

Tektronix[®]
COMMITTED TO EXCELLENCE

FUNCTION
GENERATOR

FG 501

INSTRUCTION MANUAL



FUNCTION
GENERATOR

FG 501

INSTRUCTION MANUAL

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

Serial Number _____

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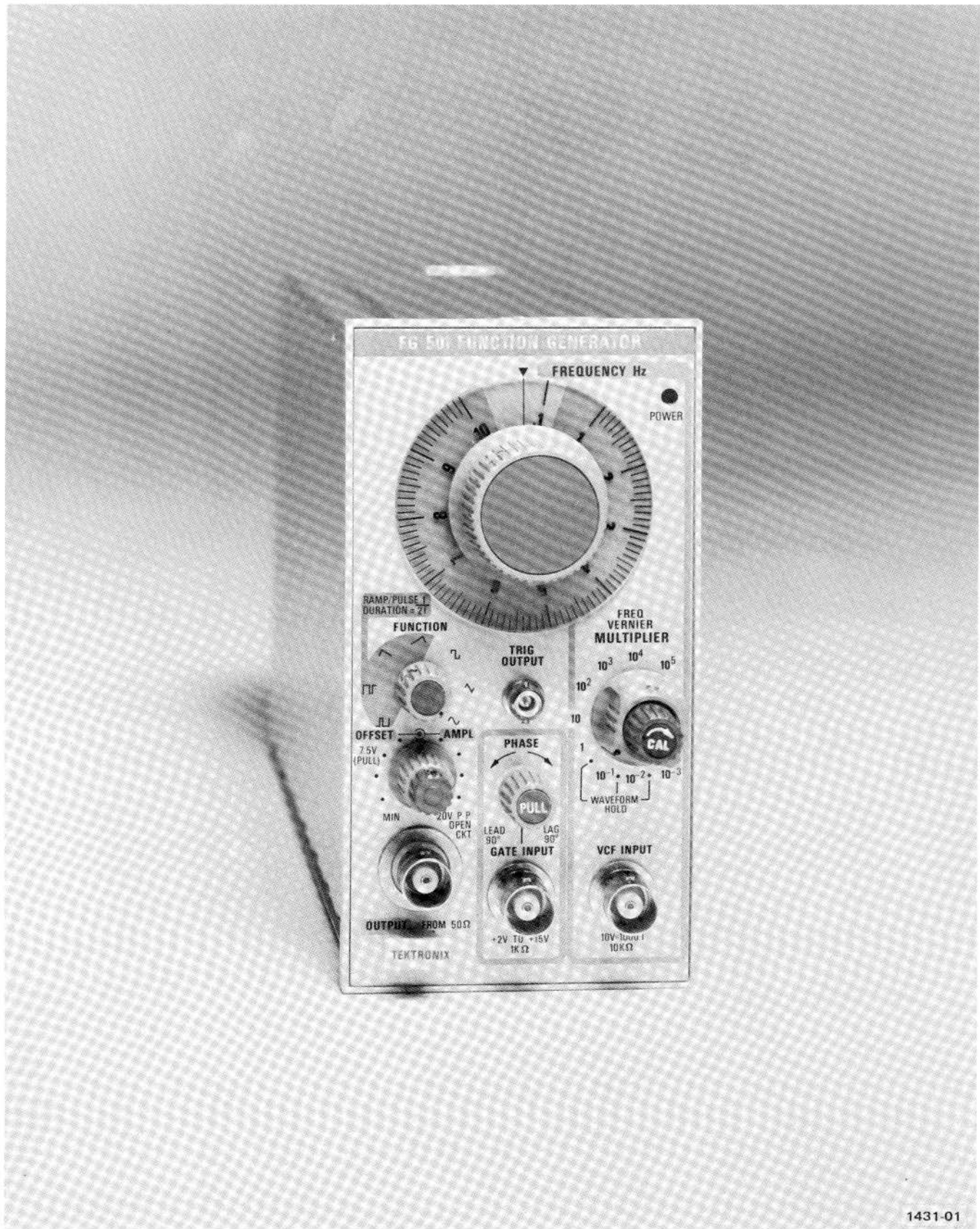
TABLE OF CONTENTS

	Page
SECTION 1 OPERATING INSTRUCTIONS	1-1
SECTION 2 SPECIFICATION AND PERFORMANCE CHECK	2-1

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

SECTION 3 ADJUSTMENT	3-1
SECTION 4 MAINTENANCE AND INTERFACING INFORMATION	4-1
SECTION 5 CIRCUIT DESCRIPTION	5-1
SECTION 6 OPTIONS	6-1
SECTION 7 REPLACEABLE ELECTRICAL PARTS	7-1
SECTION 8 DIAGRAM AND CIRCUIT BOARD ILLUSTRATION	8-1
SECTION 9 REPLACEABLE MECHANICAL PARTS AND EXPLODED VIEW	9-1
CHANGE INFORMATION	



1431-01

Fig. 1-1. FG 501 Function Generator

OPERATING INSTRUCTIONS

INTRODUCTION

The FG 501 Function Generator is designed to operate in a TM 500-Series power module. Low distortion sine, square, triangle, pulse, and ramp waveforms from 0.001 Hz to 1 MHz as well as a +2.5 volt square-wave trigger are available at the front panel. Variable DC offset of ± 7.5 volts is also provided. A "hold" feature allows the generator output to be abruptly halted at its instantaneous voltage level and held there until manually switched on again.

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 or below the selected frequency to a maximum of 1000:1 depending on the polarity and amplitude of the VCF input and the selected output frequency.

Also included is an external gate input that allows the generator to be turned on for the duration of an externally applied gating signal. This mode provides either a single cycle output or a train (burst) of preselected waveforms depending on the gating signal width and the generator frequency setting. The phase (start level) of the waveform burst can be varied $\pm 90^\circ$ by a front-panel control.

The variety of swept and modulated signals available from the FG 501 make it especially useful for such applications as testing servo-system or amplifier response, distortion, and stability; FM generation and frequency multiplication; or simply used as a variable beat-frequency oscillator, repetition-rate, or tone-burst generator. The square-wave trigger output can be used as a source for transistor-transistor logic (TTL) or to synchronize an external device such as an oscilloscope or counter.

The FG 501 is calibrated and ready for use when received. It is designed to operate in any compartment of a TM 500-Series power module only. Refer to the power module Instruction Manual for line voltage requirements and power module operation.

Installation and Removal

CAUTION

Turn the power module off before inserting the plug-in; otherwise, damage may occur to the plug-in circuitry. Because of the high current drawn by the FG 501, it is also recommended that the power module be turned off before removing the FG 501. Refer to Fig. 1-2. Check to see that the plastic barriers on the interconnecting jack of the selected power module compartment match the cut-outs in the FG 501 circuit board edge connector.

Align the FG 501 chassis with the upper and lower guides of the selected compartment. Push the module in and press firmly to seat the circuit board in the interconnecting jack.

Pull the Power switch on the front panel of the power module to apply power to the FG 501. Observe that the POWER indicator light on the FG 501 comes on.

Remove the FG 501 from the power module by pulling the release latch at the bottom of the front panel and sliding the unit straight out of the power module.

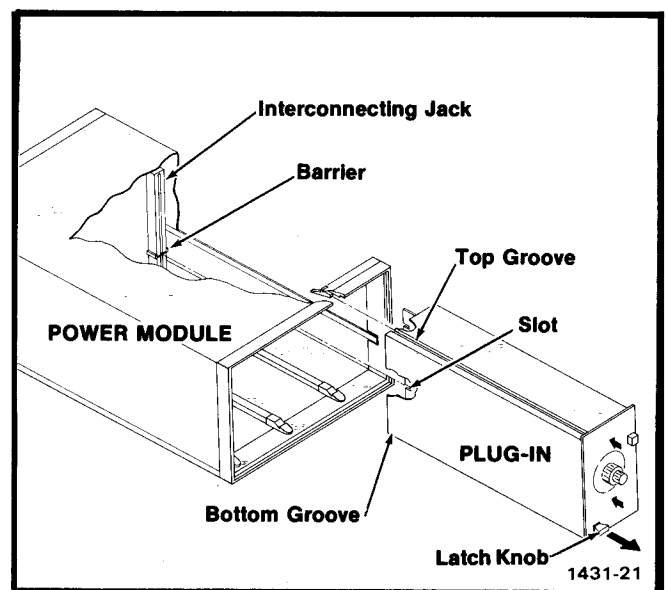


Fig. 1-2. Plug-in installation and removal.

OPERATING CONSIDERATIONS

NOTE

Before using the FG 501 for the first time, read the Operating Considerations in this section and the description of the front-panel controls, connectors, and indicators in Fig. 1-3.

Output Connections

The output of the FG 501 is designed to operate as a voltage source in series with $50\ \Omega$ and working into a $50\ \Omega$ load. At the higher frequencies, an unterminated or improperly terminated output will cause excessive aberrations on the output waveform (see Impedance Matching discussion). Loads less than $50\ \Omega$ will reduce the waveform amplitude.

Excessive distortion or aberrations due to improper termination is less likely to occur at the lower frequencies (especially with sine and triangle waveforms). However, to ensure that waveform purity is preserved, observe the following precautions:

1. Use quality $50\ \Omega$ coaxial cables and connectors.
2. Make all connections tight and as short as possible.
3. Use quality attenuators, if necessary, to reduce waveform amplitude to sensitive circuits.
4. Use terminators or impedance-matching devices to avoid reflections when using long cables, i.e., six feet or more.
5. Ensure that attenuators, terminations, etc. have adequate power-handling capabilities for the output waveform (approximately 0.5 W into a $50\ \Omega$ load).

Power output is determined by the selected waveform, its amplitude, and the amount of offset voltage selected.

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

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

If there is a dc voltage across the output load, the output pulse amplitude will be compressed; or in some cases, if the voltage exceeds $\pm 10\ \text{V}$, it may short the output. To prevent this from occurring, the output must be coupled through a dc blocking capacitor to the load. The time constant of the coupling capacitor and load must be long enough to maintain pulse flatness.

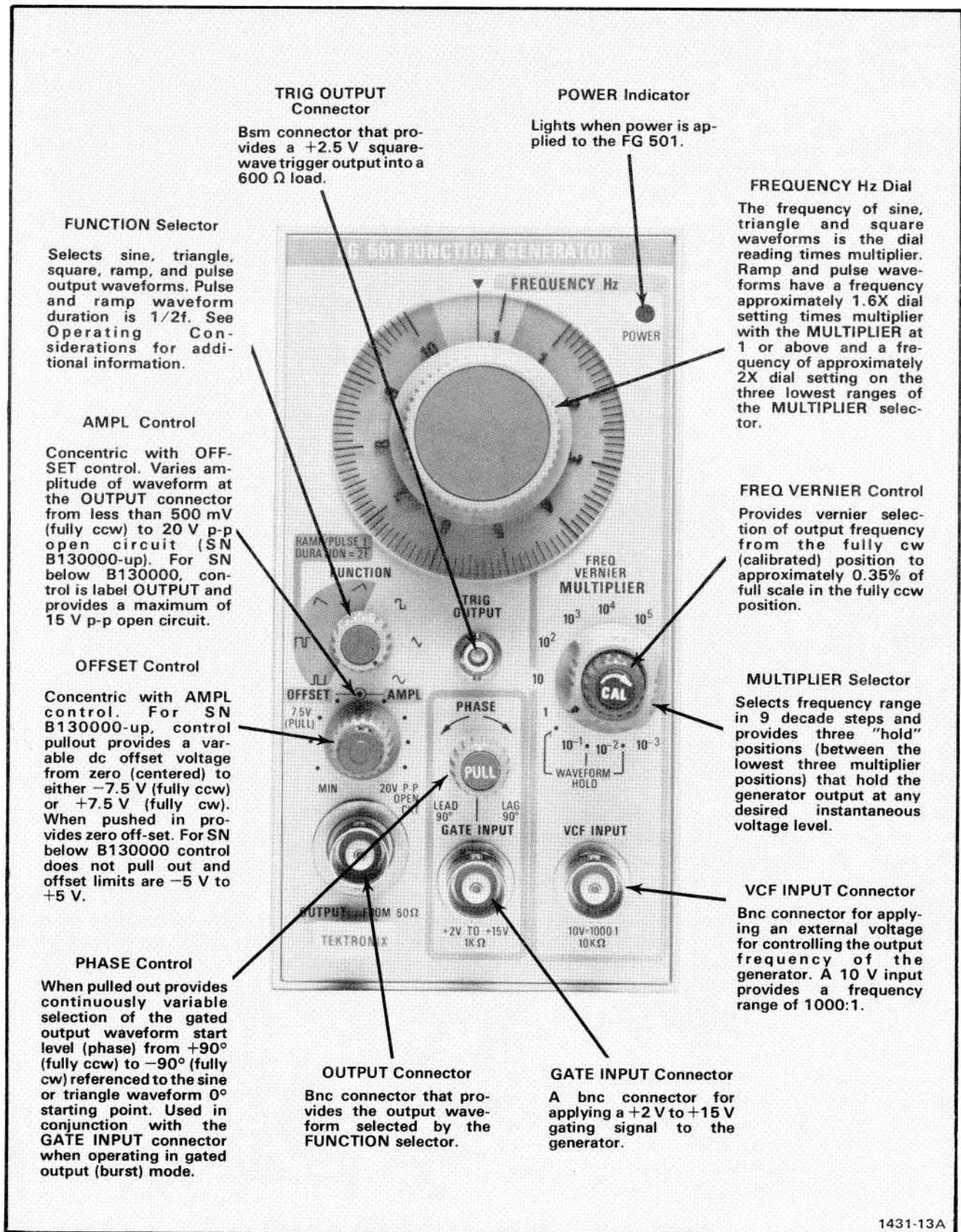
Risetime and Falltime

If the output pulse from the FG 501 is used for measuring the rise or falltime of a device, the risetime characteristics of associated equipment may have to be considered. If the risetime of the device under test is at least 10 times greater than the combined risetimes of the FG 501 plus the monitoring oscilloscope and associated cables, the error introduced will not exceed 1% and generally can be ignored. If the rise or falltime of the test device, however, is less than 10 times as long as the combined risetimes of the testing system, the actual risetime of the device will have to be determined from the risetime of each component making up the system. This equals the square root of the sum of the squares of the individual risetimes. Conversely, the risetime of the device under test can be found from the same relationship if all the actual risetimes in the system are known except that of the device under test.

Impedance Matching

Reflections. As a pulse travels down a transmission line, each time it encounters a mismatch, or an impedance different than the transmission line, a reflection is generated and sent back along the line to the source. The amplitude and polarity of the reflections are determined by the amount of the encountered impedance in relation to the characteristic impedance of the cable. If the mismatch impedance is higher than the line, the reflection will be of the same polarity as the applied signal; if it is lower, the reflection will be of opposite polarity. If the reflected signal returns before the pulse is ended, it adds to or subtracts from the amplitude of the pulse. This distorts the pulse shape and amplitude.

Matching Networks. The following describes methods for matching impedance networks into relatively low impedances. If the FG 501 is driving a high impedance, such as the $1\ \text{M}\Omega$ input impedance of the vertical input for an oscilloscope, the transmission line must be terminated



TRIG OUTPUT Connector

Bsm connector that provides a +2.5 V square-wave trigger output into a 600 Ω load.

POWER Indicator

Lights when power is applied to the FG 501.

FUNCTION Selector

Selects sine, triangle, square, ramp, and pulse output waveforms. Pulse and ramp waveform duration is 1/2f. See Operating Considerations for additional information.

FREQUENCY Hz Dial

The frequency of sine, triangle and square waveforms is the dial reading times multiplier. Ramp and pulse waveforms have a frequency approximately 1.6X dial setting times multiplier with the MULTIPLIER at 1 or above and a frequency of approximately 2X dial setting on the three lowest ranges of the MULTIPLIER selector.

AMPL Control

Concentric with OFFSET control. Varies amplitude of waveform at the OUTPUT connector from less than 500 mV (fully ccw) to 20 V p-p open circuit (SN B130000-up). For SN below B130000, control is label OUTPUT and provides a maximum of 15 V p-p open circuit.

FREQ VERNIER Control

Provides vernier selection of output frequency from the fully cw (calibrated) position to approximately 0.35% of full scale in the fully ccw position.

OFFSET Control

Concentric with AMPL control. For SN B130000-up, control pullout provides a variable dc offset voltage from zero (centered) to either -7.5 V (fully ccw) or +7.5 V (fully cw). When pushed in provides zero off-set. For SN below B130000 control does not pull out and offset limits are -5 V to +5 V.

MULTIPLIER Selector

Selects frequency range in 9 decade steps and provides three "hold" positions (between the lowest three multiplier positions) that hold the generator output at any desired instantaneous voltage level.

PHASE Control

When pulled out provides continuously variable selection of the gated output waveform start level (phase) from +90° (fully ccw) to -90° (fully cw) referenced to the sine or triangle waveform 0° starting point. Used in conjunction with the GATE INPUT connector when operating in gated output (burst) mode.

VCF INPUT Connector

Bnc connector for applying an external voltage for controlling the output frequency of the generator. A 10 V input provides a frequency range of 1000:1.

OUTPUT Connector

Bnc connector that provides the output waveform selected by the FUNCTION selector.

GATE INPUT Connector

A bnc connector for applying a +2 V to +15 V gating signal to the generator.

1431-13A

Fig. 1-3. Operating controls and connectors.

Operating Instructions—FG 501

into a 50 Ω attenuator and a 50 Ω termination at the oscilloscope input. The attenuator isolates the input capacity of the device. Distortion can be caused by this input capacity.

A simple resistive impedance-matching network that provides minimum attenuation is illustrated in Fig. 1-4. To match impedance with the illustrated network, the following conditions must exist:

$$\frac{(R_1 + Z_2)R_2}{R_1 + Z_2 + R_2} \text{ must equal } Z_1$$

and

$$R_1 + \frac{Z_1 R_2}{Z_1 + R_2} \text{ must equal } Z_2$$

Therefore:

$$R_1 R_2 = Z_1 Z_2; \text{ and } R_1 Z_1 = R_2 (Z_2 - Z_1)$$

$$\text{or } R_1 = \sqrt{Z_2(Z_2 - Z_1)}$$

$$\text{and } R_2 = Z_1 \sqrt{\frac{Z_2}{Z_2 - Z_1}}$$

For example; to match a 50 Ω system to a 125 Ω system, Z_1 equals 50 Ω and Z_2 equals 125 Ω.

Therefore:

$$R_1 = \sqrt{125(125 - 50)} = 96.8 \Omega$$

$$\text{and } R_2 = 50 \sqrt{\frac{125}{125 - 50}} = 64.6 \Omega$$

When constructing such a device, the environment surrounding the components should also be designed to provide a transition between the impedances. Keep in mind that the characteristic impedance of a coaxial device is determined by the ratio between the outside diameter of the inner conductor to the inside diameter of the outer conductor. $z_0 = 138 / \epsilon \log_{10} D/d$, where D is the inside diameter of the outer conductor, and d is the outside diameter of the inner conductor. ϵ is the dielectric constant (1 in air).

Attenuation Ratios. Though the network in Fig. 1-4 provides minimum attenuation for a purely resistive impedance-matching device, the attenuation as seen from one end does not equal that seen from the other end. A signal (E_1) applied from the lower impedance source (Z_1) encounters a voltage attenuation (A_1) which is greater than 1 and less than 2, as follows:

$$A_1 = \frac{E_1}{E_2} = \frac{R_1}{Z_2} + 1$$

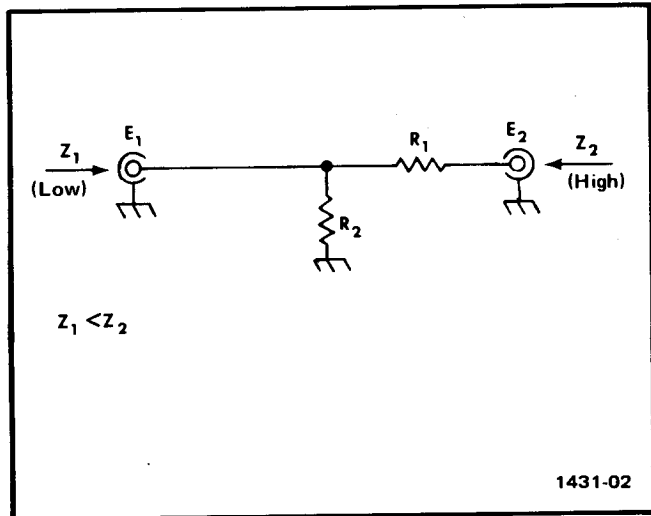


Fig. 1-4. Impedance-matching network that provides minimum attenuation.

A signal (E_2) applied from the higher impedance source (Z_2) encounters a greater voltage attenuation (A_2) which is greater than 1 and less than 2 (Z_2/Z_1):

$$A_2 = \frac{E_2}{E_1} = \frac{R_1}{R_2} + \frac{R_1}{Z_1} + 1$$

In the example of matching 50 Ω to 125 Ω.

$$A_1 = \frac{96.8}{125} + 1 = 1.77$$

$$A_2 = \frac{96.8}{64.6} + \frac{96.8}{50} + 1 = 4.44$$

The illustrated network can be modified to provide different attenuation ratios by adding another resistor (less than R_1) between Z_1 and the junction of R_1 and R_2 .

Duration of Ramps and Pulses

The duration of ramp and pulse waveforms is always equal to the half-cycle time of the sine, square, or triangle waveform frequency. For MULTIPLIER settings of 1 or greater, the retrace/off time is such that the waveform has a duty cycle of approximately 80%, i.e., frequency equals approximately 1.6X FREQUENCY Hz dial setting. For MULTIPLIER settings less than 1, the retrace/off time is from 10 ms to 100 ms, which results in duty cycles approaching 100%; i.e., frequency equals approximately 2X FREQUENCY Hz dial setting.

OPERATION

Free-Running Output

The following procedure provides a free-running waveform output with variable frequency and amplitude.

1. Set the AMPL control to the fully counterclockwise position and the OFFSET control to the 0 (centered) position. Check that the PHASE control is pushed in (off).

2. Set the FUNCTION selector to the desired waveform (see Fig. 1-5).

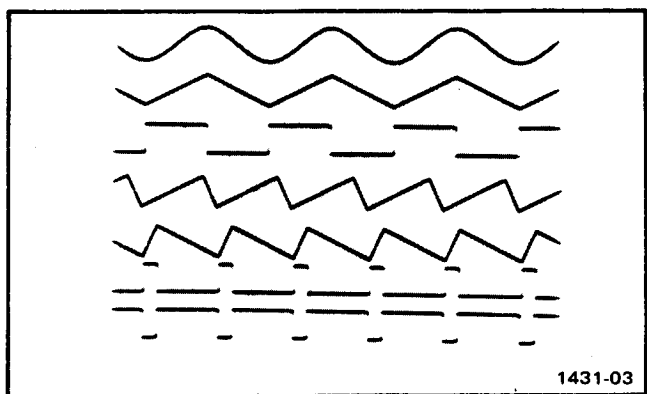


Fig. 1-5. Output waveforms available from the FG 501.

3. Select the desired frequency with the MULTIPLIER selector and FREQUENCY Hz dial. For example, if the MULTIPLIER selector is set to the 10^5 position and the FREQUENCY Hz dial is at 5, output frequency is 500 kHz; i.e., MULTIPLIER setting X FREQUENCY Hz setting. The output frequency is calibrated when the FREQUENCY VERNIER control is in the fully clockwise position. The duration of ramp and pulse waveforms is dependent on the MULTIPLIER setting. See Duration of Ramps and Pulses under Operating Considerations for further information.

4. Connect the load to the OUTPUT connector and adjust the AMPL control for the desired output amplitude.

Variable DC Offset

Pull outward on the OFFSET control (pull switch added at SN B020000) to position the dc level (baseline) of the output waveform. For example, +5 V of offset will increase the dc + peak ac voltage of a 7.5 V p-p output to +5 and +12.5 V dc + peak ac while -5 V of offset will reduce the dc + peak ac output to +2.5 V and -5 V.

Gated (Burst) Output and Variable Phase

A gating signal of 2 to 15 V amplitude applied to the GATE INPUT connector with the PHASE control pulled out will provide a burst of cycles at the OUTPUT connector. The duration of the burst and number of cycles in the burst depend on the gating signal duration and the output frequency selected. When the gating signal goes to the zero level, the generator completes its last cycle and remains quiescent until the next gating signal.

Single cycles can be obtained by applying a gating signal with a period approximately equal to the period of the FG 501 output waveform. The number of cycles per burst can be approximated by dividing the gating signal duration by the period of the FG 501 output frequency.

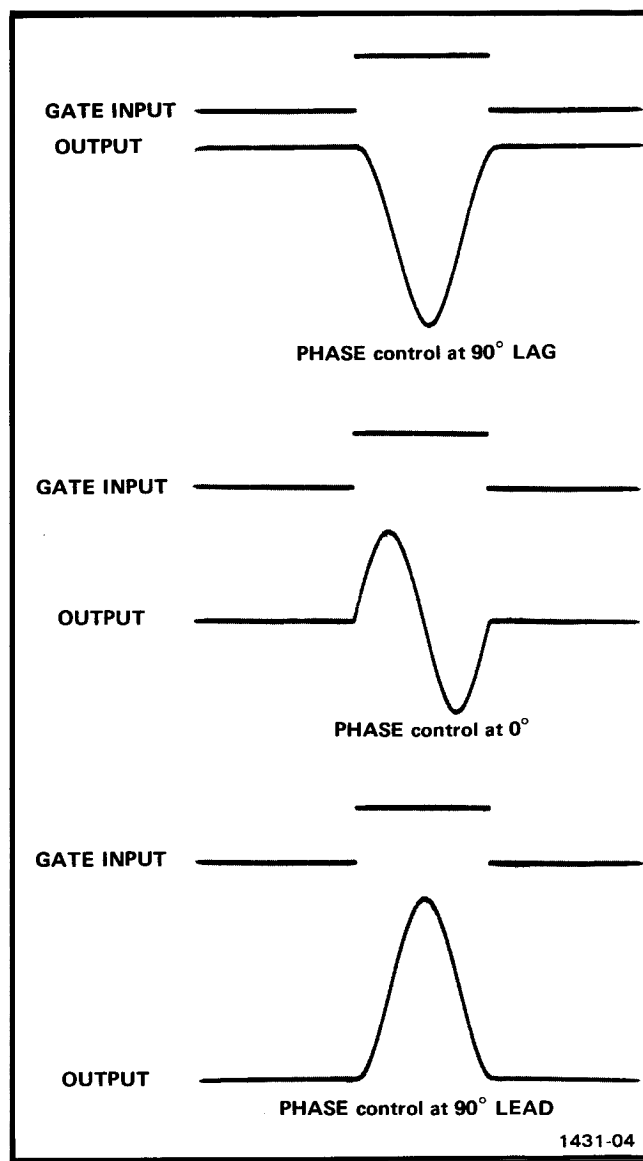


Fig. 1-6. Single cycle output with variable phase.

Operating Instructions—FG 501

The phase (start level) of the waveform burst can be varied $\pm 90^\circ$ by pulling out and turning the PHASE control either counterclockwise or clockwise from the 0 (centered) position (see Fig. 1-6). The phase of the output burst is referenced to the sine or triangle waveform 0° start point.

Output frequency can be varied during the burst duration by applying a voltage-controlled frequency (VCF) signal to the VCF INPUT connector.

Voltage-Controlled Frequency (VCF) Output

The output frequency of any selected waveform can be swept within a range of 1000:1 by applying a 0 to 10 V signal to the VCF INPUT connector. The polarity of the VCF input signal determines which direction the output

frequency sweeps from the frequency set by the MULTIPLIER selector and FREQUENCY Hz dial; i.e., a + signal sweeps the frequency upward as shown in Fig. 1-7(A), a - signal sweeps the frequency downward as shown in Fig. 1-7(B).

The maximum swept frequency range of 1000:1 encompasses the sensitive uncalibrated range of the FREQUENCY Hz dial, i.e., $<.1$ to 1. Therefore, 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 10 and a 0 to -10 V signal be applied to the VCF IN connector. The output will thus sweep downward at least 1000:1 from a FREQUENCY Hz dial setting of 10 as shown in Fig. 1-7(B). It may be necessary to vary the CAL control to obtain the full 1000:1 swept range or the lowest swept frequency desired.

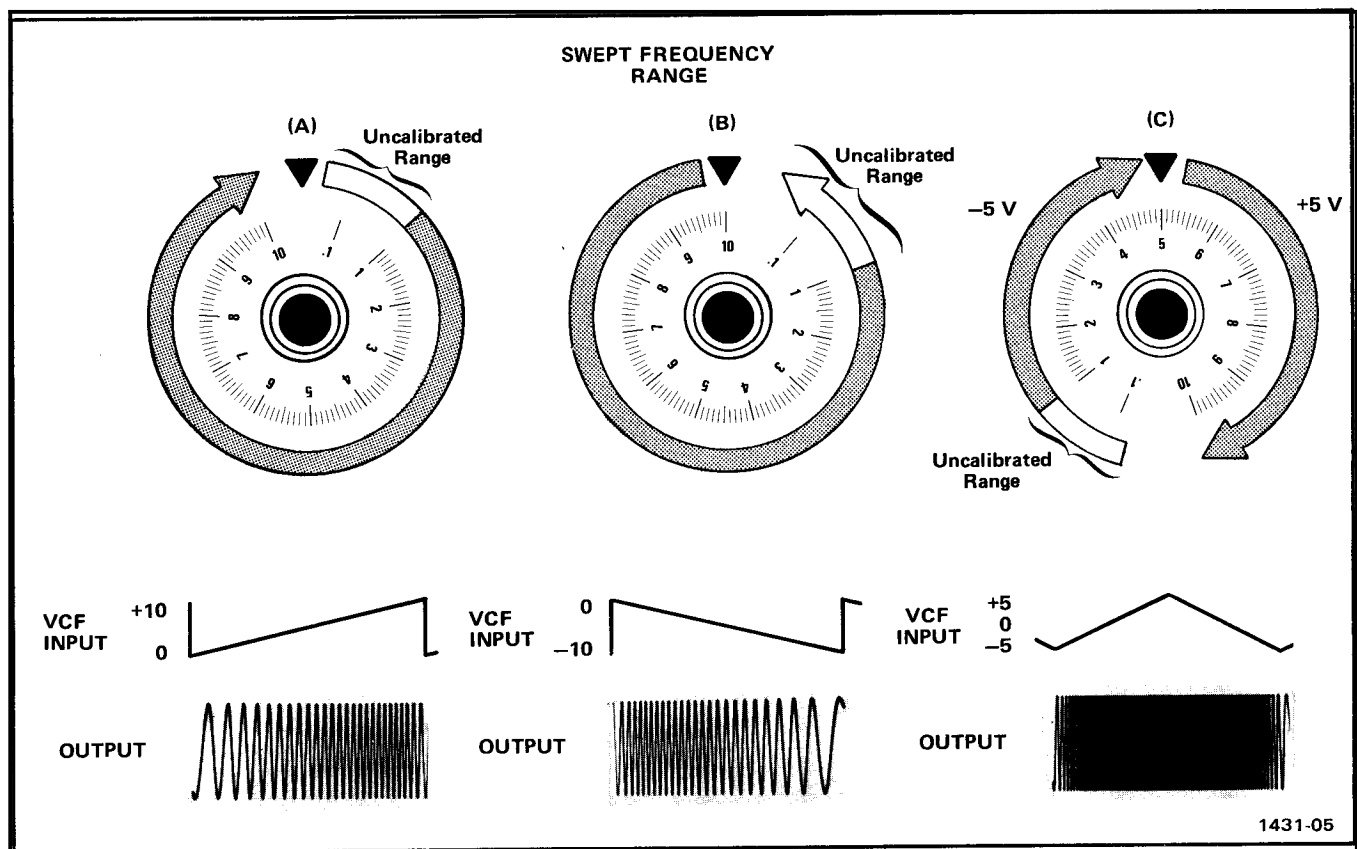


Fig. 1-7. Swept Frequency range with 10 V signals applied to VCF IN connector.

An input signal that varies symmetrically about a 0 V level will also sweep the generator symmetrically about the center frequency set by the MULTIPLIER selector and FREQUENCY Hz dial as shown in Fig. 1-7(C).

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

Hold Mode

Three detented HOLD positions are provided between the lowest three MULTIPLIER selector positions. By switching to any one of the HOLD positions, the generator can be stopped at its instantaneous voltage level and held there until the MULTIPLIER selector setting is changed.

Trigger Output

A TTL-compatible +2.5 V square wave is available from the TRIG OUTPUT connector. The frequency of the trigger output is determined by the output frequency selected by the MULTIPLIER selector and FREQUENCY Hz dial (see Fig. 1-8). When the FUNCTION selector is set for ramp or pulse, the trigger output frequency is about 1.6 times the dial indications. Output impedance is 600 Ω.

