TEKTRONIX®

SG 503

LEVELED SINE WAVE GENERATOR

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97005

Serial Number _____

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WARRANTY

All TEKTRONIX instruments are warranted against defective materials and workmanship for one year. Any questions with respect to the warranty should be taken up with your TEKTRONIX Field Engineer or representative.

All requests for repairs and replacement parts should be directed to the TEKTRONIX Field Office or representative in your area. This will assure you the fastest possible service. Please include the instrument Type Number or Part Number and Serial Number with all requests for parts or service.

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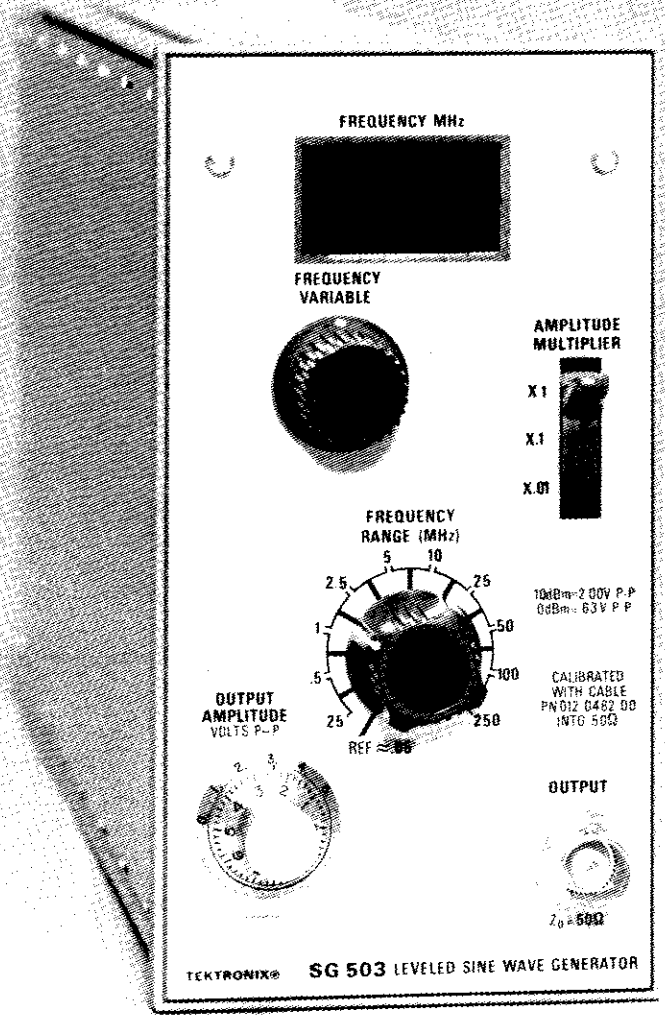

FREQUENCY MHz
FREQUENCY VARIABLE
AMPLITUDE MULTIPLIER
X 1
X.1
X.01
FREQUENCY RANGE (MHz)
5
10
2.5
25
1
50
.5
100
25
250
REF
10dBm=2.00V P-P
0dBm=.63V P-P
CALIBRATED WITH CABLE PN 012-0482-00 INTG 50Ω
OUTPUT AMPLITUDE VOLTS P-P
OUTPUT
TEKTRONIX®
SG 503 LEVELED SINE WAVE GENERATOR

OPERATING INSTRUCTIONS

INTRODUCTION

Description

The SG 503 Leveled Sine-Wave Generator provides a regulated, constant-amplitude versus frequency output into a 50 ohm load. The SG 503 is primarily intended to be used as an oscilloscope calibration device for measuring bandwidths up to 250 MHz. The SG 503 can also be used as a signal source for general electronics design and development.

Nine overlapping ranges cover the frequency band from 250 kHz to 250 MHz, with an additional range reserved for a 50 kHz reference frequency.

A digital counter with automatic ranging and a front panel LED readout is used for frequency indication.

Installation and Removal

The SG 503 is calibrated and ready for use as received. Referring to Fig. 1-1, install the SG 503 and turn on the Power Module.

CAUTION

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

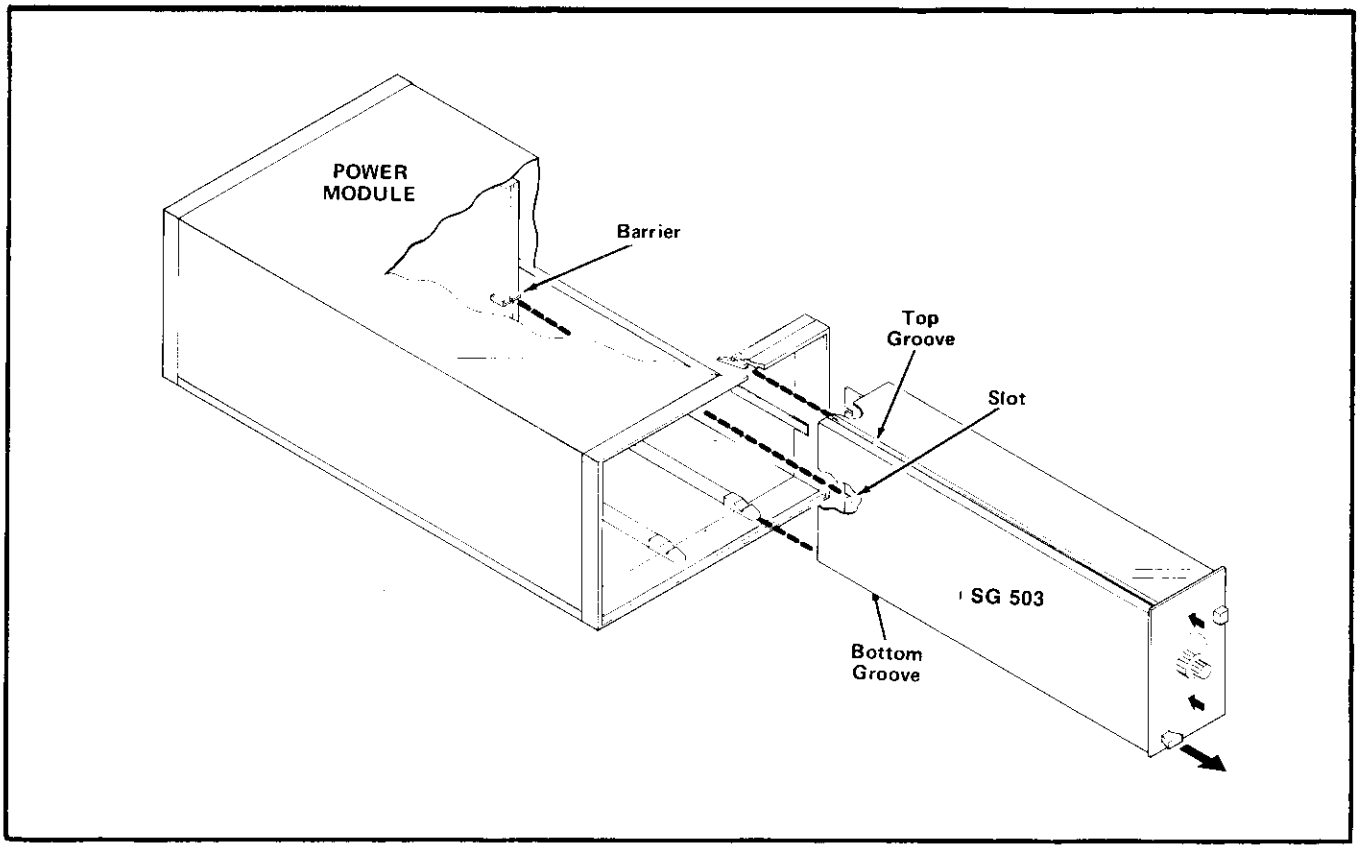


Fig. 1-1. Plug-in Installation and Removal.

Power application to the SG 503 is indicated by the three-digit LED display being lighted. Turn the FREQUENCY RANGE (MHz) control between the detent positions to test the LED's (888 display). Reset the FREQUENCY RANGE (MHz) control to the desired range. Allow 15 to 20 minutes warmup time for all equipment before using the SG 503.

To remove the SG 503, pull the release latch to disengage the plug-in from the Power Module and pull straight out.

Refer to the foldout pages for a description of front panel CONTROLS & CONNECTORS and REAR CONNECTOR PIN ASSIGNMENTS.

OPERATING CONSIDERATIONS

Introduction

The SG 503 has been designed and calibrated with a high quality coaxial cable (PN 012-0482-00) to operate as a closely matched system when terminated into a 50 ohm load. See Fig. 1-2A. The absolute amplitude across the load is directly related to its impedance. PN 012-0482-00 should be connected directly to the equipment under test if the input impedance of the equipment is 50 ohms. For equipment with an input impedance much greater than 50 ohms, an accurate 50 ohm feed-through terminator should be connected between the coaxial cable and the equipment. Any additional length of coaxial cable, T-connectors or wire of any type between the 50 ohm feed-through termination and the equipment being tested will produce some variation in the calibrated output amplitude at higher frequencies.

Coaxial cables of lesser quality or cables that are longer or shorter than PN 012-0482-00 can be used, but the output amplitude flatness specifications are no longer applicable. Cables that are 2 feet longer or 2 feet shorter than PN 012-0482-00 can cause amplitude variations that are as much as 4% low or 2% high (respectively) when compared to the calibrated amplitudes at 250 MHz.

