

Tektronix[®]
COMMITTED TO EXCELLENCE

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**FG 501A
2 MHz FUNCTION
GENERATOR**

Français Deutsch 日本語

INSTRUCTION MANUAL

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NOTE

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OPERATOR 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.

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.

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.

Grounding the Product

This product is grounded through the grounding conductor of the power module 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 module 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.

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 module connected to a power source that will not apply more than

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.

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NOTE

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SPECIFICATION

INTRODUCTION

This section of the manual contains a general description of the FG 501A and complete electrical, environmental, and physical specifications. Standard accessories are also listed. Instrument option information is located in the back of this manual in a separate section.

INSTRUMENT DESCRIPTION

The FG 501A Function Generator provides low distortion sine, square, triangle, ramp, and pulse waveforms over the frequency range 0.002 Hz to 2 MHz in eight decade steps. Dc offset up to ± 13 V is available. Waveform triggering and gating functions, in addition to being slope (+ or -) selectable, are provided with variable phase control capable of up to $\pm 90^\circ$ phase shift. The symmetry of the output waveform may also be varied from 5 to 95%. Step attenuators provide up to 60 dB of attenuation in 20 dB steps. A variable amplitude control provides an additional 20 dB attenuation.

A voltage-controlled frequency (VCF) input is provided to control the output frequency from an external voltage source. The output frequency can be swept above and below the selected frequency to a maximum of 1000:1 depending on the polarity and amplitude of the VCF input signal and the selected output frequency.

ACCESSORIES

The only accessory shipped with the FG 501A is the Instruction Manual.

PERFORMANCE CONDITIONS

The electrical characteristics are valid with the following conditions:

1. The instrument must have been adjusted at an ambient temperature between $+20^\circ\text{C}$ and $+30^\circ\text{C}$ and operating at an ambient temperature between 0°C and $+50^\circ\text{C}$.
2. The instrument must be in a non-condensing environment whose limits are described under Environmental.
3. Allow twenty minutes warm-up time for operation to specified accuracy; sixty minutes after exposure to or storage in high humidity (condensing) environment.

Items listed in the Performance Requirements column of the Electrical Characteristics 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 1-1

ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
Frequency Range Sine-wave, square-wave, and triangle	.002 Hz to 2 MHz	Provided in eight decade steps plus variable, with overlap on all ranges. Calibrated portion of dial extends from 20 to 2. Portion of dial from 2 to .2 is uncalibrated .0002 Hz to .002 Hz uncalibrated portion of dial.
Ramp and Pulse002 Hz to 200 kHz $\pm 10\%$ calibrated portion of dial.	Measured at 50% duty cycle. .0002 Hz to .002 Hz uncalibrated portion of dial.
Variable Symmetry Duty Cycle	$\leq 5\%$ to $\geq 95\%$.	Activation of Symmetry control divides output frequency by ≈ 10 .
Output Amplitude	At least 30 V P-P into an open circuit, at least 15 V p-p into 50 Ω . (Front panel only.)	Offset control off.
Output Impedance		Front panel $z_o = 50 \Omega \pm 10\%$. ATTEN in 0 dB position. Rear interface $z_o = 600 \Omega - 10\%$.
Offset Range	At least ± 13 V into open circuit, at least ± 6.5 V into 50 Ω . Maximum peak signal plus offset cannot exceed ± 15 V into an open circuit, or ± 7.5 into 50 Ω . (Front panel only.) Offset reduced by attenuators.	
Frequency Resolution		1 part in 10^4 of full scale with frequency vernier control.
Stability (Frequency) Time		$\leq 0.1\%$ for 1 hour, $\leq 0.5\%$ for 24 hours.
Temperature		Within 2% from .2 Hz to 2 MHz, and within 10% from .002 Hz to .2 Hz. The FREQUENCY Hz dial must be on the calibrated portion. The instrument must be in a temperature between 0°C and +50°C and checked after a 1 hour warmup. VAR SYMM control disabled.

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Amplitude Flatness	Measured with 0 dB ATTEN button "IN" and output driving 50 Ω load. (Front panel only.)	
Sinewave (10 kHz Sinewave Ref)	± 0.1 dB 20 Hz to 20 kHz ± 0.5 dB 20 kHz to 1 MHz ± 1 dB 1 MHz to 2 MHz	Typically ± 0.5 dB .002 Hz to 20 Hz.
Squarewave (10 kHz Squarewave Ref)	Peak to peak amplitude within ± 0.5 dB of squarewave reference amplitude 20 Hz to 2 MHz.	Typically within ± 0.5 dB .002 Hz to 20 Hz.
Triangle (10 kHz Triangle Ref)	Peak to peak amplitude within ± 0.5 dB of triangle wave reference amplitude 20 Hz to 200 kHz. Within 2 dB 200 kHz to 2 MHz.	Typically within ± 0.5 dB .002 Hz to 20 Hz.
Sinewave Distortion	$\leq 0.25\%$ 20 Hz to 20 kHz on 10^1 range and below. $\leq 0.5\%$ 20 kHz to 100 kHz. All harmonics at least 30 dB below fundamental from 100 kHz to 2 MHz.	20° to 30°C. Measured with with average responding THD meter. Measurement bandwidth limited to approximately 300 kHz. Verified at 15 V p-p into 50 Ω load. Must be on calibrated portion of dial. VAR SYMM control off. Offset control off. Trig output driving open circuit.
Squarewave Output	Step ATTEN in 0 dB position.	
Risetime and Faltime	≤ 25 ns at 15 V p-p into 50 Ω .	
Aberrations (p-p)	$\leq 3\%$ (Front panel only.)	
Pulse Output	Step ATTEN in 0 dB position.	
Risetime and Faltime	≤ 25 ns at 15 V p-p into 50 Ω .	
Aberrations (p-p)	$\leq 3\%$ (Front panel only.)	
VCF Input	10 V $\geq 1000:1$	Applicable within the range of top dial frequency to top dial frequency/1000. Positive going voltage increases frequency. Maximum Slew Rate = 0.5 V/ μ s. Maximum input ≤ 15 V pk.
Ext Trig/Gate Input		
Impedance		≈ 2 k Ω
Threshold Level	+1 V $\pm 20\%$.	Maximum input ≤ 15 V pk.
Trigger Output	$\geq +4$ V into open circuit. $\geq +2$ V into 50 Ω .	
Variable Phase Range	At least $\pm 90^\circ$.	Sine and Triangle only.

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Attenuators		60 dB in 20 dB steps. >20 dB additional attenuation with amplitude control.
Accuracy	± 1 dB.	Verified at 20 kHz.
Dial Accuracy	Within 3% of full scale. 20 to 12, except within 5% between 0° and 15°C and 35° and 50°C on the 10 ⁵ Multiplier Range.	2 to .2 Uncal.
Triangle Linearity		Greater than or equal to 99% 20 Hz to 200 kHz. 97% 200 kHz to 2 MHz (calibrated). Measured from 10% to 90% of waveform.
Time Symmetry	Better than 1% 20 Hz to 200 kHz 5% 200 kHz to 2 MHz (calibrated).	

Table 1-2

MISCELLANEOUS

Characteristics	Description
Power Consumption	12 W or less. (Plug-in only)
Recommended Adjustment Interval	1000 hours or 6 months, whichever occurs first.
Warm-up Time	20 minutes.

Table 1-3

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	Exceeds MIL-T-28800B, class 5.
	95% RH, 0°C to 30°C
	75% RH to 40°C
	45% RH to 50°C
Altitude	Exceeds MIL-T-28800B, class 5.
Operating	4.6 Km (15,000 ft)
Non-operating	15 Km (50,000 ft)
Vibration	Exceeds MIL-T-28800B, class 5, when installed in qualified power modules. ^b
	0.38 mm (0.015") peak to peak, 5 Hz to 55 Hz, 75 minutes.

Table 1-3 (cont)

Characteristics	Description
Shock	30 G's (1/2 sine), 11 ms duration, 3 shocks in each direction along 3 major axes, 18 total shocks.
Bench Handling ^c	12 drops from 45°, 4" or equilibrium, whichever occurs first.
Transportation ^c	Qualified under National Safe Transit Association Preshipment Test Procedures 1A-B-1, and 1A-B-2.
EMC	Within limits of MIL-461A, and F.C.C. Regulations, Part 15, Subpart J, Class A.
Electrical Discharge	20 kV maximum charge applied to instrument case.

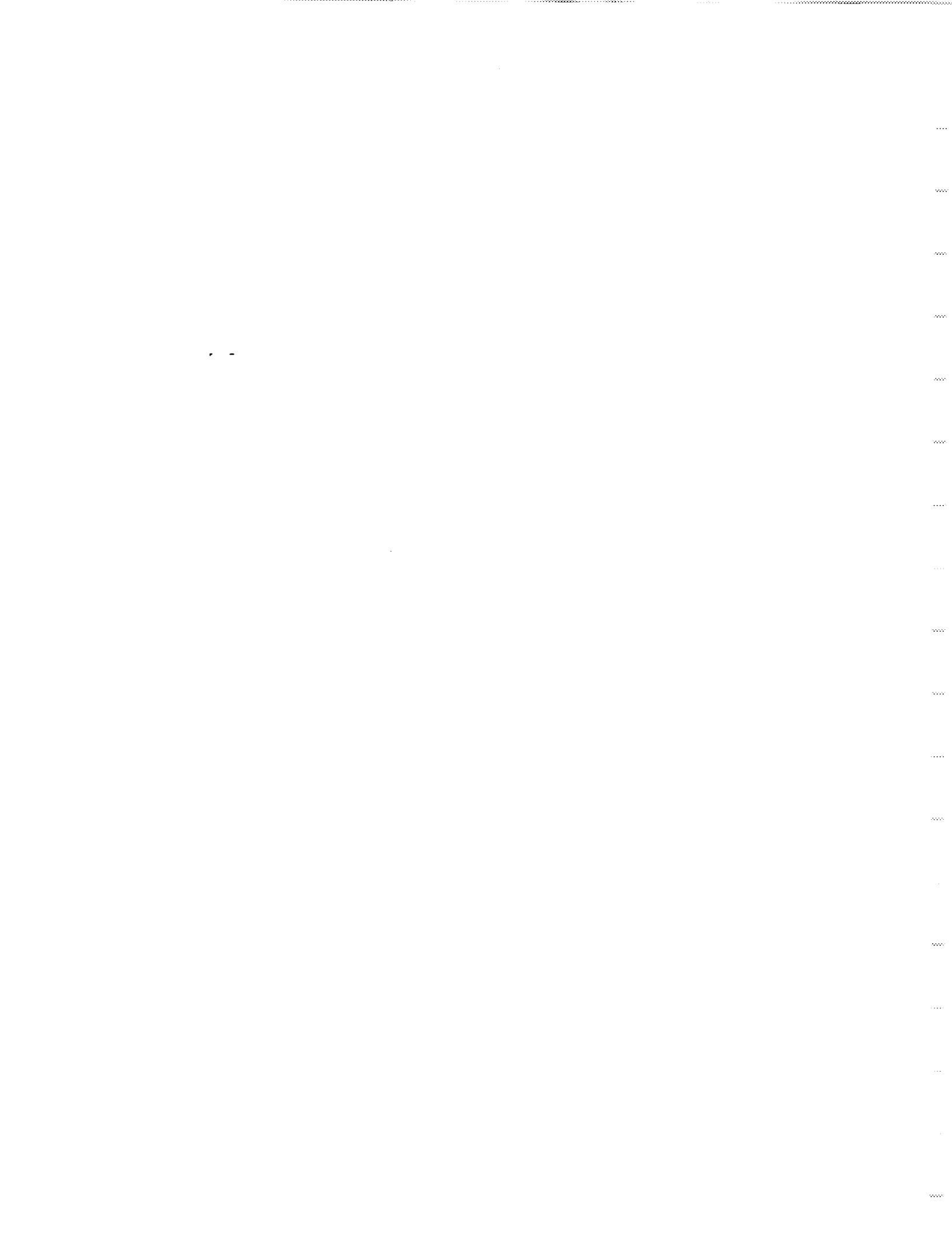
^a With power module.

^b Refer to TM 500 power module specifications.

^c Without power module.

Table 1-4
PHYSICAL CHARACTERISTICS

Characteristics	Description
Finish	Plastic/aluminum laminate front panel. Anodized aluminum chassis.
Net Weight	1.88 lbs (.85 kg)
Overall Dimensions	Height 5 in (126mm) Width 2.6 in (67mm) Length 11.9 in (303mm)



OPERATING INSTRUCTIONS

INTRODUCTION

This section of the manual provides operating information required to obtain the most effective performance from the FG 501A. Included are installation and removal instructions, a functional description of the front panel controls, and a general description of the operating modes. Some basic applications of the instrument are also briefly discussed.

INSTALLATION AND REMOVAL

The FG 501A is calibrated and ready to use when received. It operates in one compartment of any TM 500-series power module. Refer to the power module instruction manual for line voltage requirements and power module operation.

CAUTION

To prevent damage to the FG 501A, turn the power module off before installation or removal of the instrument from the mainframe. Do not use excessive force to install or remove.

Check to see that the plastic barriers on the interconnecting jack of the selected power module compartment match the cutouts in the FG 501A circuit board edge connector. If they do not match, do not insert the instrument until the reason is found. When the units are properly matched, align the FG 501A chassis with the upper and lower guides of the selected compartment (see Fig. 2-1). Insert the FG 501A into the compartment and press firmly to seat the circuit board edge connector in the power module interconnecting jack. Apply power to the FG 501A by operating the power switch on the power module.

To remove the FG 501A from the power module, pull the release latch (located in the lower left corner) until the interconnecting jack disengages. The FG 501A will now slide straight out.

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.

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 instrument dimensions. Cushion the instrument by tightly packing dunnage or urethane foam between the carton and the instrument, on all sides. Seal the carton with shipping tape or an industrial stapler.

The carton test strength for your instrument is 200 pounds.

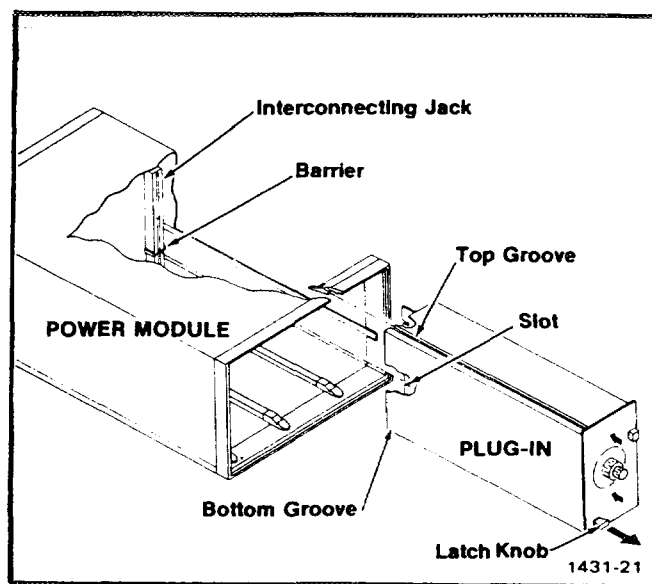
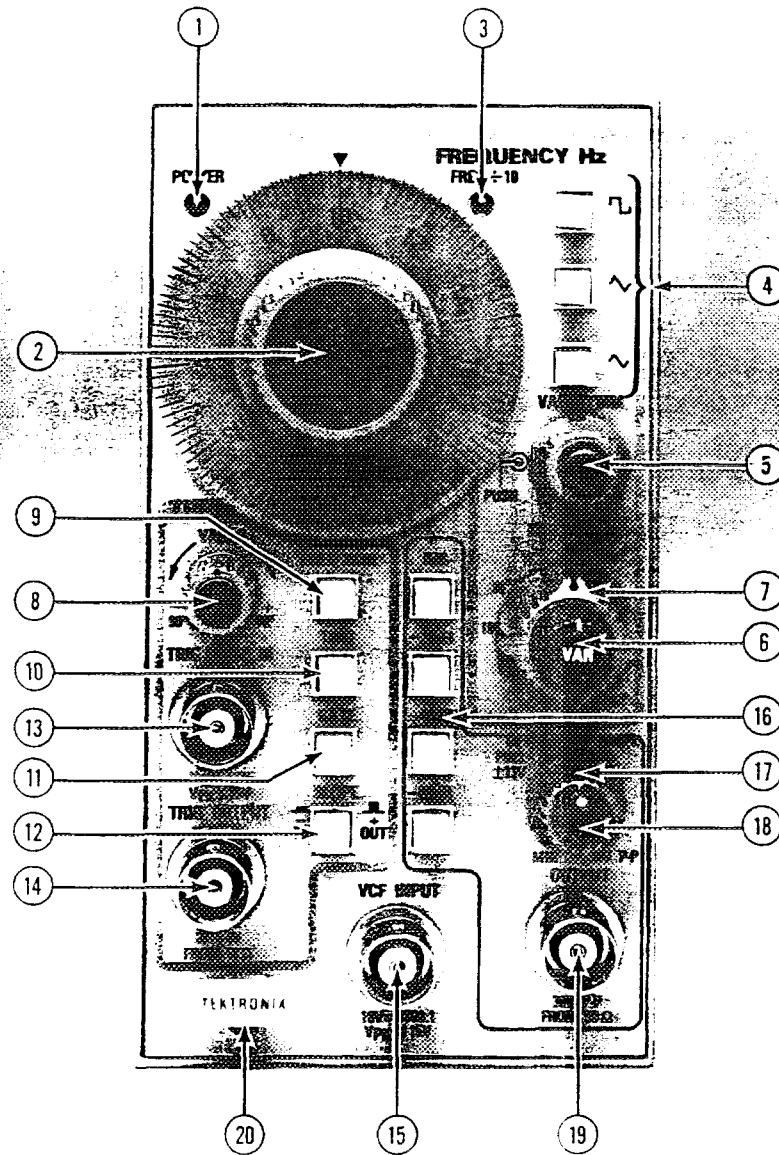


Fig. 2-1. Plug-in installation and removal.

CONTROLS AND CONNECTORS

Although the FG 501A 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 operation of the instrument are located on the front panel. A brief description of these controls follows. Refer to Fig. 2-2.



2957-01

Fig. 2-2. Controls and connectors.

- ① **POWER**—Illuminated when power is applied to the FG 501A.

FREQUENCY CONTROL AND FUNCTION SELECTION

- ② **FREQUENCY Hz**—Selects the frequency of the output waveform in conjunction with the **MULTIPLIER** control.
- ③ **FREQ ÷ 10**—Illuminated when the variable symmetry function is activated.
- ④ **FUNCTION BUTTONS**—Select square, triangle, and sine waveforms.
- ⑤ **VAR SYMM**—(push to enable) adjusts time-based symmetry of the selected output waveform. Reduces the frequency of the output waveform by a factor ≈ 10 and illuminates the **FREQ ÷ 10** indicator.
- ⑥ **FREQUENCY VERNIER**—For fine adjustment of output frequency to at least 1 part in 10^4 of full scale.
- ⑦ **MULTIPLIER**—Selects the output frequency in eight decade steps in conjunction with the **FREQUENCY Hz** control.

TRIGGER AND GATE CONTROLS

- ⑧ **VAR θ** —Selects phase lead or lag, up to $\pm 90^\circ$, relative to input trigger or gate waveform.
- ⑨ **FREE RUN**—When pressed causes continuous waveform output.
- ⑩ **TRIG**—When pressed causes output of one cycle of selected waveform for each trigger pulse applied to the **TRIG/GATE IN** connector.

- ⑪ **GATE**—When pressed causes continuous output of the selected waveform for the duration of the gating pulse.

- ⑫ **SLOPE**—Button selects, in **TRIG** mode, the slope of the input signal which will trigger the selected output waveform. In **GATE** mode, whether output gating will occur when the level of the input signal is above or below the threshold level of +1 V.

- ⑬ **TRIG/GATE IN**—Bnc connector used to apply the external trigger or gating signal.

- ⑭ **VCF INPUT**—Bnc connector for applying an external voltage for controlling the output frequency of the generator.

- ⑮ **TRIGGER OUTPUT**—Bnc connector which outputs one positive pulse for each cycle of the selected output waveform.

OUTPUT CONTROLS

- ⑯ **ATTENUATOR BUTTONS**—Attenuate the amplitude of the selected output waveform in 20 dB steps to a maximum of 60 dB when pressed.

- ⑰ **AMPL**—Varies the amplitude of the selected output waveform, between steps of the attenuator buttons.

- ⑱ **OFFSET**—Pull and turn control, concentric with the **AMPL** control, provides up to ± 13 V dc offset of the output waveform.

- ⑲ **OUTPUT**—Bnc connector for output of the selected waveform.

- ⑳ **RELEASE LATCH**—Pull to disengage the FG 501A from the power module.

OPERATING CONSIDERATIONS

OUTPUT CONNECTIONS

The output of the FG 501A 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 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 cables (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.

RISETIME AND FALLTIME

If the FG 501A is used to measure the rise or falltime of a device, the risetime characteristics of associated equipment should be considered. If the risetime of the device under test is at least 10 times greater than the combined risetimes of the FG 501A and associated equipment, the error introduced will not exceed 1%, and generally can be ignored. When the rise or falltime of the test device is less than 10 times as long as the combined risetimes of the testing system, the actual risetime of the system must be calculated. The risetime of the device under test can be determined once the risetime of the system is known.

IMPEDANCE MATCHING

If the FG 501A is driving a high impedance such as the 1 M Ω 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 to the oscilloscope input. The attenuator isolates the input capacitance of the device, and the FG 501A is properly terminated.

FIRST TIME OPERATION

The Controls and Connectors pages give a description of the front panel controls and connectors. The waveform selection and frequency determining controls are outlined in blue, the trigger function controls and inputs are outlined in green, and the output controls are outlined in black.

The following exercise will familiarize the operator with most functions of the FG 501A.

NOTE

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

Preset the controls as follows:

Blue section:

FREQUENCY Hz	10
MULTIPLIER	10 ²
FREQUENCY VERNIER	Fully cw
WAVEFORM—SINE	in
VAR SYMM	off

Green section:

FREE RUN	in
----------	----

Black section:

ATTENUATOR	−20 dB
AMPL (variable)	Centered
OFFSET	off

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

Vertical	1 V/Div DC Coupled
Horizontal (Time Base)	1 ms/Div

The oscilloscope should display 1 complete cycle per division of the sine waveform (approximately 10 cyc' across the graticule).

1. Alternately press the square, triangle and sine buttons and observe the different waveshapes. Return to the preset condition.

2. Alternately press the four attenuator buttons and rotate the AMPL (variable) control to verify that the waveform amplitude changes. Return these controls to the preset condition.

3. Pull the OFFSET knob out and rotate it. Notice the change in dc level of the displayed waveform. Return the OFFSET knob to the in position.

4. Push the VAR SYMM button to release it to the out position. Observe that the $FREQ \div 10$ indicator is illuminated and only one cycle of the output waveform is displayed. Rotate the VAR SYMM control through its range and notice the change in shape of the square, triangle, and sine waveforms (with the appropriate buttons pushed in). Return the controls to the preset condition.

5. Rotate the FREQUENCY control and the MULTIPLIER switch while observing the change in frequency of the displayed waveform. Return these controls to the preset condition.

OPERATING MODES

FREE-RUNNING OUTPUT

The following procedure will provide a free-running output with variable frequency and amplitude.

1. Select the desired waveform.
2. Set the AMPL control fully counterclockwise. Check that the VAR SYMM and OFFSET controls are in the off (in) position.
3. Select the desired frequency with the FREQUENCY Hz dial and MULTIPLIER switch. Frequency equals dial setting times multiplier setting.
4. Connect the load to the FG 501A output connector and adjust the AMPL control for the desired output amplitude.

TRIGGERED OR GATED (BURST) OPERATION

With the FG 501A set for free-running operation, as described in previous paragraphs, apply the triggering or gating signal to the TRIG/GATE IN connector.

If only one cycle of the output waveform per trigger is desired, push the TRIG button and select + or - slope. One output cycle will now be generated for each input trigger cycle.

If more than one cycle of the output waveform is desired, push the GATE button. The output will now be continuous for the duration of the gating waveform. The number of cycles per burst can be approximated by dividing the gating signal duration by the period of FG 501A output frequency.

In triggered or gated operation the PHASE control varies the start of the output waveform by $\pm 90^\circ$. This phase change is measured from the 0 V, 0° point on the output waveform.

VOLTAGE CONTROLLED FREQUENCY (VCF) OPERATION

The output frequency of any selected waveform can be swept within a range of 1000:1 by applying an external voltage to the VCF INPUT connector. The polarity of the VCF input signal determines which direction the output frequency sweeps from the selected frequency. A positive (+) going signal increases the frequency while a negative (-) going signal decreases the frequency. The amplitude and polarity of the input voltage can be selected within a range of ± 10 V depending on the FREQUENCY Hz dial setting.

The maximum swept frequency range of 1000:1 encompasses the uncalibrated portion of the FREQUENCY Hz dial ($< .2$ to 2). To ensure that the frequency does sweep at least a range of 1000:1, it is recommended that the FREQUENCY Hz dial be set at $.2$ and a 0 to $+10$ V signal be applied to the VCF INPUT connector. It may be necessary

to vary the FREQUENCY VERNIER control to obtain the full 1000:1 swept range or the lowest swept frequency desired.

Since the VCF input amplitude is a linear relationship, the frequency output range can be determined from the VCF input amplitude.

TRIGGER OUTPUT

A 14 V square wave is available from the TRIGGER OUTPUT connector. The frequency of the trigger output is determined by the frequency of the selected output waveform. One trigger pulse is generated for each positive cycle of the output signal except when square waves are selected. When generating square waves, one trigger pulse is generated for each negative cycle of the output signal. Trigger output impedance is 50 Ω .

BASIC WAVEFORM CAPABILITIES

The following photographs illustrate the basic waveform capabilities of the FG 501A.

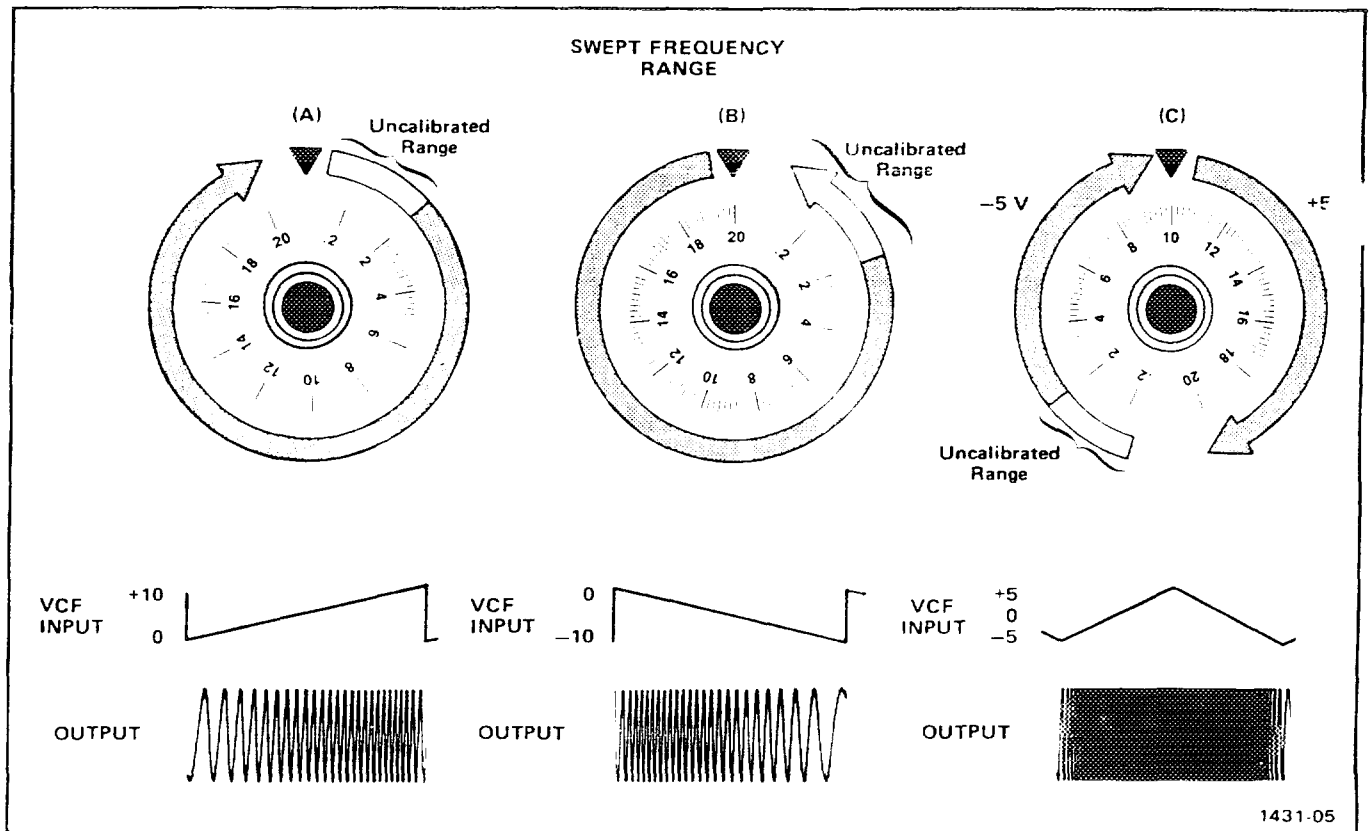


Fig. 2-3. Swept Frequency range with 10 V signals applied to VCF IN connector.

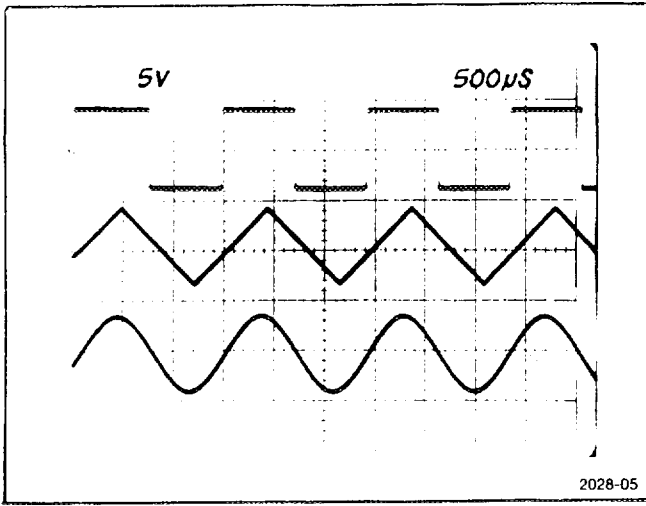


Fig. 2-4. BASIC FUNCTIONS. Square, triangle, and sine waveforms selected by front panel pushbuttons.

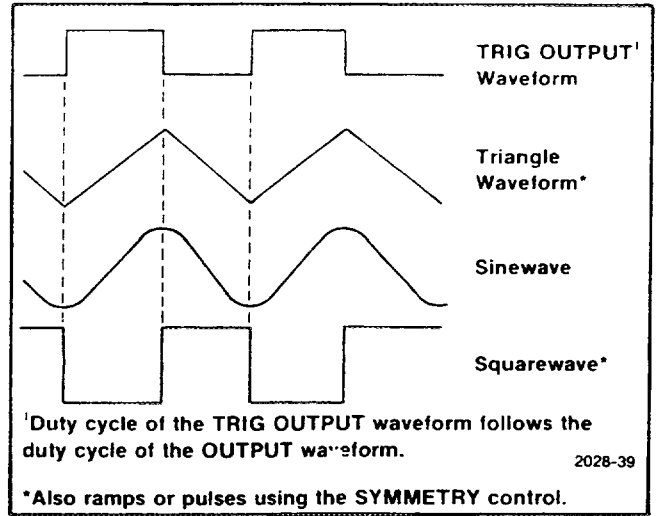


Fig. 2-6. Phase relationships between OUTPUT waveforms and the TRIG OUT waveform.

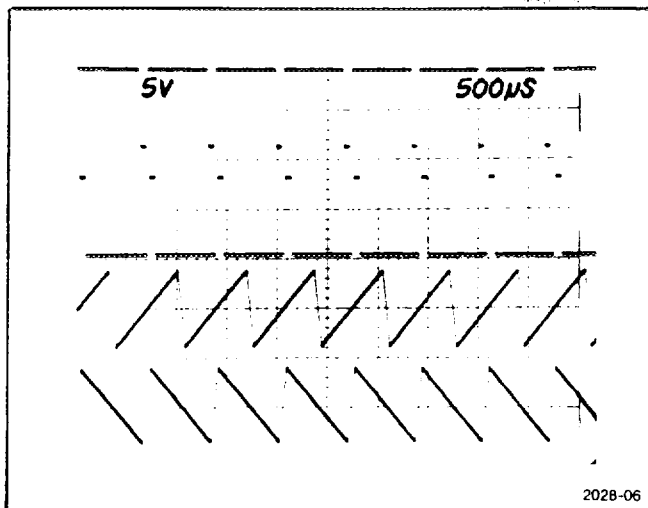


Fig. 2-5. RAMPS AND PULSES. These are obtained from the basic waveforms by using the SYMMETRY control.

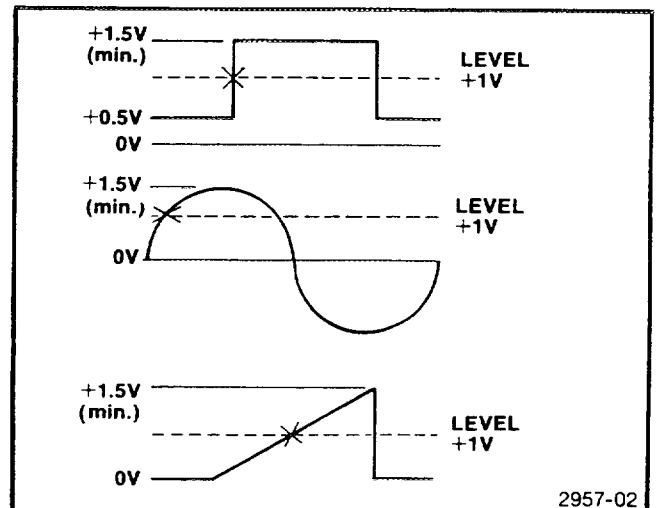


Fig. 2-7. Trigger Signal amplitude requirements and triggering points.

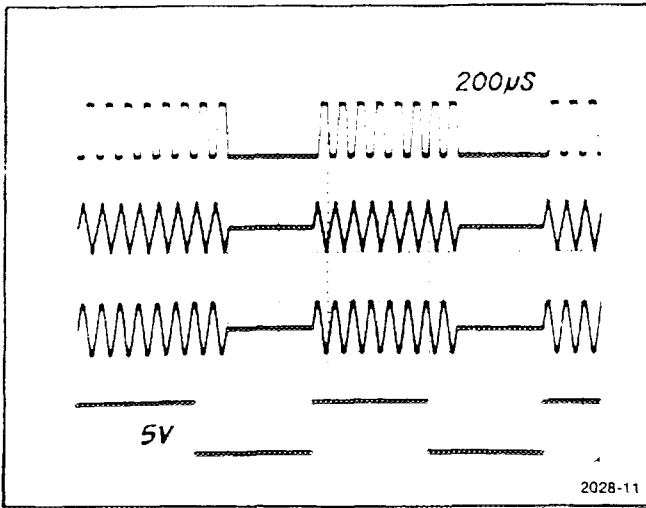


Fig. 2-8. GATED OPERATION. The top three traces are various output waveforms and the bottom trace is the gating waveform applied to the trigger INPUT connector with the GATE pushbutton pressed in. Note the additional cycle completed after the waveforms are gated off.

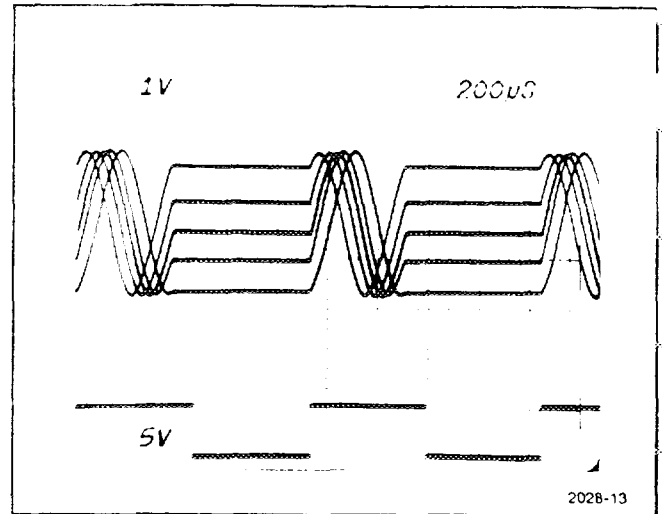


Fig. 2-10. PHASE CONTROL OPERATION. This photograph illustrates PHASE control usage in the triggered mode. The five super-imposed traces illustrate the effect of the phase control. This control provides $\pm 90^\circ$ of shift. The bottom trace is the triggering waveform.

