Tektronix®
COMMITTED TO EXCELLENCE

FG 502 FUNCTION GENERATOR

INSTRUCTION MANUAL

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

Serial Number _____

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

OPERATORS SAFETY SUMMARY

Terms In This Manual

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

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

Terms As Marked on Equipment

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

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

Symbols As Marked on Equipment


DANGER — High voltage.


Protective ground (earth) terminal.


ATTENTION — refer to manual.

Power Source

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

Grounding the Product

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

Danger Arising From Loss of Ground

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

Use the Proper Power Cord

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

Use only a power cord that is in good condition.

Use the Proper Fuse

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

Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

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

Do Not Operate Plug-In Unit Without Covers

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

SERVICE SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY

Refer also to the preceding Operators Safety Summary.

Do Not Service Alone

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

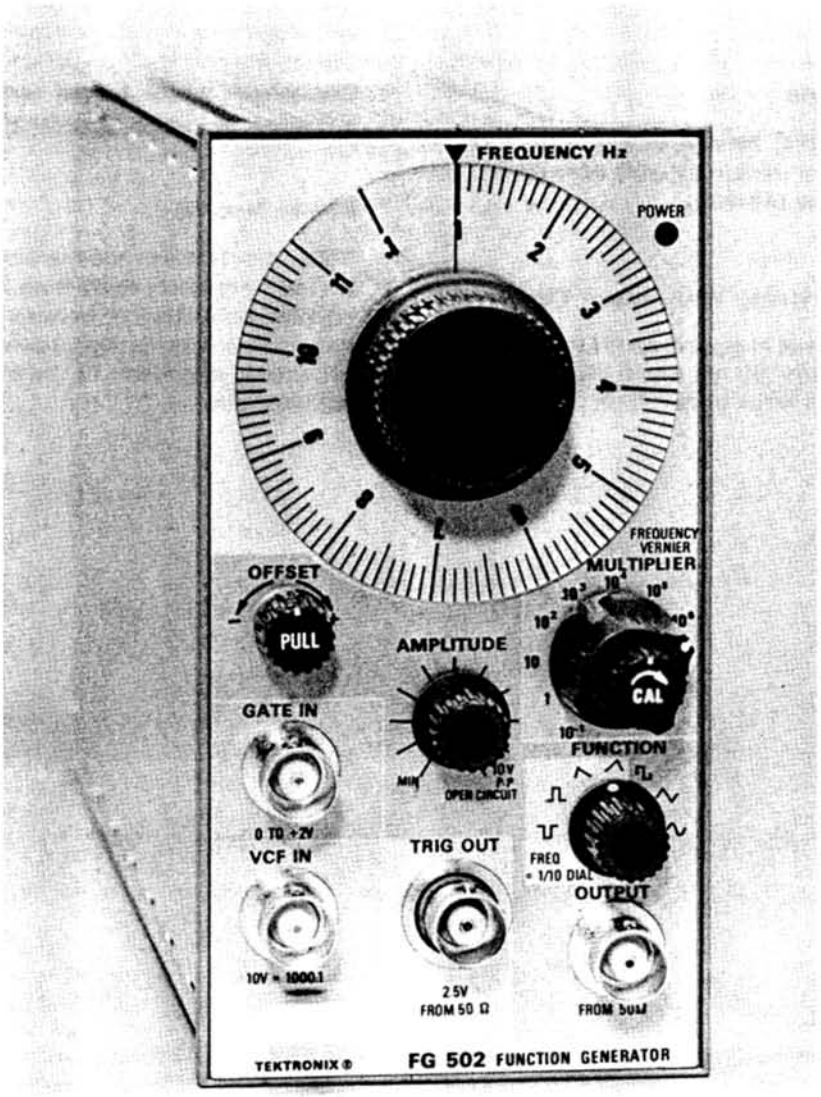
Use Care When Servicing With Power On

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

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

Power Source

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



FG 502 FUNCTION GENERATOR

SPECIFICATION

INTRODUCTION

The FG 502 Function Generator is designed to operate in a TM 500 series power module. It generates low distortion sine, square, triangle, positive and negative pulse, and ramp waveforms from 0.1 Hz to 11 MHz. A square wave trigger is available at the front panel. Variable DC offset is also provided.

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

An external gate input allows the generator to operate for the duration of an externally applied gating signal. This mode provides either a single cycle output, or a train of preselected waveforms, depending on the gating signal width and the generator frequency setting.

The variety of swept and modulated signals available from the FG 502 make it especially useful for such applications as testing servo-system or amplifier response, distortion, and stability. It can be used for FM generation, frequency multiplication, or as a variable beat-frequency oscillator. It can also be used to generate repetition rates or tone bursts. The square wave trigger output can be used as a source for TTL logic, or to synchronize an external device such as an oscilloscope or counter.

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

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

Any conditions that are unique to a particular characteristic are expressly stated as part of that characteristic.

The electrical and environmental performance limits together with their related validation procedures comprise a complete statement of the electrical and environmental performance of a calibrated instrument.

Table 1-1

ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
Frequency Range	0.1 Hz to 11 MHz.	
Frequency Resolution		1 part in 10^4 of full scale setting using FREQUENCY VERNIER control.
Frequency Stability		≤ 0.1% for 1 hour, ≤ 0.5% for 24 hours. Dial must be on calibrated portion and ambient temperature must be 25° C ±5° C.
Pulse and Ramp Frequency	1/10 triangle frequency.	
Dial Range	1 to 11 calibrated. 0.1 to 1 uncalibrated.	

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Dial Accuracy	≤ 3% of full scale from 0.1 Hz to 1 MHz. ≤ 5% of full scale from 1 MHz to 10 MHz. 11 MHz setting not less than 11 MHz.	
Output Amplitude	≥ 10 V P-P open circuit. ≥ 5 V P-P into a 50 Ω load, excluding offset. Referenced at 10 kHz.	
Amplitude Flatness		
Sinewave	Within ± 1.5 dB, reference at 10 kHz.	
Square and triangle to sine-wave amplitude	Within ± 3 dB.	
Offset Range	≥ + and −5 V, open circuit. ≥ + and −2.5 V into a 50 Ω load.	
Sinewave Distortion	≤ 0.5% from 10 Hz to 50 kHz. Harmonics > −30 dB down at all other frequencies.	Dial must be on calibrated portion, and ambient temperature must be 25° C ±5° C.
Triangle Symmetry	Within 1% from 0.1 Hz to 1.1 MHz. Within 3% from 1.1 MHz to 11 MHz using 10^6 MULTIPLIER setting.	Dial must be on calibrated portion. Ambient temperature must be 25° C ±5° C.
Triangle Linearity		Within 1.0% from 0.1 Hz to 110 kHz, within 3% from 100 kHz to 1.1 MHz using 10^5 MULTIPLIER setting, within 5% from 1 MH to 11 MHz using 10^6 MULTIPLIER setting.
Squarewave and Pulse Output		
Risetime	≤ 20 ns.	
Aberrations	≤ 3% P-P at full amplitude into 50 Ω load.	
Pulse and Ramp Aspect Ratio		95/5.
Voltage Controlled Frequency Input (VCF)		
Range	A 10 V signal shifts frequency ≥ 1000:1 where $freq_{max}$ ≥ 11 X MULTIPLIER setting and $freq_{min}$ ≤ 0.011 X MULTIPLIER setting.	
Slew Rate		≤ 0.5 V/μs.
External Gate Input	0 V to ≥ +2 V, not to exceed +15 V. Baseline of output waveform during off period within 500 mV measured from 0 V. Usable on the 10^6 MULTIPLIER setting only for sine, triangle or square waveform output.	
ıput Impedance		1 KΩ.
rigger Output	≥ 5 V open circuit, ≥ 2.5 V into 50 Ω load.	
²ower Consumption		15 W.

Table 1-2

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 inch 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 1-3

PHYSICAL CHARACTERISTICS

Characteristics	Dimensions
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)

OPERATING INSTRUCTIONS

Initial Operation

CAUTION

Turn the Power Module off before inserting the plug-in; otherwise, damage may occur to the plug-in circuitry or connector.

The FG 502 is calibrated and ready for use when received. It is designed to operate in any compartment of the TM 500 series power module. Refer to the power module instruction manual for line voltage requirements and power module operation. See Fig. 2-1 for installation removal procedure. Be sure that the FG 502 is fully inserted in the power module. Pull the PWR switch on the power module. Check that the green POWER light on the FG 502 is on. The Controls and Connectors Fig. 2-2 gives a complete description of the front panel controls and connectors.

Functions Available At Rear Connector

Refer to the rear connector assignment illustration in the Maintenance Section of this manual for pin assignments.

A slot between pins 23 and 24 on the rear connector identifies the FG 502 as a member of the signal source family. A barrier may be inserted 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 if specialized connections are made to that compartment. Consult the Building A System section of the power module manual for further information.

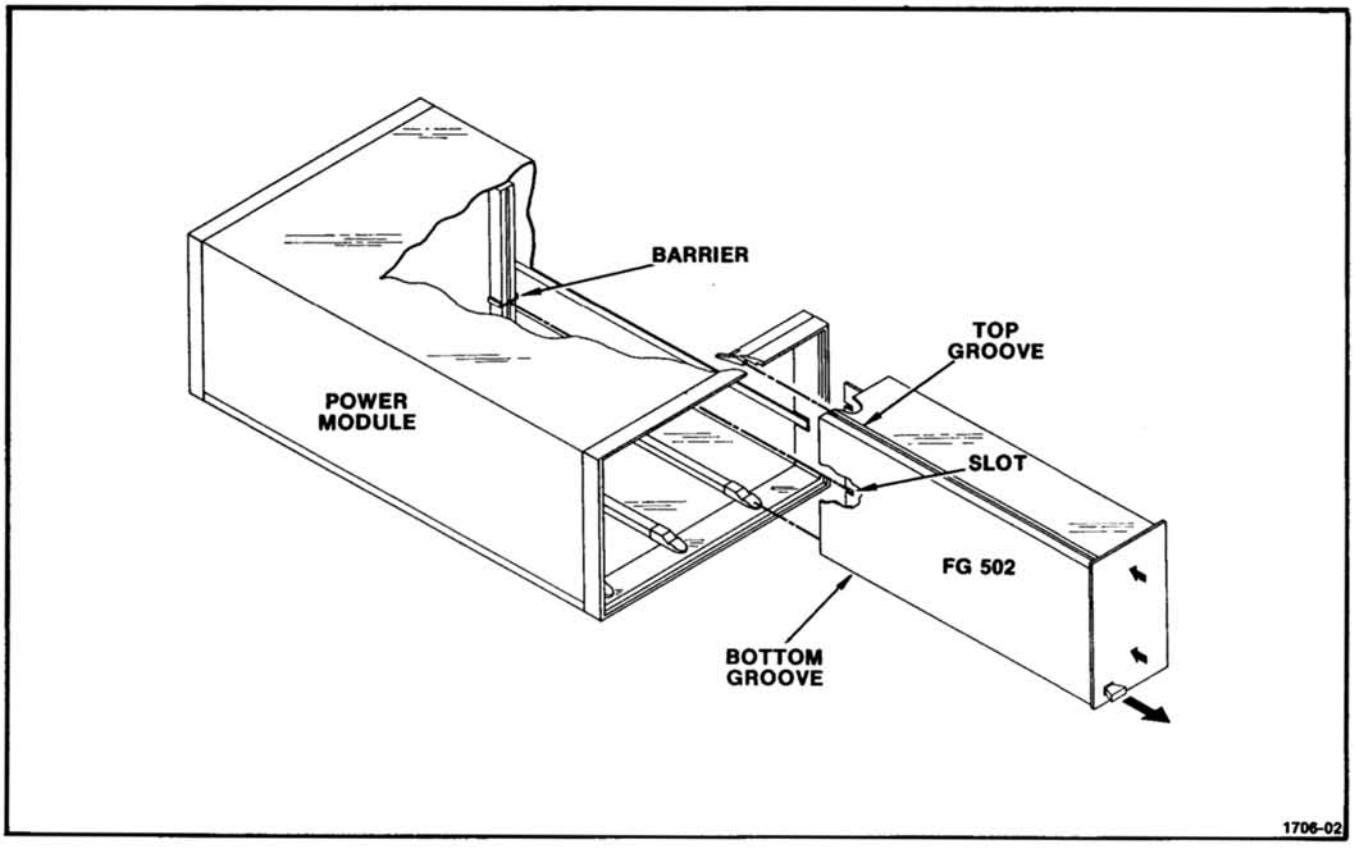


Fig. 2-1. FG 502 Installation and removal.

CONTROLS AND CONNECTORS

(1) OFFSET Control

Pull and adjust for output waveform DC offset.

(2) AMPLITUDE Control

Adjusts amplitude of output waveform.

(3) GATE IN Connector

Voltage applied permits gating of output waveform.

(4) VCF IN Connector

Applied external voltage changes output waveform frequency.

(5) LATCH

Pull to remove plug-in.

(6) TRIG OUT Connector

Square-wave output for applications requiring an external trigger.

(7) OUTPUT Connector

BNC connector for waveform output.

(8) FUNCTION Switch

Selects output waveform.

(9) VERNIER Control

Allows fine adjustment of output frequency.

(10) MULTIPLIER Switch

Sets basic frequency range.

(11) FREQUENCY Hz Dial

Multiply dial reading by MULTIPLIER setting for frequency out.

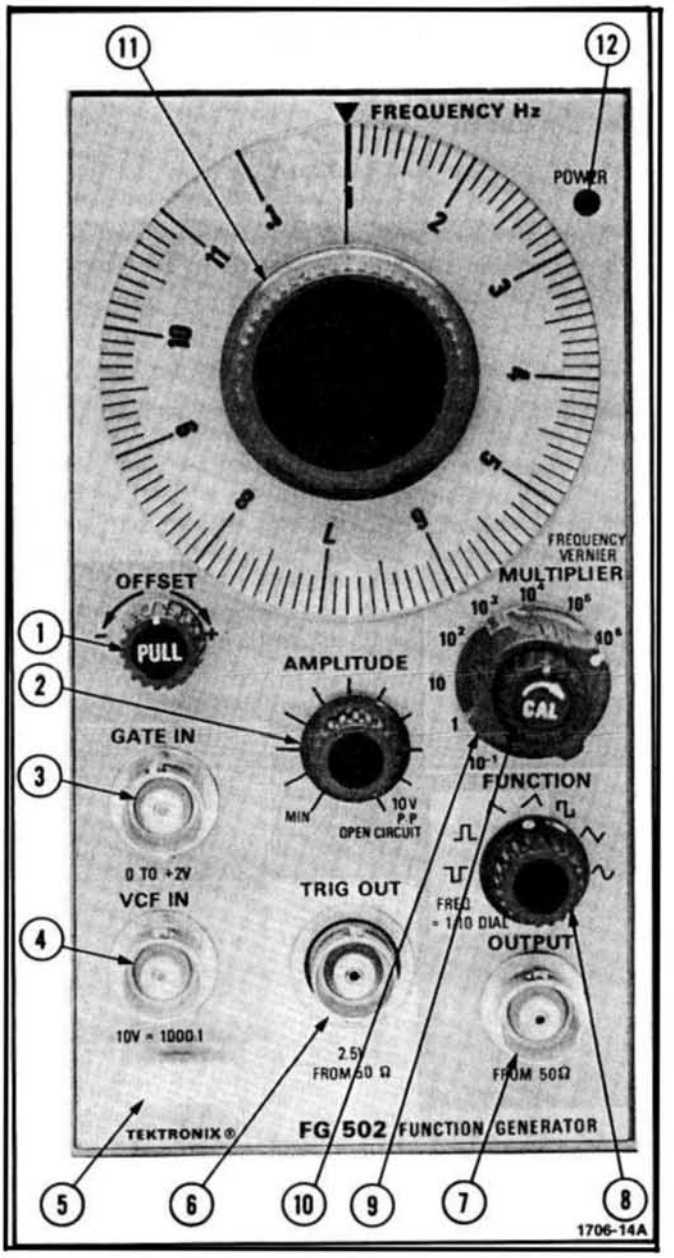


Fig. 2-2. Controls and Connectors.

(12) POWER On Pilot Light

Illuminated when power is applied to unit.

OPERATING CONSIDERATIONS

Output Connections

The output of the FG 502 is designed to operate as a 50 Ω voltage source working into a 50 Ω load. At higher frequencies, an unterminated or improperly terminated output causes excessive aberrations on the output waveform (see Impedance Matching discussion). Loads less than 50 Ω reduce the waveform amplitude.

Excessive distortion or aberrations, due to improper termination, are less likely to occur at the lower frequencies (especially with sine and triangle waveforms). To retain waveform purity, observe the following precautions:

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

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

3. Use good quality attenuators if it is necessary to reduce waveform amplitude to sensitive circuits.

4. Use terminators or impedance-matching devices to avoid reflections when using long cables.

5. Ensure that attenuators, terminations, etc. have adequate power handling capabilities for the output waveform.

Risetime and Falltime

If the output pulse from the FG 502 is used to measure the rise or falltime of a device, consider the risetime characteristics of the associated equipment used. If the risetime of the device under test is at least 10 times greater than the combined risetimes of the FG 502 plus the monitoring oscilloscope and associated cables, the error introduced will not exceed 1%. This error can generally be ignored. When the rise or falltime of the test device is less than 10 times as long as the combined risetimes of the testing system, the actual risetime of the device must be determined. This is found from the risetime of each component making up the system. The total risetime equals the square root of the sum of the squares of the individual risetimes. $R_t = (R_1)^2 + (R_2)^2 + (R3)^2 + \ldots$ Conversely, the risetime of the device under test can be found from the same relationship if the actual risetimes in the system are known.

The physical and electrical characteristics of the pulse transmitting cable determine the characteristic impedance, velocity of propagation, and amount of signal loss. Signal loss is related to frequency; therefore, a few feet of cable can attenuate high frequency information in a fast-rise pulse. It is important to keep 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 ±10 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.

Impedance Matching

As the pulse travels down a transmission line, each time it encounters a mismatch, or an impedance different than that of the transmission line, a reflection is generated and sent back along the line to the source. The amplitude and polarity of the reflections are determined by the 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. If the FG 502 is driving a high impedance such as the 1 MΩ vertical input to an oscilloscope, connect the transmission line to a 50 Ω attenuator, 50 Ω termination, and then the oscilloscope input. The attenuator isolates the input capacitance of the device, and the FG 502 is properly terminated.

A simple resistive impedance-matching network that provides minimum attenuation is illustrated in Fig. 2-3. 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

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

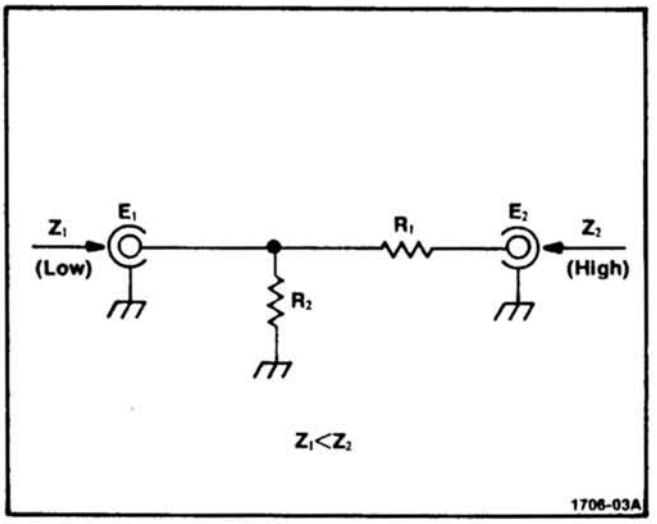


Fig. 2-3. Impedance matching network that provides minimum attenuation.

Therefore:

$$R_1R_2 = Z_1Z_2; \text{ and } R_1Z_1 = R_2(Z_2 - Z_1)$$

or

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

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:

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

and

$$R R_2 = 50\sqrt{\frac{125}{125-50}} = 64.6\ \Omega.$$

When constructing such a device, the environment surrounding the components should be designed to provide a transition between the impedances. 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

$$(Z_o = \frac{138}{\sqrt{\Sigma}} \log_{10} D/d).$$

D is the inside diameter of the outer conductor, d is the diameter of the inner conductor, and Σ is the dielectric constant (1 in air).

The network in Fig. 2-3 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 encounters a voltage attenuation (A_1) that is greater than 1 and less than 2, as follows:

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

A signal (E_2) applied from the higher impedance source (Z_2) encounters a greater voltage attenuation (A_2) that 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,

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

and

$$A_2 = \frac{96.8}{64.6} + \frac{96.8}{50} + 1 = 4.43.$$

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.

OPERATION

Free-Running Output

Set the AMPLITUDE control fully clockwise, and make certain the OFFSET control is pushed in. Set the FUNCTION selector to the desired waveform. See Fig. 2-4. Select the desired frequency with the MULTIPLIER and FREQUENCY Hz dials. Note the ramp and pulse frequencies are one-tenth the FREQUENCY Hz and MULTIPLIER dial settings. The output frequency is calibrated when the FREQUENCY VERNIER control is in the full clockwise position. Connect the load to the OUTPUT connector and adjust the AMPLITUDE control for the desired output amplitude. Pull and adjust the OFFSET control to position the DC level (baseline) of the output waveform above or below 0 V as desired.

Gated Output

A gating signal of at least 0 V to +2 V applied to the GATE IN connector provides gated waveforms. The duration of the output waveforms depends upon the duration of the gating signal. The number of cycles during the burst depends upon the FREQUENCY Hz and MULTIPLIER dial settings. Single cycles can be obtained by applying a gating signal with a period approximately equal to the period of the FG 502 output. The number of cycles per burst may be approximated by dividing the gating signal duration by the period of the FG 502 output.

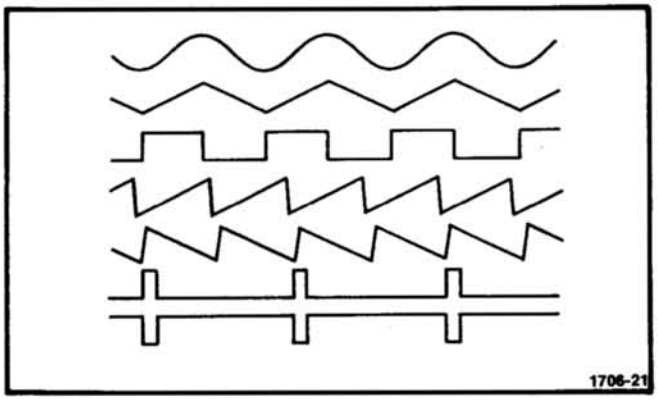


Fig. 2-4. Output waveforms available from the FG 502.

Output frequency can be varied during the burst duration by applying the proper voltage to the VCF IN connector. See Voltage-Controlled Frequency (VCF) Output following.

Voltage-Controlled Frequency (VCF) Output

The output frequency of the FG 502 can be swept over a frequency range of 1000:1, depending on the MULTIPLIER setting, by applying a 0 V to 10 V signal to the VCF IN connector. It may be necessary to vary the CAL control to obtain the full 1000:1 swept range or the lowest swept frequency desired. See Fig. 2-5 for maximum VCF range for each MULTIPLIER setting.

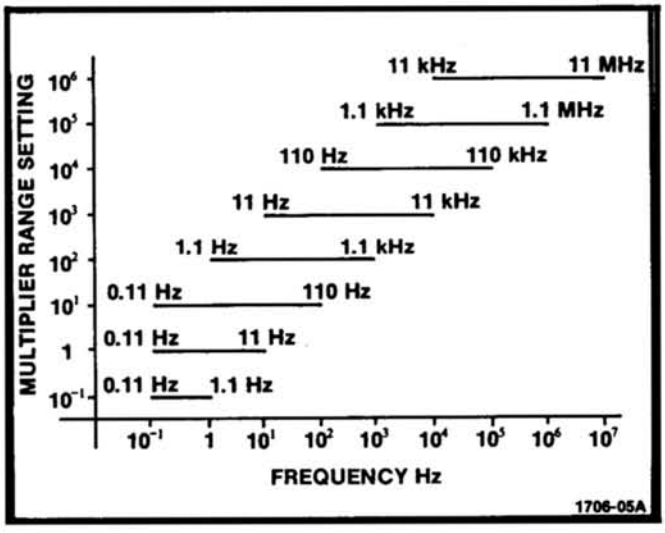


Fig. 2-5. Graph showing range of frequencies for each MULTIPLIER setting that can be swept with a 0 to 10 V signal applied to the VCF input.