Optimum performance is obtained when the setting of the OUTPUT AMPLITUDE control is in the 1.0 to 5.0 range. For example; when an output amplitude of 0.5 V p-p is desired, set OUTPUT AMPLITUDE control to 5.0 and AMPLITUDE MULTIPLIER switch to X.1 instead of 0.5 and X1.

The sine wave output from the SG 503 may be applied to an external dc level that does not exceed ±1 volt. At higher dc offset levels, couple the output through a dc blocking capacitor. When operating the SG 503 always consider the total load impedance and its effect on the output amplitude.

Open-Circuit Operation

When the SG 503 is operating into an impedance much greater than 50 ohms, up to twice the maximum terminated output amplitude can be obtained. Under open-circuit conditions, the actual output amplitude will be two times the amplitude indicated by the front panel controls.

Open-circuit amplitude flatness is not specified, but is adequate for many applications in the lower frequency bands because the steady state 50 ohm output impedance of the SG 503 reverse-terminates the characteristic impedance of a 50 ohm coaxial cable. The reverse termination keeps the output amplitude constant at the unterminated end of the cable even though standing waves may exist in the coaxial cable.

Capacitive Loads

The input capacitance of the equipment under test will affect the bandwidth. The equivalent circuits shown in Fig. 1-2B and Fig. 1-2C are useful in estimating the amplitude changes caused by reactive loads. Note that as system input capacitance increases, bandwidth decreases. The bandwidth of an oscilloscope with a high input impedance is usually specified using an equivalent 25 ohm source.

When operating the SG 503 on the higher frequency bands with no output attenuation, the front-panel display may flash, indicating an unleveled output amplitude. Switch the AMPLITUDE MULTIPLIER control to the X.1 position and if the display flashing ceases, the problem may be related to an extreme mismatch between the SG 503 and the load. If the SG 503 is operating into a high SWR, a 3 dB attenuator inserted between the output and the load may improve the operation at full output amplitude (X1 position of the AMPLITUDE MULTIPLIER switch).

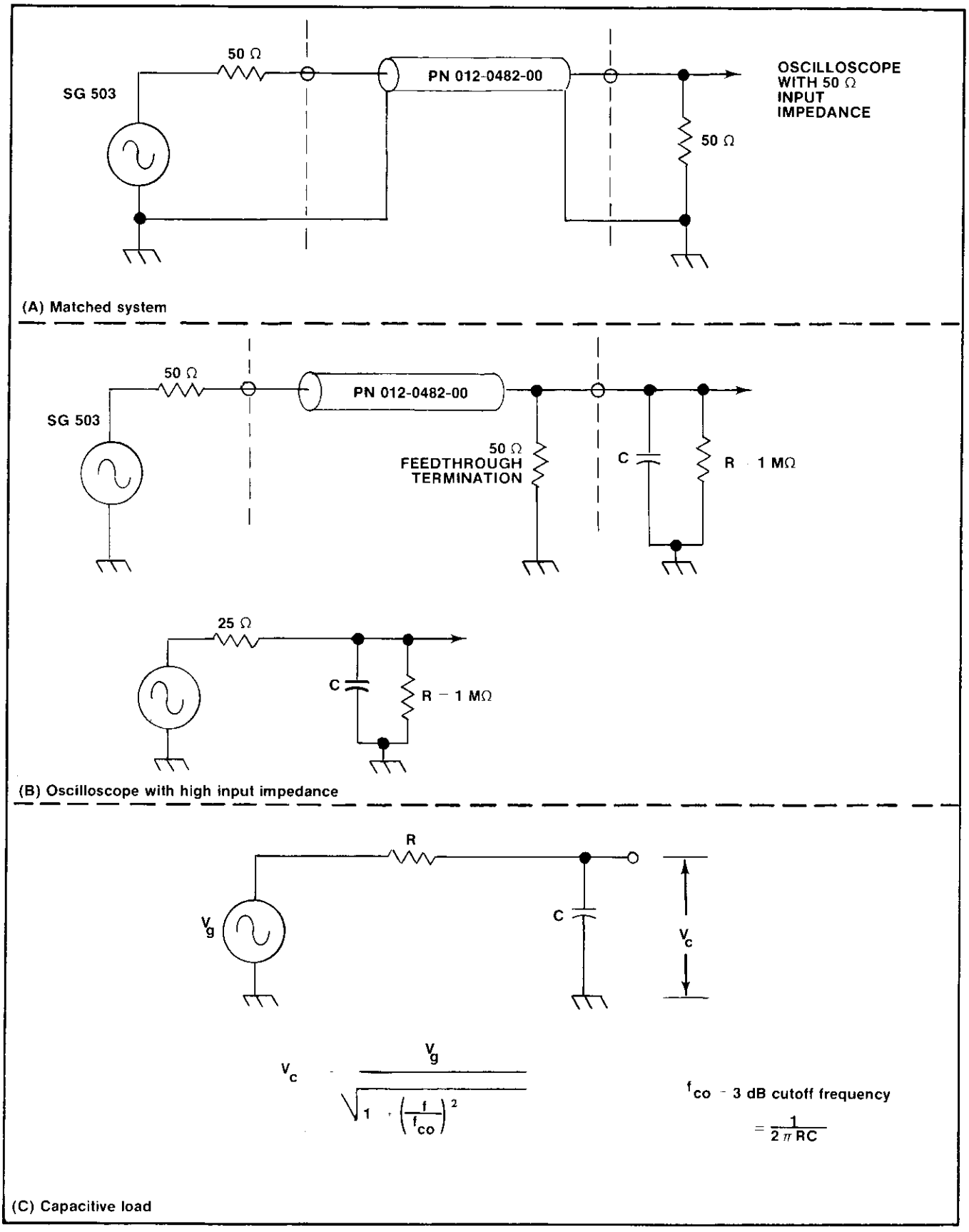


Fig. 1-2. Equivalent circuits for SG 503, 50 ohm coaxial cable and various terminations.

ELECTRICAL CHARACTERISTICS

Performance Conditions

The electrical performance is valid only if the SG 503 is calibrated at an ambient temperature between +20° C and +30° C and operated between 0° C and +50° C, unless otherwise noted. The SG 503 is internally calibrated for use with a furnished coaxial cable accessory (PN 012-0482-00) terminated into a 50 ohm load.

FREQUENCY

Range: 250 kHz to 250 MHz, plus 50 kHz reference frequency.

Accuracy: Within ±0.7 of one count of the least significant displayed digit for the indicated frequency.

AMPLITUDE

Range: 5 mV to 5.5 V peak-to-peak over three decade ranges and terminated into a 50 ohm load.

Accuracy: (At 50 kHz reference frequency.) Within 3% of indicated amplitude on X1 range, 4% on X.1 range, and 5% on X.01 range.

FLATNESS (Peak-to-Peak)

Referenced to NBS corrections of Tektronix standards. NBS uncertainties not included.

AMPLITUDE MULTIPLIER SETTINGS: X1, X.1, X.01

From 250 kHz to 50 MHz output amplitude will not vary more than 1% of the value at 50 kHz. From 100 MHz to 250 MHz amplitude variation is within 3% of the value at 50 kHz.

50 MHz to 100 MHz Range

AMPLITUDE MULTIPLIER SETTINGS: X1

Output amplitude will not vary more than 1% of the value at 50 kHz.

AMPLITUDE MULTIPLIER SETTINGS: X.1 and X.01

Output amplitude will not vary more than +1.5% and −1.0% of the value at 50 kHz.

HARMONIC CONTENT

Harmonic suppression relative to fundamental: Second harmonic at least 35 dB down. Third and all higher harmonics at least 40 dB down.

REMOTE LEVELING

Maximum safe voltage range: zero to −12 volts dc.

THEORY OF OPERATION

Introduction

Refer to the complete schematics and block diagram located in the pull-out pages at the back of this manual, as an aid in understanding the SG 503 theory of operation.

Oscillator Circuits ◇1◇4

Both oscillator sections, Q130 and Q140, are common-base Hartley configurations with inductive feedback (tapped coils for each frequency range). Amplitude control is accomplished by varying the dc emitter currents. Q300 operates as a variable current source, with its collector current controlled by the output of operational amplifier U280.

The oscillators operate in a non-linear mode (Class C) and the collector current for Q130 or Q140 is a series of pulses at the operating frequency. This series of pulses contain a large number of harmonics and a high Q parallel resonant tank circuit is required to obtain a good sine wave output. The tapped coils allow the highest possible operating Q factor at a given supply voltage and collector-base breakdown rating for the transistors. Spurious oscillations are reduced by the L/R combinations in the collector lead for each transistor.

For those coils that have tuning slugs, the slug position determines the inductance, coupling between windings (leakage inductance) and the Q factor for the oscillating circuit. All of the above factors combine to determine the frequency range, harmonic suppression and maximum available output amplitude.

Output Buffer Amplifier and Filter ◇1

Signals from the oscillator sections are applied via a 100 ohm strip line to the base of Q190. The output of Q190 feeds a low-pass filter which has a cut-off frequency of about 300 MHz.