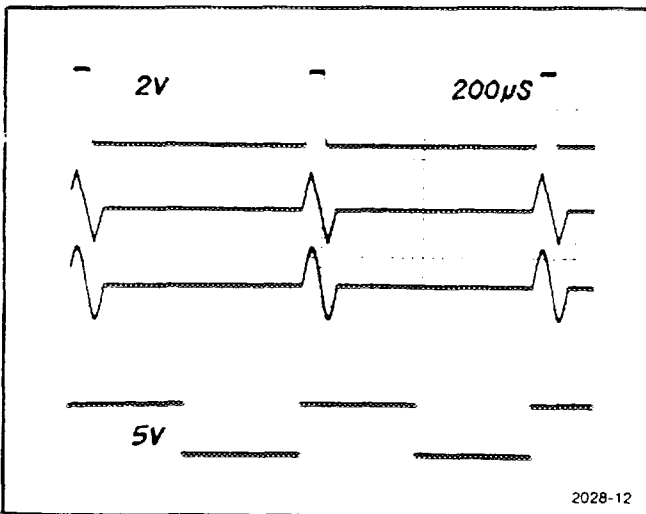


Fig. 2-9. TRIGGERED OPERATION. The top three traces are the various output traces selected. The bottom trace is the triggering waveform applied to the trigger INPUT connector with the TRIG mode selected. Note that only one cycle of the output waveforms is completed.

APPLICATIONS

RESPONSE ANALYSIS

The FG 501A is particularly suited for determining response characteristics of circuits or systems. This application utilizes the VCF input of the FG 501A to sweep the generator over a range of frequencies. Refer to the Voltage Controlled Frequency (VCF) Operation discussion under Operating Modes for additional information.

1. Connect the equipment as shown in Fig. 2-11.
2. Set the MULTIPLIER selector and FREQUENCY Hz dial for the desired upper or lower frequency limit (depending on the direction you wish to sweep).
3. Apply the desired waveform to the VCF INPUT connector. (A positive-going waveform will increase the frequency while a negative-going waveform will decrease it.)
4. Adjust the amplitude of the VCF input waveform for the desired output frequency range.

5. Observe the response characteristics on the monitoring oscilloscope.

The frequency at which a displayed response characteristic occurs can be determined by first removing the VCF input waveform, then manually adjusting the FREQUENCY Hz dial to again obtain the particular characteristic observed in the swept display and reading that frequency on the FREQUENCY Hz dial.

TONE-BURST GENERATION OR STEPPED FREQUENCY MULTIPLICATION

The FG 501A can be used as a tone-burst generator or frequency multiplier for checking tone-controlled devices. This application utilizes a ramp generator, such as the TEKTRONIX RG 501, as a VCF signal source and a pulse generator, such as the TEKTRONIX PG 501, as a gating signal source.

The following procedure describes a technique for obtaining a tone-burst or frequency multiplied output

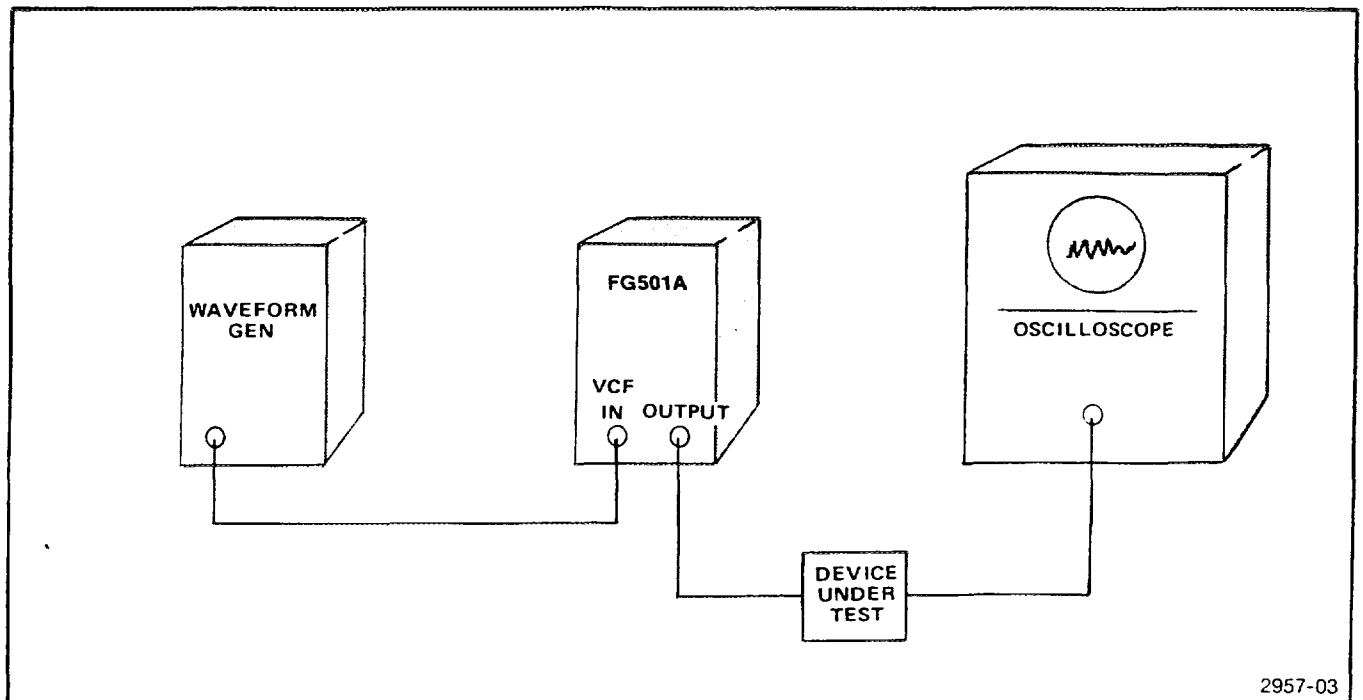


Fig. 2-11. Analyzing circuit or system response.

from the FG 501A. Refer to the Gated (burst) Output and Variable Phase and the Voltage-controlled Frequency (VCF) Output discussions under Operation for additional information.

Adjust the pulse generator duration for the desired burst width.

1. Connect the equipment as shown in Fig. 2-12.
2. Push the GATE button in and set the PHASE control to the desired phase.
3. Set the ramp generator for the desired ramp duration and polarity.
4. Adjust the pulse generator period for the desired number of bursts within the selected ramp duration.

5. Select the sweep frequency range by adjusting the FREQUENCY Hz dial for one end of the sweep range (upper or lower limit depending on the polarity of the ramp). Then, adjust the ramp generator amplitude for the other swept frequency limit.

Various other tone-burst or frequency multiplied characteristics can be obtained by using different gating input waveforms, i.e., triangle, sine, square, etc.

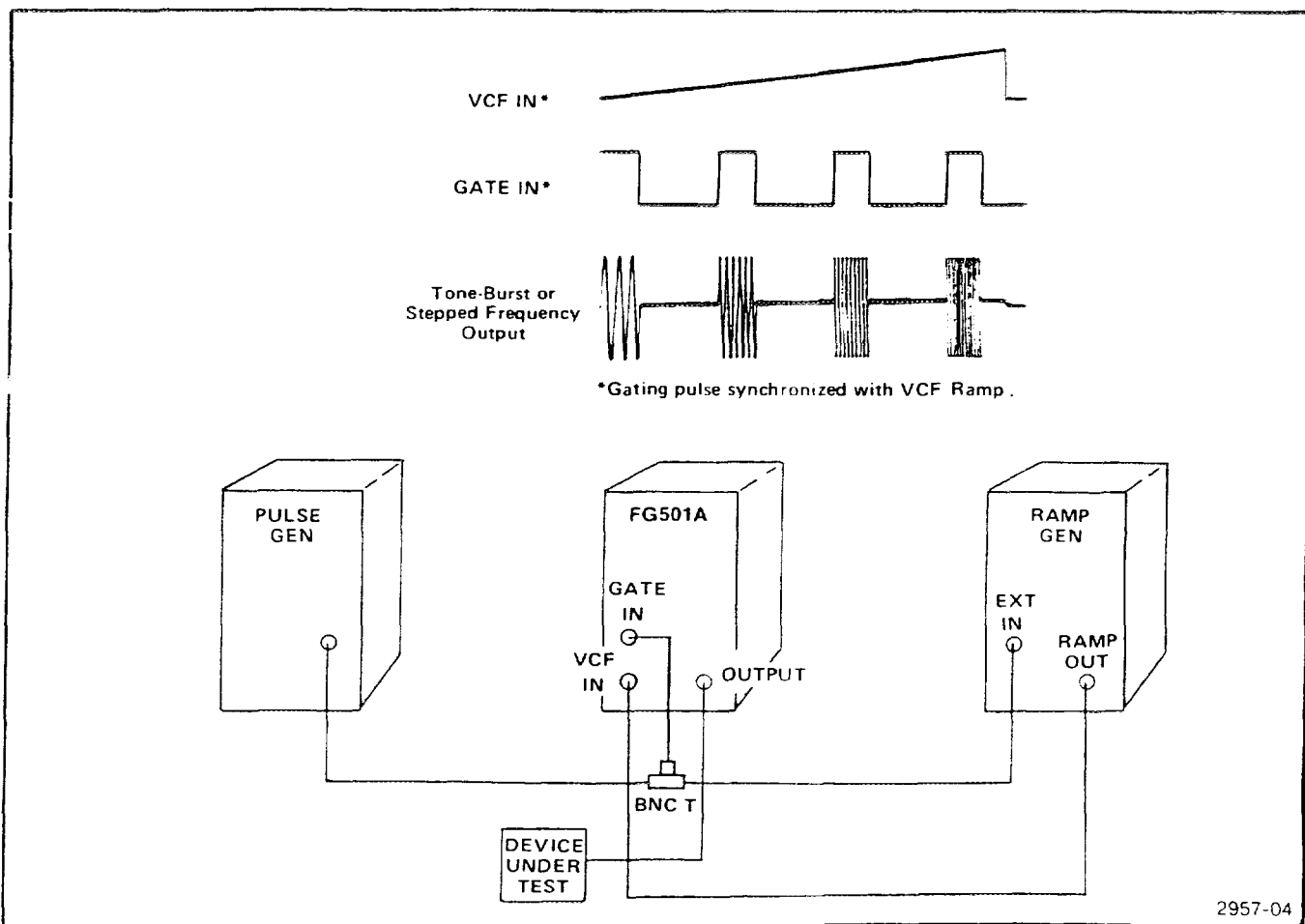


Fig. 2-12. Tone-burst generation or stepped frequency multiplication.

INSTRUCTIONS D'UTILISATION

INTRODUCTION

Ce chapitre fournit les instructions d'utilisation nécessaires pour utiliser le FG 501A selon ses possibilités maximales. Sont également incluses les instructions d'utilisation et de retrait, une description du rôle des commandes du panneau avant et une information générale sur les modes d'utilisation. Certaines applications de base sont également brièvement fournies.

INSTALLATION ET RETRAIT

Le FG 501A est livré étalonné et prêt à fonctionner. Il peut être utilisé dans n'importe quel boîtier d'alimentation de la série TM 500. Se reporter au manuel d'instructions du châssis d'alimentation pour toute information relative à la mise sous tension de l'appareil. La figure 2-1 montre la méthode d'insertion et de retrait de l'appareil.

ATTENTION

Couper l'alimentation du châssis avant d'insérer ou d'extraire le FG 501A (autrement, des arcs électriques pourraient se produire au niveau des connecteurs de l'interface arrière, diminuer leur durée de vie et endommager les circuits du tiroir).

Vérifier que les détrompeurs en plastique situés sur le connecteur du châssis d'alimentation sélectionné s'adaptent aux encoches situées sur le connecteur arrière du circuit imprimé du FG 501A. Aligner ensuite le tiroir avec les rainures supérieure et inférieure du compartiment sélectionné. Insérer à fond le FG 501A afin que le circuit imprimé se place correctement dans le connecteur.

Pour extraire le FG 501A, tirer le loquet de verrouillage (situé au coin inférieur gauche) jusqu'à ce que le connecteur soit libéré. Faire ensuite glisser l'appareil vers l'extérieur.

INSTRUCTIONS DE REEMBALLAGE POUR EXPEDITION

Si un appareil Tektronix doit être expédié à un centre de maintenance Tektronix, pour entretien ou réparation, attachez à l'appareil une étiquette portant les indications suivantes : nom du propriétaire, l'adresse complète et le nom du responsable pouvant être contacté. Ne pas oublier de mentionner le type complet de l'instrument, le numéro de série et une description de l'intervention souhaitée.

Nous vous recommandons de conserver le carton et le matériel d'emballage d'origine dans lesquels vous avez reçu votre appareil. Si vous n'avez pas préservé ceux-ci, emballez l'instrument de la manière suivante :

- Procurez-vous une boîte de carton ondulé dépassant d'au moins 15 cm les dimensions de l'appareil de manière à pouvoir entourer celui-ci de matériaux protecteurs.
- Entourez l'instrument d'une feuille de polyéthylène de manière à assurer la protection du boîtier.
- Intercalez entre le carton et l'instrument de la mousse d'uréthane, d'une épaisseur de 7,6 cm de chaque côté.
- Fermez le carton au moyen d'une bande adhésive ou d'une grosse agrafeuse industrielle.

Test de résistance de l'emballage pour cet appareil : 100 kg.

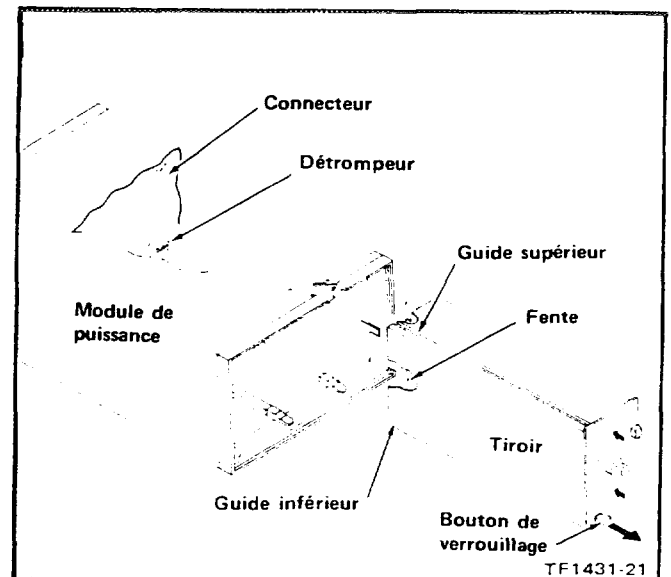


Fig. 2-1. Installation et retrait du tiroir.

COMMANDES ET BORNES

Bien que le FG 501A soit étalonné et prêt à être utilisé, il est nécessaire de se familiariser avec le rôle des commandes et bornes avant de procéder à la mise en service de l'appareil.

Toutes les commandes nécessaires à l'utilisation de l'appareil se trouvent sur le panneau avant (ci-dessous une rapide description de ces commandes). Se reporter à la figure 2-2.

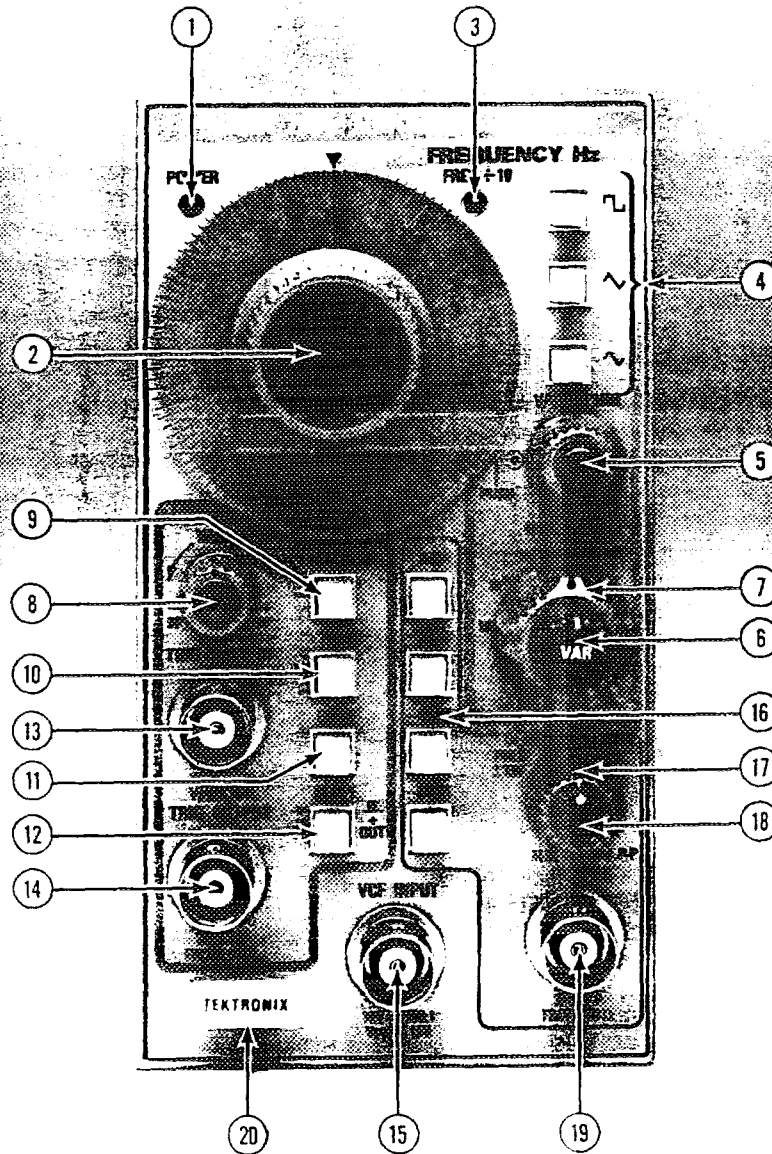


Fig. 2-2. Commandes et bornes.

2957-01

- ① **POWER.** Voyant s'allumant lorsque la tension est appliquée au FG 501A.

SELECTION DE LA FREQUENCE ET DE LA FONCTION

- ② **FREQUENCY Hz.** Commande sélectionnant la fréquence du signal de sortie en association avec la commande **MULTIPLIER.**
- ③ **FREQ ÷ 10.** S'allume lorsque le mode «symétrie» (**VAR SYMM**) est en service.
- ④ **FUNCTION.** Boutons de fonction sélectionnant les signaux carrés, triangulaires et sinusoïdaux.
- ⑤ **VAR SYMM (enfoncer pour le valider).** Commande réglant la symétrie du signal de sortie sélectionné. Réduit la fréquence de sortie dans un rapport de 10 et éclaire le témoin lumineux **FREQ ÷ 10.**
- ⑥ **FREQUENCY VERNIER.** Bouton permettant un réglage fin de la fréquence de sortie dans un rapport d'au moins 1 pour 10^4 de la pleine échelle.
- ⑦ **MULTIPLIER.** Détermine la fréquence de sortie en huit décades. Est associé à la commande **FREQUENCY Hz.**

COMMANDES DE DECLENCHEMENT ET DE VALIDATION

- ⑧ **VAR Ø.** Sélectionne la phase du signal en sortie jusqu'à $\pm 90^\circ$ par rapport au signal de déclenchement ou de validation.
- ⑨ **FREE RUN.** En position «enfoncé» commande provoquant un fonctionnement continu du générateur.
- ⑩ **TRIG.** En position «enfoncé», commande provoquant la sortie d'une seule période du signal sélectionné pour chaque impulsion de déclenchement appliquée au connecteur **TRIG/GATE IN.**

- ⑪ **GATE.** En position «enfoncé», commande provoquant la sortie continue du signal sélectionné pendant la durée de l'impulsion de validation.
- ⑫ **SLOPE.** Bouton sélectionnant, dans le mode «déclenché» (**TRIG**), la pente du signal d'entrée qui déclenchera le signal de sortie sélectionné. Dans le mode «validé» (**GATE**), quel que soit le signal de sortie, la validation se produit lorsque le niveau du signal d'entrée se situe au-dessus ou au-dessous du seuil de +1 V.
- ⑬ **TRIG/GATE IN.** Connecteur BNC utilisé pour appliquer le signal de déclenchement externe ou le signal de validation.
- ⑭ **VCF INPUT (entrée de vobulation externe).** Connecteur BNC destiné à appliquer une tension externe pour faire varier la fréquence de sortie.
- ⑮ **TRIGGER OUT (sortie de déclenchement).** Connecteur BNC délivrant une impulsion positive pour chaque période du signal de sortie.

COMMANDES DE SORTIE

- ⑯ **ATTENUATOR.** Boutons atténuant l'amplitude du signal de sortie par bonds de 20 dB jusqu'à un maximum de 60 dB, lorsqu'ils se trouvent en position enfoncée.
- ⑰ **AMPL.** Commande modifiant l'amplitude du signal de sortie entre les positions étalonnées des boutons d'atténuation.
- ⑱ **OFFSET (tension de décalage).** Tirer et tourner la commande, concentrique à la commande **AMPL**, pour décaler le signal de sortie jusqu'à ± 13 V.
- ⑲ **OUTPUT.** Connecteur BNC sortant le signal sélectionné.
- ⑳ **RELEASE LATCH (verrou de sécurité).** Tirer pour dégager le FG 501A du châssis d'alimentation

INSTRUCTIONS D'UTILISATION

CONNEXIONS DE SORTIE

La sortie du FG 501A est conçue pour fonctionner en source de tension de 50Ω d'impédance, chargée par 50Ω . Aux fréquences plus élevées, une charge mal adaptée provoquera des aberrations sur le signal de sortie. Les charges inférieures à 50Ω réduiront l'amplitude du signal.

Les distorsions ou aberrations excessives, provoquées par une impédance de charge mal adaptée, sont moins grandes aux fréquences basses (plus particulièrement avec des signaux sinusoïdaux et carrés). Pour s'assurer de la pureté d'un signal, il faut observer les précautions suivantes :

1. Utiliser des câbles coaxiaux 50Ω et des connecteurs de bonne qualité.
2. Les connexions doivent être soigneusement réalisées et aussi courtes que possible.
3. Utiliser des atténuateurs de bonne qualité s'il est nécessaire de réduire l'amplitude du signal appliqué.
4. Utiliser des terminaisons ou des adaptateurs d'impédance pour éviter les réflexions lorsque l'on emploie des câbles de grande longueur (2 m ou plus).
5. S'assurer que les atténuateurs, terminaisons, etc... peuvent supporter la puissance maximale délivrée à la sortie du générateur.

Si le générateur doit débiter sur une charge comportant une tension continue, utiliser un condensateur couplé en série avec la charge. La constante de temps du condensateur et de la charge doit être suffisamment grande pour pouvoir maintenir une impulsion correcte.

TEMPS DE MONTEE ET DE DESCENTE

Si le FG 501A est utilisé pour mesurer le temps de montée ou de descente d'un équipement, il faut tenir compte des caractéristiques du temps de montée des équipements associés. Si le temps de montée de l'appareil sous test est dix fois supérieur aux temps de montée du FG 501A et des équipements associés, l'erreur introduite ne dépassera pas 1 % ; elle peut même généralement être ignorée. Lorsque le temps de montée ou de descente de l'appareil sous test est inférieur à 10 fois le temps de montée global du système de test, le temps de montée réel du système doit être calculé. Le temps de

montée du système connu, il est possible de calculer le temps de montée de l'appareil sous test.

ADAPTATION D'IMPEDANCE

Si le FG 501A attaque une haute impédance telle qu'une impédance d'entrée de $1 M\Omega$ (avec en parallèle une capacité déterminée) de l'entrée verticale d'un oscilloscope, terminer la ligne de transmission par un atténuateur 50Ω , une terminaison 50Ω et la connecter à l'entrée de l'oscilloscope. L'atténuateur isole la capacité d'entrée de l'équipement sous test et le FG 501A est correctement chargé.

PREMIERE MISE EN SERVICE

Les pages « Commandes et bornes » fournissent une description des commandes et bornes du panneau avant. Les commandes sélectionnant la forme et la fréquence du signal sont entourées de bleu, les commandes et connecteurs de la fonction déclenchement et les commandes de sortie de noir.

Les opérations ci-dessous vont permettre à l'utilisateur de se familiariser avec la plupart des fonctions du FG 501A.

NOTA

Si l'on rencontre des anomalies durant cette opération, il faut avoir recours à un personnel qualifié pour pouvoir effectuer un réglage interne.

Prépositionner les commandes comme suit :

Zone bleue :	
FREQUENCY Hz	10
MULTIPLIER	10^2
FREQUENCY VERNIER	à fond dans le sens horaire
WAVEFORM SINE	In (position « enfoncé »)
VAR SYMM	OFF (hors service)

Zone verte :	
FREE RUN	In (position « enfoncé »)

Zone noire :	
ATTENUATOR	-20 dB
AMPL (variable)	centrée
OFFSET	Off (hors service)

Connecter un câble coaxial BNC 50Ω terminé par 50Ω à l'entrée verticale d'un oscilloscope. Positionner les commandes de l'oscilloscope :

VERTICAL	1 V/div couplage continu
HORIZONTAL (B. de temps)	1 ms/div

L'écran de l'oscilloscope doit afficher une période complète du signal sinusoïdal par division (environ 10 périodes sur tout le réticule).

1. Appuyer séquentiellement sur les boutons délivrant des formes d'ondes carrées, triangulaires et sinusoïdales et observer les différentes formes d'ondes obtenues. Retourner aux conditions initiales.

2. Appuyer sur chaque atténuateur et faire tourner la commande variable AMPL afin de vérifier que l'amplitude du signal varie. Repositionner ces commandes sur leur position initiale.

3. Tirer et tourner le bouton de tension de décalage OFFSET. Noter la variation du niveau continu du signal visualisé. Enfoncer le bouton OFFSET.

4. Appuyer et relacher le bouton «symétrie variable» (VAR SYM). Noter que le témoin lumineux $FREQ \div 10$ s'allume et que seule une période du signal de sortie est visualisée. Faire tourner la commande VAR SYM tout au long de sa course et observer une variation de la forme des signaux, qu'ils soient carrés, triangulaires ou sinusoïdaux (le bouton approprié étant enfoncé). Retourner aux positions initiales.

5. Tourner la commande FREQUENCY et le commutateur MULTIPLIER tout en notant la variation de la fréquence du signal visualisé. Repositionner ces commandes sur leur position initiale.

MODES D'UTILISATION

SORTIE

La méthode suivante fournit une sortie à amplitude et fréquence variables.

1. Sélectionner la forme d'onde désirée.
2. Placer la commande AMPL à fond dans le sens anti-horaire. Vérifier que les commandes VAR SYM et OFFSET sont hors service (position «IN»).
3. Sélectionner la fréquence désirée à l'aide du cadran FREQUENCY Hz et du commutateur MULTIPLIER. La fréquence est égale à l'indication du cadran multipliée par l'indication du multiplicateur.

4. Relier la charge au connecteur de sortie du FG 501A et régler la commande AMPL pour obtenir l'amplitude de sortie désirée.

FONCTION DECLENCHEMENT OU PORTE DE VALIDATION (SALVE)

Régler le FG 501A pour un fonctionnement normal, conformément aux indications du paragraphe précédent. Appliquer ensuite le signal de déclenchement ou de validation au connecteur TRIG/GATE IN.

Si l'on ne désire qu'une seule période du signal de sortie par déclenchement, appuyer sur le bouton TRIG et sélectionner une pente positive (+) ou négative (-). Une période de sortie sera alors générée pour chaque période de déclenchement à l'entrée.

Si l'on désire plus d'une période du signal de sortie, appuyer sur le bouton GATE. La sortie se maintiendra alors pendant toute la durée du signal de validation. Le nombre de périodes par train est environ égal à la durée du signal de validation divisé par la période du signal de sortie du FG 501A.

En mode «Déclenchement» ou «Validation», la commande PHASE fait varier le démarrage du signal de sortie d'environ $\pm 90^\circ$. Cette variation de phase se mesure à partir du niveau 0 V, point 0° sur le signal de sortie.

FONCTIONNEMENT EN CONTROLE DE FREQUENCE PAR TENSION (VCF)

La fréquence de sortie de tout signal choisi peut être balayée dans un rapport maximal de 1 000 : 1 en appliquant une source de tension externe sur le connecteur d'entrée VCF INPUT. La polarité du signal d'entrée détermine la direction de l'excursion de fréquence à partir de la fréquence sélectionnée. Un signal positif augmente la fréquence alors qu'un signal négatif l'abaisse. Il est possible de sélectionner l'amplitude et la polarité de la tension d'entrée dans une plage de ± 10 V, en fonction de la position du cadran FREQUENCY Hz.

La plage de fréquence maximale voulue dans un rapport de 1 000 à 1 inclut la fraction non étalonnée du cadran FREQUENCY Hz ($< .2$ à 2). Pour s'assurer que la fréquence est balayée sur une plage d'au moins 1 000 à 1, il est recommandé de placer le cadran FREQUENCY Hz sur $.2$ et d'appliquer un signal de 0 à +10 V sur le connecteur VCF INPUT. Il peut être nécessaire de modifier la commande FREQUENCY VERNIER pour balayer soit toute la gamme 1 000 : 1, soit les plus basses fréquences.

Etant donné que l'amplitude d'entrée VCF suit une loi linéaire, la plage de fréquence du signal de sortie peut être déterminée à partir de l'amplitude d'entrée VCF.

que à celle du signal de sortie sélectionné. Une impulsion de déclenchement est générée pour chaque période positive du signal de sortie excepté sur les formes d'ondes carrées. Lorsque des signaux carrés sont générés, une impulsion de déclenchement est générée pour chaque période négative du signal de sortie. Son impédance de sortie est de 50 Ω.

SORTIE DE DECLENCHEMENT

Un signal carré de 4 V est disponible sur la borne TRIG OUTPUT. La fréquence du signal de déclenchement est identi-

CARACTERISTIQUES DES FORMES D'ONDES DE BASE

Les photographies suivantes illustrent les caractéristiques des formes d'ondes de base délivrées par le FG 501A.

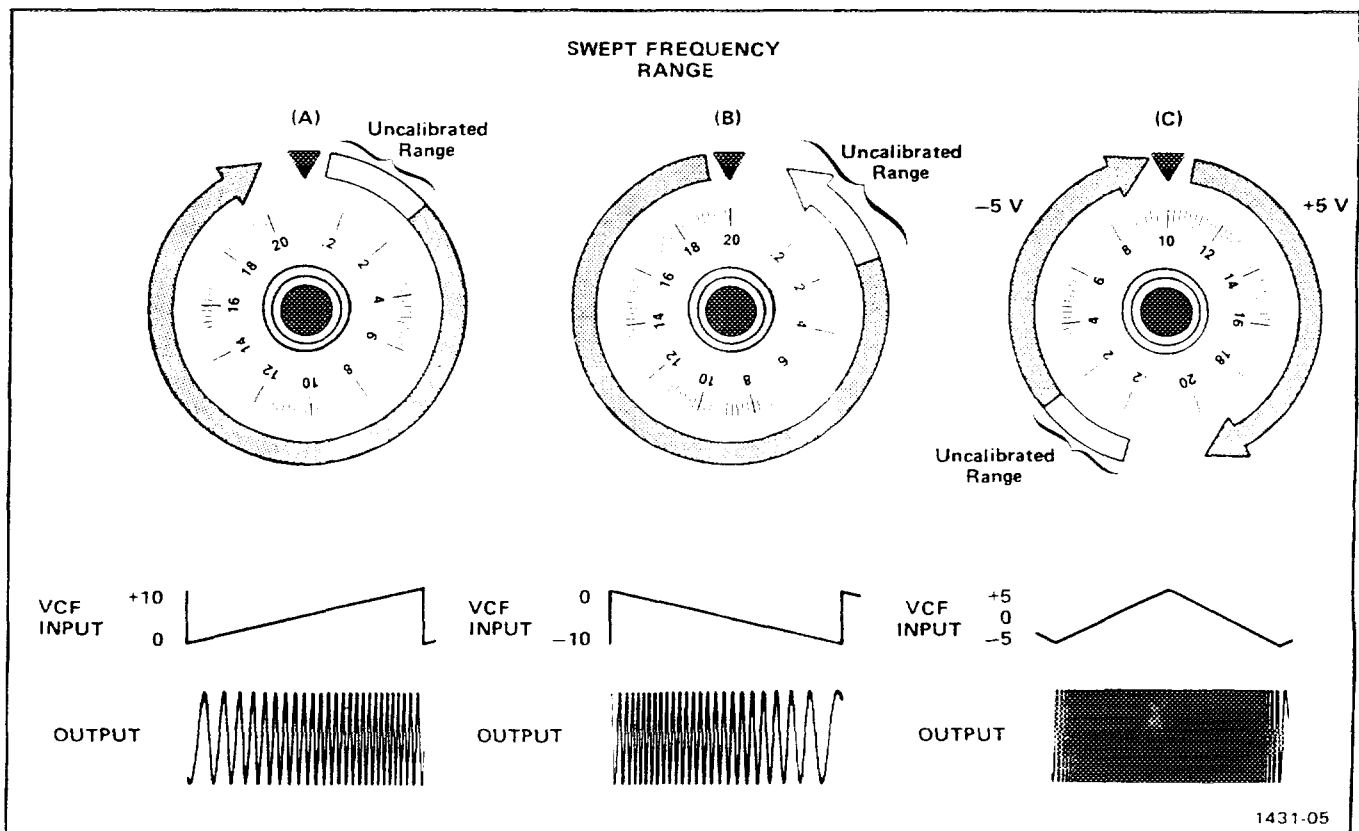


Fig. 2-3. Plage de fréquence volubée avec des signaux de 10 V appliqués sur le connecteur VCF IN.

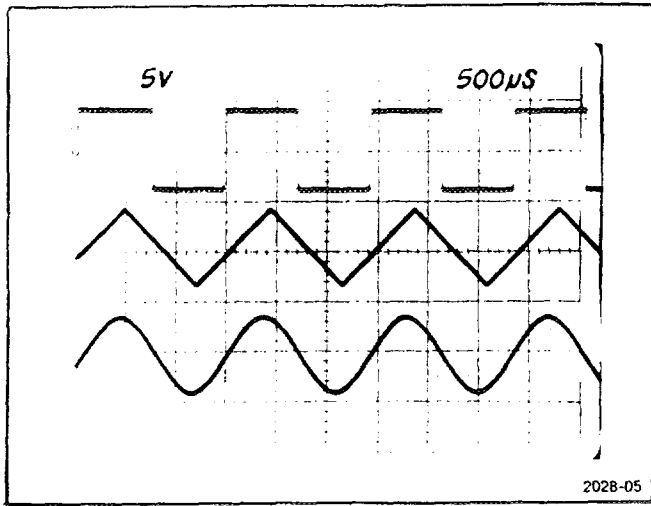
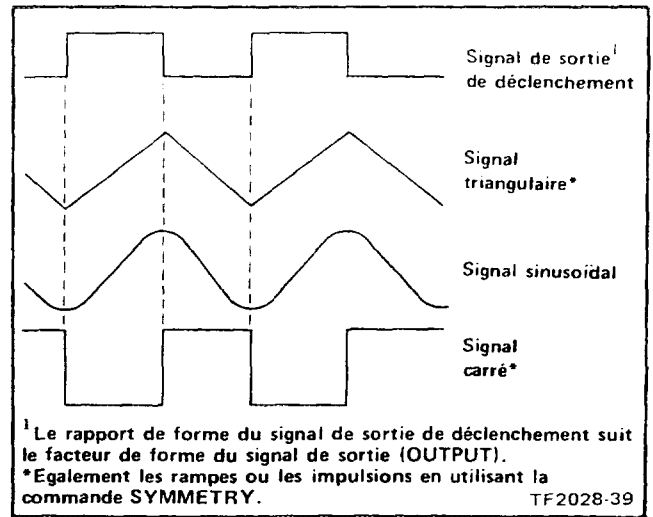
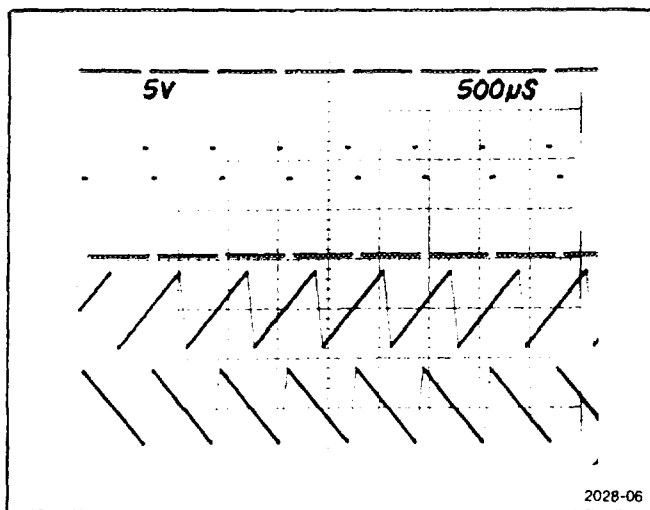


Fig. 2-4. FONCTIONS DE BASE. Formes d'ondes carrées, triangulaires et sinusoïdales sélectionnées par les boutons poussoirs du panneau avant.