The polarity of the VCF input signal determines the direction the output frequency is swept from the frequency set by the MULTIPLIER, FREQUENCY Hz, and VERNIER controls. A positive-going voltage raises the frequency, while a negative-going voltage lowers the frequency. A voltage that varies symmetrically about 0 V sweeps the output frequency symmetrically about the center frequency determined by the frequency controls. See Fig. 2-6.

Since the VCF input amplitude versus frequency is a linear relationship, the frequency output range may be determined from the VCF input amplitude. Refer to the following test under the heading Response Analysis for a typical application using the VCF feature.

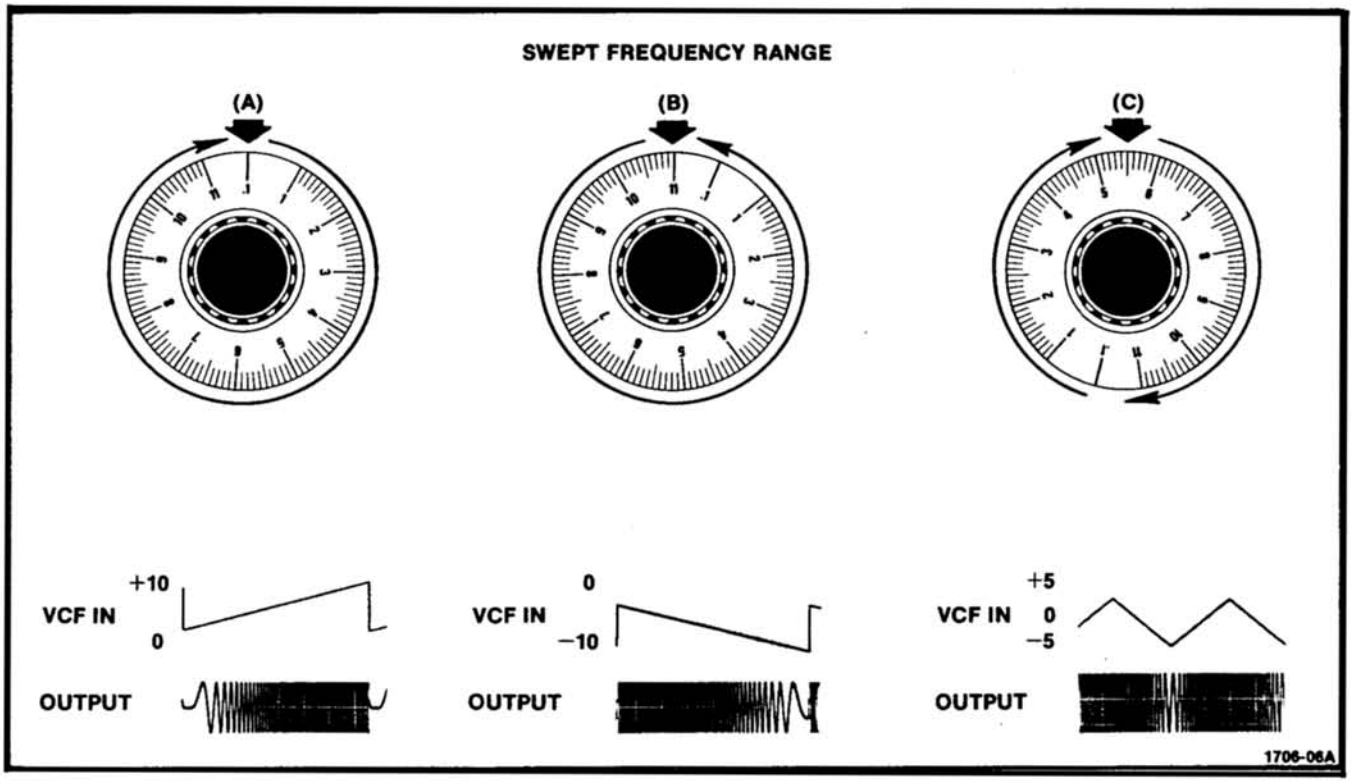


Fig. 2-6. Swept Frequency range with 10 V signals applied to VCF IN Connector.

APPLICATIONS

Response Analysis

The FG 502 is particularly suited for determining response characteristics of circuits or systems. This application utilizes the VCF input of the FG 502 to sweep the generator over a range of frequencies. By applying the desired waveform from the FG 502 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 502. Refer to the Voltage-Controlled Frequency (VCF) Output discussion under Operation for additional information.

1. Connect the equipment as shown in Fig. 2-8.

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). See Fig. 2-5 for VCF ranges and MULTIPLIER settings.

3. Apply the desired waveform to the VCF IN connector.

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 removing the VCF input waveform, then manually adjusting the FREQUENCY Hz dial to again obtain the particular characteristic observed in the swept display. Read the frequency on the FREQUENCY Hz dial.

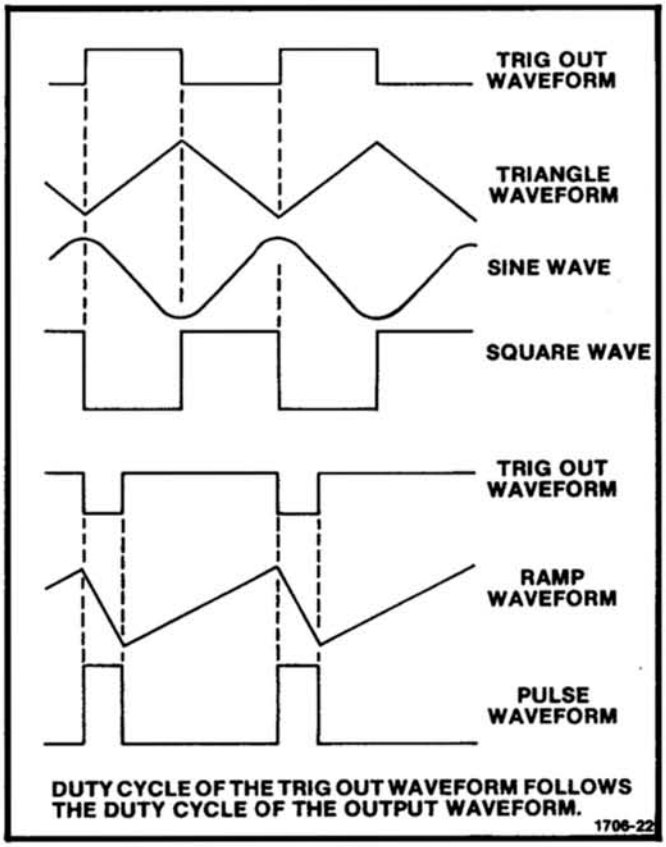


Fig. 2-7. Phase relationships between various OUTPUT waveforms and the TRIG OUT waveform.

Tone-Burst Generation or Stepped Frequency Multiplication

The FG 502 can be used as a tone-burst generator or frequency multiplier for checking tone-controlled devices. This application utilizes a Pulse Generator (such as the Tektronix PG 501) as a gating signal source and a Ramp Generator (such as the Tektronix RG 501) as a VCF signal source.

The following procedure describes a technique for obtaining a tone-burst or frequency multiplied output from the FG 502. Refer to the Gated (Burst) Output and the Voltage-Controlled Frequency (VCF) Output discussions under Operation for additional information.

1. Connect the equipment as shown in Fig. 2-9.

2. 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.

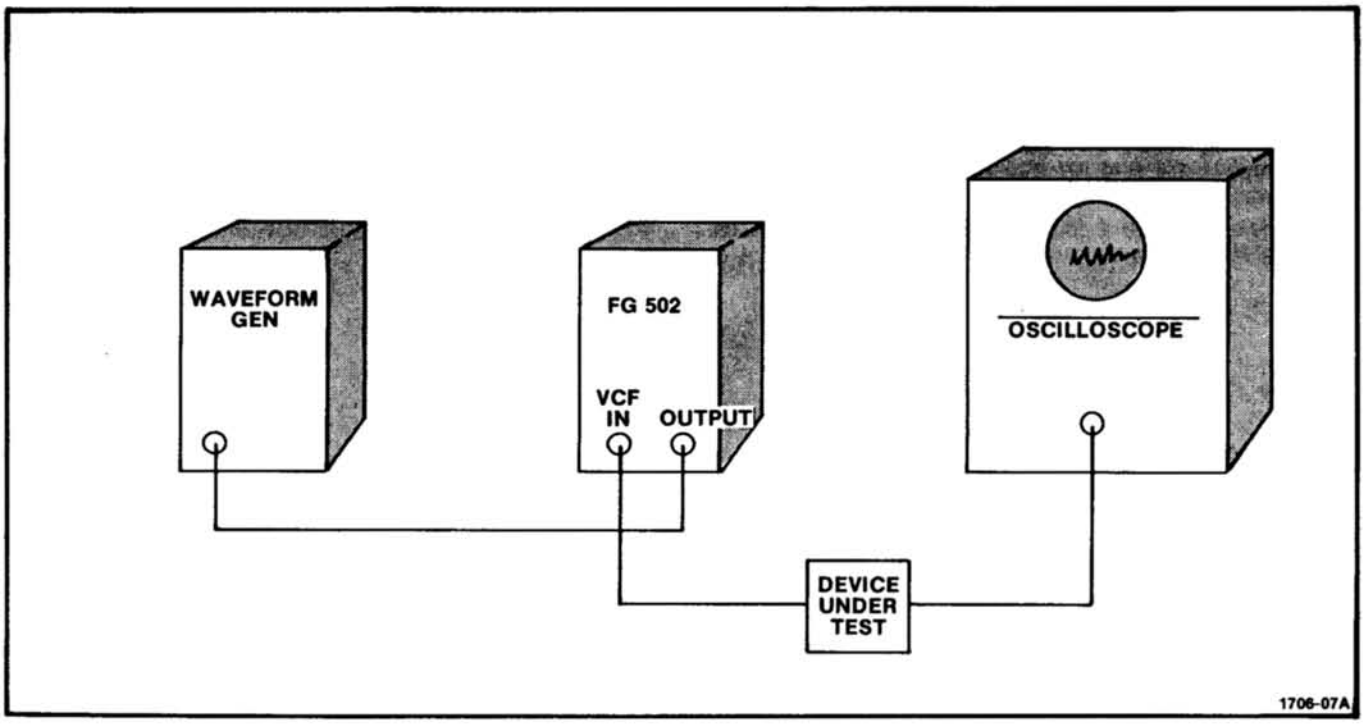


Fig. 2-8. Analyzing circuit or system response.

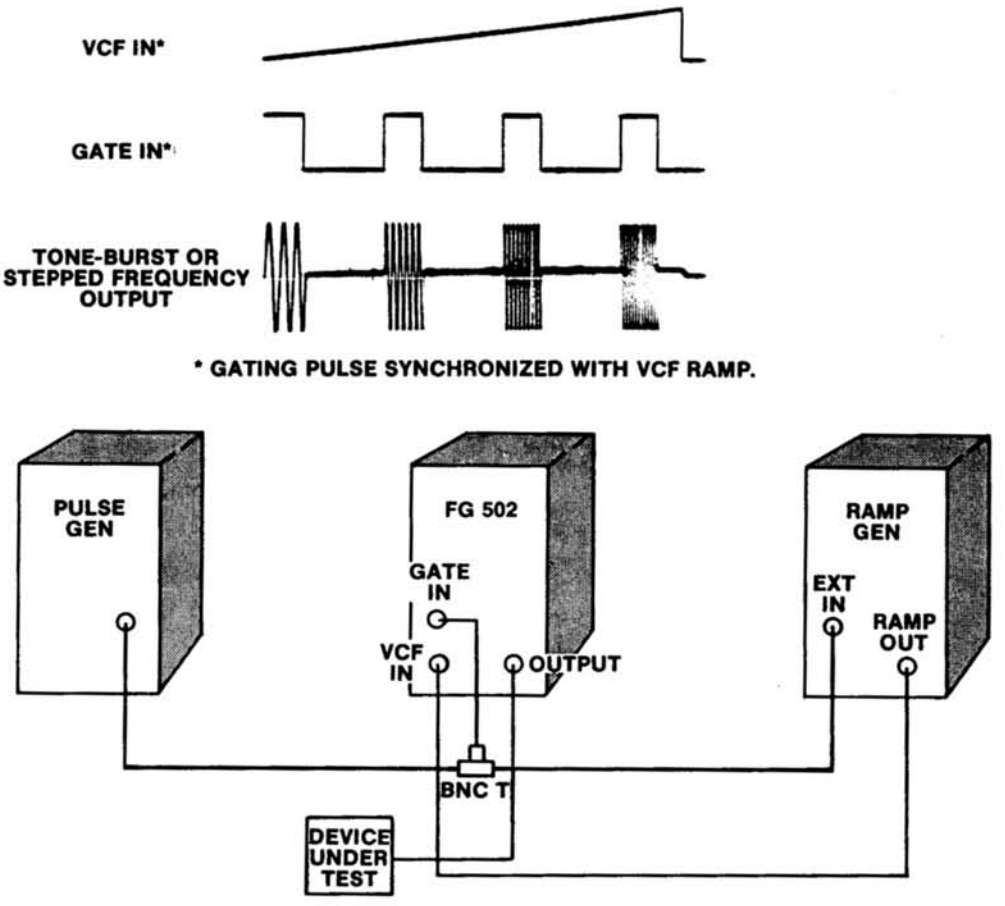


Fig. 2-9. Tone burst generation or stepped frequency multiplication.

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.

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

THEORY OF OPERATION

Introduction

The triangle waveform is the basic waveform in the FG 502. The ramp waveforms are triangle waveforms with non-equal runup and rundown times. The sine wave is derived from the triangle waveform, using a four-step approximation. The square and pulse waveforms are generated by the triangle generator control circuitry.

Refer to the simplified Block Diagram and the circuit diagrams in the pullout pages of this manual, along with the following discussion, for a complete understanding of the FG 502 operation.

Triangle Generator (Diagram 1)

Operational amplifier U140, Q140, and the positive timing resistors form a positive constant current source. U175, Q175, and the negative timing resistors form a negative constant current source. These constant current sources supply the current (either positve or negative) to charge the timing capacitor, generating the triangle waveform.

To understand the operation of this circuit, assume the junction of CR140 and CR170 is positive with respect to ground. CR140 is off and CR170 is conducting. CR175 is off, and the capacitor is charging from the positive current source through CR145. Q292 is off, and the junction of CR140 and CR170 is held at approximately 5 V above ground. This is done by CR300, CR304, CR308 and CR312. Current to hold the junction of CR140 and CR170 positive is supplied by R155 from the +17 V supply.

In this state CR248 is on, CR245 is off, and the voltage level at the base of Q230A (not conducting) is set by the current flowing through R245, CR246, and R240.

The ramp, moving in a positive direction, appears at the base of Q230B through the action of source follower Q200 and its constant current source Q202. Q204 and Q210, complementary emitter followers, drive the AC compensated attenuator (RT224, C224, and R220).

When the base of Q230B (now conducting) reaches the same voltage as the base of Q230A (Q230A and Q230B form a comparator) Q230B stops conduction and Q230A turns on. The collector of Q230A goes positive, turning Q292 on and Q290 off. The collector of Q292 goes negative, limited to about −5 V by diodes CR302, CR306, CR310 and CR314. This action turns diodes CR248 and CR246 off, setting the level at the base of Q230A slightly below ground. The negative voltage at the junction of CR140 and CR170 turns CR175 on and CR170 and CR145 off. This action disconnects the positive current source from the timing capacitor and connects the negative current source through CR175, causing the ramp to go in the negative direction. The action continues until Q230B is turned on (by the negative ramp at its base) and the cycle is repeated. R250 sets the voltage at the base of Q230A and thereby the DC level of the triangle waveform.

The frequency of the triangle waveform is controlled by two factors: (1) the value of the timing capacitor, and (2) the amount of current available to charge it. The current is varied by changing the value of the timing resistors (the larger the value of the timing resistors and capacitors, the slower the rate of rise), and the voltage across the timing resistors.

The voltage across the timing resistors is essentially the voltage at pin 3 of operational amplifier U140 in the positive current source, and U175 in the negative current source. The voltage at pin 3 of U140 is controlled by summing amplifier U135. The voltage at pin 3 of U175 is controlled by summing amplifier U170. Input voltage to these summing amplifiers is controlled by the FREQUENCY Hz dial through U100, or the voltage at the VCF IN front panel connector. When the voltage at pin 3 of U100 goes more positive by increasing the FREQUENCY Hz dial setting, or through the VCF IN input, the voltage at pin 6 of U140 goes negative and pin 6 of U175 positive. This action increases the voltage across the timing resistors. The values of the timing resistors and timing capacitor are selected by the front panel MULTIPLIER switch. R170 improves low frequency symmetry by compensating for bias currents in the operational amplifiers when operating at low levels. Voltage levels through this circuit are 0 to about +10 V at the input of U100. This is translated at about +7 V to +17 V at pin 6 of U135.

During non-gated operation, the base of Q332 is two diode drops above ground. Q332 is off and Q330 is conducting. Q325 is on and Q315 off, back biasing CR315 and allowing normal operation of the triangle generator. When the proper level gating signal is applied to the front panel GATE IN connector, the base of Q332 alternates with the gating signal. When the gating signal is low (ground potential) Q332 conducts. This action causes conduction in Q315 and forward biases CR315. This locks the junction of CR140 and CR170 at the level set by R155,

causing these diodes to conduct the timing capacitor charging current to ground through Q315. Operation of the triangle generator is inhibited by this action. When the gating signal goes positive, CR315 is back biased and the generator functions normally.

Ramp waveforms are generated by changing the value of either the positive or negative timing resistor to create different rise and fall times.

The square wave that controls charging of the timing capacitor is picked off at the collector of Q290 and operates the trigger out amplifier. The impedance looking into the emitter of Q268 is about 51 Ω. The same waveform operates the isolation diode bridge CR260, CR262, CR264, and CR266. The output from this bridge is the square or pulse waveforms. The triangle waveform (to the output amplifier and sine shaper) is taken from the emitter of Q210.

Sine Shaper (Diagram 2)

This circuitry derives a four step approximation of a sine wave from the triangle waveform by use of a diode ladder configuration. This circuit consists of four bridges. All inputs to these bridges are connected to R350, and all outputs are connected to their common load resistor R395. Each bridge is supplied by current from the +17 V and −17 V supplies through different value resistors, R358, R368, R378, R388 and their equal value complementary resistors in the negative supply leads.

As the triangle waveform increases in voltage, each bridge reaches a current limit whereby it can no longer increase current through load resistor R395. These current limits are set by R382, R384, R388, in one bridge and similar resistances for the other bridges. R350 and R250 are set for minimum sine wave distortion.

Sine Wave Buffer

This circuit operates as an inverting operational amplifier, with a gain of about four. The sine wave output from the shaper is fed to the base of Q400. A negative-going signal at the base of Q400 causes its collector to go positive and the collector of Q410 negative. The collectors of Q420 and Q430 respond in the opposite polarity. Q440 inverts the waveform at the collector of Q420, and the bases of Q442 and Q444 are driven in phase. Output and negative feedback are taken from the junctions of R442 and R444. R450 in the negative feedback loop sets the DC gain and C450 sets the AC gain.

Output Amplifier (Diagram 3)

This circuit operates as an inverting operational amplifier. The selected waveform is applied to the base of Q480 through AMPLITUDE control R465. Q480 and Q490 operate as an emitter-coupled amplifier. The collector of Q480 drives the base of Q500. The base of Q515 is driven by the collector of Q500. The collector of Q490 drives the base of Q506. The polarities are such that the collectors of Q515 and Q506 move in phase. Their collectors drive the output stage (Q530, Q532, Q540, and Q542). The bypassed resistors in the emitter circuit of the output transistors limit the output current. R550, R552, R555, and R556 provide a back termination of 50 Ω. Negative feedback is taken from the junction of the current limiting resistors in the output stage. R566, in the feedback loop, sets the DC gain while C566 and C568, adjust the AC gain. R475, the OFFSET control, places an adjustable DC bias on the input of the amplifier to change the amplifier output level.

Power Supplies (Diagram 4)

Diode bridge CR600 rectifies 25 V AC from the power module. The full wave rectified DC is filtered by C602 and applied as regulated +20 V DC to the circuitry in the FG 502 through the series pass transistor located in the power module.

VR610 sets the voltage at pin 3 of U615. U615 has a gain of approximately three. The output at pin 6 therefore, is about 20 V. Emitter follower Q620 drives the base of the series pass transistor. Should the +20 V load increase, pin 2 of U615 (through R623 and R625) goes negative. This causes pin 6 to go positive, increasing current flow and restoring the +20 V to its previous level. Should the current drawn increase so the voltage across R632 is sufficient to turn Q622 on, current limiting occurs. Q620 reduces conducting, reducing the current through the series pass transistor to a safe level. CR632 protects the +20 V supply, if it should short to the minus supply.

U664 is an operational amplifier with a gain of about one. The reference voltage is the +20 V applied through a divider at pin 2. The output at pin 6 (−20 V) drives emitter follower Q662. Q662 drives the series pass transistor located in the power module. Current limiting takes place when current through R655 turns Q660 on. Feedback occurs through R678. The action of this circuit is similar to the +20 V regulator. CR655 protects this supply should a short occur to −20 V.

The +17 V is referenced to the +20 V. U635, with a gain of about one, controls Q635, the series pass transistor for this supply. Feedback occurs at pin 2 of U635. Current limiting in the +20 V supply protects this circuit.

The −17 V supply is compared to the +17 V at pin 2 of U650. The gain of U650 is about one. Q650 serves as the series pass transistor for this supply. Feedback occurs through R640. Current limit for this supply is the −20 V supply current limiting.

The regulation of the +17 V and −17 V supplies is similar to that in the 20 V supplies.

CALIBRATION PROCEDURE

PERFORMANCE CHECK PROCEDURE

Introduction

The performance check procedure checks the electrical performance requirements listed in the Specification section in this manual. Perform the Adjustment procedure if the instrument fails to meet these checks. If recalibration does not correct the discrepancy, troubleshooting is indicated. This procedure may be used to determine acceptability of performance in an incoming inspection facility.

For convenience, some steps in the procedure check the performance of this instrument at only one value in the specified performance range. Performance requirements for various temperature ranges are listed in this procedure. When performing the procedure, use only the limits listed for the ambient temperature that the instrument is operating in.

Calibration Interval

To ensure instrument accuracy, check the calibration every 2000 hours of operation or at a minimum of every six months if used infrequently.

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.

Test Equipment Required

The following test equipment or equivalent is suggested to perform the Performance Check and Adjustment Procedure.

Table 4-1

TEST EQUIPMENT REQUIRED

Performance Description	Requirement	Application	Example
Oscilloscope	Bandwidth dc to 100 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 465B 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 501A*.
Frequency Counter	Frequency range 0.1 Hz to above 11 MHz; accuracy within one part of 10^5 ±1 count.	Basic timing & VCF INPUT.	TEKTRONIX DC 503* or equivalent.
Pulse Generator	0 to +2 V square-wave output into 50 Ω load.	External Gate check	TEKTRONIX PG 501* or equivalent.
Variable dc Power Supply	Output 0 to 20 V at 0.4 A or greater.	Check VCF INPUT.	TEKTRONIX PS 501-1* or equivalent.
Distortion Analyzer	Frequency range from 1 Hz to at least 500 kHz. Distortion resolution <0.5%	Check sine wave distortion.	Hewlett-Packard 334A Distortion Analyzer or equivalent.

Table 4-1 (cont)

Performance Description	Requirement	Application	Example
50 Ω Feedthrough Termination (2)	bnc connectors.	Steps 1, 2, 3, 5, 6, 8, and 9.	Tektronix Part No. 011-0049-01.
50 Ω Coaxial Cables (2 ea)	bnc connectors.	All.	Tektronix Part No. 012-0057-01.
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 power module 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 502 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.