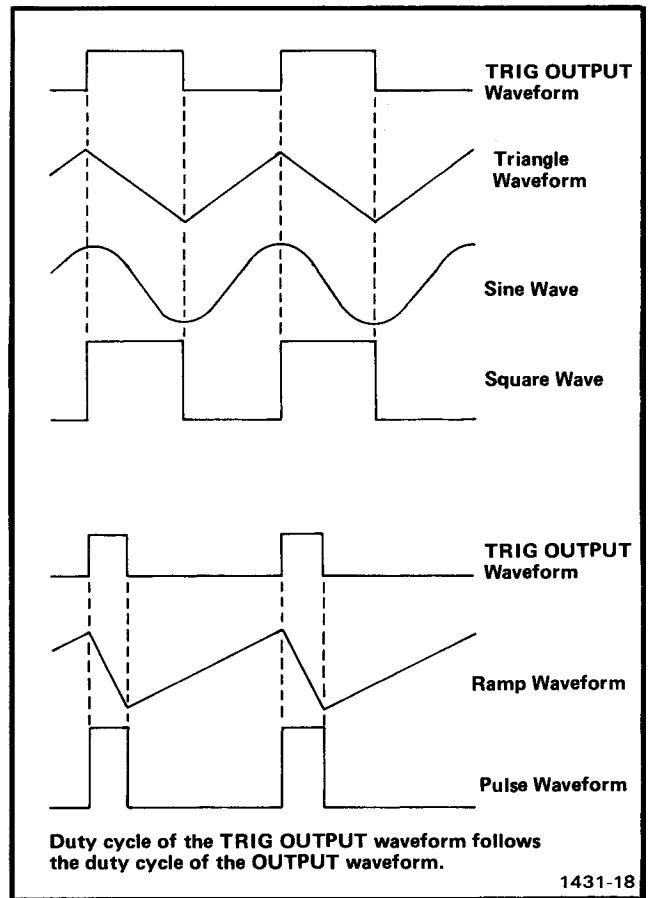


Fig. 1-8. Phase relationships between various waveforms from OUTPUT and TRIG OUTPUT connectors.

APPLICATIONS

Response Analysis

The FG 501 is particularly suited for determining response characteristics of circuits or systems. This application utilizes the VCF input of the FG 501 to sweep the generator over a range of frequencies. By applying the desired waveform from another FG 501 (or equivalent) to a device under test and sweeping the waveform frequency over a selected range, various response characteristics can be observed on a monitoring oscilloscope.

The following procedure describes a technique for determining response characteristics of any frequency-sensitive device that operates within the frequency range of the FG 501. Refer to the Voltage-Controlled Frequency (VCF) Output discussion under Operation for additional information.

1. Connect the equipment as shown in Fig. 1-9.
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 sweep the frequency upwards from the FREQUENCY Hz dial setting while a negative-going waveform will sweep downwards.

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.

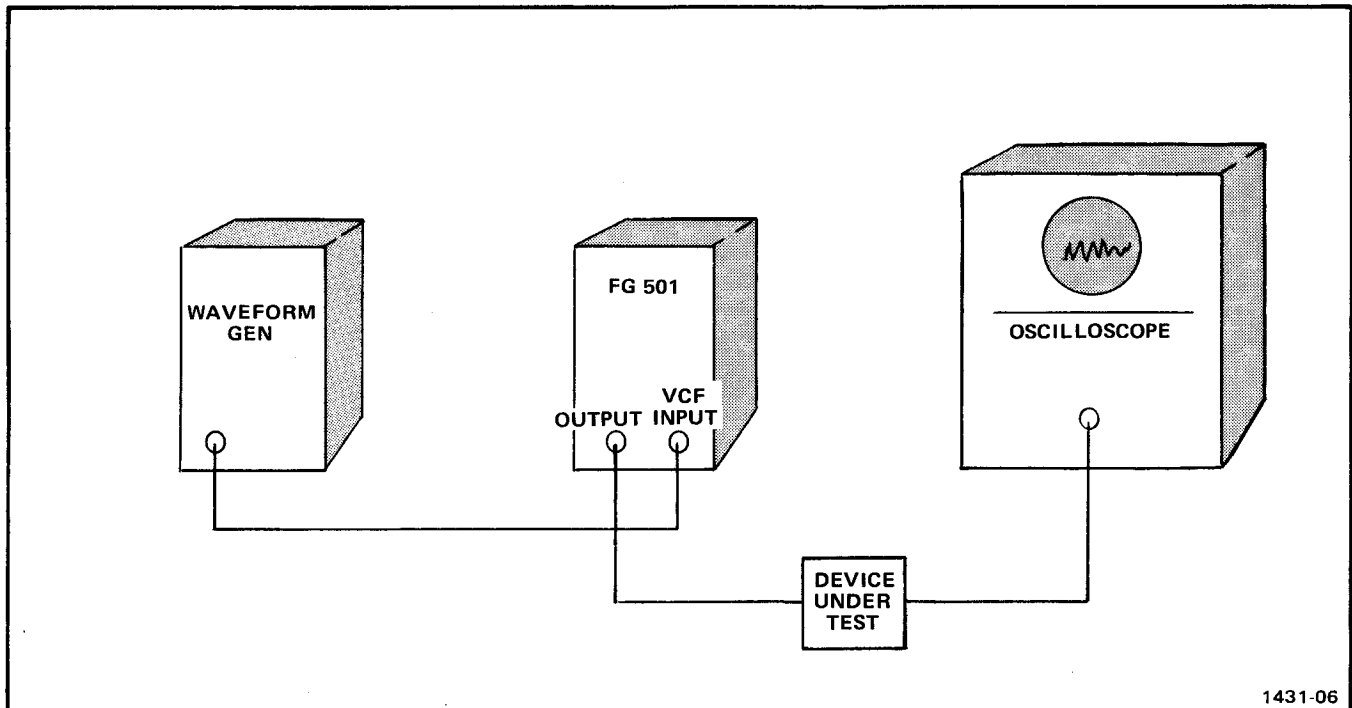


Fig. 1-9. Analyzing circuit or system response.

Tone-Burst Generation or Stepped Frequency Multiplication

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

2. Pull out the FG 501 PHASE control. Set the ramp generator for the desired ramp duration and polarity.

3. Adjust the pulse generator period for the desired number of bursts within the selected ramp duration. Adjust the pulse generator duration for the desired burst width.

4. Select the sweep frequency range by adjusting the FREQUENCY Hz dial for one end of the swept 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.

1. Connect the equipment as shown in Fig. 1-10.

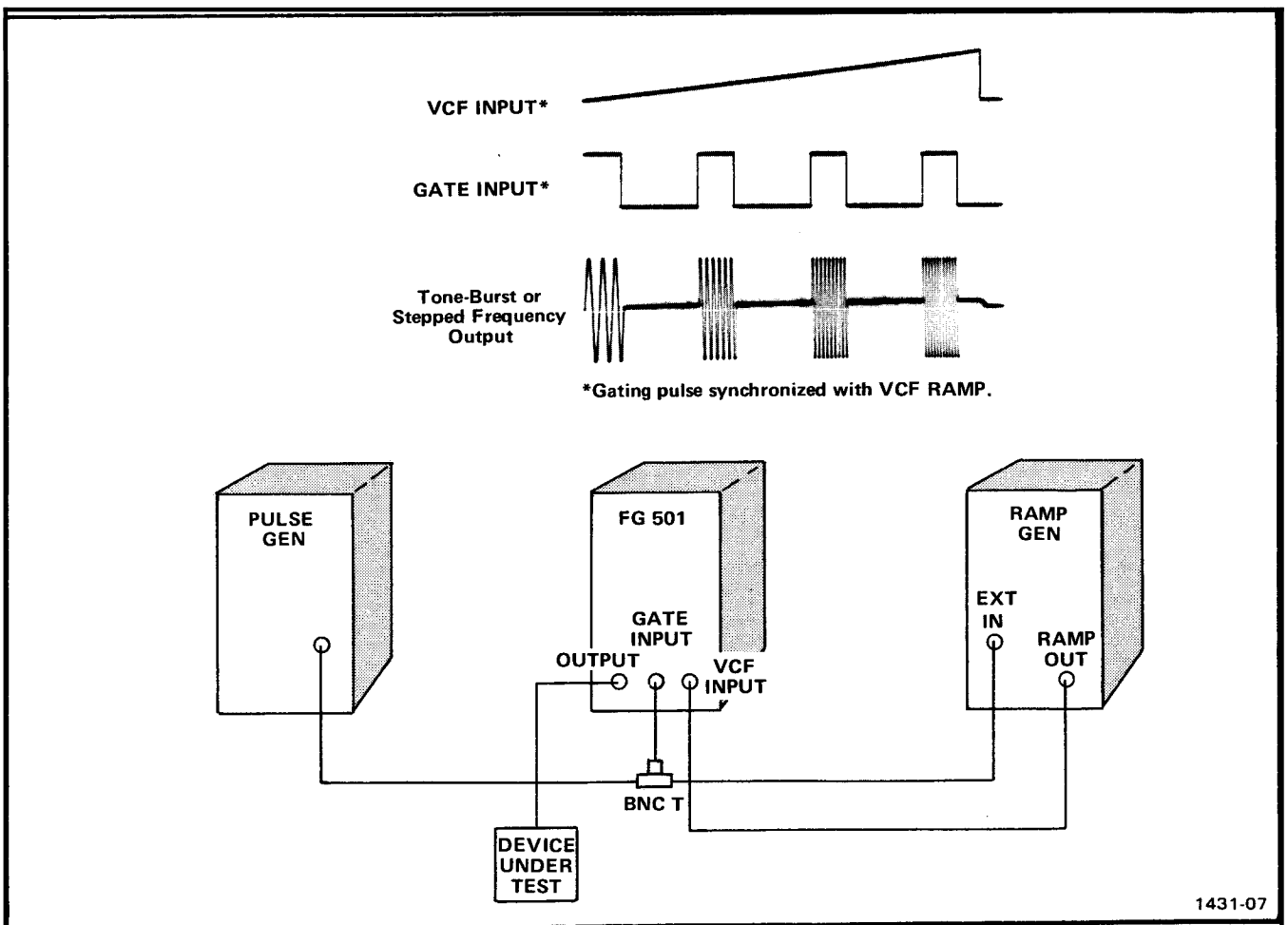


Fig. 1-10. Tone-burst generation or stepped frequency multiplication.

SPECIFICATION AND PERFORMANCE CHECK

SPECIFICATION

Performance Conditions

The electrical characteristics are valid only if the FG 501 has been calibrated at an ambient temperature between +20°C and +30°C and is operating at an ambient temperature between 0°C and +50°C unless otherwise noted. Forced air circulation is required for ambient temperature above +40°C.

Only those items listed in the Performance Requirements column of the Electrical Characteristics table are normally verified when doing the Performance Check procedure of this manual. Items listed in the Supplemental Information column are either explanatory notes or minimum performance characteristics for which no tolerance ranges are specified, and which normally require verification only after repairs or parts replacement.

Table 2-1
ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
Frequency		
Range Sine Wave, Square Wave, and Triangle	0.01 Hz to 1 MHz in 9 decade steps.	
Accuracy	Within 3% of full scale 1 to 10; .1 to 1 uncalibrated.	
Resolution		1 part in 10 ⁴ of full scale with FREQUENCY VERNIER control.
Stability Temperature		Within 2% from 0.1 Hz to 1 MHz, and within 10% from 0.001 Hz to 0.1 Hz, 0°C to +50°C.
Time		Within 0.1% for 10 minutes. Within 0.25% for 24 hours.
Pulse and Ramp range		≈2X dial setting with MULTI- PLIER at 10 ⁻³ to ≈1.6X dial set- ting with MULTIPLIER AT 10 ⁵ setting.
Time Symmetry Sine Wave, Square Wave, and Triangle	Within 1% from 0.001 Hz to 1 MHz on calibrated portion (1 to 10) of FREQUENCY Hz dial, +20°C to +50°C.	Within 10% on uncalibrated por- tion (0.1 to 1) of FREQUENCY Hz dial.

Table 2-1 (cont)

Characteristic	Performance Requirement	Supplemental Information
Amplitude (excluding offset)	SN B130000-up: 20 V p-p open circuit. 10 V p-p into 50 Ω load. Sine, triangle, and square wave amplitudes matched within 5% for single setting of AMPLITUDE control. Below SN B130000, OUTPUT control provides 15 V p-p open circuit and 7.5 V p-p into 50 Ω load.	Power-supply limiting causes compression of output waveform when maximum amplitude and maximum offset are used simultaneously.
Stability Temperature		Within 2% from 0.1 Hz to 1 MHz. Within 10% from 0.001 Hz to 0.1 Hz, 0°C to +50°C.
Time		Within 0.1% for 10 minutes. Within 0.25% for 24 hours.
Hold Mode Stability		Within 5% of full output voltage in 1 hour at +25°C on 0.001 Hz range.
Offset		
Amplitude		
Into Open Circuit	SN B130000-up: + or - 7.5 V SN below B130000: + or - 5 V	
Into 50 ohm Load	SN B130000-up: + or - 5 V SN below B130000: + or - 2.5 V	
Range		
Into Open Circuit	At least + and - 15 V peak signal plus offset.	
Into 50 ohm Load	SN B130000-up: At least + and - 6 V peak signal plus offset. SN below B130000: At least + and - 5 V peak signal plus offset.	
Output Impedance		50 Ω.
Trigger Output		
Amplitude	≥ +2.5 V square wave into a 600 Ω load.	
Frequency	Same as frequency at output connector.	
Triangle and Ramp Linearity (between 10% and 90% points)		Within 1% from 0.001 Hz to 100 kHz excluding first 200 ns after switch points. Within 2% from 100 kHz to 1 MHz, excluding first 200 ns after switch points.

Table 2-1 (cont)

Characteristics	Performance Requirement	Supplemental Information
Ramp Duration		$\approx \frac{1}{2f}$ (see Operating Considerations).
Sine Wave Distortion	1% or less from 0.001 Hz to 1 Hz. 0.5% or less from 1 Hz to 20 kHz. 1% or less from 20 kHz to 100 kHz. 2.5% or less from 100 kHz to 1 MHz at 10 ⁵ MULTIPLIER setting.	Applies to calibrated portion of dial only (1 to 10). Valid from +10°C to +50°C.
Square Wave and Pulse Outputs		
Risetime	100 ns or less.	10% to 90%.
Aberrations	5% or less measured p-p with output amplitude at 10 V into external 50 Ω load.	
Pulse Duration		$\approx \frac{1}{2f}$ (see Operating Considerations).
External Gate Input		
Input Signal		Square wave at least +2 V, but not to exceed +15 V. Output bursts are synchronized with gate input.
Burst Length		Determined by selected output frequency and gating pulse width.
Phasing		Continuously variable from -90° to +90° referred to 0° sine or triangle start points.
Input Impedance		≈1 kΩ.
External Voltage-Controlled Frequency (VCF) Input		
Output Frequency Range	At least 1000:1 with 10 V VCF input. Negative-going voltage decreases frequency; positive-going increases frequency. $f_{\max} = 10X \text{ MULTIPLIER setting}$, $f_{\min} = \frac{\text{MULTIPLIER setting}}{100}$	
Slew Rate		≈0.5 V/μs.

Table 2-2
ENVIRONMENTAL CHARACTERISTICS

Characteristics	Information
Temperature	
Operating	0°C to 50°C.
Storage	-40°C to +75°C.
Altitude	
Operating	To 15,000 feet. Maximum operating temperature decreased by 1°C/100 feet from 5000 to 15,000 feet.
Storage	To 50,000 feet.
Vibration	
Operating and non-operating	With the instrument complete, vibration frequency swept from 10 to 55 to 10 Hz at 1 minute per sweep. Vibrate 15 minutes in each of the three major axes at 0.015" total displacement. Hold 10 minutes at any major resonance; or, if none, at 55 Hz. Total time, 75 minutes.
Shock	
Operating and non-operating	30 g, 1/2 sine, 11 ms duration, 3 shocks in each direction along 3 major axes, for a total of 18 shocks.
Transportation	Qualified under National Safe Transit Committee Test Procedure 1A, Category II.

Table 2-3
PHYSICAL CHARACTERISTICS

Characteristic	Dimension
Overall Size (measured at maximum points)	
Height	5.0 in (12.7 cm)
Width	2.6 in (6.6 cm)
Length	12.2 in (31 cm)
Net Weight (Instrument only)	2 lbs (0.906 kg)

PERFORMANCE CHECK

Introduction

This procedure checks the electrical characteristics of the FG 501 that appear in the Specification section of this manual. This procedure can also be used by an incoming inspection facility to determine acceptability of performance. If the instrument fails to meet the requirements given in this performance check, the adjustment procedure should be performed.

The electrical characteristics in Table 2-1 are valid only if the FG 501 is calibrated at an ambient temperature of +20°C to +30°C and operated at an ambient temperature of 0°C to +50°C. Forced air circulation is required for ambient temperature above +40°C.

Tolerances that are specified in this performance check procedure apply to the instrument under test and do not include test equipment error.

Test Equipment Required

The test equipment listed in Table 2-4, or equivalent, is required to perform the performance check. Test equipment characteristics listed are the minimum required to verify the performance of the equipment under test. Substitute equipment must meet or exceed the stated requirements. All test equipment is assumed to be operating within tolerance.

Table 2-4

LIST OF TEST EQUIPMENT REQUIREMENTS

Performance Description	Requirement	Application	Example
Oscilloscope	Bandwidth dc to 15 MHz; deflection factor 10 mV/div to 5 V/div; sweep rate 20 ns/div to 1 ms/div.	Steps 1, 2, 3, 5, 7, 8, and 9.	TEKTRONIX T921 or equivalent.
Power Module	Three compartments or more.	All tests.	TEKTRONIX TM 503, TM 504, or equivalent.
Digital Voltmeter	Range 0 to ± 20 V dc; displayed error less than 0.5%.	VCF INPUT and Offset range checks.	TEKTRONIX DM 501 ^a .
Frequency Counter	Frequency range 0.1 Hz to above 1 MHz; accuracy within one part of 10^5 ± 1 count.	Basic timing & VCF INPUT.	TEKTRONIX DC 504 ^a or equivalent.
Pulse Generator	0 to +2 V square-wave output into 50 Ω load. Period 0.2 ms; duration 0.1 ms.	Phase range check.	TEKTRONIX PG 501 ^a or equivalent.
Variable dc Power Supply	Output 0 to 20 V at 0.4 A or greater.	Check VCF INPUT.	TEKTRONIX PS 501 ^a or equivalent.

^aRequires TM 500-Series power module.

Table 2-4 (cont)

Performance Description	Requirement	Application	Example
Distortion Analyzer	Frequency range from 1 Hz to at least 600 kHz. Distortion resolution <0.5%.	Check sine wave distortion.	Hewlett-Packard 334A Distortion Analyzer or equivalent.
50 Ω Feedthrough Termination (2)	bnc connectors.	Steps 1, 2, 3, 5, 6, 8, and 9.	Tektronix Part No. 011-0049-01.
600 Ω Feedthrough Termination	bnc connectors.	TRIG OUTPUT Amplitude check	Tektronix Part No. 011-0092-00.
50 Ω Coaxial Cables (2 ea)	bnc connectors.	All.	Tektronix Part No. 012-0057-01.
Adapter	bsm-to-bnc.	TRIG OUTPUT Amplitude check.	Tektronix Part No. 103-0036-00.
Adapter	Dual banana plug-to-bnc female.	VCF INPUT check.	Tektronix Part No. 103-0090-00.
Tee Connector	bnc connectors.	Basic timing check.	Tektronix Part No. 103-0030-00.
10X Attenuator	bnc connectors 50 Ω impedance.	Square wave checks.	Tektronix Part No. 011-0059-02.

PRELIMINARY PROCEDURE

1. Ensure that the correct nominal line selector block has been installed on the line selector pins on the power module interface board, and the regulating range selected includes the applied line voltage. Refer to the installation section of the power module manual.

2. Ensure that all test equipment is suitably adapted to the applied line voltage.

3. Install the FG 501 into the power module and, if applicable, install the TM 500-Series test equipment into the test equipment power module.

4. Connect the equipment under test and the test equipment to a suitable line voltage source. Turn on all equipment and allow at least 20 minutes for the equipment to stabilize.

¹Below SN B130000 AMPL control is labeled OUTPUT.
²For SN below B130000 set OFFSET to zero.

PERFORMANCE CHECK PROCEDURE

1. Dial Alignment

a. Set the FG 501 controls as follows:

FUNCTION	Triangle
AMPL ¹	Fully cw
OFFSET ²	Midrange and In
PHASE	In
MULTIPLIER	10 ³
FREQ VERNIER	Fully cw
FREQUENCY Hz	Near 10

b. Adjust the oscilloscope vertical for dc coupling at 2 V/div sensitivity. Set the time base sweep speed to .1 ms/div. Set the triggering controls to internal source + slope operation.

c. Connect the OUTPUT of the FG 501 through a 50 Ω coaxial cable and a 50 Ω termination, with the 50 Ω termination at the vertical input of the oscilloscope.

d. Adjust the oscilloscope trigger level control for a stable display of approximately 1 cycle per division.

e. CHECK—that the display stops changing frequency within ± 0.5 minor division of the 10 mark as the FREQUENCY Hz dial is adjusted back and forth around 10. (For ease in viewing the change in frequency, position the waveform so the trailing edge can be observed.)

f. Disconnect the 50 Ω cable and termination from the oscilloscope vertical input.

2. Square Wave Aberrations and Symmetry

a. Set the FG 501 controls as follows:

FUNCTION	Square Wave
AMPL ¹	Fully cw
OFFSET ²	In
PHASE	In
MULTIPLIER	10 ⁵
FREQ VERNIER	Fully cw
FREQUENCY Hz	8.0

b. Set the oscilloscope for a dc-coupled vertical input at 1 V/div sensitivity and a sweep speed of .05 μ s/div. Trigger on + slope.

c. Connect the FG 501 OUTPUT through a 50 Ω coaxial cable and a 50 Ω termination to the oscilloscope vertical input.

d. Adjust the test oscilloscope trigger level control to display the entire rising portion of the square wave.

e. Adjust the FG 501 OFFSET and AMPL controls for a five-division display (2.5 divisions above and below the graticule centerline).

f. Adjust the FG 501 high frequency compensation (C281) for a risetime of approximately 70 ns (10% to 90%).

g. Adjust the test oscilloscope trigger level to display the entire falling portion of the square wave. Check that the falltime is approximately 70 ns. Readjust C281 (if necessary) to balance risetime and falltime.

h. Set the oscilloscope time/div to .5 μ s/div. Check that aberrations on the positive and negative front corners of the square wave are less than 5%.

i. Set the oscilloscope vertical sensitivity to 1 V/div.

j. Adjust the oscilloscope sweep speed and variables to display one full cycle of the square wave in 10 divisions.

k. Set the oscilloscope X10 sweep magnifier on. Position the square-wave center voltage transition to exact display center.

l. Change the trigger polarity from + slope to – slope.

m. CHECK—that the center transition of the display does not shift horizontally more than 1 division (within 1%).

n. Disconnect the 50 Ω cable and 50 Ω termination.

3. Basic Timing

a. Set the FG 501 controls as follows:

FUNCTION	Triangle
AMPL ¹	Fully cw
OFFSET ²	Off (in)
PHASE	In
MULTIPLIER	10 ⁵
FREQ VERNIER	Fully cw
FREQUENCY Hz	10 (exactly)

b. Connect a 50 Ω coaxial cable and 50 Ω termination from the FG 501 OUTPUT to the frequency counter input.

¹Below SN B130000 AMPL control is labeled OUTPUT.
²For SN below B130000 set OFFSET to zero.

Specification and Performance Check—FG 501

c. CHECK—the FG 501 timing according to the following chart.

Counter Measurement Interval	FG 501 Frequency Hz Dial	FG 501 Multiplier	Frequency ($\pm 3\%$ of full scale)
.1 SEC	10	10^5	1 MHz ± 30 kHz (1.03 MHz—.970 MHz)
1 SEC	10	10^4	100 kHz ± 3 kHz (103 kHz—97 kHz)
1 SEC	10	10^3	10 kHz ± 300 Hz (10.3 kHz—9.7 kHz)
1 SEC	10	10^2	1 kHz ± 30 Hz (1.03 kHz—.97 kHz)
10 SEC	1	10^2	100 Hz ± 30 Hz (130 Hz—70 Hz)
1 SEC	1	10^3	1 kHz ± 300 Hz (1.3 kHz—700 Hz)
1 SEC	1	10^4	10 kHz ± 3 kHz (13 kHz—7 kHz)
1 SEC	1	10^5	100 kHz ± 30 kHz (130 kHz—70 kHz)

d. Set the frequency counter (dc coupled) to measure period for FG 501 MULTIPLIER settings slower than 10^2 in the following chart.

Counter	FG 501 Frequency Hz Dial	FG 501 Multiplier	Period ($\pm 3\%$ of full scale)
10 SEC	10	10	10.0 ms $\pm .33$ ms (10.33—9.67 ms)
1 SEC	10	1	100 ms ± 3.3 ms (103.3—96.7 ms)
1 SEC	10	10^{-1}	1000 ms ± 33.3 ms (1033.3—976.7 ms)

e. Disconnect the coaxial cables, terminations and tee connectors from all units.

¹Below SN B130000 AMPL control is labeled OUTPUT.

²For SN below B130000 set OFFSET to zero.

4. VCF INPUT

a. Set the FG 501 controls as follows:

FUNCTION	Triangle
AMPL ¹	Fully cw
OFFSET ²	In
PHASE	In
MULTIPLIER	10^5
FREQ VERNIER	Fully cw
FREQUENCY Hz	10 (exactly)

b. Connect a 50 Ω coaxial cable and 50 Ω feedthrough termination from the FG 501 OUTPUT to the frequency counter input for a reading of 1 MHz.

c. Adjust the 0-20 V power supply for zero volts out.

d. Connect a banana-to-bnc adapter and 50 Ω cable from the 0-20 V power supply output to the FG 501 VCF INPUT. Make sure the ground side of the banana-to-bnc adapter goes to the + terminal on the power supply.

e. Adjust the power supply output voltage to change the frequency of the FG 501 as read on the digital counter to 0.001 MHz.

f. Disconnect the bnc cable from the FG 501 VCF INPUT and connect the variable dc power supply to the digital voltmeter input.

g. CHECK—that the voltage measured on the digital voltmeter is ≤ -10 V.

h. Adjust the power supply output voltage to zero.

i. Disconnect the cables and termination from all units.

5. OUTPUT Signal Amplitude and Waveshape

a. Set the FG 501 controls as follows:

FUNCTION	Sinewave
AMPL ¹	Fully cw
OFFSET ²	In
PHASE	In
MULTIPLIER	10^3
FREQ VERNIER	Fully cw
FREQUENCY Hz	10

b. Set the oscilloscope vertical for dc-coupling at 2 V/div sensitivity. Set the triggering controls to internal, + slope. Set the time base sweep speed to 20 μ s.

c. Connect a 50 Ω coaxial cable and 50 Ω termination from the FG 501 OUTPUT to the oscilloscope vertical input and obtain a triggered display.

d. Turn the FG 501 FUNCTION selector to each position.

e. CHECK—that the peak-to-peak amplitude of each output signal is ≥ 10 volts for SN B130000-up; ≥ 7.5 volts for SN below B130000.

f. CHECK—that the waveform for each position of the FUNCTION selector corresponds to that shown on the front panel of the FG 501.

g. Disconnect the 50 Ω termination and 50 Ω cable from the oscilloscope.

6. OFFSET Range

a. Set the FG 501 as follows:

FUNCTION	Triangle
AMPL	Fully ccw
OFFSET	OUT (SN B130000-up)
PHASE	In
MULTIPLIER	10^3
FREQ VERNIER	Fully cw
FREQUENCY Hz	10

b. Set the digital voltmeter to the 20 dc volts scale.

c. Connect the FG 501 OUTPUT with a 50 Ω coaxial cable terminated in 50 Ω at the digital multimeter input.

d. Adjust the FG 501 OFFSET to the fully clockwise position.

e. CHECK—SN B130000-up for at least +3.75 V; SN below B130000 for at least +2.5 V.

f. Adjust the FG 501 OFFSET to the fully counterclockwise position.

g. CHECK—SN B130000-up for at least -3.75 V; SN below B130000 for at least -2.5 V.

¹Below SN B130000 AMPL control is labeled OUTPUT.

²For SN below B130000 set OFFSET to zero.

h. Disconnect the 50 Ω cable and 50 Ω termination from the digital voltmeter.

7. TRIG OUTPUT Amplitude

a. Set the FG 501 as follows:

FUNCTION	Triangle
AMPL ¹	Fully cw
OFFSET ²	In
PHASE	In
MULTIPLIER	10^3
FREQ VERNIER	Fully cw
FREQUENCY Hz	10

b. Set the oscilloscope for 1 V/div vertical sensitivity.

c. Connect a bsm-to-bnc adapter to the FG 501 TRIG OUTPUT. Connect a 50 Ω coaxial cable from the adapter to a 600 Ω through-signal termination. Connect the 600 Ω termination to the oscilloscope vertical input. Set oscilloscope triggering to internal and + slope. Set the triggering level for a stable display.

d. CHECK—for a square wave display equal to or greater than 2.5 volts in amplitude.

e. Disconnect the adapter, cable, and 600 Ω termination from both units.

8. Sine Wave Distortion

a. Set the FG 501 controls as follows:

FUNCTION	Sine wave
AMPL ¹	Fully cw
OFFSET ²	In
PHASE	In
MULTIPLIER	10
FREQ VERNIER	Fully cw
FREQUENCY Hz	10

b. If using a distortion analyzer similar to the HP 334A, connect the 50 Ω cable and 50 Ω termination from the FG 501 OUTPUT connector to the distortion analyzer input. Place a 50 Ω termination on the FG 501 VCF IN connector.

Specification and Performance Check—FG 501

c. CHECK—the sine wave distortion at frequencies and amplitudes as shown on the following chart:

FG 501 Frequency	FG 501 Multiplier	Distortion Analyzer Frequency	Percent Distortion
10	10	100 Hz	0.5%
10	10 ³	10 kHz	0.5%
10	10 ⁴	100 kHz	1.0%
6	10 ⁵	1 MHz	2.5%
5	10 ³	5 kHz	0.5%

d. Disconnect cable and terminations from FG 501 and distortion analyzer.

9. Phase Range

a. Set the FG 501 controls as follows:

FUNCTION	Triangle
AMPL ¹	Midrange
OFFSET ²	In
PHASE	In
MULTIPLIER	10 ³
FREQ VERNIER	Fully cw
FREQUENCY Hz	10

b. Set the oscilloscope vertical for dc-coupling at 1 V/div sensitivity. Trigger on the + slope, automatic, internal, and ac coupled. Set the time base sweep speed to 50 μ s.

c. Connect a 50 Ω coaxial cable from the pulse generator + output to a 50 Ω termination at the vertical input of the oscilloscope.

d. Adjust the pulse generator for a 2-volt square wave, 0.1 ms duration and 0.2 ms period.

e. Disconnect the pulse generator output cable and termination from the oscilloscope and connect them to the FG 501 GATE IN.

f. Connect a 50 Ω coaxial cable from the FG 501 OUTPUT to a 50 Ω termination at the oscilloscope vertical input.

g. Pull the FG 501 PHASE control knob out and turn it fully clockwise.

h. Check—that the flat portion of the display moves to the top peak of the triangle waveform as observed on the oscilloscope.

i. Set the FG 501 PHASE control fully counterclockwise.

j. Check—that the flat portion of the display moves to the bottom peak of the triangle.

k. Set the FG 501 PHASE control to 0° and push it in.

l. Adjust the FG 501 PHASE control fully clockwise and counterclockwise.

m. Check—that there is no change in the oscilloscope display.

n. Disconnect all cables and terminations.

This concludes the FG 501 Performance Check.

¹Below SN B130000 AMPL control is labeled OUTPUT.

²For SN below B130000 set OFFSET to zero.

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

ADJUSTMENT

Introduction

This adjustment procedure is to be used to restore the FG 501 to original performance specifications. Adjustment need not be performed unless the instrument fails to meet the Performance Requirements of the Electrical Characteristics listed in the Specification section, or the Performance Check cannot be completed satisfactorily.

Completion of all adjustment steps in this procedure ensures that the instrument will meet the performance requirements listed in the Specification section. However, to fully ensure satisfactory performance, it is recommended that the Performance Check be performed after any adjustment is made.

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 listed in Table 3-1, or equivalent, is required for adjustment of the FG 501. Specifications given for the test equipment are the minimum necessary for accurate adjustment and measurement. All test equipment is assumed to be correctly calibrated and operating within specification.

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

A flexible TM 500 extender cable, Tektronix Part No. 067-0645-02, is useful for troubleshooting or adjusting the FG 501; however, the complete Adjustment Procedure can be performed without use of the extender.

Table 3-1

LIST OF TEST EQUIPMENT REQUIREMENTS

Description	Performance Requirement	Application	Example
Oscilloscope	Bandwidth dc to 15 MHz; deflection factor 10 mV/div to 5 V/div; sweep rate 20 ns/div to 1 ms/div.	Steps 4 through 15	TEKTRONIX T921 or equivalent
Power Module	Three compartments or more	All steps	TEKTRONIX TM 503, TM 504, or equivalent
Digital Voltmeter	Range 0 to ± 20 V dc; displayed error less than 0.5%.	Set power supply voltages	TEKTRONIX DM 501 ^a
Frequency Counter	Frequency range 0.1 Hz to above 1 MHz; accuracy within one part in 10^5 ± 1 count.	Basic timing & VCF INPUT	TEKTRONIX DC 504 ^a or equivalent
Pulse Generator	0 to +2 V square-wave output into 50 Ω load. Period 0.2 ms; duration 0.1 ms.	Set phase range	TEKTRONIX PG 501 ^a or equivalent

Table 3-1 (cont)

Description	Performance Requirement	Application	Example
Distortion Analyzer	Frequency range from 1 Hz to at least 600 kHz. Distortion resolution <0.5%.	Set sine wave for minimum distortion	Hewlett-Packard 334A Distortion Analyzer or equivalent
50 Ω Feedthrough Termination (2)	bnc connectors	As required	Tektronix Part No. 011-0049-01
600 Ω Feedthrough Termination	bnc connectors	Sine wave upper and lower level adjustment	Tektronix Part No. 011-0092-00
50 Ω Coaxial Cables (2 ea)	bnc connectors	As required	Tektronix Part No. 012-0057-01
Adapter	bsm-to-bnc	Sine wave upper and lower level adjustment	Tektronix Part No. 103-0036-00
Tee Connector	bnc connectors	As required	Tektronix Part No. 103-0030-00
10X Attenuator	bnc connectors; 50 Ω impedance.	As required	Tektronix Part No. 011-0059-02
Variable Auto-transformer	Output to 135 V (270 V) at \approx 500 W	Setting power supplies	General Radio W10MT3W or equivalent
TM 500 Extender Cable	Make connections between FG 501 and power module.	As required	Tektronix Part No. 067-0645-02 or equivalent

^aRequires TM 500-Series Power Module.