2-6. Relations de phase entre les signaux de sortie (OUTPUT) et la sortie de déclenchement (TRIG OUT).



2-5. RAMPES ET IMPULSIONS. Elles s'obtiennent à partir des formes d'ondes de base en utilisant la commande de symétrie (SYMMETRY).

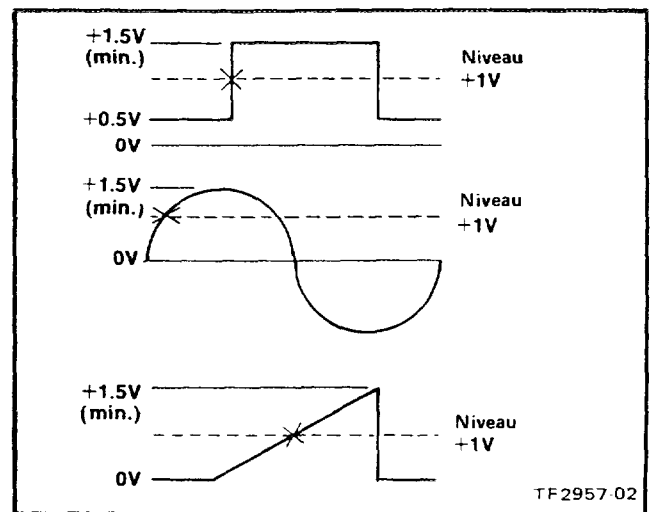


Fig. 2-7. Amplitude nécessaire au signal de déclenchement et points de déclenchement.

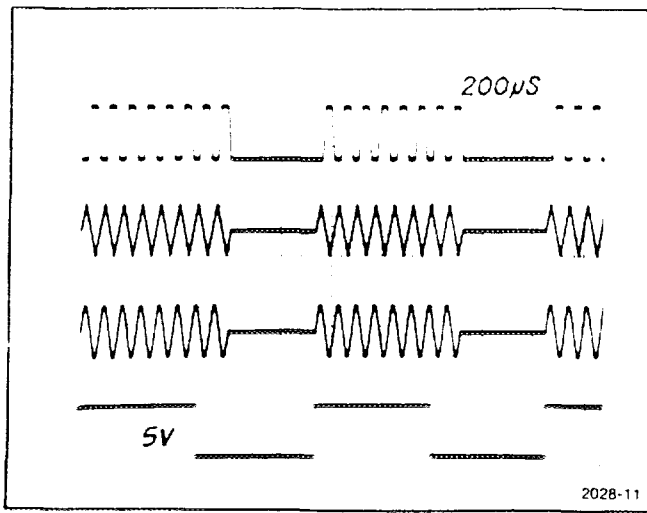


Fig. 2-8. FONCTIONNEMENT VALIDE. Les trois traces supérieures représentent les divers signaux de sortie et la trace inférieure est le signal de validation appliqué au connecteur de déclenchement INPUT. Le bouton poussoir GATE étant en position «enfoncé». Noter qu'une période supplémentaire complète est générée après la fin du signal de validation.

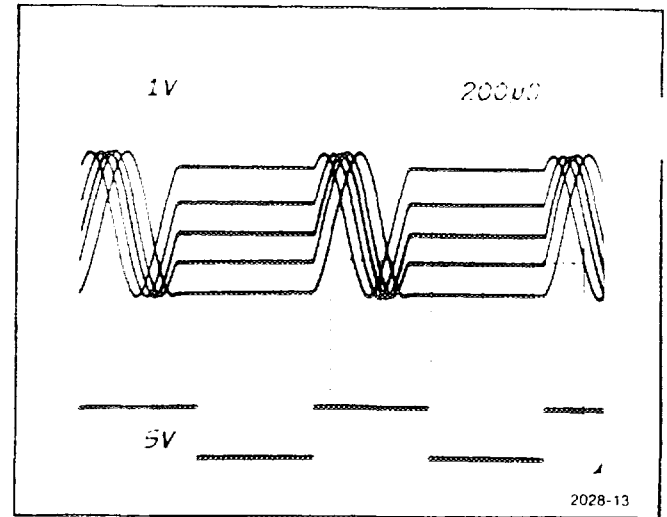


Fig. 2-10. UTILISATION DE LA COMMANDE PHASE. Cette photographie illustre l'utilisation de la commande PHASE dans le mode déclenché. Les cinq traces superposées illustrent l'effet de la commande de phase. Cette commande fournit un décalage de $\pm 90^\circ$. La trace inférieure est le signal de déclenchement.

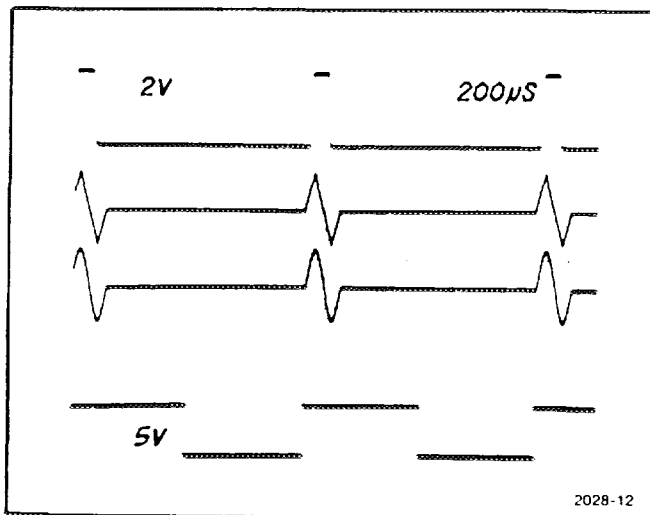


Fig. 2-9. FONCTIONNEMENT DECLENCHE. Les trois traces supérieures représentent les divers signaux de sortie sélectionnés. La trace inférieure correspond au signal de déclenchement appliqué au connecteur de déclenchement TRIG INPUT, le mode TRIG étant sélectionné. Noter qu'une seule période des signaux de sortie est générée.

APPLICATIONS

ANALYSE DE REPONSE

Le FG 501A convient particulièrement à la mesure des caractéristiques de réponses des circuits ou des systèmes. Cette application utilise l'entrée VCF du FG 501A pour vobuler le générateur sur une plage de fréquences. Se reporter à la rubrique « Modes d'utilisation » pour toute information complémentaire.

1. Connecter les appareils selon les indications de la figure 2-11.
2. Régler le sélecteur MULTIPLIER et le cadran FREQUENCY Hz pour la fréquence limite supérieure ou inférieure désirée (en fonction de la direction dans laquelle vous souhaitez vobuler).
3. Appliquer le signal souhaité sur le connecteur d'entrée VCF. (Un signal positif augmente la fréquence alors qu'un signal négatif l'abaisse).
4. Régler l'amplitude du signal d'entrée VCF pour obtenir la gamme de fréquence souhaitée.

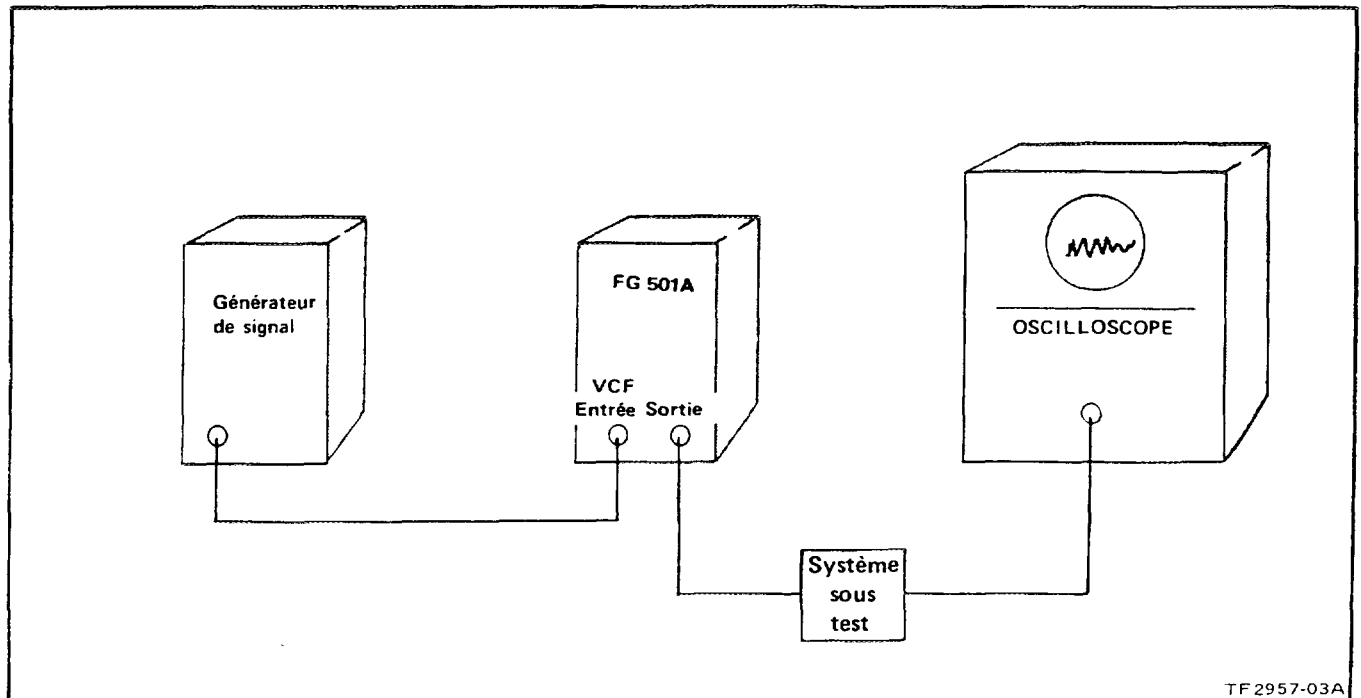
5. Observer la réponse en fréquence sur l'oscilloscope de contrôle.

La fréquence à laquelle une caractéristique de réponse est visualisée peut être déterminée en inhibant en premier lieu le signal d'entrée VCF puis en réglant manuellement le cadran FREQUENCY Hz afin d'obtenir à nouveau la caractéristique particulière observée sur la représentation vobulée. Il suffit de lire la fréquence sur le cadran FREQUENCY Hz.

GENERATION DE SALVES DE SIGNAUX OU MULTIPLICATION DE LA FREQUENCE PAR PALIERS

Le FG 501A peut être utilisé comme générateur de salves de signaux ou comme multiplicateur de fréquence pour vérifier les équipements de contrôle. Cette application utilise un générateur de rampes, tel que le TEKTRONIX RG 501, utilisé comme source de signal VCF et un générateur d'impulsions, tel que le TEKTRONIX PG 501, utilisé comme source de signal de validation.

La méthode suivante décrit une technique permettant d'obtenir une salve de signaux ou une sortie à fréquence



TF 2957-03A

Fig. 2-11. Réponse des circuits ou des systèmes.

variable à l'aide du FG 501A. Se reporter aux informations sur la sortie validée (salve), la variation de phase et la sortie VCF pour toute information complémentaire.

Régler la durée du générateur d'impulsions pour la largeur de salves souhaitée.

1. Relier les appareils selon les indications de la Fig. 2-12.
2. Appuyer sur le bouton GATE (position «enfoncé») et placer la commande PHASE sur la valeur désirée.
3. Régler le générateur de rampes à la durée et à la polarité désirées.
4. Régler la période du générateur d'impulsions pour un nombre de salves désiré, dans les limites de la durée de la rampe.

5. Sélectionner la plage de modulation de fréquence en réglant le cadran FREQUENCY Hz sur une extrémité de cette plage (limite supérieure ou inférieure, en fonction de la polarité de la rampe). Puis, régler l'amplitude du générateur de rampes pour l'autre limite de fréquence.

De multiples combinaisons de salves de signaux, de fréquence multipliée peuvent être obtenues en utilisant divers signaux d'entrée de validation, tels que les signaux triangulaires, sinusoidaux, carrés, etc...

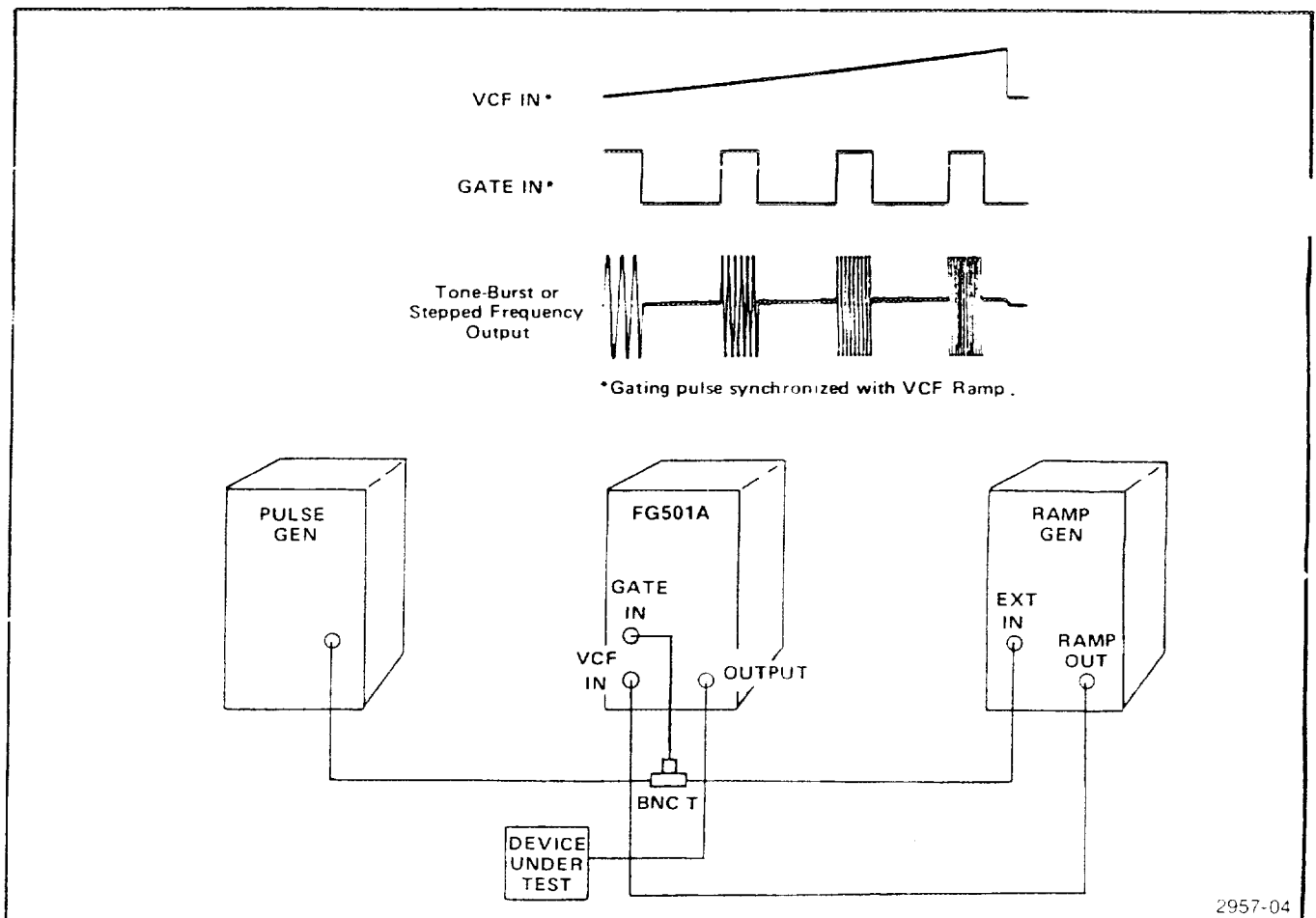


Fig. 2-12. Génération de salves de signaux ou multiplication de la fréquence par paliers.

BEDIENUNGSANLEITUNG

EINFÜHRUNG

Im Rahmen dieses Kapitels wird die Bedienung des FG 501A beschrieben. Die Beschreibung enthält Informationen hinsichtlich der Installation, eine Funktionsbeschreibung der Bedienelemente und Anschlüsse der Frontplatte sowie die Erläuterung der einzelnen Betriebsarten des FG 501A. Am Ende dieser Beschreibung werden einige Grundanwendungen kurz aufgeführt.

INBETRIEBNAHME

Der FG 501A ist bei Lieferung kalibriert und kann sofort verwendet werden. Er wird in einem Einschubfach eines beliebigen Stromversorgungsmoduls der Serie TM 500 betrieben. Informationen hinsichtlich der Stromversorgung und des Betriebs der Stromversorgungs-Module entnehmen Sie der entsprechenden Bedienungsanleitung.

VORSICHT

Um eine Zerstörung des FG 501A zu vermeiden, ist die Stromversorgungseinheit auszuschalten, bevor der Einschub ein- oder ausgeschoben wird.

Vergewissern Sie sich, daß die Kunststoffstege des Verbindungssockels der gewählten Stromversorgungseinheit mit der Aussparung des Verbindungssteckers des FG 501A übereinstimmen. Nachdem dies überprüft ist, kann der FG 501A in die Führungsschiene gesetzt und eingeschoben werden. Durch vorsichtiges Drücken werden Sockel und Stecker verbunden.

Zur Herausnahme des FG 501A wird die Verriegelungslasche (obere linke Ecke) gezogen, um die Verbindung von Sockel und Stecker zu lösen. Danach wird der FG 501A gerade herausgezogen. Vergewissern Sie sich, daß der FG 501A voll in die Stromversorgungseinheit eingeschoben ist. Danach schalten Sie die Stromversorgung an der Stromversorgungseinheit ein.

VERPACKUNG DES GERÄTES

Für den Versand des Gerätes an den Tektronix-Service sollte ein Etikett mit folgenden Angaben beigelegt wer-

den: Ihre Adresse mit der Angabe der zuständigen Kontaktperson, die Seriennummer sowie die Serviceanleitung.

Für den Fall, daß die Originalverpackung nicht mehr zur Verfügung steht, wird das Gerät wie folgt verpackt:

Schützen Sie das Instrument mit einer Kunststoffhülle oder ähnlichem. Verwenden Sie einen stabilen Karton, dessen Innenmaße die Geräteabmessungen nicht mehr als 15 cm überschreitet. Schützen Sie das Gerät, indem Sie den Raum zwischen Gerät und Karton an allen Seiten mit geeignetem Füllmaterial ausfüllen.

Der Karton muß eine Testfestigkeit von 90 kg haben.

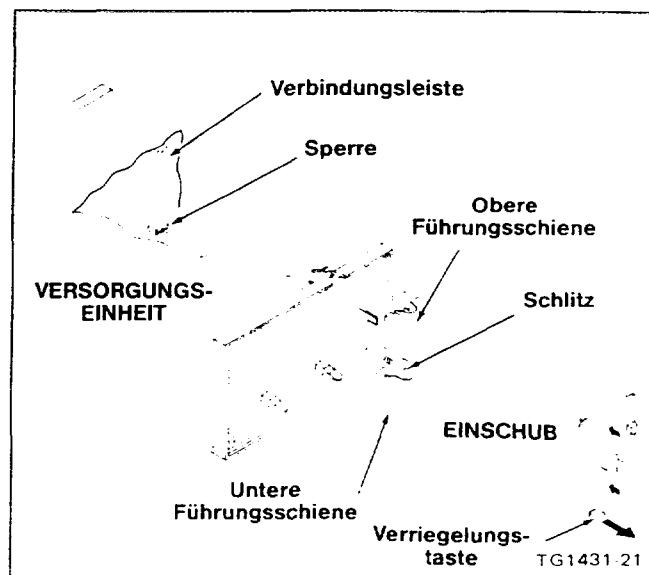
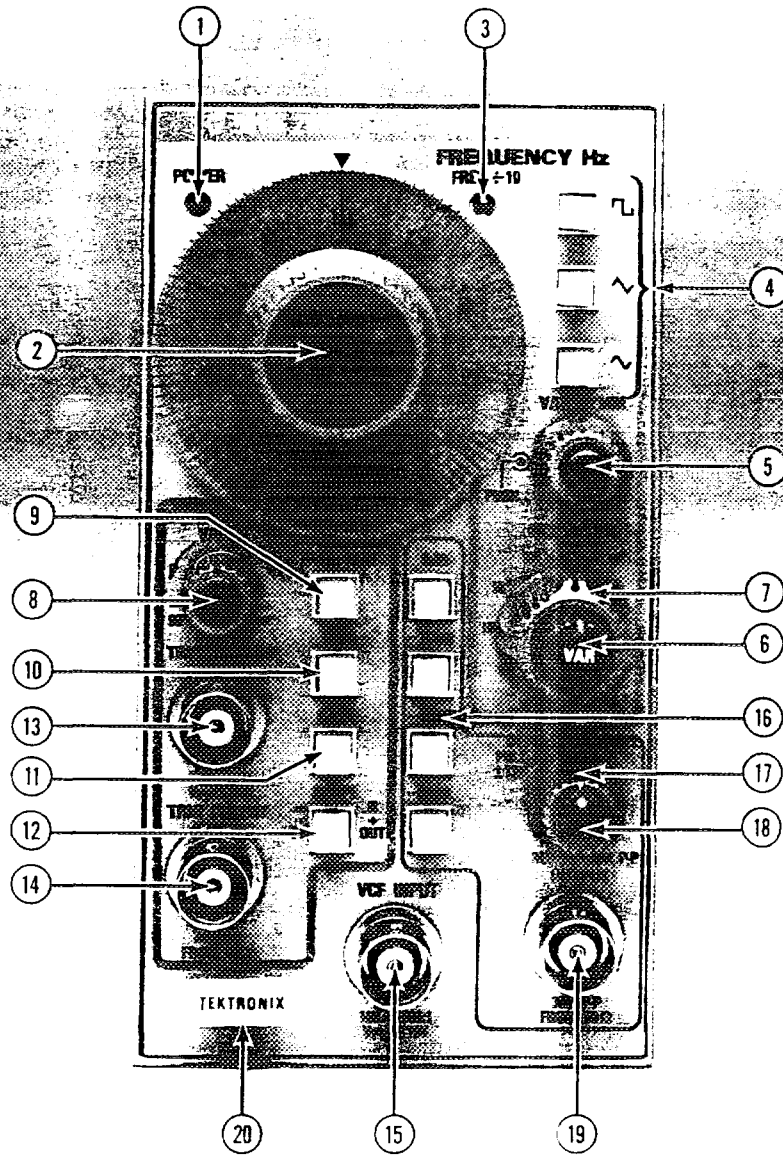


Abb. 2-1: Installation des Einschubs

BEDIENUNGSELEMENTE UND ANSCHLÜSSE

Obwohl der FG 501A bei Erhalt kalibriert und betriebsbereit ist, sollte vor Verwendung des Einschubs die Funktion der Bedienungselemente und Anschlüsse überprüft werden. Alle, für die Bedienung notwendigen Bedie-

nungselemente und Anschlüsse befinden sich an der Frontplatte. Diese Elemente werden im folgenden kurz beschrieben.



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Abb. 2-2: Bedienungselemente und Anschlüsse

- ① **POWER** – Stromversorgung. Das Leuchten der Lampe zeigt an, daß das Gerät eingeschaltet ist.

FREQUENZEINSTELLER UND FUNKTIONSWAHLSCHALTER

- ② **FREQUENCY Hz** – Frequenz in Hz. Die Einstellskala dient in Verbindung mit dem Einsteller **MULTIPLIER** zur Wahl der Frequenz des Ausgangssignals.
- ③ **FREQ ÷ 10** – Frequenz ÷ 10. Die Lampe leuchtet, wenn die Funktion „variable Symmetrie“ arbeitet.
- ④ **FUNCTION** – Funktionstasten. Diese Tasten wählen die Funktionen Rechteck, Dreieck und Sinus.
- ⑤ **VAR SYMM** – Variable Symmetrie. Gedrückte Taste stellt eine zeitbezogene Symmetrie des gewählten Ausgangssignals ein. Die Frequenz des Ausgangssignals wird um den Faktor 10 verringert und die Anzeigelampe **FREQ ÷ 10** leuchtet.
- ⑥ **FREQUENCY VERNIER** – Feineinsteller der Frequenz. Gestattet Feineinstellung der Ausgangsfrequenz bis zu einem Teil eines vollen Skalenwertes von 10^4 .
- ⑦ **MULTIPLIER** – Multiplizierer. Wählt in Verbindung mit **FREQUENCY Hz** die Ausgangsfrequenz in 8 dekadischen Stufen.

TRIGGER- und GATE-ELEMENTE

- ⑧ **VAR Ø** – Variabler Einsteller. Wählt Phasenverteilung oder Phasennacheilung bis zu $\pm 90^\circ$ relativ zum Trigger- oder Gatesignal.
- ⑨ **FREE RUN** – Freilaufender Betrieb. Bei gedrückter Taste läuft das Ausgangssignal frei.
- ⑩ **TRIG** – Triggerung. Bei gedrückter Triggertaste wird mit jedem Triggerimpuls des an **TRIG/GATE IN** angeschlossenen Triggersignals ein Zyklus des gewählten Ausgangssignals erzeugt.

- ⑪ **GATE** – Tor. Bei gedrückter **GATE**-Taste wird die gewünschte Signalform für die Dauer des Gate-Impulses am Ausgang des FG 501A erzeugt.

- ⑫ **SLOPE** – Flankenwahl. Im **TRIG**-Betrieb wählt dieses Bedienungselement die Flanke des Eingangssignals, auf der die Triggerung des Ausgangssignals erfolgt. Im **GATE**-Betrieb erfolgt die Torsteuerung des Ausgangssignals auch dann noch, wenn der Pegel des Eingangssignals oberhalb oder unterhalb des Schwellpegels von +1 V liegt.

- ⑬ **TRIG/GATE IN** – Eingangsbuchse. An diese BNC-Buchse wird das Triggersignal oder das Gate-Signal angeschlossen.

- ⑭ **VCF INPUT** – Frequenzmodulationseingang. Eingang für Frequenzmodulation. Externe Spannungen, die an diesen Eingang gelegt werden, erzeugen Frequenzveränderungen.

- ⑮ **TRIGGER OUTPUT** – Triggerausgang. An dieser BNC-Buchse wird für jeden erzeugten Signalzyklus ein positiver Impuls ausgegeben.

BEDIENUNGSELEMENTE DES AUSGANGS

- ⑯ **ATTENUATOR** – Abschwächer. Die Drucktasten dienen zur Abschwächung der Ausgangsamplitude in 20 dB-Stufen bis zu 60 dB.

- ⑰ **AMPL** – Amplitude. Dient zur Veränderung der Amplitude des gewählten Ausgangssignals zwischen den Stufen der **ATTENUATOR**-Tasten.

- ⑱ **OFFSET** – Offsetspannung. Mit dem Regler wird dem Ausgangssignal eine Gleichspannung von ± 13 V unterlegt.

- ⑲ **OUTPUT** – Ausgang. An diesen BNC-Anschluß kann das mit den Funktionswählern gewählte Signal entnommen werden.

- ⑳ **RELEASE LATCH** – Verriegelungsklinke. Durch Ziehen dieser Klinke wird der FG 501A aus der Stromversorgungseinheit gelöst.

BEDIENUNGSHINWEISE

AUSGANGSANSCHLÜSSE

Der Ausgang des FG 501A ist so ausgelegt, daß er als 50 Ω -Spannungsquelle an 50 Ω -Systemen arbeitet. Bei höheren Frequenzen führt ein nichtabgeschlossener bzw. unkorrekt abgeschlossener Ausgang zu Abweichungen am Ausgangssignal. Lasten $< 50 \Omega$ reduzieren die Amplitude des Ausgangssignals.

Hohe Verzerrung oder Abweichungen, die auf einem unkorrekten Abschluß beruhen, sind bei niedrigen Frequenzen (insbesondere bei den Signalformen Sinus und Rechteck) weniger erkennbar. Um sicherzustellen, daß ein „sauberes“ Signal erhalten wird, sind folgende Punkte zu beachten:

1. Verwenden Sie nur 50 Ω -Koaxialkabel und Anschlüsse von guter Qualität.
2. Halten Sie alle Verbindungen so kurz wie möglich.
3. Falls für den Anschluß an empfindliche Schaltkreise eine Reduzierung der Signalamplitude erforderlich ist, sollten nur erstklassige Abschwächer verwendet werden.
4. Bei der Verwendung längerer Kabel (ab 2 Meter) muß zur Verhinderung von Reflexionen eine Anpassung vorgenommen werden.
5. Vergewissern Sie sich, daß die verwendeten Abschwächer, Abschlüsse etc. die für das Ausgangssignal geeigneten Stromwerte aufweisen.

Falls eine Gleichspannung an der Ausgangslast auftritt, wird ein Koppelkondensator in Serie zu der Last gelegt. Die Zeitkonstante des Koppelkondensators und der Last muß so groß sein, daß die Impulsdachschräge nicht beeinflußt wird.

ANSTIEGS- UND ABFALLZEITEN

Wird der FG 501A zur Messung von Anstiegs- und Abfallzeiten verwendet, müssen die Anstiegscharakteristiken der gesamten Anordnung berücksichtigt werden. Ist die Anstiegszeit des Testgerätes nicht größer als der 10fache Wert der Gesamtanstiegszeit des FG 501A und der Ausstattung, ist der zu erwartende Fehler nicht größer als 1% und kann vernachlässigt werden. Ist die Anstiegs- oder Abfallzeit des Testgerätes kleiner als der 10fache Wert der Gesamtanstiegszeit, muß die aktuelle Anstiegszeit errechnet werden. Ist die Anstiegszeit des Systems bekannt, kann die Anstiegszeit des Testgerätes bestimmt werden.

IMPEDANZANPASSUNG

Wird der FG 501A mit Geräten betrieben, die eine hohe Eingangsimpedanz aufweisen, wie z. B. der 1 M Ω -Ein-

gang eines Oszilloskops, wird die Übertragungsleitung über einen 50 Ω -Abschwächer und 50 Ω -Abschluß an den Eingang des Oszilloskops angeschlossen. Der Abschwächer trennt die Eingangskapazität des Gerätes, so daß der FG 501A korrekt abgeschlossen ist.

INBETRIEBNAHME

Zur besseren Übersicht sind die vorgehend beschriebenen Bedienungselemente der Frontplatte in logische Funktionsgruppen unterteilt, die farblich gekennzeichnet sind. Der Funktionswähler sowie die frequenzbestimmenden Bedienungselemente sind mit der Farbe Blau gekennzeichnet, die Triggerelemente und Eingänge in Grün und Bedienungselemente für den Ausgang in Schwarz.

Anhand des folgenden Beispiels können Sie sich mit den meisten Funktionen des FG 501A vertraut machen.

BEACHTEN

Sollten bei der Durchführung des folgenden Beispiels Fehler am FG 501A auffindig gemacht werden, setzen Sie sich bitte mit Ihrem Service in Verbindung.

Nehmen Sie am FG 501A folgende Einstellungen vor:

Blauer Bereich

FREQUENCY	10
MULTIPLIER	10 ²
FREQUENCY VERNIER	Rechtsanschlag
WAVEFORM SINE	Gedrückt (Sinus)
VAR SYMM	Aus

Grüner Bereich

FREE RUN	Gedrückt
----------	----------

Schwarzer Bereich

ATTENUATOR	– 20 dB
AMPL (variabel)	Mitte
OFFSET	Aus

Schließen Sie ein 50 Ω -BNC-Koaxialkabel, das mit 50 Ω abgeschlossen ist, an den Eingang eines Oszilloskops. Nehmen Sie am Oszilloskop folgende Einstellungen vor:

Vertikal	1 V/Teil, gleichspannungsgekoppelt
Horizontal	1 ms/Teil

Das Oszilloskop sollte einen kompletten Zyklus eines Sinussignals pro Teil darstellen (insgesamt etwa 10 Zyklen)

1. Wählen Sie nun abwechselnd die Funktionen Rechteck, Dreieck und Sinus und beobachten Sie die Darstellung auf dem Bildschirm des Oszilloskops.

2. Betätigen Sie nun abwechselnd die vier ATTENUATOR-Tasten und drehen Sie den Regler AMPL (variabel), um zu überprüfen, ob sich die Amplituden ändern. Stellen Sie diese Bedienungselemente wieder zurück.

3. Ziehen Sie den Knopf OFFSET und bewegen Sie ihn. Auf dem Bildschirm können Sie eine Änderung des Gleichspannungspegels beobachten. Stellen Sie den Knopf OFFSET wieder zurück.

4. Lösen Sie die Taste VAR SYMM. Die Anzeigelampe $FREQ \div 10$ leuchtet jetzt und nur ein Zyklus des Ausgangssignals wird auf dem Bildschirm dargestellt. Bewegen Sie den Knopf VAR SYMM durch seinen gesamten Einstellbereich und beobachten Sie auf dem Bildschirm die Veränderung der Signalform des Rechtecks, Dreiecks und Sinus (Drücken Sie die entsprechende Taste). Stellen Sie die Bedienungselemente wieder zurück.

5. Bewegen Sie den Wahlschalter FREQUENCY und den Schalter MULTIPLIER und beobachten Sie die Frequenzänderung des auf dem Bildschirm dargestellten Signals. Stellen Sie die Bedienungselemente wieder zurück.

BETRIEBSARTEN

FREILAUFENDER AUSGANG

Im folgenden wird die Betriebsart FREE RUNNING OUTPUT mit variabler Frequenz und variabler Amplitude beschrieben.

1. Wählen Sie die gewünschte Signalform.
2. Stellen Sie AMPL auf Linksanschlag ein. Überprüfen Sie, ob die Bedienungselemente VAR SYMM und OFFSET ausgeschaltet sind (gedrückt).
3. Stellen Sie mit Hilfe der Bedienungselemente FREQUENCY Hz und MULTIPLIER die gewünschte Frequenz ein.
4. Schließen Sie die Last an die Ausgangsbuchse des FG 501A an und stellen Sie mit Hilfe von AMPL die gewünschte Ausgangsamplitude ein.

GETRIGGERTER ODER TORGESTEUERTER (BURST) BETRIEB

Stellen Sie den vorgehend beschriebenen freilaufenden Ausgang ein und schließen Sie das Trigger- oder Gatesignal an den Eingang TRIG/GATE IN.

Soll nur ein Zyklus des Ausgangssignals pro Triggerimpuls erzeugt werden, drücken Sie die Taste TRIG und wählen Sie mittels SLOPE positive oder negative Flanke. Mit jedem Trigger wird jetzt ein Ausgangszyklus erzeugt.

Ist mehr als ein Signalzyklus erwünscht, drücken Sie die Taste GATE. Während der Dauer des Gate-Signals wird jetzt ein fortlaufendes Ausgangssignal erzeugt. Die Anzahl der Zyklen pro Burst kann näherungsweise durch Division der Gate-Signaldauer durch die Periodendauer der Ausgangsfrequenz des FG 501A bestimmt werden.

In der getriggerten bzw. torgesteuerten Betriebsart kann der Start des Ausgangssignals mit Hilfe von PHASE um $\pm 90^\circ$ variiert werden. Die Phasenänderung wird vom 0 V, 0°-Punkt des Ausgangssignals gemessen.

FREQUENZMODULATION (VCF-BETRIEB)

Die Ausgangsfrequenz aller gewählten Signalformen kann innerhalb des Bereichs 1000 : 1 mit Hilfe einer externen Spannung, die an den Eingang VCF INPUT angeschlossen wird, variiert werden. Die Polarität des VCF-Eingangssignals bestimmt die Richtung der Frequenzänderung in Bezug zur gewählten Frequenz. Ein positives (+) Signal erhöht die Frequenz und ein negatives Signal (–) verringert die Frequenz. Amplitude und Polarität der Eingangsspannung können im Bereich von ± 10 V in Abhängigkeit der Einstellung von FREQUENCY Hz gewählt werden.

Der maximale Variationsbereich der Frequenz von 1000 : 1 enthält den unkalibrierten Teil des Wahlschalters FREQUENCY Hz ($< 0,2$ bis 2). Um sicherzustellen, daß der Bereich höchstens 1000 : 1 ist, wird empfohlen, den Wahlschalter FREQUENCY auf die Position 0,2 einzustellen und ein Signal von 0 V bis 10 V an die Eingangsbuchse

TRIGGERAUSGANG

VCF INPUT anzuschließen. Unter Umständen muß das Bedienungselement FREQUENCY VERNIER benutzt werden, um den vollen Bereich von 1000 : 1 zu erhalten.

Da die VCF-Eingangsamplitude in einer linearen Beziehung steht, kann der Frequenzausgangsbereich über die VCF-Eingangsamplitude bestimmt werden.

Am Triggerausgang TRIG OUTPUT steht ein +4 V Rechtecksignal zur Verfügung. Die Frequenz des Triggerausgangs wird durch die Frequenz des gewählten Ausgangssignals bestimmt. Für jeden positiven Zyklus des Ausgangssignals (mit Ausnahme der Funktion Rechteck) wird ein Triggerimpuls erzeugt. Für das Rechtecksignal wird für jeden negativen Zyklus des Ausgangssignals ein Triggerimpuls erzeugt. Die Ausgangsimpedanz ist 50 Ω.