1. FREQUENCY CALIBRATION

a. Set the FG 502 controls as follows:

FUNCTION	Sine Wave
AMPLITUDE	Mid-range
OFFSET	In
MULTIPLIER	10^3
FREQUENCY VERNIER	Fully cw
FREQUENCY Hz	10

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

c. Verify that the FG 502 output frequency is 10 kHz ±3% of full scale. (9.67 kHz to 10.33 kHz)

d. Verify that the FREQUENCY Hz dial setting vs output frequency is within the specified accuracy at each of the remaining positions of the multiplier switch (±3% of full scale .1 Hz to 1 MHz; ±5% of full scale, 1 MHz to 10 MHz).

e. Set the FREQUENCY Hz dial to 5 and check that the output frequency as indicated on the counter is within the specified accuracy on each range setting of the MULTIPLIER switch.

f. Set the FREQUENCY Hz dial to 1 and check that the output frequency as indicated on the counter is within the specified accuracy on each range setting of the MULTIPLIER switch.

2. VCF RANGE CHECK

a. Set the FG 502 controls as follows:

FUNCTION	Sine Wave
AMPLITUDE	Mid-range
OFFSET	In
MULTIPLIER	10^5
FREQUENCY VERNIER	Fully cw
FREQUENCY Hz	11.0

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

c. Set the output frequency to 1.1 MHz.

d. Connect the negative output from the variable power supply to the VCF input. Adjust the voltage from 0 V to 10.0 V. Verify that the output frequency goes to less than 1.1 kHz before the input voltage reaches 10.0 V.

e. Remove the power supply connection to the VCF input.

3. PULSE/RAMP FREQUENCY CHECK

a. Set the FG 502 controls as in step 2. Read the output frequency on the counter.

b. Switch the FUNCTION switch to a pulse output position.

c. The output frequency should now be approximately 1/10 the frequency of step a.

4. OUTPUT AMPLITUDE FLATNESS CHECK

a. Set the FG 502 controls as follows:

FUNCTION	Sine Wave
AMPLITUDE	Fully cw
OFFSET	In
MULTIPLIER	10^3
FREQUENCY VERNIER	Fully cw
FREQUENCY Hz	10

b. Connect a coaxial cable from the FG 502 OUTPUT through a 50 Ω termination to the input of the oscilloscope.

c. Adjust the oscilloscope for a display of 5 major divisions of signal.

d. Switch the MULTIPLIER switch to all other ranges and check that the signal amplitude remains within ±1.5 dB. (4.2 to 5.95 major divisions of deflection)

e. Verify that the amplitudes of the triangle and square wave outputs are within 0.7 to 1.4 times the sine wave amplitude on all ranges.

5. OUTPUT AMPLITUDE CHECK

a. Set the FG 502 controls as follows:

FUNCTION	Sine Wave
AMPLITUDE	Fully cw
OFFSET	In
MULTIPLIER	10^3
FREQUENCY VERNIER	Fully cw
FREQUENCY Hz	10

b. Connect a coaxial cable from the FG 502 OUTPUT to the vertical input of the oscilloscope.

c. Verify that the output amplitude of the sine wave is 10 V p-p or greater.

d. Connect a 50 Ω termination at the oscilloscope input and verify that the amplitude of the sine wave is 5 V p-p or greater.

6. OFFSET RANGE CHECK

a. Set the FG 502 controls as follows:

FUNCTION	Sine Wave
AMPLITUDE	Fully ccw
OFFSET	In
MULTIPLIER	10^3
FREQUENCY VERNIER	Fully cw
FREQUENCY Hz	10

b. Connect a coaxial cable from the OUTPUT of the FG 502 to the oscilloscope vertical input.

c. Verify that the OFFSET control has a output signal offset range of +5 V or greater when the OFFSET knob is pulled out and rotated from end to end of its range.

d. Add a 50 ⩾ termination at the oscilloscope input and check for an offset range of +2.5 V.

7. SYMMETRY CHECK

a. Set the FG 502 controls as follows:

FUNCTION	Square Wave
AMPLITUDE	Mid-range
OFFSET	In
MULTIPLIER	10^3
FREQUENCY VERNIER	Fully cw
FREQUENCY Hz	10

b. Connect a coaxial cable from the OUTPUT of the FG 502 to the oscilloscope vertical input.

c. Adjust the oscilloscope so that one complete waveform is displayed over 10 major divisions of the CRT.

d. Verify that the center transition of the waveform is within 0.5 minor divisions of the center vertical graticule line.

8. SQUARE WAVE ABERRATION AND RISE TIME CHECK

a. Set the FG 502 controls as follows:

FUNCTION	Square Wave
AMPLITUDE	Fully cw
OFFSET	In
MULTIPLIER	10^5
FREQUENCY VERNIER	Fully cw
FREQUENCY Hz	5.0

b. Connect a coaxial cable from the OUTPUT of the FG 502. Add a 50 Ω feed through termination to the far end of the cable and connect it to the input of the oscilloscope.

c. Adjust the oscilloscope for 5 major divisions of vertical deflection.

d. Verify that the aberrations on the top of the square wave do not exceed 1.5 minor divisions p-p. (3%)

e. Verify that the rise time of the leading edge of the square wave does not exceed 20 ns. (10% to 90% points of the wave shape)

9. DISTORTION CHECK

a. Set the FG 502 controls as follows:

FUNCTION	Sine Wave
AMPLITUDE	Mid-range
OFFSET	In
MULTIPLIER	10^3
FREQUENCY VERNIER	Fully cw
FREQUENCY Hz	10

b. Connect the 50 Ω cable and 50 Ω termination from the FG 502 OUTPUT connector to the distortion analyzer input. Place a 50 Ω termination on the FG 502 VCF IN connector.

c. Check that the sine wave distortion is equal to or less than 0.5%.

10. EXTERNAL GATE INPUT CHECK

a. Set the FG 502 controls as follows:

FUNCTION	Sine Wave
AMPLITUDE	Mid-range
OFFSET	In
MULTIPLIER	10^3
FREQUENCY VERNIER	Fully cw
FREQUENCY Hz	10

b. Connect a coaxial cable from the FG 502 OUTPUT through a 50 Ω termination to the input of the oscilloscope.

c. Adjust the pulse generator for a waveform varying from 0 V to +2 V with a period of approximately 1 ms.

d. Connect a coaxial cable from the positive output of the pulse generator to the GATE IN on the FG 502.

e. Verify that the output of the FG 502 is pulsed on and off.

11. TRIGGER OUTPUT CHECK

a. Set the FG 502 controls as follows:

FUNCTION	Sine Wave
AMPLITUDE	Mid-range
OFFSET	In
MULTIPLIER	10^3
FREQUENCY VERNIER	Fully cw
FREQUENCY Hz	10

b. Connect a coaxial cable from the TRIG OUT jack on the FG 502 to the input of the oscilloscope.

c. Verify that the trigger amplitude is 5 V or more.

d. Connect a termination at the input of the oscilloscope and verify that the trigger amplitude is now 2.5 V or more.

ADJUSTMENT PROCEDURE

1. Adjust +20 V Supply

a. Connect the positive lead of the voltmeter (set to read +20 V) to the +20 V TP and the negative lead to the GND TP.

b. Adjust R625 (+20 V Adj.) for a reading of 20 V ±1%.

2. Check Power Supply Voltages

a. Connect the negative lead of the voltmeter (set to read 20 V) to the −20 V TP and the positive lead to the GND TP.

b. Check that the reading is 20 V ±1%.

c. Move the negative lead to the −17 V TP and note the reading. Now measure the +17 V by switching the negative lead to the GND TP and the positive lead to the +17 V TP. The absolute values of these voltages must be within 2% of each other.

3. Check Power Supply Ripple

a. On the FG 502, set the MULTIPLIER knob to 10^{-1}, the FREQUENCY Hz dial to 0.1, and the FUNCTION switch to the triangular waveform.

b. Using the differential amplifier in the oscilloscope, set the vertical sensitivity to 1 mV/Div and set both inputs for ac coupling.

c. Using 1X probes, connect one input of the Differential amplifier to any of the GND TP connectors in the FG 502. Connect the other 1X input probe in turn to the +20 V, −20 V, +17 V, and −17 V supplies at their respective test points.

d. Check that the ripple is less than 500μV peak-to-peak at each of the test points. Ripple shows up as a broadening of the oscilloscope trace. Disregard the humps caused by generator feedback when checking the minor supplies for ripple.

4. Adjust Waveform Symmetry

a. Connect the FG 502 output through a 50 Ω coaxial cable terminated in 50 Ω to the oscilloscope input.

b. Adjust the FG 502 for an approximate 10 kHz square-wave with the AMPLITUDE control at Maximum (5 V p-p).

c. Set the oscilloscope to show 1 cycle in 10 divisions of display. Adjust R170 (Sym) for best square-wave symmetry.

5. Adjust Sinewave Distortion (SN B010168 and up)

a. Connect the FG 502 output to the input of the distortion analyzer with a 50 Ω cable terminated at the distortion analyzer input.

b. Set the FUNCTION switch for sinewave output.

c. Set the FREQUENCY Hz dial at 1 and the MULTIPLIER knob at 10^4.

d. Adjust R250 (DC Level) and R350 (Sine Drive) for minimum distortion on the distortion analyzer. Repeat several times, since considerable interaction exists.

6. Adjust Sinewave Distortion (SN B010100—B010167)

a. Connect a distortion analyzer to the output of the FG 502 using coaxial cable.

b. Set the FUNCTION switch for sinewave output.

c. Set the FREQUENCY Hz dial at 1 and the MULTIPLIER at 10^4. Terminate the coaxial cable from the FG 502 at the distortion analyzer input.

d. Adjust R250, DC Level, R350, Sine Drive, R356, R366, R376, and R386, Sine Shapers, for minimum distortion. Go over these controls several times, since considerable interaction exists.

7. Adjust High Frequency Sine Distortion

a. Change the FG 502 MULTIPLIER knob to 10^6 and reset the FREQUENCY Hz dial to 1.

b. Connect the output of the FG 502 to the oscilloscope via a 50 Ω coaxial cable, 10X attenuator, and 50 Ω termination.

c. Obtain a stable sinewave display on the oscilloscope. Adjust C350 (HF Sine Adj.) for the smoothest and best looking sinewave peaks.

8. Adjust Triangle Peak

a. Connect the FG 502 output to the oscilloscope with terminated 50 Ω cable.

b. Set the FG 502 FREQUENCY Hz dial to .1 and FUNCTION switch to triangle.

c. Adjust the oscilloscope so the top portion of the triangle is displayed (positive 1/2 cycle in 8 divisions).

d. Adjust C287 for linear slopes and equal rise and fall times on the triangle peaks.

9. Adjust Low Frequency Timing

a. Connect the FG 502 to the counter with 50 Ω terminated cable.

b. Set the FG 502 MULTIPLIER knob to 10^3, the FREQUENCY Hz dial to 11, the AMPLITUDE control fully cw, and the FREQUENCY VERNIER dial to the CAL position.

c. Adjust R105 (X10 Cal) for a counted frequency of 11 kHz.

d. Set the FREQUENCY Hz dial to 1.

e. Adjust R130 (X1 Cal) for a counted frequency of 1 kHz. Repeat both adjustments until the timing is within specifications.

10. Adjust 1.1 MHz Timing (SN B010100—B010161, B040000 and up)

a. Change MULTIPLIER to 10^5 and FREQUENCY Hz dial to 11.

b. Adjust C158, 1.1 MHz Adj., for an output frequency of 1.1 MHz.

11. Adjust High Frequency Timing

a. Set the FG 502 MULTIPLIER knob to 10^6 and the FREQUENCY Hz dial to 10.

b. Adjust C162 (Low Dial Top Range) for 10 MHz on the counter.

c. Set the FREQUENCY Hz dial to 11 and check for 11 MHz count or greater.

12. Check Timing Accuracy

a. Check all MULTIPLIER ranges with the FREQUENCY Hz dial at 1 and 11 for accuracy to specifications (3% of full scale from 0.1 Hz to 1 MHz, 5% of full scale from 1 MHz to 10 MHz, and 11 MHz not less than 11 MHz).

13. Adjust Triangle Amplitude

a. Set the MULTIPLIER knob for 10^4, the FREQUENCY Hz dial to 1, and AMPLITUDE control fully cw, and the FUNCTION switch to triangle.

b. Connect the FG 502 output to the oscilloscope using a to Ω coaxial cable without termination.

c. Adjust R460 (Triangle Amp) for exactly 10 V peak-to-peak signal.

d. Install a 50 Ω termination between the cable and oscilloscope and check the signal to be within specifications (between 5.0 and 5.2 V peak-to-peak).

14. Adjust Sinewave Low Frequency Amplitude

a. Set the FUNCTION switch to sinewave.

b. Remove the 50 Ω termination between the cable and oscilloscope. Leave all other controls as in the previous step.

c. Adjust R450 (Sinewave Amp) for exactly 10 V peak-to-peak.

d. Re-install the 50 Ω termination between the cable and oscilloscope and check as in the preceding step.

15. Adjust Square-Wave Low Frequency Amplitude

a. Set the FUNCTION switch for a square-wave.

b. Remove the 50 Ω termination between the cable and oscilloscope. Leave all other controls as in the preceding step.

c. Adjust R255 (Pulse Amp) for exactly 10 V peak-to-peak, and check as in steps (12) and (13).

16. Adjust Square-Wave Compensation

a. Connect the FG 502 to the oscilloscope through a 50 Ω coaxial cable, a 10X attenuator, and a 50 Ω termination.

b. Set the MULTIPLIER knob to 10^5, the FREQUENCY dial to 1 (100 kHz), and the AMPLITUDE control to maximum.

c. Adjust the oscilloscope for 1 cycle in 10 divisions.

d. Adjust C566 and C568 (Square-Wave Comp) for a fast rising edge and square corner (also C574 SN B010100—B031169).

e. Check that the rise time is less than 20 ns, and aberrations are less than 3% peak-to-peak.

17. Check Sinewave High Frequency Amplitude and Distortion

a. Connect the FG 502 to the oscilloscope through a terminated 50 Ω coaxial cable.

b. Set the MULTIPLIER knob to 10^6 and the FREQUENCY Hz dial to 11 MHz.

c. Check that the amplitude of the sinewave is 5 divisions ±0.8 division (±1.5 dB referenced at 10 kHz).

d. Disconnect the cable from the oscilloscope, and remove the 50 Ω termination.

e. Connect a cable from the FG 502 to the spectrum analyzer. Set the spectrum analyzer Frequency Span/Div control for 10 MHz.

f. Check that the second and third harmonic frequencies are at least 30 dB below the fundamental frequency.

g. Adjust C450 for the maximum 11 MHz sinewave amplitude with the second and third harmonics still 30 dB below the fundamental frequency amplitude.

h. Set the FG 502 FREQUENCY Hz dial to 10 and the MULTIPLIER knob to 10^5.

i. Set the spectrum analyzer Frequency Span/Div control to 1 MHz.

j. Check that the second and third harmonic frequencies are at least 30 dB below the fundamental frequency amplitude.

k. Set the FG 502 MULTIPLIER knob to 10^4, the spectrum analyzer Frequency Span/Div control to 0.1 kHz, and check that the second and third harmonic frequencies are at least 30 dB below the fundamental frequency amplitude.

18. Adjust Output Amplifier DC Balance

a. Connect the FG 502 through a terminated 50 Ω coaxial cable to the oscilloscope.

b. Set the FUNCTION switch to triangle, the AMPLITUDE control for minimum amplitude, the MULTIPLIER knob to 10^3, and the FREQUENCY Hz dial to 11.

c. Set the vertical deflection factor on the oscilloscope for 0.1 V/Div.

d. Ground the vertical input of the oscilloscope momentarily to establish a 0 V dc reference for the display.

e. Adjust R485 (DC Bal) so that the output waveform is centered around the 0 V reference level.

19. Adjust Gate Baseline

a. Connect the square-wave generator (set for at least a 0 V to +2 V, 1 kHz square-wave) to the GATE IN connector on the FG 502.

b. Set the FG 502 FUNCTION switch for a sinewave and the FREQUENCY Hz dial to 5 with the MULTIPLIER Knob at 10^3 for 1 kHz bursts of the 5 kHz waveform.

c. Adjust R320 to position the baseline exactly half way between the positive and the negative sinewave peaks.

20. Check Trigger Out

a. With a X1 probe or an unterminated 50 Ω cable, check for a signal on the bnc TRIG OUT connector on the FG 502. Minimum signal should be 5 V.

b. A terminated cable will show approximately 1/2 of the unterminated amplitude.

21. Check VCF

a. Set the FREQUENCY Hz dial to 10 and the MULTIPLIER knob to 10^5.

b. Verify that the output frequency changes to less than 1 kHz when −10 V is connected to the VCF input.

MAINTENANCE

GENERAL

Introduction

This section of the manual is meant to support the entire TM 500 Series family with a general coverage of the most commonly-needed service information pertinent to preventive maintenance, troubleshooting, ordering parts, and replacing components and sub-assemblies.

Cabinet Removal

WARNING

Dangerous potentials exist at several points throughout the system. When the system must be operated with the cabinet removed, do not touch exposed connections or components. Some transistors have voltage present on their cases. Disconnect power before cleaning the system or replacing parts.

Cleaning

CAUTION

Avoid using chemical cleaning agents which might damage plastic parts. Avoid chemicals containing benzene, toluene, xylene, acetone, or similar solvents.

Exterior. Loose dust may be removed with a soft cloth or a dry brush.

Interior. Cleaning the interior of a unit should precede calibration since the cleaning processes 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 brush, cotton-tipped swab, or a cloth dampened in a solution of water and mild detergent.

Preventive Maintenance

Preventive maintenance steps performed on a regular basis will enhance the reliability of the instrumentation systems. However, periodic checks of the semiconductors in the absence of a malfunction are not recommended as preventive maintenance measures. See the semiconductor checking information under Troubleshooting Techniques which follow. A convenient time to perform preventive maintenance is just before instrument calibration.

Calibration

To ensure accurate signal generation and measurement, the performance of individual units in the system should be checked periodically. Refer to the Instruction Manual for each unit for complete calibration and verification procedures.

TROUBLESHOOTING AIDS

Introduction

The following is provided to augment information contained elsewhere in this and other TM 500 series family manuals when troubleshooting becomes necessary.

Circuit Description

Each manual has a section devoted to explaining circuit operating theory. Used with the schematics, this can be a powerful analytic tool.

Diagrams

Block diagrams and detailed circuit schematics are located on foldout pages in the service section of most of the TM 500 Series Family manuals. The schematic diagrams show the component values and assigned circuit reference numbers of each part necessary to the circuit design. Usually the first page of the service section defines the circuit symbols and reference designators used in that particular instrument. 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 a dark outline.

Cam Switch Charts

Cam switches shown on the diagrams are coded on 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 indicate with a solid dot when each contact is closed.

Circuit Board Illustrations

Line illustrations showing component locations keyed with a grid scheme for each circuit board are usually placed on the back of a foldout page and sequenced as close as possible to an associated schematic. The GRID LOC columns, located near the Parts Location Grid, keys each component to easy location on the board.

Component and Wiring Color Codes

Color 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. The wiring coding follows the same EIA standards with the exception of the ac power cord of the Power Modules. It is coded like this:

Power Cord Conductor Identification

Conductor	Color	Alternate Color
Undergrounded (Line)	Brown	Black
Grounded (Neutral)	Blue	White
Grounding (Earthing)	Green-Yellow	Green-Yellow

Testing Equipment

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

TROUBLESHOOTING TECHNIQUES

Introduction

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

Control Settings

Incorrect control settings can appear to be trouble that does not exist. If there is any question about the correct function or operation of any control, see the Operating Instructions section of the manual for the instrument involved.

System and Associated Equipment

Before proceeding with troubleshooting the TM 500 Series system, check that the instruments in the system are operating correctly. Check for proper interconnection between the power module and the plug-in modules. Check the line voltage at the power source. Verify that the signal is properly connected and that the interconnecting cables and signal source are not defective.

The associated plug-in modules can be checked for proper operation quickly by substituting other like units known to be operating properly. If the trouble persists after substitution, then the power module is probably at fault. Moving a properly operating plug-in from compartment to compartment will help determine if one or more compartments have a problem.

Visual Check

Inspect the portion of the system in which the trouble is suspected. Many troubles can be located by visual clues such as unsoldered connections, broken wires, damaged circuit board, damaged components, etc.

Instrument Calibration

Check the calibration of the suspected plug-in module or the affected circuit if the trouble is obviously in a certain circuit. The trouble may only be a result of misadjustment or may be corrected by re-calibration. Complete calibration instructions are given in the manual for each instrument in the system.

Circuit Isolation

Note the trouble symptoms. These often identify 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 the power supplies. Using a multimeter, check first for correct voltages of the individual regulated supplies according to the plug-in module schematics and calibration 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 schematic or in the calibration procedures. Such waveforms and voltage labels are typical indications and will vary between instruments. To obtain operating conditions similar to those used to take these readings, refer to the first diagram in the service sections.

Component Checking

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

Transistors and IC's. 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. An anti-static suction-type desoldering tool must be used to remove soldered-in transistors; see component replacement procedure for details.

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 IC's. Operating waveforms, logic levels, and other operating information for the IC's are given in the circuit description information of the appropriate manual. Use care when checking voltages and waveforms around the IC's so that the adjacent leads are not shorted together. A convenient means of clipping a test probe to the 14- and 16-pin in-line IC's 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 a diode.

A diode may be checked for an open or shorted condition by measuring the resistance between terminals. With an ohmmeter scale having an internal source of between 8 mV, and 3 V, the resistance should be very high in one direction and very low when the leads are reversed. (A few diode types may even be damaged by 3 V.)

Resistors. Check the resistors with an ohmmeter. Resistor tolerances are given in the Electrical Parts List in every manual. 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 that 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 capacity meter, or by checking whether it passes ac signals.

PARTS ORDERING AND REPLACING

Ordering

Obtaining Replacement 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.

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 information:

1. Instrument Type (PS 501, SG 502, DC 501, etc.)

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 Mechanical Parts List, located to the rear of most manuals, may be especially helpful when disassembling or reassembling individual components or sub-assemblies.

Circuit Boards. If a circuit board is damaged beyond repair, either the entire assembly including all soldered-on components, or the board only, 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. Some boards may be held fast by plastic mounting clips around the board edges. For these, push the mounting clips away from the circuit board edges to free the board. Also, 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 or removal. Use care when replacing pin connectors. If forced into place incorrectly positioned, the pin connectors may be damaged.

Transistors and IC's. Transistors and IC's 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 instruments. When a transistor is replaced, check the operation of the part of the instrument that may be affected.

Replacement semiconductors should be of the original type or a direct replacement. Figure 5-1 shows the lead configurations of the semiconductors used in this instrument system. When removing soldered-in transistors, use a suction-type desoldering 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. If an extracting tool is not available, use care to avoid damaging the pins. Pull slowly and evenly on both ends of the IC. Try to avoid having one end of the IC disengage from the socket before the other end.

Static-Sensitive Components

CAUTION

Static discharge can damage any semiconductor component in this instrument.

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

Observe the following precautions to avoid damage:

1. Minimize handling of static-sensitive components.

2. Transport and store static-sensitive components or assemblies in their original containers, on a metal rail, or a conductive foam. Label any package that contains static-sensitive assemblies or components.

3. Discharge the static voltage from your body by wearing a wrist strap while handling these components. Servicing static-sensitive assemblies or components should be performed only at a static-free work station by qualified service personnel.