Harmonic distortion is generated in the oscillator circuits and also in the Output Buffer Amplifier. At low frequencies, the Output Buffer Amplifier is practically ideal and contributes negligible distortion. However, at higher frequencies distortion increases and becomes more critically dependent on the collector current operating point for Q190. By choosing a frequency where the oscillator signal is fairly clean, most of the observed distortion will be due to the Output Buffer Amplifier. The collector current can then be set for minimum distortion by the adjustment of R175. Distortion is also somewhat dependent on the drive level to Q190. The final adjustment of R175 should result in minimum distortion over the full amplitude range from 0.5 V to 5.5 V, establishing a collector current operating point which falls in the 80 to 110 mA range.

Leveling Circuitry ◇1

The leveling circuitry is composed of a reference voltage divider, a hybrid peak-to-peak detector, temperature compensation diodes CR216-CR218, and error amplifier U280 with its associated components.

The major components of the hybrid peak-to-peak detector (U225) are diodes CR225A and CR225B with their associated storage capacitors, C225A and C225B, coupling capacitor C225C and output resistor R225A. The peak-to-peak detector produces a dc output across C225A and C225B that is approximately equal to the peak-to-peak voltage at the leveling point (junction of C225C and R225A).

To aid in understanding operation of the peak-to-peak detector, assume perfect diodes, 10 volts peak-to-peak at the leveling point and the reference voltage (set by R260) disconnected. C225A would charge by normal rectifier action to −5 V dc and C225B to +5 V dc. If the reference voltage level set by R260 is −10 V and now applied to C225A (series opposing) the dc levels on C225A, C225B and coupling capacitor C225C will shift by an amount equal to one half the peak-to-peak amplitude at the leveling point. There will now be zero volts dc across C225B, −10 V dc across C225A, and coupling capacitor C225C will be charged to −5 V dc. The sinewave at the junction of the two diodes is now centered at −5 V dc. For an actual complete circuit with non-ideal diodes, the potential difference between C225A and C225B is about equal to the peak-to-peak amplitude at the leveling point.

Because the reference voltage and the dc output of the peak-to-peak detector are connected series opposing, any algebraic difference between these two voltages will be applied to the input of the error amplifier U280. When the generator output is leveled, equal dc potentials (about −.7 V dc) exist at the − and − input terminals of U280 and the system is stabilized.

If the peak-to-peak output amplitude from an oscillator section changes for any reason, a corresponding change in detector output produces an error signal at the – input terminal of U280 which is converted into a collector current change in Q130 or Q140 in such a direction to restore the original peak-to-peak amplitude at the leveling point.

The high-gain leveling system (closed loop) establishes a steady state impedance point at the junction of C225C and R225A which approaches zero ohms. R225A, therefore, sets the generators output impedance and reverse terminates a 50 ohm coaxial cable.

CR200, CR202, VR200 and VR202 reduce transients which can be caused by sudden load changes, while R278, R276, CR276 and CR274 reduce switching transients when changing frequency ranges.

Display Flash Multivibrator ◇1◇

Q296 and Q290, with their associated components, is a multivibrator circuit that is held in a normally stable state as long as the sine-wave output amplitude is leveled. If the output is not leveled, pin 6 of U280 swings positive with respect to ground and turns on CR280. The multivibrator then operates as an astable circuit with a period of about 2 Hz. The waveform at the collector of Q290 is applied to pins 6 and 7 of U490 (State Generator). This signal causes binary zeros to be supplied to the Display Drivers, which turns off the display. The result is a visible flashing of the front panel LED display.

50 Ohm Wideband Attenuators ◇1◇

In the X1 position of the AMPLITUDE MULTIPLIER switch, the output signal bypasses the hybrid chip attenuators.

The hybrid chip attenuators (U245 and U240) are labeled on the circuit board as "X.1 & X.01" and "FIRST ÷ 10, X.01".

In the X.1 position of the AMPLITUDE MULTIPLIER switch, U245 divides the generators output by ten.

In the X.01 position of the AMPLITUDE MULTIPLIER switch, U240 divides the generators output by ten and then U245 divides again by ten for a total division of one hundred.

In the X.1 and X.01 positions of the AMPLITUDE MULTIPLIER switch, the 50 ohm attenuators provide additional isolation between the oscillators and a large mismatched load.

Auto-Ranging Counter ◇2◇◇3◇

The input circuit to the Auto-Ranging Counter is through emitter-follower Q320, which provides a low impedance single-ended drive to U350. U350 is a dual-differential amplifier that provides high gain in two stages. R335 and R342 are the constant-current sources for internal emitter connections and the output voltage on pins 6 and 7 start to limit at low input amplitudes. The emitter currents are set for about 8 mA, providing symmetrical output signal amplitudes of about 800 millivolts across R358 and R362. L362 is used to boost the high-frequency signal amplitudes to the prescaling circuitry.

Signals from U350 are applied to a divide by 8 prescaling circuit consisting of U390, U400A, and U400B (each IC divides by 2) and to the base of Q410. The positive-going edge of the signal at pin 7 of U390 and the negative-going edge of the signal at the base of Q410 are significant to the counting operation. Signal prescaling does not occur for the 50 kHz reference frequency or for other frequencies up to and including .999 MHz.

A self-biasing arrangement is provided for U390 to ensure that the input bias level on pin 7 is always centered in the hysteresis window. The average of the complementary outputs on pins 2 and 3 is obtained from the junction of R396 and R398 and fed back to pin 7 through L365 and R365 to automatically compensate for any internal temperature drift.

Four counters, U430, U435, U436 and U437 are used for the counting process, but only three decimal digits are displayed on the front panel after the BCD data has been decoded by the BCD-to-Seven Segment Decoder Drivers. U430 frequency divides the input by 10 and its output is used to round off the count held in the remaining counters, allowing a more accurate three-digit display.

The 1 MHz reference clock circuit, U460A and U460B, with inverter U460D, drives U465, which produces two functions. Frequency division by 16 and frequency division by 2 produces a clock signal with a period of 16 microseconds on pin 11 and a clock signal with a period of 2 microseconds on pin 12.

U455B, U455C, U455D, and U460C are positive NAND gates. The logic levels at pin 5 of U455B and pin 10 of U460C determine whether a clock signal with a period of 16 microseconds or 2 microseconds appears at the output of U455D. These logic levels are determined by the output level of positive NAND gate U455C and inverter U455A.

When the FREQUENCY RANGE (MHz) control is in the REF ≈ .05 position, pin 1 of U445A and pin 13 of U445B are held LO (= 0) by the closure of S100B. This clears U445A and U445B, setting both $\overline{Q}$ terminals (pin 6 of U445A and pin 8 of U445B) to a HI (= 1) level. A HI level is established on pins 9 and 10 of U455C, setting its output to a LO level. A LO on pin 5 of U455B locks out the clock signal with a 16 microsecond period, while the HI level on pin 10 of U460C allows the 2 microsecond clock to be gated through to the output of U455D.

The HI level on pin 10 of U460C is also transmitted through VR375, reverse biasing CR410 and disabling the divide by 8 signal prescaling circuitry. The 50 kHz signal is then processed by Q410 and Q420 with the positive-going edge of the signal at pin 1 of U425A significant to counting operation only during the time that pin 2 of U425A is HI (gating signal).

For 50 kHz counting, the 10^{-1} decimal source point (anode of VR475) is always HI and the 2 microsecond clock signal is frequency divided by 1000 by Gate Time Clock Dividers U480, U481, and U482. Positive NAND gates U475A, U475B and U475D are locked out due to the LO levels set at the output of inverting input AND gates U450B, U450C and U450D. With pins 10, 9 and 13 of U485B set to a HI level by the $\overline{Q}$ terminals of U445A and U445B, a 2000 microsecond clock signal is gated through U485B and U485A to pin 1 of U490.

If the leveling circuitry is operating properly, a HI level is set on pins 6 and 7 of U490, allowing it to count. U490 frequency divides by 5 from pin 1 to 11 and frequency divides by 2 from pin 14 to pin 12. This frequency division produces a signal with a period of 10 milliseconds at pin 11 and a square wave with a period of 20 milliseconds at pin 12. The square wave signal (50% duty cycle) on pin 12 is the reference waveform for the counting period, display time and counter reset time. Refer to Fig. 2-1 for waveform time relationships involved with the State Generator circuits.

The square-wave signal on pin 12 of U490 is applied through inverter U432A to pin 2 of positive NAND gate U425A with the positive half of the square wave acting as a gating signal that allows the counters to count for 50% of the total period (10 milliseconds for 50 kHz counting).

If the sine wave output amplitude from the SG 503 is not leveled, pins 6 and 7 of U490 goes negative at approximately a 2 Hz rate. The result is a blinking front-panel display because U490 is cleared to zero. Zeros supplied to pin 10 of the Display Drivers (U510, U520, and U530) causes them to blank the display for about 0.25 second.

The Auto Ranging circuits operate when S100B is open to change the output levels of U455C, U450B, U450C, and U450D at the proper time to set the decimal point in its proper location and to select the proper gate time intervals for the counting, display, and reset process.

Only one decimal point shift (from .999 MHz to 1.00 MHz) will be discussed as the operation is similar for other decimal point shifts. Overflow Detector U440A detects when it is necessary to shift the decimal point as frequency is increased, while U440B detects when it is necessary to shift the decimal point as frequency is decreased.

