays the modulating waveform. The upper peak of the modulating waveform is at 0 V and the bottom peak is at −10 V. The overall level of the modulating waveform must be carefully adjusted for true suppressed carrier operation.

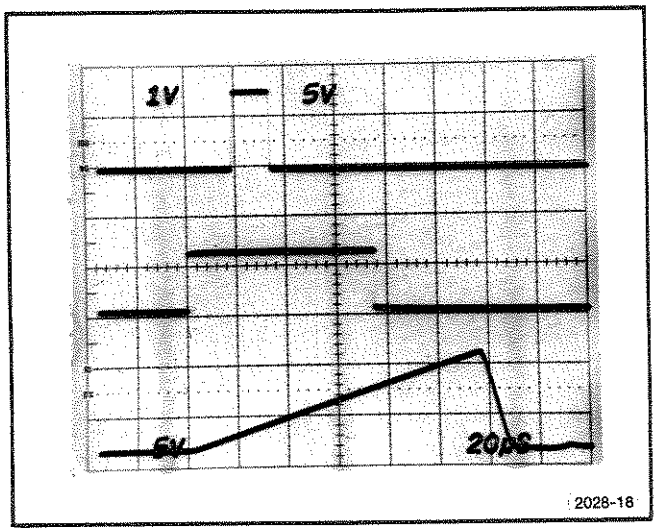


Fig. 2-20. DELAYED OPERATION. A wide range of delay times are available by using the internal sweep generator as a delay generator. The middle trace is the underlayed input signal applied to the SWEEP TRIG INPUT. The bottom trace is at the LIN SWP OUT connector. This ramp is applied to the external trigger INPUT connector. The top trace is the delayed output pulse. The amount of delay is proportional to the sweep duration and the setting of the TRIG LEVEL control. Be sure when using the sweep as a delay generator to set the STOP FREQ dial fully ccw.

Tone Burst Testing

The FG 504, with an external pulse generator, may be used for tone burst testing. Connect the output of a TEKTRONIX PG 501 (or equivalent) pulse generator to the trigger INPUT connector. Select the GATE mode of operation. Set the external pulse generator for the desired pulse duration and repetition rates. Now select the desired sweep time for the FG 504. Select the start and stop frequencies. The output of the FG 504 will now be a series of tone bursts as shown in Figure 2-21.

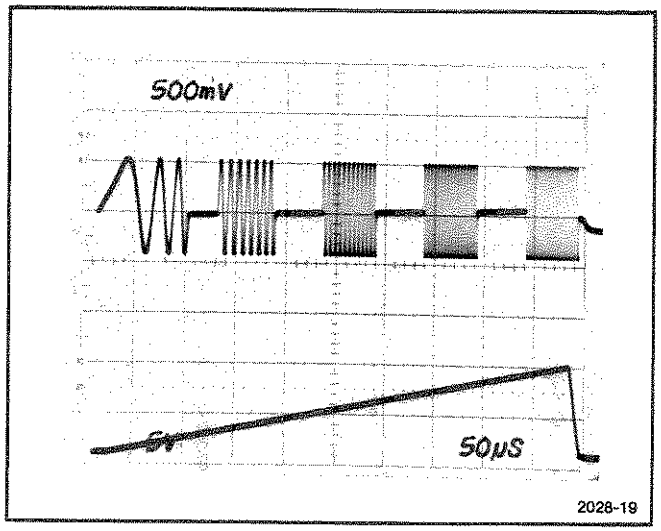


Fig. 2-21. TONE BURST TESTING. The lower trace is the linear ramp from the LIN SWEEP OUTPUT terminal.

Filter Testing

The swept frequency capabilities of the FG 504 make it quite suitable for sweep testing filters. When using the FG 504 in this application, it is best to use the LOG SWP Mode. Figures 2-22 and 2-23 illustrate the advantages of using logarithmic sweeps.

