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Title & Document Type: **4815A RF Vector Impedance Meter Operating and Service Manual**

Manual Part Number: **04815-90011**

Revision Date: **August 1966**

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MODEL 4815A

RF VECTOR IMPEDANCE METER

SERIALS PREFIXED 631

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HP Part No. 04815-90011

Printed: August 1966

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Table 1-1. Specifications

FREQUENCY

Range: 500 kHz to 108 MHz in five bands: 500 kHz to 1.5 MHz, 1.5 to 4.5 MHz, 4.5 to 14 MHz, 14 to 35 MHz, 35 to 108 MHz.

Accuracy: ±2% of reading, ±1% of reading at 1.592 and 15.92 MHz.

RF monitor output: 150 mV minimum into 50 ohms.

IMPEDANCE MAGNITUDE MEASUREMENT

Range: 1 ohm to 100K ohms; full-scale ranges: 10, 30, 100, 300, 1K, 3K, 10K, 30K, 100K ohms.

Accuracy: $\pm 4\%$ of full scale $\pm \left(\frac{f}{30\ \text{MHz}} + \frac{Z}{5\ \text{K}\Omega}\right)\%$ of reading, where f = frequency in MHz and Z in ohms; reading includes probe residual impedance.

Calibration: linear meter scale with increments 2% of full scale.

PHASE ANGLE MEASUREMENT

Range: 0 to 360° in two ranges: 0 ± 90°, 180° ± 90°.

Accuracy: $\pm\left(3 + \frac{f}{30\ \text{MHz}} + \frac{Z}{25\ \text{K}\Omega}\right)$ degrees; where f = frequency in MHz and Z is in ohms.

Calibration: increments of 2°.

Adjustments: front panel screwdriver adjustments for Magnitude and Phase Zero.

RECORDER OUTPUTS

Frequency: 0 to 1 volt from 0 to 1K ohm source, proportional to dial rotation.

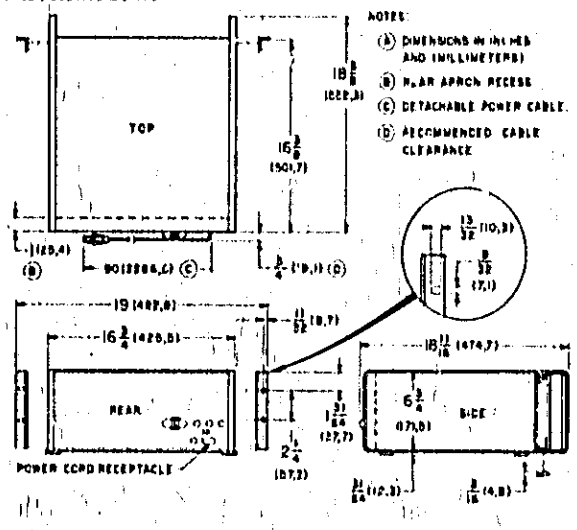
Impedance magnitude: 0 to 1 volt from 1K ohm source.

Phase angle: 0 ± 0.0 volt from 1K ohm source.

ACCESSORIES FURNISHED:

1. 00600A Accessory Kit.
2. Rack Mounting Kit.
3. Plugin board extender.

DIMENSIONS:



WEIGHT: net 39 lbs. (17,6 kg), shipping 50 lbs. (22,5 kg).

POWER: 105 to 125 v or 210 to 250 v, 50 to 400 Hz, 50 w.

Table 1-2. Additional Information

MEASURING TERMINAL CHARACTERISTICS

Configuration: Both excitation and measuring circuits are contained in a single sampling probe attached to instrument by a cable. Measurement is made between probe center pin and ground pin on probe case.

Residuals: Indicated impedance includes approximately 0.5 ohm resistance and 8 nH inductance in series with the unknown, and 0.3 pF capacitance in parallel with the unknown.

Impedance: 25 ohms in series with 0.01 μF, looking into probe. Probe is constant-current driving source to circuit being measured.