GRUNDSIGNALFORMEN

Die folgenden Abbildungen zeigen die Grundsignalformen des FG 501A.

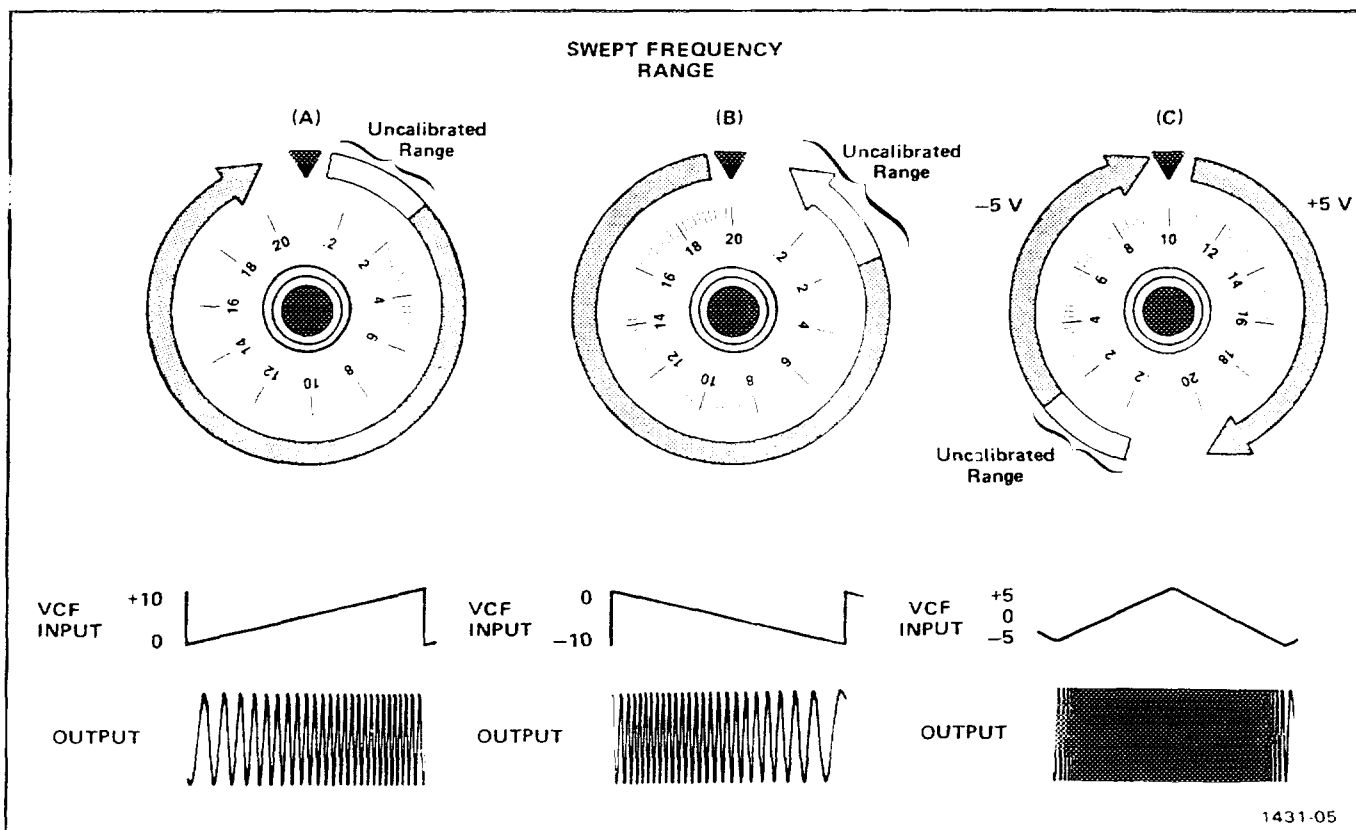


Abb. 2-3: Frequenzvariationsbereich mit 10 V-Signalen am Eingang VCF IN.

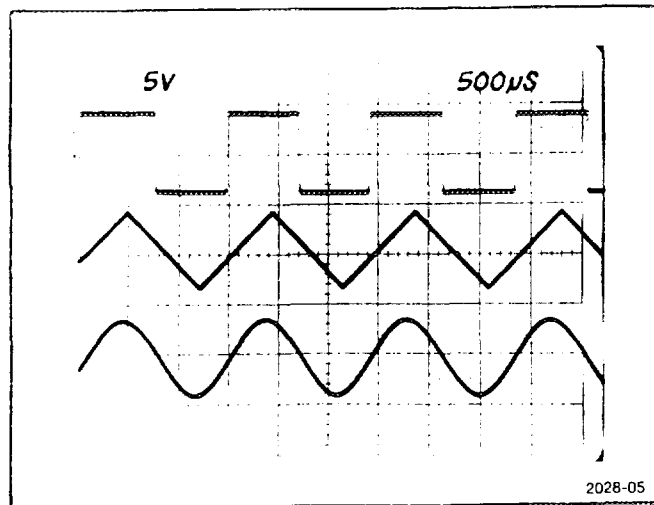
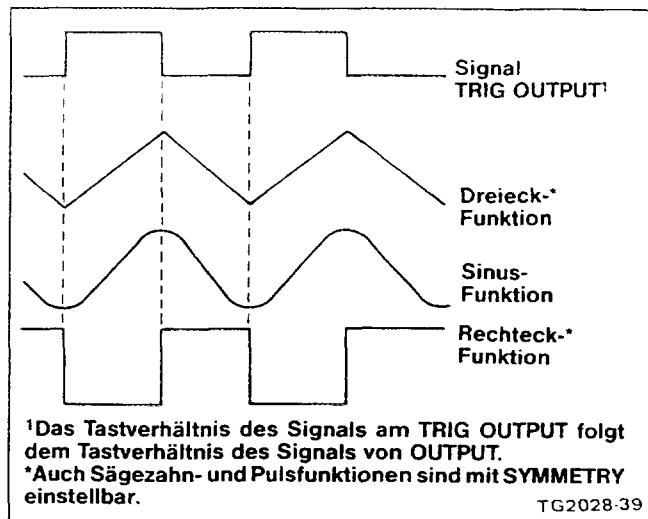


Abb. 2-4: Grundfunktionen. Rechteck, Dreieck und Sinus werden über die Drucktasten der Frontplatte gewählt.



¹Das Tastverhältnis des Signals am TRIG OUTPUT folgt dem Tastverhältnis des Signals von OUTPUT.
 *Auch Sägezahn- und Pulsfunktionen sind mit SYMMETRY einstellbar.

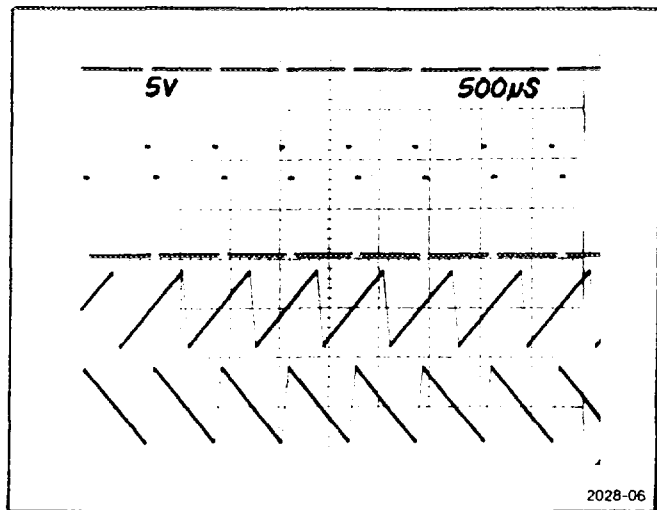


Abb. 2-5: Sägezähne und Pulse. Diese werden mit Hilfe des Bedienungselementes SYMMETRY aus den Grundsignalformen erhalten.

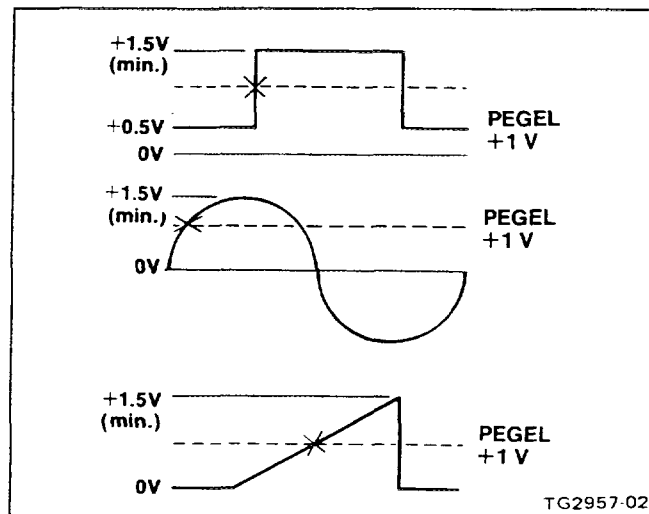


Abb. 2-7: Triggersignalamplitude und Triggerpunkte.

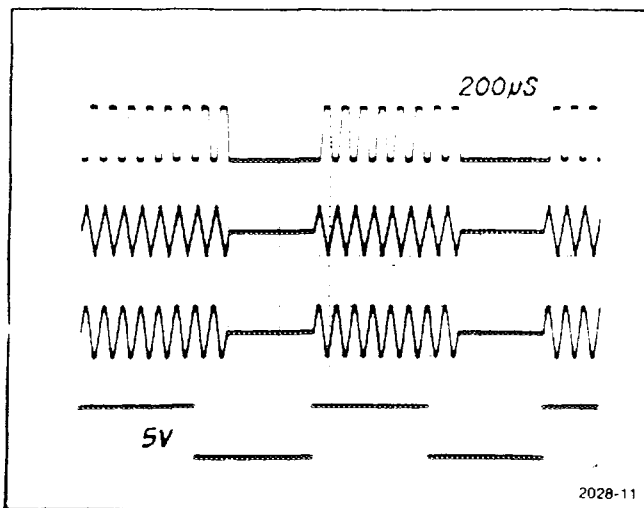


Abb. 2-8. GATE-Betrieb. Oben werden 3 Ausgangssignalformen dargestellt und unten das Gate-Signal, das bei gedrückter GATE-Taste an den Triggereingang angeschlossen ist. Der letzte Schwingungszyklus wird nach Abnahme des Gate-Signals beendet.

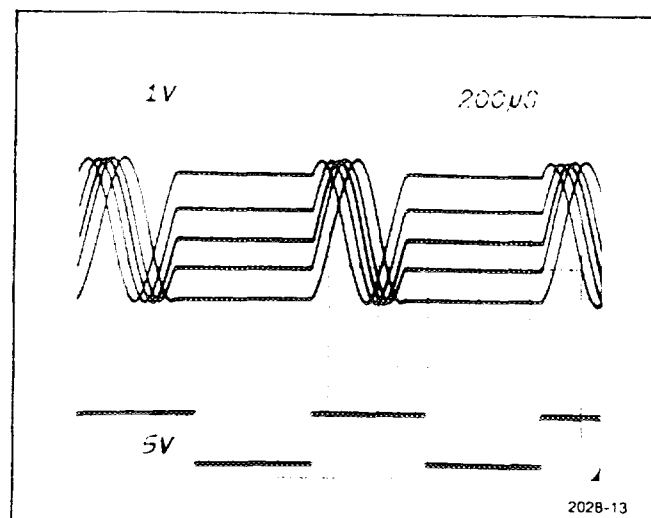


Abb. 2-10: Phasensteuerung. Diese Abbildung zeigt die Verwendung von PHASE im Triggerbetrieb. Die oberen Ablenkstrahle zeigen die Arbeitsweise von PHASE. Dieses Element gestattet eine Verschiebung der Phase von $\pm 90^\circ$. Der untere Ablenkstrahl ist das Triggersignal.

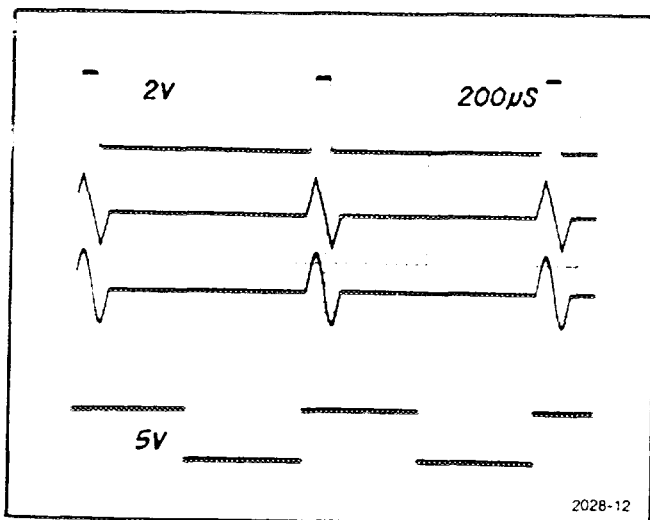


Abb. 2-9: Triggerbetrieb. Die oberen drei Ablenkstrahle zeigen verschiedene Ausgänge. Der untere Ablenkstrahl ist das an den Triggereingang angeschlossene Triggersignal in der Betriebsart TRIG. Es wird immer nur ein kompletter Schwingungszyklus erzeugt.

ANWENDUNGEN

ANALYSE DES ÜBERTRAGUNGSVERHALTENS

Der FG 501A eignet sich sehr gut zur Bestimmung des Übertragungsverhaltens von Schaltkreisen und Systemen. In dieser Anwendung wird der VCF-Eingang des FG 501A dazu verwendet, den Generator über einen Frequenzbereich zu wobbeln.

1. Nehmen Sie die Anschlüsse entsprechend Abb. 2-11 vor.

2. Stellen Sie den Wahlschalter MULTIPLIER und FREQUENCY Hz auf die gewünschten oberen oder unteren Frequenzgrenzen ein (je nach gewünschter Wobbelrichtung).

3. Schließen Sie das gewünschte Signal an den Eingang VCF INPUT. (Ein positives Signal erhöht die Frequenz und ein negatives Signal verringert sie.)

4. Stellen Sie die Amplitude des VCF-Eingangssignals entsprechend dem gewünschten Ausgangsfrequenzbereich ein.

5. Das Übertragungsverhalten kann auf dem Bildschirm des Oszilloskops beobachtet werden.

TONFREQUENZBURST-GENERATOR ODER STUFENFREQUENZ-MULTIPLIKATION

Zur Überprüfung tongesteuerter Geräte kann der FG 501A als Tonfrequenzburst-Generator oder als Frequenzmultiplizierer benutzt werden. In dieser Anwendung wird ein Sägezahngenerator wie z. B. ein RG 501 von Tektronix, als VCF-Signalquelle und ein Impulsgenerator, wie z. B. der PG 501 von Tektronix, als Gate-Signalquelle verwendet.

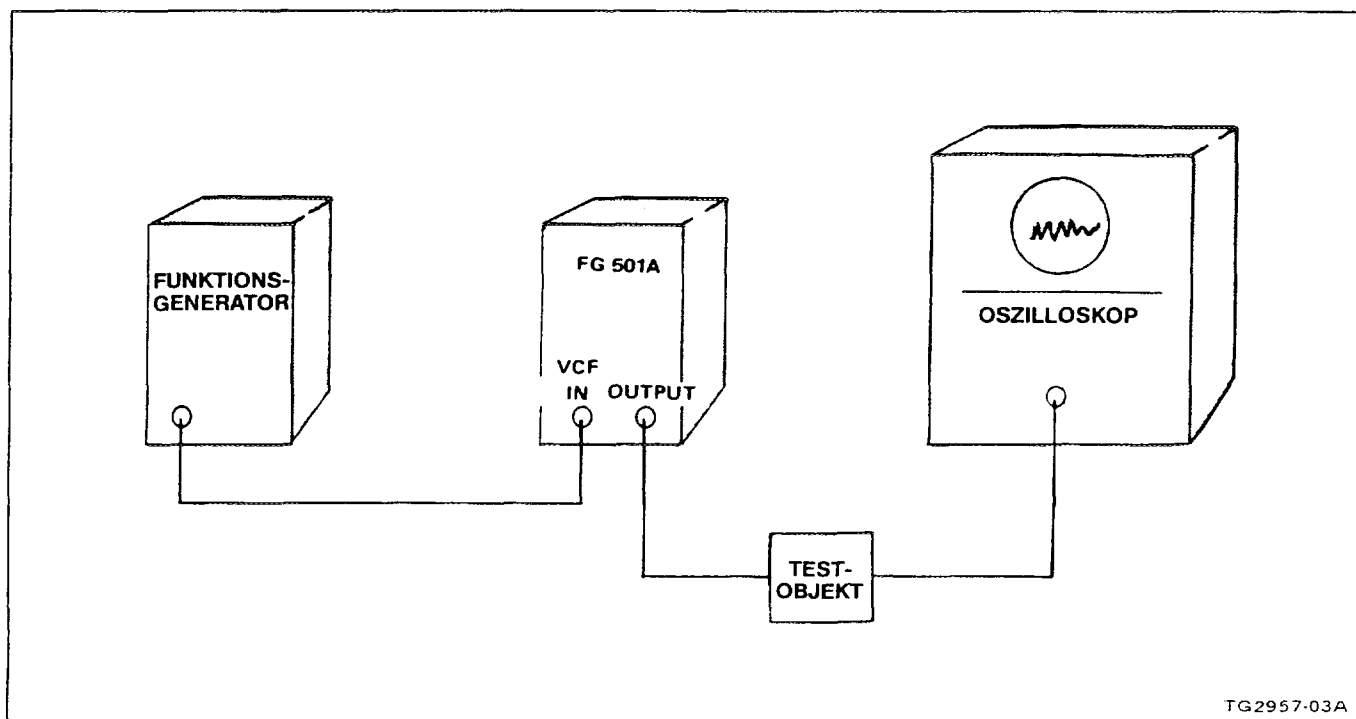


Abb. 2-11: Analyseschaltkreis oder Systemverhalten.

Im folgenden wird die Technik beschrieben, wie am Ausgang des FG 501A ein Tonfrequenzburst oder ein frequenzmultiplizierter Ausgang erhalten wird.

Sägezahnperiode und die Pulsdauer für die gewünschte Burstbreite ein

1. Nehmen Sie die Anschlüsse entsprechend der Abb. 2-12 vor.

2. Drücken Sie die Taste GATE und stellen Sie PHASE auf die gewünschte Phase ein.

3. Stellen Sie den Sägezahngenerator auf die Periodendauer und Polarität ein.

4. Stellen Sie die Periodendauer des Pulsenerators auf die gewünschte Anzahl von Bursts innerhalb der

5. Der Wobelfrequenzbereich wird mit Hilfe von FREQUENCY Hz eingestellt (obere oder untere Grenze). Die andere Grenze wird dann über die Amplitude des Sägezahngenerators gewählt.

Durch die Verwendung anderer Gate-Signale wie z. B. Dreieck, Sinus, Rechteck etc. können noch viele andere Tonfrequenzburst-Charakteristika erhalten werden.

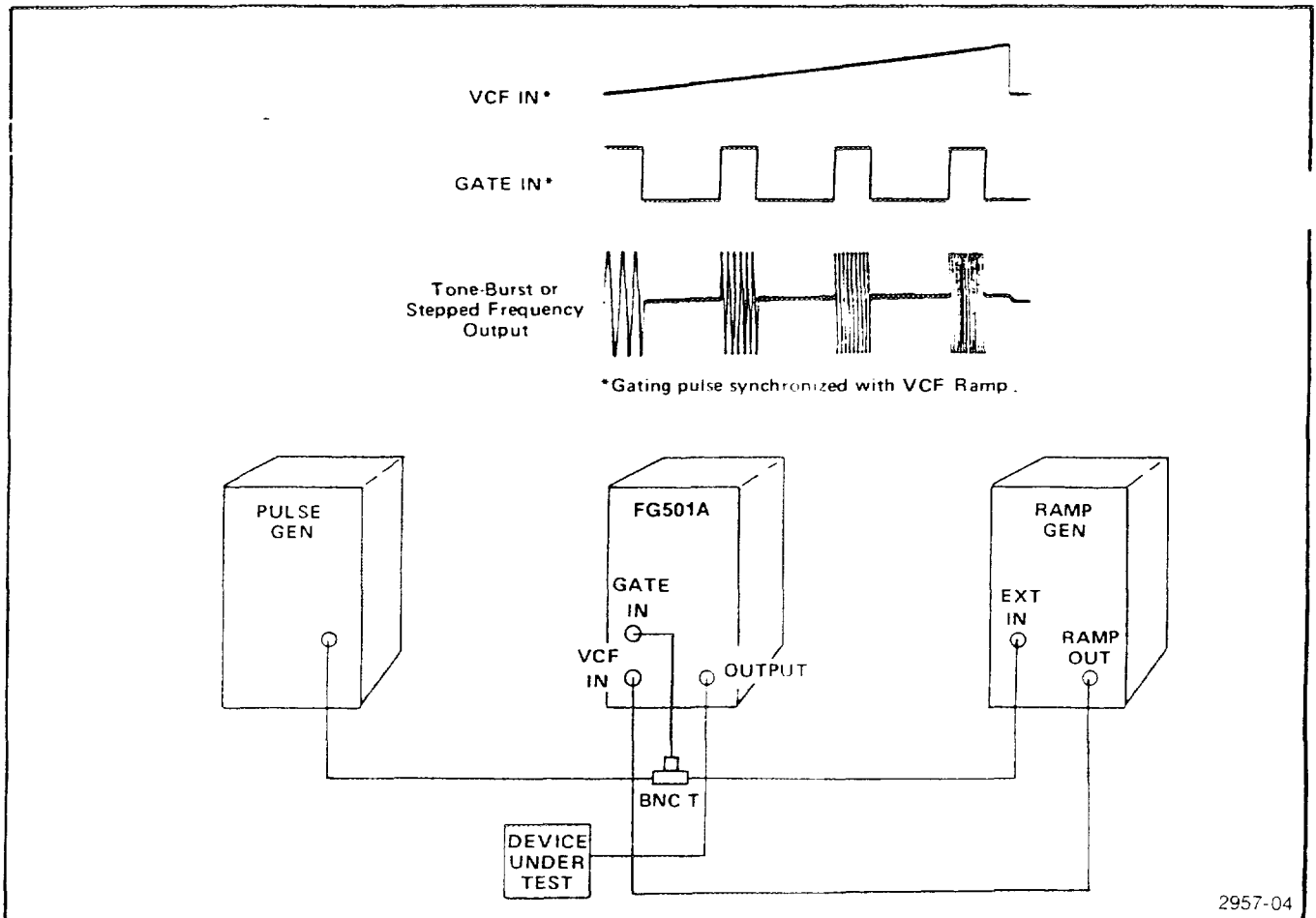


Abb. 2-12: Tonfrequenzgenerator oder Stufenfrequenzmultiplikation.

取扱説明

概要

この章ではFG501A型を最も有効にお使い頂くために必要な取扱いについて書かれています。さらに取付および取はずし方法、前面パネルのコントロールとコネクタの機能および動作モードと基本的な応用についても説明しています。

取付および取はずし方法

FG501A型は2プラグイン幅ですからTM501型を除くTM500シリーズの本体に組込んで使用します。出荷時に校正されていますのですぐにご使用できます。電源電圧については本体の取扱説明書をご覧ください。

注意

FG501A型を抜き差しする場合には本体の電源を切ってから行なって下さい。切らずに抜き差ししますと後部のインターフェイス・コネクタにアークが生じ、コネクタの寿命を縮めるばかりでなく、中の回路にも悪影響を与えます。

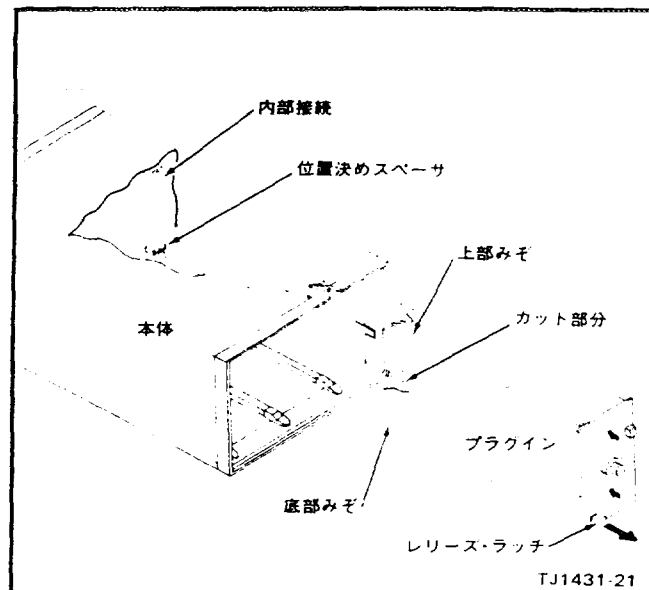
本体のコネクタ内に入っているプラスチックの位置決めスペーサとFG501A型のエッジ・コネクタのカット部分とが一致していることを確認します。差し込もうとする本体のコンパートメントの上下のガイド（2-1図）に沿ってFG501A型を押し込み、さらに本体のコネクタにFG501A型のエッジ・コネクタがしっかりと固定されるまで押しして下さい。本体の電源をオンにします。FG501A型を取りはずす場合には、左下隅にあるつまみを引っぱりそのまま引き抜きます。

梱包方法

修理のため、機器を送り返す際には、連絡先および故障の内容、シリアル番号を記入したタグを付けて下さい。

納入時に機器が梱包されていた箱を使用すれば簡単に再梱包ができますが、もしその箱がない時には次のように行なって下さい。

機器の塗装を保護するためにホリエチレン・シートのような物でくるみます。機器の長さよりも15cm位長い丈夫なダンボール箱を用意し、その箱の中にウレタン・フォームのようなクッション材を、上下左右に均等に箱と機器のあいだに詰めます。箱をテープもしくは大型ホチキスでシールします。FG501A型を梱包する箱はおよそ90kgの重量に耐えられる強度が必要です。

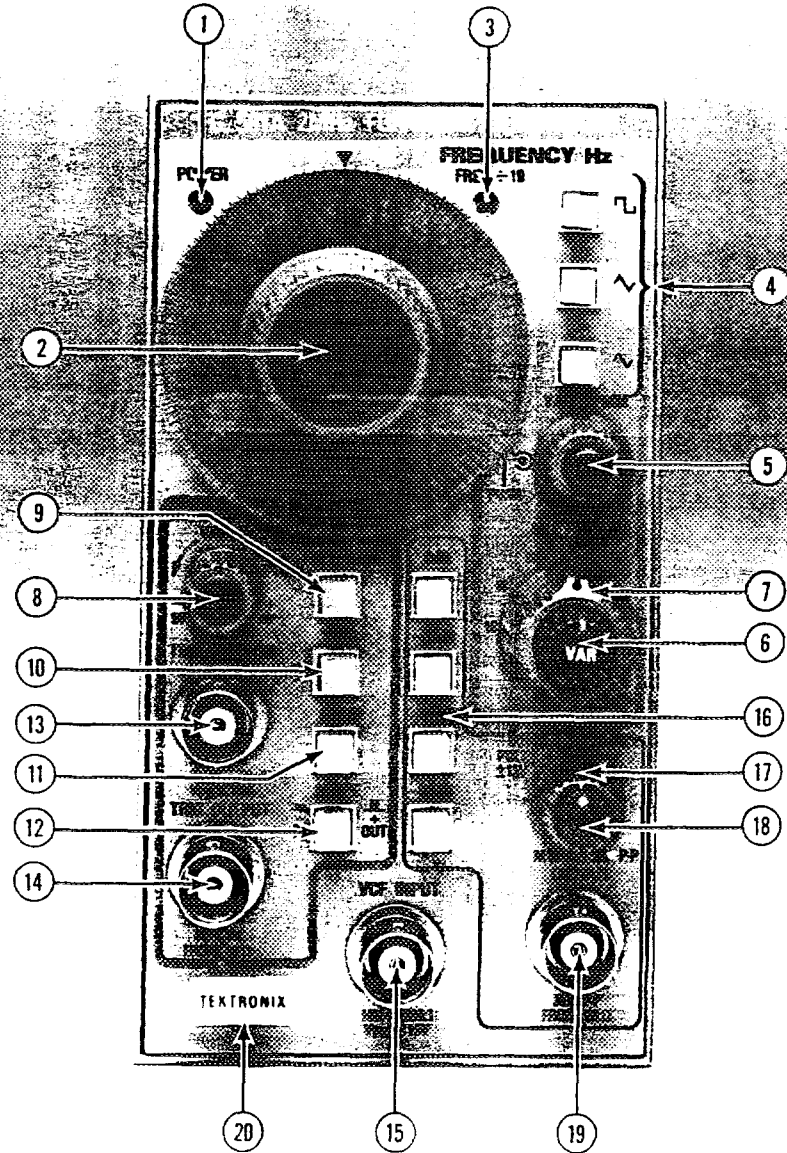


2-1図 取付および取りはずし方法

コントロールとコネクタ

FG501A型はすぐ使用できるよう校正されていますが、操作する前にもう一度コントロールとコネクタの機能と動作をお確かめ下さい。機器の操作に必要なすべてのコントロール

は、前面パネル上にあります。コントロールの説明が、別に書かれています。2-2図参照。



2957-01

2-2図 コントロールとコネクタ

① POWER インジケータ

本体から FG501A型に電源が供給されている時に点灯します。

周波数コントロールおよびファンクション

② FREQUENCY Hz ダイヤル

周波数を設定します。MULTIPLIERスイッチと共に使用されます。

③ FREQ \div 10 インジケータ

バリエブル・シンメトリ機能が作動中の時点燈します。

④ FUNCTION ボタン

方形波、三角波および正弦波からいずれか一つの出力波形を選択します。

⑤ VAR SYMM ダイヤル

押し出された状態で動作します。出力波形のX軸方向の対称性を調整します。出力波形の周波数がおよそ $\frac{1}{2}$ に減少し同時にFREQ \div 10インジケータが点燈します。

⑥ FREQUENCY VERNIER ダイヤル

フル・スケールの少なくとも $\frac{1}{10}$ までの出力周波数の微調整を行います。

⑦ MULTIPLIER スイッチ

FREQUENCY Hz ダイヤルと共に使用され8ディケイドのステップで出力周波数を設定します。

トリガおよびゲート・コントロール

⑧ VAR ϕ ダイヤル

トリガまたはゲート信号を基準として出力波形の位相を $\pm 90^\circ$ の範囲で変化させます。

⑨ FREE RUN ボタン

押されている状態で波形を連続して出力します。

⑩ TRIG ボタン

ボタンが押されると、TRIG/GATE IN コネクタに入力された各トリガ・パルスごとに一周期分の波形が出力されます。

⑪ GATE ボタン

ボタンが押されると、TRIG/GATE IN コネクタに入力されたトリガ・パルス幅の間のみ連続した波形が出力されます。

⑫ SLOPE ボタン

トリガ・モードの時にトリガ入力信号のスロープを選択します。またGATEモードでは+1Vの電圧をスレショルド・レベルとして、入力信号がそのレベルよりマイナスかプラスかによってゲート動作をオン、オフさせます。

⑬ TRIG/GATE IN コネクタ

外部トリガまたはゲート信号を入力するBNCコネクタです。

⑭ VCF INPUT コネクタ

出力周波数をコントロールするための外部電圧を入力するBNCコネクタです。正方向電圧により周波数は増加します。

⑮ TRIGGER OUTPUT コネクタ

出力波形の1周期ごとに1個の正トリガ・パルスを出力するBNCコネクタです。

出力

⑯ ATTENUATOR ボタン

最大60dBまで、20dBステップで出力波形の振幅を減衰させます。

⑰ AMPL ダイヤル

アッテネータ・ボタンのステップ間の出力波形の振幅を変えることができます。

⑱ OFFSET ダイヤル

このダイヤルを手前に引いてから回しますと出力波形に $\pm 13V$ までのDCオフセット電圧を加えることができます。

⑲ OUTPUT コネクタ

波形を出力するBNCコネクタです。

⑳ リリーズ・ラッチ

本体からFG501A型を引き抜く時に使うつまみです。

操作について

出力コネクタ

FG501A型の出力は50Ωの電圧源として、50Ω負荷、で動作するよう設計されています。より高い周波数で、終端されないか、もしくは不適切に終端された場合にはアブレーションの悪い波形が出力されます。50Ω以下の負荷では出力波形の振幅は減少します。

不適切な終端による過大なひずみやアブレーションは、低い周波数では余り目立ちません。特に正弦波および方形波。真の出力波形を確認するためには次の手順をお守り下さい。

1. 良質な50Ωの同軸ケーブルおよびコネクタを使用します。
2. できるだけケーブルは短かくして、しっかりと接続します。
3. もし感度の良い回路に波形を入力する時は、振幅を減衰させるために良質のアテネータを使用します。
4. 1.8m以上の長いケーブルを使用する時には反射を防ぐため、終端するかあるいはインピーダンス整合を行います。
5. 出力波形に対して、アテネータやターミネーションなどは適切な定格電圧を持っているかを確認します。

もし出力にDC電圧が重畳している時は、負荷に直列にカップリング・キャパシタを挿入します。パルスの平坦度を維持するため、カップリング・キャパシタと負荷の時間定数は十分長くする必要があります。

立上りおよび立下り時間

立上りまたは立下り時間を**FG501A型**を使用して測定する際には、他の機器の立上り時間も考慮に入れる必要があります。測定しようとする機器の立上り時間と**FG501A型**と他に使用する機器とのシステムとしての立上り時間と比較して、10倍以上早い立上り時間の時には誤差は1%以下となりほとんど無視することができます。測定しようとする機器の立上りまたは立下り時間と、測定システムの立上り時間と比較して10倍以下の時には誤差が大きくなるため、実際の立上り時間は計算して求める必要があります。一度、システムの立上り時間が解れば測定しようとする機器の立上り時間は容易に決めることができます。

インピーダンス整合

FG501A型を1MΩ入力インピーダンス（並列に容量を含む）を持つオシロスコープの垂直軸入力のような、高イン

ピーダンス入力に接続する時は、伝送ライン、50Ωアテネータ、50Ωターミネーションを通じてオシロスコープに入力します。アテネータは機器の入力容量をアイソレートしてターミネーションは**FG501A型**を適切に終端します。

基本操作

前面パネルのコントロールの機能については、コントロールとコネクタの項で説明されています。

波形の選択および周波数を設定するためのコントロールは青色、トリカ機能と入力は緑色、出力コントロールは黒色にそれぞれ色分けされています。

FG501A型の各機能については以下の手順で操作して下さい。

注

操作中に何んらかの支障が起きた際にはフィールド・エンジニアにお問い合わせ下さい。

操作する前に次のようにコントロールをセットします。

青の部分

FREQUENCY Hz	
MULTIPLIER	10 ²
FREQUENCY VERNIER	右回し一枚
VAR SYMM	オフ
～(正弦波)	押した状態
他はすべてボタンを外に出した状態にします。	

緑色の部分

FREE RUN	押した状態
他はすべてボタンを外に出した状態にします。	

黒色の部分

ATTENUATOR	−20dB
AMPL (バリアブル)	中央
OFFSET	オフ
他はすべてボタンを外に出した状態にします。	

50Ωで終端された50Ω同軸ケーブルをオシロスコープの垂直軸入力に接続します。オシロスコープを次のように設定します。

垂直軸	1 V/div、DC結合
水平軸(時間軸)	1 ms/div

1目盛りに1周期の正弦波がオシロスコープに表示されます(全体は10サイクルになります)。

1. 方形波、三角波および正弦波を二次演算用の各波形を波形を確認します。最初の設定には、コントロールを戻します。
2. 4つのアテネータ・ボタンを順次押し、またAMPLITUDE (可変)ダイヤルを回して、波形の振幅が変化するのを確かめます。最初の設定にコントロールを戻します。
3. OFFSETダイヤルを引き、回転させます。表示された波形のDCレベルが変化します。OFFSETダイヤルを押し込みます。

1. VAR SYMMダイヤルを押し、単に出した状態に戻します。FREQ = 10 (1000 Hz) が点灯し表示波形が1周期になることを確認します。VAR SYMMダイヤルを回して方形波、三角波、正弦波の各波形が変化するのを確かめます。最初の設定にコントロールを戻します。
5. FREQUENCYダイヤルとMULTIPLIERスイッチを変えることにより、表示波形の周波数が変化するのを確かめます。最初の設定にコントロールを戻します。

動作モード

フリーラン出力

次は任意の周波数および振幅で連続したフリーラン出力を得る方法です。

1. 任意の波形を選びます。
2. AMPLダイヤルを左回し一杯にして、VAR SYMMおよびOFFSETダイヤルがオフになっていることを確認します。
3. FREQUENCY HzダイヤルとMULTIPLIERスイッチにより任意の周波数を選びます。周波数はダイヤルの設定値とMULTIPLIERスイッチの設定値とを掛けた値となります。
4. FG501A型の出力コネクタに負荷を接続し任意の振幅になるようAMPLダイヤルで調整します。

