TEKTRONIX®

TR 501

TRACKING GENERATOR

INTERIM

INSTRUCTION MANUAL

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

Serial Number _____

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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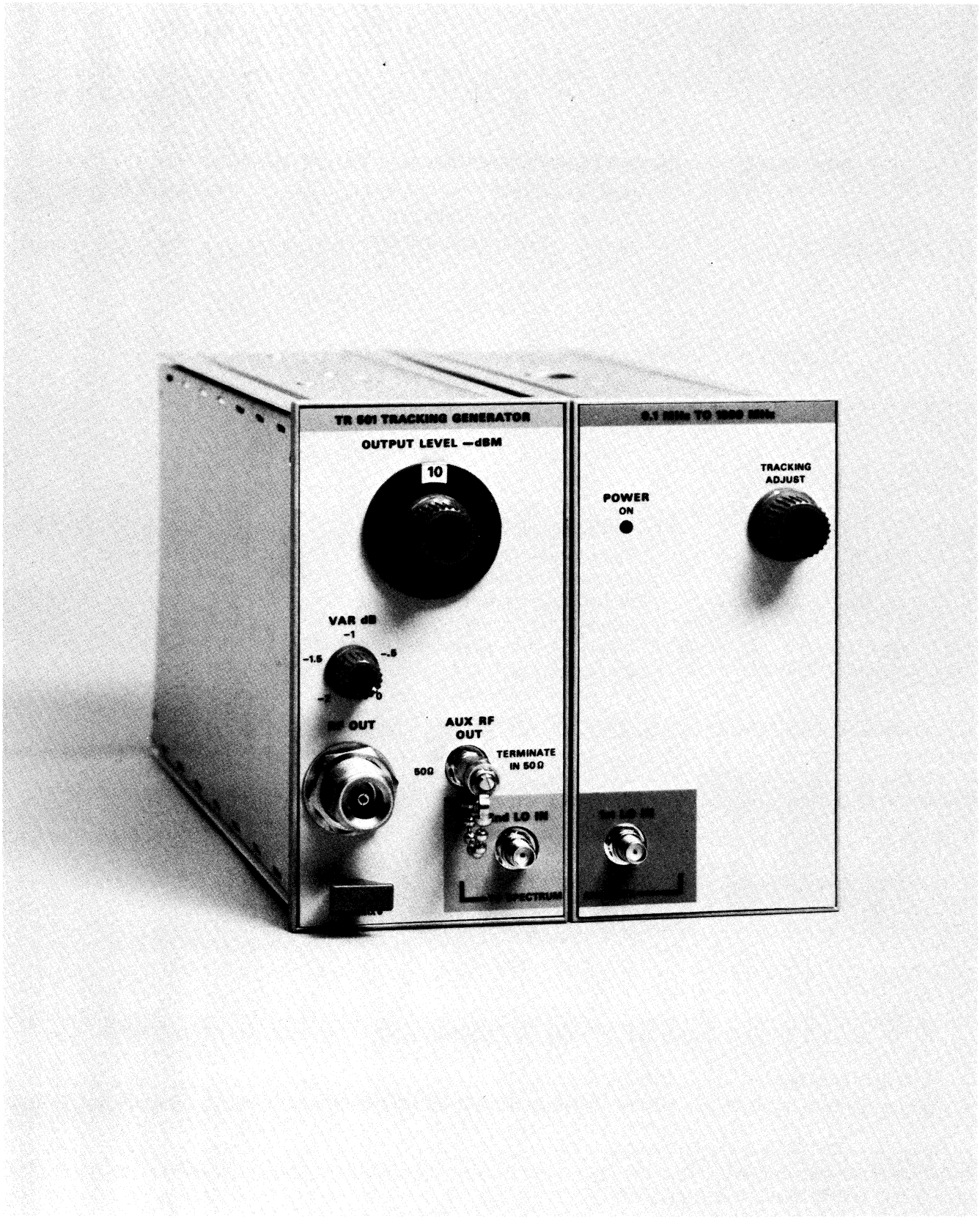


Fig. 1-1. TR501 Tracking Generator

GENERAL INFORMATION AND SPECIFICATIONS

Introduction

This is an interim manual containing some of the information that will be provided in the final manual. The manual (final) will be divided into the following major sections:

Section 1—General Information and Specifications: Contains the instrument description and specifications.

Section 2—Operation Instructions: Information relative to installing and operating the instrument.

Section 3—Performance Check: Provides procedures to check the operational performance of the instrument plus additional performance check procedures that require test equipment to verify that instrument performance is in accordance to specifications.

Section 4—Calibration Procedure: Describes test equipment setup and adjustment procedures required to calibrate the instrument.

Section 5—Circuit Description: Provides basic and general circuit analysis that may be useful when servicing or operating the instrument.

Section 6—Maintenance Instructions: Describes routine and corrective maintenance procedures with detailed instructions for replacing assemblies, sub-assemblies, and individual components. An exploded drawing is part of Section 10. Troubleshooting procedures plus general information that may aid in servicing the instrument are also provided.

Section 7—Options and Modifications: Provides data on production options available.

Section 8—Electrical Parts List: Provides information necessary to order replaceable parts and assemblies.

Section 9—Diagrams: Provides functional block diagram and detailed circuit schematics. Located adjacent to the diagram (usually on the back of the preceding diagram) are pictorial layout drawings which show sub-assembly and component locations.

Section 10—Mechanical Parts List, Exploded Drawings and Accessories: Provides information necessary to order replaceable parts. The Parts List is cross-referenced to the Electrical Parts List. Exploded drawing shows sequence of assembly and identifies assemblies.

Changes and Corrections: Provides updating information for the manual in the form of inserts. These inserts are incorporated into the manual text and diagrams when the manual is updated.

SPECIFICATIONS

Description

The TR 501 Tracking Generator operates with the 7L12 or 7L13 Spectrum Analyzer to provide a calibrated rf signal for swept frequency application from 100 kHz to 1.8 GHz. The output frequency of the TR 501 can be adjusted to track the Spectrum Analyzer frequency within 10 Hz. The TR 501, a two-wide unit compatible with the TM 500 Modular Series instruments, is normally used with the TM 503 Power Module. This permits the optional use of a frequency counter such as the DC 502 to 500 MHz. The AUX RF output of the TR 501 can be used with higher range counters to 1.8 GHz.

ELECTRICAL CHARACTERISTICS

The following characteristics and features apply to the TR 501 and TR 501/7L12 Spectrum Analyzer system. They are applicable over the environmental specification criteria for the TM 500 and 7000-Series mainframes.

Frequency Range:	The TR 501 tracks the 7L12/7L13 tuned input frequency from 100 kHz to 1.8 GHz.
Amplitude	
Maximum Amplitude:	0 dBm, ±0.5 dB.
Range:	0 dBm to −11 dBm, in a 1 dB steps, within 0.1 dB/dB, with an additional continuous vernier control range of 2 dB.
Output Impedance:	50 Ω nominal, VSWR is 2:1 or less to 1.8 GHz.
Flatness	
TR 501:	Within 1.0 dB, from 100 kHz to 1.3 GHz, and within 1.5 dB from 100 kHz to 1.8 GHz.

TR 501/7L12 System: Within 2 dB, from 100 kHz to 1.3 GHz, and within 3 dB from 100 kHz to 1.8 GHz.

Dynamic Range
(TR 501/7L12 system): 100 dB or more.

Residual FM
(peak-to-peak)

TR 501/7L12: ≤200 Hz.

Auxiliary Output: 0.1 V rms into 50 Ω load.

Spurious Output

Harmonic Content: ≥20 dB down from the carrier.

Non-Harmonic content: ≥40 dB down from the carrier.

ENVIRONMENTAL CHARACTERTICS

This instrument will meet the electrical characteristics over the environmental limits of the TM 500 Series Test and Measurement System Power Module. Complete details on test procedure, including failure criteria, etc., can be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or Representative.

ACCESSORIES

Standard Accessories

Two rf coaxial cables, 50 Ω, 28.5 inches	012-0649-00
One Adapter "N male to BNC female"	103-0045-00
Retainer Plug-In	343-0604-01
Manual, Instruction	070-1735-00

Optional Accessories

14 dB, 3mm attenuator: (Used in the 2nd LO Input line to improve TR 501/7L12 isolation thus improving measurement dynamic range.)	015-1002-00

OPERATING INSTRUCTIONS

Introduction

This section describes the function of the front panel controls and connectors, installation of the TR 501 into the TM 500-Series mainframe, interface connections to the Spectrum Analyzer and a Frequency Counter, adjustments required to calibrate the TR 501 to the Spectrum Analyzer, and how to use the Tracking Generator.

General

The TR 501 Tracking Generator is a two wide plug-in unit for the TM 500 Series Power Modules. It operates with the 7L13 or 7L12 Spectrum Analyzers to provide a constant level, calibrated rf signal source that precisely tracks the spectrum analyzer input frequency from 100 kHz to 1.8 GHz. Signal output level is calibrated and adjustable from 0 dBm to −11 dBm in 1 dB steps. The Spectrum Analyzer/Tracking Generator system can be used to plot frequency response of any device (e.g. filter, amplifier, etc.) that is connected between the Tracking Generator RF OUTput and the Spectrum Analyzer Input connector.

If the TR 501 is installed in a three wide or larger power module, a frequency counter such as the DC 502 can be connected to the AUX OUT. The counter will then accurately measure the frequency for any fixed position of the span. When the analyzer is in a non-sweep mode, the TR 501 output is a cw signal and the counter reads frequency continuously.

To install the TR 501 in the TM 500 mainframe, align the upper and lower guide rails of the TR 501 with the plug-in compartment tracks then push the TR 501 in until the front panel is flush with the mainframe front panel. To remove, pull the release latch to disengage the unit from the plug-in compartment then remove the unit.

Function of the Front Panel Controls and Connectors

The following paragraphs describes the function of the TR 501 controls and connectors. This should help to understand the operation and application of the Tracking Generator.

OUTPUT LEVEL: Selects 0 dB to 11 dB of attenuation of the calibrated signal in 1 dB steps.

VAR dB: This control with its calibrated range of 2 dB, provides continuous output level adjustment between each position of the OUTPUT LEVEL selector.

TRACK ADJUST: Adjusts the frequency offset between the Tracking Generator output signal and the tuned input frequency of the Spectrum Analyzer.

OUTPUT CONNECTORS:

RF OUT: A 0 dBm to −13 dBm signal source with a frequency that tracks the Spectrum Analyzer. Output level depends on the setting of OUTPUT LEVEL and VAR dB controls.

AUX RF OUT: A source of the output signal for auxiliary test equipment such as a frequency counter. This output connector must be terminated in a 50 Ω load to maintain flatness.

INPUT CONNECTORS:

1st LO IN and 2nd LO IN: These interface to the Spectrum Analyzer 1st LO and 2nd LO Output connectors.