Adjustment Locations

See Fig. 3-1 for the locations of all adjustable components and test points mentioned in this procedure. All adjustable components are located on the left side of the FG 501 circuit board.

Preparation

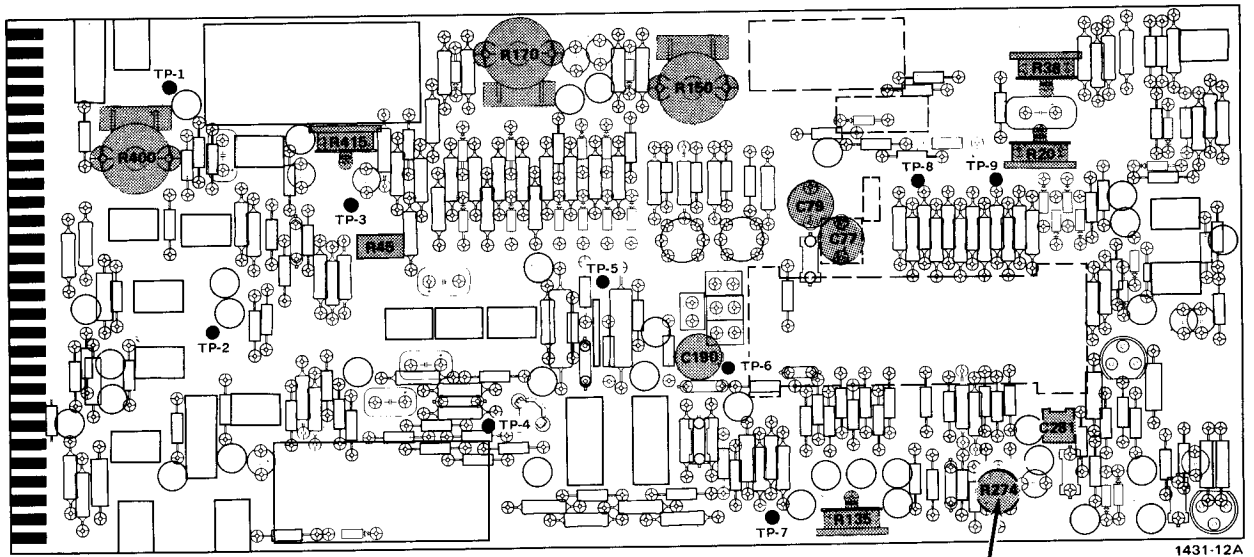
a. Disconnect the power module from the power source. Make sure the power module is set for the line voltage to be applied (see power module manual for line voltage setting). If the adjustments are to be made with the FG 501 plugged into the power module, remove the covers from the power module. If the adjustments are to be made with the FG 501 on an extender cable (Tektronix Part No. 067-0645-02), be sure the extender cable is oriented with the top of one connector toward the top of the FG 501 and the top of the other connector toward the top of the power module.

b. Remove the side covers of the FG 501 to gain access to the components and test points on the circuit board. Pull the rear end of the side cover outward from the side of the instrument (the covers snap into place).

c. Install all required TM 500-Series test equipment into the power module(s). Install the FG 501 (in left compartment of power module if extender cable is not used).

d. Connect the power module that powers the FG 501 to a variable autotransformer that is set to the middle of the line voltage operating range selected by the line voltage selector block in the power module. Connect the autotransformer to a line voltage source and turn the FG 501 on.

e. Connect all test equipment to a suitable line voltage source and turn it on. Allow at least 30 minutes warmup time before starting the adjustment procedure. All adjustments must be made at an ambient temperature between +20°C and +30°C.



SN B130000-up only.

Fig. 3-1. Adjustment and test point locations, SN B020000 & up.

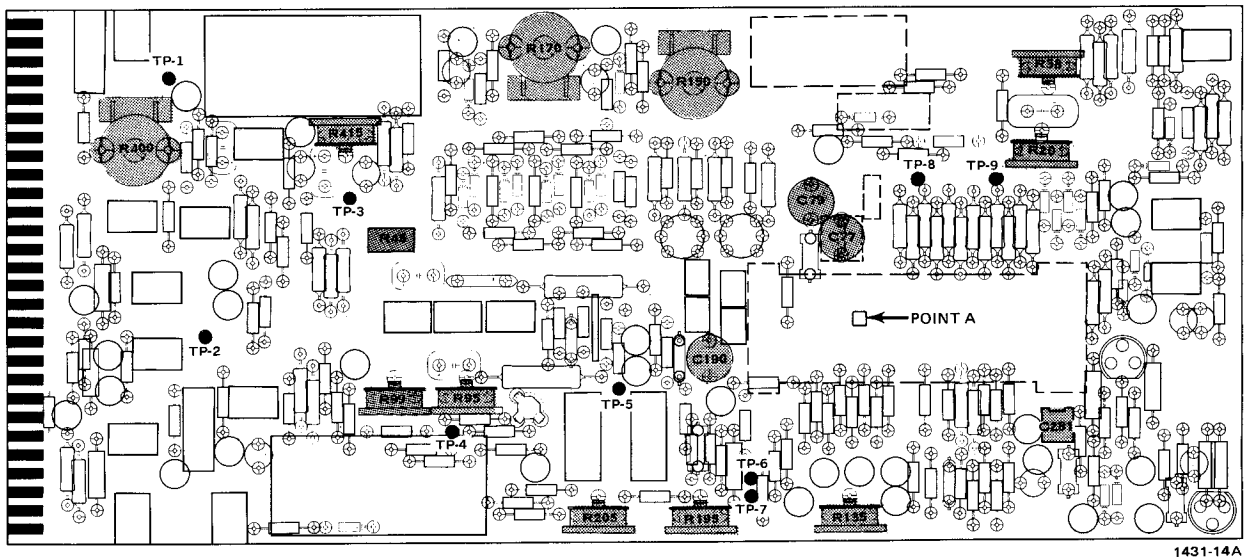


Fig. 3-2. Adjustment and test point locations, below SN B020000.

Adjustment—FG 501

Initial Control Settings

Set the following controls during warm-up time:

FG 501

FUNCTION	Triangle
AMPL ¹	Fully cw
OFFSET ²	In (off)
PHASE	Off (pushed in, set to 0°)
FREQ VERNIER	Calibrated (fully cw)
MULTIPLIER	10 ⁴
FREQUENCY Hz	1

DM 501

Range/Function switch 20 DC Volts

PROCEDURE (SN B020000 and up)

1. Reference Current Adjustment (+13.8 V dc)

a. Connect the digital voltmeter Lo input lead to ground (at negative end of C400). Connect the Hi input meter lead to TP1 on the FG 501 (see Fig. 3-1).

b. ADJUST—R400 (Reference Current) for a meter reading of +13.8 V dc.

2. +20 Volt Supply Adjustment

a. Move the digital voltmeter Hi input lead to TP3 on the FG 501.

b. ADJUST—R415 (+20 Volts) for a meter reading of +20.0 V dc.

3. +17 Volt Supply Check

a. Move the digital voltmeter Hi input lead to TP8 on the FG 501.

b. CHECK—for a meter reading of +17 V dc, ± 200 mV (+16.80 V to +17.20 V).

4. -17 Volt Supply Check

a. Move the digital voltmeter Hi input lead to TP9 on the FG 501.

b. CHECK—for a meter reading of -17 V dc, ± 200 mV (-17.20 to -16.80 V).

c. Disconnect the digital voltmeter leads from the FG 501.

¹Below SN B130000 AMPL control is labeled OUTPUT.
²For SN below B130000 set OFFSET to zero.

5. Adjust Square-Wave High-frequency Compensation and Check Risetime

Control Setting Changes:

FG 501

FUNCTION Square wave

Oscilloscope

Time/div 2 μ s (Mag off)
Volts/div 2 V
Input Coupling Dc

a. Connect the FG 501 OUTPUT connector through a 50 Ω coaxial cable to a 50 Ω termination at the oscilloscope vertical input connector. Check that the display amplitude is at least 10 V peak-to-peak (SN B130000-up); 7.5 V peak-to-peak for SN below B130000.

b. Set the oscilloscope variable volts/div, triggering, intensity, focus, and position controls for a visible, triggered, vertically-centered five-division display.

c. ADJUST—C281 (square-wave high-frequency compensation) for a square front corner and flat top with minimum aberrations on the positive-going portion of the square-wave display (this adjustment will affect square-wave risetime).

d. Set the oscilloscope time base to 20 ns (Mag on). Set intensity, triggering, and position controls as necessary to observe the positive-going square-wave leading edge over approximately five horizontal graticule divisions.

e. Measure the risetime of the leading edge (refer to the oscilloscope instruction manual for risetime measurement techniques). Adjust the position controls as required. At a sweep speed of 20 ns/div, the risetime reading should be no more than five horizontal divisions between the 10% and 90% risetime points (100 ns or less).

f. If necessary, repeat parts c through e for a compromise between best leading edge and flat top (aberrations not to exceed 5%) with a risetime of no more than 100 ns.

6. Dial Calibration

Control Settings:

FG 501

FUNCTION Triangle

Oscilloscope

Time base 10 μ s
Triggering For triggered display

a. Set the FREQUENCY Hz dial just to the point (near 10) where the frequency of the displayed waveform becomes maximum and there is not further change. This will be a few degrees before the waveform disappears (there is no signal output for a part of the area above 10 and below .1). For ease in determining the point of maximum frequency, use the oscilloscope horizontal position control to move the display so that the right end of the sweep can be viewed.

b. CHECK—that the FREQUENCY Hz dial reads 10 at the point where the frequency of the output signal ceases to increase.

c. If the dial does not read 10, loosen the two setscrews on the brass collar behind the dial and panel; then position the dial to 10 while holding the potentiometer shaft with needle-nose pliers. Re-tighten the setscrews.

7. X.1 Symmetry Adjustment

Control Settings:

FG 501	
FUNCTION	Square wave
FREQUENCY Hz	Near 1

a. Set the oscilloscope to display one full triggered square-wave cycle over 10 graticule divisions.

b. ADJUST—R45 (X.1 Symmetry) so that the positive-going and negative-going portions of the signal are of equal duration. Switch the oscilloscope triggering slope repeatedly from plus to minus while making final adjustments to R45.

c. Disconnect the 50 Ω termination from the oscilloscope input connector.

8. X10 Calibration

Note

Use of an oscilloscope in this step is optional.

Control Settings:

FG 501	
MULTIPLIER	10 ³
FREQUENCY Hz	10
FUNCTION	Triangle waveform
Counter	
Function	1 Hz
Hold	Fully ccw
Source	Ext
Trigger Level	0

a. Connect the FG 501 output through a 50 Ω coaxial cable and 50 Ω termination to the counter input (if the waveform is also to be displayed on an oscilloscope, insert a tee connector between the 50 Ω termination and the inputs to the counter and oscilloscope).

Oscilloscope

Time base	.1 ms
Triggering	Set for stable, triggered display

b. ADJUST—R20 (X10 Cal) for a counter reading of 10,000 (an oscilloscope display of approximately one cycle per division).

9. X1 Calibration

Control Settings:

FG 501	
FREQUENCY Hz	1
Oscilloscope (use of an oscilloscope in this step is optional)	
Time base	1 ms

a. Connect the FG 501 through a 50 Ω coaxial cable and 50 Ω termination to a tee connector. Connect the inputs of the counter and oscilloscope to the tee connector.

b. ADJUST—R38 (X1 Cal) for a counter reading of 1.0000 (note an oscilloscope display of about 1 cycle/division).

c. Set the FG 501 FREQUENCY Hz dial to 10 and the oscilloscope time base to .1 ms.

d. CHECK—for a counter reading of 10.000. If necessary, re-adjust R20 (X10 Cal) for a 10.000 reading (note an oscilloscope display of about 1 cycle/division).

e. Repeat Steps 8 and 9 as necessary.

10. 10⁵ Timing Adjustment

Control Settings:

FG 501	
MULTIPLIER	10 ⁵
FREQUENCY Hz	10
Oscilloscope (use of an oscilloscope in this step is optional)	
Time base	1 μs
Counter	
Function	.1 kHz

Adjustment—FG 501

a. ADJUST—C190 (10^5 X1 Timing) for a counter reading of 1.0000 (note an oscilloscope display of about 1 cycle/division).

11. 10^5 X1 Timing Adjustment

Control Settings:

FG 501

FREQUENCY Hz 1

**Oscilloscope
(use of an oscilloscope
in this step is optional)**

Time base $10 \mu\text{s}$

a. ADJUST—C79 (10^5 X1 Timing) for a counter reading of .1000 (note an oscilloscope display of about 1 cycle/division).

12. 10^4 X10 Timing Adjustment (Below SN B060000 only)

Control Settings:

FG 501

MULTIPLIER 10^4
FREQUENCY Hz 10

a. ADJUST—C77 (10^4 Timing) for a counter reading of .1000 (note an oscilloscope display of about 1 cycle/division).

13. Sine-wave Upper and Lower Level Adjustment

Control Settings:

FG 501

FUNCTION Sine-wave
MULTIPLIER 10
FREQUENCY Hz 10 (100 Hz)
AMPL¹ Clockwise
PHASE In (off)
OFFSET² In (off)

a. Connect the FG 501 to the Distortion Analyzer through a 50 Ω coaxial cable and 50 Ω termination.

b. ADJUST—Upper Level Adjustment R150 and Lower Level adjustment R170 for minimum distortion as read by the Distortion Analyzer.

c. Check the distortion at the frequencies listed in Table 3-2.

¹Below SN B130000 AMPL control is labeled OUTPUT.
²For SN below B130000 set OFFSET to zero.

Table 3-2

FG 501 FREQUENCY	FG 501 MULTIPLIER	FREQUENCY	PERCENT DISTORTION
10	10	100 Hz	0.5%
10	10^3	10 kHz	0.5%
10	10^4	100 kHz	1.0%
5	10^3	5 kHz	0.5%

d. Set the FREQUENCY Hz dial for .1 and the MULTIPLIER switch to 10^3 . Place a 50 Ω termination on the VCF INPUT connector. Set the FUNCTION switch to square wave.

e. Disconnect the FG 501 OUTPUT cable and termination from the distortion analyzer and connect them to the input of an oscilloscope. Set the oscilloscope to display one full triggered square-wave cycle over 10 graticule divisions. Switch the oscilloscope triggering slope repeatedly from plus to minus and check the square-wave symmetry. If it is no longer symmetrical, repeat the X.1 Symmetry Adjustment (Step 7 of this procedure).

g. Repeat Step 13 parts c and d as necessary.

14. Triangle DC Level and Phase Range Adjustment

Control Setting:

FG 501

FUNCTION Triangle
MULTIPLIER 10^4
FREQUENCY Hz 10

Pulse Generator

Period .2 ms
Duration .1 ms
Amplitude +2 V into 50 Ω

Oscilloscope

Time base .1 ms

a. Connect the pulse generator + output through a 50 Ω coaxial cable and 50 Ω termination to the FG 501 GATE INPUT connector.

b. Pull the FG 501 PHASE control out (on).

c. CHECK—that the display is several bursts of triangle waveforms with a horizontal bar connecting one burst to the next. Rotate the PHASE control fully

clockwise and the horizontal bars should move to at least the top of the triangle burst waveforms. Rotate the PHASE control fully counterclockwise and the horizontal bar should move to at least the bottom of the triangle burst waveforms.

d. ADJUST—R135 (triangle DC Level) if operation is not as described in Step 14 part c above (adjust for equal movement of bar above and below the burst waveforms).

e. Repeat parts c and d above as necessary.

f. Return the PHASE knob to 0° and press it in (off).

g. Disconnect the cable and termination from the pulse generator and FG 501 GATE INPUT.

15. Adjust Output Balance (SN B130000 and up)

Control Settings:

FG 501	
AMPL ¹	Minimum Output (ccw)
OFFSET ²	In (off)

Oscilloscope	
Volts/div	.1 V

- Center the oscilloscope trace.
- ADJUST—output balance control R274 until the trace is centered on the screen of the oscilloscope.
- Disconnect all test equipment.

This completes the FG 501 adjustment procedure.

PROCEDURE (SN BELOW B020000)

Steps 1 through 4: perform Steps 1 through 4 as shown for SN B020000-up on page 3-4 except refer to Fig. 3-2.

5. Adjust +4.5 Volts Triangle Amplitude

Control Setting Changes:

FG 501	
MULTIPLIER	10 ²

Oscilloscope	
Volts/Div	0.2 V
Vertical Input Coupling	Dc
Triggering	Auto
Time Base	1 ms
Intensity, Level & Position	For visible, triggered display

¹Below SN B130000 AMPL control is labeled OUTPUT.

²For SN below B130000 set OFFSET to zero.

a. Connect a 10X probe from the oscilloscope to test point 6 (if TP6 is not present use point A, the circuit board pad below C77 and right of R251). Connect probe ground clip to chassis ground.

b. Set FREQUENCY Hz for maximum frequency as viewed on test oscilloscope.

c. Set oscilloscope vertical input coupling to ground and use Position control to vertically center the trace at the center horizontal graticule line. Return input coupling to dc.

d. ADJUST—R195 (+4.5 volts \wedge Ampl) so the positive peaks on the display extend 2.25 divisions above the graticule center.

e. ADJUST—R205 (-4.5 volts \wedge Ampl) so the negative peaks on the display extend 2.25 divisions below graticule center.

f. Repeat parts d and e as necessary.

6. Triangle DC Level

a. Move probe tip to TP7 (emitter of Q38).

b. ADJUST—R135 (\wedge DC Level) so the display extends an equal distance above and below graticule center.

7. Gate Centering

a. Move the 10X probe tip to TP5 (Q85 base).

b. Use vertical position control to center the display on the graticule.

c. Move the probe tip to TP4 (center tap of Gate Centering R95).

d. ADJUST—R95 to re-center the display on the graticule.

e. Disconnect the probe tip and ground clip from the FG 501 and disconnect probe from oscilloscope.

8. Square Wave Amplitude

a. Connect a 50 Ω cable from the FG 501 OUTPUT connector to a 50 Ω termination at the oscilloscope vertical input connector.

b. Set OFFSET and OUTPUT for a 6 division display.

c. Set FUNCTION to \square (square wave).

d. ADJUST—R99 (\square Ampl Cal) for a 6-division display. If necessary, adjust OFFSET to keep display vertically centered.

Adjustment—FG 501

9. Square-Wave High Frequency Compensation

Control Setting Changes:

Oscilloscope

Time Base 2 μ s
Triggering & Position As Required

a. ADJUST—C281 (\square HF Comp) for best flat top and square corner on the display.

10. Dial Calibration

Control Setting Changes:

FG 501

FUNCTION \wedge (triangle waveform)
FREQUENCY Hz Maximum displayed
 frequency

Oscilloscope

Time base 1 ms/division

a. CHECK—that the FREQUENCY Hz dial reads 10; if not, perform part b.

b. Loosen the two set screws on the brass collar behind the FREQUENCY Hz knob. Hold R25 shaft with pliers to maintain maximum frequency display while rotating dial to read 10, then tighten screws.

11. X10 Calibration

a. ADJUST—R20 (X10 Cal) for 1 triangle waveform/division.

12. X1 Calibration

a. Set FREQUENCY Hz to 1 and oscilloscope time base for 10 ms/division.

b. ADJUST—R38 (X1 Cal) for one triangle waveform/division.

c. Set FREQUENCY Hz to 10 and oscilloscope time base for 1 ms/division.

d. CHECK—for one triangle waveform/division. If not, readjust R20 and repeat parts a through d for best calibration.

13. X1 Symmetry

a. Set MULTIPLIER to 10^3 and FUNCTION to \square (square-wave). Set oscilloscope time base for 10 ms/division.

b. ADJUST—R45 (X.1 Sym) so the upper and lower portions of the displayed square wave are of equal duration.

14. 10^5 X10 Timing

Control Setting Changes:

FG 501

FUNCTION \wedge (triangle)
MULTIPLIER 10^5
FREQUENCY Hz 10

Oscilloscope

Time base 1 μ s/division

a. ADJUST—C190 (10^5 X10 Timing) for one triangle waveform/division.

15. 10^5 X1 Timing

a. Set FREQUENCY Hz to 1 and oscilloscope time base for 10 μ s/division.

b. ADJUST—C79 (10^5 X1 Timing) for one triangle waveform/division. Repeat steps 14 and 15 as necessary for best calibration.

16. 10^4 X10 Timing

a. Set MULTIPLIER to 10^4 , FREQUENCY Hz to 10, and oscilloscope time base for 10 μ s/division.

b. ADJUST—C77 (10^4 X10 Timing) for one triangle waveform/division.

c. Disconnect the 50 Ω termination from the oscilloscope input.

17. Upper and Lower Sine-Wave Level

Control Setting Changes:

FG 501

FUNCTION \sim (sine wave)
MULTIPLIER 10^4
FREQUENCY Hz 1

a. Connect the 50 Ω termination on OUTPUT cable to the distortion analyzer input.

b. ADJUST—R150 (\sim Upper Level) and R170 (\sim Lower Level) for a minimum distortion reading on the analyzer.

MAINTENANCE AND INTERFACING INFORMATION

PREVENTIVE MAINTENANCE

Preventive maintenance steps performed on a regular basis will enhance the reliability of the FG 501. However, checks of the semiconductors in the absence of a malfunction are not recommended as preventive maintenance measures. The recommended time for performing preventive maintenance is just before instrument adjustment.

Cleaning



Do not use acetone, MEK, MIBK, benzene, toluene, carbon tetrachloride, trichloroethylene, methyl alcohol, methylene chloride, sulphuric acid, or Freon compounds for cleaning the FG 501. Use only clean water and a mild detergent.

Exterior. Loose dust may be removed with a soft cloth or dry brush. Water and a mild detergent may be used; however, abrasive cleaners should never be used.

Interior. Cleaning the interior of the unit should precede adjustment since the cleaning process could alter the settings of calibration adjustments. Use low-velocity compressed air to blow off accumulated dust. Hardened dirt can be removed with a soft dry brush, cotton-tipped swab, or a cloth dampened in a solution of water and mild detergent.

Adjustment

After cleaning or repairs, do the performance check as described in Section 2 of this manual. If all functions are within specification, no adjustment is needed. If one or more of the specifications are not met, calibrate the instrument as directed in Section 3, Adjustment.

Lubrication

No lubrication is required in the FG 501.

TROUBLESHOOTING AIDS

Circuit Descriptions

Section 5 of this manual explains circuit operation in detail. Used conjointly with the circuit diagrams, the section can be a powerful analytic tool.

Diagrams

A block diagram and detailed circuit diagrams are located on foldout pages in the diagrams section. The circuit diagrams show the component values and assigned circuit reference numbers of each component. The first page of the Diagrams section defines the circuit symbols and reference designators used in the manual. Major circuits are usually identifiable by a series of component numbers. Important waveforms and voltages may be shown within the diagrams, or on adjoining aprons. Those portions of the circuits located on circuit boards are enclosed with gray tint outline.

Cam Switch Charts

Cam switches shown on the diagrams are coded on comprehensive charts to locate the cam number of the switch contact in the complete switch assembly, counting from the front, or knob end, toward the rear of the switch. The charts also indicate with a solid dot when each contact is closed.

Circuit Board Illustrations

Line illustrations showing component locations keyed with a grid locator and table are placed on the back of a foldout page and sequenced as closely as possible to the related circuit diagrams.

To identify electrical components when troubleshooting, turn to the appropriate Parts Location Grid in the Diagrams section. Component values, descriptions, and ordering data are given in the Replaceable Electrical Parts list.

Component and Wiring Color Codes

Colored stripes or dots on electrical components signify electrical values, tolerances, etc. according to EIA standards. Components not color coded usually have information printed on the body. Some wiring coding follows the same EIA standards.

Testing Equipment

Generally, a wide-band oscilloscope, a low-capacitance probe, and a multimeter are all that is needed to perform basic waveform and voltage checks for diagnostic purposes. The calibration procedure and performance check procedure list specific test equipment necessary to adequately check out the instrument.

TROUBLESHOOTING TECHNIQUES

This troubleshooting procedure is arranged in an order that checks the simple trouble possibilities before proceeding to extensive troubleshooting.

Control Settings

Incorrect control settings can indicate a trouble that does not exist. If there is any question about the correct function or operation of any control, see the operating instructions in Section 1.

If the FG 501 is operating as part of an interconnected system or test setup, also check control settings of the other instruments in the setup. Check for proper interconnections between the power module and the plug-in modules. Check that the signal is properly connected and that the interconnecting cables and signal source are not defective. Check the power source.

If the power module is suspected, try substituting another FG 501 known to be good into the power module. If the trouble persists after substitution, move the FG 501 to another compartment in the power module to determine if the trouble is confined to one compartment or is common to all of them.

Visual Check

Remove the covers from the FG 501 and look for broken wires, loose or unsoldered connections, damage to the circuit board, and the like. If components damaged from overheating are found, determine the cause of overheating before replacing the component; otherwise, the new component may also be damaged.

Circuit Isolation

Note the symptom. It often identifies the circuit in which the trouble is located. When trouble symptoms appear in more than one circuit, check the affected circuits by making waveform and voltage measurements.

Incorrect operation of all circuits often means trouble in power supplies. Using a multimeter, check first for correct voltages of the individual regulated supplies according to the circuit diagrams and adjustment procedures. Then check the unregulated supplies of the power modules. Defective components elsewhere in the instruments can appear as power supply problems. In these instances, suspected circuits should be disconnected from apparently bad power supplies one at a time to narrow the search.

Voltages and Waveforms

Often defective components can be located by using waveform and voltage indications when they appear on the circuit diagram or in the adjustment procedures. Such waveforms and voltage labels are typical indications and will vary between instruments.

Component Checking

If a component cannot be disconnected from its circuit, the effects of the associated circuitry must be considered when evaluating the measurement. Except for soldered-in transistors and integrated circuits, one end of most components can be unsoldered and lifted from the circuit board.

Transistors and Integrated Circuits (IC). Turn the power switch off before removing or replacing any semiconductor.

A good check of transistor operation is actual performance under operating conditions. A transistor can most effectively be checked by substituting a new component for it (or one which has been checked previously). However, be sure that circuit conditions are not such that a replacement transistor might also be damaged. If substitute transistors are not available, use a dynamic tester. Static-type testers are not recommended since they do not check operation under simulated operating conditions. A wick-type desoldering tool can be used to remove soldered-in transistors.

Integrated circuits can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of the circuit description is essential to troubleshooting circuits using integrated circuits. Operating waveforms, logic levels, and other operating information for the integrated circuits are given in the circuit description information. Use care when checking voltages and waveforms around the integrated circuits so that adjacent leads are not shorted together. A convenient means of clipping a test probe to the 14- and 16-pin in-line integrated circuits is with an integrated circuit test clip. This device also doubles as an extraction tool.

Diodes. Do not use an ohmmeter that has a high internal current. High currents may damage the diode, so use the RX1000 scale on the ohmmeter.

Ordinary signal diodes may be checked for an open or shorted condition by measuring the resistance between terminals. With the ohmmeter set to the RX1000 scale, the resistance should be very high in one direction and very low when the leads are reversed.

Resistors. Check resistors with an ohmmeter. Resistor tolerances are given in the Replaceable Electrical Parts list. Resistors do not normally need to be replaced unless the measured value varies widely from the specified value.

Capacitors. A leaky or shorted capacitor can be detected by checking resistance with an ohmmeter on the highest scale. Use an ohmmeter which will not exceed the voltage rating of the capacitor. The resistance reading should be high after initial charge of the capacitor. An open capacitor can best be detected with a capacitor tester, or by checking whether it passes ac signals.

PARTS ORDERING AND REPLACING

Ordering

Standard Parts. Most electrical and mechanical parts can be obtained through your local Tektronix field office or representative. However, you should be able to obtain many of the standard electronic components from a local commercial source in your area. Before you purchase or order a part from a source other than Tektronix, Inc., please check the electrical parts list for the proper value, rating, tolerance, and description. When selecting replacement parts, it is important to remember that the physical size and shape of the component may affect its performance in an instrument. All replacement parts should be direct replacements unless it is known that a different component will not adversely affect the instrument performance.

Special Parts. 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 system have been manufactured by Tektronix, Inc. Order all special parts directly from the local Tektronix Field Office or representative.

Ordering Procedure. When ordering replacement parts from Tektronix, Inc., please include the following minimum information:

1. Instrument Type (FG 501).

2. Instrument Serial Number (for example, B010251).
3. A description of the part (if electrical, include the circuit number).
4. Tektronix part number.

Please do not return any instruments or parts before receiving directions from Tektronix, Inc.

A listing of Tektronix Field Offices, Service Centers, and Representatives can be found in the Tektronix Product Catalog and Supplements.

Replacing

The exploded view drawings associated with the Replaceable Mechanical Parts list, located at the rear of the manual, may be especially helpful when disassembling or reassembling individual components or sub-assemblies.

Circuit Boards. If a circuit board is damaged beyond repair, the entire assembly, including all soldered-on components, can be replaced.

To remove or replace a board, proceed as follows:

1. Disconnect all leads connected to the board (both soldered lead connections and solderless pin connections).
2. Remove all screws holding the board to the chassis or other mounting surface. Remove any knobs, etc., that would prevent the board from being lifted out of the instrument.
3. Lift the circuit board out of the unit. Do not force or bend the board.
4. To replace the board, reverse the order of removal. Use care when replacing pin connectors; if forced into place mis-aligned, the pin connectors may be damaged.

Transistors and Integrated Circuits. Transistors and integrated circuits should not be replaced unless they are actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement or switching of semiconductor devices may affect the calibration of the instrument. When a transistor is replaced, check the operation of the part of the instrument that may be affected.

Maintenance and Interfacing Information—FG 501

Replacement semiconductors should be of the original type or a direct replacement. Figure 4-1 shows the lead configuration of the semiconductors used in this instrument system. When removing soldered-in transistors, use a suction-type de-soldering tool to remove the solder from the holes in the circuit board.

An extracting tool should be used to remove the 14- and 16-pin integrated circuits to prevent damage to the pins. This tool is available from Tektronix, Inc. Order Tektronix Part No. 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 having one end of the integrated circuit disengage from the socket before the other end.

Cam Switches. Repair of cam-type switches should be undertaken only by experienced maintenance personnel. Switch 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-type 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. Using both thumbs, pull the bottom edges of the metal switch covers apart far enough to where they will slip past the detents and come off. 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) which 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 re-install the switch assembly, reverse the above procedure.

Incandescent Bulbs. The POWER light bulb is mounted on the sub-panel using a plastic sleeve. Unsolder the lead wires and pull the bulb out of the sleeve from the rear of the sub-panel.

Customizing the Interface

Input and output access to the FG 501 is available at the rear of the main circuit board. Fig. 4-2 identifies the contacts and their respective I/O assignments.

A power module mainframe option (Option 2) is available that provides a rear-panel, multi-pin connector to which I/O lines can be hard-wired for external access. Also possible are intra-compartment connections with other plug-in modules in multiple-compartment mainframes.

A slot between pins 23 and 24 on the rear connector identifies the FG 501 as a member of the signal source family. If the interface is customized, insert a barrier in the corresponding position of the power module jack to prevent other than signal source plug-ins from being used in that compartment. This protects the plug-in should specialized connections be made to that compartment. Consult the Building A System section of the power module manual for further information.

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.