U445A and U445B operate as a 4-bit shift register (memory). Exclusive-OR gates U438A and U438B act as control devices to determine whether the register shifts right or left to produce the proper output data, thereby speeding up the Auto Ranging process.

Frequencies from .250 MHz up to and including .999 MHz do not cause the output data from U445A and U445B to change state. Consequently, the output level of U455C remains LO for these frequencies and the gating signal at pin 12 of U490 is the same as for 50 kHz counting.

When U436 and U437 contain binary data equivalent to decimal 99, the next input count to U435 causes pin 11 of U436 to go negative and triggers U440B to force pin 9 of U440B to a HI (= 1). When U435, U436 and U437 contain binary data equivalent to decimal 999, the next input count to U435 causes pin 11 of U437 to go negative and triggers U440A to force pin 13 of U440A to a LO (= 0). At the transition point from .999 MHz to 1.00 MHz U440B and U440A have been triggered and set.

A HI on pin 9 of U440B along with a HI on pin 6 of U445A and a LO on pin 9 of U445B results (through the action of U438A and U438B) in a HI (= 1) being transferred to the D input terminal (pin 2) of U445A and a LO (= 0) to the D input terminal (pin 12) of U445B. Pin 5 of U425B (Auto Range Clock Enable) has also been set to a HI through the action of U425D.

On the next Auto Range Clock signal from U450A, pin 6 of U425B goes LO and this negative transition triggers both U445A and U445B, transferring the data from the D terminals to the Q terminals. After data transfer, pin 6 of U445A will be LO (= 0) and pin 5 will be a HI (= 1); pin 9 of U445B will be a LO (= 0) and pin 8 will be a HI (= 1). These logic levels are decoded by U455C, U450B, U450C and U450D to shift the decimal point one place to the right, select the proper gating signal from the Gate Time Clock Dividers, and enables the signal prescaling circuitry.

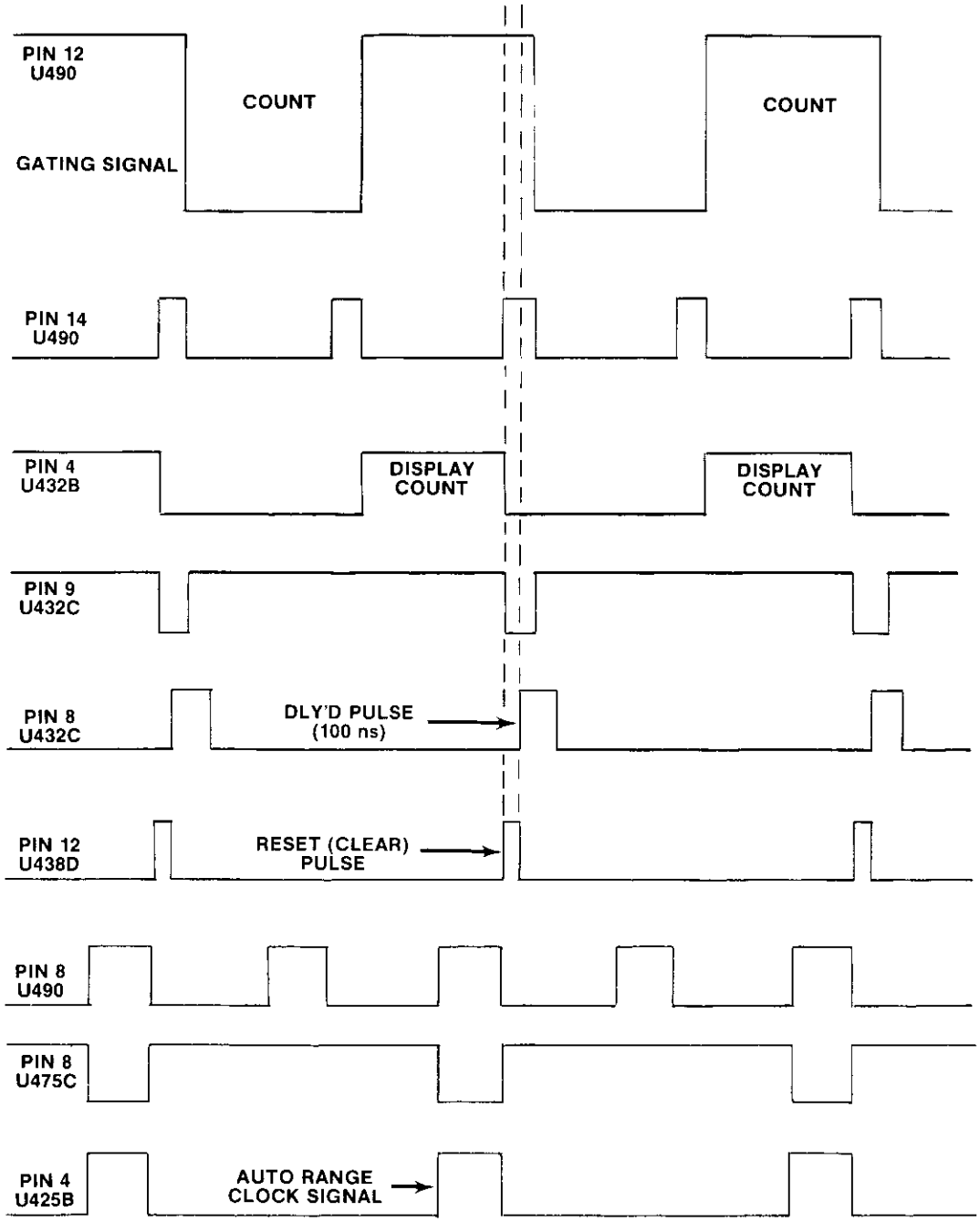


Fig. 2-1. State Generator waveform time relations.

For the logic levels given, the 2 microsecond clock signal is locked out from U460C and the 16 microsecond clock signal is gated through to the output of U455D. After frequency division by 100, a 1600 microsecond signal is gated through U475D and U485A to appear at pin 1 of U490. U475D is enabled because the output of U450B is HI and all other decoding gate output levels are LO. Although new gate time intervals are selected for Auto Ranging, the waveform time relationships remain the same as illustrated in Fig. 2-1.

Due to the change from a HI to a LO on pin 6 of U445A, the output level of U438B goes HI during the count interval. The output of U440A is now at a HI level because it was reset by the clear pulse and not triggered during count time. This results in a LO level at pin 5 of U425B, which locks out the Auto Ranging clock signal, preventing U445A and U445B from being triggered. U445A and U445B will not change their output data unless it again becomes necessary to change the decimal point location.

For the next decimal point shift, (for example, from 9.99 MHz to 10.0 MHz) the same sequence of events occur with Exclusive-OR gates U438A and U438B sensing the previous output data of the 4-bit register. The proper binary code is then set at the outputs of U445A and U445B (when triggered by the Auto Ranging clock signal) to shift the decimal point one more place to the right. U475A is enabled by the output level of U450C going HI and a 160 microsecond clock signal is gated through to pin 1 of U490.

Power Supplies ◇3◇

The −22 V supply is referenced to ground with a reference voltage point established on pin 5 of voltage regulator U695 by the voltage divider action of R697 and R698. The voltage divider composed of R693, R694 and R695 establishes a voltage sensing point at pin 4 of U695. U695 regulates its output by comparing the voltage level on pin 4 with an internal reference. R694 (−22 V ADJ) sets the quiescent level at the base of Q685 which, in turn, sets the quiescent current level through the PNP series-pass transistor located in the Power Module mainframe. If the −22 V output level starts to go positive, this change is sensed at pin 4 of U695 and pin 9 of U695 goes negative. This voltage change is transmitted through emitter-follower Q685 to the base of the PNP series-pass transistor, causing it to increase conduction through the load and return the output level to −22 V. Q690 operates as a load current limiter with R680 acting as the current sensing element.

The +5 V supply is referenced to the −22 V supply with the reference voltage point established at pin 3 of U610 by voltage divider R610-R612. This reference level is about −5 V. In a quiescent state, the voltage on pin 2 of U610 is also about −5 V. If the +5 V output level goes more positive, the voltage change appears at pin 2 of U610 which amplifies and inverts the signal to apply a negative change at the base of Q610. VR610 operates only as a dc level shifter. A positive voltage change at the base of Q600 causes the base of the NPN series-pass transistor located in the Power Module mainframe to decrease conduction through the load, returning the output level to +5 V. Q620 is for current over-load protection. If the load current exceeds about 1.8 A, R624 acts as a current sensing element to turn on Q620. If Q620 turns on, its collector goes positive, turning on CR612. A positive voltage change at pin 2 of U610 turns off the NPN series-pass transistor. The non-polarized connections for C620 and C619 integrate T^2L spikes which may occur on the +5 V level, preventing them from turning on Q620 and shutting down the power supply during current surges.

CR640 prevents the +5 V supply from going more negative than about −0.7 V if F620 opens. Q640 protects the load from over-voltage conditions that could occur if the NPN series-pass transistor shorted. If the output level exceeds about 6.2 volts, VR640 conducts, developing a SCR gating signal across R640. This gating signal turns on Q640, clamping the output level to about +0.2 volt.

SERVICING INFORMATION

INTRODUCTION

Calibration Interval

To ensure instrument accuracy, check the calibration of the SG 503 every 1000 hours of operation, or every six months if used infrequently. Before calibration, thoroughly clean and inspect this instrument as outlined in the service section of the Power Module instruction manual.