Operational Check and Calibration

The TR 501 plugs into and receives its power from a TM 500-Series mainframe. It operates with the 7L12 or 7L13 Spectrum Analyzer. The 1st and 2nd LO signals from the Spectrum Analyzer are applied via coaxial cables to the TR 501 Ist and 2nd LO INput connectors. If the TR 501/7L12 system is used with a frequency counter, the AUX OUT is connected through a 50 Ω coaxial cable to the input of the counter.

Preliminary

a. Insert the TR 501 in a TM 500 power unit mainframe and the Spectrum Analyzer into a 7000-Series mainframe.

b. Connect the 1st and 2nd LO Output ports of the Spectrum Analyzer to the 1st and 2nd LO INput ports of the TR 501, using the coaxial cables supplied with the standard accessories, then connect the RF OUT to the RF Input of the Spectrum Analyzer. If a frequency counter is used, connect the AUX OUTPUT of the TR 501 to the input of the counter.

c. Set the Spectrum Analyzer Span/Div to Max, Resolution to 3 MHz, Display Mode to 10 dB/Div, Reference Level to 0 dBm, and switch on the power to all units.

d. Set the OUTPUT LEVEL of the TR 501 to −10 dBm and check for a constant amplitude display across the screen (100 kHz to 1.8 GHz span) of the Spectrum Analyzer display.

1. Check Output Level

a. Change the Spectrum Analyzer Reference Level to 0 dBm. Set the TR 501 OUTPUT LEVEL and VAR dB controls for an output of 0 dBm (fully clockwise).

b. With the TR 501 OUTPUT LEVEL at 0 dBm, change the Spectrum Analyzer Freq Span/Div to 1 MHz and the Display Mode to 2 dB/Div. Adjust the Spectrum Analyzer Ref Var control or the TR 501 VAR dB control to set the display to some graticule division.

c. Decrease the TR 501 OUTPUT LEVEL in 1 dB steps and note that the display level decreases proportionately. Return the OUTPUT LEVEL and VAR dB control to 0 dBm.

d. Rotate the REF VAR control through its range and note that the display level decrease 2 dB. Return the control to its 0 dB position and/or the Spectrum Analyzer Ref Var to Cal.

2. Tracking Adjust

This control adjusts the TR 501 output frequency to the input frequency of the Spectrum Analyzer.

a. Set the Spectrum Analyzer Reference Level to +10 dBm and the Display Mode to 2 dB/Div. Set the TR 501 OUTPUT LEVEL and VAR dB controls for an output of 0 dBm (fully clockwise).

b. Decrease the Spectrum Analyzer Freq Span/Div towards 500 Hz while adjust the TRACKING ADJUST control for minimum frequency offset or maximum response on the display.

3. Measuring Frequency

Connect the AUX OUTPUT through a 50 Ω coaxial cable to the input of a frequency counter. Use the Spectrum Analyzer in the non-sweep mode to measure frequency.

PERFORMANCE CHECK

Introduction

This section contains two subparts: operational check-out procedures, for incoming inspection and instrument familiarization (this requires no test equipment); and a performance check procedure, that requires test equipment as the measurement standard to verify instrument specifications, such as attenuator accuracy and output flatness characteristics.

1. Preliminary Preparation

Connect the TR 501 to the Spectrum Analyzer and perform the preliminary front panel set-up procedures and calibration described in the operating instructions.

2. Check Frequency Range

a. Set the Spectrum Analyzer Reference level to 0 dBm by inserting rf attenuation. Set the vertical display to 10 dB/Div, the Span/Div to Max Span with the Resolution coupled (3 MHz) to the Span/Div selector.

b. Set the TR 501 OUTPUT LEVEL dBm selector to 0 and connect the TR 501 RF OUT to the Spectrum Analyzer RF IN by means of a short 50 Ω coaxial cable.

c. The display should be a horizontal line near full screen amplitude over the full 1800 MHz span across the screen.

3. Check RF OUT Amplitude Range

a. Set the Spectrum Analyzer Center Frequency to 500 MHz. Set Freq Span/Div to 5 MHz with the Resolution coupled. Switch the display mode to 2 dB/Div and leave the Reference Level at 0 dBm.

b. Reduce the TR 501 OUTPUT LEVEL control setting from 0 dBm to −11 dBm. Display level on the Spectrum Analyzer should drop by 5.5 ±1 division.

c. Rotate the VAR dB control through its full range. The display level on the Spectrum Analyzer should change about 1 division. Return the VAR dB control to its 0 dB position.

4. Check Flatness

a. Set the Spectrum Analyzer Freq Span/Div to Max Span with the Resolution control coupled. Leave the vertical display at 2 dB/Div and the Reference Level at 0 dBm.

b. Observe the display flatness. Display should be flat (with ±1.5 division −30 dB) over the 100 kHz to 1.8 GHz range. Disregard the Spectrum Analyzer 0 Hz response at the left edge of the display.

PERFORMANCE CHECKS WHICH REQUIRE TEST EQUIPMENT

Introduction

The following procedures check the amplitude range and accuracy, TR 501 output flatness, residual FM, auxiliary output level, and output level of spurious signals.

Equipment Required

a. Power Meter: Measurement range to 0 dBm. General Microwave Model 454A or Hewlett Packard Model 432A.

b. Spectrum Analyzer: Tektronix 7L12 or 7L13.

c. Mainframe for Spectrum Analyzer: Tektronix 7000-Series with storage; such as 7613.

1. Check Amplitude Range

a. Set the Spectrum Analyzer Center Frequency to 50 MHz. Decrease the Freq Span/Div to 0 Hz so the Spectrum Analyzer frequency is not swept.

b. Connect the TR 501 RF OUT to the power meter with a short length of 50 Ω coaxial cable. Set the VAR dB control to 0 dB and the OUTPUT LEVEL dBm selector to 0. The power meter should indicate 0 dBm ±0.5 dB.

c. Reduce the OUTPUT LEVEL dBm indication in 1 dB steps. The level indicated by the power meter should reduce in 1 dB ±0.1 dB steps in accordance with Table 3-1.

TABLE 3-1

TR 501 OUTPUT LEVEL dBm Setting	0	1	2	3	4	5	6	7	8	9	10	11
Power meter indication compared to the level indicated at 0 dBm	0[1]	0.9 to 1.1	1.8 to 2.2	2.7 to 3.3	3.6 to 4.4	4.5 to 5.5	5.4 to 6.6	6.3 to 7.7	7.2 to 8.8	8.1 to 9.9	9.0 to 11.0	9.0 to 12.1

[1]This is a normalized reference for comparing changes in indication. Absolute value can be between +0.5 dBm and −0.5 dBm.

2. Check TR 501 Output Flatness

a. Leave the Spectrum Analyzer controls as previously set in step 1.

b. Tune the Spectrum Analyzer frequency from 100 kHz to 1800 MHz while observing the TR 501 output level as indicated by the power meter. The output power level should not vary by more than ±1.5 dB over the 100 kHz to 1800 MHz range.

3. Check Auxiliary Output Power

a. Leave the Spectrum Analyzer controls as previously set in step 1. Connect the power meter to the TR 501 AUX RF OUTput. Set the OUTPUT LEVEL dBm control to −11 dBm to terminate the RF OUT connector.

b. Tune the Spectrum Analyzer frequency over the 100 kHz to 1800 MHz range and check that the AUX RF OUT power is at least −7 dBm (0.1 V rms into 50 Ω) as indicated on the power meter.

4. Check Residual FM (peak-to-peak)

a. Tune the Spectrum Analyzer frequency to 50 MHz. Leave the Freq Span/Div at 0 Hz.

b. Connect the TR 501 RF OUT to the input of a test 7L12 or 7L13 Spectrum Analyzer. Set the test Spectrum Analyzer Reference Level at 0 dBm, the Freq Span/Div at 500 Hz with the resolution at 300 Hz. Adjust the TR 501 output frequency with the Spectrum Analyzer so its output is centered on the test Spectrum Analyzer display. Check the display for residual fm. Should not exceed 200 Hz.

5. Check For Spurious Signals

a. Leave the TR 501 Spectrum Analyzer system controls as previously set in step 4.

b. Set the test Spectrum Analyzer controls as follows: Freq Span/Div 20 MHz with resolution coupled, Center Frequency 100 MHz, and Display Mode of 10 dB/Div.

c. Check that harmonic related spurii at 100 MHz, 150 MHz, and 200 MHz are at least 20 dB down from the Tracking Generator output level at 50 MHz.

d. Tune the test Spectrum Analyzer frequency up to 1800 MHz checking that all non-harmonic (not multiples of 50 MHz) spurii are at least 40 dB down from the reference level at 50 MHz.

CIRCUIT DESCRIPTION

This section describes the functions of the major circuits and their relationship to each other. The description is general and is intended as an aid for the technician and operator to facilitate servicing the instrument or operating it to its fullest capabilities. The section starts with a block diagram description, followed with a more detailed analysis of the major circuits. The diagrams contain typical waveform and voltage data to help understand circuit functions and aid in troubleshooting.

BLOCK DIAGRAM DESCRIPTION

The Spectrum Analyzer (7L12 or 7L13) up-converts the input signal frequency by the 1st LO frequency then down-converts this frequency by the 2nd LO frequency to obtain an IF of 105 MHz. The TR 501 Tracking Generator reverses this sequence to generate an output signal with a frequency equal to the input frequency to the Spectrum Analyzer. For example: an input signal frequency of 900 MHz to the Spectrum Analyzer is converted up to 2.095 GHz by the mixing action with the 1st LO frequency of 2.995 GHz. This signal is then converted down to 105 MHz by heterodyning the 2.095 GHz with the 2nd LO signal frequency of 2.2 GHz. The Tracking Generator converts 105 MHz to 2.095 GHz by using the 2nd LO signal (2.2 GHz) in a phase-lock loop. This 2.095 GHz is then mixed with the 1st LO signal of 2.995 GHz to generate an output of 900 MHz.

The Tracking Generator 2.095 GHz oscillator is phase-locked 105 MHz below the Spectrum Analyzer 2nd LO frequency. This difference frequency, from the mixer, is maintained at 105 MHz by dividing it down to 52.5 MHz and comparing this to a 52.5 MHz crystal controlled oscillator. A voltage that is proportional to the phase difference is fed back as an error signal to keep the 2.095 GHz oscillator offset 105 MHz below the 2nd LO input signal.

The 2.095 GHz signal is passed through a coupler to couple off signal for the phase-lock loop, a normalizing attenautor to establish amplitude level, a 2.2 GHz low-pass filter to attenuate harmonics and upper sidebands from the output mixer, a second leveling attenuator, a isolation amplifier, and a 6 dB attenuator into the output mixer. The isolation amplifier prevents energy from the output mixer feeding back into the 2.095 GHz oscillator and the phase-lock mixer circuit. At zero frequency the 1st LO is near 2.095 GHz which, if allowed to feed back to the 2.095 GHz oscillator, would disable the phase-lock operation. The 6 dB attenuator provides the proper impedance termination into the output mixer to reduce the effects of VSWR characteristics of the isolation amplifier.