4. Nothing capable of generating or holding a static charge should be allowed on the work station surface.

5. Keep the component leads shorted together whenever possible.

6. Pick up components by the body, never by the leads.

7. Do not slide the components over any surface.

8. Avoid handling components in areas that have a floor or work surface covering capable of generating a static charge.

9. Use a soldering iron that is connected to earth ground.

10. Use only special antistatic suction type or wick type desoldering tools.

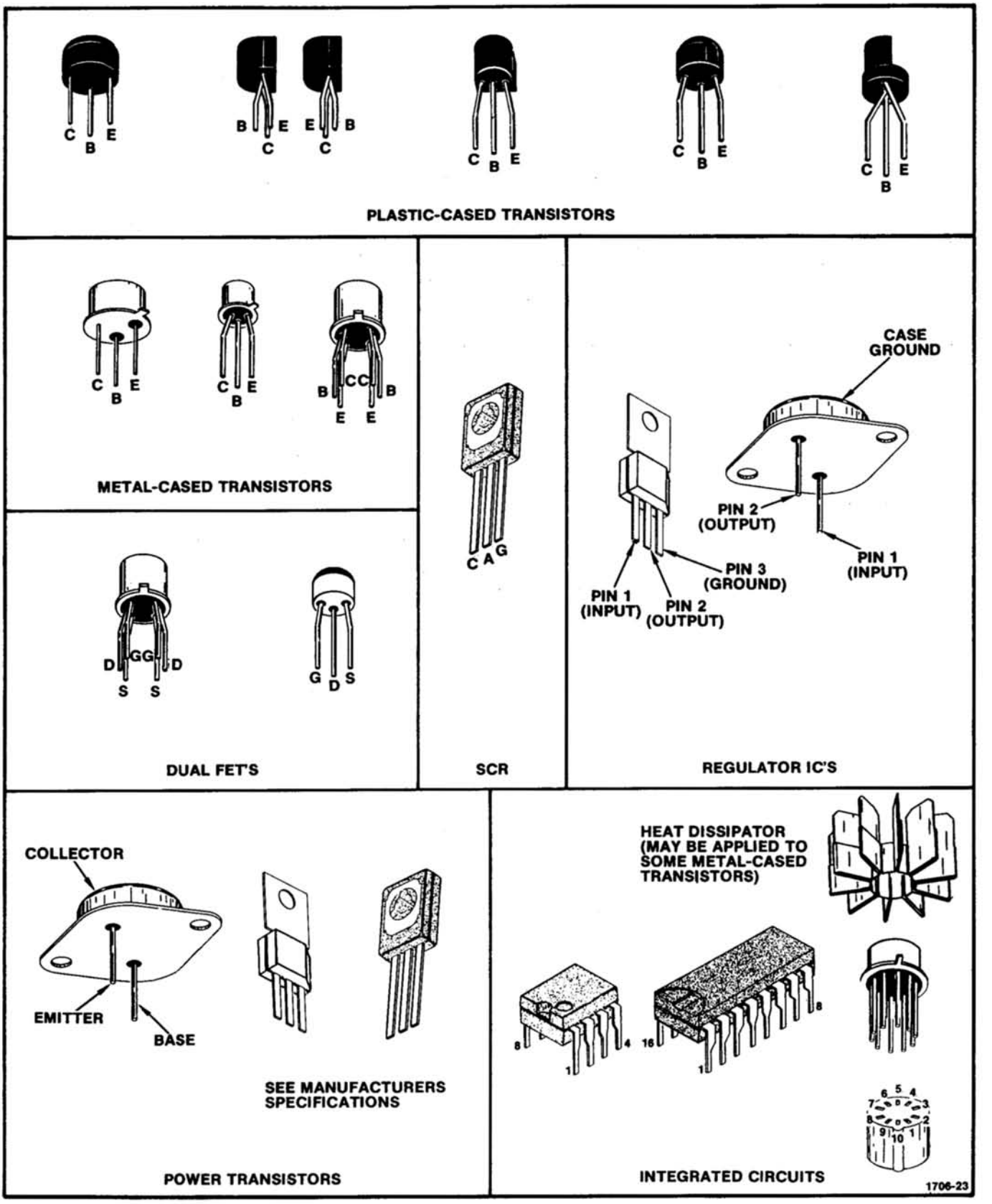


Fig. 5-1. Semiconductor device lead configurations found in the TM 500 family.

Test Equipment

Before using any test equipment to make measurements on static-sensitive components or assemblies, be certain that any voltage or current supplied by the test equipment does not exceed the limits of the component to be tested.

Interconnecting Pins. To replace a pin that is mounted on a circuit board, first disconnect any pin connectors. Then, unsolder the damaged pin and pull it out of the board with a pair of pliers. Be careful not to damage the wiring on the board with too much heat. Ream out the hole in the circuit board with a 0.031-inch drill. Remove the ferrule from the new interconnecting pin and press the new pin into the hole in the circuit board. Position the pin in the same manner as the old pin and solder it in. If the old pin was bent at an angle to mate with a connector, bend the new pin to match the associated pins.

NOTE

A pin replacement kit including necessary tools, instructions, and replacement pins is available from Tektronix, Inc.

Table 5-1

RELATIVE SUSCEPTIBILITY TO STATIC DISCHARGE DAMAGE

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

***Voltage equivalent for levels:**

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

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

Table 5-2

MAINTENANCE AIDS

The following maintenance aids include items required for some maintenance procedures in this instrument. Equivalent products may be substituted for examples given providing characteristics are similar.

Description	Specifications	Use	Example
1. Soldering Iron	15 Watt	General soldering and unsoldering	ANTEX PRECISION Model C
2. Screwdriver	Phillips #1 tip	Assembly and Disassembly	Xcelite Model X108
3. Screwdriver	Phillips #2 tip	Assembly and Disassembly	Xcelite Model X102
4. Screwdriver	Three-inch shaft; 3/32 inch flat bit	General	Xcelite R3323
5. Torque Screwdriver	1.5 inch-pounds	FUNCTION switch assembly	Sturtevant-Richmont Torque Products Model PM-5-Roto-Torq
6. Nutdrivers	1/4 inch, 5/16 inch 3/8 inch, 7/16 inch	General	Xcelite #8, #10, #12 & #14
7. Open End Wrench	11/16 inch	General	
8. Solder Wick		Unsoldering	Hex Wik #887-10
9. Lubricant	Versilube	FUNCTION switch lubrication	Tektronix Part No. 006-1353-00
10. Spray Cleaner	No Noise	FUNCTION switch pad cleaning	Tektronix Part No. 006-0442-02
11. Vacuum Desoldering Tool	Antistatic	General	Tektronix Part No. 003-0795-00
12. I.C. Extracting Tool		General	Tektronix Part No. 003-0619-00
13. Cam Switch Repair Kit		Cam switches	Tektronix Part No. 040-0541-00
14. Extender Cables		General	Tektronix Part No. 067-0645-02

Table 5-3

REAR CONNECTOR PIN ASSIGNMENTS

	B		A	
Trigger Output Common	28	Signal source plug-in barrier slot	28	Output
Trigger Output	27		27	Output Common
	26		26	
Gate In Common	25		25	
Gate In	24		24	
	23		23	
VCF In Common	22		22	
VCF In	21		21	
	20		20	
	19		19	
	18		18	
	17		17	
	16		16	
	15		15	
	14		14	
25 VAC Winding	13		13	25 VAC Winding
+33.5 V Filtered DC	12		12	+33.5 V Filtered DC
Collector lead of PNP Series-Pass Transistor	11		11	Base lead of PNP Series-Pass Transistor
Transformer Shield	10	TM 500 barrier slot	10	Emitter lead of PNP Series-Pass Transistor
33.5 V Common	9		9	33.5 V Common
−33.5 V Filtered DC	8		8	−33.5 V Filtered DC
Collector lead of NPN Series-Pass Transistor	7		7	Emitter lead of NPN Series-Pass Transistor
Not Used	6		6	Base lead of NPN Series-Pass Transistor
17.5 VAC Winding	5		5	17.5 VAC winding
+11.5 V Common	4		4	+11.5 V Common
+11.5 V Common	3		3	+11.5 V Common
+11.5 V Filtered DC	2		2	+11.5 V Filtered DC
25 VAC Winding	1		1	25 VAC Winding
	B		A	

Rear-view of plug-in

Assignments listed for pins 1A—13A and 1B—13B are available in all power modules; however only those pins marked with an asterisk (*) are used by the FG 502.

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), the name of an individual at your firm that can be contacted, complete instrument serial number and a description of the service required.

Save and re-use the package in which your instrument was shipped. If the orignal 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.

OPTIONS

There are no options 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
01295	TEXAS INSTRUMENTS, INC., SEMICONDUCTOR GROUP	P O BOX 5012, 13500 N CENTRAL EXPRESSWAY	DALLAS, TX 75222
02111	SPECTROL ELECTRONICS CORPORATION	17070 EAST GALE AVENUE	CITY OF INDUSTRY, CA 91745
02735	RCA CORPORATION, SOLID STATE DIVISION	ROUTE 202	SOMERVILLE, NY 08876
04713	MOTOROLA, INC., SEMICONDUCTOR PROD. DIV.	5005 E MCDOWELL RD,PO BOX 20923	PHOENIX, AZ 85036
07263	FAIRCHILD SEMICONDUCTOR, A DIV. OF FAIRCHILD CAMERA AND INSTRUMENT CORP.	464 ELLIS STREET	MOUNTAIN VIEW, CA 94042
09023	CORNELL-DUBILIER ELECTRONIC DIVISION FEDERAL PACIFIC ELECTRIC CO.	2652 DALRYMPLE ST.	SANFORD, NC 27330
13511	AMPHENOL CARDRE DIV., BUNKER RAMO CORP.		LOS GATOS, CA 95030
14193	CAL-R, INC.	1601 OLYMPIC BLVD.	SANTA MONICA, CA 90404
14433	ITT SEMICONDUCTORS	3301 ELECTRONICS WAY P O BOX 3049	WEST PALM BEACH, FL 33402
24546	CORNING GLASS WORKS, ELECTRONIC COMPONENTS DIVISION	550 HIGH STREET	BRADFORD, PA 16701
27014	NATIONAL SEMICONDUCTOR CORP.	2900 SEMICONDUCTOR DR.	SANTA CLARA, CA 95051
28480	HEWLETT-PACKARD CO., CORPORATE HQ.	1501 PAGE MILL RD.	PALO ALTO, CA 94304
32293	INTERSIL, INC.	10900 N. TANTAU AVE.	CUPERTINO, CA 95014
50434	HEWLETT-PACKARD COMPANY	640 PAGE MILL ROAD	PALO ALTO, CA 94304
52769	SPRAGUE GOODMAN ELEC., INC.	134 FULTON AVENUE	GARDEN CITY PARK, NY 11040
56289	SPRAGUE ELECTRIC CO.	87 MARSHALL ST.	NORTH ADAMS, MA 01247
71744	CHICAGO MINIATURE LAMP WORKS	4433 RAVENSWOOD AVE.	CHICAGO, IL 60640
72982	ERIE TECHNOLOGICAL PRODUCTS, INC.	644 W. 12TH ST.	ERIE, PA 16512
73138	BECKMAN INSTRUMENTS, INC., HELIPOT DIV.	2500 HARBOR BLVD.	FULLERTON, CA 92634
74970	JOHNSON, E. F., CO.	299 10TH AVE. S. W.	WASECA, MN 56093
75042	TRW ELECTRONIC COMPONENTS, IRC FIXED RESISTORS, PHILADELPHIA DIVISION	401 N. BROAD ST.	PHILADELPHIA, PA 19108
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
80031	ELECTRA-MIDLAND CORP., MEPCO DIV.	22 COLUMBIA ROAD	MORRISTOWN, NJ 07960
84411	TRW ELECTRONIC COMPONENTS, TRW CAPACITORS	112 W. FIRST ST.	OGALLALA, NE 69153
90201	MALLORY CAPACITOR CO., DIV. OF P. R. MALLORY AND CO., INC.	3029 E. WASHINGTON STREET 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	670-2595-00	B010100	B029999	CKT BOARD ASSY:FUNCTION GENERATOR	80009	670-2595-00
A1	670-2595-01	B030000	B031238	CKT BOARD ASSY:FUNCTION GENERATOR	80009	670-2595-01
A1	670-2595-02	B031239	B034785	CKT BOARD ASSY:FUNCTION GENERATOR	80009	670-2595-02
A1	670-2595-03	B034786	B038154	CKT BOARD ASSY:FUNCTION GENERATOR	80009	670-2595-03
A1	670-2595-04	B038155	B039999	CKT BOARD ASSY:FUNCTION GENERATOR	80009	670-2595-04
A1	670-2595-05	B040000		CKT BOARD ASSY:FUNCTION GENERATOR	80009	670-2595-05
C148 C150 C152 C154	295-0126-00	B010100	B010160	CAP.SET,MTCHD:10,1,0.1,0.01UF,990PF	84411	TEK55-0005R5
C148 C150 C152 C154 C156	295-0164-00	B010161	B038154	CAP.SET,MTCHD:10,1,0.1,0.01UF,950PF	80009	295-0164-00
C148 C150 C152 C154	295-0190-00	B038155		CAP.SET,MTCHD:10.0UF,1.0UF,0.1UF,0.01UF	80009	295-0190-00
C156	283-0645-00	B010100	B010160X	CAP.,FXD,MICA D:790PF,1%,100V	00853	D151E791F0
C156	283-0645-00	XB038155		CAP.,FXD,MICA D:790PF,1%,100V	00853	D151E791F0
C157	283-0600-00	B010100	B010437X	CAP.,FXD,MICA D:43PF,5%,500V	00853	D105E430J0
C158	281-0125-00	B010100	B010160X	CAP.,VAR,MICA D:90-400PF,175V	52769	GMC30900
C158	281-0509-00	XB010438	B038154	CAP.,FXD,CER DI:15PF,+/-1.5PF,500V	72982	301-000C0G0150K
C158	281-0125-00	B038155		CAP.,VAR,MICA D:90-400PF,175V	52769	GMC30900
C160	281-0540-00	B010100	B010112	CAP.,FXD,CER DI:51PF,5%,500V	72982	301-000U2J0510J
C160	283-0600-00	B010113		CAP.,FXD,MICA D:43PF,5%,500V	00853	D105E430J0
C162	281-0205-00			CAP.,VAR,PLSTC:4-65PF,100V	80031	2810C5R565QJ02F0
C190	290-0572-00			CAP.,FXD,ELCTLT:0.1UF,20%,50V	56289	196D104X0050HA1
C192	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C204	281-0504-00			CAP.,FXD,CER DI:10PF,+/-1PF,500V	72982	301-055C0G0100F
C224	283-0604-00	B010100	B010437	CAP.,FXD,MICA D:304PF,2%,300V	00853	D153F3040G0
C224	283-0646-00	B010438		CAP.,FXD,MICA D:170PF,1%,100V	00853	D151E171F0
C240	283-0646-00	B010100	B010112	CAP.,FXD,MICA D:170PF,1%,100V	00853	D151E171F0
C240	283-0598-00	B010113	B010437	CAP.,FXD,MICA D:253PF,5%,300V	09023	CD15EC(253)J03
C240	283-0672-00	B010438		CAP.,FXD,MICA D:200PF,1%,500V	00853	D155F2010F0
C245	283-0024-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	72982	8121N083Z5U0104Z
C247	283-0648-00	B010100	B010437X	CAP.,FXD,MICA D:10PF,5%,100V	00853	D151C100D0
C247	281-0611-00	XB030000	B034785	CAP.,FXD,CER DI:2.7PF,+/-0.25PF,200V	72982	374001C0J279C
C247	----- -----			(NOMINAL VALUE,SELECTED)		
C247	281-0658-00	B034786		CAP.,FXD,CER DI:6.2PF,+/-0.25PF,500V	72982	301-000C0H0629C
C268	283-0615-00			CAP.,FXD,MICA D:33PF,5%,500V	00853	D155E330J0
C272	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C287	281-0064-00			CAP.,VAR,PLSTC:0.25-1.5PF,600V	74970	273-0001-301
C288	283-0663-00			CAP.,FXD,MICA D:16.8PF,+/-0.5PF,500V	00853	D155C16.8D0
C292	283-0024-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	72982	8121N083Z5U0104Z
C332	283-0600-00			CAP.,FXD,MICA D:43PF,5%,500V	00853	D105E430J0
C350	281-0207-00			CAP.,VAR,PLSTC:2-18PF,100V	80031	2807C00218MH02F0
C351	290-0536-00	B010100	B010112X	CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C352	283-0618-00			CAP.,FXD,MICA D:130PF,2%,400V	00853	D155E131G0
C390	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C392	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C395	281-0589-00			CAP.,FXD,CER DI:170PF,5%,500V	72982	301000Z5D0171J
C405	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C418	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C420	283-0024-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	72982	8121N083Z5U0104Z
C428	283-0024-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	72982	8121N083Z5U0104Z

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C430	283-0615-00			CAP.,FXD,MICA D:33PF,5%,500V	00853	D155E330J0
C432	281-0518-00			CAP.,FXD,CER DI:47PF,+/-9.4PF,500V	72982	301-000U2J0470M
C442	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C450	281-0204-00			CAP.,VAR,PLSTC:2-22PF,100V	80031	287C00222MJ02
C452	283-0600-00			CAP.,FXD,MICA D:43PF,5%,500V	00853	D105E430J0
C460	283-0629-00			CAP.,FXD,MICA D:62PF,1%,500V	00853	D105E620F0
C462	283-0672-00			CAP.,FXD,MICA D:200PF,1%,500V	00853	D155F201OF0
C480	281-0504-00			CAP.,FXD,CER DI:10PF,+/-1PF,500V	72982	301-055C0G0100F
C494	281-0523-00			CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C498	283-0024-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	72982	8121N083Z5U0104Z
C504	283-0024-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	72982	8121N083Z5U0104Z
C512	283-0691-00			CAP.,FXD,MICA D:650PF,1%,300V	00853	D153F651F0
C530	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C532	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C533	283-0002-00	XB038155		CAP.,FXD,CER DI:0.01UF,+80-20%,500V	72982	811-546E103Z
C536	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C540	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C542	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C546	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C552	283-0003-00	B010100	B010112	CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-558Z5U-103Z
C552	283-0268-00	B010113	B031238X	CAP.,FXD,CER DI:0.015UF,10%,50V	72982	8121N083X7R0153K
C564	283-0636-00	B010100	B010112	CAP.,FXD,MICA D:36PF,1.4%,100V	00853	D155F360G0
C564	283-0600-00	B010113	B031238X	CAP.,FXD,MICA D:43PF,5%,500V	00853	D105E430J0
C566	281-0207-00			CAP.,VAR,PLSTC:2-18PF,100V	80031	2807C00218MH02F0
C568	281-0207-00			CAP.,VAR,PLSTC:2-18PF,100V	80031	2807C00218MH02F0
C574	281-0202-00	B010100	B031238X	CAP.,VAR,PLSTC:1.5-5.5PF,100V	80031	2807C1R406MM02F
C602	290-0324-00			CAP.,FXD,ELCTLT:750UF,+75-10%,40V	56289	D46454
C632	290-0559-00			CAP.,FXD,ELCTLT:22UF,20%,35V	90201	TDC226M035WLG
C635	290-0559-00	XB010150		CAP.,FXD,ELCTLT:22UF,20%,35V	90201	TDC226M035WLG
C640	290-0559-00	XB010438		CAP.,FXD,ELCTLT:22UF,20%,35V	90201	TDC226M035WLG
C655	290-0559-00			CAP.,FXD,ELCTLT:22UF,20%,35V	90201	TDC226M035WLG
C680	290-0324-00			CAP.,FXD,ELCTLT:750UF,+75-10%,40V	56289	D46454
CR140	152-0457-00			SEMICOND DEVICE:SILICON,25V	28480	5082-2068
CR145	152-0457-00			SEMICOND DEVICE:SILICON,25V	28480	5082-2068
CR170	152-0457-00			SEMICOND DEVICE:SILICON,25V	28480	5082-2068
CR175	152-0457-00			SEMICOND DEVICE:SILICON,25V	28480	5082-2068
CR204	152-0141-02	XB030000		SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR230	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
CR232	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
CR245	152-0141-02	B010100	B034785	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR245	152-0153-00	B034786		SEMICOND DEVICE:SILICON,15V,50MA	07263	FD7003
CR246	152-0141-02	B010100	B034785	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR246	152-0153-00	B034786		SEMICOND DEVICE:SILICON,15V,50MA	07263	FD7003
CR248	152-0141-02	B010100	B034785	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR248	152-0153-00	B034786		SEMICOND DEVICE:SILICON,15V,50MA	07263	FD7003
CR250	152-0141-02	B010100	B034785	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR250	152-0153-00	B034786		SEMICOND DEVICE:SILICON,15V,50MA	07263	FD7003
CR260	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR262	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR264	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR266	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR268	152-0457-00			SEMICOND DEVICE:SILICON,25V	28480	5082-2068
CR300	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR302	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR304	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR306	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
CR308	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR310	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR312	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR314	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR315	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR318	152-0141-02	XB010438		SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR326	152-0141-02	XB040000		SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR332	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR334	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR336	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR338	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR352	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR352	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR354	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR354	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR356	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR356	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR358	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR358	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR362	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR362	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR364	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR364	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR366	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR366	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR368	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR368	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR372	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR372	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR374	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR374	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR376	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR376	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR378	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR378	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR382	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR382	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR384	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR384	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR386	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR386	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR388	152-0141-02	B010100	B029999	SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR388	152-0333-00	B030000		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH-6012
CR430	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR432	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR520	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR522	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR524	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR600	152-0488-00			SEMICOND DEVICE:SILICON,200V,1500MA	04713	3N55 FAMILY
CR632	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	14433	LG4016
CR642	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR644	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR655	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	14433	LG4016
CR664	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR666	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
CR680	152-0488-00			SEMICOND DEVICE:SILICON,200V,1500MA	04713	3N55 FAMILY

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
DS630	150-0109-00			LAMP,INCAND:18V,26MA	71744	CM7220
J125	131-0955-00			CONN,RCPT,ELEC:BNC,FEMALE	13511	31-279
J285	131-0274-00			CONNECTOR,RCPT,:BNC	91836	KC79-67
J340	131-0955-00			CONN,RCPT,ELEC:BNC,FEMALE	13511	31-279
J555	131-0955-00			CONN,RCPT,ELEC:BNC,FEMALE	13511	31-279
Q140	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
Q175	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
Q200						
Q202	151-1042-00			SEMICOND DVC SE:MATCHED PAIR FET	27014	SF50031
Q204	151-0301-00			TRANSISTOR:SILICON,PNP	27014	2N2907A
Q210	151-0160-00			TRANSISTOR:SILICON,NPN	80009	151-0160-00
Q230	151-0301-00	B010100	B010112X	TRANSISTOR:SILICON,PNP	27014	2N2907A
Q230	----- -----			(Q230, REPLACED BY Q230A,B)		
Q230A,B	151-0261-00	XB010113		TRANSISTOR:SILICON,PNP,DUAL	80009	151-0261-00
Q232	151-0301-00	B010100	B010112X	TRANSISTOR:SILICON,PNP	27014	2N2907A
Q232	----- -----			(Q232, REPLACED BY Q230A,B)		
Q268	151-0302-00			TRANSISTOR:SILICON,NPN	07263	S038487
Q290	151-0302-00	B010100	B010437	TRANSISTOR:SILICON,NPN	07263	S038487
Q290	151-0424-00	B010438		TRANSISTOR:SILICON,NPN	04713	SPS8246
Q292	151-0302-00	B010100	B010437	TRANSISTOR:SILICON,NPN	07263	S038487
Q292	151-0424-00	B010438		TRANSISTOR:SILICON,NPN	04713	SPS8246
Q315	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
Q318	151-0188-00	B010100	B010437X	TRANSISTOR:SILICON,PNP	04713	SPS6868K
Q325	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
Q330	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
Q332	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
Q400	151-0188-00	B010100	B039999	TRANSISTOR:SILICON,PNP	04713	SPS6868K
Q400A,B	151-0354-00	B040000		TRANSISTOR:SILICON,PNP,DUAL	32293	ITS1200A
Q410	151-0188-00	B010100	B039999X	TRANSISTOR:SILICON,PNP	04713	SPS6868K
Q420	151-0302-00			TRANSISTOR:SILICON,NPN	07263	S038487
Q430	151-0302-00			TRANSISTOR:SILICON,NPN	07263	S038487
Q440	151-0301-00			TRANSISTOR:SILICON,PNP	27014	2N2907A
Q442	151-0302-00			TRANSISTOR:SILICON,NPN	07263	S038487
Q444	151-0301-00			TRANSISTOR:SILICON,PNP	27014	2N2907A
Q480	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
Q490	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
Q500	151-0302-00	B010100	B031238	TRANSISTOR:SILICON,NPN	07263	S038487
Q500	151-0103-00	B031239		TRANSISTOR:SILICON,NPN	80009	151-0103-00
Q506	151-0302-00	B010100	B031238	TRANSISTOR:SILICON,NPN	07263	S038487
Q506	151-0103-00	B031239		TRANSISTOR:SILICON,NPN	80009	151-0103-00
Q515	151-0301-00	B010100	B031238	TRANSISTOR:SILICON,PNP	27014	2N2907A
Q515	151-0134-00	B031239		TRANSISTOR:SILICON,PNP	80009	151-0134-00
Q530	151-0103-00			TRANSISTOR:SILICON,NPN	80009	151-0103-00
Q532	151-0134-00			TRANSISTOR:SILICON,PNP	80009	151-0134-00
Q540	151-0103-00			TRANSISTOR:SILICON,NPN	80009	151-0103-00
Q542	151-0134-00			TRANSISTOR:SILICON,PNP	80009	151-0134-00
Q620	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
Q622	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
Q635	151-0311-01			TRANSISTOR:SILICON,NPN	04713	SJE908
Q650	151-0324-00			TRANSISTOR:SILICON,PNP	04713	SJE915
Q660	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
Q662	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
R100	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	91637	MFF1816G40200F
R105	311-1560-00			RES.,VAR,NONWIR:5K OHM,20%,0.50W	73138	91-82-0
R110	311-1576-00			RES.,VAR,WW:10K OHM,3%,2W	02111	152B-S103A
R115	311-0258-00			RES.,VAR,NONWIR:PNL,100 OHM,0.50W	01121	WA1GO24S101UA