Services Available

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

System Maintenance

System maintenance procedures are provided in the Power Module manual; i.e., preventive maintenance, troubleshooting aids, parts removal and replacement procedures, parts ordering information, etc.

In certain areas in this instrument, it is not recommended to use a suction type desoldering tool when repairing or replacing parts. Use a soldering wick when removing or replacing oscillator coils or the Output Buffer Amplifier (Q190).

Oscillator Maintenance

The oscillator sections can be checked out independent of the leveling circuitry (feedback loop) by removing Q300 and connecting a 500 ohm potentiometer between the socket pins for the collector and emitter.

When replacing components for the oscillator sections be certain that they are as close to the original mechanical layout as possible. Lead length for the transistors, Q130 and Q140, should be 0.2 inch. Replace the heat sinks as originally installed (flush with the top of the transistor case). Do not allow any heat sink to touch any other part or the chassis. Distributed capacity from Q140 heat sinks to surroundings determines the upper frequency limit on the 100-250 MHz range.

The air-core coil for the 100-250 MHz range should not need adjustment or repair. If it becomes necessary to perform a repair in this area, use extreme caution and do not break or damage the 50 nF disc capacitor that grounds one end of the coil to the variable capacitor.

Replacing Output Buffer Amplifier

WARNING

The ceramic portions of power transistor Q190 contain BERYLLIUM OXIDE as a major ingredient. Beryllium Oxide heat sinks are safe under most conditions. The only hazard is that a toxic effect may occur if fumes or fine particles are inhaled. Grinding, crushing, or heating above 1800° F can produce fumes or fine particles. Avoidance of such action and subsequent inhalation will assure the absence of any hazard. No hazard is present in normal instrument operation or maintenance.

The Output Buffer Amplifier power transistor (Q190) can be replaced without removing the Attenuator-Output Buffer Amplifier circuit board by unsoldering the leads and removing a 5/16 nut on the mounting stud. Cut the leads of the new transistor to the proper length, keeping note of the position of the collector lead. Apply Dow Corning 4 silicone compound on the under surface of the transistor and about two threads of the mounting stud. Use a very small amount and avoid placing silicone compound on the transistor leads or on the ceramic case. Orient the collector lead toward the rear of the instrument. Seat the transistor to its heat sink and tighten the 5/16 nut on the mounting stud. For efficient heat sinking, the maximum torque for first time replacement should be 6 and 1/2 inch-pounds and 5 inch-pounds for repeated installation of the same transistor. When resoldering the transistor leads to the circuit board, avoid large amounts of solder which may flow through the circuit board holes.

Removal and Replacement of Attenuator-Output Buffer Circuit Board

Remove metal shield cover for the attenuators. The circuit board is held in place by six screws. Four corner screws hold this circuit board to the main board and two counter-sunk screws hold the Output Buffer Amplifier heat sink bracket to the side rail of the chassis. For removal of this board, it may be necessary to loosen the screws holding the main circuit board to the same side rail so that the heat-sink bracket can be withdrawn.

NOTE

Do not loosen the three nuts that hold the heat sink bracket to the circuit board. If it becomes necessary to remove this heat sink from the circuit board it is important to reinstall the three 35 mil washers and plastic insulation between the heat sink and the under side of the board.

When replacing the Attenuator-Output Buffer circuit board, ensure that all pin connections from the main circuit board are aligned and seated properly. Install the six screws, but do not tighten. The two counter-sunk screws on the chassis side rail must be tightened first in order to ensure efficient heat transfer and minimum stress. Tighten the main circuit board screws, and then tighten the four Attenuator-Output Buffer Amplifier circuit board screws last. Replace metal shield.

Alignment of FREQUENCY RANGE (MHz) Control

If it becomes necessary to remove this knob from the front panel, or if it becomes loose on the shaft of the high frequency cam switch, alignment upon reinstallation is accomplished by setting the cam switch on the 50-100 MHz range. This position can be noted by observing when the three switch contacts on the main circuit board first open when rotating the shaft clockwise.

Test Equipment and Accessories Required

The following test equipment and accessories, or its equivalent, is required for complete calibration of the SG 503. Specifications given for the test equipment are the minimum necessary for calibration and measurements. All test equipment is assumed to be correctly calibrated and operating within specifications.

If other test equipment is substituted, control settings or calibration setup may need to be altered to meet the requirements of the equipment used. Detailed operating instructions for the test equipment are not given in the adjustment or calibration procedures. Refer to the instruction manual for the test equipment if more information is desired.

1. TM 500 Series Power Module.

2. TM 500 Series Plug-in Extender. Tektronix Part No. 067-0645-01.

3. Variable Autotransformer. Must be capable of supplying sufficient wattage (depends on number of plug-ins in Power Module) over a range of 90 to 132 V or 180 to 264 V. Autotransformer must have an ac voltmeter.

4. Digital Multimeter. Input resistance 10 megohm. Tektronix DM 501.

5. Test Oscilloscope. Tektronix 7000-Series mainframe with 7B70 or 7B71 Time Base and 7A13 Differential Comparator.

6. Amplitude Calibrator. Tektronix Calibration Generator PG 506 or Calibration Fixture 067-0502-01.

7. Spectrum Analyzer. Tektronix 7L12 with 7000-Series mainframe.

8. Peak-to-Peak Detector. Tektronix Calibration Fixture 067-0625-00.

9. Two 2X attenuators, Tektronix Part No. 011-0069-02.

10. BNC Female to GR adapter. Tektronix Part No. 017-0063-00.

11. 50 ohm feedthrough termination. Tektronix Part No. 011-0049-01.

12. Coaxial cable. PN 012-0482-00 (supplied with SG 503).

13. Two coaxial cables. 50 ohm impedance, BNC connectors. Maximum length 42 inches. Tektronix Part No. 012-0057-01.

14. Two BNC Female to Dual Banana adapters. Tektronix Part No. 103-0090-00.

15. One 2.4 megohm, 5% resistor.

16. Alignment Tools: Low capacitance screwdriver, Tektronix Part No. 003-0000-00; Insert, nylon. For 5/64 inch inside diameter hex cores, Tektronix Part No. 003-0310-00; Plastic Rod, 5 inches long, for slotted cores, Tektronix Part No. 003-0301-00.

SYMBOLS AND REFERENCE DESIGNATORS

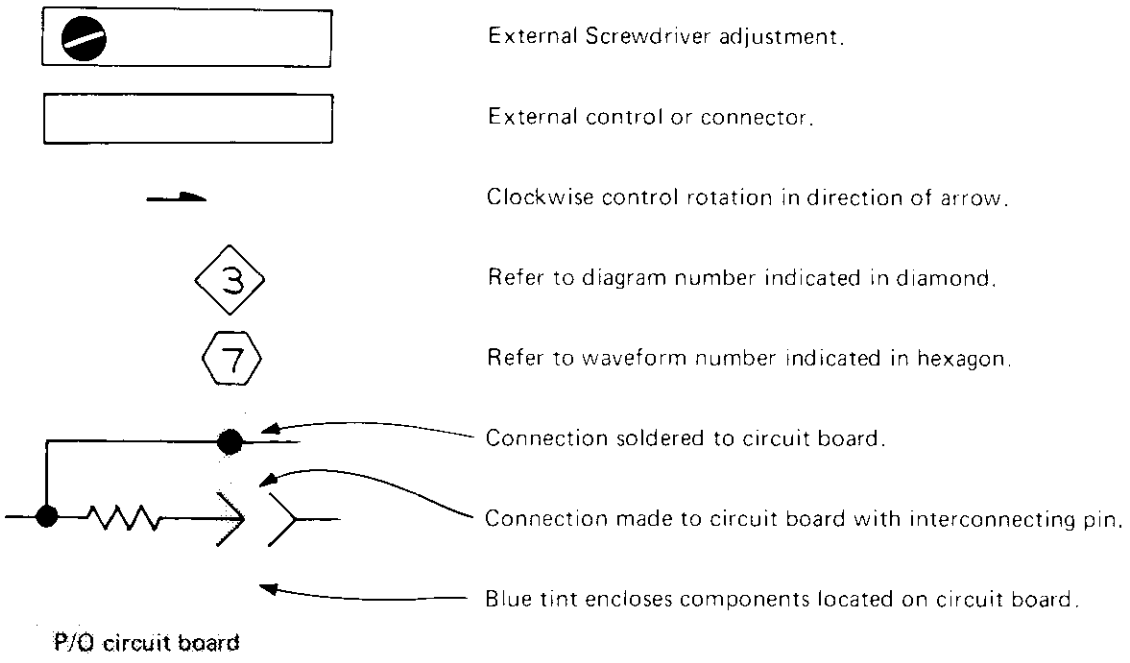
Electrical components shown on the diagrams are in the following units unless noted otherwise:

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

Symbols used on the diagrams are based on ANSI Y32.2 – 1970.

Logic symbology is based on MIL-STD-806B in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The following special symbols are used on the diagrams:



External Screwdriver adjustment.

External control or connector.

Clockwise control rotation in direction of arrow.

Refer to diagram number indicated in diamond.

Refer to waveform number indicated in hexagon.

Connection soldered to circuit board.

Connection made to circuit board with interconnecting pin.

Blue tint encloses components located on circuit board.