The conversion loss through the output mixer is constant with frequency. The amplitude level of the IF signal tracks the amplitude of the RF signal with about 6 dB to 8 dB of loss. The IF level is therefore set by controlling the RF input level. A constant output level is maintained by means of a feedback amplifier loop that controls the attenuation between the 2.095 GHz signal path and the output mixer. The forward signal path through the attenuator affects the signal level at the level detector. The feedback path applies this level to the leveling attenuator as a correction signal so the output remains constant over the frequency range of the instrument.

The input signal from the 1st LO is about 3 mW. This is amplified by the input amplifier so the level into the output mixer is between 5 mW to 10 mW. Harmonics of the input signal frequencies are blocked by the 2.1 GHz to 3.9 GHz bandpass filter. Good termination for the amplifier and bandpass filter is provided by the two isolators. Isolation between the output mixer and the 1st LO is provided by the two isolators and the amplifier. This isolation and the filter prevent signals in the 0 to 1.8 GHz range from getting back into the Spectrum Analyzer. These signals, if allowed to feedback to the Spectrum Analyzer, would degrade the analyzer sensitivity and cause the baseline of the display to lift.

DETAILED DESCRIPTION

RF and Microwave Circuits

The RF section consists of microwave assemblies that include microwave integrated circuits in metal enclosures. Because repair of these assemblies requires special techniques and equipment we recommend replacing the entire assembly if it should fail. The diagrams for these assemblies show only the basic configuration and illustrate their function and dc paths between the external connectors.

The input signal from the Spectrum Analyzer 1st LO is amplified to a level of about 10 mW by the 2.1 GHz to 3.9 GHz amplifier. Gain of the amplifier is nominally 6 dB. This amplifier operates as a limiter and provides a relatively constant output over a wide range of input signal levels. This limiting action provides a constant LO signal level to the output mixer when the TR 501 is interfaced with different Spectrum Analyzers.

The 2 to 4 GHz isolators have less than 0.4 dB loss in the forward direction and more than 20 dB loss in the reverse direction. The 4.5 GHz low-pass filter is a tubular type filter used to attenuate the re-entrant load frequency of the interdigital bandpass filter (third multiple of its pass band). This bandpass filter attenutates harmonics of 2.1 GHz to 3.9 6GHz signals generated by the Spectrum Analyzer and the saturated 2.1 GHz to 3.9 GHz amplifier. This filter also attenuates any 0 to 1.8 GHz and 4.2 GHz to 6 GHz signals that return from the output mixer of the TR 501.

The mixer requires about 5 mW into the LO port and a nominal −24 dBm into the RF port. The IF output of the mixer is about −30 dBm over the frequency range of 0 to 1.8 GHz.

The 2nd LO signal from the Spectrum Analyzer is applied through a 20 dB attenuator, a 2.2 GHz low-pass filter, and a four-cavity bandpass filter to the mixer. The 2.2 GHz low-pass filter attenuates or blocks the re-entrant modes (6.6 GHz and 11.0 GHz) of the multi-cavity bandpass filter. The pass band of the filter is narrow enough to attenuate the 2.095 GHz oscillator signal and prevent it from getting back into the Spectrum Analyzer. Adjustment of the bandpass filter response is accomplished by the four tuning screws, one for each cavity. The signal then passes to a two-diode balanced mixer where it is mixed with the 2.095 GHz oscillator signal.

The 105 MHz IF signal from the mixer is passed through a directional coupler and an all-pass network to the 105 MHz amplifier. The all-pass network terminates the high frequencies that come through the directional coupler.

The 2.095 GHz oscillator uses a resonant micro-strip line in the collector of a common base transistor to establish its frequency. It is tuned a small amount (about 20 MHz) by varying the collector voltage to change the collector-to-base capacitance.

The 2.095 GHz signal is fed from the directional coupler to a PIN diode attenuator with the diode operating as a variable resistor. The circuit is basically a "T" type attenuator with the resistance of the diode the inverse of the current. As the current increases the diode resistance varies from open circuit to about 5 Ω (current increase from 0 to about 5 mA). This variable allows for the initial adjustment of the output level range.

The 2.2 GHz low-pass filter attenuates harmonics of the 2.095 GHz frequency in the forward direction, and higher frequencies (i.e., 3.9 GHz and higher) that get through the isolation amplifier from the output mixer.

The leveling attenuator is constructed the same as the normalizing attenuator. The isolation amplifier gain is about 7 dB with greater than 20 dB of reverse isolation. Its output drives the mixer through a 6 dB attenuator.

The lower sideband frequencies from the mixer pass through a 3 dB attenuator and low-pass filter to the wideband amplifier. The 3 dB attenuator provides a wideband (to 6.6 GHz) termination for the mixer. The low-pass filter attenuates 2.095 GHz and its upper sideband frequency components (that come out of the mixer) from reaching the wideband amplifier.

The low-pass filter is flat to 1.8 GHz and rolls off with a sharp notch around 2.095 GHz. The 0 to 1.8 GHz signal is then amplified about 40 dB by the wideband amplifier, then passed through another 1.8 GHz low-pass filter to the power divider and level detector.

The 1.8 GHz low-pass filter attenuates harmonic frequencies above 1.8 GHz which may be generated by the amplifier. Harmonic distortion increases as the signal frequency approches and exceeds 1.8 GHz.

The level detector is a directional peak detector that senses the forward power but not the reflected or reverse power. Forward power is independent of the load. Power loss through the divider to the RF OUT connector is about 6 dB and 9.5 dB to the AUX OUT connector. Power at the AUX OUT port is therefore about 3.5 dB below the power at the RF OUT port. The output attenuator provides calibrated 1 dB steps of output power to the RF OUT connector.

Bias Circuitry and Leveling Loop

Bias for the amplifiers, in the microwave assembly and the isolation amplifier, is supplied by five bias supplies (U150, U160, U170, U180, and U240) on the bias circuit board. The bias circuits and amplifier are connected as a feedback loop with the collector load current of the amplifier sensed as a voltage by the input resistor (R_i) to the operational amplifier. This voltage is compared to a +10 V reference. The amplifier output drives the base of the rf amplifier to set the bias. The collector voltage is therefore held constant at +10 V. The load resistors for the output amplifiers are R140, R162, R174, and the resistor in the microwave assembly for the last amplifier stage. These resistors set the collector currents of the first two amplifiers at about 10 mA, the third at 20 mA, and the last at 30 mA. The load resistor for the isolation amplifier is R242. Collector current is about 15 mA.

The +10 V reference for the bias circuits is generated by a voltage regulator circuit using an operational amplifier U250. The reference for the regulator is a 6.2 V Zener diode VR258 which sets the voltage level at the inverting input of the amplifier. The amplifier boosts this voltage to +10 V. The +10 V supply provides the bias current for the 6.2 V Zener. A 7.2 V Zener (VR250) is connected from the output to the +15 V supply to start the regulator. As soon as the output of the regulator exceeds 7.2 V the Zener diode no longer draws current and does not affect regulator operation.

Diode CR250, between the +15 V line and ground, protects the microwave circuitry from any unintentional application of negative voltage on the line.

The leveling loop consists of a level detector and temperature compensating diode driving a differential amplifier. The output of the amplifier drives another amplifier which sets the attenuation of the leveling attenuator. The diodes are biased so their output is approximately +0.4 V with no power into the detector. The output of the diodes drive the inputs of a differential amplifier U200. The output of the compensation diode is summed with a voltage set by the leveling control circuit. The temperature compensating diode compensates detector output changes due to temperature. As the power into the detector increases, the output is an average signal that is below +0.4 V with the positive excursions of the signal clamped at 0.4 V.

U200 is an operational amplifier configured as an integrator. Its output is a signal around the reference level set by the voltage at the non-inverting input. This reference voltage depends on the output of a voltage divider network, consisting of adjustments R225, R220, R222, and the front panel VAR dB control. Min Output Level adjustment R225, sets the offset constant or minimum level. Max Output Level adjustment R220, sets the range of the VAR dB control to about 2 dB and R222, shapes the response of the output level versus the rotation of the control so the dial is calibrated in dB. A 6.2 V Zener diode (CR262) sets the reference for the output level control circuitry.

Phase Lock

The 2.095 GHz oscillator in the TR 501 is phase locked to the 2.2 GHz signal from the Spectrum Analyzer. The difference signal (105 MHz) from the mixer is amplified through four amplifier stages, then divided by 2 to 52.5 MHz and compared with a 52.5 MHz crystal-controlled oscillator signal. A voltage that is proportional to the phase difference is fed back to correct the phase of the 2.095 GHz oscillator so that its resultant output is locked 105 MHz below the 2nd LO of the Spectrum Analyzer.

U500 and U540 are differential amplifiers with emitter follower outputs. The differential output of U500A drives the differential input of U500B and the output of U540B drives the differential input to U540A. Gain of each stage is about 15 dB. The output level of the amplifier stages remains relatively constant over an input level range from −45 dBm to +10 dBm. This output is applied to a divide-by-two counter (U550) and the resultant 52.5 MHz is applied to the phase/frequency detector U545 for comparison to the 52.5 MHz crystal oscillator signal.

The reference 52.5 MHz signal from the crystal-controlled oscillator U520A is applied through a buffer stage U520B to the other input of the phase/frequency detector. The crystal operates in its third overtone which is selected by the low Q resonant circuit tuned by C524. The frequency can be tuned through 52.5 MHz by C530 and the voltage that is applied to the variable capacitance diode CR526. Bias to the diode is varied by the front panel TRACKING ADJUST control R10. (Voltages for the adjustment are supplied by U365B.) This control allows the operator to set the TR 501 output frequency at the Spectrum Analyzer input frequency or offset the frequency a slight amount.

The output of the detector is applied to a compensating amplifier U365A, Q420. The compensating amplifier is connected as an operational amplifier with a buffered output that drives the collector of the 2.095 GHz transistor oscillator. Q440 limits the output current if the output should inadvertently be shorted.

Transistors Q445 and Q430 are the active components for a anti-latch circuit. This circuit, when activated, drives the compensating amplifier so its output tune voltage causes the 2.095 GHz oscillator to search through a frequency band until it locks to the 2.2 GHz 2nd LO frequency of the Spectrum Analyzer. When the tune voltage drops to +3 V or less, Q445 is cut off. The collector voltage rises towards Vcc and allows C432 to charge through R438 and R444 until it reaches 0.7 V above the gate potential of the programmable unijunction transistor Q430. When the programmable unijunction transistor turns on, the charge on the capacitor C432 is transferred to the cathode and through CR432 to the non-inverting input of the operational amplifier and capacitor C428. The output of the compensating amplifier steps positive to about +18 V then decays at a linear rate towards 0 V. As it passes through the voltage required to generate an oscillator frequency that will lock to the 2nd LO of the Spectrum Analyzer, the phase lock circuit regains control. If the oscillator fails to start or lock, the cycle repeats.

Q410 is the current source for the 2.095 GHz oscillator. Q480 is the +20 V supply source for U365 and Q430—Q445.