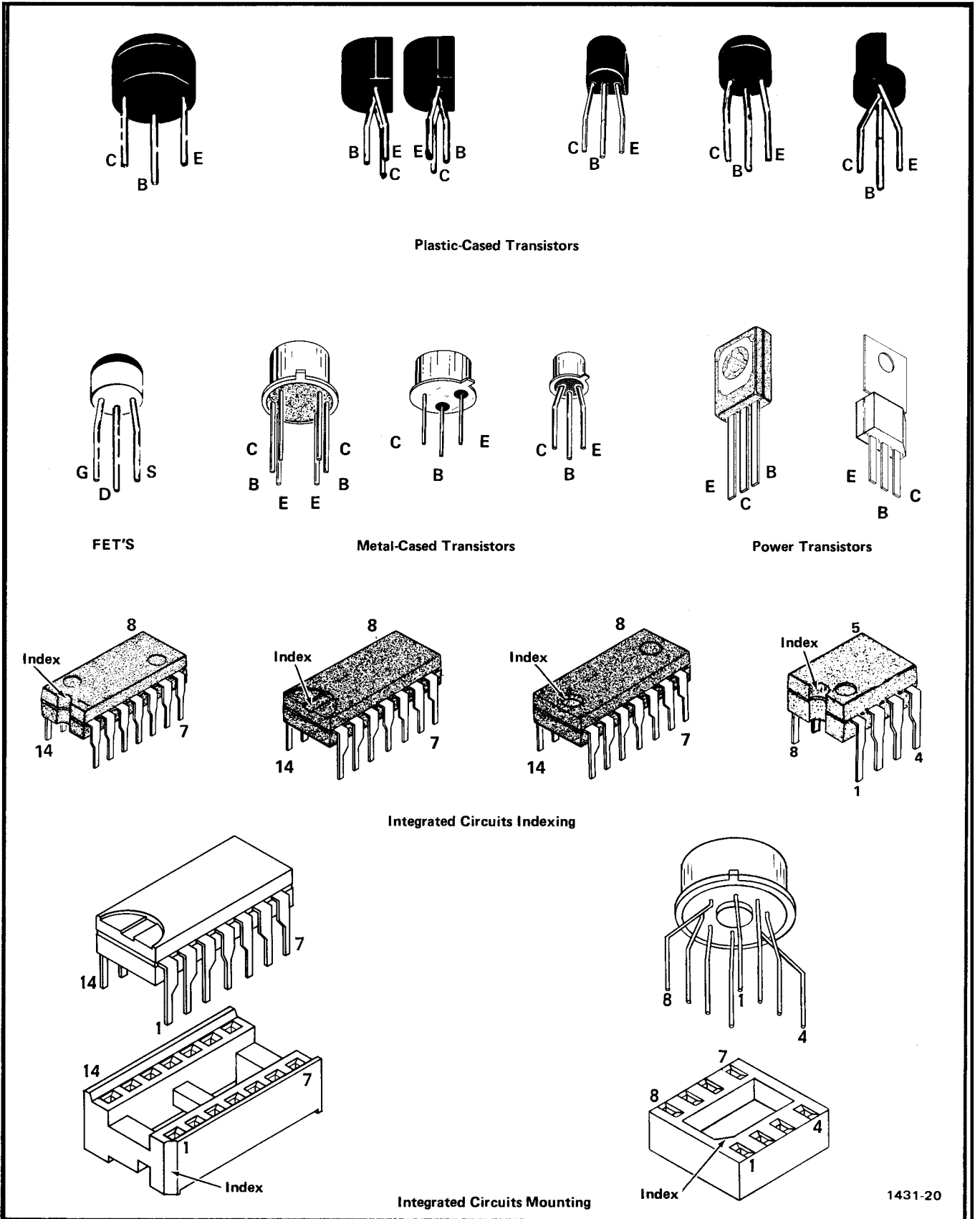


Fig. 4-1. Semiconductor device lead configurations found in the FG 501.

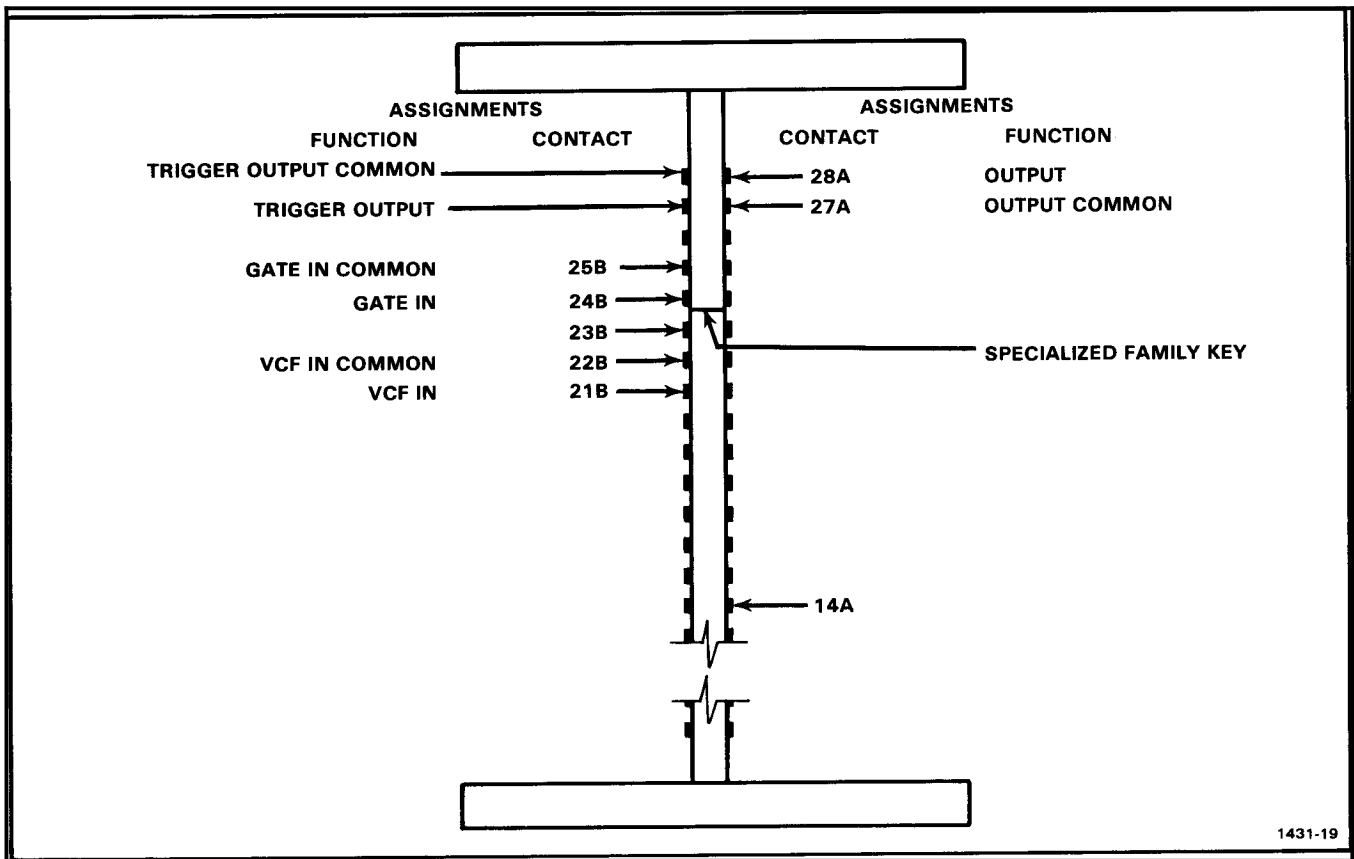


Fig. 4-2. Input/output assignments at rear interface connector, rear view.

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

Surround the instrument with polyethylene sheeting to protect the finish of the instrument. Obtain a carton of corrugated cardboard of the correct carton strength and having inside dimensions of no less than six inches

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

The carton test strength for your instrument is 200 pounds.

CIRCUIT DESCRIPTION

Introduction

The following is a description of the electrical circuits in the FG 501. Refer to the simplified block diagram and the detailed schematic diagrams on the foldout pages at the back of the manual to aid in understanding this description.

LOOP GENERATOR

Triangle Waveform Generation

Operational amplifiers U45 and U48 in conjunction with Q45A/B and Q48A/B are voltage followers. Thus, the voltage at pin 3 of U45 and U48 is also present at the emitters of Q45A/B and Q48A/B. Switch S50 (MULTIPLIER) and resistance network R53 through R60 provide constant current to the emitters of Q45A/B which, together with U45, compose a positive current source that charges the timing capacitor selected by S50 (C72 through C79). Resistor network R63 through R70 provides constant current to the emitters of Q48A/B that, together with U48, compose a negative current source that also charges the timing capacitor selected by S50.

The current sources for the operational amplifiers and the timing capacitor are separate. Thus, input current requirements of the amplifiers have little effect upon the timing current supply. Q45A and Q45B are identical current sources. Q45A supplies approximately 70 nA to U45 input (the remaining current goes to ground), while Q45B supplies charging current to the timing capacitor.

The current switch, composed of CR100 through CR103 and emitter-coupled transistors Q85 and Q90, determines whether the positive current source or negative current source charges the timing capacitor. For example, if CR100 is turned off, all the current from Q45B goes through CR102 to charge the timing capacitor in the positive direction at a linear rate. Emitter follower Q138 passes the linear ramp through divider network R190/R191 and to pins 3 and 5 of upper and lower level comparators U195A/B. The voltage at pin 2 of U195A sets the upper hysteresis. The voltage at pin 6 sets the lower hysteresis. With CR100 off, U195A is in the negative state until the ramp at pin 3 reaches +1.77 V; then the output at pin 10 goes positive. The output of inverting amplifier U80C then goes negative, which causes nor gate U80D output to go positive. Thus, pin 9 of lower-level comparator U195B goes positive, which enables lower-level comparator U195B. Consequently, emitter-coupled switch Q85 turns on. The collector of Q85 moves in the negative direction, which turns on CR100 and turns off CR101. Thus, the negative current source now charges the

timing capacitor and the ramp starts to go negative at a linear rate. Again, the ramp is applied to the divider network R190/R191, and to pin 5 of U195B. When the ramp reaches -1.77 V, the output at pin 10 of U195B goes negative. This causes the output of U80C to go positive, pin 13 of U80D goes negative, Q85 turns off, and Q90 turns on. CR101 turns on again, while CR100 turns off. This action is repeated to form a triangle waveform output from the loop generator. The slope (frequency) of the triangle is determined by how much current the positive and negative current sources provide to the timing capacitors.

Potentiometer R25 (FREQUENCY Hz) provides 0 V to approximately 10 V to pin 3 of voltage follower U30. The output of U30 is fed to pin 2 of voltage summing amplifier U15 where it is summed with an offset voltage (approximately -7 V) from potentiometer R38 (X1 Cal) and any VCF input applied to J10. Voltage summing amplifier U15 has an output range of +7 to +17 V which drives the positive current source. This 10 V swing across the timing resistors provides a wide current (frequency) range.

The negative current source is also driven by the positive voltage output of U15. However, the polarity is reversed by inverting amplifier U40. Thus, the voltage change at pin 3 of U48 in the negative current source very closely tracks that at pin 3 of U45 in the positive current source. Low frequency symmetry is adjustable by potentiometer R45 (X.1 Sym).

Frequency Switching

Frequency (decade) switching from 1 Hz to 1 MHz is accomplished by changing timing capacitors, and from 1 Hz to 0.0001 Hz by changing timing resistors.

External Voltage-Controlled Frequency (VCF) Mode

Voltage-controlled frequency is accomplished by applying a voltage to J10 (VCF INPUT) which is summed with the voltage set by R25 (FREQUENCY Hz). Subsequently, the current to the timing capacitor is changed, which changes the generator output frequency as described under Triangle Waveform Generation.

Circuit Description—FG 501

Level Shifting

Level shifting occurs in the circuit composed of Q125 and Q130. Q130 is a current source for Q125. Q130 also ensures that any bias across source follower Q120 is dropped across R127, which shifts the level of the input to the sine shaper circuit (Q150 and Q170) with respect to 0 V (+7.5 V to -7.5 V).

Sine Waveform Generation

The sine shaper is composed of Q150, Q170, and an associated divider-diode network. The resistor network composed of R155, R156, R158, R160, and R162 forms a voltage divider with a diode connected to each junction. In series with the diodes are resistors R157, R159, R161, and R163. A positive-going ramp from the emitter of Q138 will turn on the diode with the least current first; in this case, CR162. Diode CR162 has the least effect on the incoming ramp. Each successive diode has a greater effect. CR155 has the maximum effect since there is no resistor at its anode end. Thus, the peaks of the triangle waveform are clipped harder than are the remaining portions. The reverse is true of the negative half of the sine shaper, i.e., Q170 and its associated divider-diode network. Potentiometers R150 (Upper Level) and R170 (Lower Level) at the bases of Q150 and Q170 adjust for minimum distortion of the sine shaper output. Thus, a sine waveform is derived from the triangle waveform.

Square Waveform Generation

A square waveform output is derived by taking the available square waveform from the collector of current switch driver Q90 and feeding it through divider R102-R105 and to switch S250 (FUNCTION).

External Gate Mode

Gating is accomplished by applying an external signal to J215 (GATE INPUT) and closing S245 (PHASE). As long as pin 12 of nor gate U80D is near ground, the loop

generator is functioning. However, a positive voltage at pin 12 of U80D will disable the loop generator.

In normal operation with no external gating signal at J215 (GATE INPUT), transistors Q80 and gate amplifier Q225 are on (saturated), which holds phase clamp switch Q230 off. When Q230 is off, the phase clamping circuit (composed of U235 and current boosting transistors Q240 and Q242) does not affect the gate of source follower Q120. Assume that switch S245 (PHASE) is closed and a square wave is applied to J215 (GATE INPUT). During the positive transition of the gating signal, the loop generator continues to run, since Q80 and Q225 are already on. However, when the gating signal goes negative, Q80 turns off because the input impedance of the gating input drops to 1 k Ω (R220 vs R81), and turns off Q80 and Q225. Pin 12 of U80D is pulled up and the loop generator is disabled. Simultaneously, Q230 turns on, which also turns on diodes CR245 through CR248. The gate of source follower Q120 is now clamped to the voltage set by U235 and associated current-boosting transistors Q240 and Q242. By adjusting the input to pin 3 of U235 with potentiometer R235 (PHASE), the clamping voltage to the gate of Q120 can be shifted to start the triangle waveform anywhere from +90° to -90° from the sine and triangle 0° start point.

Hold Mode

Cam switch S50 (MULTIPLIER) has three positions between the three lowest frequency range settings that stop the triangle waveform at its instantaneous voltage level (i.e., the timing capacitor charge holds at its instantaneous level) until S50 is switched back to a range position. The hold contacts on cam switch S50 are normally closed.

OUTPUT AMPLIFIER

Cam switch S250 (FUNCTION) selects a triangle, square, or sine waveform and feeds it to the output amplifier.

Transistors Q250 and Q255 are complementary emitter followers that offset (via R281 and Q276) any differential between the input and output voltage and provide temperature compensation.

Assume that a triangle waveform is selected by S250 (FUNCTION). The triangle waveform voltage applied to the output amplifier is varied in amplitude by potentiometer R260A (OUTPUT), then summed with the current through R268. The output amplifier is basically an operational amplifier. Its gain is determined by input resistor R279 and feedback resistor R281. Transistor Q270 provides the positive input. Now, when Q270 turns on (i.e., a positive voltage is applied to its base), Q290 turns on

which turns on Q295 and pulls the output up. If Q276 turns on (i.e., Q270 turns off when a negative voltage is applied to its base), Q280 turns on, which turns on Q285. Consequently, Q298 turns on and pulls the output down. R298 establishes the source impedance of the output. Potentiometer R274 provides an adjustment for dc balance.

Pulse and Ramp Generation

Switch S250 (FUNCTION) also applies pulses and ramp waveforms to the output amplifier.

When a positive or negative ramp waveform is selected by S250, a lower resistance is switched into the positive or negative current sources, depending on the polarity of the selected ramp waveform. For instance, if the positive current source had the least resistance, then current would increase in that source and consequently increase the slope of that particular side of the ramp. The reverse is true if the negative current source has the least resistance.

Positive or negative pulses are obtained by changing the duty cycle of the square waveform. The output pulse is derived from the "on" portion of the square waveform. The triangle generator frequency determines the frequency of the square waveform and, thus, the pulse frequency.

POWER SUPPLIES

+20 V Reference Supply

The +20 V Supply is the reference for all the supplies. Diode bridge network CR400 and capacitor C400 convert the raw 25 V ac from the power module to +33 V dc, which is then fed to the +20 V Reference Supply. Field effect transistor Q400 along with R405 compose a constant current source for 6.2 V zener diode VR405. VR405 is temperature compensated at approximately 7 mA when potentiometer R400 (Reference Current) is adjusted for 7 V across R405, which then establishes the 6.2 V reference for non-inverting operational amplifier U410. Negative feedback is provided through resistor network R410-R415. Potentiometer R415 (+20 Volts) is adjusted for +20 V output. When output current exceeds 200 mA, sensing resistor R417 in the emitter of series pass transistor Q410 turns Q415 on, which pulls down the base of Q410 and shuts the +20 V Supply off.

+20 V Decoupled Supply

Voltage follower U420, in conjunction with current booster Q420, drives the series pass transistor in the power module. Current sensing resistor R424 turns on Q424 when output current exceeds 400 mA, which pulls down the base of Q420 and shuts off the +20 V Decoupled Supply.

−20 V Reference Supply

The −20 V Supply consists of inverting operational amplifier U480. Input resistor R481 and feedback resistor R482 are 0.1%, thereby ensuring that the −20 V Reference Supply accurately follows the +20 V Reference Supply. As in the +20 V Reference Supply, series pass transistor Q488, current sensing resistor R487, and transistor Q485 provide overcurrent shutdown (in excess of 200 mA).

−20 V Decoupled Supply

Voltage follower U470 with its associated current booster Q472 and current sensing resistor R473 operate identically to the +20 V Decoupled Supply.

+17 V Supply

Voltage follower U430 with voltage divider R430/R431 compose the +17 V Supply. Divider R430-R431 establishes +17 V at pin 3 of U430, while feedback is supplied to pin 2 from current booster Q430. There is no current sensing resistor in the 17 V Supply since the voltage for the 17 V Supply is supplied by the +20 V Reference Supply, which has overcurrent protection.

−17 V Supply

The −17 V Supply consists of inverting operational amplifier U460, current booster Q468 and 0.1% resistors R464 and R465 which provide an accurate −17 V with respect to the +17 V Supply.

+5 V Supply

Divider R441-R442 provides +5 V to pin 3 of voltage follower U440. If excessive current is drawn, current sensing resistor R446 turns on Q447 which pulls down the base of current booster Q445 and shuts off the +5 V Supply. The collector of Q445 connects to the unregulated +11.5 V from the Power Module.

−5 V Supply

The −5 V Supply consists of emitter follower Q450. No current limiting is provided since the collector is tied to the current limited −20 V Reference Supply. Diode CR450 provides temperature compensation for Q450.

OPTIONS

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

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.

SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number

00X Part removed after this serial number

ITEM NAME

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.

ABBREVIATIONS

ACTR	ACTUATOR	PLSTC	PLASTIC
ASSY	ASSEMBLY	QTZ	QUARTZ
CAP	CAPACITOR	RECP	RECEPTACLE
CER	CERAMIC	RES	RESISTOR
CKT	CIRCUIT	RF	RADIO FREQUENCY
COMP	COMPOSITION	SEL	SELECTED
CONN	CONNECTOR	SEMICOND	SEMICONDUCTOR
ELCTLT	ELECTROLYTIC	SENS	SENSITIVE
ELEC	ELECTRICAL	VAR	VARIABLE
INCAND	INCANDESCENT	WW	WIREWOUND
LED	LIGHT EMITTING DIODE	XFMR	TRANSFORMER
NONWIR	NON WIREWOUND	XTAL	CRYSTAL

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
00853	SANGAMO ELECTRIC CO., S. CAROLINA DIV.	P O BOX 128	PICKENS, SC 29671
01121	ALLEN-BRADLEY COMPANY	1201 2ND STREET SOUTH	MILWAUKEE, WI 53204
02111	SPECTROL ELECTRONICS CORPORATION	17070 EAST GALE AVENUE	CITY OF INDUSTRY, CA 91745
02735	RCA CORPORATION, SOLID STATE DIVISION	ROUTE 202	SOMERVILLE, NY 08876
04713	MOTOROLA, INC., SEMICONDUCTOR PROD. DIV.	5005 E MCDOWELL RD, PO BOX 20923	PHOENIX, AZ 85036
05091	TRI-ORDINATE CORPORATION	343 SNYDER AVENUE	BERKELEY HEIGHTS, NJ 07922
05397	UNION CARBIDE CORPORATION, MATERIALS SYSTEMS DIVISION	11901 MADISON AVENUE	CLEVELAND, OH 44101
07910	TELEDYNE SEMICONDUCTOR	12515 CHADRON AVE.	HAWTHORNE, CA 90250
24931	SPECIALTY CONNECTOR CO., INC.	3560 MADISON AVE.	INDIANAPOLIS, IN 46227
34553	AMPEREX ELECTRONIC CORP., COMPONENT DIV.	35 HOFFMAN AVE.	HAPPAUGE, NY 11787
56289	SPRAGUE ELECTRIC CO.	1142 W. BEARDSLEY AVE.	NORTH ADAMS, MA 01247
71450	CTS CORP.	4433 RAVENSWOOD AVE.	ELKHART, IN 46514
71744	CHICAGO MINIATURE LAMP WORKS	644 W. 12TH ST.	CHICAGO, IL 60640
72982	ERIE TECHNOLOGICAL PRODUCTS, INC.	2500 HARBOR BLVD.	ERIE, PA 16512
73138	BECKMAN INSTRUMENTS, INC., HELIPOT DIV.	33 E. FRANKLIN ST.	FULLERTON, CA 92634
74868	BUNKER-RAMO CORP., THE AMPHENOL RF DIV.	401 N. BROAD ST.	DANBURY, CT 06810
75042	TRW ELECTRONIC COMPONENTS, IRC FIXED RESISTORS, PHILADELPHIA DIVISION	P O BOX 500	PHILADELPHIA, PA 19108
80009	TEKTRONIX, INC.	9220 SUNSET BLVD.	BEAVERTON, OR 97077
81483	INTERNATIONAL RECTIFIER CORP.	112 W. FIRST ST.	LOS ANGELES, CA 90069
84411	TRW ELECTRONIC COMPONENTS, TRW CAPACITORS	3029 E WASHINGTON STREET	OGALLALA, NE 69153
90201	MALLORY CAPACITOR CO., DIV. OF P. R. MALLORY AND CO., INC.	P O BOX 372	INDIANAPOLIS, IN 46206
91637	DALE ELECTRONICS, INC.	P. O. BOX 609	COLUMBUS, NE 68601
91836	KINGS ELECTRONICS CO., INC.	40 MARBLEDALE ROAD	TUCKAHOE, NY 10707

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A1	670-2105-00	B010100	B125502	CKT BOARD ASSY:MAIN	80009	670-2105-00
A1	670-2105-01	B125503	B129999	CKT BOARD ASSY:MAIN	80009	670-2105-01
A1	670-2105-02	B130000		CKT BOARD ASSY:MAIN	80009	670-2105-02
A2	670-2248-00	B010100	B129999	CKT BOARD ASSY:FUNCTION	80009	670-2248-00
A2	670-2248-01	B130000		CKT BOARD ASSY:FUNCTION	80009	670-2248-01
C34	290-0519-00			CAP.,FXD,ELCTLT:100UF,20%,20V	90201	TDC107M020WLD
C40	290-0517-00			CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
C72 ¹	295-0126-00	B010100	B119999	CAP.SET,MTCHD:10,1,0.1,0.01UF,990PF MTCHD	84411	TEK55-0005R5
C73						
C74						
C75						
C76						
C72 ¹	295-0164-00	B120000		CAP.,SET,MTCHD:10,0.01UF,995PF	80009	295-0164-00
C73						
C74						
C75						
C76						
C77	281-0167-00	B010100	B059999X	CAP.,VAR,CER DI:9-45PF,200V	72982	538-011-D 9-45
C77	281-0513-00	XB125503		CAP.,FXD,CER DI:27PF,+/-5.4PF,500V	72982	301-000P2G0270M
C78	281-0540-00			CAP.,FXD,CER DI:51PF,5%,500V	72982	301-000U2J0510J
C79	281-0092-00			CAP.,VAR,CER DI:9-35PF,200V	72982	538-011 D9-35
C80	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-558Z5U-103Z
C85	290-0527-00	XB060000	B089999	CAP.,FXD,ELCTLT:15UF,20%,20V	90201	TDC156M020FL
C85	290-0536-00	B090000		CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C89	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C95	290-0512-00			CAP.,FXD,ELCTLT:22UF,20%,15V	56289	196D226X0015KA1
C120	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-558Z5U-103Z
C130	283-0003-00	XB060000		CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-558Z5U-103Z
C150	290-0572-00			CAP.,FXD,ELCTLT:0.1UF,20%,50V	56289	196D104X0050HA1
C162	281-0519-00	XB130000		CAP.,FXD,CER DI:47PF,+/-4.7PF,500V	72982	308-000COG0470K
C170	290-0572-00			CAP.,FXD,ELCTLT:0.1UF,20%,50V	56289	196D104X0050HA1
C190	281-0092-00			CAP.,VAR,CER DI:9-35PF,200V	72982	538-011 D9-35
C191	281-0629-00	B010100	B019999	CAP.,FXD,CER DI:33PF,5%,600V	72982	308-000COG0330J
C191	281-0511-00	B020000	B059999X	CAP.,FXD,CER DI:22PF,+/-2.2PF,500V	72982	301-000COG0220K
C196	283-0001-00	XB060000		CAP.,FXD,CER DI:0.005UF,+100-0%,500V	72982	831-559E502P
C204	283-0001-00	XB110000		CAP.,FXD,CER DI:0.005UF,+100-0%,500V	72982	831-559E502P
C211	283-0067-00	XB020000	B129999X	CAP.,FXD,CER DI:0.001UF,10%,200V	72982	835-515B102K
C235	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039 E 105Z
C242	290-0517-00			CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
C250	281-0651-00	B010100	B059999	CAP.,FXD,CER DI:47PF,5%,200V	72982	374-001T2H0470J
C250	281-0511-00	B060000		CAP.,FXD,CER DI:22PF,+/-2.2PF,500V	72982	301-000COG0220K
C251	283-0637-00	B010100	B129999X	CAP.,FXD,MICA D:20PF,2.5%,100V	00853	D151E200D0
C255	290-0529-00	XB060000	B109999	CAP.,FXD,ELCTLT:47UF,20%,20V	05397	T368C476M020AZ
C255	290-0719-00	B110000		CAP.,FXD,ELCTLT:47UF,20%,25V	56289	196D476X0025TE3
C271	283-0178-00			CAP.,FXD,CER DI:0.1UF,+80-20%,100V	72982	8131N145 E 104Z
C279	281-0627-00	B010100	B129999X	CAP.,FXD,CER DI:1PF,+/-0.25PF,500V	72982	301-000C0K0109C
C281	281-0151-00	B010100	B010203	CAP.,VAR,CER DI:1-3PF,100V	72982	518-600A1-3
C281	281-0178-00	B010204		CAP.,VAR,PLSTC:1-3.5PF,500V	34553	2222-809-05001
C286	281-0523-00	XB130000		CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C291	281-0523-00			CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C294	290-0517-00			CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
C297	290-0517-00			CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
C400	290-0324-00			CAP.,FXD,ELCTLT:750UF,+75-10%,40V	56289	D46454

¹Individual timing capacitors in this assembly must be ordered by the 9-digit part number, letter suffix and tolerance printed on the timing capacitor to be replaced. The letter suffix and the tolerance should be the same for all of the timing capacitors in the assembly.

EXAMPLE: 285-XXXX-XX F-

Replaceable Electrical Parts—FG 501

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscnt	Name & Description	Mfr Code	Mfr Part Number
C406	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C415	283-0000-00	B010100	B019999	CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C415	290-0517-00	B020000		CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
C455	290-0531-00			CAP.,FXD,ELCTLT:100UF,20%,10V	90201	TDC107M010WLC
C482	283-0111-00	XB125503		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8121-NO88Z5U104M
C485	283-0000-00	B010100	B019999	CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C485	290-0517-00	B020000		CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
C490	290-0324-00			CAP.,FXD,ELCTLT:750UF,+75-10%,40V	56289	D46454
C495	290-0531-00			CAP.,FXD,ELCTLT:100UF,20%,10V	90201	TDC107M010WLC
CR15	152-0141-02	XB130000		SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR16	152-0141-02	XB130000		SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR17	152-0141-02	XB130000		SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR45	152-0141-02	XB130000		SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR100	152-0249-00			SEMICONV DEVICE:SILICON,DIODE ASSY	80009	152-0249-00
CR101	152-0249-00			SEMICONV DEVICE:SILICON,DIODE ASSY	80009	152-0249-00
CR102	152-0249-00			SEMICONV DEVICE:SILICON,DIODE ASSY	80009	152-0249-00
CR103	152-0249-00			SEMICONV DEVICE:SILICON,DIODE ASSY	80009	152-0249-00
CR150	152-0141-02	XB020000		SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR155	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR156	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR158	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR160	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR162	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR170	152-0141-02	XB020000		SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR175	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR176	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR178	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR180	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR182	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR215	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR218	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR230	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR235	152-0141-02	XB130000		SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR240	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR242	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR245	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR246	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR247	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR248	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR285	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR290	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR400	152-0488-00			SEMICONV DEVICE:SILICON,200V,1500MA	80009	152-0488-00
CR410	152-0141-02	XB130000		SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR450	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	07910	1N4152
CR490	152-0488-00			SEMICONV DEVICE:SILICON,200V,1500MA	80009	152-0488-00
DS495	150-0109-00			LAMP,INCAND:18V,26MA	71744	CM7220
J10	131-0955-00			CONNECTOR,RCPT,:BNC,FEMALE,W/HARDWARE	05091	31-279
J80	131-0282-00			CONNECTOR,RCPT,:FEEDTHRU	74868	74300MB
J81	131-1003-00			CONNECTOR BODY,:CKT CD MT,3 PRONG	80009	131-1003-00
J215	131-0955-00			CONNECTOR,RCPT,:BNC,FEMALE,W/HARDWARE	05091	31-279
J290	131-0679-00	B010100	B103149	CONNECTOR,RCPT,:BNC W/HARDWARE	24931	28JRL68-1

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
J290	131-0679-02	B103150	B125502	CONNECTOR, RCPT, :BNC W/HARDWARE	24931	28JR270-1
J290	131-0274-00	B125503		CONNECTOR, RCPT, :BNC	91836	KC79-67
LR298	108-0105-00	XB030000	B129999X	COIL, RF:1.8UH	80009	108-0105-00
Q45A,B	151-0261-00			TRANSISTOR:SILICON,PNP,DUAL	80009	151-0261-00
Q48A,B	151-0232-00			TRANSISTOR:SILICON,NPN,DUAL	80009	151-0232-00
Q80	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q85	151-0192-00			TRANSISTOR:SILICON,NPN,SEL FROM MPS6521	80009	151-0192-00
Q90	151-0192-00			TRANSISTOR:SILICON,NPN,SEL FROM MPS6521	80009	151-0192-00
Q120A,B	151-1042-01			TRANSISTOR:SILICON,FET,MATCHED PAIR	80009	151-1042-01
Q125	151-0192-00			TRANSISTOR:SILICON,NPN,SEL FROM MPS6521	80009	151-0192-00
Q130	151-0192-00			TRANSISTOR:SILICON,NPN,SEL FROM MPS6521	80009	151-0192-00
Q138	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q150	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q170	151-0188-00	B010100	B059999	TRANSISTOR:SILICON,PNP	80009	151-0188-00
Q170	151-0164-00	B060000		TRANSISTOR:SILICON,PNP	80009	151-0164-00
Q225	151-0192-00			TRANSISTOR:SILICON,NPN,SEL FROM MPS6521	80009	151-0192-00
Q230	151-0192-00			TRANSISTOR:SILICON,NPN,SEL FROM MPS6521	80009	151-0192-00
Q240	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q242	151-0188-00			TRANSISTOR:SILICON,PNP	80009	151-0188-00
Q250	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q255	151-0188-00			TRANSISTOR:SILICON,PNP	80009	151-0188-00
Q270	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q276	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q280	151-0188-00			TRANSISTOR:SILICON,PNP	80009	151-0188-00
Q285	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q290	151-0133-00			TRANSISTOR:SILICON,PNP	80009	151-0133-00
Q295	151-0136-00	B010100	B129999	TRANSISTOR:SILICON,NPN	02735	35495
Q295	151-0439-00	B130000		TRANSISTOR:SILICON,NPN	80009	151-0439-00
Q298	151-0322-00	B010100	B129999	TRANSISTOR:SILICON,PNP	80009	151-0322-00
Q298	151-0440-00	B130000		TRANSISTOR:SILICON,PNP	80009	151-0440-00
Q400	151-1066-00			TRANSISTOR:SILICON,FE,P-CHANNEL	80009	151-1066-00
Q410	151-0311-01			TRANSISTOR:SILICON,NPN	80009	151-0311-01
Q415	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q420	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q424	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q430	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q445	151-0311-01			TRANSISTOR:SILICON,NPN	80009	151-0311-01
Q447	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q450	151-0188-00			TRANSISTOR:SILICON,PNP	80009	151-0188-00
Q468	151-0188-00			TRANSISTOR:SILICON,PNP	80009	151-0188-00
Q472	151-0188-00			TRANSISTOR:SILICON,PNP	80009	151-0188-00
Q474	151-0188-00			TRANSISTOR:SILICON,PNP	80009	151-0188-00
Q485	151-0188-00			TRANSISTOR:SILICON,PNP	80009	151-0188-00
Q488	151-0335-00			TRANSISTOR:SILICON,PNP	80009	151-0335-00
R10	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R11	315-0102-00	B010100	B129999	RES.,FXD,CMPNS:1K OHM,5%,0.25W	01121	CB1025
R11	321-0151-00	B130000		RES.,FXD,FILM:365 OHM,1%,0.125W	91637	MFF1816G365R0F
R13	315-0332-00			RES.,FXD,CMPNS:3.3K OHM,5%,0.25W	01121	CB3325
R15	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R18	321-0272-00	B010100	B069999	RES.,FXD,FILM:6.65K OHM,1%,0.125W	91637	MFF1816G66500F
R18	315-0822-00	B070000	B129999	RES.,FXD,CMPNS:8.2K OHM,5%,0.25W	01121	CB8225