トリガおよびゲート(バースト)モード動作

FG501A型がフリーラン・モードになっていることを確認して、TRIG/GATE INコネクタにトリガまたはゲート信号を入力します。

1個のトリガ信号で1周期のみの出力波形を得る場合にはTRIGボタンを押し、スローフの+カーを選びます。各トリガ信号に同期した出力波形が得られます。

1周期以上の出力波形が必要な場合にはGATEボタンを押し、ゲート信号のゲート幅の期間だけ連続した出力波形が得られます。バーストの繰返し数は、ゲート幅をFG501A型出力波形の周期で割った値となります。

トリガまたはゲート・モード動作では、PHASEダイヤルにより $\pm 90^\circ$ の範囲で出力波形のスタート点を変えることができます。この位相を変えるダイヤルの値は出力波形上の0V、 0° を基準としています。

外部周波数コントロール(VCF)動作

VCF INPUTコネクタに外部電圧を入力することにより1000:1の範囲内で出力波形の周波数を掃引させることができます。VCF入力信号の極性を切替えることにより設定された周波数からどちらの方向に周波数が掃引されるかが決まります。正(+)方向の信号により周波数は高くなり負(-)方向の信号で周波数は低くなります。

FREQUENCY Hzダイヤルの設定により ± 10 Vの範囲内で入力信号の電圧と極性を選ぶことができます。

1000:1の最大周波数掃引レンジではFREQUENCY Hzダイヤル($< 0.2 \sim 2$)の非校正部分が含まれてしまいます。周波数が1000:1まで掃引されるのを確認するためには、FREQUENCY Hzダイヤルを0.2に設定しVCF INPUTコネクタに0から-10Vに変化する信号を入力します。その

時は、FREQUENCY VERNIER 0.1 の値を10001に設定し、
 0.1 または最大既知周波数100 kHzの範囲から、ある1周調
 整が必要となります。

出力周波数とVCF INの接続は、以下の図に示されています。

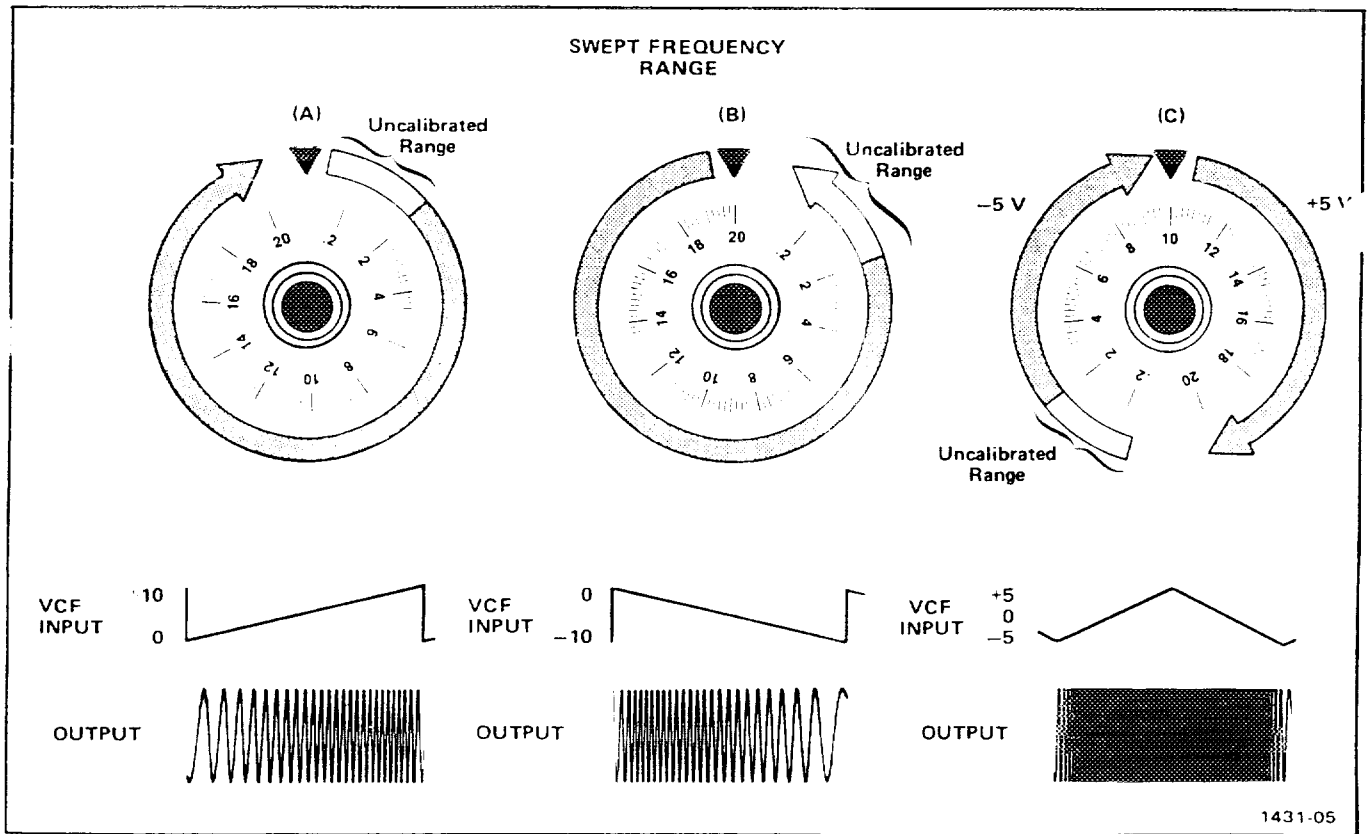
トリガ出力

TRIG OUTPUT コネクタからは+5Vの方形波が出力され
 ます。この出力の周波数は出力波形の周波数によって決ま
 ります。三角波以外の波形を選入した時には出力波形期間の
 各正方向過渡で1個のトリガ・パルスが発生します。

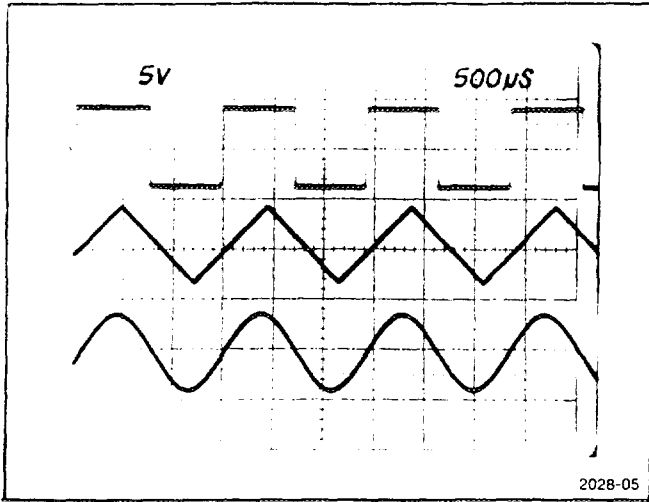
方形波出力を選入した時は、その出力波形期間の各正方向
 部分で1個のトリガ・パルスが発生します。トリガ出力イン
 ピーダンスは50Ωになっています。

基本的な波形出力

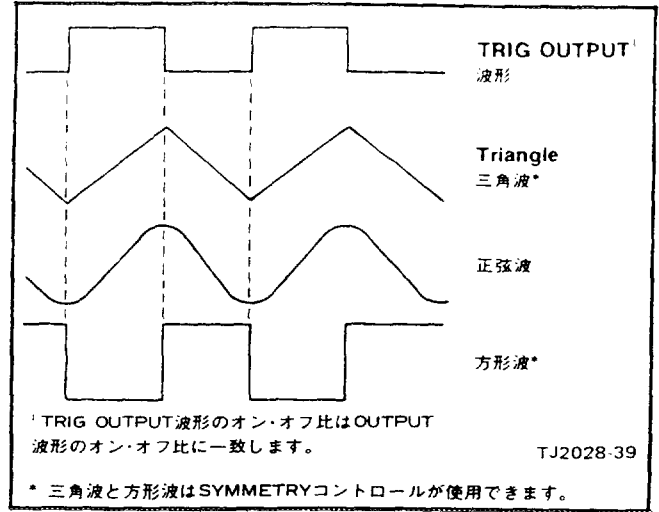
以下の図はFG501A型の基本的な波形出力です。



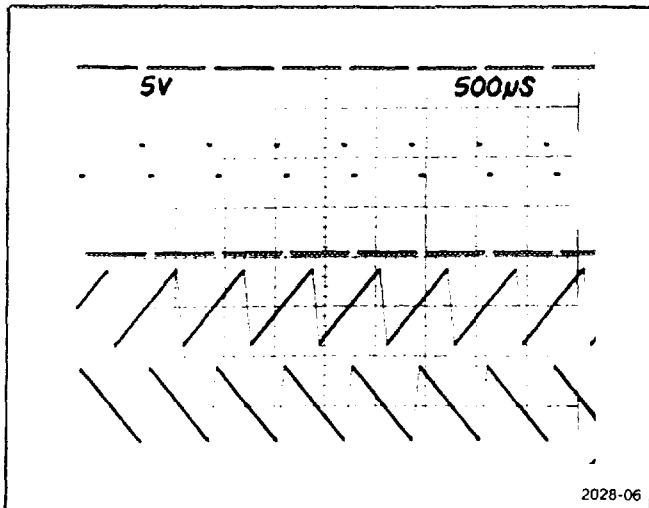
2-3 図 VCF INコネクタに10V信号を加えた時の掃引周波数レンジ



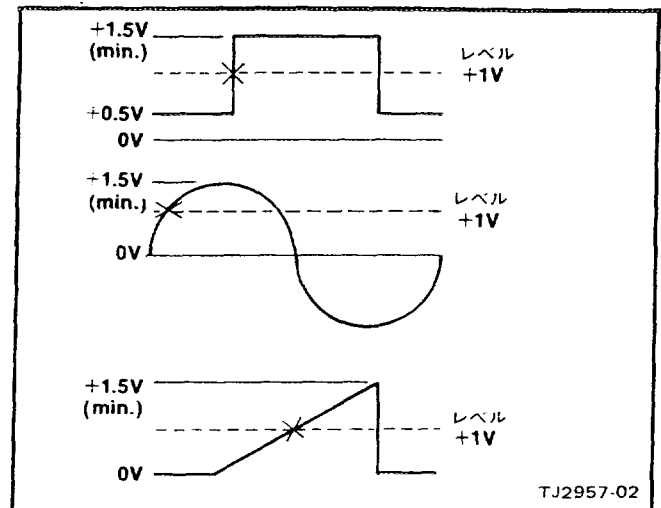
2-4 図 前面パネルの押しボタンにより選ばれた方形波、三角波、正弦波の基準となる各波形を示しています。



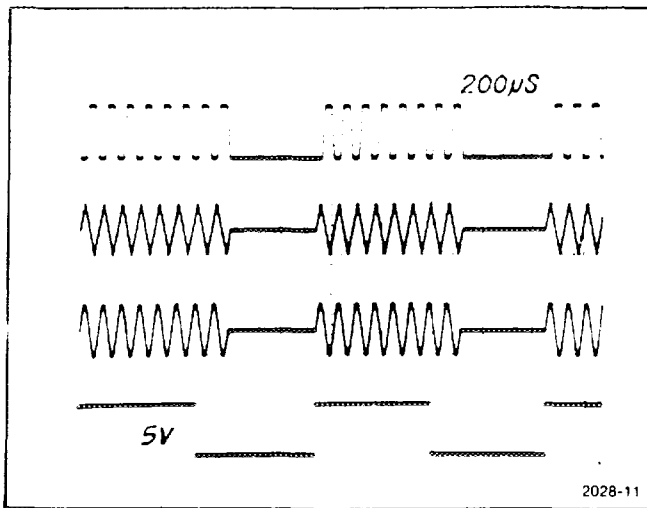
2-6 図 OUTPUT 波形と TRIG OUT 波形との位相関係を示しています。



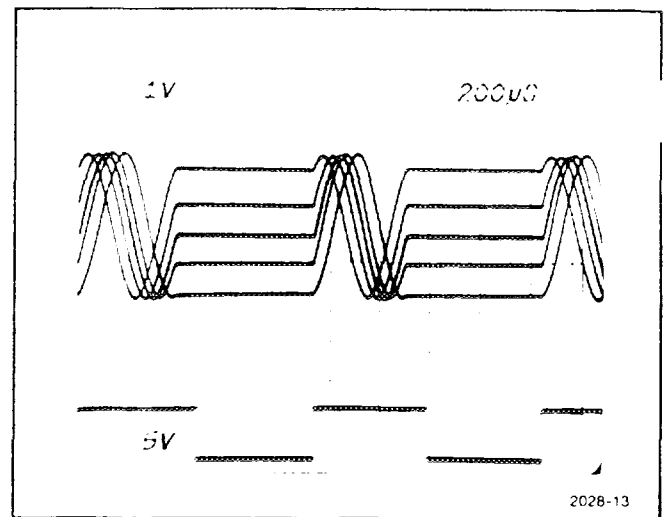
2-5 図 のこぎり波とパルス。SYMMETRY ダイヤルを使ってこのような波形をつくることができます。



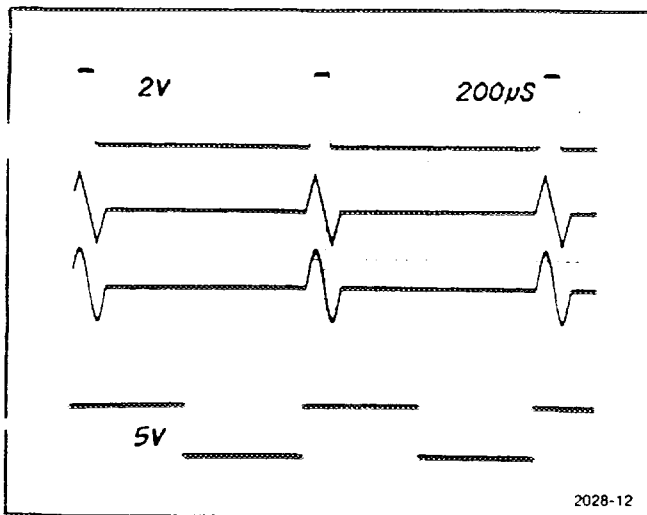
2-7 図 トリガ信号として必要な振幅とそのトリガ・ポイントです。



2-8図 ゲート動作。GATEボタンが押されて、トリガINPUTコネクタにゲート信号が入力された時の、上側3個が出力波形で、下側がゲート波形です。ゲート波形がオフになってもすぐにはハーストの繰返しは停止しないことに留意して下さい。



2-10図 位相調整。トリガ・モードでのPHASEダイヤルによる動作を示しています。5個の重ねられた波形は位相調整による結果です。このダイヤルにより90°の位相を変えられます。下側の波形はトリガ信号です。



2-9図 トリガ動作 TRIGモードが選択され、トリガINPUTコネクタにトリガ信号が入力された時の、上側3個が出力波形で、下側がトリガ波形です。出力波形が1周期であることに注意して下さい。

応 用

周波数特性試験

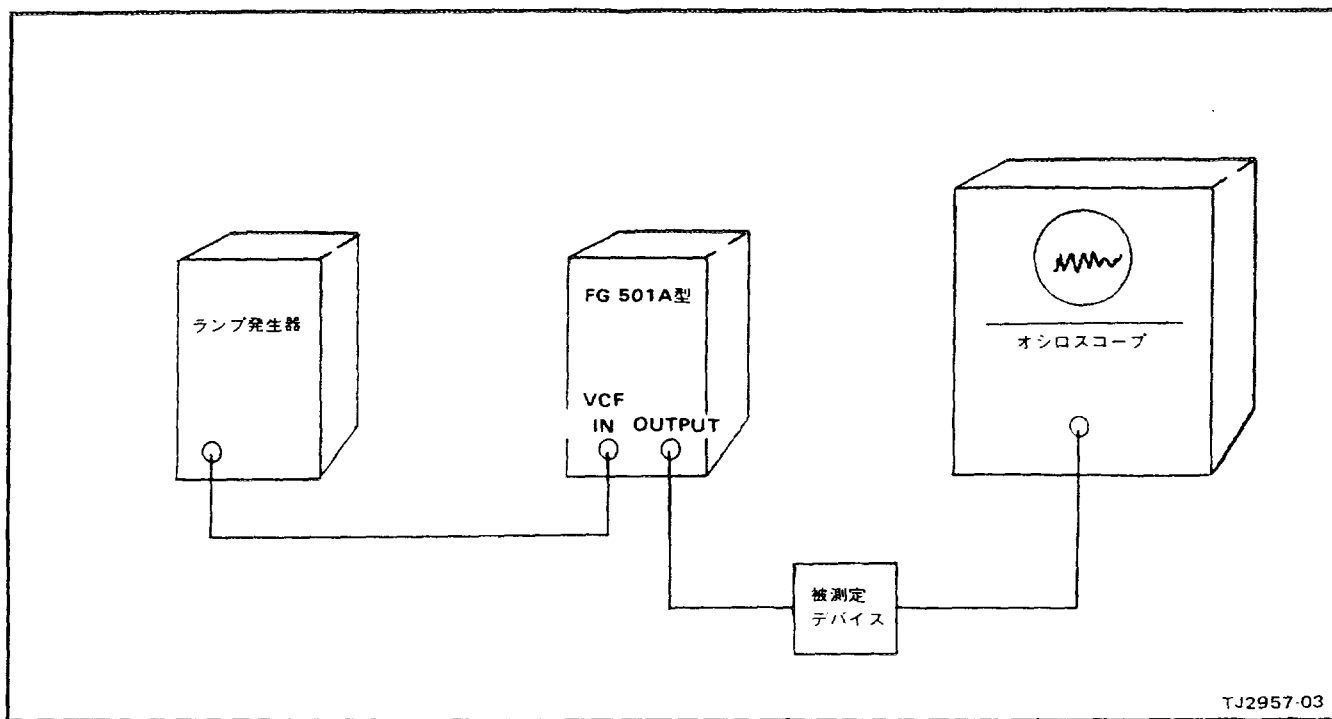
FG501A型は特に回路やシステムの周波数特性を求めるのに適しています。この応用ではFG501A型のVCF入力を使用します。詳細については動作モードのVoltage Controlled Frequency, VCF（動作の項をご参照下さい。

1. 2-11図の様に機器を接続します。
2. MULTIPLIERスイッチとFREQUENCY Hzダイヤルにより上限と下限の周波数を設定します。
3. VCF INPUT コネクタに掃引信号を加えます。（正方向信号では周波数が増加し、負方向信号では周波数が減少します。）
4. VCF入力信号の振幅を調整して、出力周波数レンジを決定します。
5. オシロスコープを使って周波数特性を観測します。

表示されている応答特性のある一部分の周波数を求めるには、VCF入力の信号を外します。次にFREQUENCY Hzダイヤルを調整して、掃引表示の特性と同じ特性になる時のFREQUENCY Hzダイヤルの周波数を読み取る事により測定出来ます。

トーン・バーストの発生

FG501A型はトーン・バースト発生器として、またはトーン・コントロール装置を試験するための周波数マルチプライヤとしても使用できます。この応用では、当社のRG501型のようなランプ発生器をVCF入力源として、当社のPG501型のようなパルス発生器をゲート信号源として使用します。

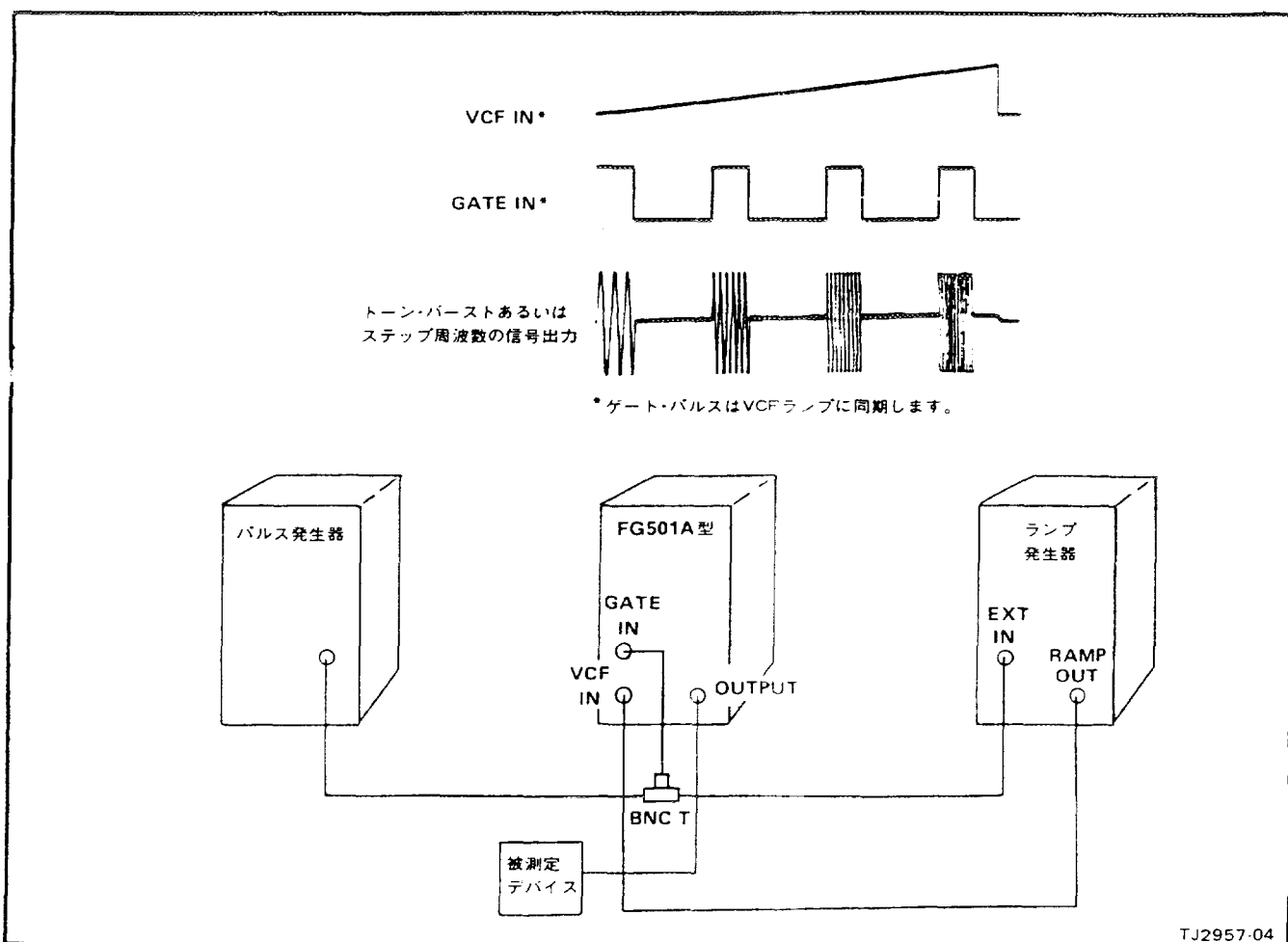


TJ2957-03

FG501A型：トーン・バーストあるいはステップ周波数の信号出力を得る手順を次に示します。詳細は動作モードのゲートされた出力（パルス）と同期する相やVCFランプの項を参照下さい。

1. 2-12図の様に機器を接続します。
2. GATE ボタンを押し込みPHASE 調整ダイヤルを使って任意の位相に合わせます。
3. ランプ発生器のランプ繰返し率と極性を設定します。
4. 選択した繰返し率のランプ時間内に任意のバースト数が入る様にハルス発生器の繰返しを調整します。又、任意のバースト幅を得られる様にハルス発生器の信号幅を調整します。

5. FREQUENCY Hz ボタンの調整で周波数、掃引速度を調整します。一部又は全部の信号の極性を決定します。ハルス発生器の幅を調整して掃引周波数の範囲を決定します。他のトーン・バーストあるいはステップ周波数の特徴は例え日他の異なる三角波、正弦波や方形波等の入力を使用する事により得られます。



2-12図 トーン・バーストあるいはステップ周波数信号発生

SERVICING 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.

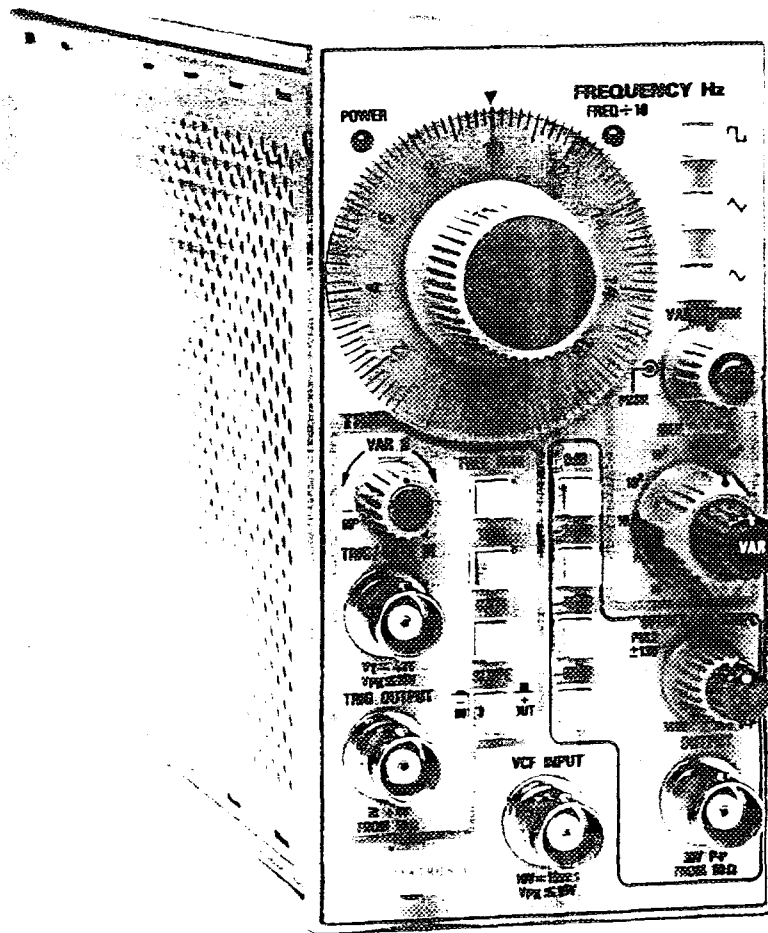
Use Care When Servicing With Power On

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.



2957-00

FG 501A 2 MHz FUNCTION GENERATOR

THEORY OF OPERATION

INTRODUCTION

This section of the manual contains a description of the electrical circuits in the FG 501A. Refer to the block diagram and schematic diagrams on the fold out pages in the back of the manual to aid in understanding this

description. Diamond enclosed numbers appearing throughout this section refer to the schematic diagram on which the circuit being discussed is located.

LOOP

FREQUENCY CONTROL AND SUMMING AMPLIFIER

The voltage developed across the frequency control divider string, R1429, R1321, R500 and R510, is applied to pin 5 of operational amplifier U1540B. This voltage is buffered by the amplifier and a current is developed through R1551. This current is applied to pin 2 of summing amplifier U1540A where it is summed with any currents developed by a voltage applied to the VCF inputs. The VCF inputs are J510 (front panel) through R1553, and pin 21B (rear interface) through R1103. These summed currents are buffered by Q1445 and flow through R1543. The voltage developed across R1543 is proportional to the frequency.

CURRENT SOURCES AND SWITCH

The voltage developed across R1543 is buffered by U1440 and Q1541 which form the negative current source for the main loop timing circuitry. This same voltage is also buffered by U1540C and Q1543 which form a current source identical to U1440 and Q1541. The output current from Q1543 flows through Q1527, Q1525, and Q1421, which form a current mirror that inverts this current to provide the positive current source for the main loop timing circuitry. The current through R1521 is the timing capacitor charging current; the current through R1536 is the discharging current. The Top Dial Symmetry Cal, R1421, adjusts the balance between these two currents so they are equal in magnitude.

In the normal mode of operation (fixed symmetry) R520 and R540 are in the emitter circuit of Q1541 and Q1543. In this condition, equal amounts of current will flow in both the positive and negative current sources. When S500, VAR SYMM, is activated, R530 is switched into the current source emitter circuits. As R530 is varied from one end to the other, unequal amounts of current flow through the

positive and negative current sources. In this manner the symmetry of the waveform generated by the loop is varied. These currents are switched into the junction of CR1531 and CR1533 where they alternately charge and discharge the timing capacitor, producing a triangle waveform. The current switch is formed by Q1531, CR1531, Q1433 and CR1533.

TIMING CAPACITORS AND CAPACITANCE MULTIPLIER

The timing capacitors provide for triangle generation in the five fastest MULTIPLIER ranges. They are switched into and out of the circuit in decade steps from 10^5 (C1631) down to 10^1 (C1741).

For the four lower MULTIPLIER ranges, 10^0 down to 10^{-1} , C1741 is switched into the feedback loop of U1930 forming an integrator. Current from the current switch is applied to operational amplifier U1940. A voltage is developed at the output of this amplifier that is proportional to the applied current times the value of R1941 (1 k Ω). This voltage is applied, across one of four resistors, to the input of U1930. These resistors, R1831, R1841, R1842, and R1843, are switched into and out of the circuit in decade steps with the MULTIPLIER switch S1731. This arrangement provides very large values of effective capacitance. The output of U1930 is now the triangle that is applied to the buffer stage.

TRIANGLE BUFFER

The voltage developed by the timing capacitor or multiplier (U1930) is applied to the triangle buffer. Q1725 and Q1723 form the differential input stage of this circuit. Q1821 serves as a constant current source for the input differential pair. Q1721 and Q1712 complete the feedback for the amplifier such that the voltage at the emitter of Q1712 is equal to the voltage at the Gate of Q1725.

Loop delay compensation is provided by a network comprised of R1712, R1812, C1712, and C1714. The buffered timing capacitor voltage is applied through this network to the level comparators.

LEVEL COMPARATORS

The level comparators detect upper and lower threshold levels. U1700A is the upper level detector and U1700B the lower. The reference level for these comparators is supplied by U1400B and C. As the threshold levels are detected, the respective comparator triggers U1600B.

REFERENCE VOLTAGES

The reference voltage supplies are composed of U1400B (–) and U1400C (+) and associated components. The upper (positive) level threshold voltage is established by adjusting R1412. This resistor is in a voltage divider string from zener diode VR1413. The voltage developed across R1412 is buffered by U1400C and set to approximately +400 mV at the output. This voltage is applied to pin 5 of U1700A as the upper threshold level reference. This same voltage is also applied to pin 9 of inverter U1400B. R1511 is used to adjust the gain of this stage so that the output is nominally –400 mV. This voltage is applied to pin 13 of U1700B as the lower threshold level reference.

LOOP LOGIC

When a rising voltage at pin 6 of U1700A passes through the threshold level set at pin 5, the output (pin 8) goes low pulling pin 10 of U1600B low. This action sets the flip-flop causing pin 9 (Q) to go high and pin 8 (\bar{Q}) to go low. Pin 8 of U1600B is tied back, through R1403, to the junction of CR1431 and VR1532. VR1532 serves as a level shifter to change the TTL output gate to the correct level to drive the current switch (Q1531, CR1531, Q1433, CR1533).

As the voltage at the junction of R1532 and R1534 drops, it pulls the bases of Q1531 and Q1433 low. Q1531 is turned on and Q1433 is turned off. Any current from the positive current source, through R1521, now flows through Q1531 and is shunted to the –15 V supply. With Q1433 turned off, any current flow through the negative current source must come from the positively charged timing capacitor through CR1533.

The falling voltage on the timing capacitor is buffered through the triangle buffer and applied to the level comparators U1700A and U1700B. As the voltage at pin 12 of U1700B falls through the threshold level set at pin 13, the output (pin 1) goes low pulling pin 13 of U1600B low. This action resets the flip-flop causing pin 9 (Q) to now go

low and pin 8 (\bar{Q}) to go high. Taking this high at pin 8 back to the current switch, Q1531 will be turned off and Q1433 turned on. This allows the timing capacitor to charge in the positive direction.

The action just described generates one entire cycle of a triangle wave.

TRIGGER GENERATOR

The square wave output at pin 8 (\bar{Q}) of U1600B also drives the trigger output amplifier. This circuit is composed of emitter follower Q1431 and associated components. Q1440, in conjunction with R1440, serves as output short circuit protection. The output of this circuit (at J2043) is a square wave 180° out of phase with the main loop signal. The output amplitude is greater than +4 V into an open circuit, and at least –2 V into a 50 Ω load.

SQUARE WAVE GENERATOR

The output at pin 9 (Q) of U1600B is a square wave, but 180° out of phase with that at pin 8. This signal is used to drive the square wave generator composed of differential pair Q1801, Q1901, and associated components. The base of Q1901 is held at a constant voltage by divider network R1815 and R1818. R1728 and R1816 form a constant current source for the differential pair. The square wave from U1600B alternately switches this constant current ground through Q1801 or through R1819 and Q1901. In this manner, a square wave voltage is developed with dc levels sufficient to drive the output amplifier for the square wave function.

PHASE CLAMP THRESHOLD DETECTOR

The output of the triangle buffer, in addition to possibly being fed to the Output Amplifier through S1901B, is connected to the base of Q1711. Q1711 and Q1611 form a differential amplifier. Q1621 and associated components provide a constant current source for the differential pair. This amplifier senses the level of the triangle waveform and compares it to the output voltage of U1400A. The output voltage of U1400A is determined by the setting of the VAR \emptyset control, R550. The voltage range of R550 is established by reference voltage supplies U1400B (–) and U1400C (+). These are the same reference voltages supplied to the Level Comparators. This arrangement permits comparison of the triangle voltage with the maximum possible positive and negative levels, and all levels between.

When the triangle voltage exceeds the reference voltage set by the VAR \emptyset control, Q1711 turns off. Any current flowing through Q1621 now flows through Q161

CURRENT AMPLIFIER

Current flowing through Q1611 also flows through R1622 and is amplified by Q1521. Temperature compensation for this amplifier is provided by CR1621. Differential pair Q1511 and Q1523 serve as a current switch. With Q1511 turned off, any current amplified by Q1521 passes through Q1523 to the junction of CR1531 and CR1533. When the timing capacitor voltage rises to the threshold

level set by the VAR \emptyset control, R550, it is clamped. Q1523 now draws exactly the amount of current that the positive current source supplies. Because the square wave at pin 5 (Q) of U1600A drives the base of Q1511, the clamping action only happens during the positive edge of the triangle wave. On the negative transition, Q1523 is shut off, and Q1511 is on. In this manner, the timing capacitor voltage can be clamped at any desired positive level.

TRIG/GATE AMP AND SINE SHAPER 3

TRIG/GATE AMP AND LOGIC

The input trigger amplifier consists of an emitter coupled differential pair (Q1320 and Q1322), current amplifier Q1324, and the required logic circuitry to control the operation of the main loop phase clamp. Input circuit protection is provided by R1203, R1204, CR1220 and CR1221. Triggering signals are applied either through front panel connector J520 or interface connections on the rear edge of the Main circuit board.

The differential pair, Q1320-Q1322, responds to the input signal when the voltage rises above (+ SLOPE) the reference voltage at the base of Q1320. This reference voltage is established by divider network R1312 and R1314. The position of S1400D, SLOPE switch, determines whether a positive or negative going input will cause the amplifier Q1324 to conduct. When the threshold level is exceeded and conduction starts, current flow through the circuit causes a voltage to be developed across R1322. This voltage is applied to the base of Q1324. The output at the collector of Q1324 is a TTL compatible waveform to drive the logic circuit, U1310. CR1320 provides temperature compensation for Q1324.

Three modes of operation are selectable with S1400; Triggered, Gated, and Free Running.

In the TRIG mode, S1400A and S1400C are positioned such that the output, pin 6, of U1310B is connected to pin 4, set input, of U1600A. In this mode, a very narrow, negative going voltage pulse is developed by U1310B each time the input waveform passes through the trigger threshold. This low sets U1600A, which deactivates the phase clamp until the triangle generator again starts in the positive direction, and allows the generator to complete one full cycle.

In the GATE mode, S1400A and S1400C are positioned such that the output, pin 3, of U1310A is connected to pin 4, set input, of U1600A. In this mode, a low level is produced whenever the input waveform exceeds the threshold if + SLOPE is selected. The generator free runs

as long as this condition exists. As soon as the level at the input connector drops below the threshold, the output voltage of U1310A rises. This high level causes the generator to again stop running when the phase clamp reaches its threshold level at the end of the last complete cycle.

In the FREE RUN mode, S1400A is positioned such that pin 4 of U1600A is held low. The generator now outputs continuous waveforms.

SINE SHAPER

The Sine Shaper is composed of three separate circuit functions: a Transconductance Amplifier, the Shaper Circuitry, and an Output Buffer.