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 CO.	1201 2ND ST. SOUTH	MILWAUKEE, WI 53204
01295	TEXAS INSTRUMENTS, INC., SEMICONDUCTOR GROUP	P. O. BOX 5012	DALLAS, TX 75222
02111	SPECTROL ELECTRONICS CORP.	17070 EAST GALE AVE.	CITY OF INDUSTRY, CA 91745
02735	RCA CORP., SOLID STATE DIVISION	ROUTE 202	SOMERVILLE, NY 08876
03508	GENERAL ELECTRIC CO., SEMI-CONDUCTOR PRODUCTS DEPT.	ELECTRONICS PARK	SYRACUSE, NY 13201
04713	MOTOROLA, INC., SEMICONDUCTOR PRODUCTS DIV.	5005 E. MCDOWELL RD.	PHOENIX, AZ 85036
07263	FAIRCHILD SEMICONDUCTOR, A DIV. OF FAIRCHILD CAMERA AND INSTRUMENT CORP.	464 ELLIS ST.	MOUNTAIN VIEW, CA 94042
07910	TELEDYNE SEMICONDUCTOR	12515 CHADRON AVE.	HAWTHORNE, CA 90250
16546	U.S. CAPACITOR CORP.	2151 N. LINCOLN	BURBANK, CA 91504
18324	SIGNETICS CORP.	811 E ARQUES	SUNNYVALE, CA 94086
27014	NATIONAL SEMICONDUCTOR CORP.	2900 SAN YSIDRO WAY	SANTA CLARA, CA 95051
32159	WEST-CAP ARIZONA	2201 E. ELVIRA ROAD	TUCSON, AZ 85706
56289	SPRAGUE ELECTRIC CO.		NORTH ADAMS, MA 01247
71400	BUSSMAN MFG., DIVISION OF MCGRAW-EDISON CO.	2536 W. UNIVERSITY ST.	ST. LOUIS, MO 63107
72136	ELECTRO MOTIVE CORP., SUB OF INTERNATIONAL ELECTRONICS CORP.	SOUTH PARK AND JOHN STREETS	WILLIMANTIC, CT 06226
72982	ERIE TECHNOLOGICAL PRODUCTS, INC.	644 W. 12TH ST.	ERIE, PA 16512
73138	BECKMAN INSTRUMENTS, INC., HELIPOT DIV.	2500 HARBOR BlVD.	FULLERTON, CA 92634
75042	TRW ELECTRONIC COMPONENTS, IRC FIXED RESISTORS, PHILADELPHIA DIVISION	401 N. BROAD ST.	PHILADELPHIA, PA 19108
76493	BELL INDUSTRIES, INC., MILLER, J. W., DIV.	19070 REYES AVE.	COMPTON, CA 90224
78488	STACKPOLE CARBON CO.		ST. MARYS, PA 15857
80009	TEKTRONIX, INC.	P. O. BOX 500	BEAVERTON, OR 97077
80294	BOURNS, INC., INSTRUMENT DIV.	6135 MAGNOLIA AVE.	RIVERSIDE, CA 92506
90201	MALLORY CAPACITOR CO., DIV. OF P. R. MALLORY CO., INC.	3029 E. WASHINGTON ST.	INDIANAPOLIS, IN 46206

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A1	670-2978-00	B010100	B029999	CKT BOARD ASSY:MAIN	80009	670-2978-00
A1	670-2978-01	B030000	B039999	CKT BOARD ASSY:MAIN	80009	670-2978-01
A1	670-2978-02	B040000	B051799	CKT BOARD ASSY:MAIN	80009	670-2978-02
A1	670-2978-03	B051800		CKT BOARD ASSY:MAIN	80009	670-2978-03
A2[1]				CKT BOARD ASSY:COIL		
A3	670-3073-00	B010100	B029999	CKT BOARD ASSY:ATTENUATOR	80009	670-3073-00
A3	670-3073-01	B030000	B039999	CKT BOARD ASSY:ATTENUATOR	80009	670-3073-01
A3	670-3073-02	B040000		CKT BOARD ASSY:ATTENUATOR	80009	670-3073-02
A4	670-2954-00			CKT BOARD ASSY:DISPLAY	80009	670-2954-00
C100A, C100B, C100C	281-0210-00	B010100	B051799	CAP.,VAR,AIR DI:5-60PF/6-80PF/10-410PF,200V	80009	281-0210-00
C100A, C100B, C100C	281-0210-01	B051800		CAP.,VAR,AIR DI:5-60PF/6-80PF/10-410PF,200V	80009	281-0210-01
C102	283-0639-00			CAP.,FXD,MICA D:56PF,1%,100V	00853	D151E560F0
C104	283-0353-00	B010100	B029999X	CAP.,FXD,CER DI:0.1UF,+/-10%,50V ML	16546	W050FH104KPSS
C106	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C112	283-0597-00			CAP.,FXD,MICA D:470PF,10%,300V	00853	D153E471K0
C118	283-0615-00			CAP.,FXD,MICA D:33PF,5%,500V	00853	D155E330J0
C124	283-0695-00			CAP.,FXD,MICA D:4440PF,1%,300V	72136	DM19F4441F0300
C130	283-0353-00			CAP.,FXD,CER DI:0.1UF,+/-10%,50V ML	16546	W050FH104KPSS
C134	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C140	283-0353-00			CAP.,FXD,CER DI:0.1UF +/-10%,50V ML	16546	W050FH104KPSS
C145	283-0064-00	B010100	B029999X	CAP.,FXD,CER DI:0.5UFD,+80%-20%,50V,W/O LEADS	72982	5855111U5U503Z
C146	290-0536-00	B010100	B029999X	CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025NLF
C150	283-0299-00			CAP.,FXD,CER DI:51PF,5%,500V	72982	8121N501A510J
C154	283-0299-00			CAP.,FXD,CER DI:51PF,5%,500V	72982	8121N501A510J
C170	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C172	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C180	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C184	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C190	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C200	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C204	281-0730-00			CAP.,FXD,CER DI:10.8PF,1%,500V	72982	301055C0G1089F
C208	281-0730-00			CAP.,FXD,CER DI:10.8PF,1%,500V	72982	301055C0G1089F
C212	281-0604-00			CAP.,FXD,CER DI:2.2PF,+/-0.25PF,500V	72982	301-000C0J0229C
C214	283-0156-00	XB040000		CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111A208E102Z
C215	283-0156-00	XB040000		CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111A208E102Z
C216	281-0661-00			CAP.,FXD,CER DI:0.8PF,+/-0.1PF,500V	72982	301-000C0K0808B
C218	283-0156-00	B010100	B039999X	CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111A208E102Z
C230	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C232	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C260	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C274	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C278	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C280	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C282	283-0156-00			CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111A208E102Z
C290	290-0535-00			CAP.,FXD,ELCTLT:33UF,20%,10V	56289	196D336X0010KA1
C296	290-0535-00			CAP.,FXD,ELCTLT:33UF,20%,10V	56289	196D336X0010KA1
C322	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C324	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C328	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C335	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C342	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C345	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C358	283-0175-00			CAP.,FXD,CER DI:10PF,5%,200V	72982	8101-200C0G0100J
C360	283-0197-00			CAP.,FXD,CER DI:470PF,5%,100V	72982	8121N064C0G471J
C365	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M

[1]Available only as assembly 263-1082-00. (S100).

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C390	283-0353-00			CAP.,FXD,CER DI:0.1UF,+/-10%,50V ML	16546	W050FH104KPSS
C422	281-0629-00			CAP.,FXD,CER DI:33PF,5%,600V	72982	308-000C0G0330J
C435	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025NLF
C436	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025NLF
C445	283-0156-00			CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111A208E102Z
C448	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C462	281-0511-00			CAP.,FXD,CER DI:22PF,+/-2.2PF,500V	72982	301-000C0G0220K
C465	281-0504-00			CAP.,FXD,CER DI:10PF,+/-1PF,500V	72982	301-055C0G0100F
C480	290-0531-00			CAP.,FXD,ELCTLT:100UF,20%,10V	90201	TDC107M010WLC
C481	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025NLF
C490	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C495	281-0536-00			CAP.,FXD,CER DI:1000PF,10%,500V	72982	301055X5P102K
C540	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C542	283-0156-00			CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111A208E102Z
C600	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C610	281-0523-00			CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C618	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025NLF
C619	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025NLF
C620	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025NLF
C630	290-0531-00			CAP.,FXD,ELCTLT:100UF,20%,10V	90201	TDC107M010WLC
C635	283-0154-00	XB030000		CAP.,FXD,CER DI:22PF,5%,50V	72982	8111A058C0G220J
C640	290-0531-00			CAP.,FXD,ELCTLT:100UF,20%,10V	90201	TDC107M010WLC
C642	290-0531-00			CAP.,FXD,ELCTLT:100UF,20%,10V	90201	TDC107M010WLC
C650	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C655	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C660	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C662	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C665	290-0559-00			CAP.,FXD,ELCTLT:22UF,20%,35V	56289	196D226X0035MA1
C675	290-0559-00			CAP.,FXD,ELCTLT:22UF,20%,35V	56289	196D226X0035MA1
C677	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C680	290-0559-00			CAP.,FXD,ELCTLT:22UF,20%,35V	56289	196D226X0035MA1
C694	281-0523-00			CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C697	290-0517-00			CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
CR130	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR200	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR202	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR216	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR218	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR274	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR276	152-0246-00			SEMICOND DEVICE:SILICON,400PIV,200MA	07910	CD12676
CR278	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR280	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR410	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR600	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR612	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR640	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	02735	37304
CR680	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	02735	37304
CR694	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
DS500	150-1004-00			LAMP,LED:RED,2.5V,15MA	08806	SSL-12
DS510	150-1011-00			LAMP,LED:RED,7-SEQUENCE	31718	FND70
DS520	150-1011-00			LAMP,LED:RED,7-SEQUENCE	31718	FND70
DS530	150-1011-00			LAMP,LED:RED,7-SEQUENCE	31718	FND70
F620	159-0021-00			FUSE,CARTRIDGE:3AG,2A,250V,FAST-BLOW	71400	AGC 2
J240	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J245	131-1315-00			CONNECTOR,RCPT,:BNC,FEMALE	80009	131-1315-00
L100	120-0939-00			TRANSFORMER,RF:50-100 MHZ	80009	120-0939-00