TEST SIGNAL CHARACTERISTICS

Waveshape: sinusoidal.

Level: approximately 4 μA on all ranges except 10-ohm scale where it is approximately 13 μA.

External oscillator input: Rear BNC connector accepts excitation signal, 100 mV ±10% into 50 ohms; maximum instantaneous rate of change 1 MHz/s.

RFI CHARACTERISTICS

Conducted and radiated leakage limits are below those specified for MIL-I-6181D, except for RF excitation and sampling pulses emitted from probe. The sampling pulses are approximately 75 mV peak to peak, from 25-ohm source, with a duration of 3 ns occurring at a maximum repetition rate of 1 MHz. Probe may be stored in front panel probe check socket to obtain full compliance with MIL-I-6181D.

SELF-CONTAINED CALIBRATION

Probe check: 100 ohms ±.6% at phase angle of 0° ± 2°.

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Model 4815A RF Vector Impedance Meter (Figure 1-1) is a general purpose, self-contained instrument for measuring complex impedance in a wide variety of laboratory applications as well as production testing of circuits and components. The frequency range is 0.5 to 108 MHz; impedance magnitude is measured in 9 ranges from 10 Ω to 100 KΩ full scale; and phase angle between 0^{0} and 360^{0} is indicated on two ranges.

1-3. Impedance measurement is made at the tip of a probe that is at the end of a 5 ft. cable, with rf test signal and measuring circuits brought close to the probe tip to reduce residual impedances.

1-4. An internal rf oscillator, 0.5 to 108 MHz supplies a test signal to the unknown impedance, 12.6 μa on the 10 ohm range and 4 μa on all other ranges. Provision is made for using an external rf source, particularly useful when measuring quartz crystals and other high Q devices.

1-5. De voltages proportional to magnitude, phase and frequency are available at the rear panel for recording equipment.

1-6. Complete specifications are given in Table 1-1.

1-7. Additional information on the Model 4815A is given in Table 1-2. The characteristics are general design parameters that are useful in the application of the Impedance Meter.

1-8. ACCESSORIES FURNISHED.

1-9. Accessory kit number 00600A is supplied with the 4815A. The kit consists of adapters for probe to BNC and Type N connectors, a probe socket for use on circuit boards, a component mounting adapter, probe holder, probe ground assembly and center pins. The probe accessories are described in detail in Paragraphs 1-9 to 1-16 and shown in Figure 1-1 and 1-2. Also supplied is a rack mounting kit with hardware (-hp- Stock No. 5060-0776) and a circuit board extender for servicing.