Power Supply Regulators

Three power supply regulators (U350, U370, and U390) provide regulated +15 V, −15 V, and +5 V, for instrument power. These IC regulators use external pass transistors that are located in the TM 500 mainframe (positive supplies) and on the mother board of the TR 501 (−15 V supply). All are short-circuit limited with foldback current limiting. For example; the −15 V supply (U390) current sensing resistor is R394, the foldback circuit includes R398, R396. If current delivered to the load becomes excessive, the voltage drop across R394 will be enough to turn the current-limiting transistor Q395 on. This decreases the current through the pass transistor Q390 and limits the current to the load. Foldback current is approximately 50 mA (1 V/20 Ω). Power dissipation in the pass transistor is about 1 watt (50 mA x 20 V). If the −15 V line is shorted to ground, the current is limited to about 35 mA (0.7 V/20 Ω). Power dissipation is now about 1.2 watts (35 mA x 35 V).

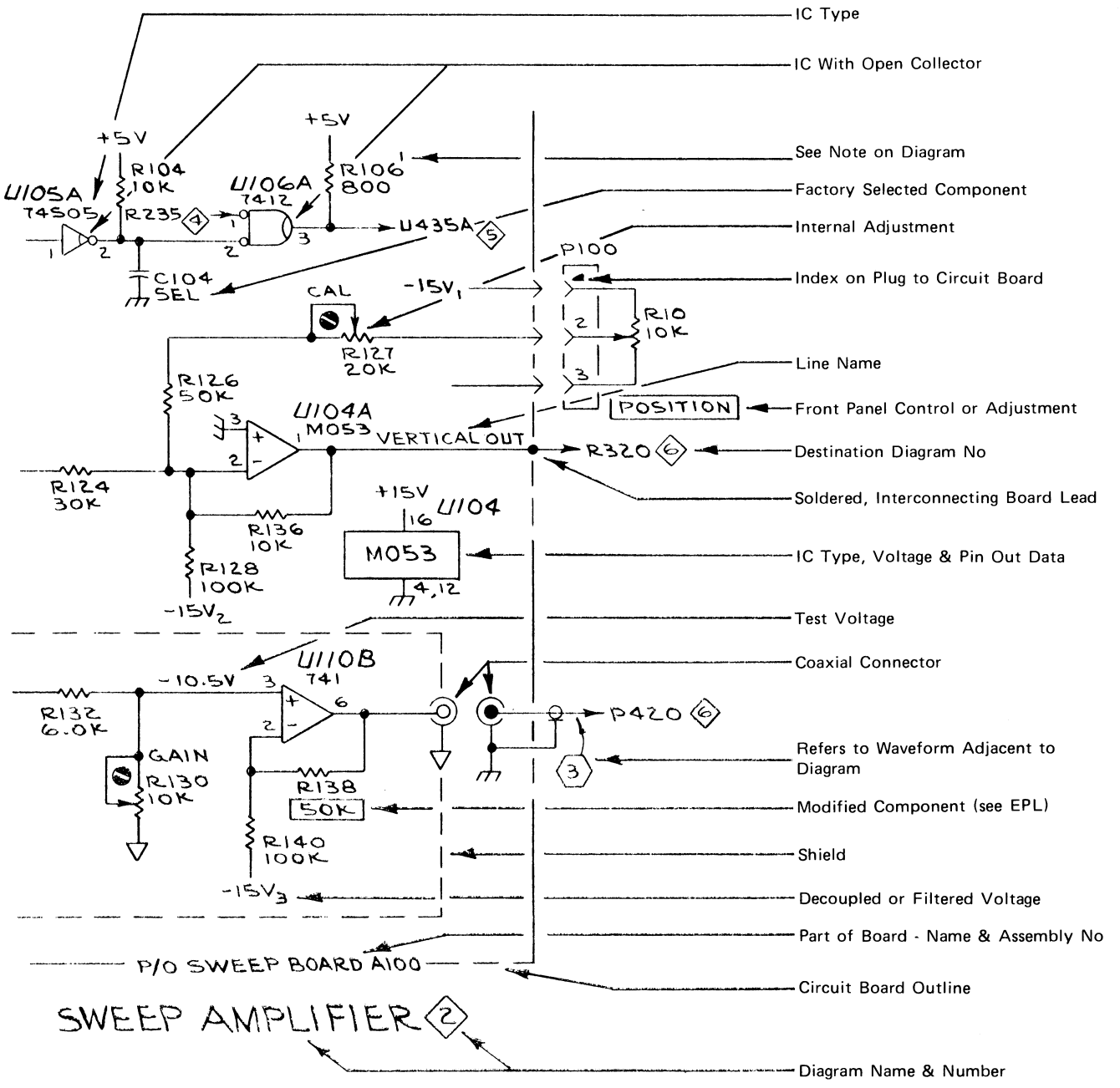
Q410 is th 25 mA current source for the 2.095 GHz oscillator. Q480 is the output of the +20 V supply for the compensation amplifier circuitry.

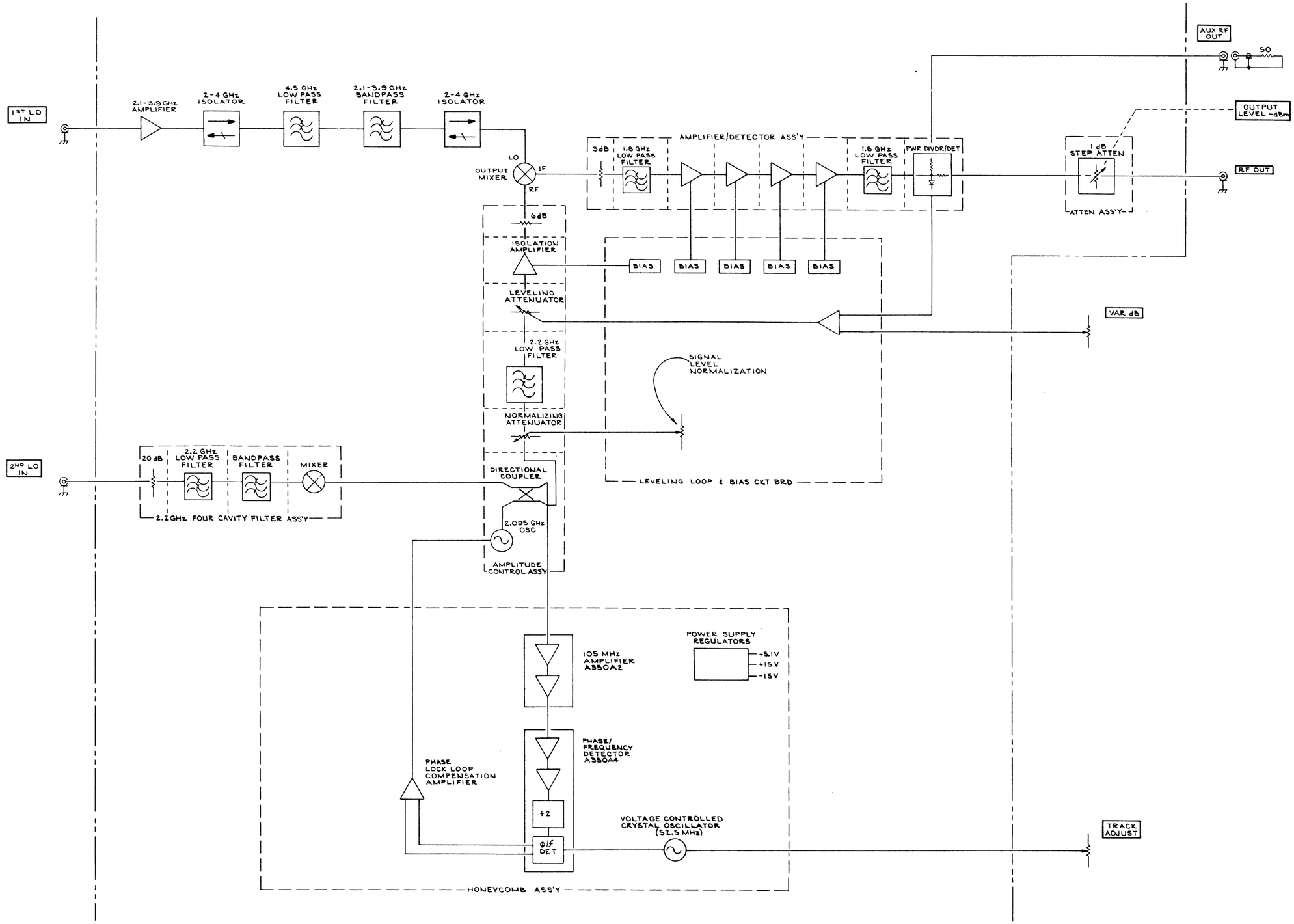
DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols and Reference Designators

Graphic symbols for electrical components and logic symbols, used on the diagrams, are based on ANSI Y32.2, 1970, and ANSI Y32.14, 1973, "American National Standards Institute." Logic symbols depict the logic function of the device in positive logic. Copies of these standards can be obtained from the Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, N.Y., 11017. Exceptions and additions to the graphic and logic symbols are shown on this sample diagram or they conform to the manufacturers data sheet or industry trends.

Resistor values are in ohms, unless noted otherwise, and the Ω symbol is omitted. Capacitor values ≥1 (e.g. 10) are in picofarads (pF) and values <1 (e.g. 0.01) are in microfarads unless otherwise noted.