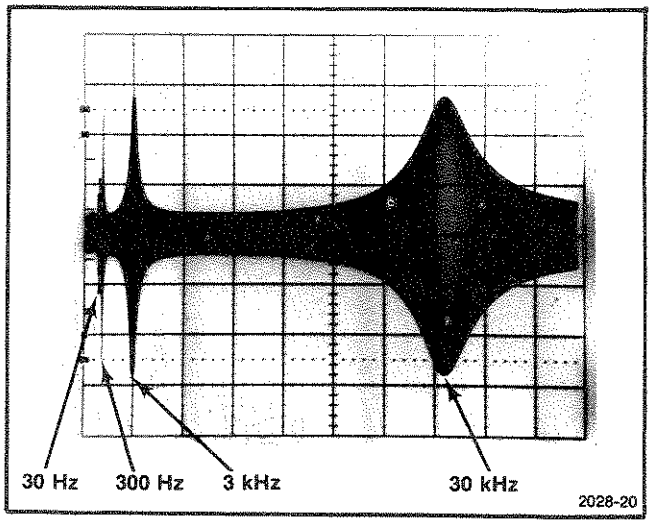


Fig. 2-22. Linear sweep showing skewed spacing of filter output frequencies.

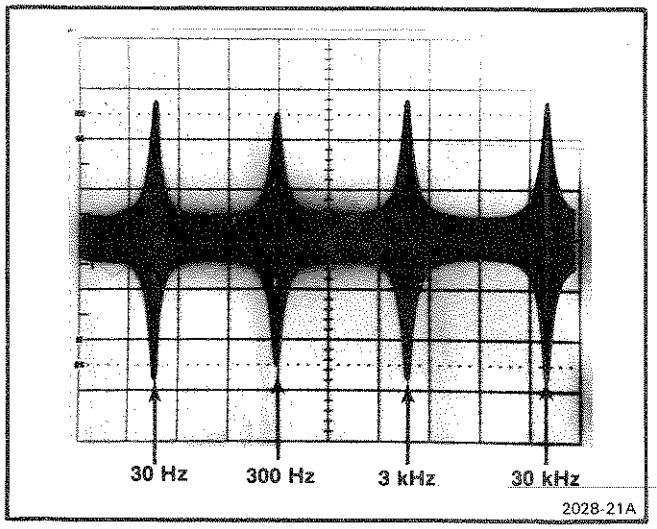


Fig. 2-23. Logarithmic sweep showing even spacings of filter output frequencies.

Pulse Shaping

The external triggering feature of the FG 504 adapts for pulse shaping. Connect the pulse to be shaped to the trigger INPUT connector and place the FG 504 in the square-wave mode. The triggering level may be selected with the TRIG LEVEL control. The rise and fall times, levels, and symmetry of the clean output pulse may be changed as desired. Figure 2-24 illustrates this application.

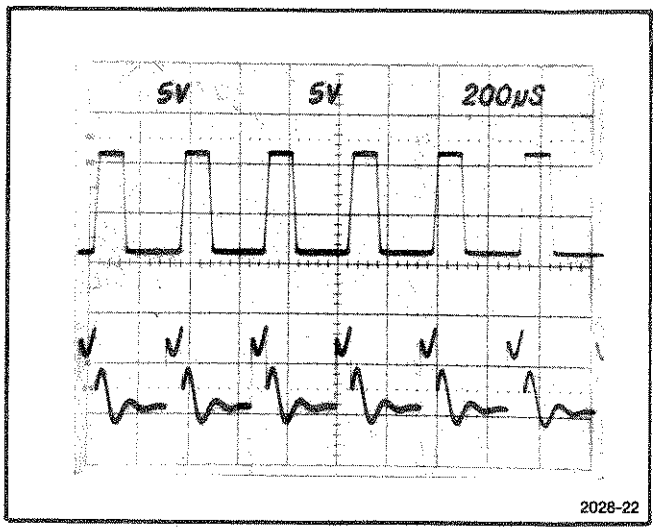


Fig. 2-24. PULSE SHAPING CAPABILITIES. The lower trace is the triggering signal.

REPACKAGING FOR SHIPMENT

If the Tektronix 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.

Save and re-use the package in which your instrument was shipped. If the original packaging is unfit for use or not available, repackage the instrument as follows:

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

The carton test strength for your instrument is 200 pounds.