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
L110	120-0938-00			TRANSFORMER,RF:25-50MHZ	80009	120-0938-00
L112	120-0937-00			TRANSFORMER,RF:10-25MHZ	80009	120-0937-00
L114	120-0936-00			TRANSFORMER,RF:5-10MHZ	80009	120-0936-00
L116	120-0935-00			TRANSFORMER,RF:2.2-5MHZ	80009	120-0935-00
L118	120-0934-00			TRANSFORMER,RF:1-2.5MHZ	80009	120-0934-00
L120	120-0933-00			TRANSFORMER,RF:0.5-1MHZ	80009	120-0933-00
L122	120-0932-00			TRANSFORMER,RF:250-500KHZ	80009	120-0932-00
L124	120-0931-00			TRANSFORMER,RF:50KHZ	80009	120-0931-00
L143	108-0794-00			COIL,RF:3 TURN,#18 AWG	80009	108-0794-00
L145	108-0472-00	B010100	B029999X	COIL,RF:160UH	80009	108-0472-00
L184	108-0606-00			COIL,RF:50NH	80009	108-0606-00
L190	276-0569-00			CORE,TOROID:	80009	276-0569-00
L191	276-0569-00			CORE,TOROID:	80009	276-0569-00
L195	108-0317-00			COIL,RF: 15UH	32159	71501M
L197	108-0795-00			COIL,RF:2.5MH	80009	108-0795-00
L200	108-0578-00			COIL,RF:45NH	80009	108-0578-00
L204	108-0578-00			COIL,RF:45NH	80009	108-0578-00
L208	108-0552-00			COIL,RF:80NH	80009	108-0552-00
L212	108-0552-00			COIL,RF:80NH	80009	108-0552-00
L245	276-0647-00			CORE,TOROID:0.285 OD X 0.150 ID X 0.280	78488	57-0126
L265	276-0576-00			CORE,TOROID:0.375 OD X 0.125 ID X 0.125	78488	57-0047
L270	276-0576-00			CORE,TOROID:0.375 OD X 0.125 ID X 0.125	78488	57-0047
L280	276-0576-00			CORE,TOROID:0.375 OD X 0.125 ID X 0.125	78488	57-0047
L290	276-0576-00			CORE,TOROID:0.375 OD X 0.125 ID X 0.125	78488	57-0047
L320	108-0733-00			COIL,RF:130NH	80009	108-0733-00
L362	108-0606-00			COIL,RF:50NH	80009	108-0606-00
L365	108-0509-00			COIL,RF:2.5UH	80009	108-0509-00
L630	108-0795-00			COIL,RF:2.5MH	80009	108-0795-00
L660	108-0472-00			COIL,RF:160UH	80009	108-0472-00
L670	108-0205-00			COIL,RF:1MH	76493	108-0205-00
L655	120-0342-00			XFMR,TOROID:10 TURNS SINGLE	80009	120-0342-00
LR110	108-0408-00			COIL,RF:85NH	80009	108-0408-00
LR112	108-0271-00			COIL,RF:0.25UH	80009	108-0271-00
LR114	108-0333-00			COIL,RF:0.9UH	80009	108-0333-00
LR130	108-0595-00			COIL,RF:64NH	80009	108-0595-00
LR135	108-0797-00			COIL,RF:2.5NH	80009	108-0797-00
LR140	108-0796-00			COIL,RF:20NH	80009	108-0796-00
LR142	108-0271-00			COIL,RF:0.25UH	80009	108-0271-00
LR150	108-0271-00			COIL,RF:0.25UH	80009	108-0271-00
LR190	108-0797-00			COIL,RF:2.5NH	80009	108-0797-00
Q130	151-0451-00	B010100	B039999	TRANSISTOR:SILICON,NPN	80009	151-0451-00
Q130	151-0211-01	B040000		TRANSISTOR:SILICON,NPN	02735	60794
Q140	151-0451-00			TRANSISTOR:SILICON,NPN,SEL FROM 2N5943	80009	151-0451-00
Q160	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q180	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q190	151-0474-00			TRANSISTOR:SILICON,NPN	80009	151-0474-00
Q290	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q296	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q300	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q320	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q410	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q420	151-0221-00			TRANSISTOR:SILICON,PNP	07263	S24849
Q600	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A

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Q610	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q620	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
Q640	151-0515-01			TRANSISTOR:50V,8A	04713	2N4441
Q685	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
Q690	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
R116	315-0471-00	XB040000		RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R134	317-0131-00			RES.,FXD,COMP:130 OHM,5%,0.125W	01121	BB1315
R138	317-0510-00			RES.,FXD,COMP:51 OHM,5%,0.125W	01121	BB5105
R140	301-0750-00			RES.,FXD,COMP:75 OHM,5%,0.50W	01121	EB7505
R145	317-0510-00			RES.,FXD,COMP:51 OHM,5%,0.125W	01121	BB5105
R146	317-0510-00			RES.,FXD,COMP:51 OHM,5%,0.125W	01121	BB5105
R150	317-0510-00			RES.,FXD,COMP:51 OHM,5%,0.125W	01121	BB5105
R160	315-0181-00			RES.,FXD,COMP:180 OHM,5%,0.25W	01121	CB1815
R162	321-0207-00			RES.,FXD,FILM:1.4K OHM,1%,0.125W	75042	CEAT0-1401F
R164	321-0319-00			RES.,FXD,FILM:20.5K OHM,1%,0.125W	75042	CEAT0-2052F
R166	315-0392-00			RES.,FXD,COMP:3.9K OHM,5%,0.25W	01121	CB3925
R174	315-0182-00			RES.,FXD,COMP:1.8K OHM,5%,0.25W	01121	CB1825
R175	311-1563-00			RES.,VAR,NONWIR:1K OHM,20%,0.50W	73138	91A-10000M
R176	315-0123-00			RES.,FXD,COMP:12K OHM,5%,0.25W	01121	CB1235
R180	315-0272-00			RES.,FXD,COMP:2.7K OHM,5%,0.25W	01121	CB2725
R184	317-0151-00			RES.,FXD,COMP:150 OHM,5%,0.125W	01121	BB1515
R190	301-0560-00			RES.,FXD,COMP:56 OHM,5%,0.50W	01121	EB5605
R192	301-0560-00			RES.,FXD,COMP:56 OHM,5%,0.50W	01121	EB5605
R195	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R197	315-0471-00	B010100	B029999	RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R197	315-0102-00	B030000		RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R204	317-0181-00			RES.,FXD,CMPSN:180 OHM,5%,0.125W	01121	BB1815
R212	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R216	315-0911-00			RES.,FXD,COMP:910 OHM,5%,0.25W	01121	CB9115
R250	315-0275-00			RES.,FXD,COMP:2.7M OHM,5%,0.25W	01121	CB2755
R255	311-1223-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	80294	3389F-P32-251
R257	321-0224-00			RES.,FXD,FILM:2.1K OHM,1%,0.125W	75042	CEAT0-2101F
R260	311-1531-00			RES.,VAR,WW:2K OHM,+/-5%,5 TURN	02111	535-9504
R262	321-0114-00			RES.,FXD,FILM:150K OHM,1%,0.125W	75042	CEAT0-1500F
R265	311-1221-00			RES.,VAR,NONWIR:50 OHM,20%,0.50W	80294	3389F-P31-500
R270	315-0204-00			RES.,FXD,COMP:200K OHM,5%,0.25W	01121	CB2045
R272	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R274	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R276	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R277	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R278	315-0513-00			RES.,FXD,COMP:51K OHM,5%,0.25W	01121	CB5135
R280	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R284	315-0123-00			RES.,FXD,COMP:12K OHM,5%,0.25W	01121	CB1235
R290	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R292	315-0562-00			RES.,FXD,COMP:5.6K OHM,5%,0.25W	01121	CB5625
R294	315-0512-00			RES.,FXD,COMP:5.1K OHM,5%,0.25W	01121	CB5125
R296	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R300	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R302	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R315	315-0391-00			RES.,FXD,COMP:390 OHM,5%,0.25W	01121	CB3915
R320	315-0181-00			RES.,FXD,COMP:180 OHM,5%,0.25W	01121	CB1815
R322	315-0510-00			RES.,FXD,COMP:51 OHM,5%,0.25W	01121	CB5105
R324	315-0272-00			RES.,FXD,COMP:2.7K OHM,5%,0.25W	01121	CB2725
R326	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R328	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715