Replaceable Electrical Parts—FG 501

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Discont	Name & Description	Mfr Code	Mfr Part Number
R18	315-0912-00	B130000		RES.,FXD,CMPSN:9.1K,(NOM VALUE),SEL	01121	CB9125
R20	311-1314-00			RES.,VAR NONWIR:5K OHM,30%,0.25W	71450	201-YA5551
R25	311-1392-00			RES.,VAR WW:10K OHM,5%,2W	02111	140-9504
R27	311-0169-00			RES.,VAR,NONWIR:100 OHM,20%,0.50W	01121	W-7564B
R30	321-0001-00			RES.,FXD,FILM:10 OHM,1%,0.125W	75042	CEAT0-10R00F
R32	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R34	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R37	321-0240-00			RES.,FXD,FILM:3.09K OHM,1%,0.125W	91637	MFF1816G30900F
R38	311-1328-00			RES.,VAR,NONWIR:100 OHM,30%,0.25W	71450	201-YA5553
R39	321-0153-00			RES.,FXD,FILM:383 OHM,1%,0.125W	91637	MFF1816G383R0F
R41	321-0926-07	B010100	B019999	RES.,FXD,FILM:4K OHM,0.1%,0.125W	91637	MFF1816C40000B
R41	321-0289-07	B020000		RES.,FXD,FILM:10K OHM,0.1%,0.125W	91637	MFF1816C10001B
R42	321-0926-07	B010100	B019999	RES.,FXD,FILM:4K OHM,0.1%,0.125W	91637	MFF1816C40000B
R42	321-0289-07	B020000		RES.,FXD,FILM:10K OHM,0.1%,0.125W	91637	MFF1816C10001B
R44	321-0289-03	B010100	B019999	RES.,FXD,FILM:10K OHM,0.25%,0.125W	91637	MFF1816D10001C
R44	321-0289-07	B020000		RES.,FXD,FILM:10K OHM,0.1%,0.125W	91637	MFF1816C10001B
R45	311-1175-00			RES.,VAR,NONWIR:100 OHM,10%,0.50W	73138	66WR10LKSM
R46	321-0289-03	B010100	B019999	RES.,FXD,FILM:10K OHM,0.25%,0.125W	91637	MFF1816D10001C
R46	321-0289-07	B020000		RES.,FXD,FILM:10K OHM,0.1%,0.125W	91637	MFF1816C10001B
R51	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R52	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R53	321-0261-00	B010100	B099999	RES.,FXD,FILM:5.11K OHM,1%,0.125W	91637	MFF1816G51100F
R53	321-0260-00	B100000		RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R54	321-0261-00	B010100	B099999	RES.,FXD,FILM:5.11K OHM,1%,0.125W	91637	MFF1816G51100F
R54	321-0260-00	B100000		RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R55	321-0775-00			RES.,FXD,FILM:45K OHM,1%,0.125W	91637	MFF1816G45001F
R56	321-0775-00			RES.,FXD,FILM:45K OHM,1%,0.125W	91637	MFF1816G45001F
R57	321-0982-00			RES.,FXD,FILM:450K OHM,1%,0.125W	91637	MFF1816G45002F
R58	321-0982-00			RES.,FXD,FILM:450K OHM,1%,0.125W	91637	MFF1816G45002F
R59	321-0983-00			RES.,FXD,FILM:4.5M OHM,1%,0.125W	91637	HMF188G45003F
R60	321-0983-00			RES.,FXD,FILM:4.5M OHM,1%,0.125W	91637	HMF188G45003F
R61	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R62	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R63	321-0261-00	B010100	B099999	RES.,FXD,FILM:5.11K OHM,1%,0.125W	91637	MFF1816G51100F
R63	321-0260-00	B100000		RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R64	321-0261-00	B010100	B099999	RES.,FXD,FILM:5.11K OHM,1%,0.125W	91637	MFF1816G51100F
R64	321-0260-00	B100000		RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R65	321-0775-00			RES.,FXD,FILM:45K OHM,1%,0.125W	91637	MFF1816G45001F
R66	321-0775-00			RES.,FXD,FILM:45K OHM,1%,0.125W	91637	MFF1816G45001F
R67	321-0982-00			RES.,FXD,FILM:450K OHM,1%,0.125W	91637	MFF1816G45002F
R68	321-0982-00			RES.,FXD,FILM:450K OHM,1%,0.125W	91637	MFF1816G45002F
R69	321-0983-00			RES.,FXD,FILM:4.5M OHM,1%,0.125W	91637	HMF188G45003F
R70	321-0983-00			RES.,FXD,FILM:4.5M OHM,1%,0.125W	91637	HMF188G45003F
R72	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R73	307-0113-00			RES.,FXD,CMPSN:5.1 OHM,5%,0.25W	01121	CB51G5
R80	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R81	315-0363-00			RES.,FXD,CMPSN:36K OHM,5%,0.25W	01121	CB3635
R82	315-0102-00	XB010204		RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R85	315-0682-00			RES.,FXD,CMPSN:6.8K OHM,5%,0.25W	01121	CB6825
R87	323-0176-00			RES.,FXD,FILM:665 OHM,1%,0.50W	75042	CECT0-6650F
R88	323-0135-00			RES.,FXD,FILM:249 OHM,1%,0.50W	91637	MFF1226G249R0F
R89	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	01121	CB2725
R94	315-0362-00	B010100	B019999	RES.,FXD,CMPSN:3.6K OHM,5%,0.25W	01121	CB3625

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R94	321-0235-00	B020000		RES., FXD, FILM:2.74K OHM, 1%, 0.125W	91637	MFF1816G27400F
R95	311-1308-00	B010100	B019999X	RES., VAR, NONWIR:250 OHM, 30%, 0.25W	71450	201-YA5550
R96	315-0202-00	B010100	B019999	RES., FXD, CMPSN:2K OHM, 5%, 0.25W	01121	CB2025
R96	321-0209-00	B020000		RES., FXD, FILM:1.47K OHM, 1%, 0.125W	91637	MFF1816G14700F
R99	311-1308-00	B010100	B019999	RES., VAR, NONWIR:250 OHM, 30%, 0.25W	71450	201-YA5550
R99	307-0113-00	B020000		RES., FXD, CMPSN:5.1 OHM, 5%, 0.25W	01121	CB51G5
R100	315-0301-00	B010100	B019999	RES., FXD, CMPSN:300 OHM, 5%, 0.25W	01121	CB3015
R100	322-0154-00	B020000		RES., FXD, FILM:392 OHM, 1%, 0.25W	91637	MFF1421G392ROF
R102	315-0102-00	B010100	B019999	RES., FXD, CMPSN:1K OHM, 5%, 0.25W	01121	CB1025
R102	321-0192-00	B020000		RES., FXD, FILM:976 OHM, 1%, 0.125W	91637	MFF1816G976ROF
R105	315-0182-00	B010100	B019999	RES., FXD, CMPSN:1.8K OHM, 5%, 0.25W	01121	CB1825
R105	321-0217-00	B020000		RES., FXD, FILM:1.78K OHM, 1%, 0.125W	91637	MFF1816G17800F
R120	315-0101-00			RES., FXD, CMPSN:100 OHM, 5%, 0.25W	01121	CB1015
R121	315-0912-00			RES., FXD, CMPSN:9.1K OHM, 5%, 0.25W	01121	CB9125
R125	315-0910-00			RES., FXD, CMPSN:91 OHM, 5%, 0.25W	01121	CB9105
R127	315-0361-00			RES., FXD, CMPSN:360 OHM, 5%, 0.25W	01121	CB3615
R129	315-0103-00	B010100	B099999	RES., FXD, CMPSN:10K OHM, 5%, 0.25W	01121	CB1035
R129	315-0822-00	B100000		RES., FXD, CMPSN:8.2K OHM, 5%, 0.25W	01121	CB8225
R130	315-0511-00			RES., FXD, CMPSN:510 OHM, 5%, 0.25W	01121	CB5115
R132	315-0101-00			RES., FXD, CMPSN:100 OHM, 5%, 0.25W	01121	CB1015
R135	311-1408-00			RES., VAR, NONWIR:1K OHM, 0.25W	71450	X201R102B
R137	315-0910-00			RES., FXD, CMPSN:91 OHM, 5%, 0.25W	01121	CB9105
R139	315-0242-00	B010100	B019999	RES., FXD, CMPSN:2.4K OHM, 5%, 0.25W	01121	CB2425
R139	315-0152-00	B020000		RES., FXD, CMPSN:1.5K OHM, 5%, 0.25W	01121	CB1525
R141	315-0621-00	B010100	B019999	RES., FXD, CMPSN:620 OHM, 5%, 0.25W	01121	CB6215
R141	321-0168-00	B020000		RES., FXD, FILM:549 OHM, 1%, 0.125W	91637	MFF1816G549ROF
R143	315-0112-00	B010100	B019999	RES., FXD, CMPSN:1.1K OHM, 5%, 0.25W	01121	CB1125
R143	321-0197-00	B020000		RES., FXD, FILM:1.1K OHM, 1%, 0.125W	91637	MFF1816G11000F
R145	315-0511-00	B010100	B019999	RES., FXD, CMPSN:510 OHM, 5%, 0.25W	01121	CB5115
R145	321-0166-00	B020000		RES., FXD, FILM:523 OHM, 1%, 0.125W	91637	MFF1816G523ROF
R150	311-1199-00	B010100	B019999	RES., VAR, NONWIR:10K OHM, 30%, 0.25W	71450	201-YA5543
R150	311-1120-00	B020000		RES., VAR, NONWIR:100 OHM, 30%, 0.25W	71450	201-YA5531
R151	315-0152-00	B010100	B019999	RES., FXD, CMPSN:1.5K OHM, 5%, 0.25W	01121	CB1525
R151	321-0243-00	B020000		RES., FXD, FILM:3.32K OHM, 1%, 0.125W	91637	MFF1816G33200F
R152	321-0158-00	XB020000		RES., FXD, FILM:432 OHM, 1%, 0.125W	91637	MFF1816G432ROF
R153	315-0101-00			RES., FXD, CMPSN:100 OHM, 5%, 0.25W	01121	CB1015
R155	315-0204-00	B010100	B019999	RES., FXD, CMPSN:200K OHM, 5%, 0.25W	01121	CB2045
R155	321-0037-00	B020000		RES., FXD, FILM:23.7 OHM, 1%, 0.125W	91637	MFF1816G2370F
R156	315-0430-00	B010100	B019999	RES., FXD, CMPSN:43 OHM, 5%, 0.25W	01121	CB4305
R156	321-0063-00	B020000		RES., FXD, FILM:44.2 OHM, 1%, 0.125W	91637	MFF1816G4420F
R157	315-0300-00	B010100	B019999X	RES., FXD, CMPSN:30 OHM, 5%, 0.25W	01121	CB3005
R158	315-0750-00	B010100	B019999	RES., FXD, CMPSN:75 OHM, 5%, 0.25W	01121	CB7505
R158	321-0085-00	B020000		RES., FXD, FILM:75 OHM, 1%, 0.125W	91637	MFF1816G75ROOF
R159	315-0681-00	B010100	B019999	RES., FXD, CMPSN:680 OHM, 5%, 0.25W	01121	CB6815
R159	321-0154-00	B020000		RES., FXD, FILM:392 OHM, 1%, 0.125W	91637	MFF1816G392ROF
R160	315-0101-00	B010100	B019999	RES., FXD, CMPSN:100 OHM, 5%, 0.25W	01121	CB1015
R160	321-0097-00	B020000		RES., FXD, FILM:100 OHM, 1%, 0.125W	91637	MFF1816G100ROF
R161	315-0152-00	B010100	B019999	RES., FXD, CMPSN:1.5K OHM, 5%, 0.25W	01121	CB1525
R161	321-0205-00	B020000		RES., FXD, FILM:1.33K OHM, 1%, 0.125W	91637	MFF1816G13300F
R162	315-0750-00	B010100	B019999	RES., FXD, CMPSN:75 OHM, 5%, 0.25W	01121	CB7505
R162	321-0085-00	B020000		RES., FXD, FILM:75 OHM, 1%, 0.125W	91637	MFF1816G75ROOF
R163	315-0332-00	B010100	B019999	RES., FXD, CMPSN:3.3K OHM, 5%, 0.25W	01121	CB3325
R163	315-0242-00	B020000		RES., FXD, CMPSN:2.4K OHM, 5%, 0.25W	01121	CB2425

Replaceable Electrical Parts—FG 501

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscent	Name & Description	Mfr Code	Mfr Part Number
R170	311-1199-00	B010100	B019999	RES.,VAR, NONWIR:10K OHM, 30%, 0.25W	71450	201-YA5543
R170	311-1120-00	B020000		RES.,VAR, NONWIR:100 OHM, 30%, 0.25W	71450	201-YA5531
R171	315-0152-00	B010100	B019999	RES.,FXD, CMPSN:1.5K OHM, 5%, 0.25W	01121	CB1525
R171	321-0243-00	B020000		RES.,FXD, FILM:3.32K OHM, 1%, 0.125W	91637	MFF1816G33200F
R172	321-0158-00	XB020000		RES.,FXD, FILM:432 OHM, 1%, 0.125W	91637	MFF1816G432ROF
R173	315-0101-00			RES.,FXD, CMPSN:100 OHM, 5%, 0.25W	01121	CB1015
R175	315-0240-00	B010100	B019999	RES.,FXD, CMPSN:24 OHM, 5%, 0.25W	01121	CB2405
R175	321-0037-00	B020000		RES.,FXD, FILM:23.7 OHM, 1%, 0.125W	91637	MFF1816G23R70F
R176	315-0430-00	B010100	B019999	RES.,FXD, CMPSN:43 OHM, 5%, 0.25W	01121	CB4305
R176	321-0063-00	B020000		RES.,FXD, FILM:44.2 OHM, 1%, 0.125W	91637	MFF1816G44R20F
R178	315-0750-00	B010100	B019999	RES.,FXD, CMPSN:75 OHM, 5%, 0.25W	01121	CB7505
R178	321-0085-00	B020000		RES.,FXD, FILM:75 OHM, 1%, 0.125W	91637	MFF1816G75R00F
R180	315-0101-00	B010100	B019999	RES.,FXD, CMPSN:100 OHM, 5%, 0.25W	01121	CB1015
R180	321-0097-00	B020000		RES.,FXD, FILM:100 OHM, 1%, 0.125W	91637	MFF1816G100ROF
R182	315-0750-00	B010100	B019999	RES.,FXD, CMPSN:75 OHM, 5%, 0.25W	01121	CB7505
R182	321-0085-00	B020000		RES.,FXD, FILM:75 OHM, 1%, 0.125W	91637	MFF1816G75R00F
R190	315-0153-00	B010100	B019999	RES.,FXD, CMPSN:15K OHM, 5%, 0.25W	01121	CB1535
R190	321-0239-00	B020000		RES.,FXD, FILM:3.01K OHM, 1%, 0.125W	91637	MFF1816G30100F
R191	315-0103-00	B010100	B019999	RES.,FXD, CMPSN:10K OHM, 5%, 0.25W	01121	CB1035
R191	321-0222-00	B020000		RES.,FXD, FILM:2K OHM, 1%, 0.125W	91637	MFF1816G20000F
R194	315-0132-00	B010100	B019999	RES.,FXD, CMPSN:1.3K OHM, 5%, 0.25W	01121	CB1325
R194	321-0293-00	B020000		RES.,FXD, FILM:11K OHM, 1%, 0.125W	91637	MFF1816G11001F
R195	311-1308-00	B010100	B019999X	RES.,VAR, NONWIR:250 OHM, 30%, 0.25W	71450	201-YA5550
R196	315-0101-00	B010100	B019999	RES.,FXD, CMPSN:100 OHM, 5%, 0.25W	01121	CB1015
R196	321-0194-00	B020000		RES.,FXD, FILM:1.02K OHM, 1%, 0.125W	91637	MFF1816G10200F
R198	301-0511-00			RES.,FXD, CMPSN:510 OHM, 5%, 0.50W	01121	EB5115
R199	315-0512-00			RES.,FXD, CMPSN:5.1K OHM, 5%, 0.25W	01121	CB5125
R204	315-0101-00	B010100	B010203	RES.,FXD, CMPSN:100 OHM, 5%, 0.25W	01121	CB1015
R204	315-0100-00	B010204	B019999	RES.,FXD, CMPSN:10 OHM, 5%, 0.25W	01121	CB1005
R204	321-0194-00	B020000		RES.,FXD, FILM:1.02K OHM, 1%, 0.125W	91637	MFF1816G10200F
R205	311-1308-00	B010100	B019999	RES.,VAR, NONWIR:250 OHM, 30%, 0.25W	71450	201-YA5550
R205	315-0300-00	B020000		RES.,FXD, CMPSN:30 OHM, 5%, 0.25W	01121	CB3005
R206	315-0152-00	B010100	B019999	RES.,FXD, CMPSN:1.5K OHM, 5%, 0.25W	01121	CB1525
R206	321-0293-00	B020000		RES.,FXD, FILM:11K OHM, 1%, 0.125W	91637	MFF1816G11001F
R208	315-0751-00			RES.,FXD, CMPSN:750 OHM, 5%, 0.25W	01121	CB7515
R210	315-0751-00	B010100	B019999	RES.,FXD, CMPSN:750 OHM, 5%, 0.25W	01121	CB7515
R210	315-0471-00	B020000		RES.,FXD, CMPSN:470 OHM, 5%, 0.25W	01121	CB4715
R211	315-0102-00	B010100	B129999	RES.,FXD, CMPSN:1K OHM, 5%, 0.25W	01121	CB1025
R211	315-0151-00	B130000		RES.,FXD, CMPSN:150 OHM, 5%, 0.25W	01121	CB1515
R212	315-0101-00	XB020000		RES.,FXD, CMPSN:100 OHM, 5%, 0.25W	01121	CB1015
R215	315-0102-00			RES.,FXD, CMPSN:1K OHM, 5%, 0.25W	01121	CB1025
R216	315-0102-00			RES.,FXD, CMPSN:1K OHM, 5%, 0.25W	01121	CB1025
R218	315-0242-00			RES.,FXD, CMPSN:2.4K OHM, 5%, 0.25W	01121	CB2425
R220	315-0102-00			RES.,FXD, CMPSN:1K OHM, 5%, 0.25W	01121	CB1025
R222	315-0102-00			RES.,FXD, CMPSN:1K OHM, 5%, 0.25W	01121	CB1025
R225	315-0102-00			RES.,FXD, CMPSN:1K OHM, 5%, 0.25W	01121	CB1025
R230	315-0103-00			RES.,FXD, CMPSN:10K OHM, 5%, 0.25W	01121	CB1035
R231	315-0152-00			RES.,FXD, CMPSN:1.5K OHM, 5%, 0.25W	01121	CB1525
R233	321-0341-00			RES.,FXD, FILM:34.8K OHM, 1%, 0.125W	91637	MFF1816G34801F
R234	321-0330-00	B010100	B099999	RES.,FXD, FILM:26.7K OHM, 1%, 0.125W	91637	MFF1816G26701F
R234	321-0326-00	B100000		RES.,FXD, FILM:24.3K OHM, 1%, 0.125W	91637	MFF1816G24301F
R235	311-1310-00			RES.,VAR, NONWIR:20K OHM, 20%, 1W	01121	10M654
R237	315-0242-00			RES.,FXD, CMPSN:2.4K OHM, 5%, 0.25W	01121	CB2425

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R240	315-0240-00			RES.,FXD,CMPSN:24 OHM,5%,0.25W	01121	CB2405
R242	317-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.125W	01121	BB4725
R251	315-0821-00			RES.,FXD,CMPSN:820 OHM,5%,0.25W	01121	CB8215
R252	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R254	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
R256	315-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
R258	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
R260A,B	311-1432-00	B010100	B129999	RES.,VAR,NONWIR:2 X 1K OHM,20%,0.50W	01121	11M688
R260A,B	311-1950-00	B130000		RES.,VAR,NONWIR:2 X 1K OHM,20%,0.50W	01121	OBD
R263	315-0300-00			RES.,FXD,CMPSN:30 OHM,5%,0.25W	01121	CB3005
R265	315-0362-00			RES.,FXD,CMPSN:3.6K OHM,5%,0.25W	01121	CB3625
R266	321-0186-00	XB130000		RES.,FXD,FILM:845 OHM,1%,0.125W	91637	MFF1816G845ROF
R267	321-0216-00	B010100	B129999	RES.,FXD,FILM:1.74K OHM,1%,0.125W	91637	MFF1816G17400F
R267	321-0213-00	B130000		RES.,FXD,FILM:1.62K OHM,1%,0.125W	91637	MFF1816G16200F
R268	315-0682-00			RES.,FXD,CMPSN:6.8K OHM,5%,0.25W	01121	CB6825
R269	321-0213-00			RES.,FXD,FILM:1.62K OHM,1%,0.125W	91637	MFF1816G16200F
R271	315-0102-00	B010100	B129999	RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R271	315-0821-00	B130000		RES.,FXD,CMPSN:820 OHM,5%,0.25W	01121	CB8215
R272	315-0100-00	B010100	B129999X	RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R273	315-0100-00	B010100	B129999X	RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R274	311-1568-00	XB130000		RES.,VAR,NONWIR:50 OHM,20%,0.50W	73138	91A R50
R275	315-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
R277	315-0102-00	B010100	B129999	RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R277	315-0821-00	B130000		RES.,FXD,CMPSN:820 OHM,5%,0.25W	01121	CB8215
R279	315-0203-00	B010100	B129999	RES.,FXD,CMPSN:20K OHM,5%,0.25W	01121	CB2035
R279	321-0213-00	B130000		RES.,FXD,FILM:1.62K OHM,1%,0.125W	91637	MFF1816G16200F
R281	315-0683-00	B010100	B129999	RES.,FXD,CMPSN:68K OHM,5%,0.25W	01121	CB6835
R281	321-0276-00	B130000		RES.,FXD,FILM:7.32K OHM,1%,0.125W	91637	MFF1816G73200F
R282	315-0101-00	B010100	B129999	RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R282	315-0821-00	B130000		RES.,FXD,CMPSN:820 OHM,5%,0.25W	01121	CB8215
R284	315-0512-00	B010100	B129999	RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
R284	315-0100-00	B130000		RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R285	315-0301-00	B010100	B129999	RES.,FXD,CMPSN:300 OHM,5%,0.25W	01121	CB3015
R285	315-0821-00	B130000		RES.,FXD,CMPSN:820 OHM,5%,0.25W	01121	CB8215
R286	315-0111-00	B010100	B129999	RES.,FXD,CMPSN:110 OHM,5%,0.25W	01121	CB1115
R286	315-0241-00	B130000		RES.,FXD,CMPSN:240 OHM,5%,0.25W	01121	CB2415
R290	315-0241-00			RES.,FXD,CMPSN:240 OHM,5%,0.25W	01121	CB2415
R291	307-0104-00			RES.,FXD,CMPSN:3.3 OHM,5%,0.25W	01121	CB33G5
R293	305-0101-00	XB130000		RES.,FXD,CMPSN:100 OHM,5%,2W	01121	HB1015
R294	301-0100-00	B010100	B125502	RES.,FXD,CMPSN:10 OHM,5%,0.50W	01121	EB1005
R294	308-0776-00	B125503		RES.,FXD,WW:10 OHM,5%,1W	75042	BW-20100HM5%
R295	301-0100-00	B010100	B125502	RES.,FXD,CMPSN:10 OHM,5%,0.50W	01121	EB1005
R295	308-0776-00	B125503		RES.,FXD,WW:10 OHM,5%,1W	75042	BW-20100HM5%
R296	301-0100-00	B010100	B125502	RES.,FXD,CMPSN:10 OHM,5%,0.50W	01121	EB1005
R296	308-0776-00	B125503		RES.,FXD,WW:10 OHM,5%,1W	75042	BW-20100HM5%
R297	301-0100-00	B010100	B125502	RES.,FXD,CMPSN:10 OHM,5%,0.50W	01121	EB1005
R297	308-0776-00	B125503		RES.,FXD,WW:10 OHM,5%,1W	75042	BW-20100HM5%
R298	303-0510-00	B010100	B039999	RES.,FXD,CMPSN:51 OHM,5%,1W	01121	GB5105
R298	303-0470-00	B040000	B129999	RES.,FXD,CMPSN:47 OHM,5%,1W	01121	GB4705
R298	305-0101-00	B130000		RES.,FXD,CMPSN:100 OHM,5%,2W	01121	HB1015
R299	315-0303-00			RES.,FXD,CMPSN:30K OHM,5%,0.25W	01121	CB3035
R400	311-1123-00			RES.,VAR,NONWIR:1K OHM,30%,0.25W	71450	201-YA5532
R403	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725

Replaceable Electrical Parts—FG 501

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R405	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R406	315-0332-00			RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
R410	321-0285-00	B010100	B079999	RES.,FXD,FILM:9.09K OHM,1%,0.125W	91637	MFF1816G90900F
R410	321-0261-00	B080000		RES.,FXD,FILM:5.11K OHM,1%,0.125W	91637	MFF1816G51100F
R411	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R412	321-0826-08	B010100	B079999	RES.,FXD,FILM:4.48K OHM,1%,0.125W	91637	MFF1816D44800F
R412	321-0231-00	B080000		RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
R415	311-1408-00			RES.,VAR,NONWIR1K OHM,0.25W	71450	X201R102B
R417	307-0110-00			RES.,FXD,CMPSN:3 OHM,5%,0.25W	01121	CB30G5
R420	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R422	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
R424	308-0685-00			RES.,FXD,WW:1.5 OHM,10%,1W	75042	BW20-1R500J
R430	321-0240-00			RES.,FXD,FILM:3.09K OHM,1%,0.125W	91637	MFF1816G30900F
R431	321-0312-00			RES.,FXD,FILM:17.4K OHM,1%,0.125W	91637	MFF1816G17401F
R434	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R441	321-0306-00			RES.,FXD,FILM:15K OHM,1%,0.125W	91637	MFF1816G15001F
R442	321-0260-00			RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R445	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R446	308-0685-00			RES.,FXD,WW:1.5 OHM,10%,1W	75042	BW20-1R500J
R450	315-0562-00			RES.,FXD,CMPSN:5.6K OHM,5%,0.25W	01121	CB5625
R452	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R455	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R461	315-0512-00	B010100	B019999	RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
R461	315-0202-00	B020000		RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R464	321-0926-07			RES.,FXD,FILM:4K OHM,0.1%,0.125W	91637	MFF1816C40000B
R465	321-0926-07			RES.,FXD,FILM:4K OHM,0.1%,0.125W	91637	MFF1816C40000B
R468	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R471	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R473	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
R475	308-0685-00			RES.,FXD,WW:1.5 OHM,10%,1W	75042	BW20-1R500J
R481	321-0926-07			RES.,FXD,FILM:4K OHM,0.1%,0.125W	91637	MFF1816C40000B
R482	321-0926-07			RES.,FXD,FILM:4K OHM,0.1%,0.125W	91637	MFF1816C40000B
R485	315-0103-00	B010100	B019999	RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R485	315-0202-00	B020000		RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R486	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R487	307-0110-00			RES.,FXD,CMPSN:3 OHM,5%,0.25W	01121	CB30G5
R493	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R495	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
S50	105-0376-00			ACTR ASSY,CAM S:	80009	105-0376-00
S245	311-1310-00			RES.,VAR,NONWIR:20K OHM,20%,1W	01121	10M654
S250	105-0378-00			ACTR ASSY,CAM S:	80009	105-0378-00
S260	311-1950-00	XB130000		RES.,VAR,NONWIR:2 X 1K OHM,20%,0.50W	01121	OBD
U15	156-0067-00	B010100	B010203	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U15	156-0067-06	B010204		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U30	156-0067-00	B010100	B010203	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U30	156-0067-06	B010204		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U40	156-0067-00	B010100	B010203	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U40	156-0067-06	B010204		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U45	156-0067-00	B010100	B010203	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U45	156-0067-06	B010204		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U48	156-0067-00	B010100	B010203	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U48	156-0067-06	B010204		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
U80	156-0043-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NOR GATE	80009	156-0043-00
U195	156-0116-00			MICROCIRCUIT,LI:DUAL COMPARATOR	04713	MC1711CL
U235	156-0067-00	B010100	B010203	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U235	156-0067-06	B010204		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U410	156-0067-00	B010100	B019999	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U410	156-0067-06	B020000	B129999	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U410	156-0400-00	B130000		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	04713	MC1436CG
U420	156-0067-00	B010100	B010203	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U420	156-0067-06	B010204	B129999	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U420	156-0400-00	B130000		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	04713	MC1436CG
U430	156-0067-00	B010100	B010203	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U430	156-0067-06	B010204		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U440	156-0067-00	B010100	B010203	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U440	156-0067-06	B010204		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U460	156-0067-00	B010100	B010203	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U460	156-0067-06	B010204		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U470	156-0067-00	B010100	B010203	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U470	156-0067-06	B010204	B129999	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U470	156-0400-00	B130000		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	04713	MC1436CG
U480	156-0067-00	B010100	B019999	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U480	156-0067-06	B020000	B129999	MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-06
U480	156-0400-00	B130000		MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	04713	MC1436CG
VR80	152-0243-00	B010100	B019999	SEMICOND DEVICE:ZENER,0.4W,15V,5%	80009	152-0243-00
VR80	153-0050-00	B020000		SEMICOND DEVICE:ZENER,0.4W,14.5V,5%,SEL	80009	153-0050-00
VR85	152-0437-00			SEMICOND DEVICE:ZENER,SI,8.2V,2%,0.4W	80009	152-0437-00
VR150	152-0306-00	B010100	B019999X	SEMICOND DEVICE:ZENER,0.4W,9.1V,5%	81483	1N960B
VR170	152-0306-00	B010100	B019999X	SEMICOND DEVICE:ZENER,0.4W,9.1V,5%	81483	1N960B
VR195	152-0461-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N821
VR205	152-0168-00			SEMICOND DEVICE:ZENER,0.4W,12V,5%	04713	1N963B
VR218	152-0243-00			SEMICOND DEVICE:ZENER,0.4W,15V,5%	80009	152-0243-00
VR225	152-0437-00			SEMICOND DEVICE:ZENER,SI,8.2V,2%,0.4W	80009	152-0437-00
VR237	152-0149-00			SEMICOND DEVICE:ZENER,0.4W,10V,5%	04713	1N961B
VR405	152-0461-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N821

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols and Reference Designators

Electrical components shown on the diagrams are in the following units unless noted otherwise:

- Capacitors = Values one or greater are in picofarads (pF).
Values less than one are in microfarads (μF).
- Resistors = Ohms (Ω).

Graphic symbols and class designation letters are based on ANSI Standard Y32.2-1975.

Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The overline on a signal name indicates that the signal performs its intended function when it goes to the low state.

Abbreviations are based on ANSI Y1.1-1972.

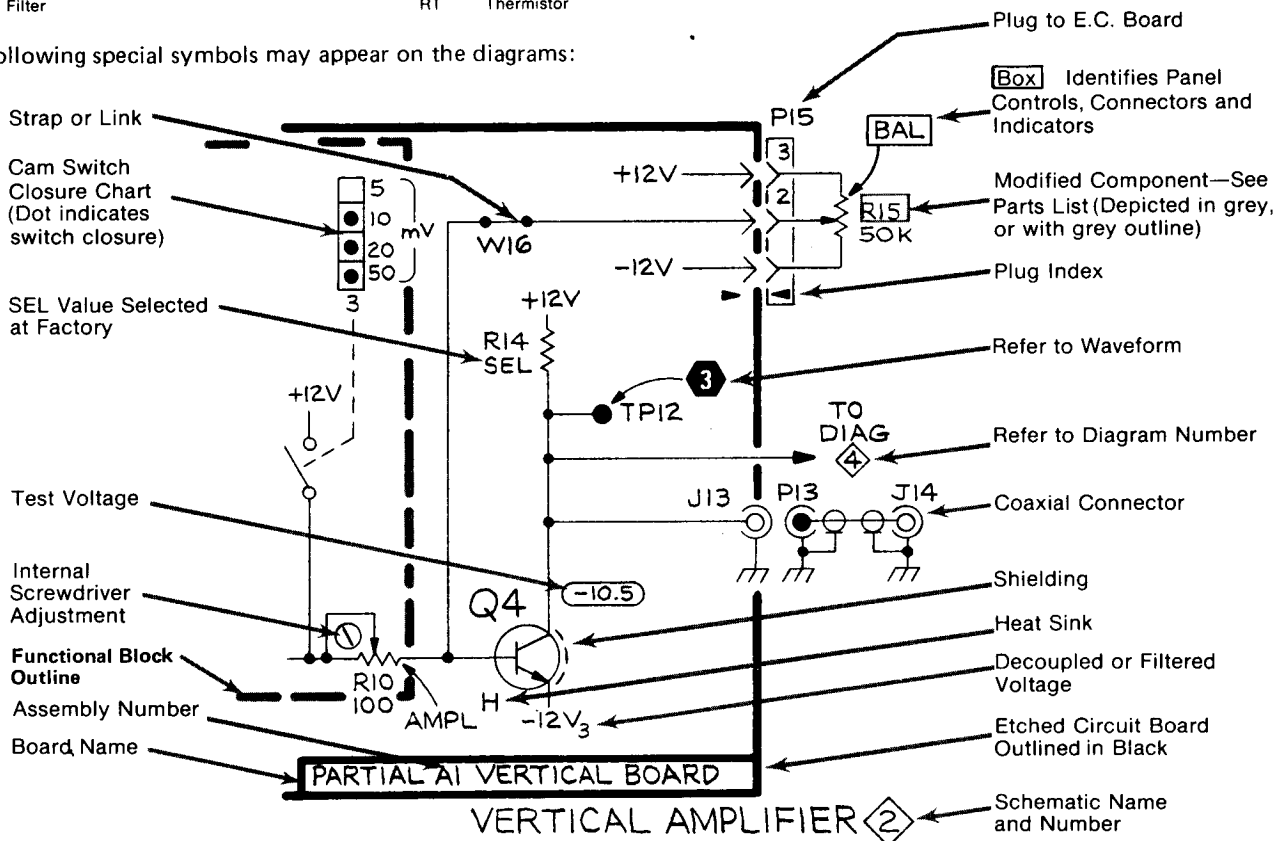
Other ANSI standards that are used in the preparation of diagrams by Tektronix, Inc. are:

- Y14.15, 1966 Drafting Practices.
- Y14.2, 1973 Line Conventions and Lettering.
- Y10.5, 1968 Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.