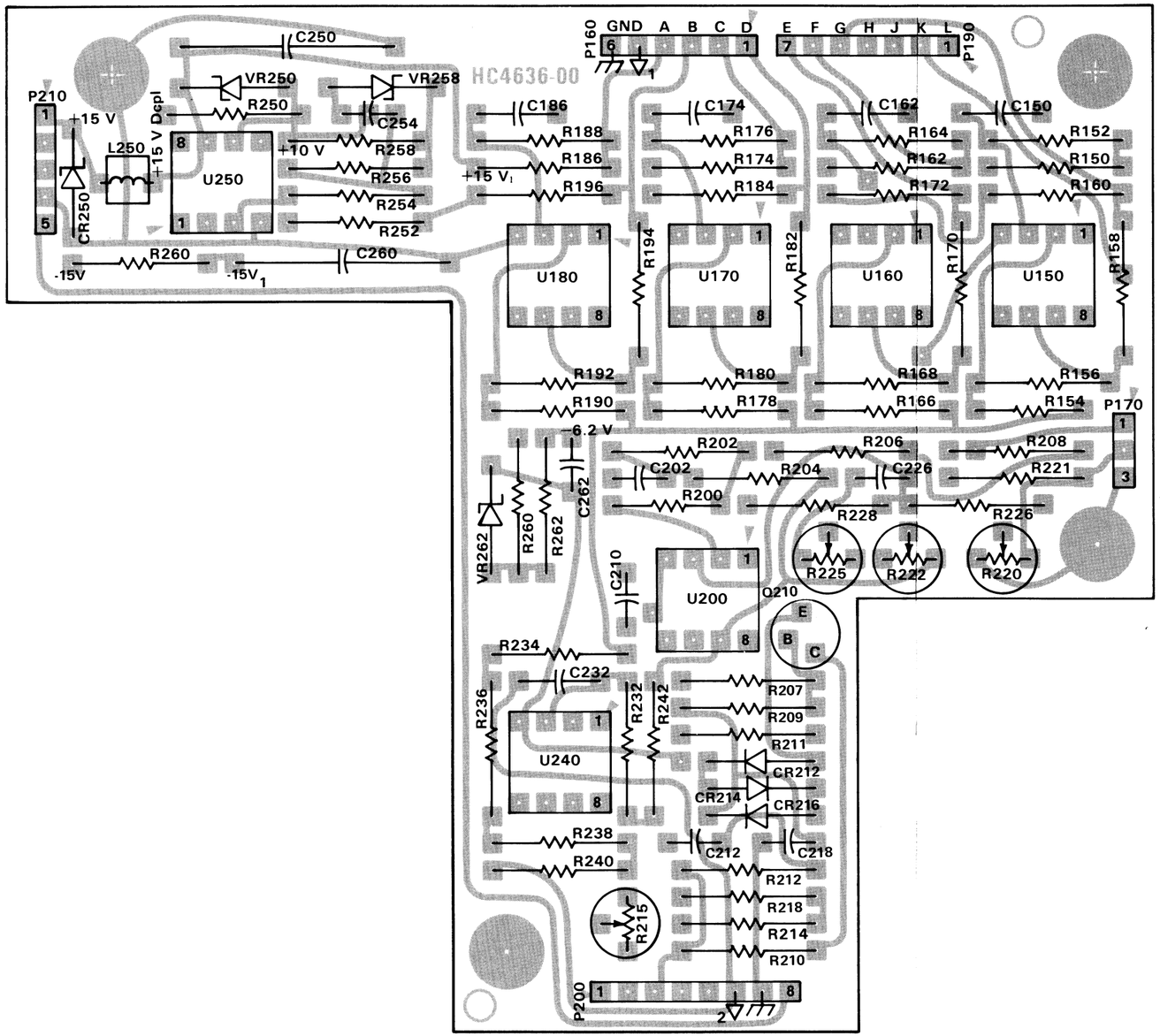




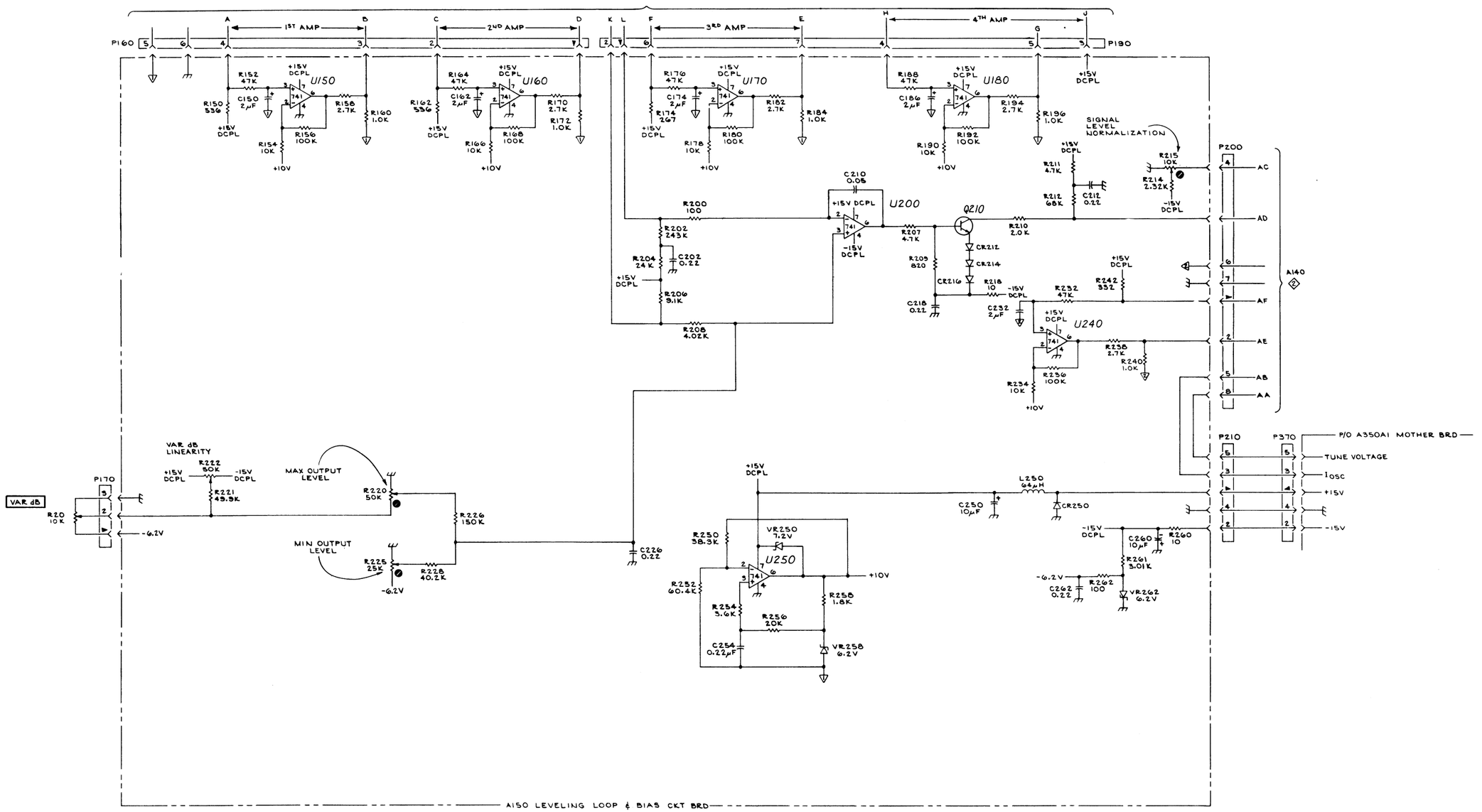
TR 501

BLOCK DIAGRAM 1

1ST LO IN
A60
2.1 - 3.9 GHz AMPLIFIER
INPUT
OUTPUT
A70
2-4 GHz ISOLATOR
P380
3
W75
A80
4.5 GHz LOW-PASS FILTER
W85
A90
2.1 - 3.9 GHz BANDPASS FILTER
W85
A100
2-4 GHz ISOLATOR
W105
A110
OUTPUT MIXER
LO
IF
RF
RF INPUT Z0 = 50Ω
AMPLITUDE CONTROLLED OUTPUT
A120 0.1-1800 MHz AMPLIFIER/DETECTOR ASSEMBLY
3dB
1.8 GHz LOW-PASS FILTER
WIDEBAND AMPLIFIER
WIDEBAND AMPLIFIER
WIDEBAND AMPLIFIER
WIDEBAND AMPLIFIER
1.8 GHz LOW-PASS FILTER
PWR DIVDR/DET
AUX OUT
W120
P120
AUX RF OUT
A130
1dB STEPS
ATTEN ASSY
RF OUT
W130
RF OUT
B
A
D
C
E
F
G
H
J
L
K
GND SENSE
BASE 1
COLLECTOR 1
BASE 2
COLLECTOR 2
BASE 3
COLLECTOR 3
BASE 4
COLL SENSE 4
COLL SUPPLY 4
DETECTOR DIODE
TEMPERATURE COMPENSATION DIODE
P190 3
P160 3
A140 2.095 GHz OSCILLATOR & AMPLITUDE CONTROL ASSEMBLY
6dB
ISOLATION AMPLIFIER
AF
COLLECTOR
AE
BASE
LEVELING ATTENUATOR
AD
LEVELING ATTENUATOR
2.2 GHz LOW-PASS FILTER
P200-4
GND SENSE
P200-5
P200 3
NORMALIZING ATTENUATOR
AC
NORMALIZING ATTENUATOR
FROM LEVELING LOOP & BIAS BRD
I OSC
TUNE VOLTAGE
AB
AA
2.095 GHz OSCILLATOR
W10
IF OUTPUT
TO A350 105 MHz AMPLIFIER
A310 MIXER ASSEMBLY
A320 2.2 GHz FOUR CAVITY FILTER ASSEMBLY
BANDPASS FILTER
2.2 GHz LOW-PASS FILTER
20dB
LO OUTPUT/ IF INPUT
J310
2ND LO IN