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R116	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R120	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R122	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R125	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R127	321-0286-00			RES.,FXD,FILM:9.31K OHM,1%,0.125W	91637	MFF1816G93100F
R129	321-0240-00			RES.,FXD,FILM:3.09K OHM,1%,0.125W	91637	MFF1816G30900F
R130	311-1567-00			RES.,VAR,NONWIR:TRMR,100 OHM,0.50W	73138	91-89-0
R131	321-0114-00	B010100	B029999	RES.,FXD,FILM:150 OHM,1%,0.125W	91637	MFF1816G150R0F
R131	321-0106-00	B030000		RES.,FXD,FILM:124 OHM,1%,0.125W	91637	MFF1816G124R0F
R135	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R137	315-0332-00			RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
R139	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R140	317-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.125W	01121	BB5115
R142	321-0346-00			RES.,FXD,FILM:39.2K OHM,1%,0.125W	91637	MFF1816G39201F
R144	321-0226-00	B010100	B010112	RES.,FXD,FILM:2.21K OHM,1%,0.125W	91637	MFF1816G22100F
R144	321-0913-03	B010113	B010437	RES.,FXD,FILM:2.22K OHM,0.25%,0.125W	91637	MFF1816D22200C
R144	321-0649-00	B010438		RES.,FXD,FILM:2.19K OHM,0.25%,0.125W	91637	MFF1816D21900C
R146	321-0442-00			RES.,FXD,FILM:392K OHM,1%,0.125W	91637	MFF1816G39202F
R148	321-0322-00	B010100	B029999	RES.,FXD,FILM:22.1K OHM,1%,0.125W	91637	MFF1816G22101F
R148	321-0643-00	B030000		RES.,FXD,FILM:22.1K OHM,0.25%,0.125W	91637	MFF1816C22101C
R150	315-0395-00			RES.,FXD,CMPSN:3.9M OHM,5%,0.25W	01121	CB3955
R152	321-0418-00			RES.,FXD,FILM:221K OHM,1%,0.125W	91637	MFF1816G22102F
R155	315-0821-00	B010100	B010437	RES.,FXD,CMPSN:820 OHM,5%,0.25W	01121	CB8215
R155	301-0821-00	B010438		RES.,FXD,CMPSN:820 OHM,5%,0.50W	01121	EB8215
R157	315-0100-00	B010100	B010437X	RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R160	321-0289-07			RES.,FXD,FILM:10K OHM,0.1%,0.125W	91637	MFF1816C10001B
R162	321-0289-07			RES.,FXD,FILM:10K OHM,0.1%,0.125W	91637	MFF1816C10001B
R164	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R169	321-0277-00			RES.,FXD,FILM:7.5K OHM,1%,0.125W	91637	MFF1816G75000F
R170	311-1175-00			RES.,VAR,NONWIR:100 OHM,10%,0.50W	73138	68WR100
R171	321-0277-00			RES.,FXD,FILM:7.5K OHM,1%,0.125W	91637	MFF1816G75000F
R175	317-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.125W	01121	BB5115
R178	321-0346-00			RES.,FXD,FILM:39.2K OHM,1%,0.125W	91637	MFF1816G39201F
R180	321-0226-00	B010100	B010112	RES.,FXD,FILM:2.21K OHM,1%,0.125W	91637	MFF1816G22100F
R180	321-0913-03	B010113	B010437	RES.,FXD,FILM:2.22K OHM,0.25%,0.125W	91637	MFF1816D22200C
R180	321-0649-00	B010438		RES.,FXD,FILM:2.19K OHM,0.25%,0.125W	91637	MFF1816D21900C
R182	321-0442-00			RES.,FXD,FILM:392K OHM,1%,0.125W	91637	MFF1816G39202F
R184	321-0322-00	B010100	B029999	RES.,FXD,FILM:22.1K OHM,1%,0.125W	91637	MFF1816G22101F
R184	321-0643-00	B030000		RES.,FXD,FILM:22.1K OHM,0.25%,0.125W	91637	MFF1816C22101C
R186	315-0395-00			RES.,FXD,CMPSN:3.9M OHM,5%,0.25W	01121	CB3955
R188	321-0418-00			RES.,FXD,FILM:221K OHM,1%,0.125W	91637	MFF1816G22102F
R190	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R192	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R200	315-0821-00			RES.,FXD,CMPSN:820 OHM,5%,0.25W	01121	CB8215
R204	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R208	315-0101-00	B010100	B038154	RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R208	315-0102-00	B038155		RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R210	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R214	315-0100-00	B010100	B039999	RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R214	321-0001-00	B040000		RES.,FXD,FILM:10 OHM,1%,0.125W	75042	CEAT0-10R00F
R216	301-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.50W	01121	EB2715
R218	301-0241-00			RES.,FXD,CMPSN:240 OHM,5%,0.50W	01121	EB2415
R220	315-0201-00	B010100	B039999	RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
R220	321-0126-06	B040000		RES.,FXD,FILM:200 OHM,0.25%,0.125W	91637	MFF1816C200R0C
R226	315-0241-00	B010100	B039999	RES.,FXD,CMPSN:240 OHM,5%,0.25W	01121	CB2415
R226	321-0928-07	B040000		RES.,FXD,FILM:250 OHM,0.1%,0.125W	91637	MFF1816C250R0B
R228	315-0153-00	B010100	B039999	RES.,FXD,CMPSN:15K OHM,5%,0.25W	01121	CB1535

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R228	321-0306-09	B040000		RES.,FXD,FILM:15K OHM,1%,0.125W	24546	NE55E1502F
R230	315-0102-00	B010100	B010112	RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R230	315-0302-00	B010113		RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R234	315-0102-00	B010100	B010112	RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R234	315-0302-00	B010113		RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R236	315-0102-00	B010100	B010112	RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R236	315-0302-00	B010113		RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R240	321-0096-00			RES.,FXD,FILM:97.6 OHM,1%,0.125W	91637	MFF1816G97R60F
R245	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	91637	MFF1816G30100F
R247	316-0565-00	B010100	B010437X	RES.,FXD,CMPSN:5.6M OHM,10%,0.25W	01121	CB5651
R248	315-0222-00	B010100	B010112	RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R248	321-0228-00	B010113		RES.,FXD,FILM:2.32K OHM,1%,0.125W	91637	MFF1816G23200F
R250	311-1563-00	B010100	B010112	RES.,VAR,NONWIR:1K OHM,20%,0.50W	73138	91-85-0
R250	311-1564-00	B010113		RES.,VAR,NONWIR:TRMR,500 OHM,0.5W	73138	91-86-0
R255	311-1565-00	B010100	B010437	RES.,VAR,NONWIR:250 OHM,20%,0.50W	73138	91-87-0
R255	311-1567-00	B010438		RES.,VAR,NONWIR:TRMR,100 OHM,0.50W	73138	91-89-0
R256	321-0100-00	B010100	B010437	RES.,FXD,FILM:107 OHM,1%,0.125W	91637	MFF1816G107R0F
R256	321-0106-00	B010438		RES.,FXD,FILM:124 OHM,1%,0.125W	91637	MFF1816G124R0F
R260	321-0215-00			RES.,FXD,FILM:1.69K OHM,1%,0.125W	91637	MFF1816G16900F
R262	321-0215-00			RES.,FXD,FILM:1.69K OHM,1%,0.125W	91637	MFF1816G16900F
R268	315-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
R272	301-0151-00	B010100	B010437	RES.,FXD,CMPSN:150 OHM,5%,0.50W	01121	EB1515
R272	301-0101-00	B010438		RES.,FXD,CMPSN:100 OHM,5%,0.50W	01121	EB1015
R274	301-0151-00	B010100	B010437	RES.,FXD,CMPSN:150 OHM,5%,0.50W	01121	EB1515
R274	301-0101-00	B010438		RES.,FXD,CMPSN:100 OHM,5%,0.50W	01121	EB1015
R278	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
R280	315-0240-00			RES.,FXD,CMPSN:24 OHM,5%,0.25W	01121	CB2405
R282	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R284	308-0685-00			RES.,FXD,WW:1.5 OHM,5%,1W	75042	BW20-1R500J
R290	315-0102-00	B010100	B010437	RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R290	301-0821-00	B010438		RES.,FXD,CMPSN:820 OHM,5%,0.50W	01121	EB8215
R292	315-0201-00	B010100	B010437	RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
R292	301-0161-00	B010438		RES.,FXD,CMPSN:160 OHM,5%,0.50W	01121	EB1615
R294	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R298	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R318	315-0751-00	XB010438	B039999	RES.,FXD,CMPSN:750 OHM,5%,0.25W	01121	CB7515
R318	315-0621-00	B040000		RES.,FXD,CMPSN:620 OHM,5%,0.25W	01121	CB6215
R319	315-0911-00	B010100	B010437	RES.,FXD,CMPSN:910 OHM,5%,0.25W	01121	CB9115
R319	315-0202-00	B010438		RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R320	311-1563-00	B010100	B010437	RES.,VAR,NONWIR:1K OHM,20%,0.50W	73138	91-85-0
R320	311-1560-00	B010438		RES.,VAR,NONWIR:5K OHM,20%,0.50W	73138	91-82-0
R321	315-0153-00	B010100	B010437	RES.,FXD,CMPSN:15K OHM,5%,0.25W	01121	CB1535
R321	315-0622-00	B010438		RES.,FXD,CMPSN:6.2K OHM,5%,0.25W	01121	CB6225
R324	315-0242-00	XB040000		RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
R325	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R327	315-0393-00	B010100	B039999	RES.,FXD,CMPSN:39K OHM,5%,0.25W	01121	CB3935
R327	315-0302-00	B040000		RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R328	315-0751-00			RES.,FXD,CMPSN:750 OHM,5%,0.25W	01121	CB7515
R330	315-0752-00			RES.,FXD,CMPSN:7.5K OHM,5%,0.25W	01121	CB7525
R332	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
R338	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R340	315-0303-00			RES.,FXD,CMPSN:30K OHM,5%,0.25W	01121	CB3035
R342	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R350	311-1567-00			RES.,VAR,NONWIR:TRMR,100 OHM,0.50W	73138	91-89-0
R351	315-0131-00	B010100	B010112X	RES.,FXD,CMPSN:130 OHM,5%,0.25W	01121	CB1315
R352	321-0354-00			RES.,FXD,FILM:47.5K OHM,1%,0.125W	91637	MFF1816G47501F
R354	315-0100-00	B010100	B010112	RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R354	321-0117-00	B010113		RES.,FXD,FILM:162 OHM,1%,0.125W	91637	MFF1816G162R0F
R356	311-1565-00	B010100	B010112X	RES.,VAR,NONWIR:250 OHM,20%,0.50W	73138	91-87-0
R358	321-0354-00			RES.,FXD,FILM:47.5K OHM,1%,0.125W	91637	MFF1816G47501F
R362	321-0304-00			RES.,FXD,FILM:14.3K OHM,1%,0.125W	91637	MFF1816G14301F
R364	315-0101-00	B010100	B010112	RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R364	321-0150-00	B010113		RES.,FXD,FILM:357 OHM,1%,0.125W	91637	MFF1816G357R0F
R366	311-1565-00	B010100	B010112X	RES.,VAR,NONWIR:250 OHM,20%,0.50W	73138	91-87-0
R368	321-0304-00			RES.,FXD,FILM:14.3K OHM,1%,0.125W	91637	MFF1816G14301F
R372	321-0307-00			RES.,FXD,FILM:15.4K OHM,1%,0.125W	91637	MFF1816G15401F
R374	315-0100-00	B010100	B010112	RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R374	321-0067-00	B010113		RES.,FXD,FILM:48.7 OHM,1%,0.125W	91637	MFF1816G48R70F
R376	311-1567-00	B010100	B010112X	RES.,VAR,NONWIR:TRMR,100 OHM,0.50W	73138	91-89-0
R378	321-0307-00			RES.,FXD,FILM:15.4K OHM,1%,0.125W	91637	MFF1816G15401F
R382	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R384	315-0101-00	B010100	B010112	RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R384	321-0110-00	B010113		RES.,FXD,FILM:137 OHM,1%,0.125W	91637	MFF1816G137R0F
R386	311-1567-00	B010100	B010112X	RES.,VAR,NONWIR:TRMR,100 OHM,0.50W	73138	91-89-0
R388	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R390	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R392	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R395	315-0820-00			RES.,FXD,CMPSN:82 OHM,5%,0.25W	01121	CB8205
R397	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R400	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R402	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
R405	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R408	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
R410	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R412	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R415	315-0912-00			RES.,FXD,CMPSN:9.1K OHM,5%,0.25W	01121	CB9125
R418	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R422	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R424	315-0431-00			RES.,FXD,CMPSN:430 OHM,5%,0.25W	01121	CB4315
R426	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R436	315-0431-00			RES.,FXD,CMPSN:430 OHM,5%,0.25W	01121	CB4315
R438	315-0431-00			RES.,FXD,CMPSN:430 OHM,5%,0.25W	01121	CB4315
R442	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R444	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R450	311-1563-00			RES.,VAR,NONWIR:1K OHM,20%,0.50W	73138	91-85-0
R452	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R460	311-1565-00			RES.,VAR,NONWIR:250 OHM,20%,0.50W	73138	91-87-0
R462	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R465	311-1427-00			RES.,VAR,NONWIR:2K OHM,20%,0.50W	01121	16M147
R467	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R470	315-0180-00			RES.,FXD,CMPSN:18 OHM,5%,0.25W	01121	CB1805
R472	315-0512-00	B010100	B029999	RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
R472	321-0260-00	B030000	B038154	RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R472	321-0257-00	B038155		RES.,FXD,FILM:4.64K OHM,1%,0.125W	91637	MFF1816G46400F
R475	311-1602-00			RES.,VAR,NONWIR:5K OHM,10%,1W	01121	13M533
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R480	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R485	311-1565-00			RES.,VAR,NONWIR:250 OHM,20%,0.50W	73138	91-87-0
R486	315-0912-00			RES.,FXD,CMPSN:9.1K OHM,5%,0.25W	01121	CB9125
R490	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
R492	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
R494	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R498	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R500	315-0241-00			RES.,FXD,CMPSN:240 OHM,5%,0.25W	01121	CB2415

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R502	315-0300-00			RES.,FXD,CMPSN:30 OHM,5%,0.25W	01121	CB3005
R504	315-0241-00			RES.,FXD,CMPSN:240 OHM,5%,0.25W	01121	CB2415
R510	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
R512	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
R515	315-0121-00			RES.,FXD,CMPSN:120 OHM,5%,0.25W	01121	CB1215
R518	315-0112-00			RES.,FXD,CMPSN:1.1K OHM,5%,0.25W	01121	CB1125
R520	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R522	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R530	315-0330-00			RES.,FXD,CMPSN:33 OHM,5%,0.25W	01121	CB3305
R532	315-0330-00			RES.,FXD,CMPSN:33 OHM,5%,0.25W	01121	CB3305
R536	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R540	315-0330-00			RES.,FXD,CMPSN:33 OHM,5%,0.25W	01121	CB3305
R542	315-0330-00			RES.,FXD,CMPSN:33 OHM,5%,0.25W	01121	CB3305
R546	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R550	303-0470-00			RES.,FXD,CMPSN:47 OHM,5%,1W	01121	GB4705
R552	303-0470-00			RES.,FXD,CMPSN:47 OHM,5%,1W	01121	GB4705
R555	303-0470-00			RES.,FXD,CMPSN:47 OHM,5%,1W	01121	GB4705
R556	303-0470-00			RES.,FXD,CMPSN:47 OHM,5%,1W	01121	GB4705
R560	315-0303-00			RES.,FXD,CMPSN:30K OHM,5%,0.25W	01121	CB3035
R564	321-0253-00	B010100	B031238	RES.,FXD,FILM:4.22K OHM,1%,0.125W	91637	MFF1816G42200F
R564	321-0192-00	B031239		RES.,FXD,FILM:976 OHM,1%,0.125W	91637	MFF1816G976R0F
R566	321-0203-00			RES.,FXD,FILM:1.27K OHM,1%,0.125W	91637	MFF1816G12700F
R568	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
R574	315-0132-00	B010100	B031238X	RES.,FXD,CMPSN:1.3K OHM,5%,0.25W	01121	CB1325
R600	308-0710-00			RES.,FXD,WW:0.27 OHM,10%,1W	75042	BW20-R2700J
R602	308-0710-00			RES.,FXD,WW:0.27 OHM,10%,1W	75042	BW20-R2700J
R610	315-0332-00			RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
R612	315-0432-00			RES.,FXD,CMPSN:4.3K OHM,5%,0.25W	01121	CB4325
R614	321-0261-00			RES.,FXD,FILM:5.11K OHM,1%,0.125W	91637	MFF1816G51100F
R616	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R618	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R620	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R623	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R625	311-1561-00			RES.,VAR,NONWIR:2.5K OHM,20%,0.50W	73138	91-83-0
R630	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
R632	308-0755-00			RES.,FXD,WW:0.75 OHM,5%,2W	75042	BWH-R7500J
R635	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	91637	MFF1816G30100F
R636	321-0312-00			RES.,FXD,FILM:17.4K OHM,1%,0.125W	91637	MFF1816G17401F
R638	321-0289-07			RES.,FXD,FILM:10K OHM,0.1%,0.125W	91637	MFF1816C10001B
R640	321-0289-07			RES.,FXD,FILM:10K OHM,0.1%,0.125W	91637	MFF1816C10001B
R642	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R650	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
R655	308-0755-00			RES.,FXD,WW:0.75 OHM,5%,2W	75042	BWH-R7500J
R662	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R664	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R666	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R670	321-0261-00			RES.,FXD,FILM:5.11K OHM,1%,0.125W	91637	MFF1816G51100F
R672	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R676	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R678	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R680	308-0710-00			RES.,FXD,WW:0.27 OHM,10%,1W	75042	BW20-R2700J
R682	308-0710-00			RES.,FXD,WW:0.27 OHM,10%,1W	75042	BW20-R2700J
RT224	307-0126-00			RES.,THERMAL:100 OHM,10%	14193	2D21-101-D
S150	263-1001-00			SW CAM ACTR AS:--FUNCTION	80009	263-1001-00
S155	263-1002-00			SW CAM ACTR AS:--MULTIPLIER	80009	263-1002-00
S475	----- -----			(FURNISHED AS A UNIT WITH R475)		

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
U100	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	02735	85145
U135	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	02735	85145
U140	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	02735	85145
U170	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	02735	85145
U175	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	02735	85145
U615	156-0067-06			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER,SEL	02735	CA741CJG
U635	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	02735	85145
U650	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	02735	85145
U664	156-0067-06			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER,SEL	02735	CA741CJG
VR139	152-0279-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	04713	SZG35010RL
VR164	152-0279-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	04713	SZG35010RL
VR610	152-0166-00	B010100	B039999	SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	SZ11738
VR610	152-0456-00	B040000		SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N827

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols

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 is in 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.

American National Standard Institute
1430 Broadway
New York, New York 10018

Component Values

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

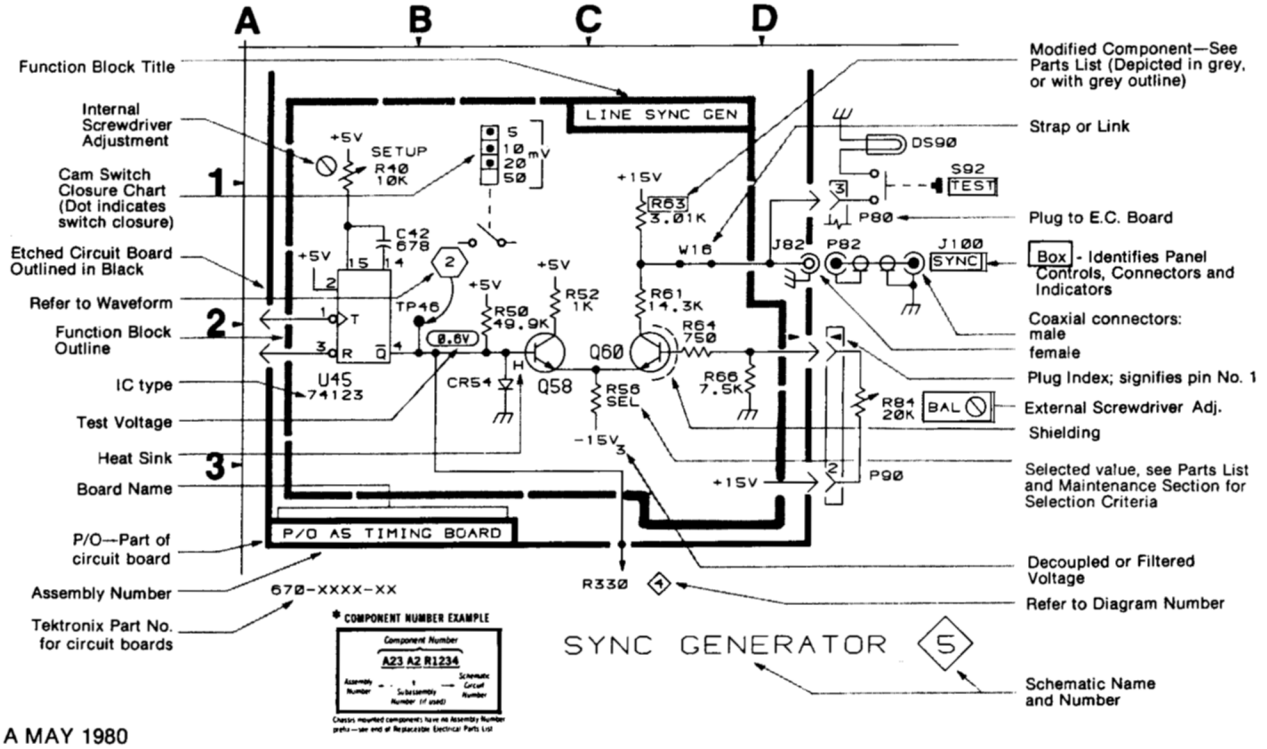
Capacitors = Values one or greater are in picofarads (pF). Values less than one are in microfarads (μF).
Resistors = Ohms (Ω).

The information and special symbols below may appear in this manual.