The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

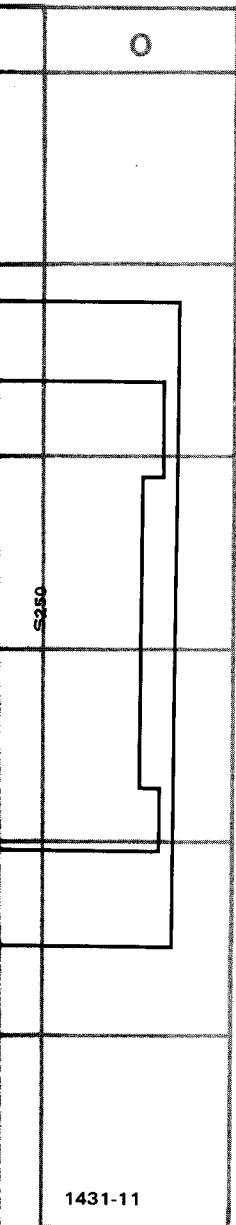
A	Assembly, separable or repairable (circuit board, etc)	H	Heat dissipating device (heat sink, heat radiator, etc)	S	Switch or contactor
AT	Attenuator, fixed or variable	HR	Heater	T	Transformer
B	Motor	HY	Hybrid circuit	TC	Thermocouple
BT	Battery	J	Connector, stationary portion	TP	Test point
C	Capacitor, fixed or variable	K	Relay	U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
CB	Circuit breaker	L	Inductor, fixed or variable	V	Electron tube
CR	Diode, signal or rectifier	M	Meter	VR	Voltage regulator (zener diode, etc.)
DL	Delay line	P	Connector, movable portion	W	Wirestrap or cable
DS	Indicating device (lamp)	Q	Transistor or silicon-controlled rectifier	Y	Crystal
E	Spark Gap, Ferrite bead	R	Resistor, fixed or variable	Z	Phase shifter
F	Fuse	RT	Thermistor		
FL	Filter				

The following special symbols may appear on the diagrams:



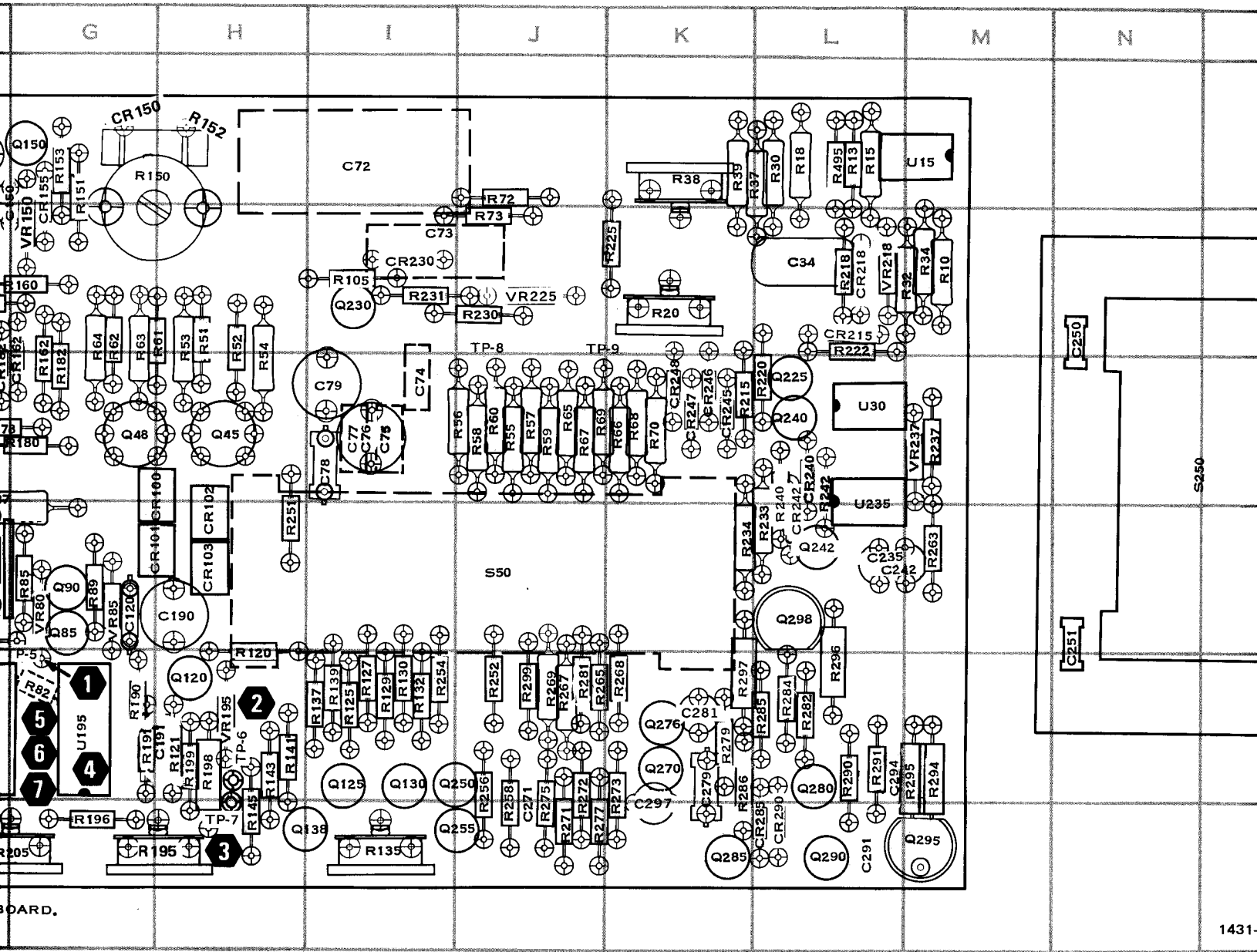
GRID LOCATION CHART
(SN B020000-BELOW)

CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC
C34	L2	CR230	I2	R34	M2	R158	F2	R294	M5	VR80	G4
C40	E3	CR240	L3	R37	L1	R159	F3	R295	M5	VR85	G4
C72†	I1	CR242	L4	R38	K1	R160	G2	R296	L5	VR150	G2
C73†	I2	CR245	K3	R39	K1	R161	F3	R297	K5	VR170	E2
C74†	I3	CR246	K3	R41	E3	R162	G3	R299	J5	VR195	H5
C75†	I3	CR247	K3	R42	D3	R163	F3	R400	B2	VR205	E5
C76†	I3	CR248	K3	R44	D3	R170	F1	R403	A2	VR218	L2
C77	I3	CR285	L6	R45	D3	R171	E1	R405	C2	VR225	J2
C78	I3	CR290	L6	R46	D3	R172	F2	R406	C2	VR237	M3
C79	I3	CR400	B1	R51	H2	R173	E1	R410	E2	VR405	B2
C80	F4	CR450	D6	R52	H2	R175	F3	R411	C2		
C89	F3	CR490	C5	R53	H2	R176	F3	R412	D2		
C95	F5			R54	H3	R178	F3	R415	D2		
C120	G4			R55	J3	R180	G3	R417	E2		
C150	G1	J81	F5	R56	J3	R182	G3	R420	B4		
C170	E1			R57	J3	R190	G5	R422	A4		
C190	H4			R58	J3	R191	G5	R424	B4		
C191	H5	Q45	H3	R59	J3	R194	F6	R430	C3		
C235	L4	Q48	G3	R60	J3	R195	H6	R431	C3		
C242	M4	Q80	F5	R61	H2	R196	G6	R434	C4		
C250	N2	Q85	G4	R62	G2	R198	H5	R441	A5		
C251	N4	Q90	G4	R63	G2	R199	H5	R442	A5		
C271	J6	Q120	H5	R64	G2	R204	F6	R445	B5		
C279	K5	Q125	I5	R65	J3	R205	G6	R446	B5		
C281	K5	Q130	I5	R66	K3	R206	F6	R450	D5		
C291	L6	Q138	I6	R67	J3	R208	E5	R452	C6		
C294	L5	Q150	G1	R68	K3	R210	E5	R455	D5		
C297	K6	Q170	E1	R69	K3	R211	D3	R461	B3		
C400	D1	Q225	L3	R70	K3	R212	E5	R464	B3		
C406	C2	Q230	I2	R72	J1	R215	L3	R465	A3		
C410	D2	Q240	L3	R73	J2	R216	C3	R468	C4		
C415	D2	Q242	L4	R80	F5	R218	L2	R471	B4		
C455	D2	Q250	J5	R81	F5	R220	L3	R473	A4		
C482†	D5	Q255	J6	R82*†	G5	R222	L2	R475	B4		
C485	C5	Q270	K5	R85	G4	R225	K2	R481	D5		
C490	D6	Q276	K5	R87	F3	R230	J2	R482	D5		
C495	E4	Q280	L5	R88	F4	R231	I2	R485	C5		
		Q285	K6	R89	G4	R233	L4	R486	C5		
		Q290	L6	R94	F4	R234	L4	R487	D4		
		Q295	M6	R95	E5	R237	M3	R493	A5		
		Q298	L4	R96	F4	R240	L3	R495	L1		
		Q400	B2	R99	D5	R242	L3				
		Q410	B1	R100	E5	R251	H4				
		Q415	D2	R102	F4	R252	J5	S50†	J4		
		Q420	A5	R105	I2	R254	I5	S250	O3		
		Q424	B5	R120	H5	R256	J5				
		Q430	C3	R121	H5	R258	J6	U15	M1		
CR100	H3	Q445	B6	R125	I5	R263	M4	U30	L3		
CR101	H4	Q447	B5	R127	I5	R265	K5	U40	E4		
CR102	H4	Q450	D5	R129	I5	R267	J5	U45	F4		
CR103	H4	Q468	C4	R130	I5	R268	K5	U48	E4		
CR150	G1	Q472	B4	R132	I5	R269	J5	U80	F5		
CR155	G1	Q474	A4	R135	I6	R271	J6	U195	G5		
CR156	G2	Q485	C5	R137	I5	R272	J5	U235	L3		
CR158	F3	Q488	C6	R139	I5	R273	K5	U410	C2		
CR160	F3			R141	H5	R275	J6	U420	B4		
CR162	G3			R143	H5	R277	K6	U430	C3		
CR170	F2	R10	M2	R145	H6	R279	K5	U440	B5		
CR175	E2	R11	C3	R150	H1	R281	J5	U460	B3		
CR176	E3	R13	L1	R151	G1	R282	L5	U470	B4		
CR178	F3	R15	L1	R152	G1	R284	L5	U480	C5		
CR180	F3	R18	L1	R153	G1	R285	L5				
CR182	F3	R20	K2	R155	F2	R286	K5				
CR215	L2	R30	L1	R156	F2	R290	L5				
CR218	L2	R32	M2	R157	E2	R291	L5				



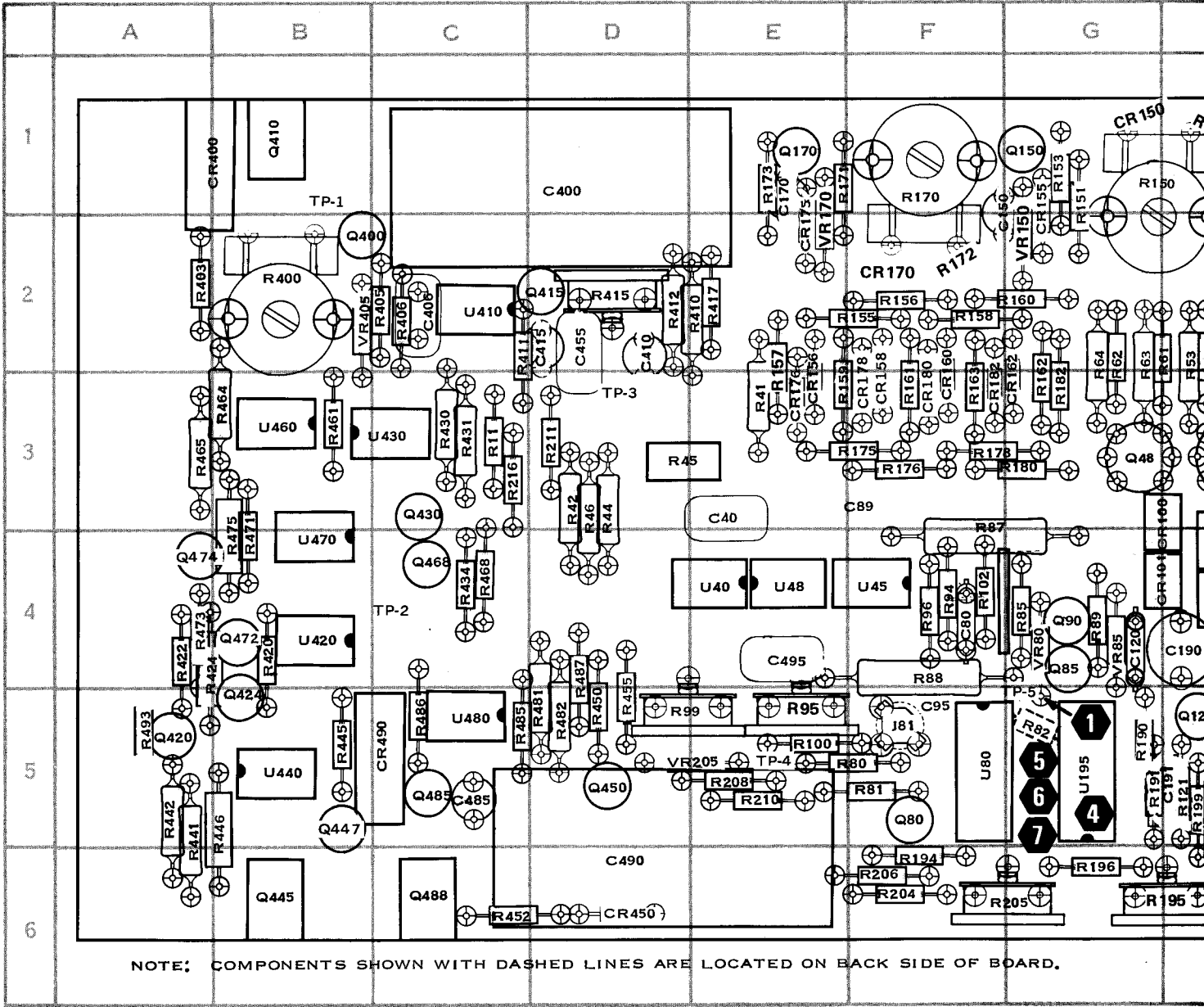
COMPONENT LOCATION GRID

Below SN B020000

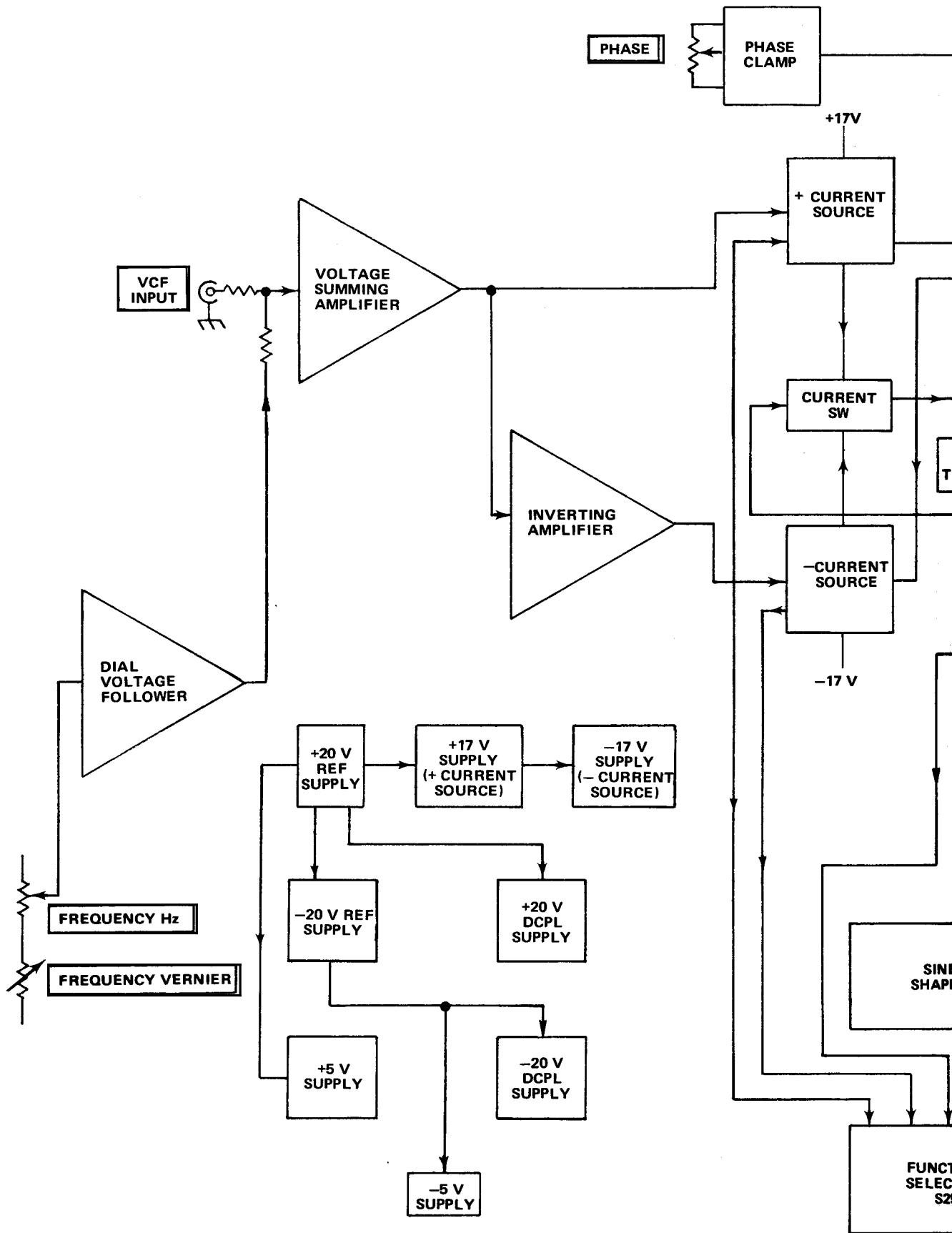


* See Parts List for serial number ranges.

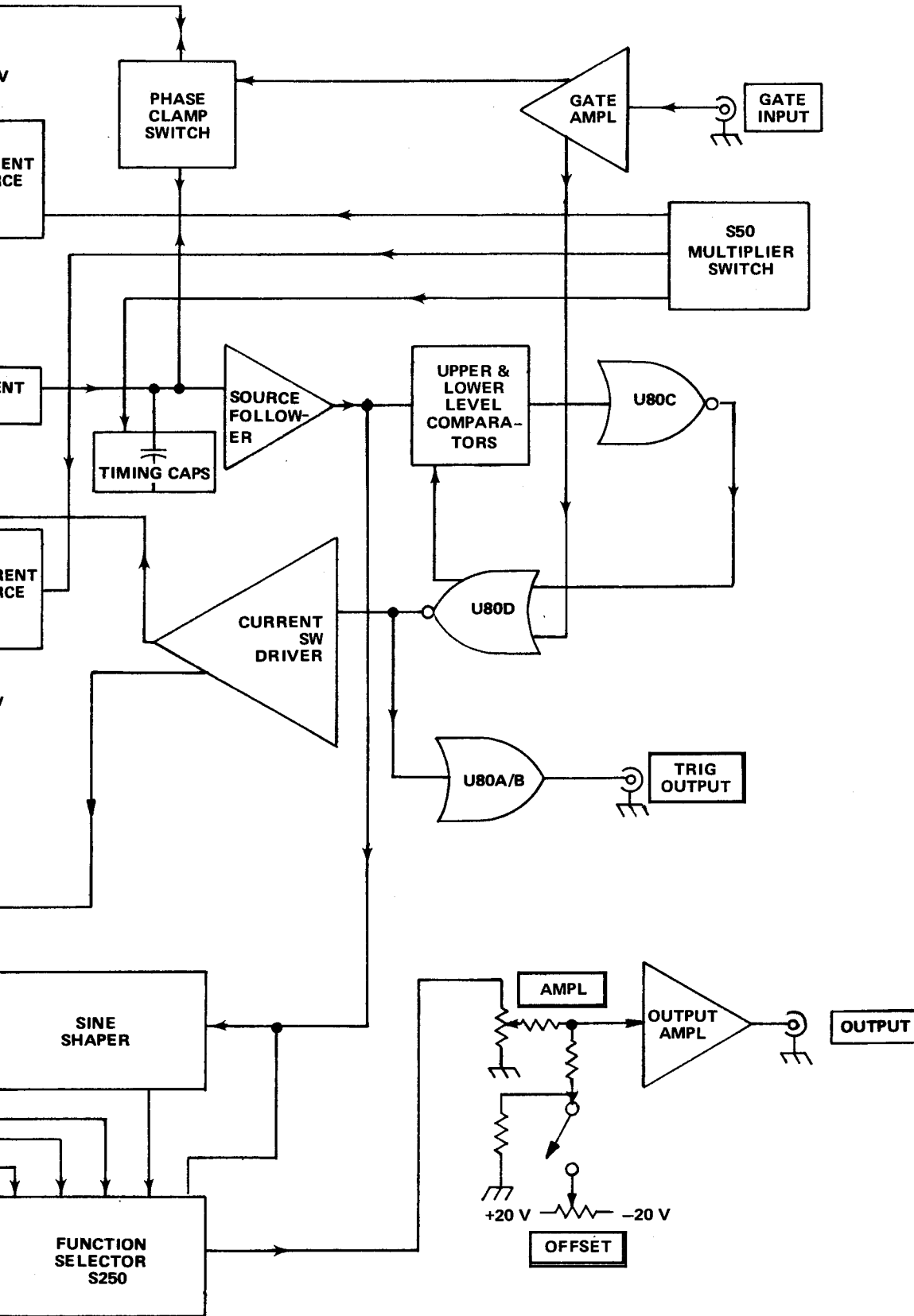
† Located on back of board.



NOTE: COMPONENTS SHOWN WITH DASHED LINES ARE LOCATED ON BACK SIDE OF BOARD.



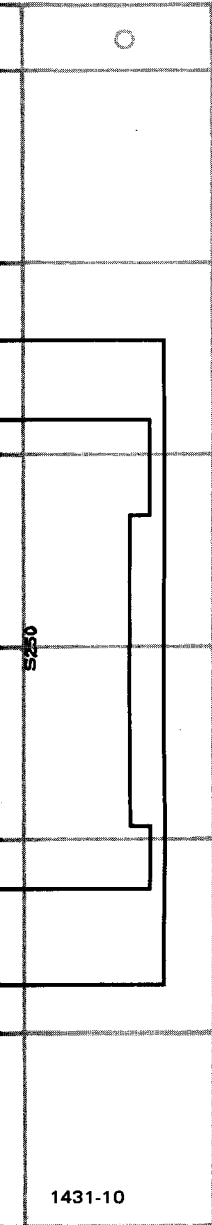
FG 501 BLOCK DIAGRAM



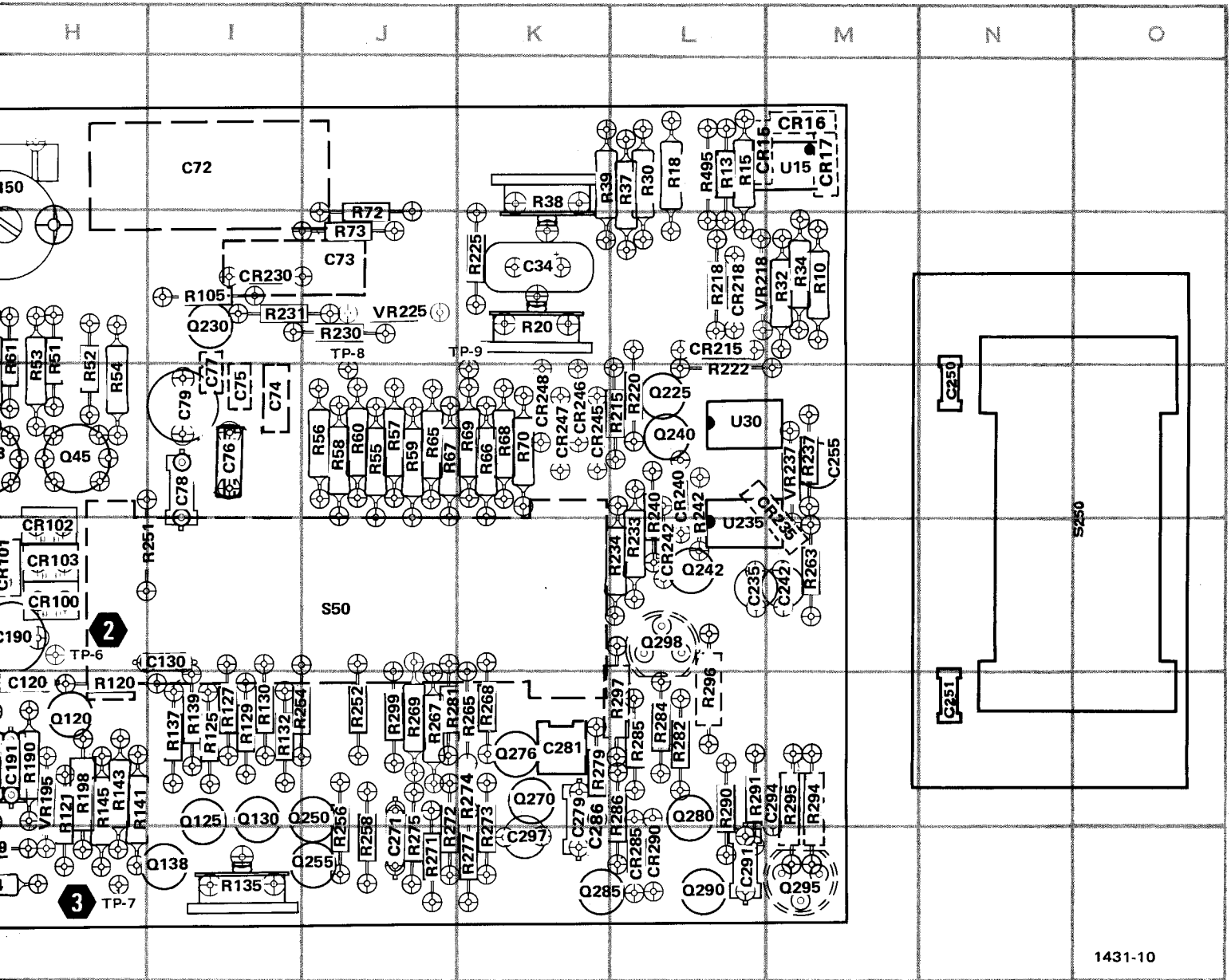
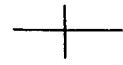
BLOCK DIAGRAM

GRID LOCATION CHART
(SN B020000-UP)

CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC
C34	K2	CR178	F3	R11	C3	R150	H1	R281	J5	U460	B3
C40	E3	CR180	F3	R13	L1	R151	G1	R282	L5	U470	B4
C72†	I1	CR182	E3	R15	L1	R152	G1	R284	L5	U480	C5
C73†	J2	CR215	L2	R18	L1	R153	G2	R285	L5		
C74†	I3	CR218	L2	R20	K2	R155	G2	R286	L5		
C75†	I3	CR230	I2	R27	F4	R156	F2	R290	L5	VR80	G4
C76†	I3	CR235*	L3	R30	L1	R158	F2	R291	L5	VR85	G4
C77*	I3	CR240	L3	R32	M2	R159	F3	R294	M5	VR195	H5
C78	I3	CR242	L4	R34	M2	R160	E2	R295	M5	VR205	E5
C79	I3	CR245	K3	R37	L1	R161	F3	R296	L5	VR218	L2
C80	F4	CR246	K3	R38	K1	R162	E2	R297	L5	VR225	J2
C85	F3	CR247	K3	R39	K1	R163	E3	R299	J5	VR237	M3
C85 ¹	G4	CR248	K3	R41	E3	R170	F1	R400	B2	VR405	C2
C89	G4	CR285	L6	R42	D3	R171	E1	R403	A2		
C95	E5	CR290	L6	R44	D3	R172	E1	R405	C2		
C120	H5	CR400	B1	R45	D3	R173	F2	R406	C2		
C130	I4	CR410*	C2	R46	D3	R175	E2	R410	E2		
C150	G1	CR450	D6	R51	H2	R176	F2	R411	D2		
C162*	F3	CR490	C5	R52	H2	R178	F2	R412	D2		
C170	F1			R53	H2	R180	E2	R415	D2		
C190	H4	J81	F5	R54	H3	R182	E2	R417	E2		
C191*	H5			R55	J3	R190	H5	R420	B4		
C196*	G6	Q45	H3	R56	J3	R191	G5	R422	A4		
C204*	F6	Q48	G3	R57	J3	R194	G6	R424	B4		
C211	D3	Q80	F5	R58	J3	R196	G6	R430	C3		
C235	L3	Q85	G4	R59	J3	R198	H5	R431	C3		
C242	M4	Q90	F4	R60	J3	R199	G6	R434	C4		
C250	N3	Q120	H5	R61	H2	R204	F6	R441	A6		
C251*	N5	Q125	I5	R62	G2	R205	G6	R442	A5		
C255	M3	Q130	I5	R63	G3	R206	F6	R445	B5		
C271	J6	Q138	I6	R64	G3	R208	E5	R446	B5		
C279*	K5	Q150	G2	R65	J3	R210	E5	R450	D5		
C281	K5	Q170	F2	R66	K3	R211	D3	R452	C6		
C286*	K6	Q225	L3	R67	J3	R212	E5	R455	D5		
C291	L6	Q230	I2	R68	K3	R215	L3	R461	B3		
C294	M5	Q240	L3	R69	K3	R216	C3	R464	A3		
C297	K6	Q242	L4	R70	K3	R218	L2	R465	A3		
C400	D1	Q250	J5	R72	J1	R220	L3	R468	C4		
C406	C2	Q255	J6	R73	J2	R222	L3	R471	B4		
C410	D2	Q270	K5	R80	E5	R225	K2	R473	A4		
C415	D2	Q276	K5	R81	F5	R230	J2	R475	B4		
C455	E4	Q280	L5	R82	F4	R231	I2	R481	D5		
C482†	D5	Q285	K6	R85	F4	R233	L4	R482	D5		
C485	C5	Q290	L6	R87	G4	R234	L4	R485	D5		
C490	D6	Q295	M6	R88	F4	R237	M3	R486	C5		
C495	E5	Q298	L4	R89	G4	R240	L3	R487	D4		
		Q400	C2	R94	E5	R242	L3	R493	A5		
		Q410	B1	R96	E5	R251	I4	R495	L1		
CR15*	M1	Q415	B2	R99	F4	R252	J5				
CR16*	M1	Q420	A5	R100	E4	R254	I5				
CR17*	M1	Q424	B5	R102	F4	R256	J6	S50†	J4		
CR45*	E4	Q430	C3	R105	I2	R258	J6	S250	O3		
CR100	H4	Q445	B6	R120	H5	R263	M4				
CR101	H4	Q447	B5	R121	H5	R265	K5	U15	M1		
CR102	H4	Q450	D4	R125	I5	R267	J5	U30	L3		
CR103	H4	Q468	C4	R127	I5	R268	K5	U40	E4		
CR150	G1	Q472	B4	R129	I5	R269	J5	U45	F4		
CR155	G2	Q474	A4	R130	I5	R271	J6	U48	E4		
CR156	G3	Q485	C5	R132	I5	R272*	J6	U80	F5		
CR158	F2	Q488	C6	R135	I6	R273*	K6	U195	G5		
CR160	F2			R137	I5	R274*	K5	U235	L4		
CR162	E2			R139	I5	R275	J6	U410	C2		
CR170	E1			R141	H5	R277	K6	U420	B4		
CR175	G3			R143	H5	R279	K5	U430	C3		
CR176	F3	R10	M2	R145	H5			U440	B5		



LOCATION GRID



- | CKT NO |
|-------------------|
| C34 |
| C40 |
| C72† |
| C73† |
| C74† |
| C75† |
| C76† |
| C77* |
| C78 |
| C79 |
| C80 |
| C85 |
| C85 ¹ |
| C89 |
| C95 |
| C120 |
| C130 |
| C150 |
| C162 |
| C170 |
| C190 |
| C191 ¹ |
| C196 ¹ |
| C204 ¹ |
| C211 |
| C235 |
| C242 |
| C250 |
| C251 ¹ |
| C255 |
| C271 |
| C279 |
| C281 |
| C286 ¹ |
| C291 |
| C294 |
| C297 |
| C400 |
| C406 |
| C410 |
| C415 |
| C455 |
| C482 ¹ |
| C485 |
| C490 |
| C495 |

* See Parts List for serial number ranges.

† Located on back of board.

¹ Alternate location.