Transconductance Amplifier. Emitter coupled transistors Q1210 and Q1212 along with current source Q1200 form the Transconductance Amplifier. The amplifier converts the triangle voltage at the base of Q1212 to a differential current. This current flows through two sets of diode wired transistors, U1120C, U1120D, U1220C, and U1220D, to the input of the shaper.

Shaper. The active portion of the Shaper is formed by two sets of emitter coupled transistors U1220A, U1220B, U1120A and U1120B. These devices have their inputs wired in series and their outputs cross coupled. U1120E and U1220E are current sources for these devices. The circuit operates by generating a power series approximation to the sine function. The devices in U1120 generate the first order term while those in U1220 generate the second order term in the approximation.

Output Buffer. The Output Buffer is an operational amplifier that converts the differential current from Q1010 and U1020D to a single ended voltage that is applied, through the function switch, to the output amplifier. U1020E is a current source for the emitter coupled differential input pair U1020A and U1020B. Q1012 serves as a current mirror for U1020A and as an active load for U1020B. U1020C is the output emitter follower and R1020 is the feedback resistor.

OUTPUT AMPLIFIER & ATTENUATORS

4

The output amplifier is basically a noninverting operational amplifier whose plus input is the base of Q2101 and minus input is the base of Q2113.

The three basic waveforms are selected by S1901 and applied across R560B and R2335 to the input stage of the amplifier. R560B varies the amplitude of the selected waveform. The feedback network consists of R2011 and R2012, connected from the output to the minus input of the amplifier. C2011 provides high frequency compensation for the feedback, and is used to adjust the squarewave front corner. The input pair, Q2101 and Q2113, amplify the difference between the input waveform and the feedback waveform.

An offset current is also summed with the feedback signal at the base of Q2113 when S510A is closed. This allows R560A to control the dc offset of the output signal.

The output of Q2101 is applied directly to Q2111 which is cascoded with Q2011. The output of Q2113 passes through an inverting amplifier, Q2211, before passing to Q2213 cascoded with Q2311. CR2111 provides temperature compensation for Q2211. The two cascodes form drivers for the amplifier output stage.

The output stage consists of Q2013 and Q2123 in parallel with Q2121 for amplification of positive going signals. Q2321 and Q2323 in parallel with Q2325 form the amplifier for negative going signals. The output is taken at the junction of R2026 and R2228. The 50 Ω output impedance is determined by parallel 100 Ω resistors R2033 and R2131. C2121 in this network provides high frequency compensation for the output impedance. The attenuator circuit is a constant impedance resistive divider network, switch selectable in 20 dB steps.

POWER SUPPLY

5

The FG 501A receives its power from the power module via interface connections on the rear edge of the Main circuit board. The power module supplies plus (+) and minus (–) 33.5 Vdc (unregulated) from which the following regulated voltages are generated.

+20 V SUPPLY

The +33.5 V from the power module is filtered and applied to voltage regulator U1210 (pins 11 and 12). This regulator contains its own reference, operational amplifier, and current limiting elements. The output of the regulator is applied to Q1231 which serves as a driver the the series pass transistor located in the power module. The +20 V output is applied across voltage divider R1201, R1301, and R1315. The output level of the supply is set by R1301 (+15 V Adj) which compares the supply output to the internal reference level of the regulator. This supply is current limited through the action of R1121 and the current limiting element in the regulator. When excessive amounts of current are drawn from the supply, the voltage developed across R1121 turns on the current limiting element in the regulator (U1210). This action reduces the base drive, through Q1231, to the series pass transistor causing the supply to reduce output. This supply is the reference for other supplies in the FG 501A.

+15 V SUPPLY

The +15 V supply consists of U1230D and Q1221. U1230D serves as an error amplifier which compares the +15 V output of the supply to a +15 V reference developed by divider network R1231, R1232 and R1233 from the

+20 V supply. Since this supply is sourced from the +20 V, it is inherently current limited by the +20 V supply.

+5 V SUPPLY

The +5 V supply consists of U1230C and Q1331. U1230C serves as an error amplifier which compares the +5 V output to a +5 V reference developed by divider network R1231, R1232 and R1233 from the +20 V supply. Since this supply is sourced from the +15 V and referenced to the +20 V supply, it is inherently current limited under the same conditions that limit those supplies.

–20 V SUPPLY

The –20 V supply is derived from –33.5 V supplied by the power module. The output of operational amplifier U1230A is applied, through Q1245, to the base of Q1241, which serves as a driver for the series pass transistor located in the power module. This supply is also referenced to the +20 V. The supply is current limited through the action of R1141 and Q1243. When excessive amounts of current are drawn through R1141, a voltage sufficient to turn Q1243 on develops across R1141. This action reduces the base drive to the series pass transistor causing the supply to reduce output.

–15 V SUPPLY

The –15 V supply consists of operational amplifier (U1230B) and a series pass feedback regulator (Q1345). The output of the supply is fed back through divider network R1247, R1341, and R1245. The output level is adjusted by R1341. Because this supply is sourced from the –20 V supply, it is current limited by the –20 V supply

CALIBRATION

PERFORMANCE CHECK

INTRODUCTION

This procedure checks the Electrical Performance Requirements as listed in the Specification section in this manual. Perform the internal adjustment procedure if the instrument fails to meet these checks. If recalibration does not correct the discrepancy, circuit troubleshooting is indicated. Also, use this procedure to determine acceptability of performance in an incoming inspection facility. For convenience, many steps in this procedure check the performance of this instrument at only one value in the

specified performance range. Any value within the specified range, within appropriate limits, may be substituted.

TEST EQUIPMENT REQUIRED

The test equipment, or equivalent, listed in Table 4-1 is suggested to perform the performance check and the adjustment procedure.

Table 4-1
TEST EQUIPMENT REQUIRED

Item	Description	Minimum Specifications	Application		Example
			Perf Check	Adj Proc	
1	Power Module	Five compartments or more.	X	X	TEKTRONIX TM 515 or TM 506
2	Oscilloscope System	Minimum Vertical deflection Sweep Rate .5 μ s.	X	X	TEKTRONIX 7704A/ 7A16A/7B50
3	Differential Comparator Amplifier	Minimum Vertical deflection factor .1 V/div	X	X	TEKTRONIX 7A13
4	Sampling System			X	TEKTRONIX 7704A/7S11/ 7T11/S-1
5	Spectrum Analyzer		X		TEKTRONIX 7L12
6	Distortion Analyzer	Frequency range from 20 Hz to at least 300 kHz. Distortion resolution <0.25%	X	X	TEKTRONIX AA 501
7	Frequency Counter	Frequency range 0.002 Hz to above 2 MHz. Accuracy within one part in $10^4 \pm 1$ count.	X	X	TEKTRONIX DC 504
8	Digital Multimeter	Range to ± 30 V 5 1/2 digits Accuracy 0.1%	X	X	TEKTRONIX DM 501
9	Pulse Generator	0 to 2 V square wave output into 50 Ω load. Period 2 μ s; Duration .1 μ s	X		TEKTRONIX PG 501
10	Power Supply	0 to 10 V range Accuracy $\pm 10\%$	X		TEKTRONIX PS 501-1

Table 4-1 (cont)

Item	Description	Minimum Specifications	Application		Example
			Perf Check	Adj Proc	
11	Flexible Extender Cable	Compatible with TM 500-Series Power Modules		X	Tektronix Part No. 067-0645-02
12	Meter Lead	Black	X	X	Tektronix Part No. 012-0462-01
13	Meter Lead	Red	X	X	Tektronix Part No. 012-0462-00
14	Oscilloscope Probe	X10 10 M Ω	X	X	Tektronix Part No. 010-6053-13
15	Coaxial Cable	50 Ω BNC Connectors	X	X	Tektronix Part No. 012-0057-01
16	Termination	50 Ω BNC Connectors	X	X	Tektronix Part No. 011-0049-01
17	X10 Attenuator	50 Ω (20 dB) BNC		X	Tektronix Part No. 011-0059-02
18	X5 Attenuator	50 Ω (14 dB) BNC		X	Tektronix Part No. 011-0060-02
19	Adapter	BNC Female to Dual Banana	X	X	Tektronix Part No. 103-0090-00

1. Check Frequency Range

a. Connect the OUTPUT connector of the FG 501 to the counter input.

b. Press the FEE RUN and 0 dB pushbuttons.

c. Press either the \sim , \square or \sim pushbuttons.

d. Make certain the VAR SYMM and OFFSET controls are off.

e. Set the FREQUENCY Hz dial to 20 and the MULTIPLIER control to the 10^1 position.

f. Adjust the AMPLITUDE control for a stable counter display.

g. CHECK—that the counter reads ≥ 2 MHz.

h. Activate the VAR SYMM control.

i. Adjust the VAR SYMM control for a 50% duty cycle pulse waveform.

j. CHECK—that the counter reads from 180 kHz to 220 kHz

k. Change the MULTIPLIER to 10^0 .

l. CHECK—for an output frequency of between 0.0019 Hz and 0.0021 Hz.

m. Disable the VAR SYMM control.

n. Change the FREQUENCY Hz dial to 2.

o. CHECK—that the FREQUENCY Hz dial can be adjusted to obtain 0.0002 Hz.

p. Disconnect the counter for the next step.

2. Check Variable Symmetry Duty Cycle

- a. Press the FREE RUN, 0 dB and \square pushbuttons.
- b. Set the MULTIPLIER to 10^3 and the FREQUENCY dial to 10.
- c. Release the VAR SYMM pushbutton.
- d. Connect the OUTPUT connector through a $50\ \Omega$ coaxial cable to the oscilloscope vertical input.
- e. Adjust the AMPLITUDE and oscilloscope controls to display a waveform that occupies exactly 10 major divisions for one cycle.
- f. Rotate the VAR SYMM control from fully cw to fully ccw.
- g. Readjust the oscilloscope controls as needed at each extreme to display one cycle for 10 major divisions.
- h. CHECK—that the oscilloscope varies each waveform half cycle from ≤ 0.5 major divisions to ≥ 9.5 major divisions.
- i. Leave these connections for the next step.

3. Check Output Amplitude

- a. Using the same setup as in the previous step, turn the AMPLITUDE control fully cw.
- b. CHECK—that the waveform on the oscilloscope display is ≥ 30 V peak to peak.
- c. Remove the coaxial cable from the oscilloscope vertical input and connect a $50\ \Omega$ termination in series with the cable.
- d. CHECK—that the oscilloscope display is ≥ 15 V peak to peak.
- e. Disconnect the $50\ \Omega$ cable and remove the $50\ \Omega$ termination from the oscilloscope for the next step.

4. Check Offset Range



- a. Press the TRIG 0 dB, and \curvearrowright pushbuttons.
- b. Make certain the VAR SYMM pushbutton is in.

- c. Connect a dmm set to read ± 15 V to the output connector.
- d. Adjust the VAR \emptyset control for a 0 V reading on the dmm.
- e. Pull and turn the OFFSET control fully cw to fully ccw.
- f. CHECK—that the dmm reads $\geq \pm 13$ V at the appropriate stops for the OFFSET control.
- g. Remove the coaxial cable from the dmm and insert a $50\ \Omega$ termination.
- h. CHECK—that the dmm reads at least ± 6.5 V at the appropriate stops of the OFFSET control.
- i. Remove the connections from the dmm for the next step.


5. Check Amplitude Flatness

- a. Press the FREE RUN, 0 dB and \curvearrowright pushbuttons.
- b. Make certain the OFFSET is off.
- c. Set the FREQUENCY Hz dial to 10 and the MULTIPLIER to 10^3 .
- d. Connect the OUTPUT connector through a $50\ \Omega$ cable and $50\ \Omega$ termination to the vertical input of the differential oscilloscope plug-in.
- e. Adjust the AMPLITUDE control and the gain of the vertical amplifier for an 8 major division peak to peak display.
- f. Increase the vertical amplifier gain by a factor of 10.
- g. Adjust the vertical amplifier plug-in offset voltage so that the waveform peaks are on the oscilloscope graticule center line.
- h. Change the output to any frequency from 20 Hz to 20 kHz.
- i. CHECK—that the display is within 0.46 major divisions from graticule center.

Calibration—FG 501A
Performance Check

- j. Change the output to any frequency from 20 kHz to 1 MHz.
 - k. CHECK—that the display is within 2.37 major divisions from graticule center.
 - l. Decrease the vertical gain of the oscilloscope by a factor of 10 and adjust the offset voltage to 0.
 - m. Adjust the output frequency to 10 kHz.
 - n. Adjust the oscilloscope vertical gain and the AMPLITUDE control for a 6 major division peak to peak display.
 - o. Change the output to any frequency from 1 MHz to 2 MHz.
 - p. CHECK—that the peak to peak display amplitude is from 5.36 to 6.73 major divisions.
 - q. Press the  pushbutton.
 - r. Set the output frequency to 10 kHz.
 - s. Adjust the AMPLITUDE control and the vertical comparator oscilloscope plug-in for an 8 major division peak to peak display.
 - t. Increase the oscilloscope vertical plug-in gain by a factor of 10.
 - u. Adjust the vertical plug-in offset voltage so that the positive peaks of the squarewaves are at graticule center.
 - v. Change the output to any frequency from 20 Hz to 2 MHz.
 - w. CHECK—that the positive squarewave peaks are within ± 2.37 major divisions from graticule center.
 - x. Press the  pushbutton.
 - y. Change the output frequency to 10 kHz.
 - z. Decrease the oscilloscope vertical plug-in gain by a factor of 10.
 - aa. Adjust the vertical plug-in offset voltage to 0.
 - bb. Adjust the AMPLITUDE control and the vertical plug-in gain for an 8 major division oscilloscope display of the triangle waveform.
 - cc. Increase the plug-in gain by a factor of 10.
 - dd. Adjust the offset voltage so that the positive peak of the triangle waveform is at graticule center.
 - ee. Change the output to any frequency from 20 Hz to 200 kHz.
 - ff. CHECK—that the positive peak of the triangle waveform is 2.37 major divisions or less from the graticule center.
 - gg. Decrease the vertical amplifier gain by a factor of 10.
 - hh. Remove the comparison voltage from the vertical plug-in.
 - ii. Adjust the AMPLITUDE control and the vertical plug-in gain for a peak to peak triangle waveform display of 6 major divisions.
 - jj. Change the output to any frequency from 200 kHz to 2 MHz.
 - kk. CHECK—that the peak to peak display reads from 4.4 major divisions to 7.6 major divisions in amplitude.
- II. Disconnect the oscilloscope for the next step.

6. Check Sinewave Distortion

- a. Press the FREE RUN, 0 dB, and  pushbuttons. The VAR SYMM, and OFFSET controls must be off (in).
- b. Connect the OUTPUT connector through a 50 Ω coaxial cable and 50 Ω termination to the distortion analyzer.
- c. Set the distortion analyzer to measure total harmonic distortion plus noise with average response.

d. Make certain the function generator is in an ambient temperature from 20°C to 30°C.

e. Select any frequency from 20 Hz to 20 kHz with the FREQUENCY Hz and MULTIPLIER controls. The FREQUENCY Hz control must be on the calibrated portion of the dial and the MULTIPLIER control must be on the 10¹ range or below.

f. Adjust the AMPLITUDE control for a 15 V peak to peak signal at the input of the distortion analyzer.

g. CHECK—that the distortion is $\leq 0.25\%$.

h. Select any frequency from 20 kHz to 100 kHz. The FREQUENCY Hz control must be on the calibrated portion of the dial.

i. CHECK—that the distortion is $\leq 0.5\%$.

j. Disconnect the distortion analyzer and the 50 Ω termination from the coaxial cable.

k. Connect the coaxial cable to the input of the spectrum analyzer.

l. Set the FREQUENCY Hz dial at 10 and the MULTIPLIER at 10⁴.

m. Adjust the AMPLITUDE control and the spectrum analyzer controls so that amplitudes 30 dB or greater below the fundamental amplitude are easily viewed on the spectrum analyzer.

n. Rotate the FREQUENCY Hz dial to 20, change the MULTIPLIER to 10⁵, and rotate the FREQUENCY Hz dial from 20 to 2.

o. CHECK—that all harmonics from 100 kHz to 2 MHz are at least 30 dB below the fundamental amplitude.

p. Remove the connections to the spectrum analyzer for the next step.

7. Check Squarewave and Pulse Output

a. Press the FREE RUN, 0 dB and \square pushbuttons. All other pushbuttons out.

b. Set the FREQUENCY Hz dial and the MULTIPLIER control for any calibrated frequency. (For ease, the FREQUENCY Hz dial at 20 and the MULTIPLIER at 10¹ are recommended.)

c. Turn the AMPLITUDE control fully cw.

d. Connect the OUTPUT connector through a 50 Ω coaxial cable and the necessary attenuators to obtain a 5 division display to the 50 Ω vertical input of the sampling oscilloscope.

e. Connect the TRIG OUTPUT connector through a 50 Ω coaxial cable and the necessary attenuators to the external trigger input on the sampling oscilloscope.

f. Obtain a stable rise and fall time display on the oscilloscope.

g. CHECK—that the rise time and fall time is ≤ 25 ns from the 10% to the 90% amplitude points.

h. CHECK—that the peak to peak amplitude of the front corner ringing does not exceed 3% of the total squarewave amplitude. (If the squarewave amplitude is 8 major divisions, maximum aberrations allowed are 0.24 major divisions.)

i. Release the VAR SYMM pushbutton.

j. Adjust the VAR SYMM control for a pulse waveform.

k. Repeat steps f and g.

l. Remove all connections for the next step.

8. Check VCF Input

a. Press the FREE RUN, 0 dB and \square pushbuttons. The VAR SYMM and OFFSET pushbuttons should be in. Set the FREQUENCY Hz dial to 20 and the MULTIPLIER to 10⁵.

b. Connect the OUTPUT connector through a 50 Ω coaxial cable to the input of the frequency counter.

c. Obtain a stable counter display.

d. Apply -10 Vdc to the VCF INPUT connector.

e. CHECK—that the frequency decreases by a factor of 1000.

f. Remove all connections for the next step.

9. Check External Trigger/Gate Input

a. Press the TRIG, 0 dB, and \checkmark pushbuttons.

b. Connect the OUTPUT connector to the vertical input of the oscilloscope.

c. Connect the pulse generator through a 50 Ω coaxial cable and 50 Ω termination to the TRIG/GATE IN connector.

d. Set the pulse generator for a 0 to 1.2 V positive going 50% duty cycle pulse at 1/2 the frequency of the FG 501A.

e. CHECK—for one cycle of a sine waveform for each trigger pulse.

f. Press the GATE pushbutton.

g. CHECK—for an output waveform that lasts for the duration of the gating waveform.

h. Remove all connections for the next step.

10. Check Trigger Output

a. Press the FREE RUN pushbutton.

b. Connect the TRIG OUTPUT connector through a 50 Ω coaxial cable to the vertical input of the oscilloscope.

c. CHECK—for a $\geq +4$ V waveform on the oscilloscope display. (The voltage varies from about +0.7 V to over +4.0 V, TTL logic levels).

d. Insert a 50 Ω termination from the coaxial cable to the oscilloscope vertical input.

e. CHECK—for a $\geq +2$ V waveform on the oscilloscope display.

f. Remove all connections for the next step.

11. Check Variable Phase Range

a. Press the FREE RUN, 0 dB, and \checkmark pushbuttons.

b. Connect the OUTPUT connector to the vertical input of the oscilloscope. Set the oscilloscope for automatic triggering.

c. Obtain a sine waveform on the oscilloscope centered around 0 V. Determine the peak-to-peak amplitude of the waveform.

d. Press the TRIG pushbutton.

e. Rotate the VAR \emptyset from stop to stop and observe the position of the free running trace on the oscilloscope display.

f. CHECK—that the straight line can be positioned at the peak amplitudes of the sine waveform.

g. Remove all connections for the next step.

12. Check Attenuator Accuracy

a. Press the FREE RUN, 0 dB and \checkmark pushbuttons.

b. Set the FREQUENCY Hz dial to 20.

c. Set the MULTIPLIER to the 10^1 position.

d. Set the AMPLITUDE control fully cw.

e. Connect the OUTPUT connector through a 50 Ω coaxial cable and 50 Ω termination to the input of the dB ratio meter (AA 501).

f. Set the AA 501 for automatic level ranging.

g. Push the 0 dB REF button on the AA 501.

h. Push the -20 dB pushbutton.

i. CHECK—that the ratio meter reads from -19 dB to -21 dB.

j. Push the -40 dB pushbutton.

k. CHECK—that the display reads from -39 dB to -41 dB.

l. Push the -60 dB pushbutton.

m. CHECK—that the display reads from -59 dB to -61 dB.

n. Remove all connections for the next step.

12A. Alternate Procedure for Checking Attenuator Accuracy

a. Press the FREE RUN, 0 dB, and \surd pushbuttons.

b. Set the FREQUENCY Hz dial to 20.

c. Set the MULTIPLIER to 10^{-3} position. Connect the output through a coaxial cable to the oscilloscope vertical input.

d. Adjust the AMPLITUDE control for exactly a 30 V peak to peak sinewave.

e. Push the -20 dB pushbutton.

f. CHECK—for a waveform amplitude from 2.67 V to 3.37 V.

g. Press the -40 dB pushbutton.

h. CHECK—for a waveform amplitude from 0.267 V to 0.337 V.

i. Press the -60 dB pushbutton.

j. CHECK—for a waveform amplitude from 0.0267 V to 0.0337 V.

k. Remove all connections for the next step.

13. Check Triangle Time Symmetry

a. Press the FREE RUN pushbutton.

b. Set the FREQUENCY Hz and MULTIPLIER control for any frequency from 20 Hz to 200 kHz in the calibrated portion of the dial. Connect the counter through a coaxial cable to the TRIG OUTPUT connector.

c. Trigger the counter to read the time of the positive-going half cycle of the trigger waveform (+ slope).

d. Record this reading.

e. Trigger the counter to read the negative-going half cycle of the triggering waveform (- slope).

f. Record this reading.

g. CHECK—that the time difference of both readings is $\leq 1\%$.

h. Set the FREQUENCY Hz and MULTIPLIER controls for a frequency from 200 kHz to 2 MHz in the calibrated portion of the FREQUENCY Hz dial.

i. Repeat steps c through f.

j. CHECK—that the time difference is $\leq 5\%$.

k. Remove all connections.

ADJUSTMENT PROCEDURE

INTRODUCTION

Use this Adjustment Procedure to restore the FG 501A to original performance requirements. This Adjustment Procedure need not be performed unless the instrument fails to meet the Performance Requirements of the Electrical Characteristics listed in the Specification section, or if the Performance Check procedure cannot be completed satisfactorily. If the instrument has undergone repairs, the Adjustment Procedure is recommended.

Satisfactory completion of all adjustment steps in this procedure assures that the instrument will meet the performance requirements.

SERVICES AVAILABLE

Tektronix, Inc. provides complete instrument repair and adjustment at local Field Service Centers and at the Factory Service Center. Contact your local Tektronix Field Office or representative for further information.

RECALIBRATION INTERVAL

Recommended recalibration interval is 2000 hours of operation or six months, whichever occurs first.

TEST EQUIPMENT REQUIRED

The test equipment (or equivalent) listed in Table 4-1 is required for adjustment of the FG 501A. Specifications given for the test equipment are the minimum necessary for accurate adjustment. All test equipment is assumed to be correctly calibrated and operating within specifications.

If other test equipment is used, calibration setup may need to be altered to meet the requirements of the equipment used.

PREPARATION

Access to the internal adjustments is achieved most easily when the FG 501A is connected to the power module with a flexible extender (see equipment list). Removal of the left side cover provides access to all internal adjustments. Refer to the Adjustment Locations in the pullout pages at the rear of the manual.

Make adjustments at an ambient temperature between +20°C and +25°C.

PRELIMINARY SETTINGS

Preset the FG 501A and test equipment controls as follows:



To prevent damage to equipment, be sure the power module and oscilloscope mainframe power is off before inserting or removing plug-in units.

Power Module

LINE SELECTOR HI

FG 501A

(pushbutton)	in
FREE RUN (pushbutton)	in
0 dB (pushbutton)	in
FREQUENCY Hz dial	20
VAR SYMM	Mid-range & in
VAR \emptyset	Mid-range
MULTIPLIER	10 ³
VAR (frequency)	cw
OFFSET	Mid-range & in
AMPL	cw

Digital Multimeter (DM 501)

RANGE/FUNCTION	20 DC VOLTS
INPUT	EXT

POWER SUPPLIES

1. Adjust the +15 V ADJ (R1301), $\pm 0.1\%$

a. Insert the FG 501A and digital multimeter into the power module.

b. Connect the power module power cord to 117 Vac source and turn on the power module.

c. Connect the test leads to the digital multimeter HI and LO INPUTS.

d. Connect the digital multimeter LO test lead to the FG 501A chassis ground. Connect the HI test lead to the FG 501A test point, TP1323 located on the Main board.

e. ADJUST—potentiometer R1301 located on the Main board until the digital multimeter readout indicates between +14.985 and +15.015.

2. **Adjust the -15 V ADJ (R1341), $\pm 0.1\%$**
 - a. Remove the digital multimeter HI test lead from TP1323 and connect to test point, TP1451 (also located on the Main board).
 - b. ADJUST—potentiometer R1341 located on the Main board until the digital multimeter readout indicates between -14.985 and -15.015.

3. **Check the +5 V Supply Accuracy, $\pm 0.5\%$**
 - a. Remove the digital multimeter HI test lead from TP1451 and connect to test point, TP1331 located on the Main board.
 - b. The digital multimeter must indicate a readout between +4.975 and +5.025.

4. **Check the +20 V Supply Accuracy, $\pm 0.5\%$**
 - a. Change the digital multimeter RANGE/FUNCTION switch to 200 DC VOLTS.
 - b. Remove the digital multimeter HI test lead from TP 1331 and connect to test point, TP1321 located on the Main board.
 - c. The digital multimeter must indicate a readout between +19.90 and +20.10.

5. **Check the -20 V Supply Accuracy, $\pm 0.5\%$**
 - a. Remove the digital multimeter HI test lead from TP1321 and connect to test point, TP1241 located on the Main board.
 - b. The digital multimeter must indicate a readout between -19.90 and -20.10.
 - c. Remove all connections.

DIAL ALIGNMENT

Refer to Fig. 4-1 test setup and preliminary control settings with the following exceptions.

7000 Series Oscilloscope

POWER	on
FOCUS	} as desired for a well-defined display
INTENSITY	
VERTICAL MODE	LEFT
HORIZONTAL MODE	B
B TRIGGER SOURCE	VERT MODE

Vertical Plug-in

VOLTS/DIV	5
VARIABLE	in
BANDWIDTH	FULL
POLARITY	+ (UP)
AC-GND-DC	DC
POSITION	centered display

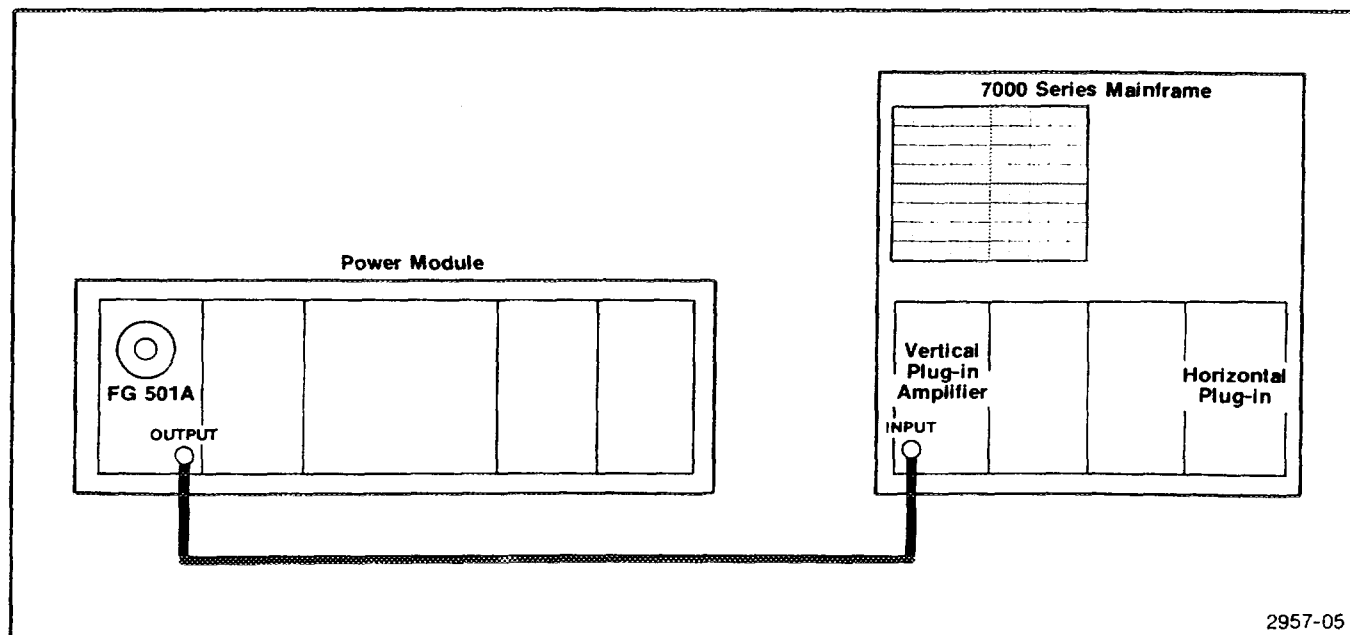


Fig. 4-1. Test setup for DIAL ALIGNMENT and OFFSET adjustment.

**Calibration—FG 501A
Adjustment Procedure**

Horizontal Plug-in

DISPLAY MODE	TIME BASE
TIME/DIV	50 μ s
VARIABLE	in
LEVEL SLOPE	┌
MODE	AUTO
COUPLING	AC
SOURCE	INT
MAGNIFIER	X1

6. Frequency Hz Dial Alignment

- a. Connect the coaxial cable from the FG 501A OUTPUT to the vertical plug-in INPUT.
- b. Adjust the horizontal plug-in LEVEL control for a stable squarewave display on the crt.
- c. Locate the coupler holding the FREQUENCY Hz potentiometer extension shaft and loosen the coupler set screw.
- d. ADJUST—the FREQUENCY Hz potentiometer counterclockwise until the displayed waveform just stops moving.
- e. While holding the potentiometer (coupler), adjust the FREQUENCY Hz dial to 20 (exact).
- f. Tighten the coupler set screw (snug only).
- g. Adjust the FREQUENCY Hz dial to 18. Then rotate dial slowly counterclockwise until the display crt waveform just stops moving.
- h. Check that the FREQUENCY Hz dial is on 20 (± 5 minor graticule division).
- i. Tighten the coupler set screw.

ADJUST OFFSET

Refer to Fig. 4-1 test setup and preliminary control settings with the following exceptions.

FG 501A

AMPLITUDE	ccw
⌞ (pushbutton)	in
FREQUENCY Hz	20
MULTIPLIER	10 ²

Vertical Plug-in

VOLTS/DIV	2
-----------	---

7. Adjust the OUTPUT OFFSET (R2201) and SINE OFFSET (R1104)

- a. The oscilloscope crt display is a triangle.
- b. ADJUST—potentiometer R2201 located on the Main board until the displayed waveform is centered on the vertical graticule line.
- c. Press the ⌞ (pushbutton) in.
- d. The oscilloscope crt display is a sinewave.
- e. ADJUST—potentiometer R1104 located on the Aux board until the displayed waveform is centered on the vertical graticule line.

ADJUST SINE DISTORTION

8. Adjust the TRIANGLE AMPL ADJ (R1412), TRIANGLE OFFSET (R1511), and TOP DIAL SYMM CAL (R1421)

Refer to Fig. 4-2 check setup and preliminary control settings with the following exceptions.

FG 501A

AMPLITUDE	cw
-----------	----

Audio Analyzer

INPUT LEVEL RANGE	20 V
FUNCTION	THD+N
PERCENT DISTORTION	AUTO
FILTERS	OUT
RESPONSE	AVE

- a. Remove the vertical plug-in INPUT connection and re-connect to the audio analyzer using a bnc to banana plug adapter.
- b. ADJUST—potentiometers R1412, R1511, and R1421 all located on the Main board for a minimum reading on the audio analyzer. Repeat these adjustments until no further improvement is noted.

9. Adjust the "C" MULT ADJ (R1951)

Refer to Fig. 4-2 test setup and preliminary control settings with the following exceptions.

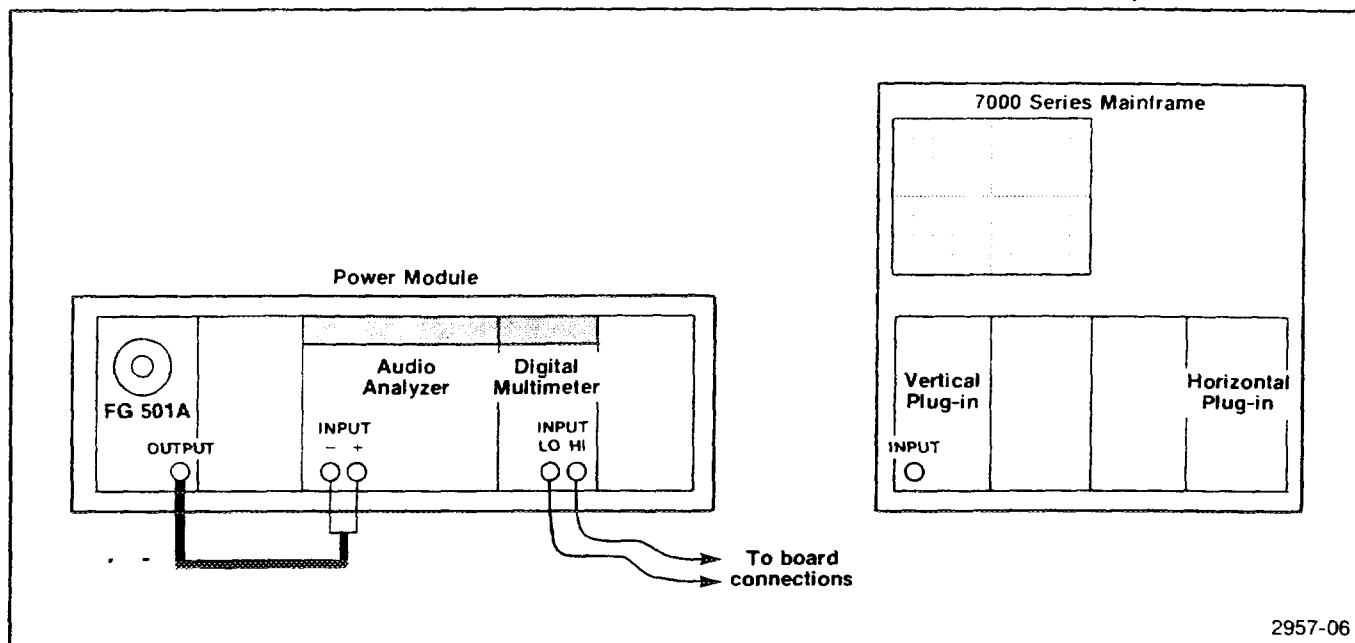


Fig. 4-2. Test setup for SINE DISTORTION adjustment.

Digital Multimeter

RANGE/FUNCTION 2 DC Volts

FG 501A

MULTIPLIER 1

a. Connect the digital multimeter LO INPUT test lead to pin 2 of IC, U1930 located on the Main board.

b. Connect the HI INPUT test lead to pin 2 of IC, U1940 also located on the Main board.

c. ADJUST—potentiometer R1951 located on the Main board for a .0000 digital multimeter readout.

d. Remove digital multimeter test leads.

10. Adjust the BOTTOM DIAL SYMM CAL (R1441)

Refer to Fig. 4-2 test setup.

a. Adjust the FG 501A FREQUENCY Hz dial to 1 and change the MULTIPLIER to 10^2 .

b. ADJUST—potentiometer R1441 for a minimum reading on the audio analyzer.

OFFSET ADJUSTS

Refer to Fig. 4-3 test setup and preliminary control settings with the following exceptions:

FG 501A

~ (pushbutton) in
MULTIPLIER 10^2
OUTPUT ccw

Vertical Plug-in

VOLTS Polarity +
+ INPUT Coupling GND
- INPUT Coupling GND
VOLTS/DIV .1

11. Adjust OUTPUT OFFSET (R2201)

a. Connect a coaxial cable with 50 Ω termination from the FG 501A OUTPUT to the vertical plug-in + INPUT.

b. Adjust the vertical plug-in POSITION control until the trace lines up on the center horizontal graticule line.

c. Change the vertical plug-in + INPUT coupling to DC.

d. Adjust the vertical plug-in COMPARISON VOLTAGE control until the positive peak of the displayed waveform appears as graticule center.