A150 Leveling Loop & Bias Ckt Brd

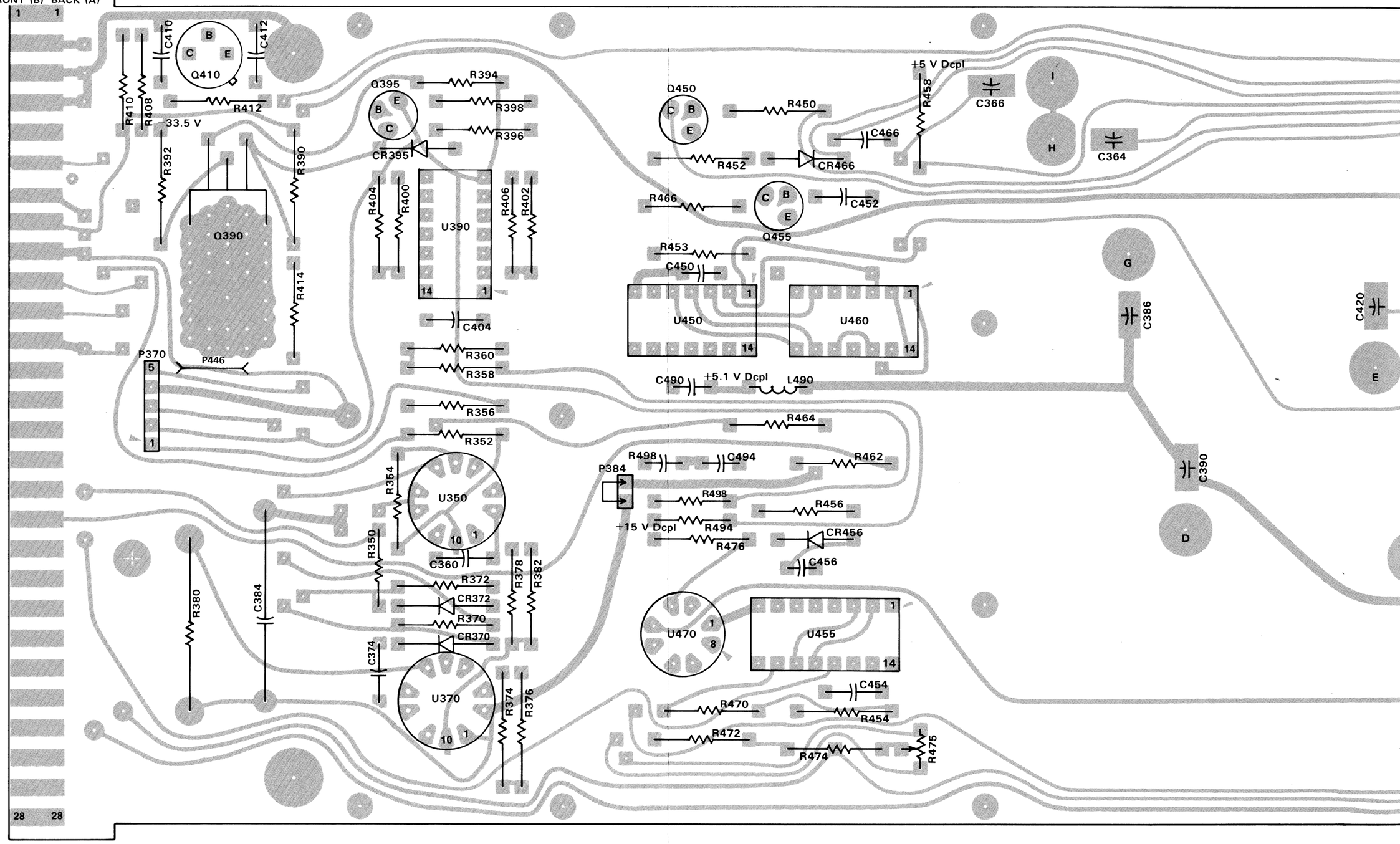


TR 501

LEVELING LOOP & AMPLIFIER BIAS CIRCUITRY ◇3

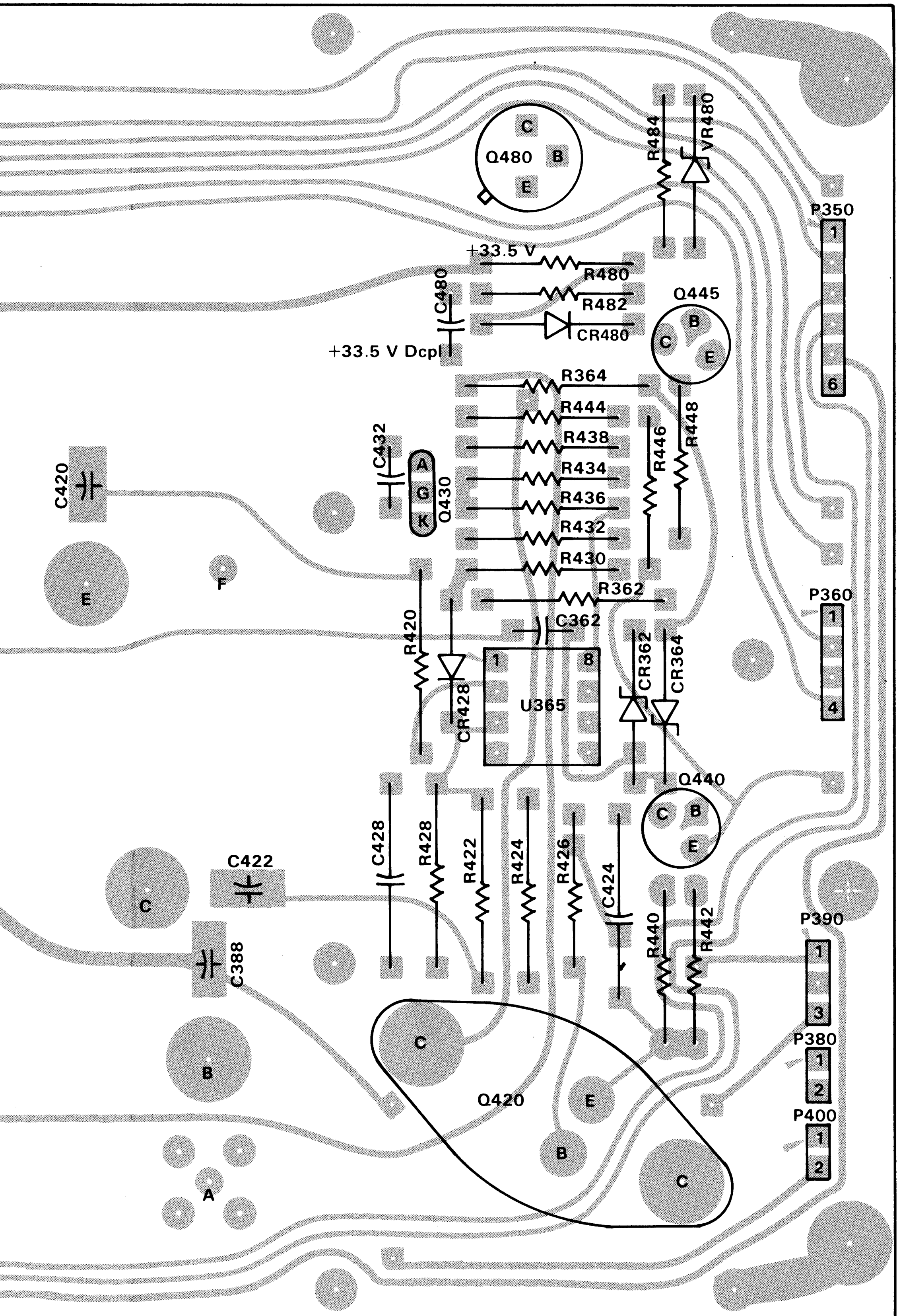
TR 501

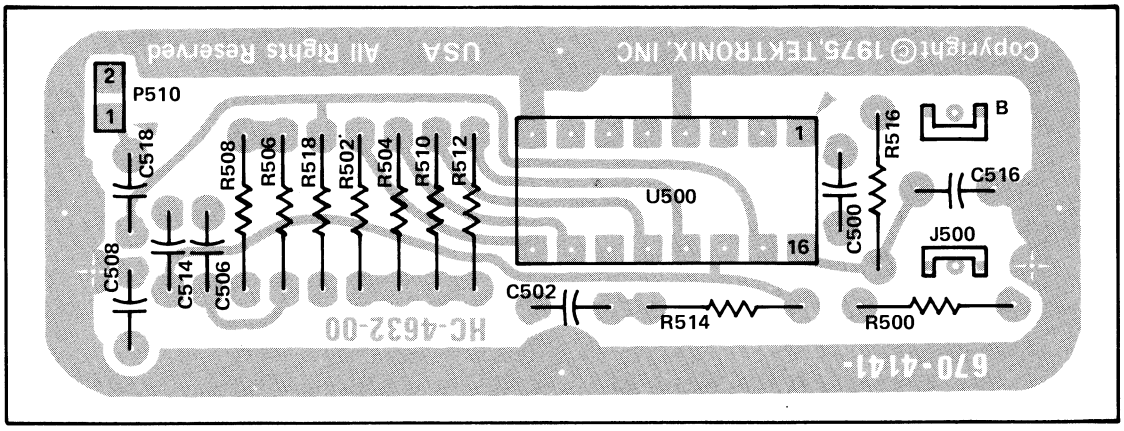
FRONT (B) BACK (A)



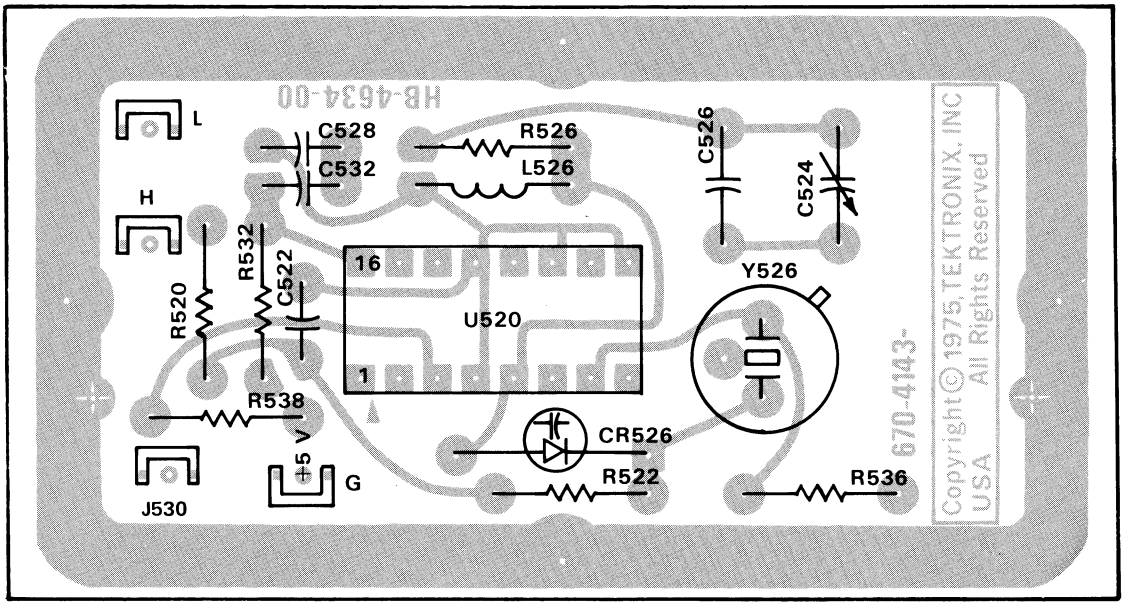
A350A1 Mother Board

COMPONENT LOCATION
FOR DIAGRAM 4

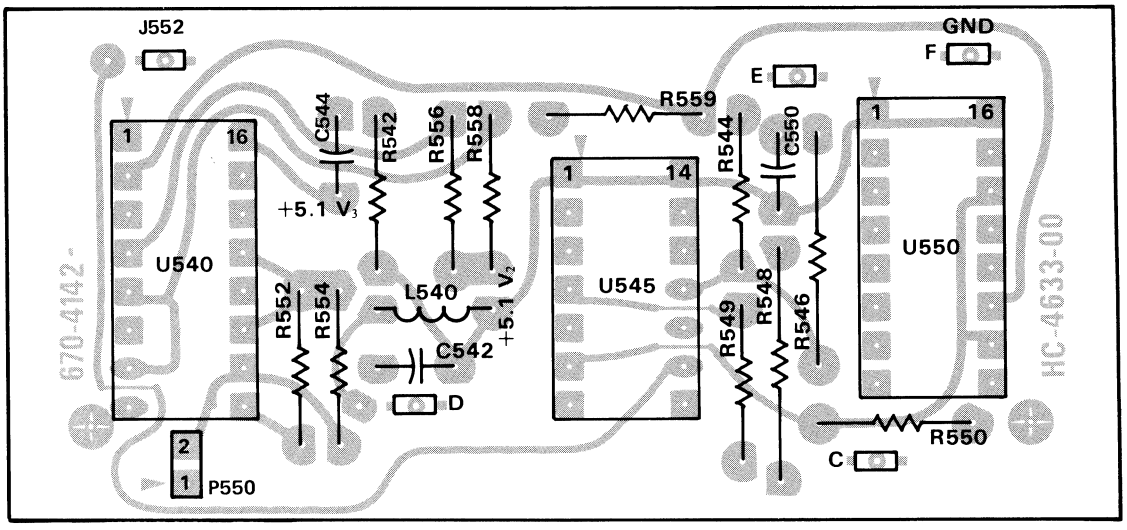

Q480
C
B
E
R484
VR480
P350
1
6
+33.5 V
R480
C480
R482
CR480
+33.5 V Dcpl
Q445
B
C
E
R364
R444
R438
R434
R436
R432
R430
R362
R446
R448
C432
A
G
K
Q430
C420
E
F
R420
CR428
C362
1
8
U365
CR362
CR364
P360
1
4
Q440
C
B
E
C428
R428
R422
R424
R426
C424
R440
R442
C422
C
C388
P390
1
3
P380
1
2
P400
1
2
B
C
Q420
E
B
C
A