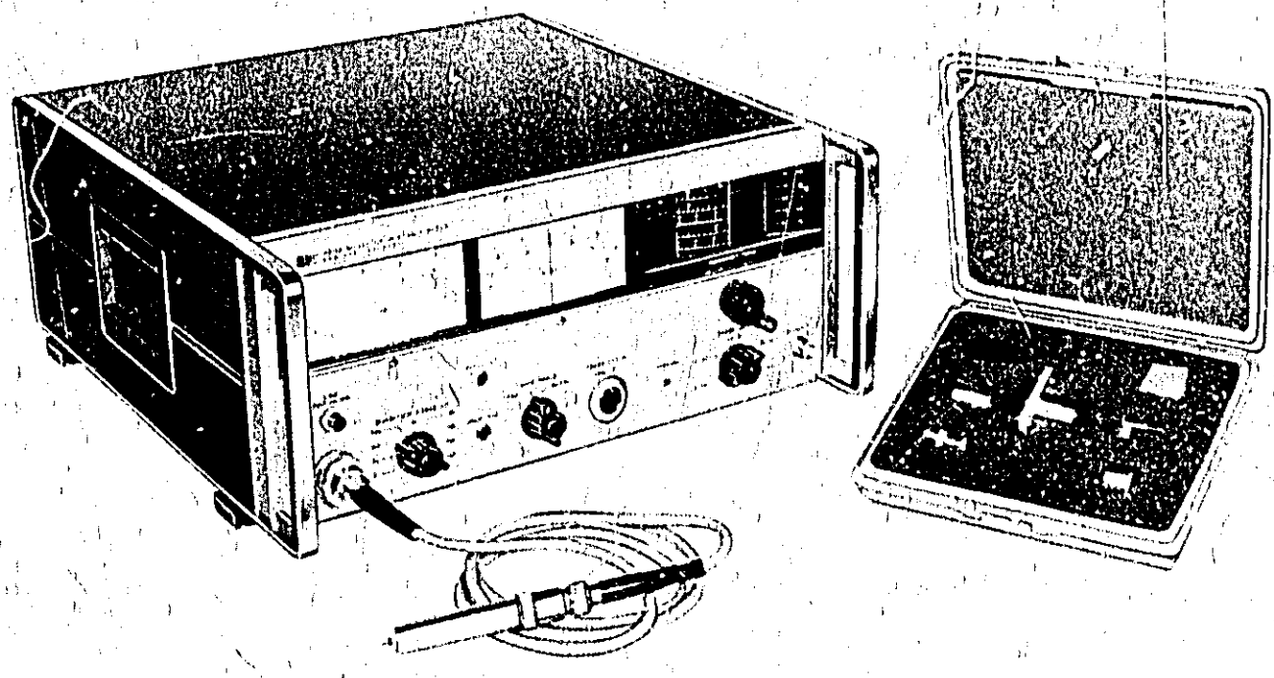


Figure 1-1. Model 4815A RF Vector Impedance Meter with 00600A Probe Accessory Kit

1-10. PROBE ADAPTER. This adapter converts the probe tip to a male type N connector and is available under accessory number 10206A.

1-11. PROBE TO BNC ADAPTER. With the use of the 10206A accessory, this adapter converts the probe tip to a male BNC connector and is available under accessory number 10207A.

1-12. PROBE SOCKET. This socket supports the probe and guides the center pin to the test point. An excellent ground return is obtained with the socket, which is available under accessory number 10210A.

1-13. COMPONENT MOUNTING ADAPTER. This adapter allows many types of components to be measured with minimum addition of residual impedance to affect measurements, and is separately available as accessory number 00601A.

1-14. PROBE GROUND ASSEMBLY is a grounding device that may be positioned at a convenient point on the probe barrel. A spring-loaded pin makes ground contact. This accessory is available as -hp- Stock No. 187B-21A-8.

1-15. PROBE CENTER PINS. Six additional center pins are supplied against possible damage or loss. The small-diameter end of the center pin is inserted into the mating jack in the probe tip.

1-16. PROBE HOLDER. This accessory clips onto the front handle of the 4815A to hold the probe when not in use, and is available separately as -hp- Stock No. 5040-0404

1-17. ACCESSORIES AVAILABLE.

1-18. SHIELDED BANANA PLUGS TO FEMALE BNC. This adapter converts banana post inputs to shielded BNC, and is available as accessory 1011A. The adapter has approximately 10 pF shunt capacity.

1-19. INSTRUMENT IDENTIFICATION.

1-20. Each Model 4815A is identified by an eight-digit (000-00000) serial number on the rear panel. The five digit number is an identification number unique to each instrument and the three digit number is a serial prefix number used to document changes.

1-21. All instruments with the same serial prefix are the same. The group of instruments to which this manual applies directly is identified on the title page. For instruments with serial numbers higher than those listed on the title page, a Manual Change sheet describing the changes is included with the manual. The manual for an instrument having special electrical modifications will include an insert sheet describing that modification. If a change sheet or special information sheet is missing, the information can be supplied by any Hewlett-Packard Sales and Service Office listed at the back of this manual.