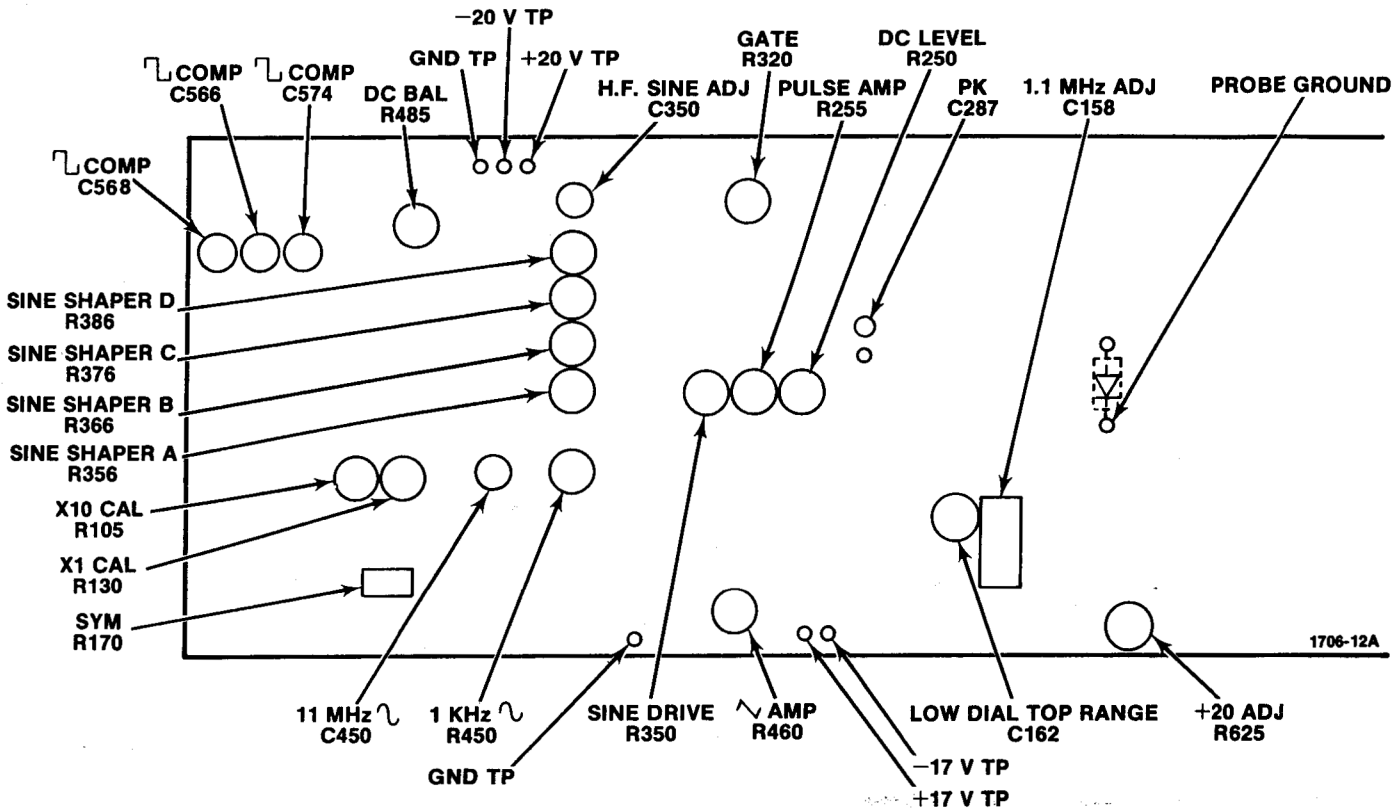
Assembly Numbers and Grid Coordinates

Each assembly in the instrument is assigned an assembly number (e.g., A20). The assembly number appears on the circuit board outline on the diagram, in the title for the circuit board component location illustration, and in the lookup table for the schematic diagram and corresponding component locator illustration. The Replaceable Electrical Parts list is arranged by assemblies in numerical sequence; the components are listed by component number *(see following illustration for constructing a component number).

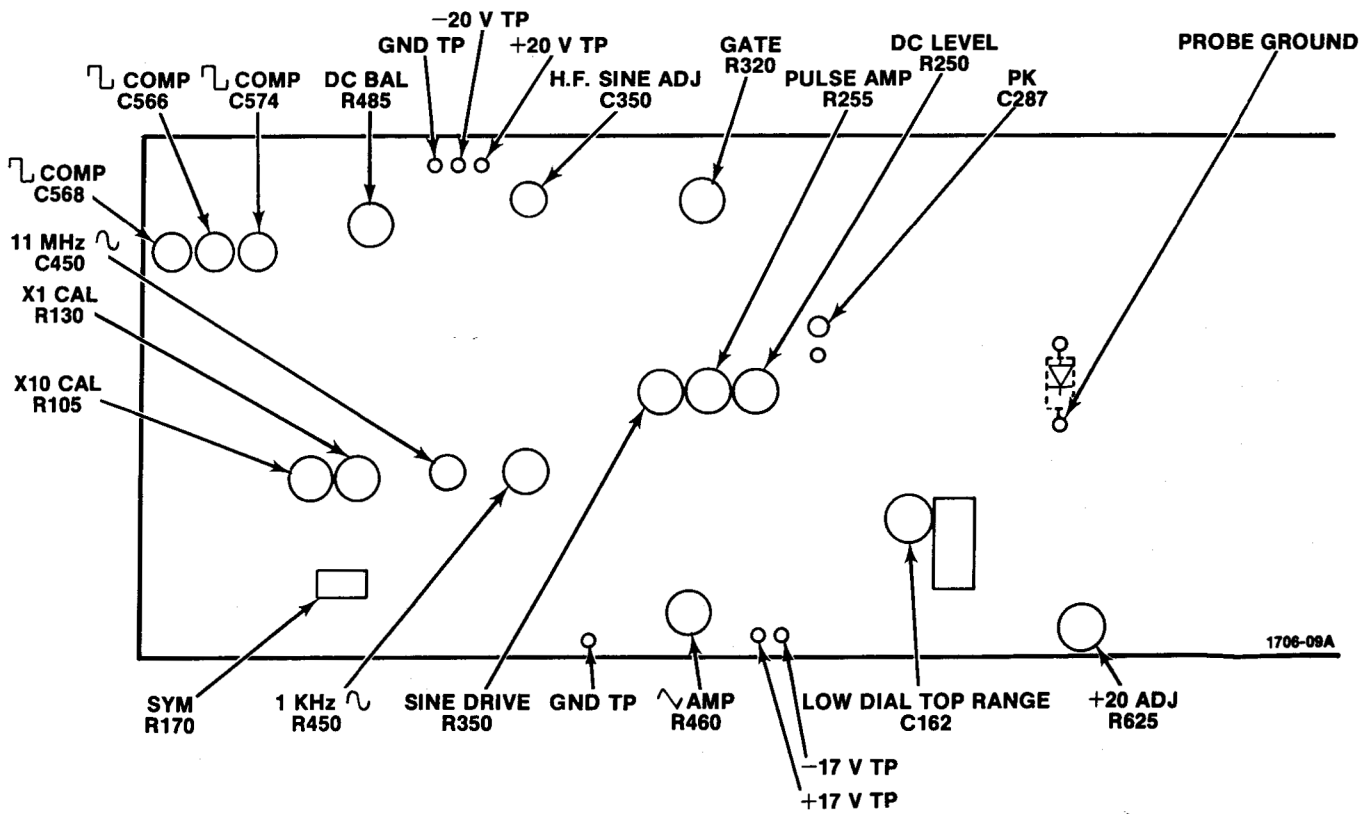
The schematic diagram and circuit board component location illustration have grids. A lookup table with the grid coordinates is provided for ease of locating the component. Only the components illustrated on the facing diagram are listed in the lookup table. When more than one schematic diagram is used to illustrate the circuitry on a circuit board, the circuit board illustration may only appear opposite the first diagram on which it was illustrated; the lookup table will list the diagram number of other diagrams that the circuitry of the circuit board appears on.



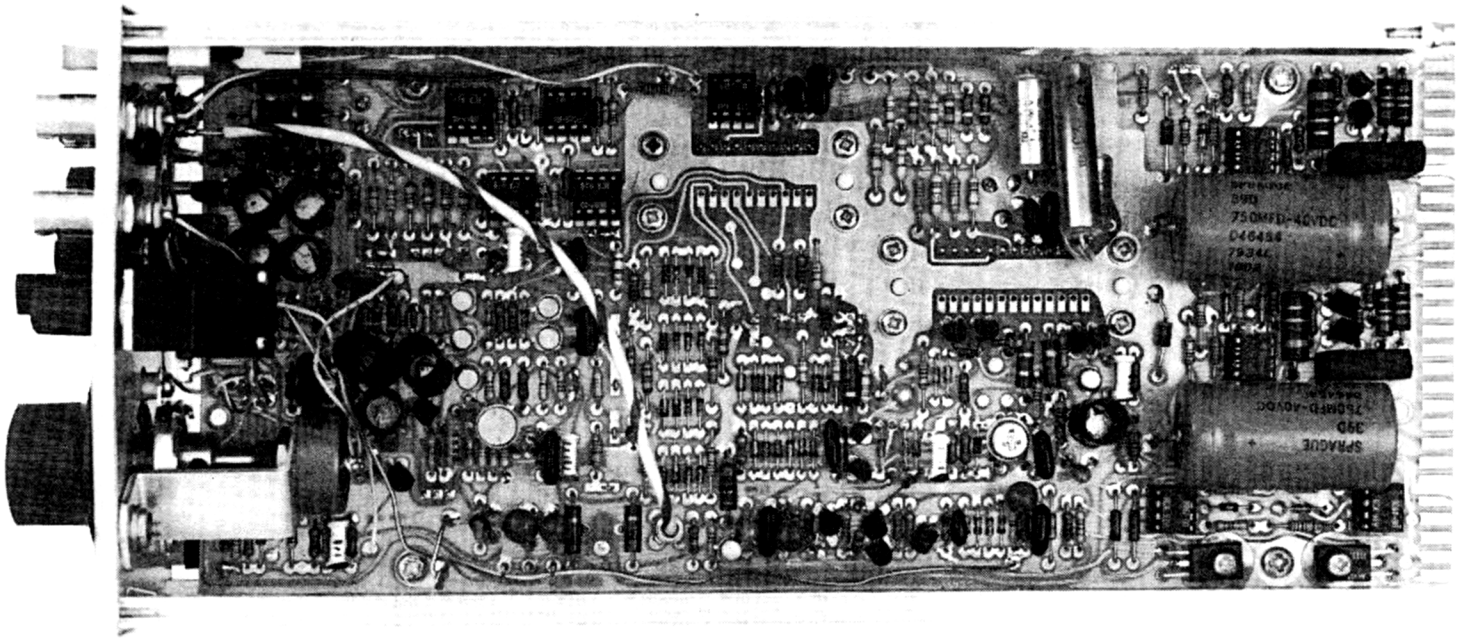
REV A MAY 1980



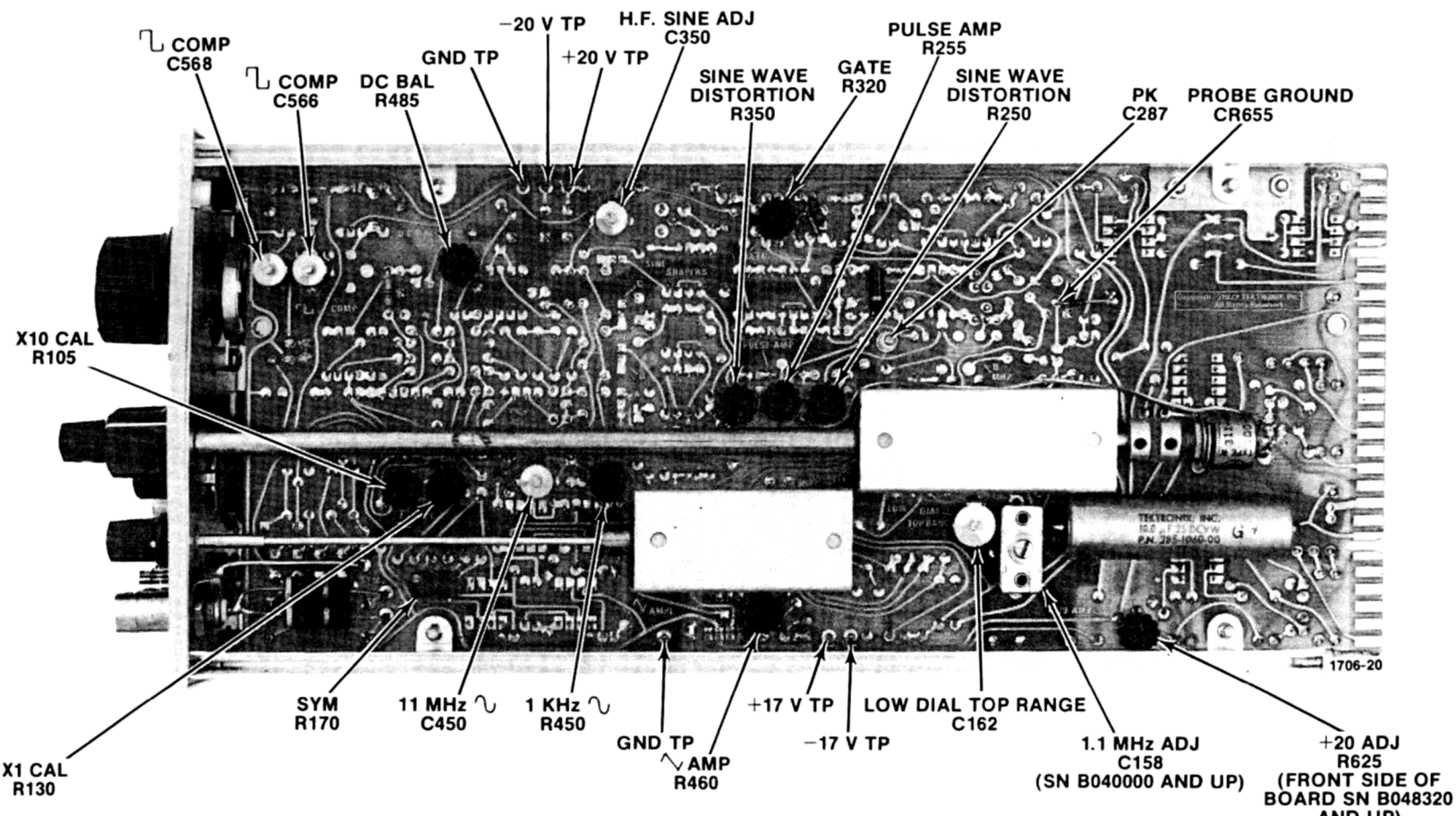
BACK SIDE A1 FUNCTION GENERATOR BOARD (SN B010100 - B010161).



BACK SIDE A1 FUNCTION GENERATOR BOARD (SN B010162 - B031169).



FRONT SIDE A1 FUNCTION GENERATOR BOARD (SN B031170 - UP).



BACK SIDE A1 FUNCTION GENERATOR BOARD (SN B031170 - UP).

VCF IN J125

FREQUENCY Hz

R110

R115

FREQ VERNIER

DIAL VOLTAGE FOLLOWER U100 ◇1

SUMMING AMPLIFIER U135 ◇1

+ CURRENT SOURCE U140 Q140 ◇1

GATE IN J340

GATE AMPLIFIER Q315 Q330 Q318 Q332 Q325 ◇1

GATE CLAMP CR300 CR302 CR304 CR306 CR308 CR310 CR312 CR314 ◇1

CURRENT SWITCH CR140 CR145 CR170 CR175 ◇1

SOURCE FOLLOWER Q200 Q202 ◇1

TRIANGLE BUFFER Q204 Q210 ◇1

SINE SHAPER CR352 THRU CR388 ◇2

SINE BUFFER Q400A,B* Q430 Q410* Q440 Q420 Q442 Q444 ◇2

CURRENT SWITCH DRIVER Q290 Q292 ◇1

UPPER & LOWER LEVEL COMPARATOR Q230 Q232 ◇1

INVERTING AMPLIFIER U170 ◇1

- CURRENT SOURCE U175 Q175 ◇1

MULTIPLIER SWITCH ◇3

SQUARE WAVE CURRENT SWITCH CR260 CR264 CR262 CR266 ◇1

FUNCTION SWITCH ◇3

TRIGGER AMPLIFIER Q268 ◇1

J285 TRIG OUT

OFFSET

R475

S475

R465 AMPLITUDE

OUTPUT AMPLIFIER Q480 Q506 Q532 Q490 Q515 Q540 Q500 Q530 Q542 ◇3

J555 OUTPUT

POWER SUPPLY ◇4

CR600 U615	Q620 Q622	+20 VOLTS
U635	Q635	+17 VOLTS
U650	Q650	-17 VOLTS
CR680 U664	Q660 Q662	-20 VOLTS

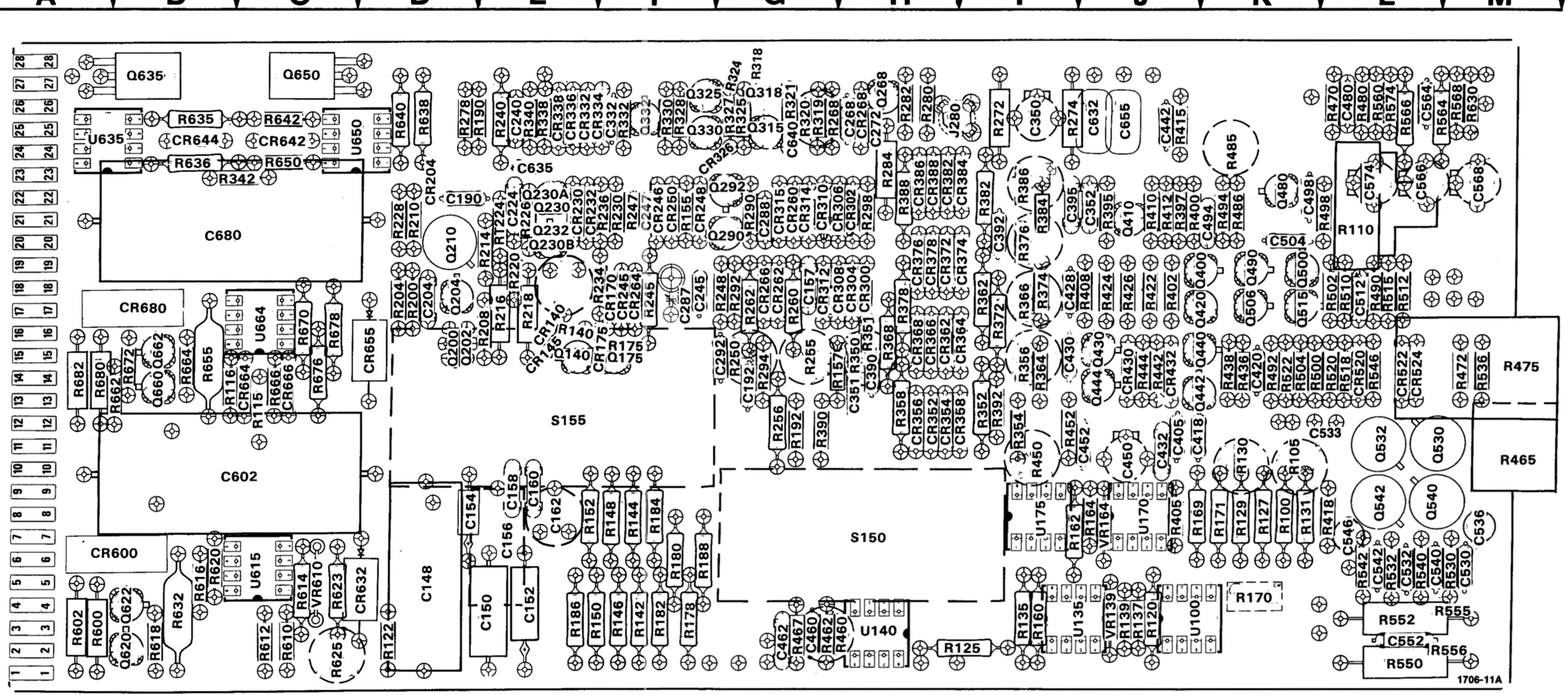
POWER

FG 502

1706-13
REV A MAY 1980

Block Diagram

FG 502



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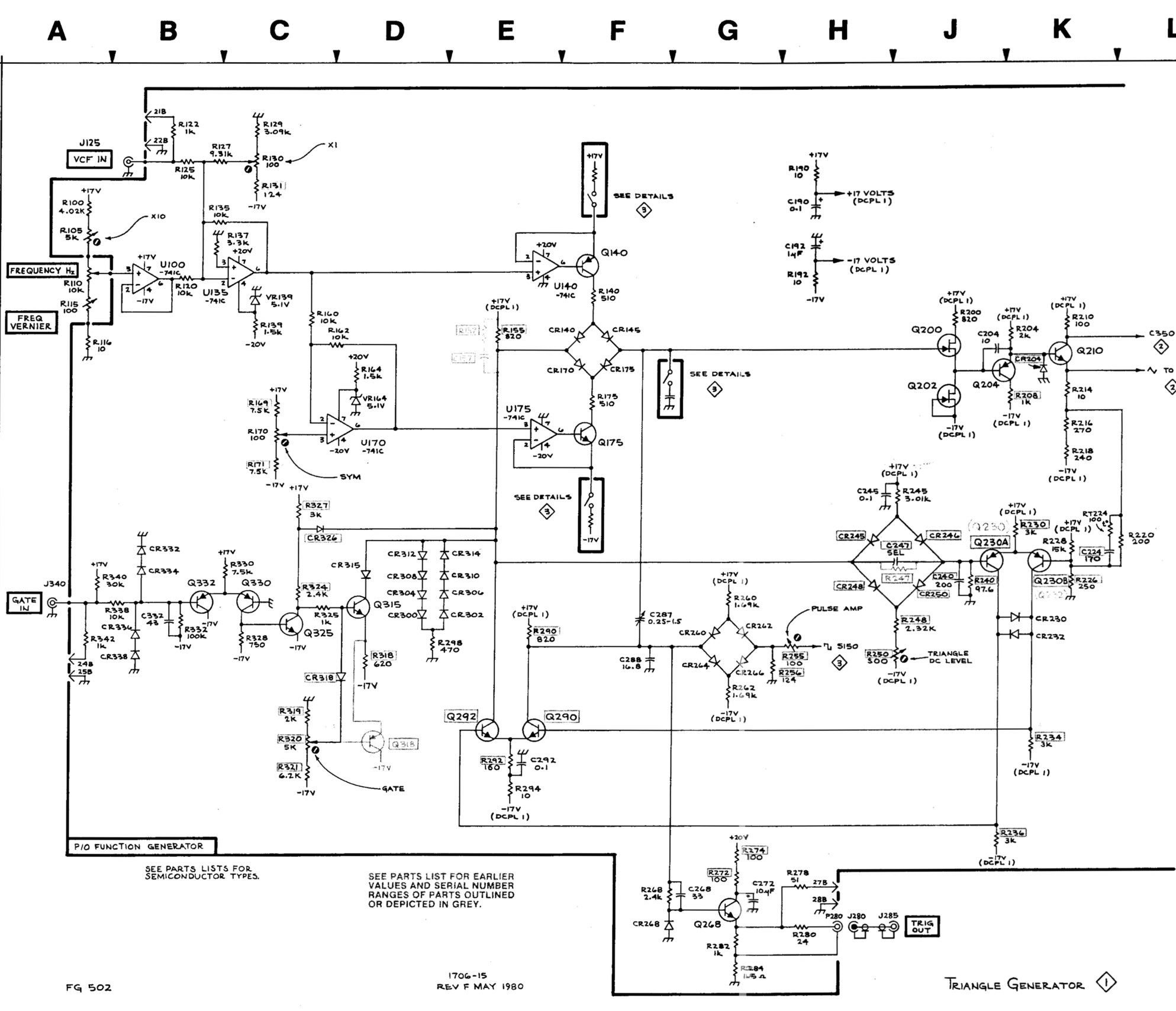
P/O A1 ASSY