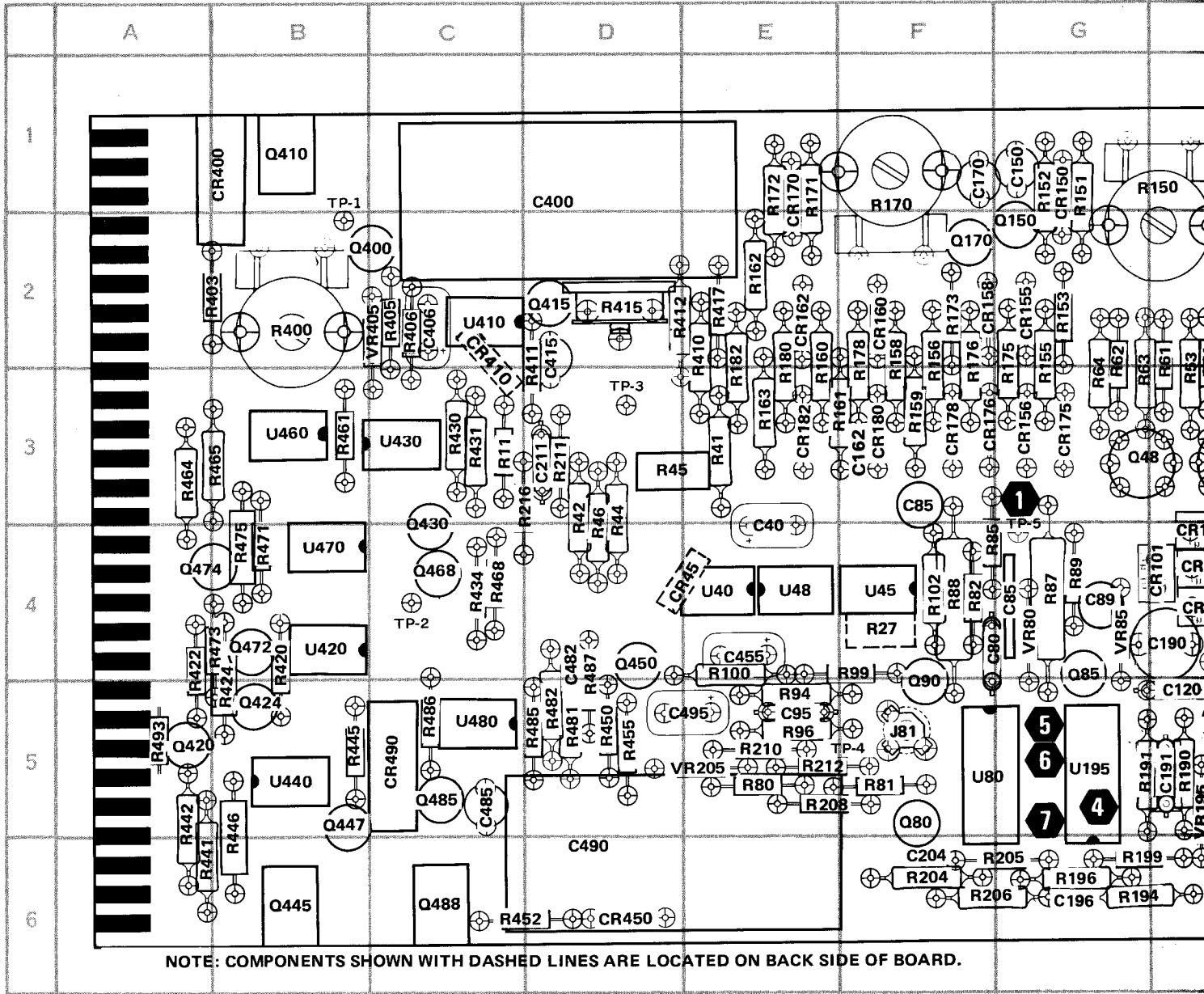
1431-10

- | |
|-------|
| CR15 |
| CR16 |
| CR17 |
| CR45 |
| CR100 |
| CR101 |
| CR102 |
| CR103 |
| CR150 |
| CR151 |
| CR152 |
| CR153 |
| CR154 |
| CR155 |
| CR156 |
| CR157 |
| CR158 |
| CR159 |
| CR160 |
| CR161 |
| CR162 |
| CR163 |
| CR164 |
| CR165 |
| CR166 |
| CR167 |
| CR168 |
| CR169 |
| CR170 |

COMPONENT LOC

SN B020000-up

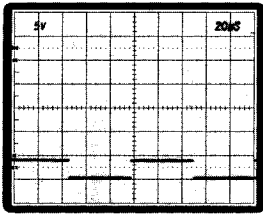
PARTS LOCATION GRID
SN B020000-UP



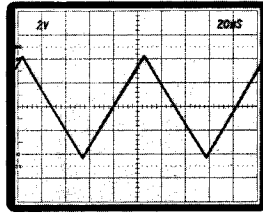
NOTE: COMPONENTS SHOWN WITH DASHED LINES ARE LOCATED ON BACK SIDE OF BOARD.

Waveform conditions:

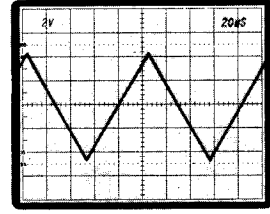
FREQUENCY Hz dial	10
Variable	Cal
MULTIPLIER	10 ³
PHASE	in (off)
OFFSET	in (off)
FUNCTION	sinewave
AMPL	fully clockwise



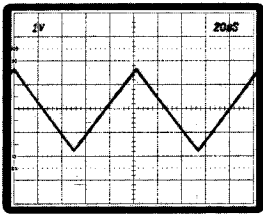
1 TP 5



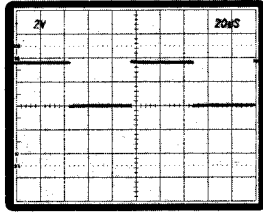
2 TP 6



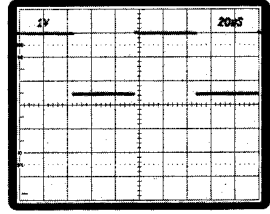
3 TP 7



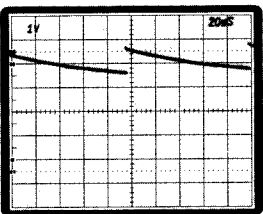
4 U195-3



5 U195-9

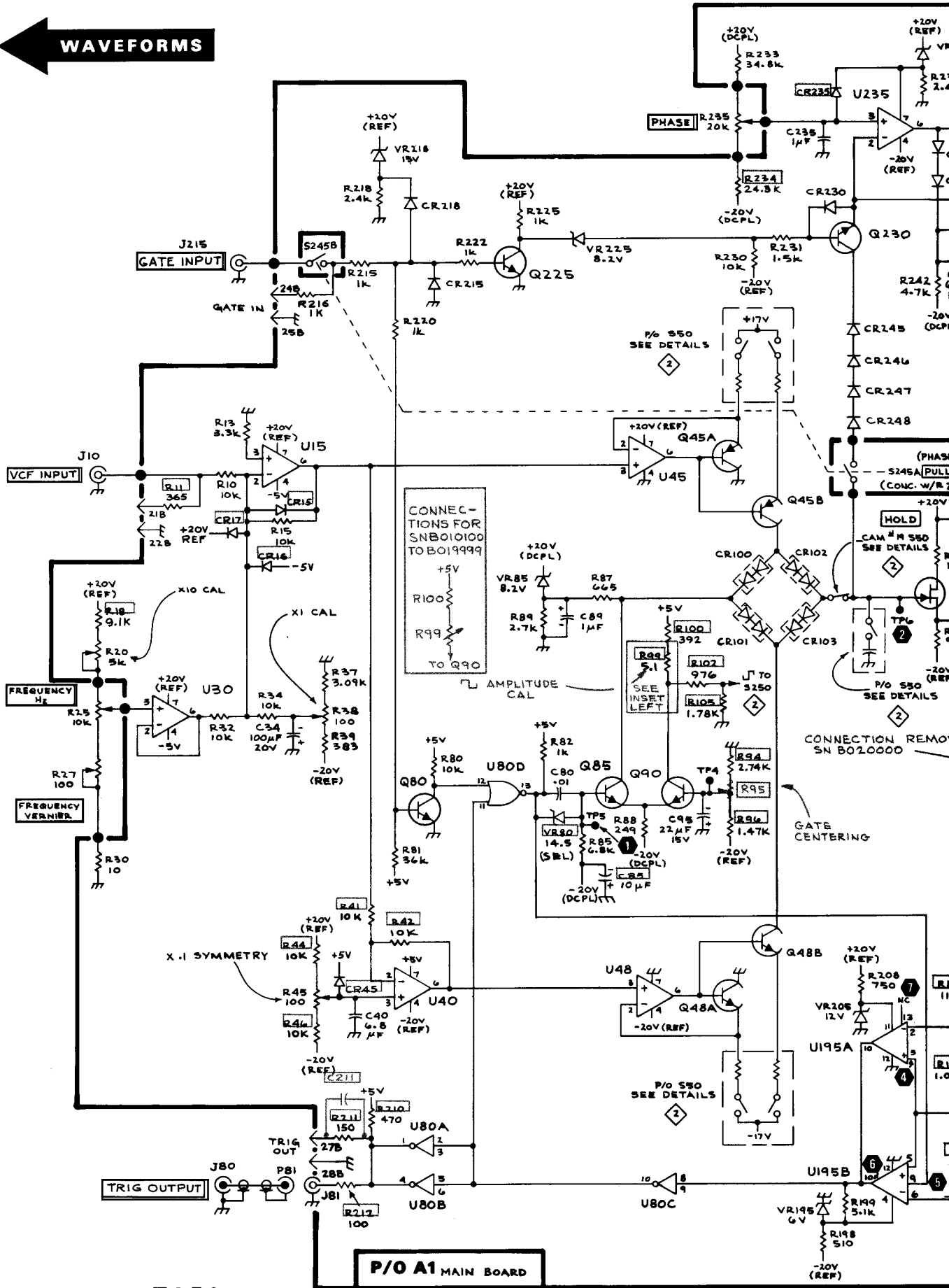


6 U195-10



7 U195-13

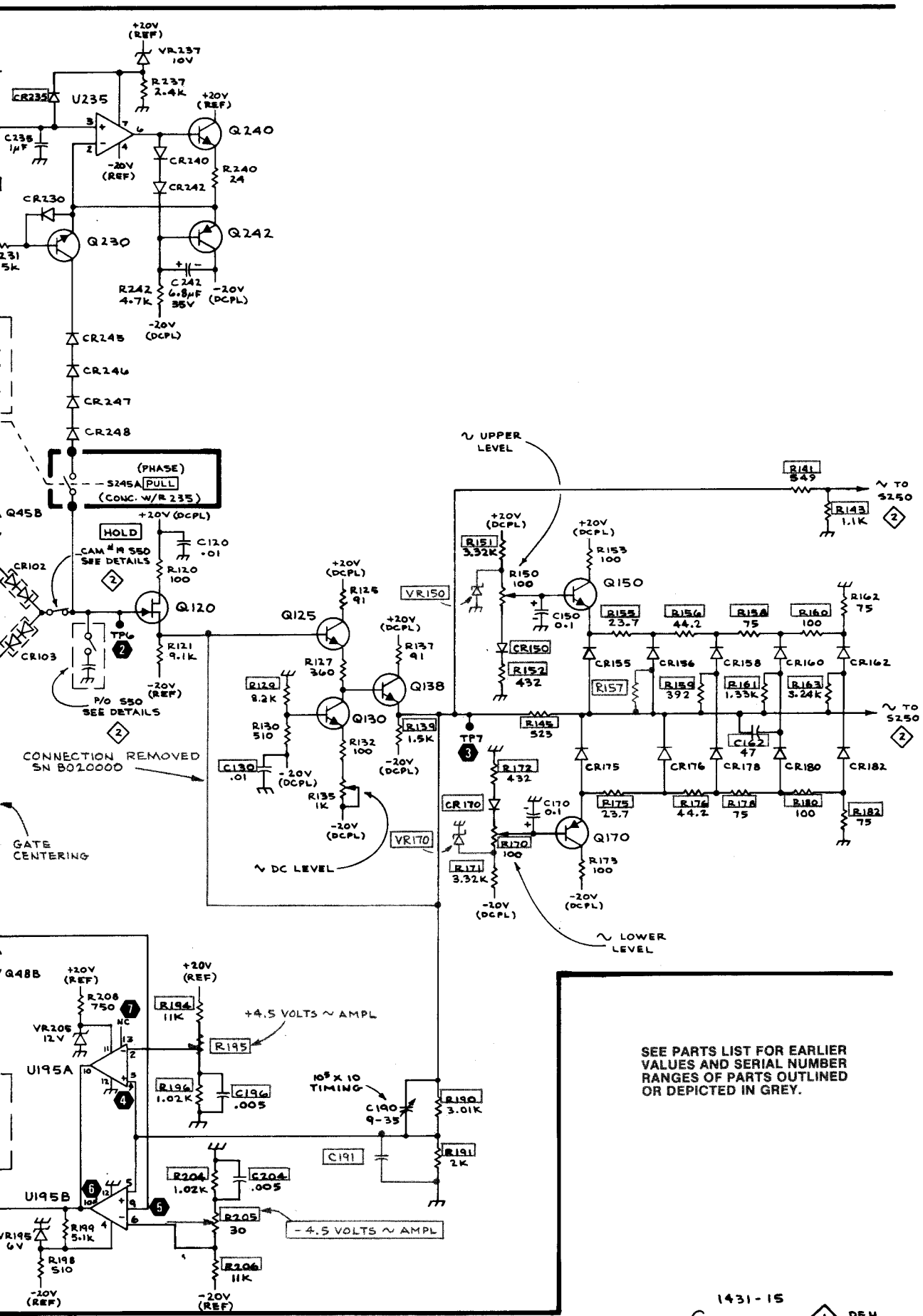
← WAVEFORMS



FG 501

P/O A1 MAIN BOARD

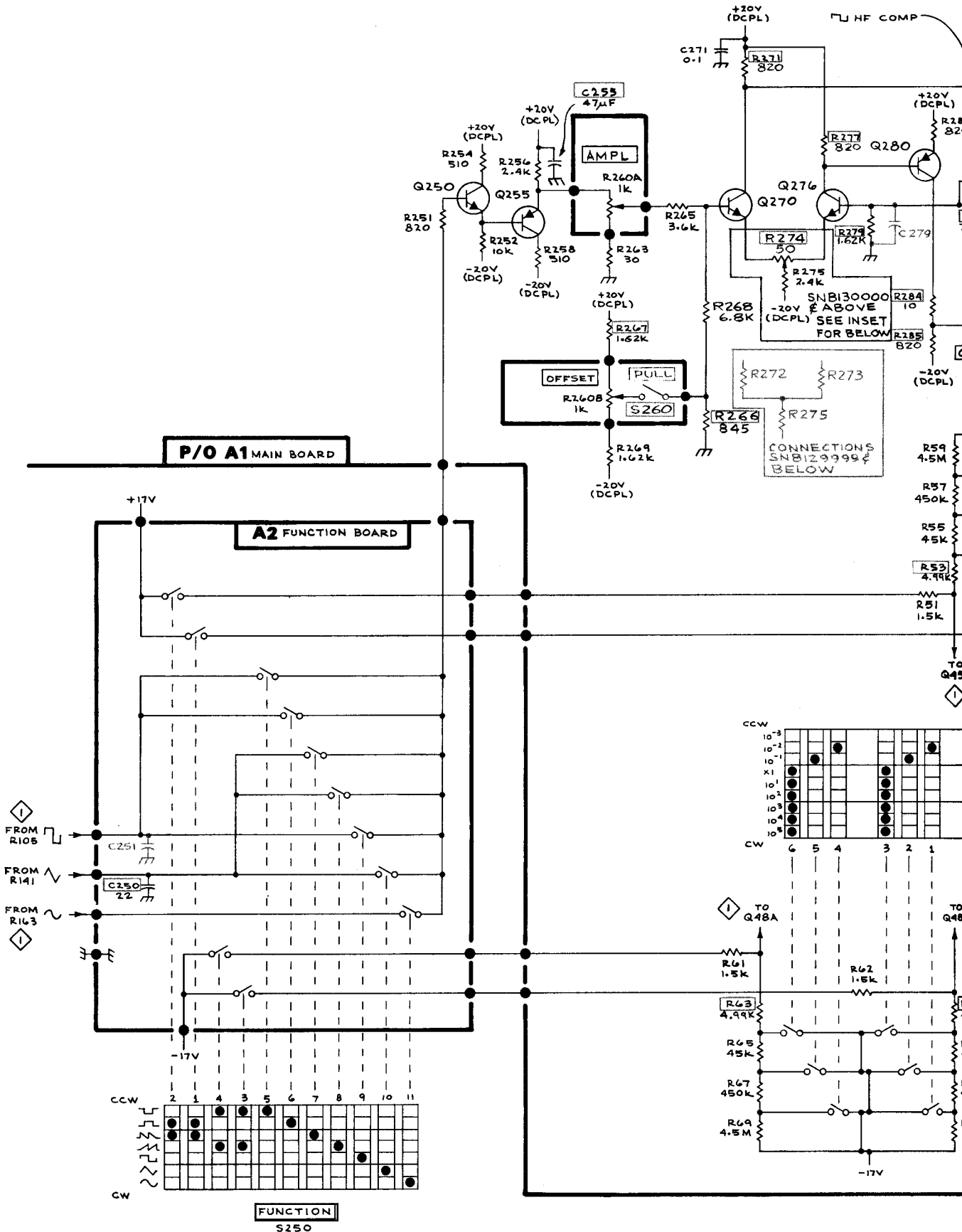
REV D, FEB 1979



GENERATOR

1

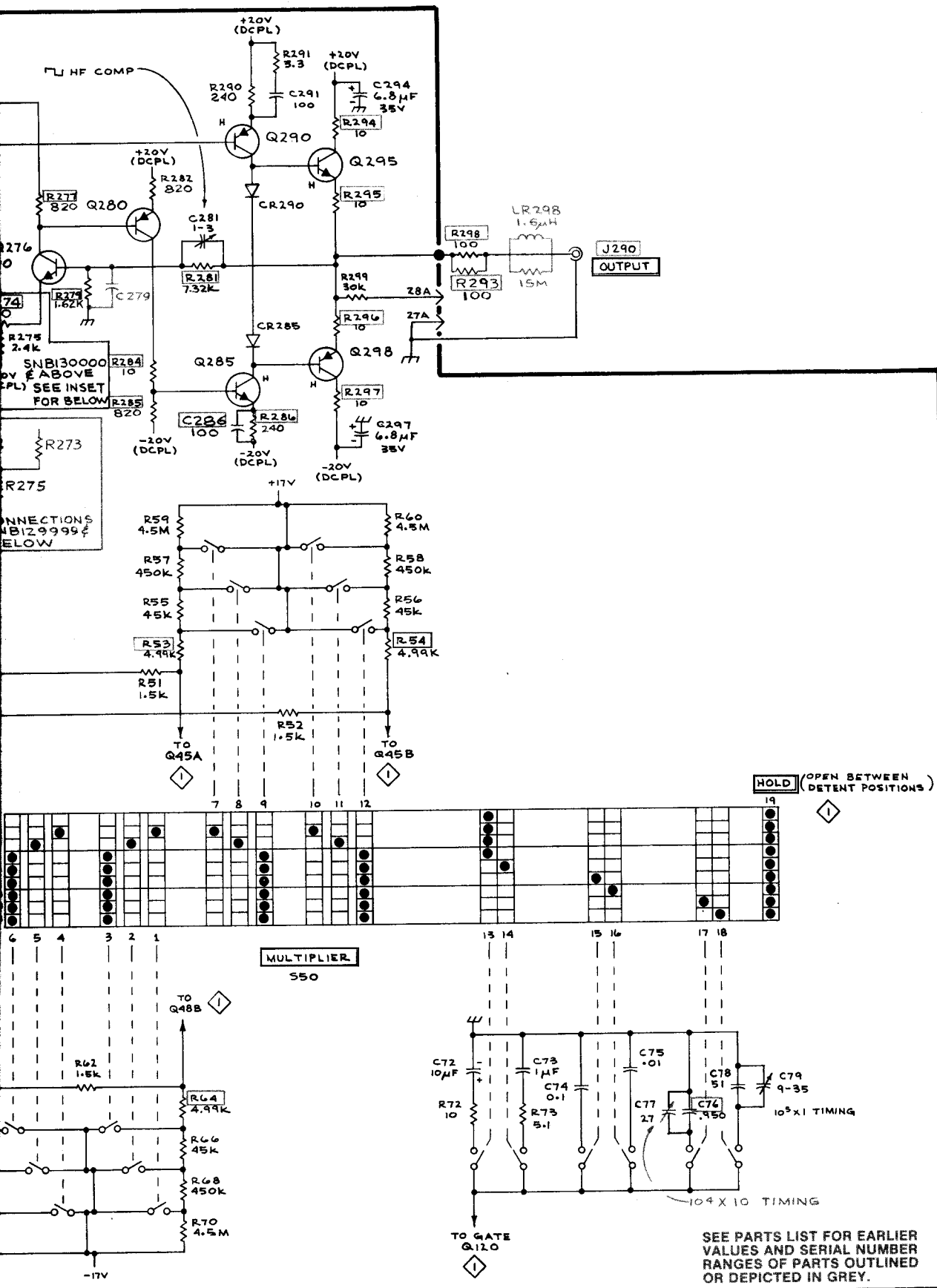
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS OUTLINED OR DEPICTED IN GREY.

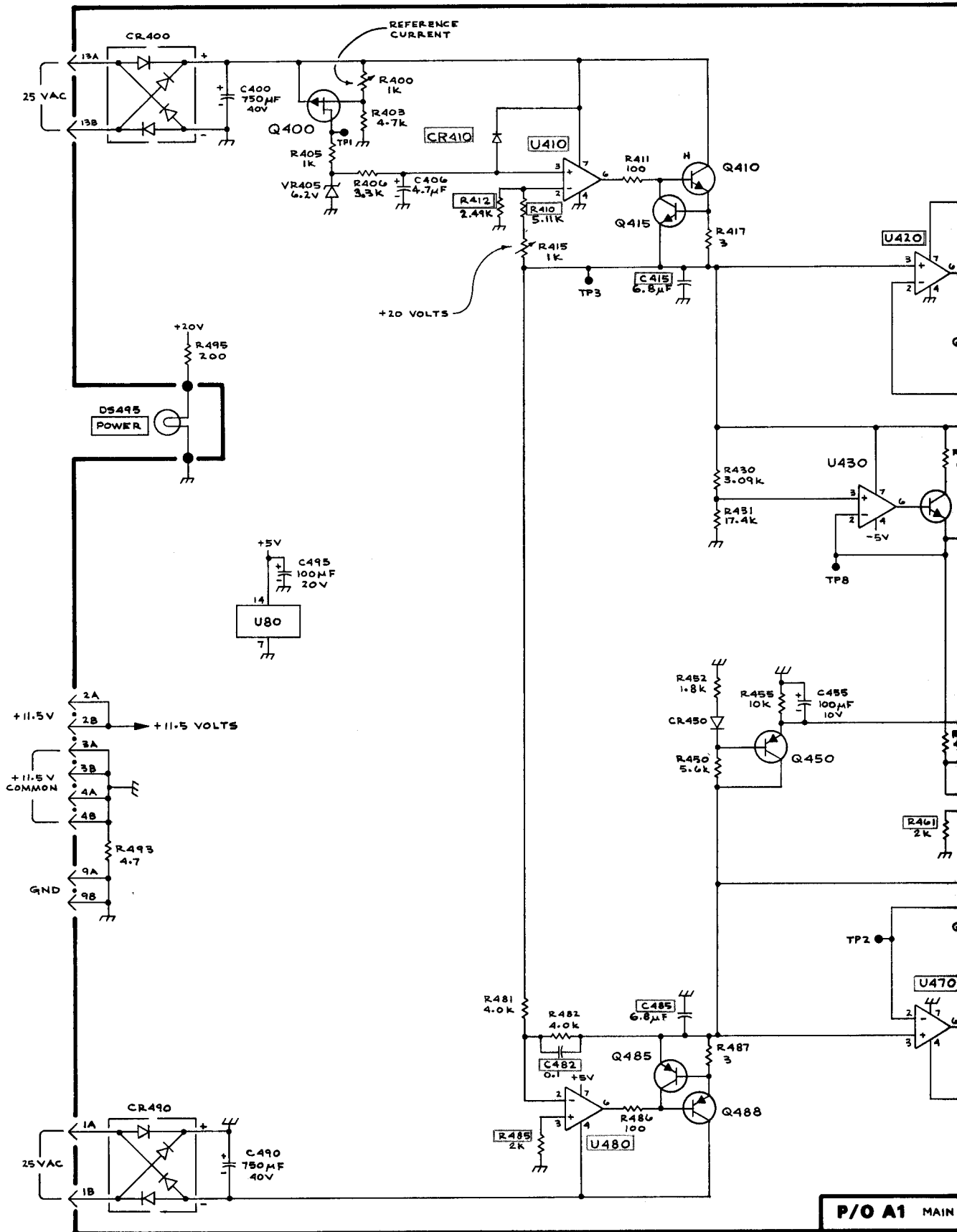


FG 501

REV H, JUL 1978

1431-16
OUTPUT AM

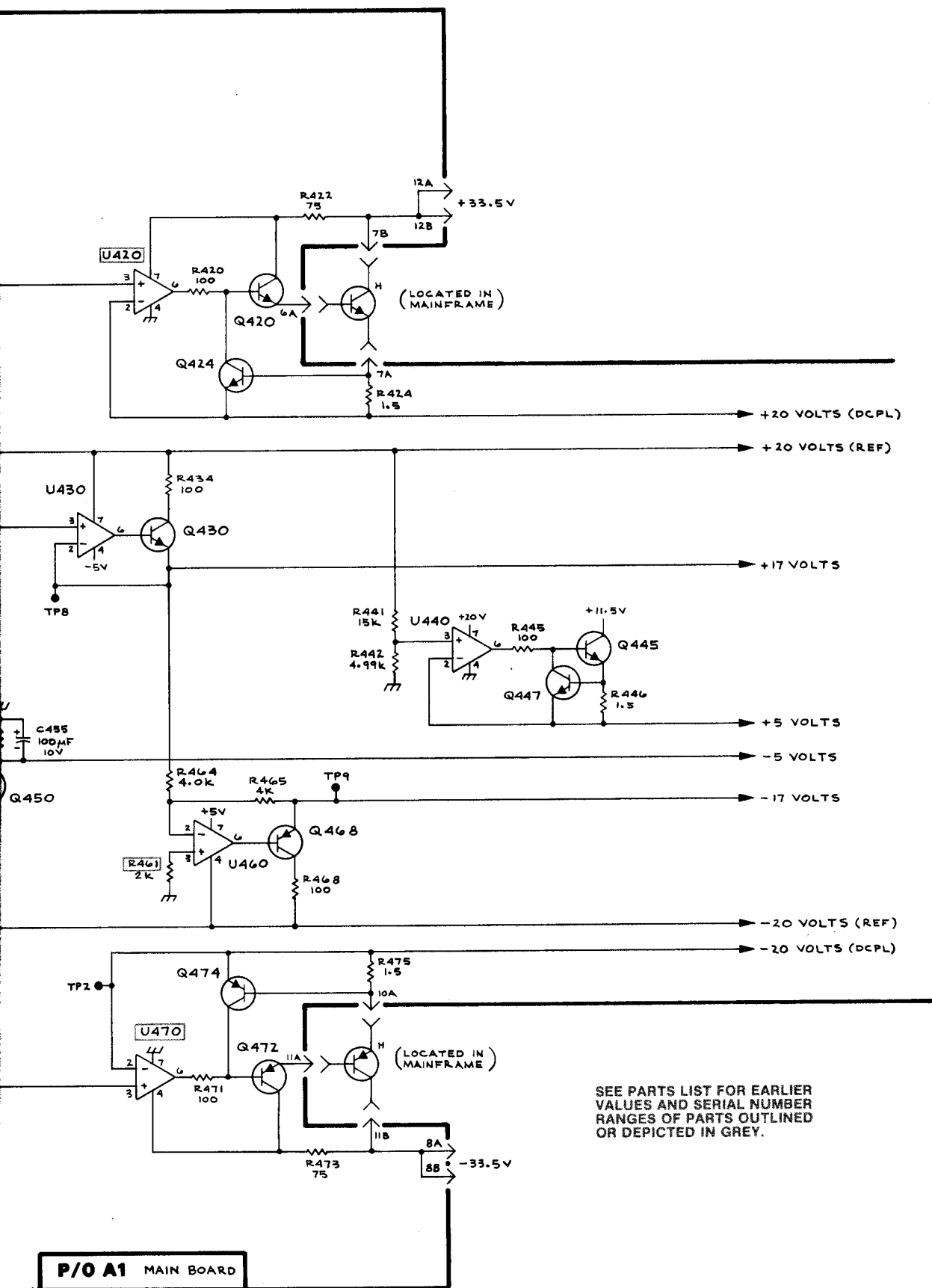




P/O A1 MAIN

FG 501

REV G, JUL 1978



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS OUTLINED OR DEPICTED IN GREY.

P/O A1 MAIN BOARD

REPLACEABLE MECHANICAL 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.

SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number
00X Part removed after this serial number

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

```

1 2 3 4 5           Name & Description
Assembly and/or Component
Attaching parts for Assembly and/or Component
-----
Detail Part of Assembly and/or Component
Attaching parts for Detail Part
-----
Parts of Detail Part
Attaching parts for Parts of Detail Part
-----

```

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol --- * --- indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

ITEM NAME

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.