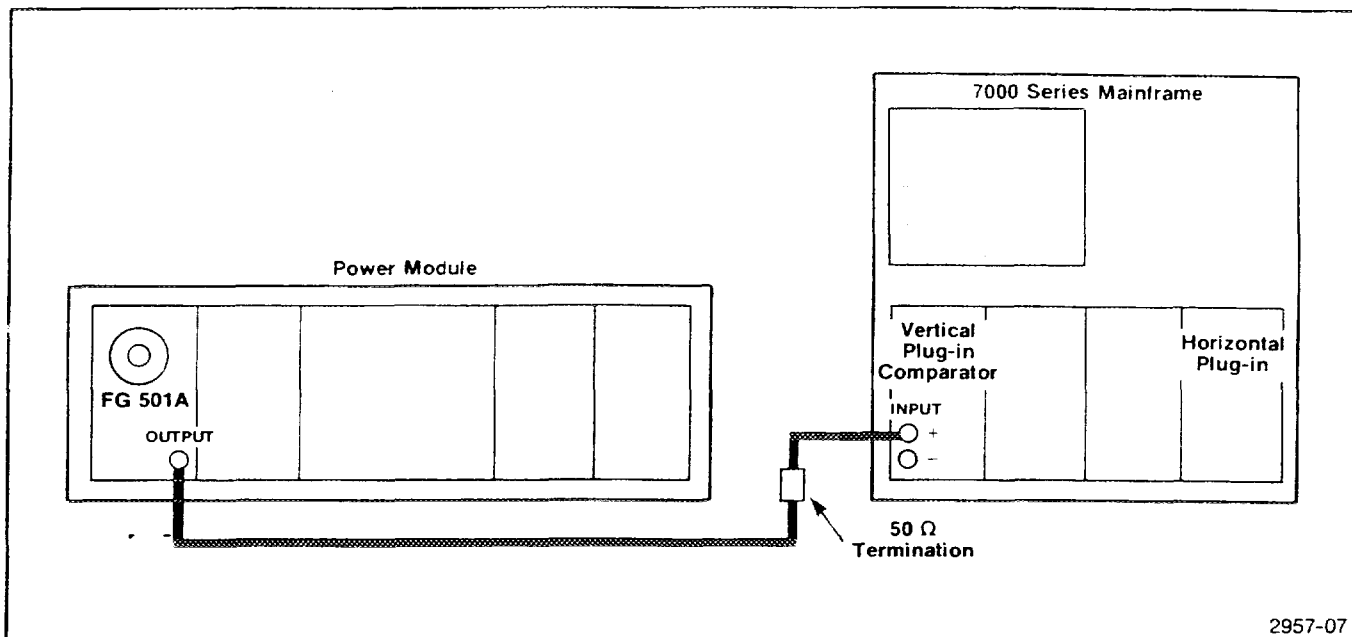


Fig. 4-3. Test setup for OFFSET and SINE/SQUARE AMPLITUDE adjustments.

e. Change the vertical plug-in VOLTS polarity to $-$.

f. Adjust the vertical plug-in COMPARISON VOLTAGE control until the negative peak of the displayed waveform moves half-way between its present position and the center horizontal graticule line.

g. ADJUST—potentiometer R2201 located on the Main board until the negative peak of the displayed waveform is on the center horizontal graticule line.

12. Adjust the SINE OFFSET (R1104)

a. Change the vertical plug-in VOLTS polarity to $+$ and press the \sim pushbutton (in).

b. Adjust the vertical plug-in COMPARISON VOLTAGE control until the positive peak of the displayed waveform appears at graticule center.

c. Change the vertical plug-in VOLTS polarity to $-$.

d. Adjust the vertical plug-in COMPARISON VOLTAGE control until the negative peak of the displayed waveform moves half-way between its present position and the center horizontal graticule line.

e. ADJUST—potentiometer R1104 located on the Aux board until the negative peak of the displayed waveform is on the center horizontal graticule line.

SINE/SQUARE AMPLITUDE ADJUSTS

Refer to Fig. 4-3 test setup and the preliminary controls settings with the following exceptions:

FG 501A	
\sim (pushbutton)	in
AMPLITUDE	cw
Vertical Plug-in	
VOLTS/DIV	.2
+INPUT Coupling	GND
-INPUT Coupling	GND

13. Adjust the SINE AMPL (R1106)

a. Adjust the vertical plug-in POSITION control until the trace lines up on the center horizontal graticule line.

b. Change the vertical plug-in VOLTS polarity to $-$.

c. Change the vertical plug-in + INPUT coupling to DC and the - INPUT coupling to VC.

d. Adjust the vertical plug-in COMPARISON VOLTAGE control until the negative peak of the displayed waveform appears at graticule center

e. Press the FG 501A \curvearrowright pushbutton (in).

f. ADJUST—potentiometer R1106 located on the Aux board until the negative peak of the displayed waveform is on the center horizontal graticule line.

14. Adjust the SQ WAVE AMPL (R1728)

a. Press the FG 501A \curvearrowright pushbutton (in).

b. Note the position of the negative level of the displayed squarewave.

c. Press the FG 501A \curvearrowleft pushbutton (in).

d. Change the vertical plug-in VOLTS polarity to +.

e. Adjust the vertical plug-in COMPARISON VOLTAGE control until the positive peak of the displayed waveform is on the center horizontal graticule line.

f. Press the FG 501A \curvearrowright pushbutton (in)

g. ADJUST—potentiometer R1728 located on the Main board until the positive level of the displayed squarewave is off of the center graticule line in the same direction and same amount as the negative level squarewave noted in step 29b.

SQUAREWAVE COMP/RISE AND FALLTIME ADJUSTS

Refer to Fig. 4-4 test setup and the preliminary control settings with the following exceptions.

FG 501A	
FREQUENCY Hz	20
MULTIPLIER	10^5
AMPLITUDE	ccw
Sampling Vertical Plug-in	
mVOLTS/DIV	200
Sampling Horizontal Plug-in	
SWEEP RANGE	$5 \mu s$
TIME/DIV	$.1 \mu s$

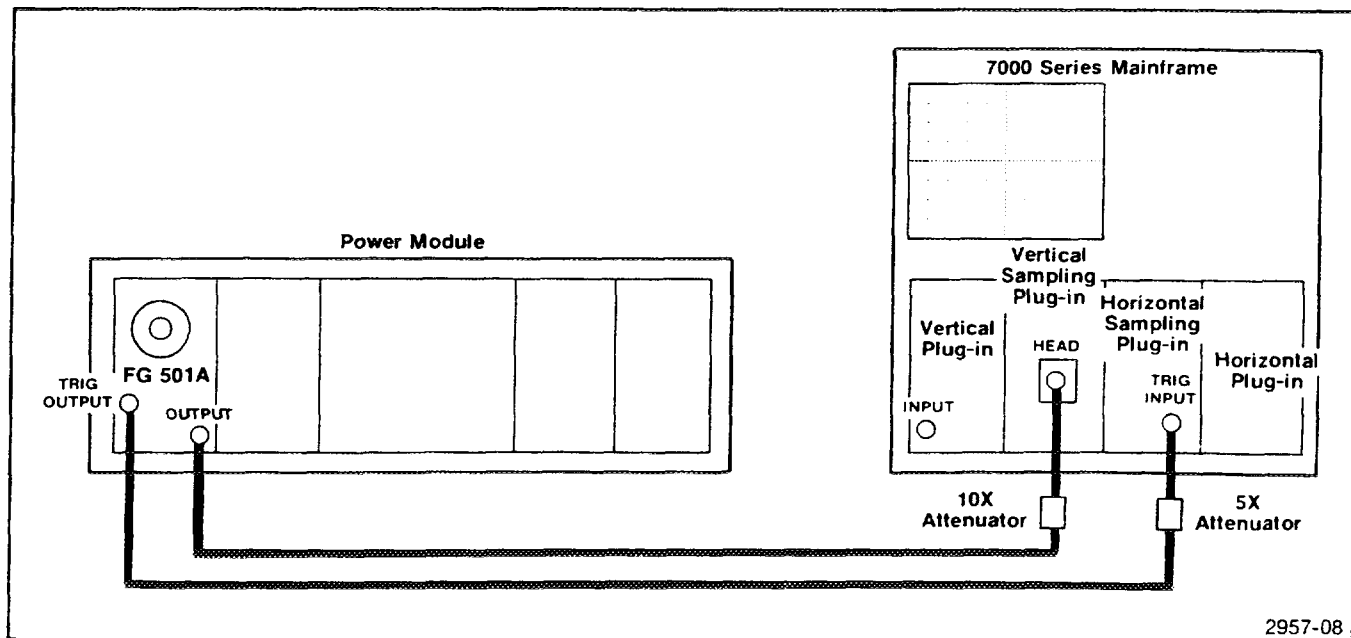


Fig. 4-4. Test setup for SQUAREWAVE COMP/RISE and FALL TIME adjustments.

15. Adjust the SQ WV COMP (C2011)

a. Connect a coaxial cable with a 10X attenuator from the FG 501A OUTPUT to the vertical plug-in sampling head input.

b. Connect a coaxial cable with a 5X attenuator from the FG 501A TRIG OUTPUT to the sampling horizontal plug-in TRIG INPUT.

c. Set the sampling vertical plug-in VARIABLE out and adjust for a displayed waveform amplitude of five major graticule divisions.

d. Change the sampling vertical plug-in mVOLTS/DIV switch to 20.

e. ADJUST—variable capacitor C2011 located on the Main board for a peak-to-peak aberration of 1 major graticule division on the displayed waveform. This aberration will appear at both the top and bottom of the waveform.

DIAL CAL/LOOP DELAY

Refer to Fig. 4-5 test setup and preliminary control settings.

16. Adjust the DIAL CAL (R1321)

a. Connect a 50 Ω coaxial cable and terminator from the FG 501A output to the counter input.

b. ADJUST—potentiometer R1321 located on the main board for a counter display of 20.00.

17. Adjust LOOP DELAY (C1714)

a. Change the FG 501A MULTIPLIER to 10⁵ and the digital counter FUNCTION to FREQUENCY/.1 kHz.

b. ADJUST—variable capacitor C1714 located on Main board for a digital counter readout of 2.000.

c. Remove all cables and connections.

This completes the Adjustment Procedure for the FG 501A.

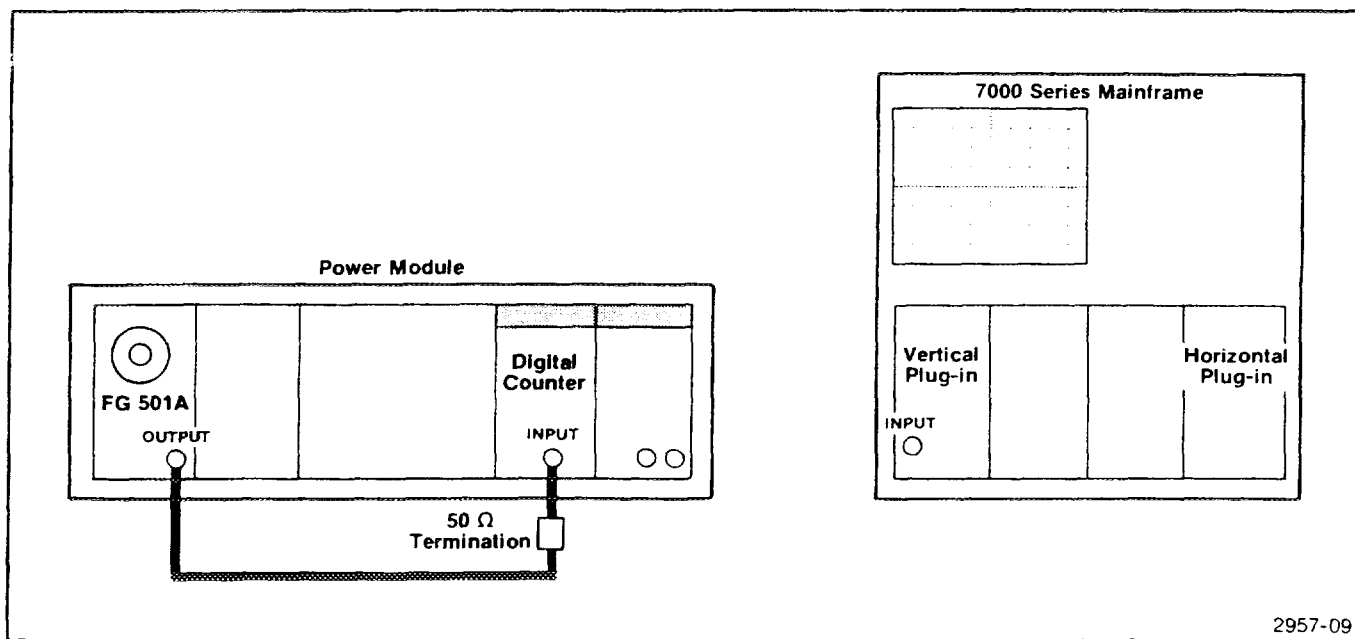


Fig. 4-5. Test setup for DIAL CAL and LOOP DELAY adjustments.

MAINTENANCE

GENERAL MAINTENANCE INFORMATION

STATIC-SENSITIVE COMPONENTS

CAUTION

Static discharge can damage any semiconductor component in this instrument.

This instrument contains electrical components that are susceptible to damage from static discharge. See Table 5-1 for relative susceptibility of various classes of semiconductors. Static voltages of 1 kV to 30 kV are common in unprotected environments.

Observe the following precautions to avoid damage:

1. Minimize handling of static sensitive components.
2. Transport and store static-sensitive components or assemblies in their original containers, on a metal rail, or on conductive foam. Label any package that contains static-sensitive assemblies or components.
3. Discharge the static voltage from your body by wearing a wrist strap while handling these components. Servicing static-sensitive assemblies or components should be performed only at a static-free work station by qualified service personnel.
4. Nothing capable of generating or holding a static charge should be allowed on the work station surface.
5. Keep the component leads shorted together whenever possible.
6. Pick up components by the body, never by the leads.
7. Do not slide the components over any surface.
8. Avoid handling components in areas that have a floor or work surface covering capable of generating a static charge.
9. Use a soldering iron that is connected to earth ground.
10. Use only special antistatic suction type or wick type desoldering tools.

Table 5-1

RELATIVE SUSCEPTIBILITY TO STATIC DISCHARGE DAMAGE

Semiconductor Classes	Relative Susceptibility Levels ^a
MOS or CMOS microcircuits or discretes or linear microcircuits with MOS inputs. (Most Sensitive)	1
ECL	2
Schottky signal diodes	3
Schottky TTL	4
High-frequency bipolar transistors	5
JFETs	6
Linear microcircuits	7
Low-power Schottky TTL	8
TTL (Least Sensitive)	9

^a Voltage equivalent for levels:

1 = 100 to 500 V	4 = 500 V	7 = 400 to 1000 V (est)
2 = 200 to 500 V	5 = 400 to 600 V	8 = 900 V
3 = 250 V	6 = 600 to 800 V	9 = 1200 V

(Voltage discharged from a 100 pF capacitor through a resistance of 100 ohms.)

CLEANING

This instrument should be cleaned as often as operating conditions require. Loose dust accumulated on the outside of the instrument can be removed with a soft cloth or small brush. Remove dirt that remains with a soft cloth dampened in a mild detergent and water solution. Do not use abrasive cleaners.

CAUTION

To clean the front panel use freon, isopropyl alcohol, or totally denatured ethyl alcohol. Do not use petroleum based cleansing agents. Before using any other type of cleaner, consult your Tektronix Service Center or representative.

The best way to clean the interior is to blow off the accumulated dust with dry, low-velocity air (approximately 5 lb/in²) or use a soft brush or cloth dampened with a mild detergent and water solution.

Hold the board so the cleaning residue runs away from the connectors. Do not scrape or use an eraser to clean the edge connector contacts. Abrasive cleaning can remove the gold plating.



Circuit boards and components must be dry before applying power.

OBTAINING REPLACEMENT PARTS

Electrical and mechanical parts can be obtained through your local Tektronix Field Office or representative. However, it may be possible to obtain many of the standard electronic components from a local commercial source. Before purchasing or ordering a part from a source other than Tektronix, Inc., check the Replaceable Electrical Parts list for the proper value, rating, tolerance, and description.

NOTE

When selecting replacement parts, remember that the physical size and shape of a component may affect its performance in the instrument.

Some parts are manufactured or selected by Tektronix, Inc., to satisfy particular requirements or are manufactured for Tektronix, Inc., to our specifications. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. To determine the manufacturer, refer to the Replaceable Parts list and the Cross Reference index, Mfr. Code Number to Manufacturer.

When ordering replacement parts from Tektronix, Inc., include the following information:

1. Instrument type and option number.
2. Instrument serial number.
3. A description of the part (if electrical, include complete circuit number).
4. Tektronix part number.

SOLDERING TECHNIQUES

WARNING

To avoid electric-shock hazard, disconnect the instrument from the power source before soldering.

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used when repairing or replacing parts. General soldering techniques which apply to maintenance of any precision electronic equipment should be used when working on this instrument. Use only 60/40 rosin-core electronic grade solder. The choice of soldering iron is determined by the repair to be made.

When soldering on circuit boards or small wiring, use only a 15 watt, pencil type soldering iron. A higher wattage soldering iron can cause the etched circuit wiring to separate from the board base material and melt the insulation from small wiring. Always keep the soldering iron tip properly tinned to ensure the best heat transfer to the solder joint. Apply only enough heat to remove the component or to make a good solder joint. To protect heat sensitive components, hold the component lead with a pair of long-nose pliers between the component body and the solder joint. Use a solder removing wick to remove excess solder from connections or to clean circuit board pads.

SEMICONDUCTORS

To remove in-line integrated circuits use an extracting tool. This tool is available from Tektronix, Inc.; order Tektronix Part Number 003-0619-00. If an extracting tool is not available, use care to avoid damaging the pins. Pull slowly and evenly on both ends of the integrated circuit. Try to avoid disengaging one end before the other end.

INTERCONNECTING PINS

Several methods of interconnection including multipin and coaxial cable, are used to electrically connect the circuit boards with other boards and components.

COAXIAL CABLES

Replacement of coaxial end lead connectors requires special tools. Damaged cables should be replaced as a unit. For cable part numbers see the Replaceable Mechanical Parts list. Fig. 5-1 shows a coaxial connector assembly.

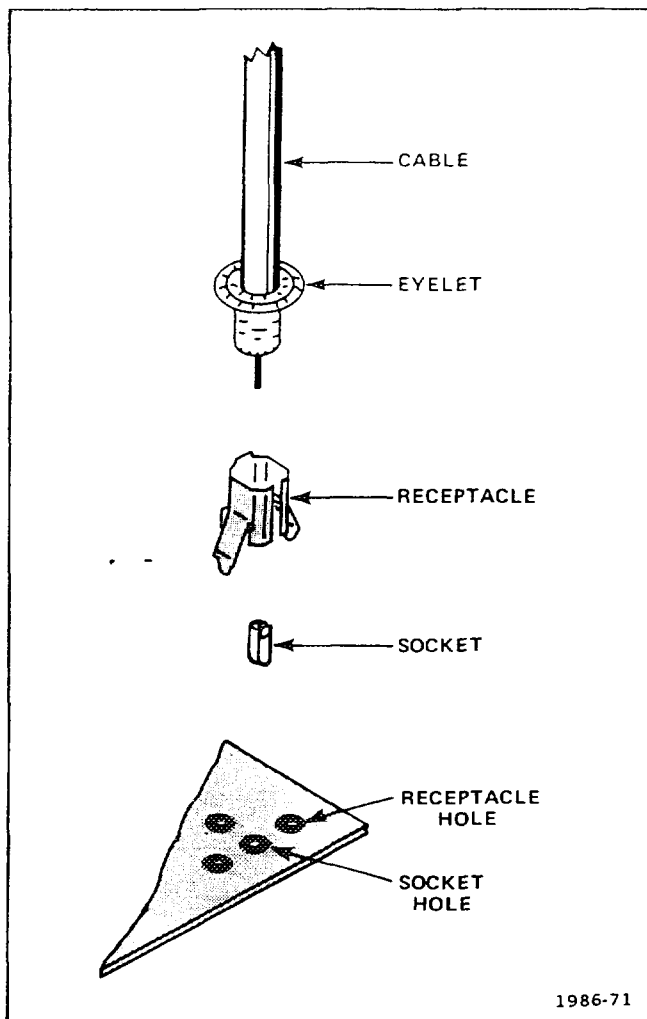


Fig. 5-1. Coaxial end lead connector assembly.

MULTIPIN CONNECTORS

The pin connectors used to connect the wires to the interconnecting pins are clamped to the ends of the wires. To replace damaged multipin connectors, remove the old pin connector from the holder. Do this by inserting a scribe between the connector and the holder and prying the connector from the holder. Clamp the replacement connector to the wire. Reinstall the connector in the holder.

If the individual end lead pin connectors are removed from the plastic holder, note the order of the individual wires for correct replacement in the holder. For proper replacement see Fig. 5-2.

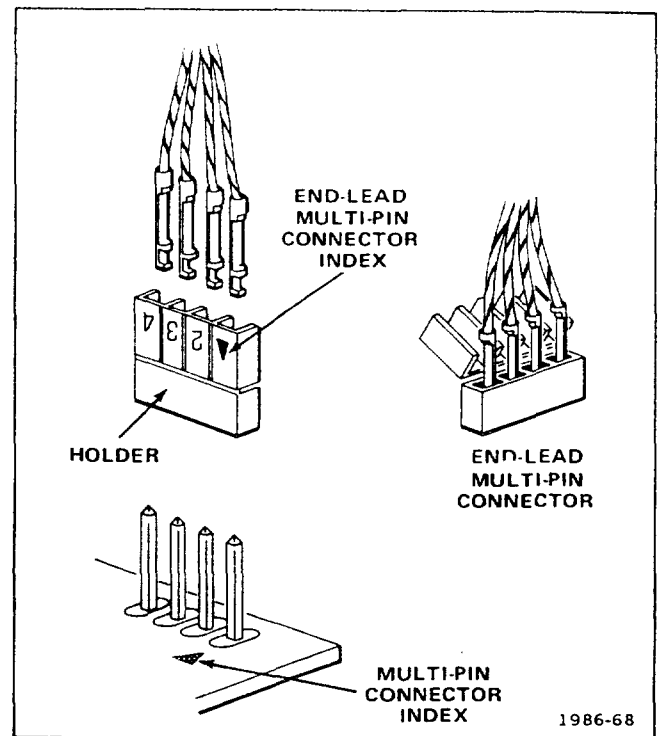


Fig. 5-2. Orientation and disassembly of multipin connectors.

CAM SWITCHES

Use care when cleaning or repairing cam switches. Shaft alignment and spring tension of the contacts must be carefully maintained for proper operation of the switch. For assistance, contact your local Tektronix Field Office or representative.

NOTE

A cam-type switch repair kit including necessary tools, instructions, and replacement contacts is available from Tektronix, Inc. Order Tektronix Part No. 040-0541-00.

The cam switches consist of rotating cam drums which are turned by front-panel knobs, and sets of spring-leaf contacts mounted on adjacent circuit boards. The contacts are actuated by lobes on the cams. These switches can be disassembled for inspection, cleaning, repair, or replacement as follows:

1. Pull the metal cover off the switch. The switch is now open for inspection or cleaning.

2. To completely remove a switch from the circuit board, first remove any knobs or shaft extensions. Loosen the coupling at the potentiometer at the rear of the switch, and pull the long shaft out of the switch assembly.
3. Remove the screws (from the opposite side of the circuit board) that hold the cam drum to the board.
4. To remove the cam drum from the front support block, remove the retaining ring from the shaft on the front of the switch and slide the cam drum out of the support block. Be careful not to lose the small detent roller.
5. To replace defective switch contacts, follow the instructions given in the switch repair kit.
6. To reinstall the switch assembly, reverse the above procedure.

PUSHBUTTON SWITCHES

See Fig. 5-3 for pushbutton switch disassembly instructions.

FRONT PANEL LATCH REMOVAL

To disassemble the latch, pry up on the pull tab bar attached to the latch assembly. The latch components can now be removed from the instrument.

REAR INTERFACE INFORMATION

FUNCTIONS AVAILABLE AT REAR CONNECTOR

A slot exists between pins 23 and 24 on the rear connector. Insert a barrier in the corresponding position of the power module jack to prevent noncompatible plug-ins from being using in that compartment. Consult the power module manual for further information. Signals for other specialized connections may be made to the rear interface connectors as shown in Fig. 5-4. A description of these connections follows.

Output (From 600 Ω) 28A

The output can be obtained at this terminal by connecting a coax cable from J2141 to J1204 on the A10 Main Board assembly. A 560 Ω resistor is in series with J2141.

Output Common 27A

This is the return connection for the output.

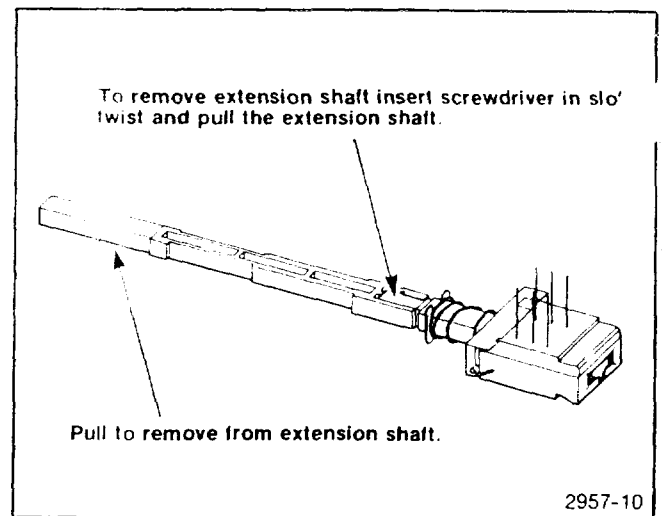


Fig. 5-3. Extension shaft and pushbutton removal.

Trigger Output (50 Ω) 27B

This terminal is connected via an internal jumper to the front panel trigger output connector. See the adjustment location illustration for the location of this jumper.

Trigger Out Common 28B

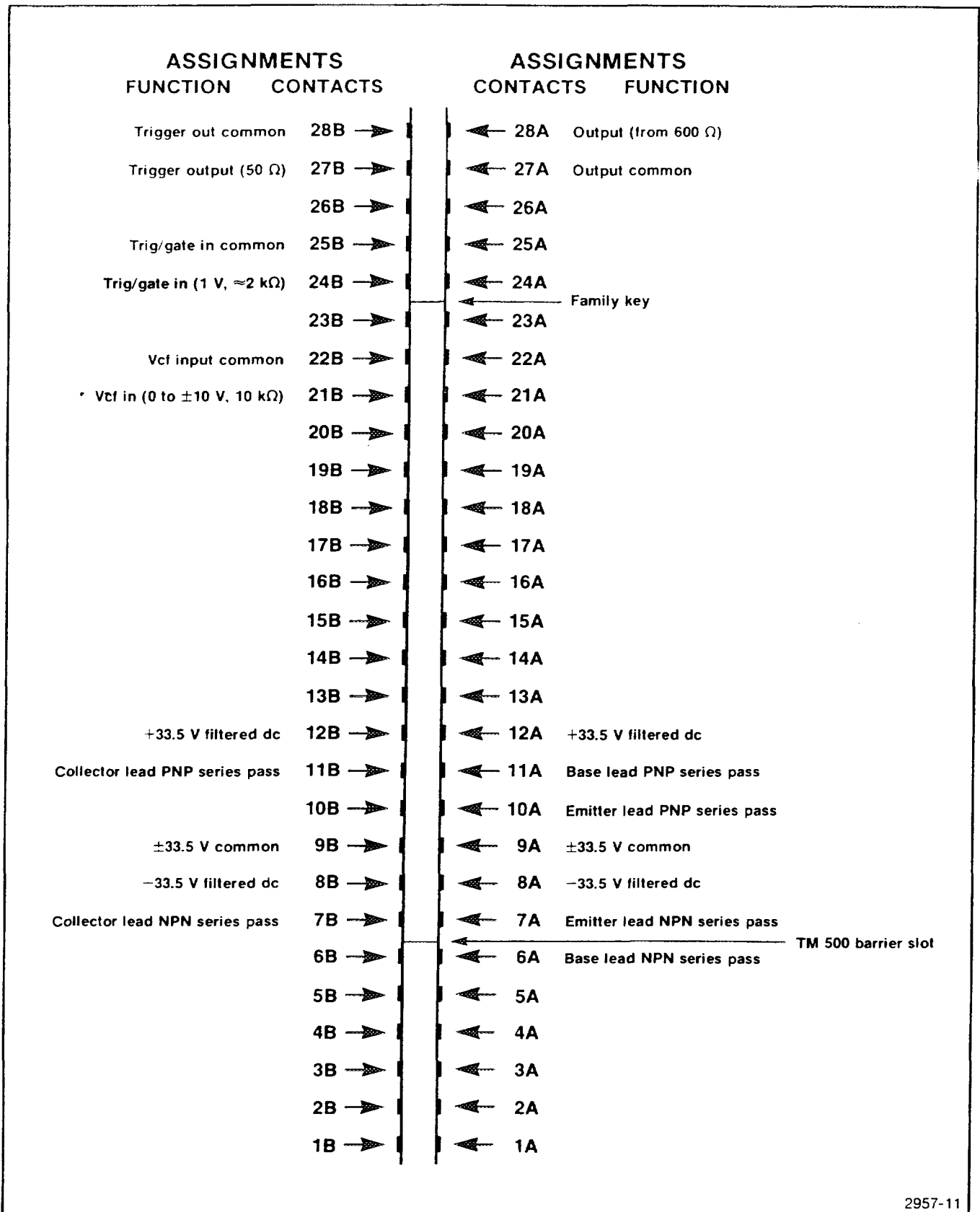
This is the return connection for the trigger output.

Trig/Gate In 24B

This terminal is connected to the trigger amplifier through a 1 K Ω resistor. The output signal is 1 V with an impedance of ≤ 10 K Ω .

Trig/Gate In Common 25B

This is the return connection for the trig/gate in.



2957-11

Fig. 5-4. Rear interface connector assignments.

VCF In 21B

This terminal is connected through a 10 K Ω resistor via an internal jumper to the virtual ground summing node of operational amplifier U1540A (pin 2). See the Adjustment Location illustration for the location of this jumper.

VCF In Common 22B

This connection is the ground return for the VCF In.

OPTIONS

There are no options for the FG 501A at the time of this printing.

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REPLACEABLE ELECTRICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

LIST OF ASSEMBLIES

A list of assemblies can be found at the beginning of the Electrical Parts List. The assemblies are listed in numerical order. When the complete component number of a part is known, this list will identify the assembly in which the part is located.

CROSS INDEX-MFR. CODE NUMBER TO MANUFACTURER

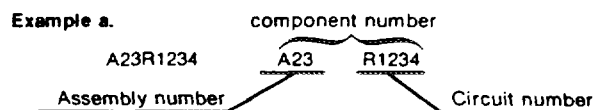
The Mfr. Code Number to Manufacturer index for the Electrical Parts List is located immediately after this page. The Cross Index provides codes, names and addresses of manufacturers of components listed in the Electrical Parts List.

ABBREVIATIONS

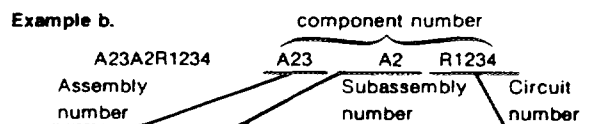
Abbreviations conform to American National Standard Y1.1.

COMPONENT NUMBER (column one of the Electrical Parts List)

A numbering method has been used to identify assemblies, subassemblies and parts. Examples of this numbering method and typical expansions are illustrated by the following:



Read: Resistor 1234 of Assembly 23



Read: Resistor 1234 of Subassembly 2 of Assembly 23

Only the circuit number will appear on the diagrams and circuit board illustrations. Each diagram and circuit board illustration is clearly marked with the assembly number. Assembly numbers are also marked on the mechanical exploded views located in the Mechanical Parts List. The component number is obtained by adding the assembly number prefix to the circuit number.

The Electrical Parts List is divided and arranged by assemblies in numerical sequence (e.g., assembly A1 with its subassemblies and parts, precedes assembly A2 with its subassemblies and parts).

Chassis-mounted parts have no assembly number prefix and are located at the end of the Electrical Parts List.

TEKTRONIX PART NO. (column two of the Electrical Parts List)

Indicates part number to be used when ordering replacement part from Tektronix.

SERIAL/MODEL NO. (columns three and four of the Electrical Parts List)

Column three (3) indicates the serial number at which the part was first used. Column four (4) indicates the serial number at which the part was removed. No serial number entered indicates part is good for all serial numbers.

NAME & DESCRIPTION (column five of the Electrical Parts List)

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

MFR. CODE (column six of the Electrical Parts List)

Indicates the code number of the actual manufacturer of the part. (Code to name and address cross reference can be found immediately after this page.)

MFR. PART NUMBER (column seven of the Electrical Parts List)

Indicates actual manufacturers part number.