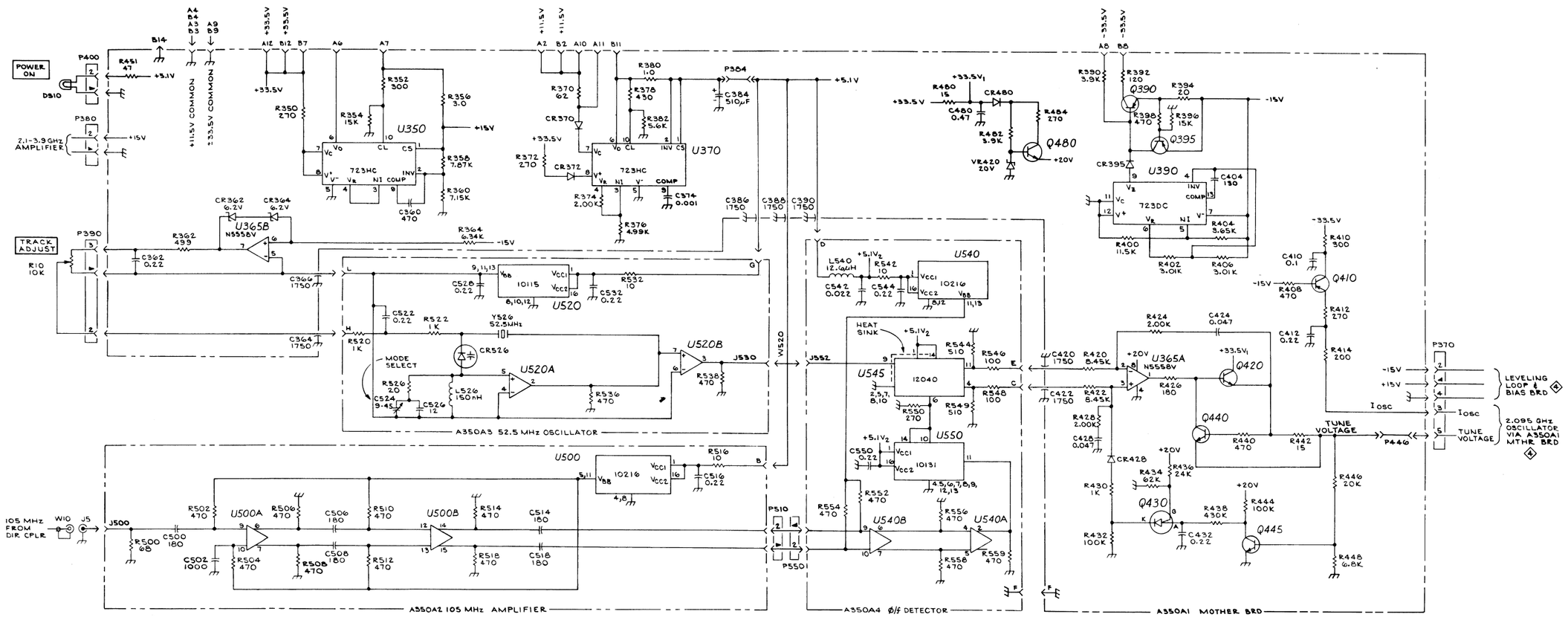
A350A2 105 MHz Amplifier



A350A3 52.5 MHz Oscillator



A350A4 ϕ/f Detector



TR 501

OPERATIONAL LOGIC, VOLTAGE REGULATOR & PHASE LOCK CIRCUITRY 4

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
01002	GENERAL ELECTRIC CO., INDUSTRIAL AND POWER CAPACITOR PRODUCTS DEPT.	JOHN ST.	HUDSON FALLS, NY 12839
01121	ALLEN-BRADLEY CO.	1201 2ND ST. SOUTH	MILWAUKEE, WI 53204
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
08806	GENERAL ELECTRIC CO., MINIATURE LAMP PRODUCTS DEPT.	NELA PK.	CLEVELAND, OH 44112
12969	UNITRODE CORP.	580 PLEASANT ST.	WATERTOWN, MA 02172
14099	SEMTECH CORP.	652 MITCHELL ROAD	NEWBURY PARK, CA 91320
22526	BERG ELECTRONICS, INC.	YOUK EXPRESSWAY	NEW CUMBERLAND, PA 17070
56289	SPRAGUE ELECTRIC CO.		NORTH ADAMS, MA 01247
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
80009	TEKTRONIX, INC.	P. O. BOX 500	BEAVERTON, OR 97077