Triangle Generator ◇1

Circuit Number	Schematic Location	Board Location
C157*	E3	G3
C190	H2	D2
C192	H2	G4
C204	J3	D3
C224	K5	E2
C240	J5	E1
C245	H4	F3
C247*	J5	F2
C268	G8	H1
C272	G8	H2
C287	F5	F3
C288	F6	G2
C292	E7	G3
C332	B5	F1
CR140	F3	E3
CR145	F3	E3
CR170	F3	F3
CR175	F3	F3
CR204*	K3	D2
CR230	K6	E2
CR232	K6	F2
CR245	H5	F3
CR246	J5	F2
CR248	H5	F2
CR250	J5	F2
CR260	G6	G2
CR262	G6	G3
CR264	G6	F3
CR266	G6	G3
CR268	F8	H1
CR300	D5	H3
CR302	E5	H2
CR304	D5	H3
CR306	E5	H2
CR308	D5	H3
CR310	E5	G2
CR312	D5	G3
CR314	E5	G2
CR315	D5	G2
CR318*†	C6	G1
CR326*†	C5	G2
CR332	B5	F1
CR334	B5	F1
CR336	B6	E1
CR338	B6	E1
J280	H8	I2
Q140	F2	F3
Q175	F4	F3
Q200	J3	D3
Q202	J3	D3
Q204	J3	D3
Q210	K3	D2
Q230*	J5	E2
Q230A*	J5	E2
Q230B*	K5	E2
Q232*	K5	E2
Q268	G8	H1
Q290	F6	G2
Q292	E6	G2
Q315	D5	G2
Q318*	D7	G1
Q325	C6	F1
Q330	C5	F1
Q332	B5	F1
R100	A2	K5
R105	A2	K4
R110	A3	L2
R115†	A3	C4
R116	A3	C4
R120	B3	J6
R122	B1	D6
R125	B1	I6
R127	B1	K5
R129	C1	K5
R130	C1	K4
R131	C2	K5
R135	B2	I6
R137	C2	J6
R139	C3	J6
R140	F3	E3
R155	E3	F2
R157*	E3	H4
R160	C3	I6
R162	D3	J5
R164	D3	J5
R169	C4	K5
R170	C4	K5
R171	C4	K5
R175	F4	F3
R190	H1	E1
R192	H2	G4
R200	J3	D3
R204	K3	D3
R208	K4	E3
R210	K3	D2
R214	K3	E3
R216	K4	E3
R218	K4	E3
R220	L5	E3
R226	K5	E2
R228	K5	D2
R230	K5	F2
R234	K7	F3
R236	K7	F2
R240	J5	E1
R245	J4	F3
R247*	J5	F2
R248	J6	G3
R250	H6	G3
R255	H6	G3
R256	H6	G4
R260	G5	G3
R262	G6	G3
R268	F8	H1
R272	G8	I1
R274	G8	J1
R278	H8	D1
R280	H8	H1
R282	G8	H1
R284	G9	H2
R290	E6	G2
R292	E7	G3
R294	E7	G4
R298	E6	H2
R318*†	D6	G1
R319	C6	G1
R320	C7	G1
R321	C7	G1
R324*†	C5	G1
R325	C5	G1
R327	C4	G1
R328	C6	F1
R330	C5	F1
R332	B6	F1
R338	B5	E1
R340	B5	E1
R342	A6	C2
RT224	K5	E2
U100	B2	K6
U135	B3	J6
U140	F3	H6
U170	D4	J5
U175	E4	I5
VR139	C3	J6
VR164	D4	J5
J125	A1	CHASSIS
J285	J8	CHASSIS
J340	A5	CHASSIS
P280	H8	CHASSIS

P/O A1 ASSY also shown on ◇2 ◇3 ◇4


J125
VCF IN
FREQUENCY Hz
FREQ VERNIER
X1
X10
SYM
GATE
J340
GATE IN
SEE DETAILS
PULSE AMP
TRIANGLE DC LEVEL
TO 5150
C350
TO 5150
TRIG OUT
J280
J285
P280
P/O FUNCTION GENERATOR
SEE PARTS LISTS FOR SEMICONDUCTOR TYPES.
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS OUTLINED OR DEPICTED IN GREY.
+17 VOLTS (DCPL 1)
-17 VOLTS (DCPL 1)
Q140
Q175
Q200
Q202
Q204
Q210
Q230A
Q230B
Q315
Q325
Q330
Q332
Q268
Q290
Q292
Q318
U100 -741C
U135 -741C
U140 -741C
U175 -741C
U170 -741C
VR139 5.1V
VR164 5.1V
CR140
CR145
CR170
CR175
CR245
CR246
CR248
CR250
CR260
CR262
CR264
CR266
CR230
CR232
CR326
CR332
CR334
CR336
CR338
CR312
CR314
CR308
CR310
CR304
CR306
CR300
CR302
CR315
CR318
C247 SEL
C287 0.25-1.5
C288 16.8
C292 0.1
C272 10pF
TRIANGLE GENERATOR
FG 502
1706-15
REV F MAY 1980

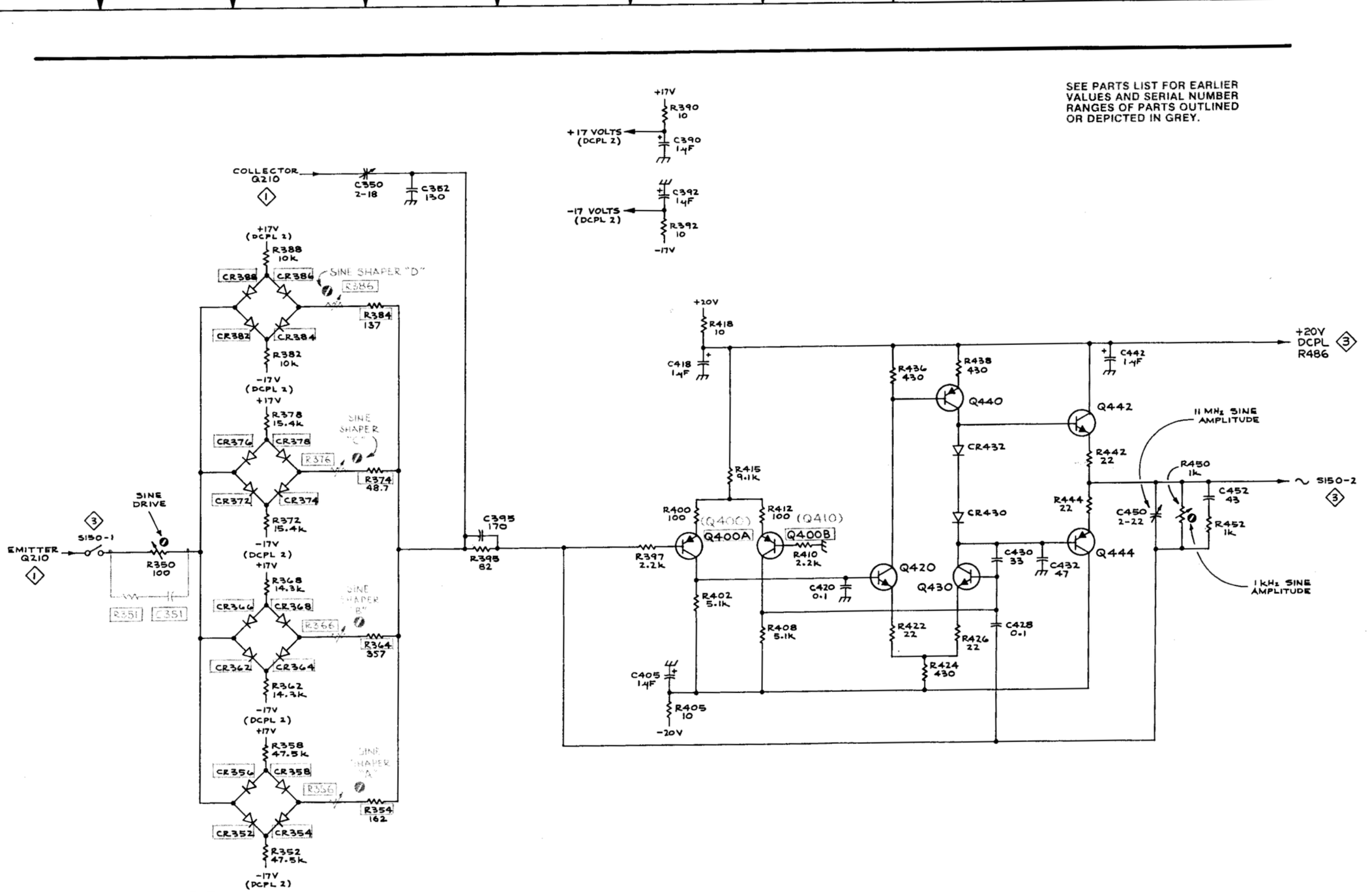
P/O A1 ASSY

Sine Shaper and Buffer 2

Circuit Number	Schematic Location	Board Location
C350	D2	I1
C351*	B5	H4
C352	D2	J2
C390	F2	H4
C392	F2	I2
C395	E4	J2
C405	F6	J4
C418	F3	K4
C420	G5	K4
C428	H5	J3
C430	H5	J3
C432	J5	J4
C442	J3	J2
C450	J4	J4
C452	K4	J4
CR352	C7	H4
CR354	C7	I4
CR356	C6	H4
CR358	C6	I4
CR362	C5	I3
CR364	C5	I3
CR366	C5	H3
CR368	C5	H3
CR372	C4	I3
CR374	C4	I3
CR376	C4	H3
CR378	C4	H3
CR382	C3	I2
CR384	C3	I2
CR386	C3	H2
CR388	C3	H2
CR430	H4	J4
CR432	H4	J4
Q400	F5	K3
Q410	G4	J2
Q420	H5	K3
Q430	H5	J3
Q440	H4	K3
Q442	J4	K4
Q444	J5	J4

Circuit Number	Schematic Location	Board Location
R350	B5	H3
R351*	B5	H3
R352	C7	I4
R354	D7	I4
R356*	C6	I4
R358	C6	H4
R362	C6	I3
R364	D5	I4
R366*	C5	I3
R368	C5	H3
R372	C4	I3
R374	D4	I3
R376*	C4	I2
R378	C4	H3
R382	C3	I2
R384	D3	I2
R386*	C3	I2
R388	C2	H2
R390	F1	G4
R392	F2	I4
R395	D5	J2
R397	F5	J2
R400	F4	K2
R402	F5	J3
R405	F6	J5
R408	G5	J3
R410	G5	J2
R412	G4	J2
R415	F4	J2
R418	F3	L5
R422	H5	J3
R424	H6	J3
R426	H5	J3
R436	H3	K4
R438	H3	K4
R442	J4	J4
R444	J4	J4
R450	K4	I4
R452	K4	J4
S150	A5	H5

P/O A1 ASSY also shown on 1 3 4



P/O FUNCTION GENERATOR

FG 502

1706-16
REV E MAY 1980

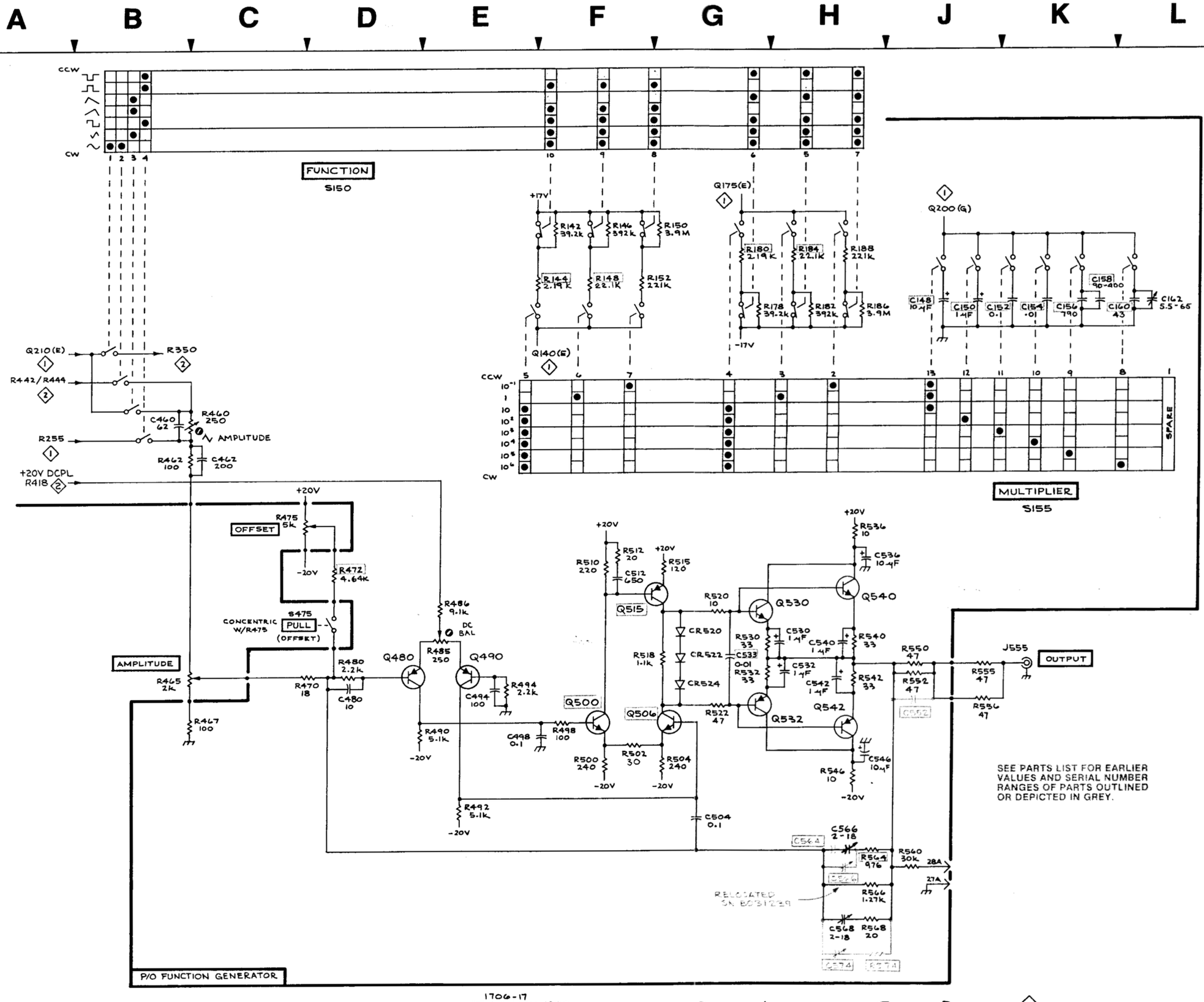
SINE SHAPER AND BUFFER 2

P/O A1 ASSY

Output Amplifier & Switch Details ◇3

Circuit Number	Schematic Location	Board Location
C148†	J3	D5
C150	J3	E6
C152	J3	E5
C154	K3	E5
C156†	K3	E5
C158*	K3	E5
C160	L3	E5
C162	L3	E5
C460	B4	G6
C462	C4	B6
C480	D6	K2
C494	E6	K2
C498	E6	K2
C504	G7	K3
C512	F5	L3
C530	H6	M5
C532	H6	L5
C533*	G6	L4
C536	J5	M5
C540	H6	M5
C542	H6	L5
C546	H7	L5
C552*	J6	L6
C564*	H7	L1
C566	H7	L2
C568	H8	M2
C574*	H8	L2
CR520	G6	L4
CR522	G6	L4
CR524	G6	L4
Q480	D6	K2
Q490	E6	K3
Q500	F6	K3
Q506	F6	K3
Q515	F5	K3
Q530	H5	M4
Q532	H6	L4
Q540	H5	M5
Q542	H6	L5
R142	F2	F6
R144	F3	F5
R146	F2	F6
R148	F3	F5
R150	G2	F6
R152	G3	F5
R178	H3	F6
R180	G2	F5
R182	H3	F6
R184	H2	F5
R186	H3	E6
R188	H2	G5
R460	C4	H6
R462	B4	H6
R465	B6	M4
R467	C6	G6
R470	D6	L1
R472	D5	M4
R475	C5	M4
R480	D6	L1
R485	E6	K2
R486	E5	K2
R490	E6	L3
R492	E7	K4
R494	E6	K2
R498	F6	L2
R500	F7	L4
R502	F7	L3
R504	G7	K4
R510	F5	L3
R512	F5	L3
R515	G5	L3
R518	F6	L4
R520	G5	L4
R522	G6	K4
R530	G6	M5
R532	G6	L5
R536	H5	M4
R540	H6	L5
R542	H6	L5
R546	H7	L4
R550	J6	L6
R552	J6	L6
R555	J6	M6
R556	J6	M6
R560	J7	L1
R564	H8	M1
R566	H8	L1
R568	H8	M1
R574*	H8	L1
S155	K5	E4
J555	K6	CHASSIS
S475	C5	CHASSIS

P/O A1 ASSY also shown on ◇1 ◇2 ◇4



1706-17
REV G MAY 1980

FG 502

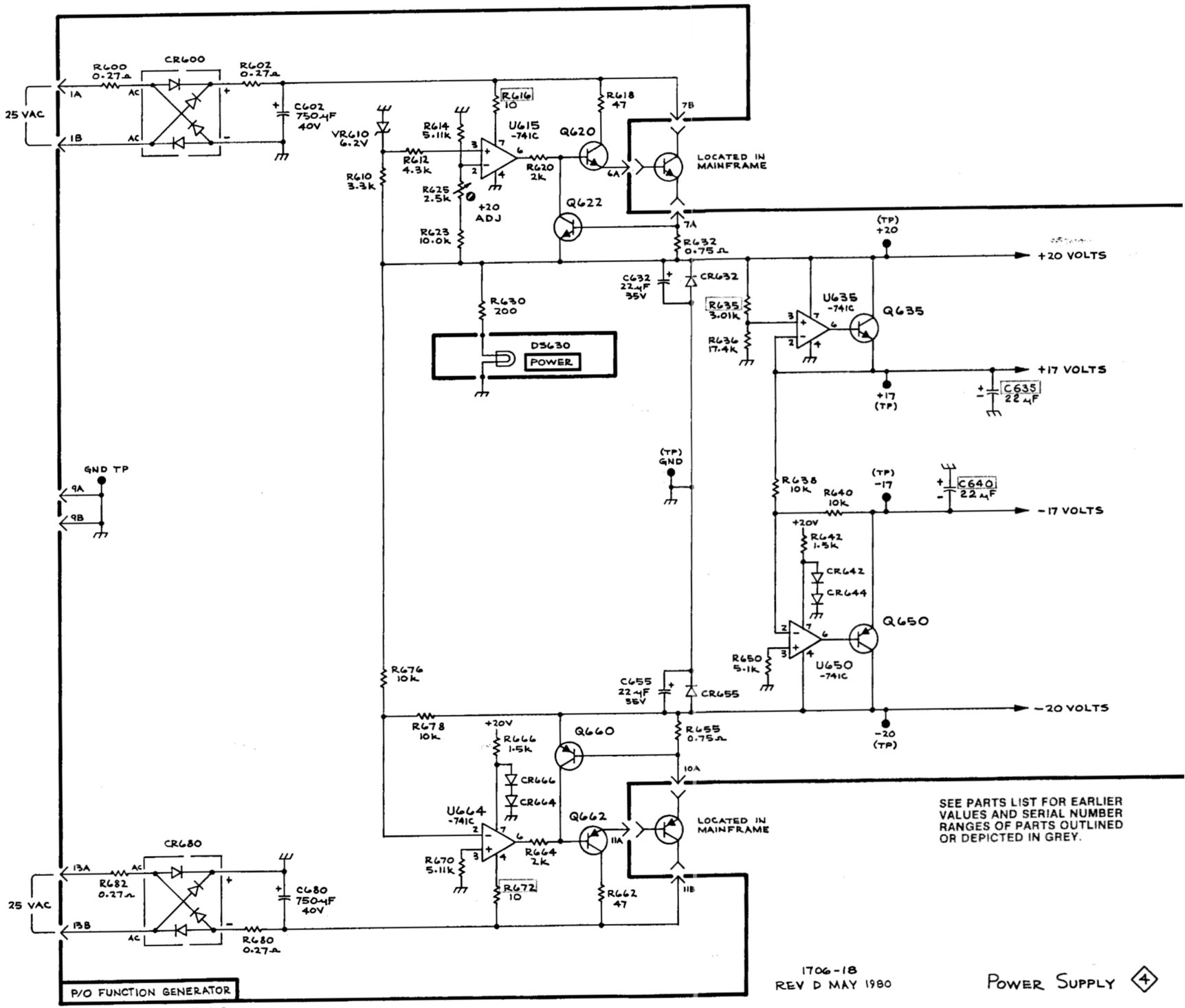
OUTPUT AMPLIFIER AND SWITCH DETAILS ③

P/O A1 ASSY

Power Supply 4

Circuit Number	Schematic Location	Board Location
C602	D2	C4
C632	F3	J1
C635*	J4	E2
C640*	J5	G2
C655	F6	J1
C680	D7	B2
CR600	C1	B5
CR632	G3	D5
CR642	H5	C2
CR644	H5	B2
CR655	G6	D3
CR664	F7	C4
CR666	F7	C4
CR680	C7	B3
Q620	F2	B6
Q622	F3	B5
Q635	H3	B1
Q650	H6	C1
Q660	F6	B4
Q662	F7	B3
R600	C1	A6
R602	D1	A6
R610	E2	C6
R612	E2	C6
R614	E2	C5
R616	F2	B5
R618	F2	B6
R620	F2	B5
R623	E3	C5
R625	E2	C6
R630	F3	M1
R632	G3	B5
R635	G3	B1
R636	G3	B2
R638	H5	D1
R640	H5	D1
R642	H5	C1
R650	G6	C2
R655	G6	B3
R662	F7	B4
R664	F7	B3
R666	F6	C4
R670	E7	C3
R672	F7	B3
R676	E6	C4
R678	E6	C3
R680	D8	A4
R682	C7	A4
U615	F2	C5
U635	H3	B2
U650	H6	D2
U664	E7	C3
VR610	D2	C5
DS630	F4	CHASSIS

P/O A1 ASSY also shown on 1 2 3


25 VAC
1A
1B
AC
CR600
R600 0.27Ω
R602 0.27Ω
C602 750μF 40V
VR610 6.2V
R610 3.3k
R612 4.3k
R614 5.11k
R616 10
R618 47
U615 -741C
Q620
Q622
R620 2k
R625 2.5k
+20 ADJ
R623 10.0k
7B
6A
7A
LOCATED IN MAINFRAME
R632 0.75Ω
(TP) +20
+20 VOLTS
C632 22μF 35V
CR632
R630 200
DS630 POWER
R635 3.01k
R636 17.4k
U635 -741C
Q635
+17 VOLTS
+17 (TP)
C635 22μF
GND TP
9A
9B
(TP) GND
R638 10k
R640 10k
(TP) -17
C640 22μF
-17 VOLTS
+20V
R642 1.5k
CR642
CR644
Q650
R650 5.1k
U650 -741C
R676 10k
C655 22μF 35V
CR655
-20 VOLTS
-20 (TP)
R678 10k
R666 1.5k
Q660
R655 0.75Ω
10A
CR666
CR664
U664 -741C
Q662
LOCATED IN MAINFRAME
R664 2k
R670 5.11k
R672 10
R662 47
11A
11B
CR680
13A
13B
R682 0.27Ω
R680 0.27Ω
C680 750μF 40V
P/O FUNCTION GENERATOR
SEE PARTS LIST FOR SEMICONDUCTOR TYPES.
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS OUTLINED OR DEPICTED IN GREY.
1706-18
REV D MAY 1980
FG 502
POWER SUPPLY 4