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
01121	ALLEN-BRADLEY COMPANY	1201 2ND STREET SOUTH	MILWAUKEE, WI 53204
01295	TEXAS INSTRUMENTS, INC. SEMICONDUCTOR GROUP	P.O. BOX 5012	DALLAS, TX 75222
02111	SPECTROL ELECTRONICS CORPORATION	17070 EAST GALE AVENUE	CITY OF INDUSTRY, CA 91745
02735	RCA CORPORATION, SOLID STATE DIVISION	ROUTE 202	SOMERVILLE, NY 08876
03508	GENERAL ELECTRIC COMPANY, SEMI-CONDUCTOR PRODUCTS DEPARTMENT	ELECTRONICS PARK	SYRACUSE, NY 13201
03888	KDI PYROFILM CORPORATION	60 S JEFFERSON ROAD	WHIPPANY, NJ 07981
04222	AVX CERAMICS, DIVISION OF AVX CORP.	P O BOX 867	MYRTLE BEACH, SC 29577
04713	MOTOROLA, INC., SEMICONDUCTOR PROD. DIV.	5005 E MCDOWELL RD, PO BOX 20923	PHOENIX, AZ 85036
05397	UNION CARBIDE CORPORATION, MATERIALS SYSTEMS DIVISION	11901 MADISON AVENUE	CLEVELAND, OH 44101
07263	FAIRCHILD SEMICONDUCTOR, A DIV. OF FAIRCHILD CAMERA AND INSTRUMENT CORP.	464 ELLIS STREET	MOUNTAIN VIEW, CA 94042
12697	CLARQSTAT MFG. CO., INC.	LOWER WASHINGTON STREET	DOVER, NH 03820
12969	UNITRODE CORPORATION	580 PLEASANT STREET	WATERTOWN, MA 02172
13511	AMPHENOL CARDRE DIV., BUNKER RAMO CORP.		LOS GATOS, CA 95030
19701	ELECTRA-MIDLAND CORP., MEPCO ELECTRA INC.	P O BOX 760	MINERAL WELLS, TX 76067
22229	SOLITRON DEVICES, INC., SEMICONDUCTOR GROUP	8808 BALBOA AVENUE	SAN DIEGO OPERS, CA 92123
22526	BERG ELECTRONICS, INC.	YOUK EXPRESSWAY	NEW CUMBERLAND, PA 17070
27014	NATIONAL SEMICONDUCTOR CORP.	2900 SEMICONDUCTOR DR.	SANTA CLARA, CA 95051
32997	BOURNS, INC., TRIMPOT PRODUCTS DIV.	1200 COLUMBIA AVE.	RIVERSIDE, CA 92507
50434	HEWLETT-PACKARD COMPANY	640 PAGE MILL ROAD	PALO ALTO, CA 94304
53184	XCITON CORPORATION	5 HEMLOCK STREET	LATHAM, NY 12110
54473	MATSUSHITA ELECTRIC, CORP. OF AMERICA	1 PANASONIC WAY	SECAUCUS, NJ 07094
56289	SPRAGUE ELECTRIC CO.	87 MARSHALL ST.	NORTH ADAMS, MA 01247
57668	R-OHM CORP.	16931 MILLIKEN AVE.	IRVINE, CA 92713
71400	BUSSMAN MFG., DIVISION OF MCGRAW- EDISON CO.	2536 W. UNIVERSITY ST.	ST. LOUIS, MO 63107
72982	ERIE TECHNOLOGICAL PRODUCTS, INC.	644 W. 12TH ST.	ERIE, PA 16512
73138	BECKMAN INSTRUMENTS, INC., HELIPOT DIV.	2500 HARBOR BLVD.	FULLERTON, CA 92634
73899	JFD ELECTRONICS COMPONENTS CORP.	PINETREE ROAD	OXFORD, NC 27565
74970	JOHNSON, E. F., CO.	299 10TH AVE. S. W.	WASECA, MN 56093
75042	TRW ELECTRONIC COMPONENTS, IRC FIXED RESISTORS, PHILADELPHIA DIVISION	401 N. BROAD ST.	PHILADELPHIA, PA 19108
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
91637	DALE ELECTRONICS, INC.	P. O. BOX 609	COLUMBUS, NE 68601
96733	SAN FERNANDO ELECTRIC MFG CO	1501 FIRST ST	SAN FERNANDO, CA 91341

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A10	670-6697-04	B010100	B034229	CKT BOARD ASSY:FUNCTION GEN	80009	670-6697-04
A10	670-6697-05	B034230		CKT BOARD ASSY:FUNCTION GEN	80009	670-6697-05
A12	670-6694-00	B010100	B020349	CKT BOARD ASSY:AUXILIARY	80009	670-6694-00
A12	670-6694-01	B020350	B022259	CKT BOARD ASSY:AUXILIARY	80009	670-6694-01
A12	670-6694-02	B022260		CKT BOARD ASSY:AUXILIARY	80009	670-6694-02
A10	670-6697-04	B010100	B034229	CKT BOARD ASSY:FUNCTION GEN	80009	670-6697-04
A10	670-6697-05	B034230		CKT BOARD ASSY:FUNCTION GEN	80009	670-6697-05
A10C1115	290-0779-00			CAP.,FXD,ELCTLT:10UF,+50-10%,50VDC	56289	502D237
A10C1201	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A10C1203	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C1224	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A10C1235	281-0763-00	B010100	B022569	CAP.,FXD,CER DI:47PF,10%,100V	04222	GA101A470KAA
A10C1235	281-0773-00	B022570		CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C1251	290-0779-00			CAP.,FXD,ELCTLT:10UF,+50-10%,50VDC	56289	502D237
A10C1253	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A10C1313	281-0820-00			CAP.,FXD,CER DI:680PF,10%,50V	05397	C114K681K1X5CA
A10C1321	290-0745-00			CAP.,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
A10C1323	290-0745-00			CAP.,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
A10C1325	290-0745-00			CAP.,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
A10C1341	290-0745-00			CAP.,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
A10C1431	283-0203-00			CAP.,FXD,CER DI:0.47UF,20%,50V	04222	5R305SE474MAA
A10C1434	283-0203-00			CAP.,FXD,CER DI:0.47UF,20%,50V	04222	5R305SE474MAA
A10C1451	290-0745-00			CAP.,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
A10C1516	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C1532	281-0762-00			CAP.,FXD,CER DI:27PF,20%,100V	04222	GC101A270M
A10C1543	281-0823-00	B020350		CAP.,FXD,CER DI:470PF,10%,50V	12969	CGB471KDN
A10C1601	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C1603	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C1611	281-0759-00			CAP.,FXD,CER DI:22PF,10%,100V	96733	R2735
A10C1613	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A10C1631	295-0164-00			CAP.SET,MTCHD:10,1.0,1.0,0.01UF,950PF	80009	295-0164-00
A10C1633	---			(PART OF C1631)		
A10C1641	---			(PART OF C1631)		
A10C1711	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C1712	281-0763-00			CAP.,FXD,CER DI:47PF,10%,100V	04222	GA101A470KAA
A10C1714	281-0158-00			CAP.,VAR,CER DI:7-45PF,25V	73899	DVJ-5006
A10C1723	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C1724	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C1725	281-0810-00			CAP.,FXD,CER DI:5.6PF,0.5%,100V	04222	GC10-1A5R6D
A10C1726	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A10C1741	---			(PART OF C1631)		
A10C1751	---			(PART OF C1631)		
A10C1811	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A10C1812	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A10C1813	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C1814	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C2006	281-0812-00			CAP.,FXD,CER DI:1000PF,10%,100V	04222	MA101C102KAA
A10C2007	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A10C2011	281-0064-00			CAP.,VAR,PLSTC:0.25-1.5PF,600V	74970	273-0001-101
A10C2013	290-0517-00			CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
A10C2020	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA

Component No.	Tektronix		Serial/Model No.		Name & Description	Mfr Code	Mfr Part Number
	Part No.	Eff	Dscont				
A10C2031	281-0773-00				CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C2121	281-0764-00				CAP.,FXD,CER DI:82PF,5%,100V	56289	492CCOG820J100B
A10C2204	281-0775-00				CAP.,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A10C2217	290-0517-00				CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
A10C2221	281-0812-00				CAP.,FXD,CER DI:1000PF,10%,100V	04222	MA101C102KAA
A10C2224	290-0517-00				CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
A10C2228	281-0773-00				CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C2229	290-0517-00				CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
A10C2301	281-0773-00				CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C2302	281-0812-00				CAP.,FXD,CER DI:1000PF,10%,100V	04222	MA101C102KAA
A10CR1431	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A10CR1531	152-0322-00				SEMICONV DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
A10CR1533	152-0322-00				SEMICONV DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
A10CR1621	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A10CR2111	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A10CR2113	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A10CR2213	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A10CR2221	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A10CR2222	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A10F1111	159-0019-00				FUSE,CARTRIDGE:3AG,1A,250V,SLOW BLOW	71400	MDL1
A10F1131	159-0019-00				FUSE,CARTRIDGE:3AG,1A,250V,SLOW BLOW	71400	MDL1
A10J1100	131-0608-00				TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
A10J1100	----				(QTY OF 2)		
A10J1121	131-0608-00				TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
A10J1202	131-0608-00				TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
A10J1202	----				(QTY OF 3)		
A10J1203	131-0608-00				TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
A10J1203	----				(QTY OF 3)		
A10J1301	131-0608-00				TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
A10J1301	----				(QTY OF 3)		
A10J1541	131-0608-00				TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
A10J1541	----				(QTY OF 4)		
A10J1611	131-0608-00				TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
A10J1611	----				(QTY OF 3)		
A10J1641	131-0608-00				TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
A10J1641	----				(QTY OF 2)		
A10J1651	131-0608-00				TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
A10J1651	----				(QTY OF 4)		
A10J1801	131-1003-00				CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A10J1921	131-1003-00				CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A10J1923	131-1003-00				CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A10J2011	131-0608-00				TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
A10J2011	----				(QTY OF 4)		
A10J2021	131-0608-00				TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	47357
A10J2021	----				(QTY OF 2)		
A10J2041	131-1003-00				CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A10J2043	131-1003-00				CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A10L1111	108-0020-00				COIL,RF:7.1UH	80009	108-0020-00
A10L1251	108-0020-00				COIL,RF:7.1UH	80009	108-0020-00
A10Q1221	151-0606-00				TRANSISTOR:SILICON,NPN	04713	SJE375
A10Q1231	151-0464-00				TRANSISTOR:SILICON,NPN	04713	SJE412
A10Q1241	151-0464-00				TRANSISTOR:SILICON,NPN	04713	SJE412
A10Q1243	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q1245	151-0350-00				TRANSISTOR:SILICON,PNP	04713	SPS6700

Component No.	Tektronix		Serial/Model No.		Name & Description	Mfr Code	Mfr Part Number
	Part No.		Eff	Dscont			
A10Q1331	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q1335	151-0188-00				TRANSISTOR:SILICON,PNP	04713	SPS6868
A10Q1345	151-0607-00				TRANSISTOR:SILICON,PNP	04713	SJE376
A10Q1421	153-0586-00				SEMICONDC DVC SE:2N3906,MATCHED PAIR	80009	153-0586-00
A10Q1421	-----				(PART OF Q1527)		
A10Q1431	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q1433	151-0367-00				TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	04713	SPS 8811
A10Q1440	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q1445	151-0435-00				TRANSISTOR:SILICON,PNP	04713	SPS8335
A10Q1511	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q1521	151-0427-00				TRANSISTOR:SILICON,NPN	80009	151-0427-00
A10Q1523	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q1525	151-0188-00				TRANSISTOR:SILICON,PNP	04713	SPS6868
A10Q1527	-----				(PART OF Q1421)		
A10Q1531	151-0438-00				TRANSISTOR:SILICON,PNP,SEL FROM SPS692	80009	151-0438-00
A10Q1541	151-0341-00				TRANSISTOR:SILICON,NPN	07263	S040065
A10Q1543	151-0341-00				TRANSISTOR:SILICON,NPN	07263	S040065
A10Q1611	151-0188-00				TRANSISTOR:SILICON,PNP	04713	SPS6868
A10Q1621	151-0188-00				TRANSISTOR:SILICON,PNP	04713	SPS6868
A10Q1711	151-0188-00				TRANSISTOR:SILICON,PNP	04713	SPS6868
A10Q1712	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q1721	151-0220-00				TRANSISTOR:SILICON,PNP	07263	S036228
A10Q1723	151-1042-00				SEMICONDC DVC SE:MATCHED PAIR FET	22229	S2089
A10Q1725	-----				(PART OF Q1723)		
A10Q1801	151-0220-00				TRANSISTOR:SILICON,PNP	07263	S036228
A10Q1821	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q1901	151-0220-00				TRANSISTOR:SILICON,PNP	07263	S036228
A10Q2011	151-0220-00				TRANSISTOR:SILICON,PNP	07263	S036228
A10Q2013	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q2101	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q2111	151-0221-00				TRANSISTOR:SILICON,PNP	04713	SPS246
A10Q2113	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q2121	151-0440-00				TRANSISTOR:SILICON,PNP	03508	X41E603
A10Q2123	151-0440-00				TRANSISTOR:SILICON,PNP	03508	X41E603
A10Q2211	151-0220-00				TRANSISTOR:SILICON,PNP	07263	S036228
A10Q2213	151-0427-00				TRANSISTOR:SILICON,NPN	80009	151-0427-00
A10Q2311	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A10Q2321	151-0220-00				TRANSISTOR:SILICON,PNP	07263	S036228
A10Q2323	151-0439-00				TRANSISTOR:SILICON,NPN	80009	151-0439-00
A10Q2325	151-0439-00				TRANSISTOR:SILICON,NPN	80009	151-0439-00
A10R500	311-1392-00				RES.,VAR,WW:PNL,10K OHM,2W	02111	140-9504
A10R1103	321-0289-00				RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
A10R1113	315-0202-00				RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
A10R1121	307-0093-00	B010100	B022569		RES.,FXD,CMPSN:1.2 OHM,5%,0.50W	01121	EB12G5
A10R1121	308-0141-00	B022570			RES.,FXD,WW:1 OHM,5%,0.5W	80009	308-0141-00
A10R1131	315-0203-00				RES.,FXD,CMPSN:20K OHM,5%,0.25W	01121	CB2035
A10R1133	321-0318-00				RES.,FXD,FILM:20K OHM,1%,0.125W	91637	MFF1816G20001F
A10R1135	321-0318-00				RES.,FXD,FILM:20K OHM,1%,0.125W	91637	MFF1816G20001F
A10R1141	307-0093-00				RES.,FXD,CMPSN:1.2 OHM,5%,0.50W	01121	EB12G5
A10R1143	315-0202-00				RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
A10R1201	321-0337-00				RES.,FXD,FILM:31.6K OHM,1%,0.125W	91637	MFF1816G31601F
A10R1203	315-0202-00				RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
A10R1225	315-0151-00				RES.,FXD,CMPSN:150 OHM,5%,0.25W	01121	CB1515
A10R1226	315-0682-00				RES.,FXD,CMPSN:6.8K OHM,5%,0.25W	01121	CB6825

Replaceable Electrical Parts—FG 501A

Component No.	Tektronix Part No.	Serial/Model No. Eff	Discont	Name & Description	Mfr Code	Mfr Part Number
A10R1227	307-0051-00			RES.,FXD,CMPSN:2.7 OHM,5%,0.50W	01121	EB27G5
A10R1228	301-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.5W	01121	EB2015
A10R1229	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A10R1231	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
A10R1232	321-0318-00			RES.,FXD,FILM:20K OHM,1%,0.125W	91637	MFF1816G20001F
A10R1233	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
A10R1235	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A10R1241	315-0103-00	B010100	B022569	RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A10R1241	315-0511-00	B022570		RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
A10R1242	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A10R1243	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A10R1245	321-0347-00			RES.,FXD,FILM:40.2K OHM,1%,0.125W	91637	MFF1816G40201F
A10R1247	321-0335-00			RES.,FXD,FILM:30.1K OHM,1%,0.125W	91637	CMF55116G30101F
A10R1301	311-1562-00			RES.,VAR,NONWIR:2K OHM,20%,0.50W	73138	91-84-0
A10R1311	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A10R1315	321-0311-00			RES.,FXD,FILM:16.9K OHM,1%,0.125W	91637	MFF1816G16901F
A10R1321	311-1561-00			RES.,VAR,NONWIR:2.5K OHM,20%,0.50W	73138	91-83-0
A10R1331	315-0682-00			RES.,FXD,CMPSN:6.8K OHM,5%,0.25W	01121	CB6825
A10R1333	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A10R1341	311-1563-00			RES.,VAR,NONWIR:1K OHM,20%,0.50W	73138	91-85-0
A10R1346	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
A10R1401	321-0193-03	B010100	B020339	RES.,FXD,FILM:1K OHM,0.25%,0.125W	91637	MFF1816D10000C
A10R1401	321-0222-00	B020340		RES.,FXD,FILM:2K OHM,1%,0.125W	91637	MFF1816G20000F
A10R1403	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A10R1411	321-0258-09			RES.,FXD,FILM:4.75K OHM,1%,0.125W	91637	MFF1816C47500F
A10R1412	311-1567-00	B010100	B020339	RES.,VAR,NONWIR:TRMR,100 OHM,0.50W	73138	91-89-0
A10R1412	311-1175-00	B020340		RES.,VAR,NONWIR:100 OHM,0.50W	32997	3299W-R27-101
A10R1413	321-0916-03			RES.,FXD,FILM:289 OHM,0.25%,0.125W	91637	MFF1816D289R0C
A10R1421	311-0605-00			RES.,VAR,NONWIR:TRMR,200 OHM,0.5W	73138	82-23-2
A10R1423	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W		
A10R1425	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W		
A10R1429	315-0392-00	B010100	B034229	RES.,FXD,CMPSN:3.9K OHM,5%,0.25W	01121	CB3925
A10R1429	315-0432-00	B034230		RES.,FXD,CMPSN:4.3K OHM,5%,0.25W	01121	CB4325
A10R1431	315-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
A10R1432	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A10R1433	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
A10R1434	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A10R1435	315-0300-00			RES.,FXD,CMPSN:30 OHM,5%,0.25W	01121	CB3005
A10R1436	315-0241-00			RES.,FXD,CMPSN:240 OHM,5%,0.25W	01121	CB2415
A10R1440	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
A10R1441	311-1559-00			RES.,VAR,NONWIR:10K OHM,20%,0.50W	73138	91-81-0
A10R1451	307-0051-00			RES.,FXD,CMPSN:2.7 OHM,5%,0.50W	01121	EB27G5
A10R1501	321-0754-07	B010100	B020339	RES.,FXD,FILM:900 OHM,0.1%,0.125W	91637	MFF1816C900R0B
A10R1501	321-0641-00	B020340		RES.,FXD,FILM:1.8K OHM,1%,0.125W	91637	MFF1816G18000F
A10R1511	311-1565-00	B010100	B020339	RES.,VAR,NONWIR:250 OHM,20%,0.50W	73138	91-87-0
A10R1511	311-1307-00	B020340		RES.,VAR,NONWIR:500 OHM,0.50W	32997	3299W-R27-501
A10R1512	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	91637	MFF1816G20000F
A10R1513	321-0245-00			RES.,FXD,FILM:3.48K OHM,1%,0.125W	91637	MFF1816G34800F
A10R1514	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
A10R1515	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
A10R1517	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A10R1518	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A10R1521	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
A10R1532	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115

Component No.	Tektronix		Serial/Model No.		Name & Description	Mfr Code	Mfr Part Number
	Part No.		Eff	Dscont			
A10R1533	315-0302-00				RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A10R1534	315-0511-00				RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
A10R1536	315-0201-00				RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
A10R1541	321-0181-00				RES.,FXD,FILM:750 OHM,1%,0.125W	91637	MFF1816G750R0F
A10R1543	321-0272-00	B010100	B034229		RES.,FXD,FILM:6.65K OHM,1%,0.125W	91637	MFF1816G66500F
A10R1543	321-0274-00	B034230			RES.,FXD,FILM:6.98K OHM,1%,0.125W	91637	CMF55116G69800F
A10R1545	321-0181-00				RES.,FXD,FILM:750 OHM,1%,0.125W	91637	MFF1816G750R0F
A10R1551	321-0289-00				RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
A10R1553	321-0289-00				RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
A10R1603	315-0101-00				RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A10R1611	315-0222-00				RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
A10R1613	315-0101-00				RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A10R1615	315-0101-00				RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A10R1621	315-0332-00				RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
A10R1622	315-0221-00				RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
A10R1623	315-0510-00				RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A10R1624	315-0101-00				RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A10R1625	315-0332-00				RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
A10R1641	321-0222-00				RES.,FXD,FILM:2K OHM,1%,0.125W	91637	MFF1816G20000F
A10R1711	315-0101-00	B010100	B020349		RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A10R1711	315-0361-00	B020350			RES.,FXD,CMPSN:360 OHM,5%,0.25W	01121	CB3615
A10R1712	321-0172-00				RES.,FXD,FILM:604 OHM,1%,0.125W	91637	MFF1816G604R0F
A10R1713	315-0102-00				RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A10R1714	315-0472-00	B020350			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
A10R1715	315-0472-00	B020350			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
A10R1721	315-0512-00				RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
A10R1723	315-0103-00				RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A10R1724	315-0751-00				RES.,FXD,CMPSN:750 OHM,5%,0.25W	01121	CB7515
A10R1725	315-0471-00				RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
A10R1727	315-0752-00				RES.,FXD,CMPSN:7.5K OHM,5%,0.25W	01121	CB7525
A10R1728	311-1566-00				RES.,VAR,NONWIR:200 OHM,20%,0.50W	73138	91-88-0
A10R1801	315-0101-00				RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A10R1812	321-0155-00				RES.,FXD,FILM:402 OHM,1%,0.125W	91637	MFF1816G402R0F
A10R1814	315-0153-00				RES.,FXD,CMPSN:15K OHM,5%,0.25W	01121	CB1535
A10R1815	321-0222-00				RES.,FXD,FILM:2K OHM,1%,0.125W	91637	MFF1816G20000F
A10R1816	321-0196-00				RES.,FXD,FILM:1.07K OHM,1%,0.125W	91637	MFF1816G10700F
A10R1817	315-0101-00				RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A10R1818	321-0313-00				RES.,FXD,FILM:17.8K OHM,1%,0.125W	91637	MFF1816G17801F
A10R1819	321-0236-00				RES.,FXD,FILM:2.8K OHM,1%,0.125W	91637	MFF1816G28000F
A10R1831	321-0289-03				RES.,FXD,FILM:10K OHM,0.25%,0.125W	91637	MFF1816D10001C
A10R1841	321-0645-00				RES.,FXD,FILM:100K OHM,0.5%,0.125W	91637	MFF1816D10002D
A10R1842	307-0465-00				RES.,FXD,FILM:10M OHM,1%,0.5W	03888	FL1/2 10M OHM 1%
A10R1843	321-0481-01				RES.,FXD,FILM:1M OHM,0.5%,0.125W	91637	MFF1816G10003D
A10R1941	321-0193-03				RES.,FXD,FILM:1K OHM,0.25%,0.125W	91637	MFF1816D10000C
A10R1950	315-0102-00				RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A10R1951	311-1559-00				RES.,VAR,NONWIR:10K OHM,20%,0.50W	73138	91-81-0
A10R2001	315-0201-00				RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
A10R2003	315-0101-00				RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A10R2004	315-0183-00				RES.,FXD,CMPSN:18K OHM,5%,0.25W	01121	CB1835
A10R2005	315-0330-00				RES.,FXD,CMPSN:33 OHM,5%,0.25W	01121	CB3305
A10R2006	315-0302-00				RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A10R2011	321-0253-00	B010100	B022569		RES.,FXD,FILM:4.22K OHM,1%,0.125W	91637	MFF1816G42200F
A10R2011	321-0254-00	B022570			RES.,FXD,FILM:4.32K OHM,1%,0.125W	91637	MFF1816G43200F
A10R2012	321-0143-00				RES.,FXD,FILM:301 OHM,1%,0.125W	91637	MFF1816G301R0F

Component No.	Tektronix Part No	Serial Model No. Eff	Discont	Name & Description	Mfr Code	Mfr Part Number
A10R2013	321-0268-00			RES.,FXD,FILM:6.04K OHM,1%,0.125W	91637	MFF1816G60400F
A10R2024	321-0134-00			RES.,FXD,FILM:243 OHM,1%,0.125W	91637	MFF1816G243R0F
A10R2025	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
A10R2026	307-0055-00			RES.,FXD,CMPSN:3.9 OHM,5%,0.50W	01121	EB39G5
A10R2031	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
A10R2033	305-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.2W	01121	HB1015
A10R2041	315-0125-00			RES.,FXD,CMPSN:1.2M OHM,5%,0.25W	01121	CB1255
A10R2043	315-0332-00			RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
A10R2045	315-0332-00			RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
A10R2047	315-0125-00			RES.,FXD,CMPSN:1.2M OHM,5%,0.25W	01121	CB1255
A10R2101	321-0112-00			RES.,FXD,FILM:143 OHM,1%,0.125W	91637	MFF1816G143R0F
A10R2111	321-0151-00			RES.,FXD,FILM:365 OHM,1%,0.125W	91637	MFF1816G365R0F
A10R2113	321-0122-00			RES.,FXD,FILM:182 OHM,1%,0.125W	91637	MFF1816G182R0F
A10R2121	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
A10R2122	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
A10R2123	315-0270-00			RES.,FXD,CMPSN:27 OHM,5%,0.25W	01121	CB2705
A10R2124	321-0049-00			RES.,FXD,FILM:31.6 OHM,1%,0.125W	91637	MFF1816G31R60F
A10R2131	305-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.2W	01121	HB1015
A10R2141	321-0002-00			RES.,FXD,FILM:10.2 OHM,1%,0.125W	91637	MFF1816G10R20F
A10R2143	321-0059-00			RES.,FXD,FILM:40.2 OHM,1%,0.125W	91637	MFF1816G40R20F
A10R2201	311-1560-00			RES.,VAR, NONWIR:5K OHM,20%,0.50W	73138	91-82-0
A10R2202	321-0238-00			RES.,FXD,FILM:2.94K OHM,1%,0.125W	91637	MFF1816G29400F
A10R2203	321-0271-00			RES.,FXD,FILM:6.49K OHM,1%,0.125W	91637	MFF1816G64900F
A10R2204	321-0238-00			RES.,FXD,FILM:2.94K OHM,1%,0.125W	91637	MFF1816G29400F
A10R2211	321-0122-00			RES.,FXD,FILM:182 OHM,1%,0.125W	91637	MFF1816G182R0F
A10R2213	321-0112-00			RES.,FXD,FILM:143 OHM,1%,0.125W	91637	MFF1816G143R0F
A10R2223	315-0270-00			RES.,FXD,CMPSN:27 OHM,5%,0.25W	01121	CB2705
A10R2225	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
A10R2226	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
A10R2227	321-0049-00			RES.,FXD,FILM:31.6 OHM,1%,0.125W	91637	MFF1816G31R60F
A10R2228	307-0055-00			RES.,FXD,CMPSN:3.9 OHM,5%,0.50W	01121	EB39G5
A10R2231	323-0088-00			RES.,FXD,FILM:80.6 OHM,1%,0.50W	75042	CECT0-80R60F
A10R2233	323-0089-00			RES.,FXD,FILM:82.5 OHM,1%,0.50W	19701	MF7CD82R50F
A10R2251	321-0059-00			RES.,FXD,FILM:40.2 OHM,1%,0.125W	91637	MFF1816G40R20F
A10R2253	321-0002-00			RES.,FXD,FILM:10.2 OHM,1%,0.125W	91637	MFF1816G10R20F
A10R2255	321-0089-00			RES.,FXD,FILM:82.5 OHM,1%,0.125W	91637	MFF1816G82R50F
A10R2257	321-0002-00			RES.,FXD,FILM:10.2 OHM,1%,0.125W	91637	MFF1816G10R20F
A10R2301	315-0183-00			RES.,FXD,CMPSN:18K OHM,5%,0.25W	01121	CB1835
A10R2303	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A10R2304	315-0330-00			RES.,FXD,CMPSN:33 OHM,5%,0.25W	01121	CB3305
A10R2335	315-0750-00	B010100	B020709	RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A10R2335	321-0046-00	B020710		RES.,FXD,FILM:29.4 OHM,1%,0.125W	91637	MFF1816G29R40F
A10R2351	315-0561-00			RES.,FXD,CMPSN:560 OHM,5%,0.25W	01121	CB5615
A10R2353	323-0089-00			RES.,FXD,FILM:82.5 OHM,1%,0.50W	19701	MF7CD82R50F
A10R2355	323-0088-00			RES.,FXD,FILM:80.6 OHM,1%,0.50W	75042	CECT0-80R60F
A10S1901	260-1268-01			SWITCH,PUSH:3 BUTTON,2 POLE,FUNCTION	80009	260-1268-01
A10S2331	260-2020-00			SWITCH,PUSH:ATTENUATOR	80009	260-2020-00
A10TP1241	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A10TP1321	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A10TP1323	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A10TP1331	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A10TP1451	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A10U1210	156-0071-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR	04713	MC1723CL
A10U1230	156-0495-00			MICROCIRCUIT,LI:OPNL AMPL	27014	LM324N

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A10U1400	156-0495-00	B010100	B022259	MICROCIRCUIT,LI:OPNL AMPL	27014	LM324N
A10U1400	156-0495-01	B022260		MICROCIRCUIT,LI:OPNL AMPL,SEL	80009	156-0495-01
A10U1440	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	01295	MICROA741CP
A10U1501	156-0991-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR	04713	MC78L05ACP
A10U1540	156-0495-00			MICROCIRCUIT,LI:OPNL AMPL	27014	LM324N
A10U1600	156-0331-03			MICROCIRCUIT,DI:DUAL D TYPE POS EDGE TRIG	80009	156-0331-03
A10U1700	156-1056-00			MICROCIRCUIT,LI:DIFFERENTIAL COMPARATOR	04713	MC1514L
A10U1930	156-1156-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	27014	LF356N
A10U1940	156-1156-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	27014	LF356N
A10VR1241	152-0149-00			SEMICONV DEVICE:ZENER,0.4W,10V,5%	04713	SZG35009K3
A10VR1413	152-0456-00			SEMICONV DEVICE:ZENER,0.4W,6.2V,5%	04713	SZG25002K1
A10VR1532	152-0667-00			SEMICONV DEVICE:ZENER,0.4W,3.0V,2%	04713	SZG30025RL
A10VR1811	152-0278-00			SEMICONV DEVICE:ZENER,0.4W,3V,5%	04713	SZG35009K20
A10VR1813	152-0212-00			SEMICONV DEVICE:ZENER,0.5W,9V,5%	04713	SZ50646RL
A10VR2213	152-0590-00			SEMICONV DEVICE:ZENER,18V,5% AT 7MA	04713	SZG35014K2
A10W1411	131-0566-00			BUS CONDUCTOR:DUMMY RES,2.375,22 AWG	57668	JWW-0200E0
A10W1503	131-0566-00			BUS CONDUCTOR:DUMMY RES,2.375,22 AWG	57668	JWW-0200E0
A10W1531	131-0566-00			BUS CONDUCTOR:DUMMY RES,2.375,22 AWG	57668	JWW-0200E0
A10W1535	131-0566-00			BUS CONDUCTOR:DUMMY RES,2.375,22 AWG	57668	JWW-0200E0

Replaceable Electrical Parts—FG 501A

Component No.	Tektronix		Serial Model No.		Name & Description	Mfr	Mfr Part Number
	Part No.	Part No.	Eff	Discont		Code	
A12	670-6694-00		B010100	B020349	CKT BOARD ASSY,AUXILIARY	80009	670-6694-00
A12	670-6694-01		B020350	B022259	CKT BOARD ASSY,AUXILIARY	80009	670-6694-01
A12	670-6694-02		B022260		CKT BOARD ASSY,AUXILIARY	80009	670-6694-02
A12C1000	290-0301-00				CAP.,FXD,ELCTLT:10UF,10%,20V	56289	150D106X9020B2
A12C1002	281-0810-00				CAP.,FXD,CER DI:5.6PF,0.5%,100V	04222	GC10-1A5R6D
A12C1020	281-0810-00				CAP.,FXD,CER DI:5.6PF,0.5%,100V	04222	GC10-1A5R6D
A12C1022	281-0810-00				CAP.,FXD,CER DI:5.6PF,0.5%,100V	04222	GC10-1A5R6D
A12C1100	290-0301-00				CAP.,FXD,ELCTLT:10UF,10%,20V	56289	150D106X9020B2
A12C1110	281-0773-00				CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C1112	281-0773-00				CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C1120	281-0773-00				CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C1200	281-0773-00				CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C1202	290-0301-00				CAP.,FXD,ELCTLT:10UF,10%,20V	56289	150D106X9020B2
A12C1215	281-0630-00	B020350			CAP.,FXD,CER DI:390PF,5%,500V	72982	630000Y5D391J
A12C1220	281-0764-00				CAP.,FXD,CER DI:82PF,5%,100V	56289	492CCOG820J100B
A12C1300	283-0177-00				CAP.,FXD,CER DI:1UF,+80-20%,25V	04222	SR302E105ZAA
A12C1310	281-0773-00				CAP.,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C1320	283-0177-00				CAP.,FXD,CER DI:1UF,+80-20%,25V	04222	SR302E105ZAA
A12CR1000	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1110	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1200	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1220	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1221	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1225	152-0141-02	B020350			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1226	152-0141-02	B020350			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1320	152-0141-02				SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
A12J1000	131-1003-00				CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A12J1020	131-1425-00				TERM SET,PIN:(36) 0.025 SQ RTANG,0.150L	22526	65521-136
A12J1220	131-1003-00				CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A12J1300	131-1003-00				CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A12J1302	131-1003-00				CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A12J1400	131-1425-00				TERM SET,PIN:(36) 0.025 SQ RTANG,0.150L	22526	65521-136
A12L1010	108-0419-00				COIL,RF:FIXED,1.1UH	80009	108-0419-00
A12Q1010	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A12Q1012	151-0188-00				TRANSISTOR:SILICON,PNP	04713	SPS6868
A12Q1200	151-0188-00				TRANSISTOR:SILICON,PNP	04713	SPS6868
A12Q1210	151-0220-00				TRANSISTOR:SILICON,PNP	07263	S036228
A12Q1212	151-0220-00				TRANSISTOR:SILICON,PNP	07263	S036228
A12Q1320	151-0188-00				TRANSISTOR:SILICON,PNP	04713	SPS6868
A12Q1322	151-0188-00				TRANSISTOR:SILICON,PNP	04713	SPS6868
A12Q1324	151-0190-00				TRANSISTOR:SILICON,NPN	07263	S032677
A12R1000	321-0256-00				RES.,FXD,FILM:4.53K OHM,1%,0.125W	91637	MFF1816G45300F
A12R1010	321-0181-00				RES.,FXD,FILM:750 OHM,1%,0.125W	91637	MFF1816G750R0F
A12R1012	321-0181-00				RES.,FXD,FILM:750 OHM,1%,0.125W	91637	MFF1816G750R0F
A12R1014	315-0242-00				RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
A12R1015	315-0622-00				RES.,FXD,CMPSN:6.2K OHM,5%,0.25W	01121	CB6225
A12R1016	315-0100-00				RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
A12R1020	321-0256-00				RES.,FXD,FILM:4.53K OHM,1%,0.125W	91637	MFF1816G45300F
A12R1022	315-0100-00				RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
A12R1100	321-0269-00				RES.,FXD,FILM:6.19K OHM,1%,0.125W	91637	MFF1816G61900F
A12R1102	321-0269-00				RES.,FXD,FILM:6.19K OHM,1%,0.125W	91637	MFF1816G61900F
A12R1104	311-0634-00				RES.,VAR,NONWIR:TRMR,500 OHM,0.5W	32997	3329H-G48-501
A12R1106	311-0643-00				RES.,VAR,NONWIR:50 OHM,10%,0.50W	73138	82-33-2

Component No.	Tektronix Part No.	Serial/Model No.		Name & Description	Mfr Code	Mfr Part Number
		Eff	Dscont			
A12R1108	321-0216-00			RES.,FXD,FILM:1.74K OHM,1%,0.125W	91637	MFF1816G17400F
A12R1110	315-0133-00			RES.,FXD,CMPSN:13K OHM,5%,0.25W	01121	CB1335
A12R1111	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
A12R1113	315-0301-00			RES.,FXD,CMPSN:300 OHM,5%,0.25W	01121	CB3015
A12R1115	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1116	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1119	315-0181-00			RES.,FXD,CMPSN:180 OHM,5%,0.25W	01121	CB1815
A12R1120	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
A12R1121	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1122	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1123	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1125	315-0301-00			RES.,FXD,CMPSN:300 OHM,5%,0.25W	01121	CB3015
A12R1200	321-0229-00	B010100	B022259	RES.,FXD,FILM:2.37K OHM,1%,0.125W	91637	MFF1816G23700F
A12R1200	321-0209-00	B022260		RES.,FXD,FILM:1.47K OHM,1%,0.125W	91637	MFF1816G14700F
A12R1202	315-0432-00	B010100	B022259	RES.,FXD,CMPSN:4.3K OHM,5%,0.25W	01121	CB4325
A12R1202	315-0112-00	B022260		RES.,FXD,CMPSN:1.1K OHM,5%,0.25W	01121	CB1125
A12R1203	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A12R1204	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A12R1210	321-0224-00			RES.,FXD,FILM:2.1K OHM,1%,0.125W	91637	MFF1816G21000F
A12R1212	321-0242-00			RES.,FXD,FILM:3.24K OHM,1%,0.125W	91637	MFF1816G32400F
A12R1215	315-0204-00	B020350		RES.,FXD,CMPSN:200K OHM,5%,0.25W	01121	CB2045
A12R1216	321-0183-00			RES.,FXD,FILM:787 OHM,1%,0.125W	91637	MFF1816G787R0F
A12R1217	321-0183-00			RES.,FXD,FILM:787 OHM,1%,0.125W	91637	MFF1816G787R0F
A12R1220	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1221	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1225	315-0472-00	B020350		RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
A12R1300	315-0361-00			RES.,FXD,CMPSN:360 OHM,5%,0.25W	01121	CB3615
A12R1310	315-0162-00			RES.,FXD,CMPSN:1.6K OHM,5%,0.25W	01121	CB1625
A12R1312	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	91637	MFF1816G20000F
A12R1313	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1314	321-0285-00			RES.,FXD,FILM:9.09K OHM,1%,0.125W	91637	MFF1816G90900F
A12R1320	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A12R1322	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W		
A12R1324	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
A12R1325	315-0621-00			RES.,FXD,CMPSN:620 OHM,5%,0.25W	01121	CB6215
A12S1400	260-2040-00			SWITCH,PUSH:4 BTN 2 POLE,MODE	80009	260-2040-00
A12U1020	156-0048-00			MICROCIRCUIT,LI:FIVE NPN TRANSISTOR ARRAY	02735	CA3046
A12U1120	156-0048-00			MICROCIRCUIT,LI:FIVE NPN TRANSISTOR ARRAY	02735	CA3046
A12U1220	156-0048-00			MICROCIRCUIT,LI:FIVE NPN TRANSISTOR ARRAY	02735	CA3046
A12U1310	156-0382-02			MICROCIRCUIT,DI:QUAD 2-INP NAND GATE	01295	SN74LS00
A12VR1200	152-0486-00	B022260		SEMICONV DEVICE:ZENER,0.25W,6.2V,5%	80009	152-0486-00

Replaceable Electrical Parts—FG 501A

Component No	Electronics Part No	Serial/Model No E#	Discont	Name & Description	Mfr Code	Mfr Part Number
CHASSIS PARTS						
CR500	150-1033-00			LT EMITTING DIO:AMBER,565NM,40MA MAX	50434	HLMP 1401
CR510	150-1029-00			LT EMITTING DIO:GREEN,565NM,35MA	53184	XC209G
J500	131-0955-00			CONN,RCPT,ELEC:BNC,FEMALE	13511	31-279
J510	131-0955-00			CONN,RCPT,ELEC:BNC,FEMALE	13511	31-279
J520	131-0955-00			CONN,RCPT,ELEC:BNC,FEMALE	13511	31-279
J530	131-0955-00			CONN,RCPT,ELEC:BNC,FEMALE	13511	31-279
R510	311-0169-00			RES.,VAR,NONWIR:100 OHM,20%,0.50W	01121	W-7564B
R520	321-0085-00			RES.,FXD,FILM:75 OHM,1%,0.125W	91637	MFF1816G75R00F
R530	311-2104-00			RES.,VAR,NONWIR:PNL,15K OHM,10%,0.25W	12697	CM41780
R530	-----			(PART OF S500)		
R540	321-0085-00			RES.,FXD,FILM:75 OHM,1%,0.125W	91637	MFF1816G75R00F
R550	311-1298-00			RES.,VAR,NONWIR:10K OHM,20%,0.50W	01121	W-7909
R560	311-2107-00			RES.,VAR,NONWIR:DUAL,PNL,1K X 50K OHM	12697	CM41781
R560	-----			(PART OF S510)		
S500	-----			(PART OF R530)		
S510	-----			(PART OF R560)		
S1731	263-1189-00			SW CAM ACTR AS:FREQUENCY MULTIPLIER	80009	263-1189-00