ABBREVIATIONS

"	INCH	ELCTRN	ELECTRON	IN	INCH	SE	SINGLE END
#	NUMBER SIZE	ELEC	ELECTRICAL	INCAND	INCANDESCENT	SECT	SECTION
ACTR	ACTUATOR	ELCTLT	ELECTROLYTIC	INSUL	INSULATOR	SEMICOND	SEMICONDUCTOR
ADPTR	ADAPTER	ELEM	ELEMENT	INTL	INTERNAL	SHLD	SHIELD
ALIGN	ALIGNMENT	EPL	ELECTRICAL PARTS LIST	LPHLDR	LAMPHOLDER	SHLDR	SHOULDERED
AL	ALUMINUM	EQPT	EQUIPMENT	MACH	MACHINE	SKT	SOCKET
ASSEM	ASSEMBLED	EXT	EXTERNAL	MECH	MECHANICAL	SL	SLIDE
ASSY	ASSEMBLY	FIL	FILLISTER HEAD	MTG	MOUNTING	SLFLKG	SELF-LOCKING
ATTEN	ATTENUATOR	FLEX	FLEXIBLE	NIP	NIPPLE	SLVG	SLEEVING
AWG	AMERICAN WIRE GAGE	FLH	FLAT HEAD	NON WIRE	NOT WIRE WOUND	SPR	SPRING
BD	BOARD	FLTR	FILTER	OD	ORDER BY DESCRIPTION	SQ	SQUARE
BRKT	BRACKET	FR	FRAME or FRONT	OD	OUTSIDE DIAMETER	SST	STAINLESS STEEL
BRS	BRASS	FSTNR	FASTENER	OVH	OVAL HEAD	STL	STEEL
BRZ	BRONZE	FT	FOOT	PH BRZ	PHOSPHOR BRONZE	SW	SWITCH
BSHG	BUSHING	FXD	FIXED	PL	PLAIN or PLATE	T	TUBE
CAB	CABINET	GSKT	GASKET	PLSTC	PLASTIC	TERM	TERMINAL
CAP	CAPACITOR	HDL	HANDLE	PN	PART NUMBER	THD	THREAD
CER	CERAMIC	HEX	HEXAGON	PNH	PAN HEAD	THK	THICK
CHAS	CHASSIS	HEX HD	HEXAGONAL HEAD	PWR	POWER	TNSN	TENSION
CKT	CIRCUIT	HEX SOC	HEXAGONAL SOCKET	RCPT	RECEPTACLE	TPG	TAPPING
COMP	COMPOSITION	HLCP	HELICAL COMPRESSION	RES	RESISTOR	TRH	TRUSS HEAD
CONN	CONNECTOR	HLEXT	HELICAL EXTENSION	RGD	RIGID	V	VOLTAGE
COV	COVER	HV	HIGH VOLTAGE	RLF	RELIEF	VAR	VARIABLE
CPLG	COUPLING	IC	INTEGRATED CIRCUIT	RTNR	RETAINER	W/	WITH
CRT	CATHODE RAY TUBE	ID	INSIDE DIAMETER	SCH	SOCKET HEAD	WSHR	WASHER
DEG	DEGREE	IDNT	IDENTIFICATION	SCOPE	OSCILLOSCOPE	XFMR	TRANSFORMER
DWR	DRAWER	IMPLR	IMPELLER	SCR	SCREW	XSTR	TRANSISTOR

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
00779	AMP, INC.	P O BOX 3608	HARRISBURG, PA 17105
01295	TEXAS INSTRUMENTS, INC., SEMICONDUCTOR GROUP	P O BOX 5012, 13500 N CENTRAL EXPRESSWAY	DALLAS, TX 75222
05091	TRI-ORDINATE CORPORATION	343 SNYDER AVENUE	BERKELEY HEIGHTS, NJ 07922
08261	SPECTRA-STRIP CORP.	7100 LAMPSON AVE.	GARDEN GROVE, CA 92642
10539	JACKSON BROS., LONDON, LTD.		CROYDEN, SURREY, ENGLAND
12360	ALBANY PRODUCTS CO., DIV. OF PNEUMO DYNAMICS CORPORATION	145 WOODWARD AVENUE	SOUTH NORWALK, CT 06586
24931	SPECIALTY CONNECTOR CO., INC.	3560 MADISON AVE.	INDIANAPOLIS, IN 46227
45722	USM CORP., PARKER-KALON FASTENER DIV.		CAMPBELLSVILLE, KY 42718
55210	GETTIG ENG. AND MFG. COMPANY	PO BOX 85, OFF ROUTE 45	SPRING MILLS, PA 16875
73743	FISCHER SPECIAL MFG. CO.	446 MORGAN ST.	CINCINNATI, OH 45206
74445	HOLO-KROME CO.	31 BROOK ST. WEST	HARTFORD, CT 06110
74868	BUNKER-RAMO CORP., THE AMPHENOL RF DIV.	33 E. FRANKLIN ST.	DANBURY, CT 06810
77250	PHEOLL MANUFACTURING CO., DIVISION OF ALLIED PRODUCTS CORP.	5700 W. ROOSEVELT RD.	CHICAGO, IL 60650
78189	ILLINOIS TOOL WORKS, INC. SHAKEPROOF DIVISION	ST. CHARLES ROAD	ELGIN, IL 60120
78584	STEWART STAMPING CORP.	630 CENTRAL PARK AVE.	YONKERS, NY 10704
79136	WALDES, KOHINOOR, INC.	47-16 AUSTEL PLACE	LONG ISLAND CITY, NY 11101
79807	WROUGHT WASHER MFG. CO.	2100 S. O BAY ST.	MILWAUKEE, WI 53207
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
83385	CENTRAL SCREW CO.	2530 CRESCENT DR.	BROADVIEW, IL 60153
91836	KINGS ELECTRONICS CO., INC.	40 MARBLEDALE ROAD	TUCKAHOE, NY 10707
93907	CAMCAR SCREW AND MFG. CO.	600 18TH AVE.	ROCKFORD, IL 61101
98978	INTERNATIONAL ELECTRONIC RESEARCH CORP.	135 W. MAGNOLIA BLVD.	BURBANK, CA 91502

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
		Eff	Dscont					
1-1	337-1399-00			2		SHLD,ELECTRICAL:SIDE	80009	337-1399-00
-2	366-1422-00	B010100	B019999	1		KNOB:	80009	366-1422-00
	366-1422-01	B020000		1		KNOB:LATCH	80009	366-1422-01
	214-1840-00	XB020000		1		. PIN,KNOB SECRG:0.094 OD X 0.120 INCH LONG	80009	214-1840-00
-3	366-1031-03	B010100	B139209	1		KNOB:RED--CAL	80009	366-1031-03
	366-1031-08	B139210		1		KNOB:GY,CAL/W/ARROW,0.127 ID,0.392 OD	80009	366-1031-08
	213-0153-00			1		. SETSCREW:5-40 X 0.125 INCH,HEX SOC STL	74445	OBD
-4	366-1170-01	B010100	B139209	1		KNOB:GRAY,4 SIDED	80009	366-1170-01
	366-1170-03	B139210		1		KNOB:GRAY,0.25 ID X 0.706 OD,0.6H	80009	366-1170-03
	213-0153-00			2		. SETSCREW:5-40 X 0.125 INCH,HEX SOC STL	74445	OBD
-5	366-1023-01	B010100	B059999	2		KNOB:GRAY	80009	366-1023-01
	366-1023-01	B060000	B139209	1		KNOB:GRAY	80009	366-1023-01
	366-1023-07	B139210		1		KNOB:GRAY,0.127 ID,0.392 OD,0.466	80009	366-1023-07
-6	366-1023-03	B060000	B139209	1		KNOB:GRAY--PULL	80009	366-1023-03
	366-1023-08	B139210		1		KNOB:GRAY--PULL	80009	366-1023-08
	213-0153-00			1		. SETSCREW:5-40 X 0.125 INCH,HEX SOC STL	74445	OBD
-7	366-1319-00			1		KNOB:GRAY	80009	366-1319-00
	213-0725-00			1		. SETSCREW:3-48 X 0.095 INCH,HEX SOC STL	74445	OBD
-8	366-1077-01	B010100	B139209	1		KNOB:GRAY	80009	366-1077-00
	366-1077-01	B139210		1		KNOB:GRAY,0.127 ID,0.5 OD,0.531H	80009	366-1077-01
	213-0153-00			1		. SETSCREW:5-40 X 0.125 INCH,HEX SOC STL	74445	OBD
-9	366-1004-00	B010100	B089999	1		KNOB:GRAY	80009	366-1004-00
	366-1007-01	B090000	B139209	1		KNOB:GRAY	80009	366-1007-01
	366-1007-05	B139210		1		KNOB:GRAY	80009	366-1007-05
	200-0844-01	B139210		1		CAP,INSERT,KNOB:	80009	200-0844-01
	213-0153-00			2		. SETSCREW:5-40 X 0.125 INCH,HEX SOC STL	74445	OBD
-10	354-0437-01	B010100	B139209	1		RING,KNOB SKIRT:	80009	354-0347-01
	354-0557-02	B139210		1		RING,KNOB SKIRT:CLEAR,1 TO 10	80009	354-0557-02
-11	211-0030-00	B010100	B099999	2		SCREW,MACHINE:2-56 X 0.25"82 DEG,FLH STL	83385	OBD
	211-0088-00	B010000		1		SCREW,MACHINE:2-56 X 0.281"82 DEG,FLH STL	77250	OBD
-12	131-0679-00	B010100	B103149	1		CONNECTOR,RCPT,:BNC W/HARDWARE	24931	28JR168-1
	131-0679-02	B103150	B125502	1		CONNECTOR,RCPT,:BNC W/HARDWARE	24931	28JR270-1
	131-0274-00	B125503		1		CONNECTOR,RCPT,:BNC	91836	KC79-67
						(ATTACHING PARTS)		
	220-0497-00	B103150		1		NUT,PLAIN,HEX.:0.5-28 X 0.562 INCH HEX,BRS	73743	OBD
	210-1039-00	B103150		1		WASHER,LOCK:INT,0.521 ID X 0.625 INCH OD	24931	OBD
						- - - * - - -		
-13	131-0955-00			2		CONNECTOR,RCPT,:BNC,FEMALE,W/HARDWARE	05091	31-279
-14	131-0282-00			1		CONNECTOR,RCPT,:FEEDTHRU	74868	74300MB
-15	-----			1		RESISTOR,VAR:(SEE R206A AND R206B EPL)		
						(ATTACHING PARTS)		
-16	210-0583-00			1		NUT,PLAIN,HEX.:0.25-32 X 0.312 INCH,BRS	73743	2X20224-402
	210-0940-00			1		WASHER,FLAT:0.25 ID X 0.375 INCH OD,STL	79807	OBD
-17	-----			1		RESISTOR,VAR:(SEE R235 AND R245 EPL)		
						(ATTACHING PARTS)		
-18	210-0583-00			1		NUT,PLAIN,HEX.:0.25-32 X 0.312 INCH,BRS	73743	2X20224-402
-19	210-0940-00			1		WASHER,FLAT:0.25 ID X 0.375 INCH OD,STL	79807	OBD
						- - - * - - -		
-20	358-0378-00			1		BUSHING,SLEEVE:PRESS MOUNT	80009	358-0378-00
-21	333-1644-00	B010100	B109999	1		PANEL,FRONT:	80009	333-1644-00
	333-1644-01	B110000	B139209	1		PANEL,FRONT:	80009	333-1644-01
	333-1644-02	B139210		1		PANEL,FRONT:	80009	333-1644-02
-22	214-1513-00	B010100	B019999	1		LCH,PL-IN RTNG:PLASTIC	80009	214-1513-00
	214-1513-01	B020000		1		LCH,PLUG-IN RET:	80009	214-1513-01
						(ATTACHING PARTS)		
-23	213-0254-00			1		SCR,TPG,THD CTG:2-32 X 0.250,100 DEG,FLH	45722	OBD
						- - - * - - -		
-24	200-0935-00			1		BASE,LAMPHOLDER:0.29 OD X 0.19 CASE	80009	200-0935-00
-25	378-0602-00			1		LENS,LIGHT:GREEN	80009	378-0602-00
-26	352-0157-00			1		LAMPHOLDER:WHITE PLASTIC	80009	352-0157-00

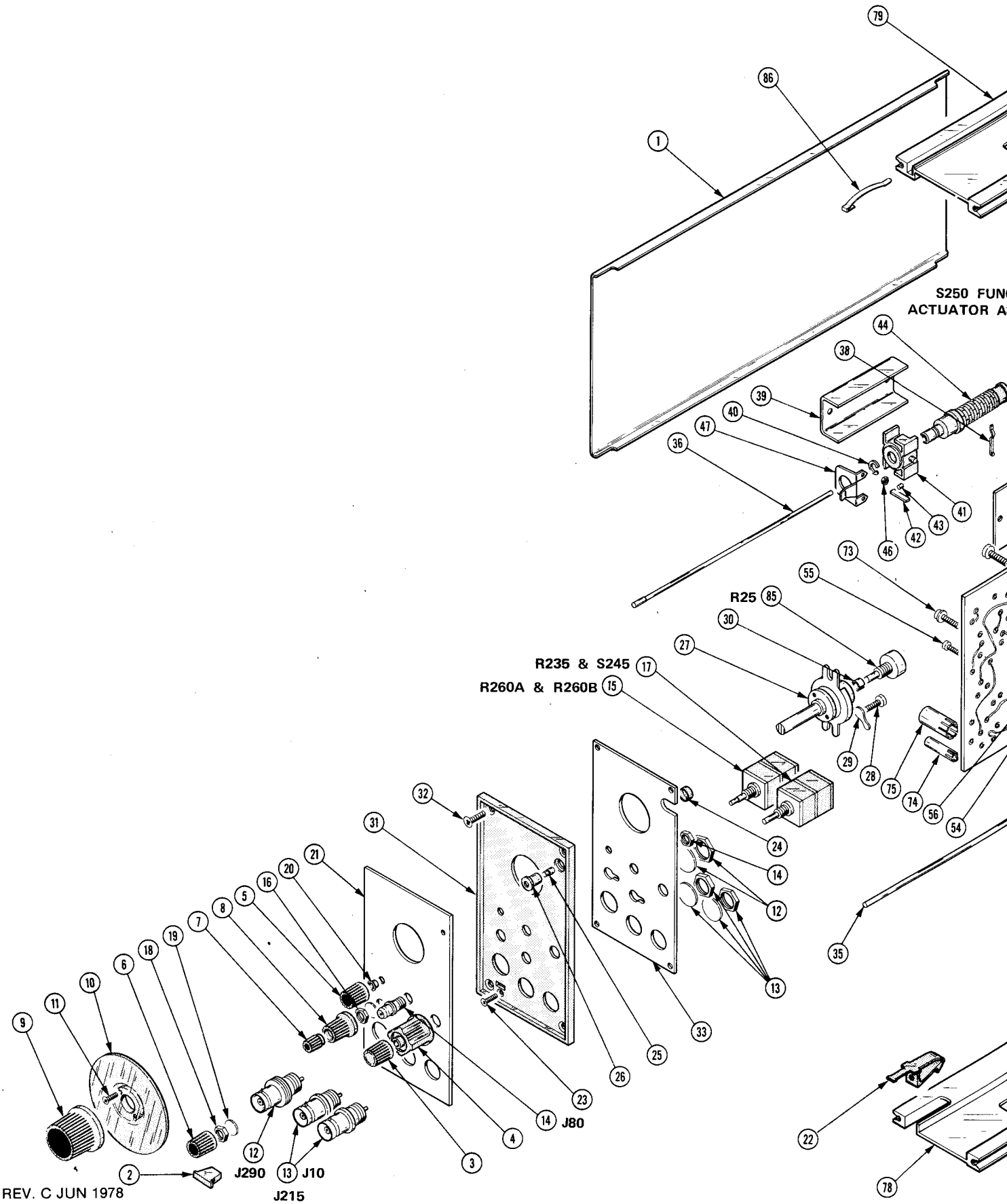
Replaceable Mechanical Parts—FG 501

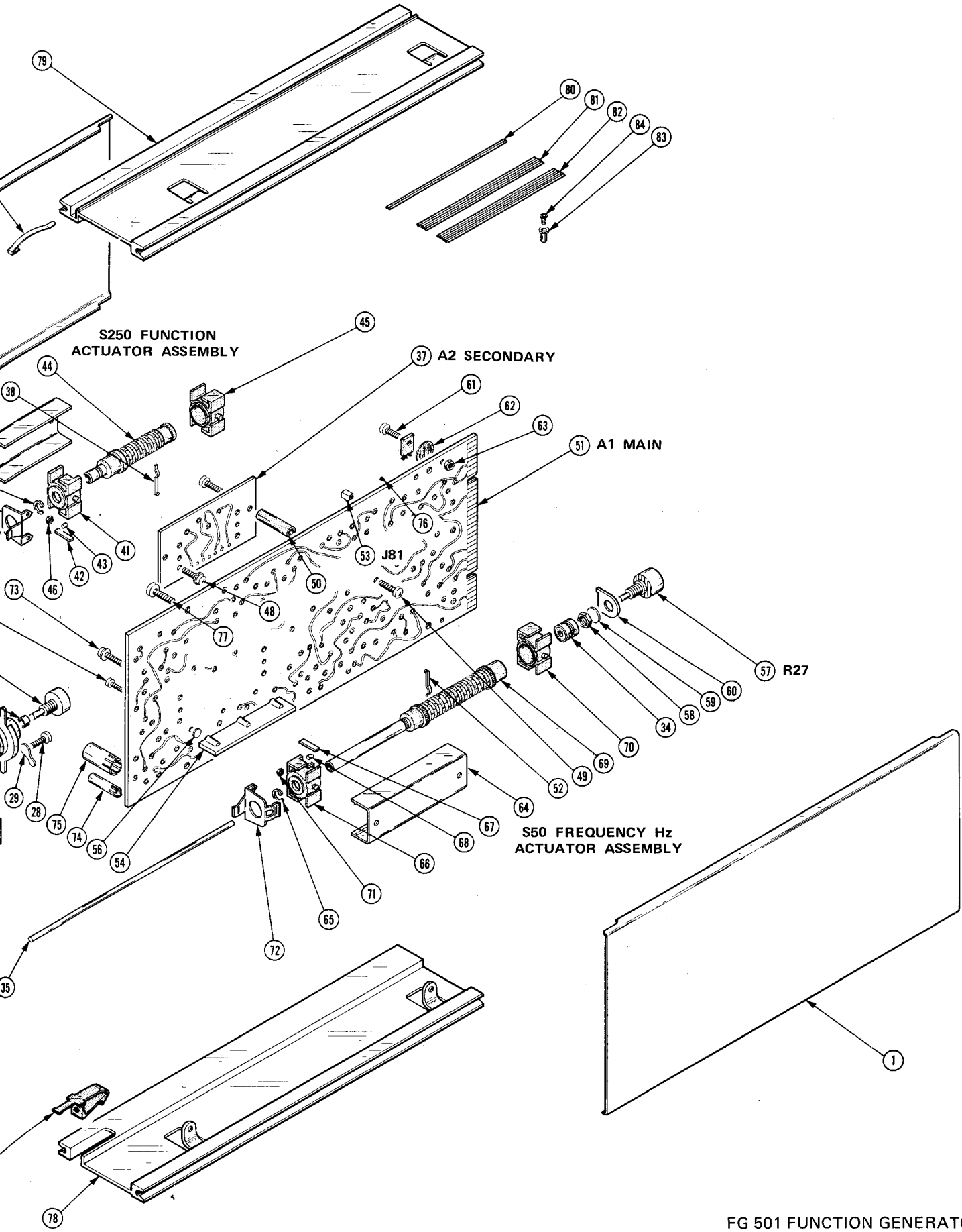
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
1-27	401-0206-00		1		GR ASSY, SP RDCN: (ATTACHING PARTS)	10539	4511/DAF
-28	213-0088-00	B010100 B010203	2		SCR, TPG, THD CTG: 4-24 X 0.25 INCH, PNH STL	83385	OBD
	213-0044-00	B010204 B099999	2		SCR, TPG, THD FOR: 5-32 X 0.188 INCH, PNH STL	83385	OBD
	213-0138-00	B010000	2		SCR, TPG, THD FOR: 4-40 X 0.188 INCH, PNH STL	83385	OBD
-29	210-0201-00		1		TERMINAL, LUG: SE #4 - - - * - - -	78189	2104-04-00-2520N
-30	358-0481-00		1		BUSHING, SLEEVE: SPLIT, 0.128 ID X 0.25 INCH OD	80009	358-0481-00
-31	386-2372-00	B010100 B109999	1		SUBPANEL, FRONT:	80009	386-2372-00
	386-2372-01	B110000	1		SUBPANEL, FRONT: (ATTACHING PARTS)	80009	386-2372-01
-32	213-0229-00		4		SCR, TPG, THD FOR: 6-20 X 0.375" 100 DEG, FLH STL - - - * - - -	93907	OBD
-33	337-1713-00	B010100 B109999	1		SHIELD, ELEC: SUBPANEL, FRONT	80009	337-1713-00
	337-1713-01	B110000	1		SHIELD, ELEC: SUBPANEL, FRONT	80009	337-1713-01
-34	376-0051-00	B010100 B089999	1		CPLG, SHAFT, FLEX: FOR 0.125 INCH DIA SHAFTS	80009	376-0051-00
	376-0051-01	B090000	1		CPLG, SHAFT, FLEX: FOR 0.125 INCH DIA SHAFTS	80009	376-0051-01
	376-0049-00		1		. CPLG, SHAFT, FLEX: PLASTIC	80009	376-0049-00
	354-0251-00		2		. RING, COUPLING: 0.251 ID X 0.375 INCH OD, AL	80009	354-0251-00
	213-0022-00	B010100 B089999	4		. SETSCREW: 4-40 X 0.188 INCH, HEX SOC STL	74445	OBD
	213-0178-00	B090000	4		. SETSCREW: 4-40 X 0.125 INCH, HEX, SOC STL	74445	OBD
-35	384-0209-00		1		EXTENSION SHAFT: 0.125 OD X 6.064 INCH LONG	80009	384-0209-00
-36	384-0406-00		1		EXTENSION SHAFT: 0.125 OD X 5.937 INCH LONG	80009	384-0406-00
-37	-----		1		CKT BOARD ASSY: SECONDARY (SEE A2 EPL)		
-38	131-0604-00		11		. CONTACT, ELEC: CKT BD SW, SPR	80009	131-0604-00
	105-0378-00		1		. ACTR ASSY, CAM S: (S250)	80009	105-0378-00
-39	200-1435-00		1		. . COVER, CAM SW:	80009	200-1435-00
-40	354-0219-00		1		. . RING, RETAINING: FOR 0.25 INCH SHAFT	79136	5103-25-MD-R
-41	401-0155-00		1		. . BEARING, CAM SW: FRONT	80009	401-0155-00
-42	214-1704-00 ¹		1		. . SPRING, FLAT: CAM SW DETENT, 0.006 INCH THK	80009	214-1704-00
	214-1704-01 ¹		1		. . SPRING, FLAT: CAM SW DETENT, 0.008 INCH THK	80009	214-1704-01
	214-1704-02 ¹		1		. . SPRING, FLAT: CAM SW DETENT, 0.010 INCH THICK	80009	214-1704-02
-43	214-1127-00		1		. . ROLLER, DETENT: 0.125 DIA X 0.125 INCH L	80009	214-1127-00
-44	105-0377-00		1		. . ACTUATOR, CAM SW:	80009	105-0377-00
-45	401-0156-00		1		. . BEARING, CAM SW: REAR	80009	401-0156-00
-46	210-0406-00		4		. . NUT, PLAIN, HEX.: 4-40 X 0.188 INCH, BRS	73743	2X12161-402
-47	131-1248-00		1		. . CONTACT, ELEC: GROUND (ATTACHING PARTS FOR ACTR ASSY)	80009	131-1248-00
-48	211-0116-00		4		. SCR, ASSEM WSHR: 4-40 X 0.312 INCH, PNH BRS - - - * - - - (ATTACHING PARTS FOR CKT BD ASSY)	83385	OBD
-49	211-0008-00		2		SCREW, MACHINE: 4-40 X 0.25 INCH, PNH STL	83385	OBD
	211-0168-00		2		SCREW, MACHINE: 4-40 X 0.25 INCH, PNH STL	12360	OBD
-50	129-0080-00		2		POST, ELEC-MECH: 0.875 INCH LONG - - - * - - -	80009	129-0080-00
-51	-----		1		CKT BOARD ASSY: MAIN (SEE A1 EPL)		
	131-0566-00	XB020229	1		. LINK, TERM. CONNE: 0.086 DIA X 2.375 INCH L	55210	L-2007-1
-52	131-0604-00		19		. CONTACT, ELEC: CKT BD SW, SPR	80009	131-0604-00
-53	131-1003-00		1		. CONNECTOR BODY, : CKT BD MT, 3 PRONG	80009	131-1003-00
-54	337-1418-01		1		. SHIELD, ELEC: CAM SWITCH (ATTACHING PARTS)	80009	337-1418-01
-55	211-0001-00		3		. SCREW, MACHINE: 2-56 X 0.25 INCH, PNH STL	83385	OBD
	210-1008-00		3		. WASHER, FLAT: 0.09 ID X 0.188" OD, BRS	12360	OBD
-56	342-0167-00		1		. INSULATOR, PLATE: 2.45 INCH LONG - - - * - - -	80009	342-0167-00
-57	-----		1		. RESISTOR, VAR: (SEE R27 EPL) (ATTACHING PARTS)		
-58	210-0583-00		1		. NUT, PLAIN, HEX.: 0.25-32 X 0.312 INCH, BRS	73743	2X20224-402
-59	210-0046-00		1		. WASHER, LOCK: INTL, 0.26 ID X 0.40" OD, STL	78189	1214-05-00-0541C
-60	407-0579-00		1		. BRKT, RES. MTG: - - - * - - -	80009	407-0579-00
-61	211-0008-00		3		. SCREW, MACHINE: 4-40 X 0.25 INCH, PNH STL	83385	OBD
-62	210-0921-00		3		. WASHER, MICA: 0.50 X 0.141 X 0.005 INCH THK	80009	210-0921-00

¹Replace only with part bearing the same color code as the original part in your instrument.

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
		Eff	Dscont					
1-63	210-0406-00			3	.	NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS	73743	2X12161-402
	105-0376-00			1	.	ACTR ASSY,CAM S:(S50)	80009	105-0376-00
-64	200-1434-00			1	.	COVER,CAM SW:	80009	200-1434-00
-65	354-0219-00			1	.	RING,RETAINING:FOR 0.25 INCH SHAFT	79136	5103-25-MD-R
-66	401-0155-00			1	.	BEARING,CAM SW:FRONT	80009	401-0155-00
-67	214-1704-00			1	.	SPRING,FLAT:CAM SW DETENT,0.006 INCH THK	80009	214-1704-00
	214-1704-01			1	.	SPRING,FLAT:CAM SW DETENT,0.008 INCH THK	80009	214-1704-01
	214-1704-02			1	.	SPRING,FLAT:CAM SW DETENT,0.010 INCH THICK	80009	214-1704-02
-68	214-1127-00			1	.	ROLLER,DETENT:0.125 DIA X 0.125 INCH L	80009	214-1127-00
-69	105-0375-00			1	.	ACTUATOR,CAM SW:	80009	105-0375-00
-70	401-0156-00			1	.	BEARING,CAM SW:REAR	80009	401-0156-00
-71	210-0406-00			4	.	NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS	73743	2X12161-402
-72	131-1248-00			1	.	CONTACT,ELEC:GROUND	80009	131-1248-00
						(ATTACHING PARTS FOR ACTR ASSY)		
-73	211-0116-00			4	.	SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS	83385	OBD
	210-0269-00	XB139210		1	.	TERMINAL,LUG:NON LOCKING,0.257" MTG HOLE	78584	OBD
						- - - * - - -		
-74	214-0269-00	B010100	B129999X	2	.	HEAT SINK,XSTR:0.312 DIA X 0.75 L	98978	TXD-032-75
-75	214-0693-00			3	.	HEAT SINK, ELEC:0.25 ID X 0.75 INCH LONG	98978	TXD017-075
	214-0579-00	XB010204		9	.	TERM.,TEST PT:0.40 INCH LONG	80009	214-0579-00
	214-2733-00	XB139210		1	.	HEAT SINK,XSTR:(2) TO -202,AL	80009	214-2733-00
						(ATTACHING PARTS)		
	211-0004-00	XB139210		2	.	SCREW,MACHINE:3-48 X 0.125,PNH,STL,CD PL POZ		
	342-0202-00	XB139219		2	.	INSULATOR,PLATE:TRANSISTOR	01295	10-21-023-106
						- - - * - - -		
-76	136-0252-00			209	.	SOCKET,PIN TERM:0.145 INCH LONG	00779	2-330808-7
						(ATTACHING PARTS FOR CKT BD ASSY)		
-77	213-0146-00			4	.	SCR,TPG,THD FOR:6-20 X 0.313 INCH,PNH STL	83385	OBD
						- - - * - - -		
	210-1270-00	XB128340		2	.	WASHER,FLAT:0.141 ID X .04THK,AL,.21 9 OD	80009	210-1270-00
	386-3657-00	XB128340		2	.	SUPPORT,PLUG-IN:	80009	386-3657-00
-78	426-0724-00			1	.	FR SECT,PLUG-IN:BOTTOM	80009	426-0724-00
-79	426-0725-00			1	.	FR SECT,PLUG-IN:TOP	80009	426-0725-00
-80	175-0825-00			FT	.	WIRE,ELECTRICAL:2 WIRE RIBBON,0.531 FT LONG	08261	OBD
-81	175-0828-00			FT	.	WIRE,ELECTRICAL:5 WIRE RIBBON,0.334 FT LONG	08261	SS-0526-710610C
-82	175-0829-00			FT	.	WIRE,ELECTRICAL:6 WIRE RIBBON,0.334 FT LONG	08261	SS-0626-710610C
-83	210-0774-00			1	.	EYELET,METALLIC:0.152 OD X 0.245 INCH L,BRS	80009	210-0774-00
-84	210-0775-00			1	.	EYELET,METALLIC:0.126 OD X 0.23 INCH L,BRS	80009	210-0775-00
-85	-----			1	.	RESISTOR,VAR:(SEE R25 EPL)		
-86	214-1061-00	XB050297		1	.	SPRING,GROUND:FLAT	80009	214-1061-00

REV. C JUN 1978





FG 501 FUNCTION GENERATOR

ACCESSORIES

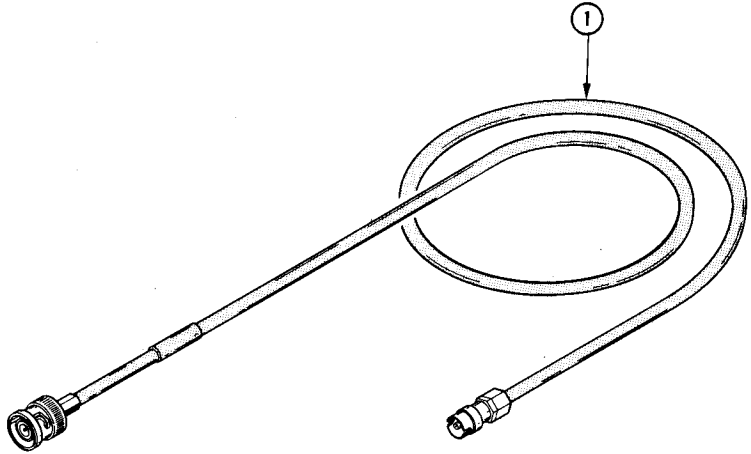


FIG. 2 ACCESSORIES

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Dscont	Qty	Name & Description					Mfr Code	Mfr Part Number	
					1	2	3	4	5		Mfr	Part Number
2- 1	012-0127-00			1						80009	012-0127-00	
	070-1431-01			1						80009	070-1431-01	

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.

SERVICE NOTE

Because of the universal parts procurement problem, some electrical parts in your instrument may be different from those described in the Replaceable Electrical Parts List. The parts used will in no way alter or compromise the performance or reliability of this instrument. They are installed when necessary to ensure prompt delivery to the customer. Order replacement parts from the Replaceable Electrical Parts List.

CALIBRATION TEST EQUIPMENT REPLACEMENT

Calibration Test Equipment Chart

This chart compares TM 500 product performance to that of older Tektronix equipment. Only those characteristics where significant specification differences occur, are listed. In some cases the new instrument may not be a total functional replacement. Additional support instrumentation may be needed or a change in calibration procedure may be necessary.

Comparison of Main Characteristics

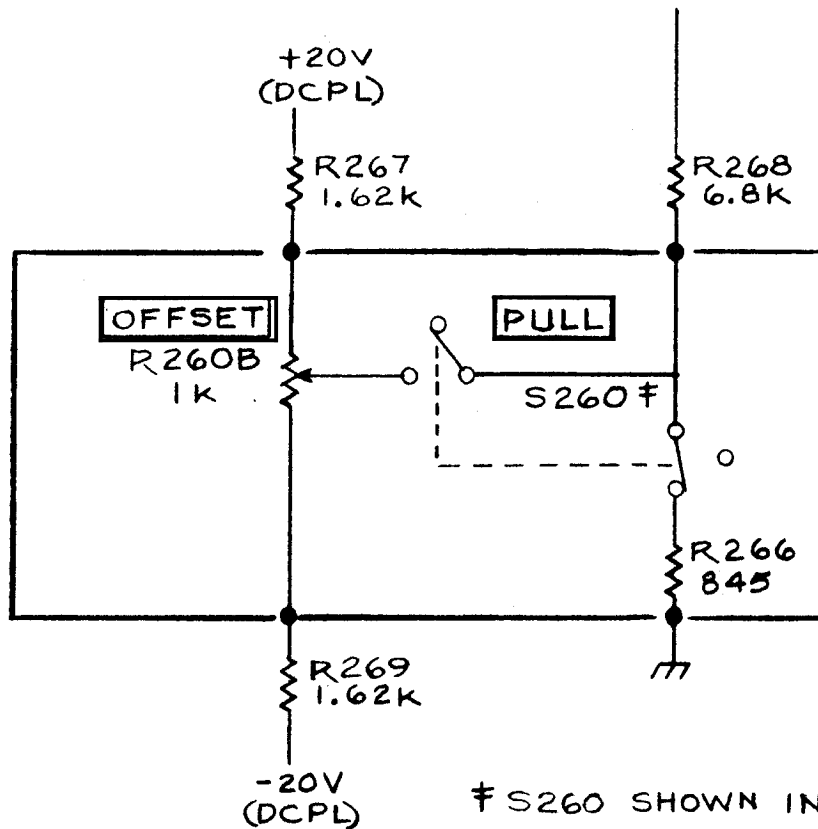
Comparison of Main Characteristics		
DM 501 replaces 7D13		
PG 501 replaces 107 108	PG 501 - Risetime less than 3.5 ns into 50 Ω . PG 501 - 5 V output pulse; 3.5 ns Risetime	107 - Risetime less than 3.0 ns into 50 Ω . 108 - 10 V output pulse 1 ns Risetime
PG 502 replaces 107 108 111	PG 502 - 5 V output PG 502 - Risetime less than 1 ns; 10 ns Pretrigger pulse delay	108 - 10 V output 111 - Risetime 0.5 ns; 30 to 250 ns Pretrigger pulse delay
PG 508 replaces 114 115 2101	Performance of replacement equipment is the same or better than equipment being replaced.	
PG 506 replaces 106 067-0502-01	PG 506 - Positive-going trigger output signal at least 1 V; High Amplitude output, 60 V. PG 506 - Does not have chopped feature.	106 - Positive and Negative-going trigger output signal, 50 ns and 1 V; High Amplitude output, 100 V. 0502-01 - Comparator output can be alternately chopped to a reference voltage.
SG 503 replaces 190, 190A, 190B 191 067-0532-01	SG 503 - Amplitude range 5 mV to 5.5 V p-p. SG 503 - Frequency range 250 kHz to 250 MHz.	190B - Amplitude range 40 mV to 10 V p-p. 0532-01 - Frequency range 65 MHz to 500 MHz.
SG 504 replaces 067-0532-01 067-0650-00	SG 504 - Frequency range 245 MHz to 1050 MHz.	0532-01 - Frequency range 65 MHz to 500 MHz.
TG 501 replaces 180, 180A 181 184 2901	TG 501 - Trigger output-slaved to marker output from 5 sec through 100 ns. One time-mark can be generated at a time. TG 501 - Trigger output-slaved to marker output from 5 sec through 100 ns. One time-mark can be generated at a time. TG 501 - Trigger output-slaved to marker output from 5 sec through 100 ns. One time-mark can be generated at a time.	180A - Trigger pulses 1, 10, 100 Hz; 1, 10, and 100 kHz. Multiple time-marks can be generated simultaneously. 181 - Multiple time-marks 184 - Separate trigger pulses of 1 and 0.1 sec; 10, 1, and 0.1 ms; 10 and 1 μ s. 2901 - Separate trigger pulses, from 5 sec to 0.1 μ s. Multiple time-marks can be generated simultaneously.

NOTE: All TM 500 generator outputs are short-proof. All TM 500 plug-in instruments require TM 500-Series Power Module.

CHANGE	DESCRIPTION
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SCHEMATIC CORRECTION

DIAGRAM 2 OUTPUT AMPL & SWITCH DETAILS- Partial



TEXT CORRECTION

Page 2-2 Table 2-1, Performance Requirement

CHANGE TO:

Offset

Amplitude

Into 50 ohm Load

SN B130000-up: + or - 3.75 V