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A60	119-0738-00			2.1-3.9 GHZ AMPLIFIER ASSY	80009	119-0738-00
A70	119-0633-00			2-4 GHZ ISOLATOR		
A80	015-1027-00			4.5 GHZ LOWPASS FILTER ASSY	80009	015-1027-00
A90	119-0751-00			2.1-3.9 GHZ BANDPASS FILTER ASSY	80009	119-0751-00
A100	119-0633-00			2.4 GHZ ISOLATOR		
A100	119-0732-00			OUTPUT MIXER ASSY	80009	119-0732-00
A120	119-0736-00			0.1-18000 MHZ AMPL/DET ASSY	80009	119-0736-00
A130	672-0562-00			ATTENUATOR,0-11 DB	80009	672-0652-00
A140	119-0737-01			2.095 GHZ OSC AND AMPLITUDE CONTROL ASSY	80009	119-0737-01
A150	670-4145-00			CKT BOARD ASSY:LEVELING LOOP AND BIAS	80009	670-4145-00
A310	119-0306-03			MIXER ASSY:	80009	119-0306-03
A320	119-0735-01			2.2 GHZ 4 CAVITY FILTER ASSY	80009	119-0735-01
A350	644-0076-00			HONEYCOMB ASSY:		
A350A1	670-4304-00			CKT BOARD ASSY:MOTHER	80009	670-4304-00
A350A2	670-4141-00			CKT BOARD ASSY:105 MHZ AMPLIFIER	80009	670-4141-00
A350A3	670-4143-00			CKT BOARD ASSY:52.5 MHZ OSCILLATOR	80009	670-4143-00
A350A4	670-4142-00			CKT BOARD ASSY:Q FREQUENCY DETECTOR	80009	670-4142-00
C150	283-0212-00			CAP.,FXD,CER DI:2UF,20%,50V	72982	8141050651205M
C162	283-0212-00			CAP.,FXD,CER DI:2UF,20%,50V	72982	8141050651205M
C174	283-0212-00			CAP.,FXD,CER DI:2UF,20%,50V	72982	8141050651205M
C186	283-0212-00			CAP.,FXD,CER DI:2UF,20%,50V	72982	8141050651205M
C202	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C210	283-0010-00			CAP.,FXD,CER DI:0.05UF,+100-20%,50V	56289	273C20
C212	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C218	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C226	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C232	283-0212-00			CAP.,FXD,CER DI:2UF,20%,50V	72982	8141050651205M
C250	290-0340-00			CAP.,FXD,ELCTLT:10UF,10%,50V	56289	109D106X9050C2
C254	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C260	290-0340-00			CAP.,FXD,ELCTLT:10UF,10%,50V	56289	109D106X9050C2
C262	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C284	290-0513-00			CAP.,FXD,ELCTLT:510UF,+75-10%,25V	01002	69F2336G7
C360	283-0032-00			CAP.,FXD,CER DI:470PF,5%,500V	72982	831-500Z5D471J
C362	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C364	281-0752-00			CAP.,FXD,CER DI:1750PF	80009	281-0752-00
C366	281-0752-00			CAP.,FXD,CER DI:1750PF	80009	281-0752-00
C374	283-0065-00			CAP.,FXD,CER DI:0.001UF,5%,100V	72982	805-505B102J
C384	290-0513-00			CAP.,FXD,ELCTLT:510UF,+75-10%,25V	01002	69F2336G7
C386	281-0752-00			CAP.,FXD,CER DI:1750PF	80009	281-0752-00
C388	281-0752-00			CAP.,FXD,CER DI:1750PF	80009	281-0752-00
C390	281-0752-00			CAP.,FXD,CER DI:1750PF	80009	281-0752-00
C404	283-0256-00			CAP.,FXD,CER DI:130PF,5%,100V	72982	8121B145P3K131J
C410	283-0178-00			CAP.,FXD,CER DI:0.1UF,+80-20%,100V	72982	8131N145651104Z
C412	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C420	281-0752-00			CAP.,FXD,CER DI:1750PF	80009	281-0752-00
C422	281-0752-00			CAP.,FXD,CER DI:1750PF	80009	281-0752-00
C424	285-0882-00			CAP.,FXD,PLSTC:0.047UF,10%,100V	56289	LP66A1B473K001
C428	285-0882-00			CAP.,FXD,PLSTC:0.047UF,10%,100V	56289	LP66A1B473K001
C432	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C480	283-0346-00			CAP.,FXD,CER DI:0.47UF,+80-20%,100V	72982	8131-M100651474Z
C500	283-0103-00			CAP.,FXD,CER DI:180PF,5%,500V	56289	40C638
C502	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C506	283-0103-00			CAP.,FXD,CER DI:180PF,5%,500V	56289	40C638
C508	283-0103-00			CAP.,FXD,CER DI:180PF,5%,500V	56289	40C638
C514	283-0103-00			CAP.,FXD,CER DI:180PF,5%,500V	56289	40C638
C516	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C518	283-0103-00			CAP.,FXD,CER DI:180PF,5%,500V	56289	40C638
C522	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C524	281-0167-00			CAP.,VAR,CER DI:9-45PF,200V	72982	538-011-D 9-45
C526	281-0508-00			CAP.,FXD,CER DI:12PF,+/-0.6PF,500V	72982	301-000C0G0120J
C526	281-0167-00			CAP.,VAR,CER DI:9-45PF,200V	72982	538-011-D 9-45
C528	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C532	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
C542	283-0191-00			CAP.,FXD,CER DI:0.022UF,20%,50V	72982	8121N063651223M
C550	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075651224M
CR212	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR214	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR216	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR250	152-0040-00			SEMICOND DEVICE:SILICON,600V,1A	14099	SC6
CR362	152-0461-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N821
CR364	152-0461-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N821
CR370	152-0242-00			SEMICOND DEVICE:SILICON,225V,200MA	12969	NDP341
CR372	152-0242-00			SEMICOND DEVICE:SILICON,225V,200MA	12969	NDP341
CR395	152-0333-00			SEMICOND DEVICE:SILICON,55V,200MA	80009	152-0333-00
CR428	152-0574-00			SEMICOND DEVICE:SILICON,120V	80009	152-0574-00
CR480	152-0061-00			SEMICOND DEVICE:SILICON,175V,100MA	80009	152-0061-00
CR526	152-0595-00			SEMICOND DEVICE:VOLT-VAR CAP,15%,12 PIV		
DS10	150-0048-01			LAMP,INCAND:NO.683,SELECTED	08806	683AS15
J500	136-0263-02			CONTACT,ELEC:		
J530	136-0263-04			CONTACT,ELEC:FOR 0.025 INCH SQUARE PIN	22526	75377-001
J552	136-0263-04			CONTACT,ELEC:FOR 0.025 INCH SQUARE PIN	22526	75377-001
L250	108-0395-00			COIL,RF:64UH	80009	108-0395-00
L526	108-0707-00			COIL,RF:150NH	80009	108-0707-00
L540	108-0724-00			COIL,RF:12.6UH,TOROIDAL		
P120	015-1025-01			TERMINAL COAX:3MM MALE,50 OHM W/CH		
Q210	151-0103-00			TRANSISTOR:SILICON,NPN	04713	2N2219A
Q390	151-0364-00			TRANSISTOR:SILICON,PNP	03508	X43C181
Q395	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
Q410	151-0136-00			TRANSISTOR:SILICON,NPN	02735	35495
Q420	151-0286-00			TRANSISTOR:SILICON,NPN		
Q430	151-0508-00			TRANSISTOR:SILICON,NPN,UNIJUNCTION	03508	2N6027
Q440	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q445	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q480	151-0136-00			TRANSISTOR:SILICON,NPN	02735	35495
R10	311-1341-00			RES.,VAR,WW:10K OHM,5%,2W		
R20	311-1298-00			RES.,VAR,NONWIR:10K OHM,20%,0.50W	01121	W-7909
R150	321-0167-00			RES.,FXD,FILM:536 OHM,1%,0.125W	75042	CEAT0-5360F
R152	315-0473-00			RES.,FXD,CMPSN:47K OHM,5%,0.25W	01121	CB4735
R154	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R156	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
R158	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	01121	CB2725
R160	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R162	321-0167-00			RES.,FXD,FILM:536 OHM,1%,0.125W	75042	CEAT0-5360F
R164	315-0473-00			RES.,FXD,CMPSN:47K OHM,5%,0.25W	01121	CB4735
R166	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R168	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
R170	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	01121	CB2725
R172	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R174	321-0138-00			RES.,FXD,FILM:267 OHM,1%,0.125W	75042	CEAT0-2670F
R176	315-0473-00			RES.,FXD,CMPSN:47K OHM,5%,0.25W	01121	CB4735
R178	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R180	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
R182	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	01121	CB2725
R184	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R188	315-0473-00			RES.,FXD,CMPSN:47K OHM,5%,0.25W	01121	CB4735
R190	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R192	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
R194	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	01121	CB2725
R196	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R200	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R202	321-0422-00			RES.,FXD,FILM:243K OHM,1%,0.125W	75042	CEAT0-2433F
R204	315-0243-00			RES.,FXD,CMPSN:24K OHM,5%,0.25W	01121	CB2435
R206	315-0912-00			RES.,FXD,CMPSN:9.1K OHM,5%,0.25W	01121	CB9125
R207	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R208	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R209	315-0821-00			RES.,FXD,CMPSN:820 OHM,5%,0.25W	01121	CB8215
R210	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	75042	CEAT0-2001F
R210	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R211	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R212	315-0683-00			RES.,FXD,CMPSN:68K OHM,5%,0.25W	01121	CB6835
R214	321-0228-00			RES.,FXD,FILM:2.32K OHM,1%,0.125W	75042	CEAT0-2321F
R215	311-1268-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	73138	62PT-351-0
R218	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R218	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R220	311-1271-00			RES.,VAR,NONWIR:50K OHM,10%,0.50W	73138	62PT-354-0
R221	321-0356-00			RES.,FXD,FILM:49.9K OHM,1%,0.125W	75042	CEAT0-4992F
R222	311-1271-00			RES.,VAR,NONWIR:50K OHM,10%,0.50W	73138	62PT-354-0
R225	311-1270-00			RES.,VAR,NONWIR:25K OHM,10%,0.50W		
R226	315-0154-00			RES.,FXD,CMPSN:150K OHM,5%,0.25W	01121	CB1545
R228	321-0347-00			RES.,FXD,FILM:40.2K OHM,1%,0.125W	75042	CEAT0-4022F
R232	315-0473-00			RES.,FXD,CMPSN:47K OHM,5%,0.25W	01121	CB4735
R234	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R236	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
R238	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	01121	CB2725
R240	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R242	321-0147-00			RES.,FXD,FILM:332 OHM,1%,0.125W	75042	CEAT0-3320F
R250	321-0345-00			RES.,FXD,FILM:38.3K OHM,1%,0.125W	75042	CEAT0-3832F
R252	321-0364-00			RES.,FXD,FILM:60.4K OHM,1%,0.125W	75042	CEAT0-6042F
R254	315-0362-00			RES.,FXD,CMPSN:3.6K OHM,5%,0.25W	01121	CB3625
R256	315-0203-00			RES.,FXD,CMPSN:20K OHM,5%,0.25W	01121	CB2035
R258	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R260	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R261	321-0237-00			RES.,FXD,FILM:2.87K OHM,1%,0.125W	75042	CEAT0-2871F
R262	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R350	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R352	315-0301-00			RES.,FXD,CMPSN:300 OHM,5%,0.25W	01121	CB3015
R354	315-0153-00			RES.,FXD,CMPSN:15K OHM,5%,0.25W	01121	CB1535
R356	307-0052-00			RES.,FXD,CMPSN:3 OHM,5%,0.50W	01121	EB30G5
R358	321-0279-00			RES.,FXD,FILM:7.87K OHM,1%,0.125W	75042	CEAT0-7871F
R360	321-0275-00			RES.,FXD,FILM:7.15K OHM,1%,0.125W	75042	CEAT0-7151F
R362	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	75042	CEAT0-4990F
R364	321-0270-00			RES.,FXD,FILM:6.34K OHM,1%,0.125W	75042	CEAT0-6341F
R370	315-0620-00			RES.,FXD,CMPSN:62 OHM,5%,0.25W	01121	CB6205
R372	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R374	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	75042	CEAT0-2001F
R376	321-0260-00			RES.,FXD,FILM:4.99K OHM,1%,0.125W	75042	CEAT0-4991F
R378	315-0431-00			RES.,FXD,CMPSN:430 OHM,5%,0.25W	01121	CB4315
R380	308-0677-00			RES.,FXD,WW:1 OHM,5%,2W	75042	BWH-1R000J
R382	315-0562-00			RES.,FXD,CMPSN:5.6K OHM,5%,0.25W	01121	CB5625
R390	301-0392-00			RES.,FXD,CMPSN:3.9K OHM,5%,0.50W	01121	EB3925
R392	301-0121-00			RES.,FXD,CMPSN:120 OHM,5%,0.50W	01121	EB1215
R394	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
R396	315-0153-00			RES.,FXD,CMPSN:15K OHM,5%,0.25W	01121	CB1535
R398	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R400	321-0295-00			RES.,FXD,FILM:11.5K OHM,1%,0.125W	75042	CEAT0-1152F
R402	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	75042	CEAT0-3011F
R404	321-0247-00			RES.,FXD,FILM:3.65K OHM,1%,0.125W	75042	CEAT0-3651F
R406	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	75042	CEAT0-3011F
R408	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R410	315-0301-00			RES.,FXD,CMPSN:300 OHM,5%,0.25W	01121	CB3015
R412	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R414	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
R420	321-0282-00			RES.,FXD,FILM:8.45K OHM,1%,0.125W	75042	CEAT0-8451F
R422	321-0282-00			RES.,FXD,FILM:8.45K OHM,1%,0.125W	75042	CEAT0-8451F
R424	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	75042	CEAT0-2001F
R426	315-0181-00			RES.,FXD,CMPSN:180 OHM,5%,0.25W	01121	CB1815
R428	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	75042	CEAT0-2001F
R430	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R432	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
R434	315-0623-00			RES.,FXD,CMPSN:62K OHM,5%,0.25W	01121	CB6235
R436	315-0243-00			RES.,FXD,CMPSN:24K OHM,5%,0.25W	01121	CB2435
R438	315-0434-00			RES.,FXD,CMPSN:430K OHM,5%,0.25W	01121	CB4345
R440	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R442	315-0150-00			RES.,FXD,CMPSN:15 OHM,5%,0.25W	01121	CB1505
R444	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
R446	315-0203-00			RES.,FXD,CMPSN:20K OHM,5%,0.25W	01121	CB2035
R448	315-0682-00			RES.,FXD,CMPSN:6.8K OHM,5%,0.25W	01121	CB6825
R451	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R480	315-0150-00			RES.,FXD,CMPSN:15 OHM,5%,0.25W	01121	CB1505
R482	315-0392-00			RES.,FXD,CMPSN:3.9K OHM,5%,0.25W	01121	CB3925
R484	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R500	315-0680-00			RES.,FXD,CMPSN:68 OHM,5%,0.25W	01121	CB6805
R502	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R504	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R506	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R508	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R510	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R512	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R514	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R516	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R518	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R520	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R522	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R526	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
R532	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R536	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R538	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R542	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R544	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
R546	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	75042	CEAT0-4990F
R548	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	75042	CEAT0-4990F
R549	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
R550	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R552	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R554	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R556	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R558	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R559	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
U150	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U160	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U170	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U180	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U200	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U240	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U250	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	80009	156-0067-00
U350	156-0053-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR	07263	U5R7723393
U365	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	80009	156-0158-00
U370	156-0053-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR	07263	U5R7723393
U390	156-0071-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR	07263	723DC
U500	156-0369-00			MICROCIRCUIT,LI:TRIPLE LINE REC		
U520	156-0308-00			MICROCIRCUIT,LI:QUAD DIFF LINE RECIEVER	04713	MC10115L
U540	156-0369-00			MICROCIRCUIT,LI:TRIPLE LINE REC		
U545	156-0518-00			MICROCIRCUIT,DI:PHASE FREQ DETECTOR		
U550	156-0230-00			MICROCIRCUIT,DI:DUAL D MA-SLAVE FLIP-FLOP	04713	MC10131L
VR250	152-0461-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N821
VR258	152-0127-00			SEMICOND DEVICE:ZENER,0.4W,7.5V,5%	04713	1N755A
VR262	152-0461-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N821
VR420	152-0304-00			SEMICOND DEVICE:ZENER,0.4W,20V,5%	04713	1N968B
W75	175-1720-00			CABLE ASSY:LOWPASS TO ISOLATOR	80009	175-1720-00
W85	175-1713-00			CABLE ASSY:INTERDIGITAL TO LOWPASS	80009	175-1713-00
W95	175-1716-00			CABLE ASSY:2-4 GHZ TO ISOLATOR	80009	175-1716-00
W105	175-1721-00			CABLE ASSY:MIXER TO ISOLATOR	80009	175-1721-00
W130	175-1756-00			CABLE ASSY:ATTENUATOR TO RF OUT	80009	175-1756-00
Y526	158-0098-00			XTAL UNIT,QTZ:52.5 AT 25 DEG SFR RES		