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

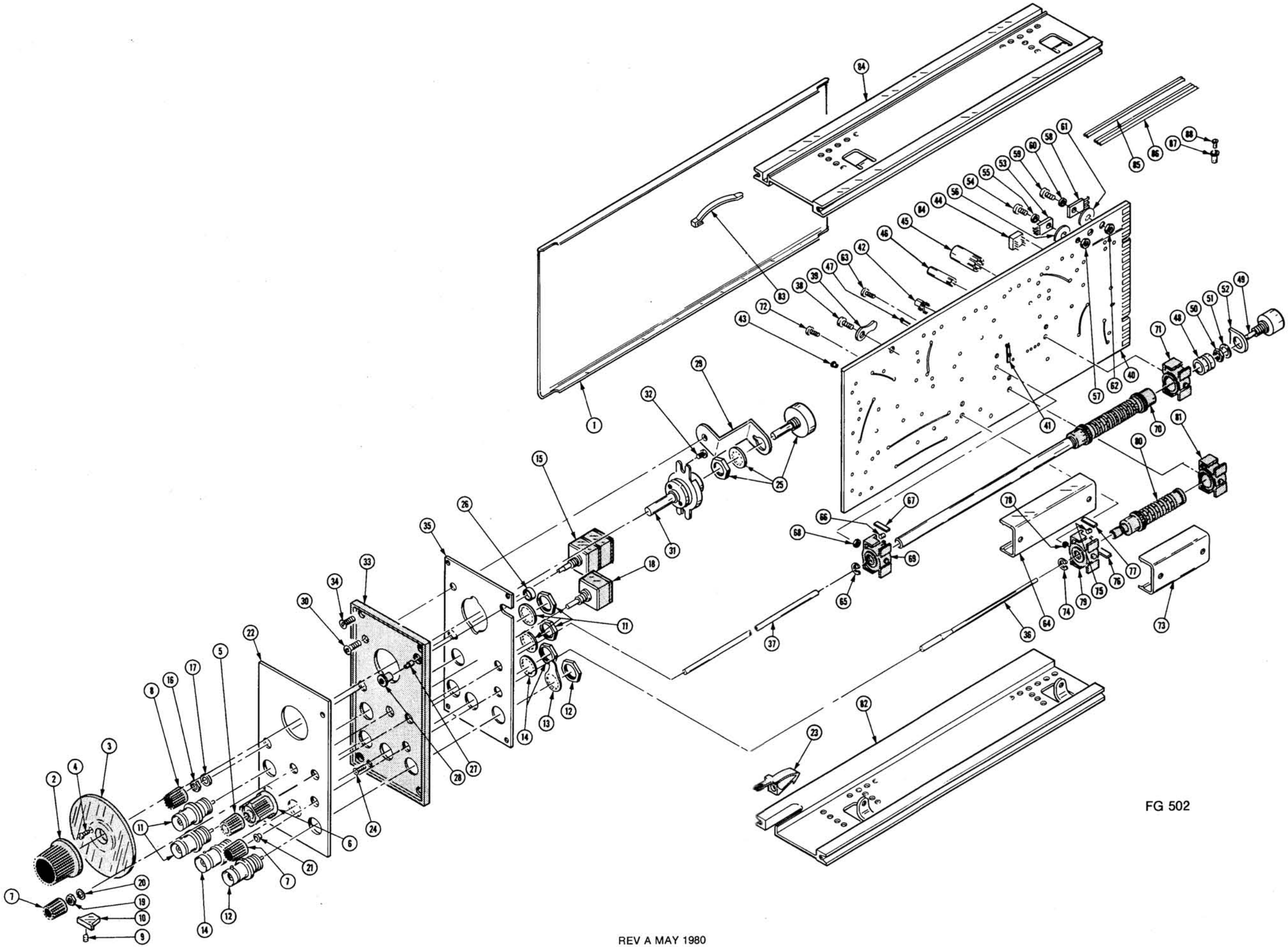
CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
K0099	JACKSON BROS (LONDON) LTD.	258 BROADWAY	NEW YORK, NEW YORK 10007
000BK	STAUFFER SUPPLY	105 SE TAYLOR	PORTLAND, OR 97214
000CY	NORTHWEST FASTENER SALES, INC.	7923 SW CIRRUS DRIVE	BEAVERTON, OR 97005
08928	ABBOTT SCREW AND MFG. COMPANY	6525 NORTH CLARK	CHICAGO, IL 60626
22526	BERG ELECTRONICS, INC.	YOUK EXPRESSWAY	NEW CUMBERLAND, PA 17070
28520	HEYMAN MFG. CO.	147 N. MICHIGAN AVE.	KENILWORTH, NJ 07033
45722	USM CORP., PARKER-KALON FASTENER DIV.		CAMPBELLSVILLE, KY 42718
70276	ALLEN MFG. CO.	P. O. DRAWER 570	HARTFORD, CT 06101
73743	FISCHER SPECIAL MFG. CO.	446 MORGAN ST.	CINCINNATI, OH 45206
73803	TEXAS INSTRUMENTS, INC., METALLURGICAL MATERIALS DIV.	34 FOREST STREET	ATTLEBORO, MA 02703
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
78471	TILLEY MFG. CO.	900 INDUSTRIAL RD.	SAN CARLOS, CA 94070
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
86928	SEASTROM MFG. COMPANY, INC.	701 SONORA AVENUE	GLENDALE, CA 91201
93907	TEXTRON INC. CAMCAR DIV	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. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
1-1	337-1399-00			2		SHLD,ELECTRICAL:SIDE	80009	337-1399-00
-2	366-1007-01			1		KNOB:GRAY	80009	366-1007-01
	213-0153-00			2		. SETSCREW:5-40 X 0.125,STL BK OXD,HEX SKT	000CY	OBD
-3	354-0437-03			1		RING,KNOB SKIRT:0.375 ID X 2.26"OD PLASTIC	80009	354-0437-03
						(ATTACHING PARTS)		
-4	211-0088-00			2		SCREW,MACHINE:2-56 X 0.281"82 DEG,FLH STL	77250	OBD
	210-0978-00			1		WASHER,FLAT:0.375 ID X 0.50 INCH OD,STL	78471	OBD
						- - - * - - -		
-5	366-1031-03			1		KNOB:RED--CAL	80009	366-1031-03
	213-0153-00			1		. SETSCREW:5-40 X 0.125,STL BK OXD,HEX SKT	000CY	OBD
-6	366-1170-01			1		KNOB:GRAY,4 SIDED	80009	366-1170-01
	213-0153-00			2		. SETSCREW:5-40 X 0.125,STL BK OXD,HEX SKT	000CY	OBD
-7	366-0494-00			2		KNOB:GRAY WITH SETSCREW	80009	366-0494-00
	213-0153-00			1		. SETSCREW:5-40 X 0.125,STL BK OXD,HEX SKT	000CY	OBD
-8	366-1023-03			1		KNOB:GRAY--PULL	80009	366-1023-03
	213-0153-00			1		. SETSCREW:5-40 X 0.125,STL BK OXD,HEX SKT	000CY	OBD
-9	214-1840-00	B010100	B034499X	1		PIN,KNOB SECRG:0.094 OD X 0.120 INCH LONG	80009	214-1840-00
-10	366-1422-01	B010100	B034499	1		KNOB:LATCH	80009	366-1422-01
	366-1690-00	B034500		1		KNOB:SIL GY,0.53 X0.23 X 1.059	80009	366-1690-00
-11	----- -----			2		CONNECTOR,RCPT,:(SEE J125,J340 REPL)		
-12	----- -----			1		CONNECTOR,RCPT,:(SEE J555 REPL)		
						(ATTACHING PARTS)		
-13	210-0255-00			1		TERMINAL,LUG:0.391" ID INT TOOTH	80009	210-0255-00
						- - - * - - -		
-14	----- -----			1		CONNECTOR,RCPT,:(SEE J285 REPL)		
-15	----- -----			1		RESISTOR,VAR:(SEE R475/S475 REPL)		
						(ATTACHING PARTS)		
-16	210-0583-00			1		NUT,PLAIN,HEX.:0.25-32 X 0.312 INCH,BRS	73743	2X20317-402
-17	210-0940-00			1		WASHER,FLAT:0.25 ID X 0.375 INCH OD,STL	79807	OBD
						- - - * - - -		
-18	----- -----			1		RESISTOR,VAR:(SEE R465 REPL)		
						(ATTACHING PARTS)		
-19	210-0583-00			1		NUT,PLAIN,HEX.:0.25-32 X 0.312 INCH,BRS	73743	2X20317-402
-20	210-0940-00			1		WASHER,FLAT:0.25 ID X 0.375 INCH OD,STL	79807	OBD
						- - - * - - -		
-21	358-0378-00	B010100	B035989	1		BUSHING,SLEEVE:PRESS MOUNT	80009	358-0378-00
	358-0599-00	B035990		1		BUSHING,SLEEVE:0.125 ID X 0.234 THK,PLSTC	28520	B-187-125
-22	333-1729-00			1		PANEL,FRONT:	80009	333-1729-00
-23	214-1513-01	B010100	B034499	1		LCH,PLUG-IN RET:	80009	214-1513-01
	105-0719-00	B034500		1		LATCH,RETAINING:PLUG-IN	80009	105-0719-00
						(ATTACHING PARTS)		
-24	213-0254-00			1		SCREW,TPG,TF:2-32 X 0.250,100 DEG,FLH	45722	OBD
						- - - * - - -		
	105-0718-00	XB034500	B036109	1		BAR,LATCH RLSE:	80009	105-0718-00
	105-0718-01	B036110		1		BAR,LATCH RLSE:	80009	105-0718-01
-25	----- -----			1		RESISTOR,VAR:W/HARDWARE(SEE R110 REPL)		
-26	200-0935-00			1		BASE,LAMPHOLDER:0.29 OD X 0.19 CASE	80009	200-0935-00
-27	378-0602-00			1		LENS,LIGHT:GREEN	80009	378-0602-00
-28	352-0157-00			1		LAMPHOLDER:WHITE PLASTIC	80009	352-0157-00
-29	407-1274-00			1		BRACKET,VAR RES:ALUMINUM	80009	407-1274-00
						(ATTACHING PARTS)		
-30	211-0559-00			1		SCREW,MACHINE:6-32 X 0.375"100 DEG,FLH STL	83385	OBD
						- - - * - - -		
-31	401-0161-00			1		DRIVE,TURNS,RED:6 1 REDUCTION	K0099	4511/DAF
	213-0020-00			2		SETSCREW:6-32 X 0.125 INCH,HEX.SOC STL	70276	OBD
						(ATTACHING PARTS FOR DR)		
-32	213-0138-00			2		SCR,TPG,TF:4-24 X 0.188 INCH,PNH STL	83385	OBD
						- - - * - - -		
-33	386-2555-00	B010100	B031699	1		SUBPANEL,FRONT:PLASTIC	80009	386-2555-00
	386-2555-01	B031700		1		SUBPANEL,FRONT:	80009	386-2555-01
						(ATTACHING PARTS)		
-34	213-0229-00	B010100	B036379	4		SCR,TPG,THD FOR:6-20 X0.375"100 DEG,FLH STL	93907	OBD
	213-0123-00	B036380		4		SCREW,TPG,TF:6-32 X 0.375,SPCL TYPE,FLH	93907	OBD
						- - - * - - -		
-35	337-1794-00			1		SHLD,ELECTRICAL:FRONT SUBPANEL	80009	337-1794-00
-36	384-0126-00			1		EXTENSION SHAFT:4.594 INCH O/A LENGTH	08928	A-3417

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
1-37	384-1258-00			1		EXTENSION SHAFT:0.125 DIA X 9.6 INCH LONG	80009	384-1258-00
	672-0067-00			1		CKT BOARD ASSY:FUNCTION AND FREQ DECADE	80009	672-0067-00
						(ATTACHING PARTS)		
-38	213-0146-00			4		SCR,TPG,THD FOR:6-20 X 0.313 INCH,PNH STL	83385	OBD
-39	210-0202-00			1		TERMINAL,LUG:0.146 ID,LOCKING,BRZ TINNED	78189	2104-06-00-2520N
						- - - * - - -		
	----- -----			-		. CKT BOARD ASSY W/CAM SWITCH INCLUDES:		
-40	----- -----			1		. CKT BOARD ASSY:--MAIN(SEE A1 REPL)		
	----- -----			-		. . CKT BOARD ASSY INCLUDES:		
-41	131-0604-00			23		. . CONTACT,ELEC:CKT BD SW,SPR,CU BE	80009	131-0604-00
-42	131-1003-00			1		. . CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
-43	136-0252-04			4		. . SOCKET,PIN TERM:U/W 0.016-0.018 DIA PINS	22526	75060-007
-44	136-0514-00			9		. . SKT,PL-IN ELEC:MICROCIRCUIT,8 DIP	73803	CS9002-8
-45	214-0269-00	B010100	B031238	5		. . HEAT SINK,XSTR:0.312 DIA X 0.75 L	98978	TXD-032-75
	214-0269-00	B031239		8		. . HEAT SINK,XSTR:0.312 DIA X 0.75 L	98978	TXD-032-75
-46	214-0693-00	B010100	B031238	7		. . HEAT SINK, ELEC:0.25 ID X 0.75 INCH LONG	98978	TXD017-075
	214-0693-00	B031239		4		. . HEAT SINK, ELEC:0.25 ID X 0.75 INCH LONG	98978	TXD017-075
-47	214-0579-00	B010100	B039999	6		. . TERM,TEST POINT:BRS CD PL	80009	214-0579-00
	214-0579-02	B040000		6		. . TERM,TEST POINT:BRASS	80009	214-0579-02
-48	376-0051-01			1		. . CPLG,SHAFT,FLEX:0.127 ID X 0.375 OD	80009	376-0051-01
	----- -----			-		. . . COUPLING INCLUDES:		
	354-0251-00			2		. . . RING,COUPLING:0.251 ID X 0.375 INCH OD,AL	80009	354-0251-00
-49	----- -----			1		. . RESISTOR,VARIABLE:(SEE R115 REPL)		
						(ATTACHING PARTS)		
-50	210-0583-00			1		. . NUT,PLAIN,HEX.:0.25-32 X 0.312 INCH,BRS	73743	2X20317-402
-51	210-0046-00			1		. . WASHER,LOCK:0.261 ID,INTL,0.018 THK,BRS	78189	1214-05-00-0541C
-52	407-0579-00			1		. . BRACKET,VAR RES:BRASS CD,PL	80009	407-0579-00
						- - - * - - -		
-53	----- -----			1		. . TRANSISTOR:(SEE Q650 REPL)		
						(ATTACHING PARTS)		
-54	211-0097-00			1		. . SCREW,MACHINE:4-40 X 0.312 INCH,PNH STL	83385	OBD
-55	210-1122-00			1		. . WASHER,LOCK:0.12 ID,DISHED,0.025 THK	86928	OBD
-56	210-0921-00			1		. . WASHER,MICA:0.50 X 0.141 X0.005 INCH THK	80009	210-0921-00
-57	210-0406-00			1		. . NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS	73743	2X12161-402
						- - - * - - -		
-58	----- -----			1		. . TRANSISTOR:(SEE Q635 REPL)		
						(ATTACHING PARTS)		
-59	211-0097-00			1		. . SCREW,MACHINE:4-40 X 0.312 INCH,PNH STL	83385	OBD
-60	210-1122-00			1		. . WASHER,LOCK:0.12 ID,DISHED,0.025 THK	86928	OBD
-61	210-0921-00			1		. . WASHER,MICA:0.50 X 0.141 X0.005 INCH THK	80009	210-0921-00
-62	210-0406-00			1		. . NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS	73743	2X12161-402
						- - - * - - -		
	263-1002-00			1		. SW CAM ACTR AS:--MULTIPLIER	80009	263-1002-00
						(ATTACHING PARTS)		
-63	211-0116-00	B010100	B049879	4		. SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS	83385	OBD
	211-0292-00	B049880		4		. SCR,ASSEM WSHR:4-40 X 0.29,BRS NI PL	78189	OBD
						- - - * - - -		
	----- -----			-		. . ACTUATOR ASSY INCLUDES:		
-64	200-1586-00			1		. . COVER,CAM SW:12 ELEMENTS	80009	200-1586-00
-65	354-0219-00			1		. . RING,RETAINING:FOR 0.25 INCH SHAFT	79136	5103-25-MD-R
-66	214-1127-00			2		. . ROLLER,DETENT:0.125 DIA X 0.125 INCH L	80009	214-1127-00
-67	214-1704-01			2		. . SPRING,FLAT:CAM SW DETENT,0.008 INCH THK	80009	214-1704-01
-68	210-0406-00			4		. . NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS	73743	2X12161-402
-69	401-0155-00			1		. . BEARING,CAM SW:FRONT	80009	401-0155-00
-70	105-0493-00			1		. . ACTUATOR,CAM SW:FREQ/DECADE	80009	105-0493-00
-71	401-0156-00			1		. . BEARING,CAM SW:REAR	80009	401-0156-00
	263-1001-00			1		. SW CAM ACTR AS:--FUNCTION	80009	263-1001-00
						(ATTACHING PARTS)		
-72	211-0116-00	B010100	B049879	4		. SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS	83385	OBD
	211-0292-00	B049880		4		. SCR,ASSEM WSHR:4-40 X 0.29,BRS NI PL	78189	OBD
						- - - * - - -		
	----- -----			-		. . ACTUATOR ASSY INCLUDES:		
-73	200-1631-00			1		. . COVER,CAM SW:9 ELEMENTS	80009	200-1631-00
-74	354-0219-00			1		. . RING,RETAINING:FOR 0.25 INCH SHAFT	79136	5103-25-MD-R
-75	214-1127-00			2		. . ROLLER,DETENT:0.125 DIA X 0.125 INCH L	80009	214-1127-00
-76	214-1704-00			1		. . SPRING,FLAT:CAM SW DETENT,0.006 INCH THK	80009	214-1704-00
-77	214-1704-01			1		. . SPRING,FLAT:CAM SW DETENT,0.008 INCH THK	80009	214-1704-01
-78	210-0406-00			4		. . NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS	73743	2X12161-402
-79	401-0155-00			1		. . BEARING,CAM SW:FRONT	80009	401-0155-00

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
1-80	105-0494-00			1		. . ACTUATOR,CAM SW:FUNCTION	80009	105-0494-00
-81	401-0156-00			1		. . BEARING,CAM SW:REAR	80009	401-0156-00
	213-0075-00			2		. . SETSCREW:4-40 X 0.094,STL BK OXD,HEX SKT	000BK	OBD
	386-3657-00	XB034500	B036661	2		SUPPORT,PLUG-IN:	80009	386-3657-00
	386-3657-01	B036662		2		SUPPORT,PLUG IN:	93907	OBD
	210-1270-00	XB034500		2		WASHER,FLAT:0.141 ID X 0.04 THK,AL	80009	210-1270-00
-82	426-0724-04			1		FR SECT,PLUG-IN:BOTTOM	80009	426-0724-04
-83	214-1061-00			1		SPRING,GROUND:FLAT	80009	214-1061-00
-84	426-0725-05			1		FR SECT,PLUG-IN:TOP	80009	426-0725-05
-85	175-0825-00			AR		WIRE,ELECTRICAL:2 WIRE RIBBON	80009	175-0825-00
-86	175-0826-00			AR		WIRE,ELECTRICAL:3 WIRE RIBBON	80009	175-0826-00
-87	210-0774-00			1		EYELET,METALLIC:0.152 OD X 0.245 INCH L,BRS	80009	210-0774-00
-88	210-0775-00			1		EYELET,METALLIC:0.126 OD X 0.23 INCH L,BRS	80009	210-0775-00



FG 502

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
						ACCESSORIES		
	070-1706-01			1		MANUAL,TECH:SERVICE	80009	070-1706-01

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.

MANUAL CHANGE INFORMATION

Tektronix® COMMITTED TO EXCELLENCE

Date: 8-25-81 Change Reference: M42128/C10881

Product: FG 502 FUNCTION GENERATOR Manual Part No.: 070-1706-01

DESCRIPTION

EFF SN B050500 (M42128)

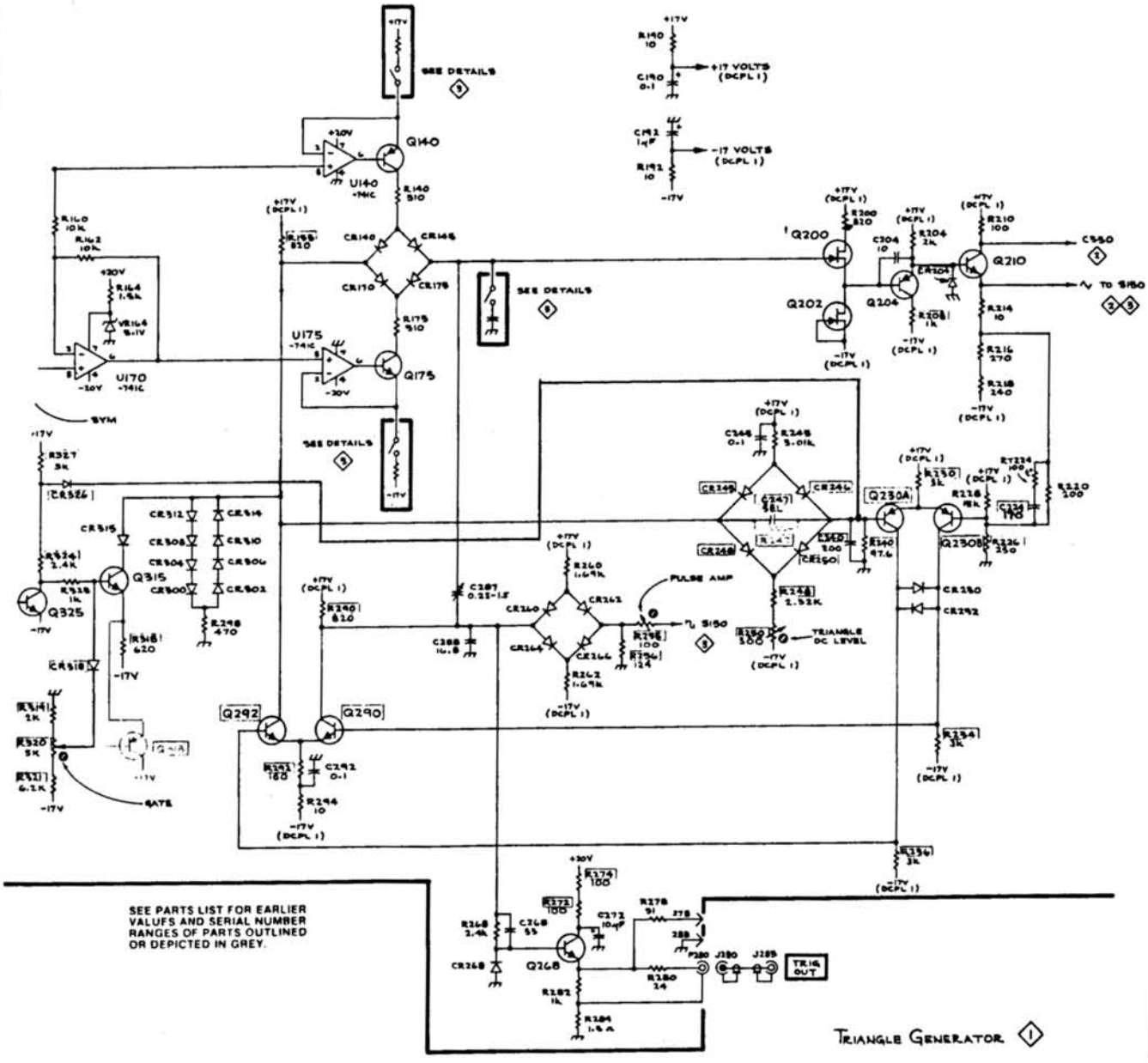
REPLACEABLE ELECTRICAL PARTS CHANGES

CHANGE TO:

Q210 151-0451-00 TRANSISTOR:SILICON,NPN,2N5943 (M42128)

(C10/881) DIAGRAM ◇1◇ TRIANGLE GENERATOR- Partial

(Cathode of CR326 should connect to C240 and R240 as shown below.)



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MANUAL CHANGE INFORMATION

Date: 8-25-81 Change Reference: M43938

Product: FG 502 FUNCTION GENERATOR Manual Part No.: 070-1706-01

DESCRIPTION

EFF SN B050740

REPLACEABLE ELECTRICAL PARTS AND SCHEMATIC CHANGES

CHANGE TO:

R125	321-0632-00	RES.,FXD,FILM:9.41K OHM,0.5%,0.125W

R125 is located on the FUNCTION GENERATOR and is shown on diagram 1 TRIANGLE GENERATOR.