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R335	315-0182-00			RES.,FXD,COMP:1.8K OHM,5%,0.25W	01121	CB1825
R338	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R340	315-0332-00			RES.,FXD,COMP:3.3K OHM,5%,0.25W	01121	CB3325
R342	315-0162-00			RES.,FXD,COMP:1.6K OHM,5%,0.25W	01121	CB1625
R345	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R350	315-0181-00			RES.,FXD,COMP:180 OHM,5%,0.25W	01121	CB1815
R352	315-0221-00			RES.,FXD,COMP:220 OHM,5%,0.25W	01121	CB2215
R355	315-0181-00			RES.,FXD,COMP:180 OHM,5%,0.25W	01121	CB1815
R358	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R360	315-0510-00			RES.,FXD,COMP:51 OHM,5%,0.25W	01121	CB5105
R362	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R365	315-0181-00			RES.,FXD,COMP:180 OHM,5%,0.25W	01121	CB1815
R376	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R395	315-0391-00			RES.,FXD,COMP:390 OHM,5%,0.25W	01121	CB3915
R396	321-0126-00			RES.,FXD,FILM:200 OHM,1%,0.125W	75042	CEAT0-2000F
R397	315-0391-00			RES.,FXD,COMP:390 OHM,5%,0.25W	01121	CB3915
R398	321-0126-00			RES.,FXD,FILM:200 OHM,1%,0.125W	75042	CEAT0-2000F
R400	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R402	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R404	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R410	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R411	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R412	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R416	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R420	315-0150-00			RES.,FXD,COMP:15 OHM,5%,0.25W	01121	CB1505
R422	315-0131-00			RES.,FXD,COMP:130 OHM,5%,0.25W	01121	CB1315
R448	315-0391-00			RES.,FXD,COMP:390 OHM,5%,0.25W	01121	CB3915
R460	315-0222-00			RES.,FXD,COMP:2.2K OHM,5%,0.25W	01121	CB2225
R465	315-0222-00			RES.,FXD,COMP:2.2K OHM,5%,0.25W	01121	CB2225
R468	315-0301-00			RES.,FXD,COMP:300 OHM,5%,0.25W	01121	CB3015
R470	315-0511-00			RES.,FXD,COMP:510 OHM,5%,0.25W	01121	CB5115
R475	315-0111-00			RES.,FXD,COMP:110 OHM,5%,0.25W	01121	CB1115
R477	315-0561-00			RES.,FXD,COMP:560 OHM,5%,0.25W	01121	CB5615
R480	315-0561-00			RES.,FXD,COMP:560 OHM,5%,0.25W	01121	CB5615
R481	315-0561-00			RES.,FXD,COMP:560 OHM,5%,0.25W	01121	CB5615
R495	315-0161-00			RES.,FXD,COMP:160 OHM,5%,0.25W	01121	CB1615
R510	315-0391-00			RES.,FXD,COMP:390 OHM,5%,0.25W	01121	CB3915
R512	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R513	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R514	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R515	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R516	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R517	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R518	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R520	315-0391-00			RES.,FXD,COMP:390 OHM,5%,0.25W	01121	CB3915
R522	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R523	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R524	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R525	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R526	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R527	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R528	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R530	315-0391-00			RES.,FXD,COMP:390 OHM,5%,0.25W	01121	CB3915

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R532	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R533	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R534	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R535	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R536	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R537	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R538	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R601	301-0220-00	XB040000		RES.,FXD,CMPSN:22 OHM,5%,0.50W	01121	EB2205
R600	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R602	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R605	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R610	321-0306-00			RES.,FXD,FILM:15K OHM,1%,0.125W	75042	CEAT0-1502F
R612	321-0358-00			RES.,FXD,FILM:52.3K OHM,1%,0.125W	75042	CEAT0-5232F
R615	321-0336-00			RES.,FXD,FILM:30.9 OHM,1%,0.125W	75042	CEAT0-3092F
R616	321-0358-00			RES.,FXD,FILM:52.3K OHM,1%,0.125W	75042	CEAT0-5232F
R620	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R624	308-0702-00			RES.,FXD,WW:0.33 OHM,5%,2W	75042	BWH-R3300J
R626	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
R640	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R680	308-0685-00			RES.,FXD,WW:1.5 OHM,10%,1W	75042	BW20-1R500J
R684	315-0560-00			RES.,FXD,CMPSN:56 OHM,5%,0.25W	01121	CB5605
R686	315-0392-00			RES.,FXD,CMPSN:3.9K OHM,5%,0.25W	01121	CB3925
R690	315-0270-00	B010100	B039999	RES.,FXD,CMPSN:27 OHM,5%,0.25W	01121	CB2705
R690	315-0471-00	B040000		RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R693	321-0236-00			RES.,FXD,FILM:2.8K OHM,1%,0.125W	75042	CEAT0-2801F
R694	311-1224-00			RES.,VAR,NONWIR:500 OHM,20%,0.50W	80294	3386F-T04-501
R695	321-0236-00			RES.,FXD,FILM:2.8K OHM,1%,0.125W	75042	CEAT0-2801F
R697	321-0236-00			RES.,FXD,FILM:2.8K OHM,1%,0.125W	75042	CEAT0-2801F
R698	321-0304-00			RES.,FXD,FILM:14.3K OHM,1%,0.125W	75042	CEAT0-1432F
S100	263-1082-00			ATTENUATOR,ASSY:CAM SW	80009	263-1082-00
S240	105-0588-00			ACTUATOR ASSY:SLIDE SW	80009	105-0588-00
U225	155-0107-00			MICROCIRCUIT,DI:HYBRID,DIODE LEVELER	80009	155-0107-00
U240	307-1024-00			ATTENUATOR,FXD:50 OHM,HYBRID 10X	80009	307-1024-00
U245	307-1024-00			ATTENUATOR,FXD:50 OHM,HYBRID 10X	80009	307-1024-00
U280	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U350	156-0534-00			MICROCIRCUIT,DI:DECADE COUNTER	01295	SN7490AN
U390	156-0228-00			MICROCIRCUIT,DI:MASTER SLAVE TYPE D F-F	04713	MC1670L
U400	156-0230-00			MICROCIRCUIT,DI:DUAL D MA-SLAVE FLIP-FLOP	04713	MC10131L
U425	156-0180-00			MICROCIRCUIT,DI:QUAD 2-INPUT NAND GATE	01295	SN74S00N
U430	156-0395-00			MICROCIRCUIT,DI:DECADE COUNTER	01295	SN7490AN
U432	156-0043-00			MICROCIRCUIT,DI:2-INPUT NOR GATE	80009	156-0043-00
U435	156-0079-00			MICROCIRCUIT,DI:DECADE COUNTER,TTL	07263	9390PC
U436	156-0079-00			MICROCIRCUIT,DI:DECADE COUNTER,TTL	07263	9390PC
U437	156-0079-00			MICROCIRCUIT,DI:DECADE COUNTER,TTL	07263	9390PC
U438	156-0062-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS EXCL GATE	04713	MC7486P
U440	156-0039-00			MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	01295	SN7473N
U445	156-0041-00			MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	27014	DM7474N
U450	156-0043-00			MICROCIRCUIT,DI:2-INPUT NOR GATE	80009	156-0043-00
U455	156-0030-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U460	156-0113-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN74L00N
U465	156-0032-00			MICROCIRCUIT,DI:4-BIT BINARY COUNTER	01295	SN7493AN
U475	156-0030-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U480	156-0079-00			MICROCIRCUIT,DI:DECADE COUNTER,TTL	07263	9390PC
U481	156-0079-00			MICROCIRCUIT,DI:DECADE COUNTER,TTL	07263	9390PC
U482	156-0079-00			MICROCIRCUIT,DI:DECADE COUNTER,TTL	07263	9390PC

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U485	156-0034-00			MICROCIRCUIT,DI:DUAL 4-INPUT NAND GATE	80009	156-0034-00
U490	156-0079-00			MICROCIRCUIT,DI:DECADE COUNTER,TTL	07263	9390PC
U510	156-0379-00			MICROCIRCUIT,DI:BCD TO 7-SEGMENT DCDR/DRVR	18324	N8T06B
U520	156-0379-00			MICROCIRCUIT,DI:BCD TO 7-SEGMENT DCDR/DRVR	18324	N8T06B
U530	156-0379-00			MICROCIRCUIT,DI:BCD TO 7-SEGMENT DCDR/DRVR	18324	N8T06B
U610	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U695	156-0071-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR	07263	723DC
VR200	152-0280-00	B010100	B029999	SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N753A
VR200	152-0337-00	B030000		SEMICOND DEVICE:ZENER,0.4W,6.1 TO 6.5 V	80009	152-0337-00
VR202	152-0280-00	B010100	B029999	SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N753A
VR202	152-0337-00	B030000		SEMICOND DEVICE:ZENER,0.4W,6.1 TO 6.5 V	80009	152-0337-00
VR475	152-0278-00			SEMICOND DEVICE:ZENER,0.4W,3V,5%	07910	1N4372A
VR610	152-0279-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	07910	1N751A
VR640	152-0280-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N753A
Y460	158-0014-00			XTAL UNIT,QTZ:1 MHZ,+/-0.005%	80009	158-0014-00