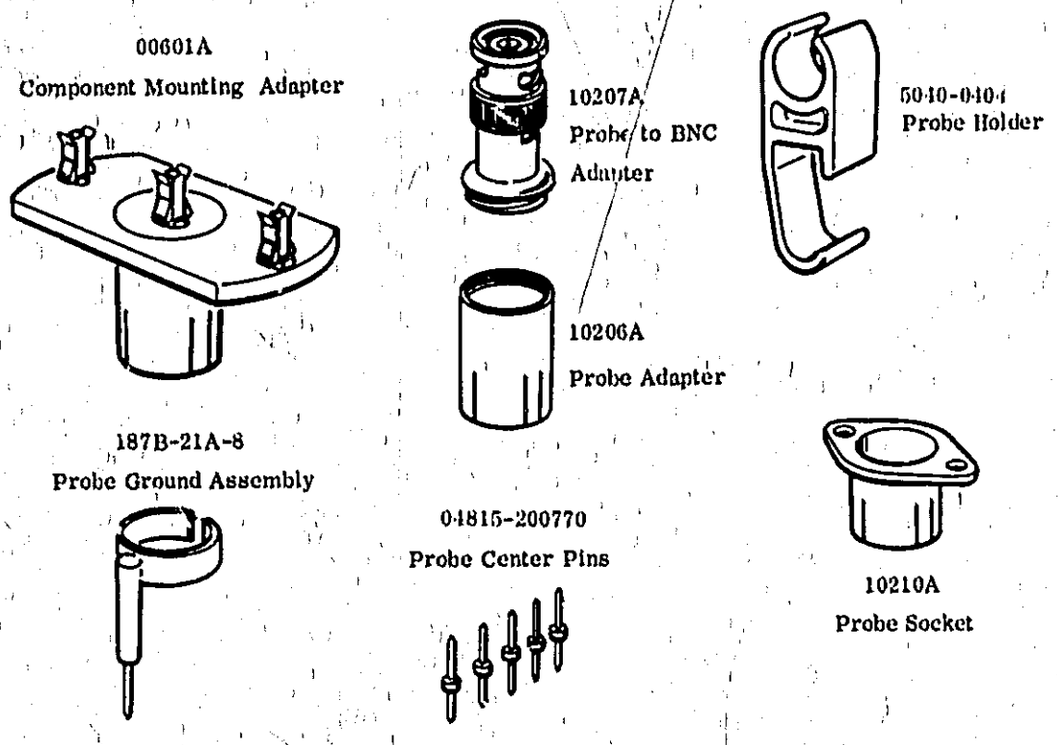


Figure 1-2. Probe Accessories

SECTION II
INSTALLATION

2-1. INITIAL INSPECTION.

2-2. Mechanical Check. If damage to the shipping carton is evident, ask that the carrier's agent be present when the instrument is unpacked. Inspect the instrument for mechanical damage (scratches, dents, broken knobs, etc.). Also check the cushioning material for signs of severe stress as an indication of rough handling in transit.

2-3. Performance Check. The electrical performance of the Model 4815A should be verified as soon as possible after receipt. A performance check that is suitable for incoming inspection is given in Section V.

2-4. Claim for Damage. If Model 4815A is mechanically damaged or fails to meet specifications on receipt, notify the carrier and the nearest Hewlett-Packard field office immediately. (A list of field offices is at the back of this manual.) Retain the shipping carton and the padding material for the carrier's inspection. The field office will arrange for the repair or replacement of your instrument without waiting for the claim against the carrier to be settled.

2-5. PREPARATION FOR USE.

2-6. POWER REQUIREMENTS.

2-7. The RF Vector Impedance Meter requires a power source of 115 or 230 v ac ±10%, 50 to 400 Hz, single phase, which can supply approximately 50 watts.

2-8. 115/230 VOLT OPERATION.

2-9. A two-position slide switch, on the rear panel, permits operation from either a 115- or 230- volt power source. Before plugging the Model 4815A into the power source, check that the number visible on the slide switch matches the nominal line voltage of the power source. If not, before connecting to the line, use a thin bladed screwdriver and flip the slide switch to the other position.

2-10. When the instrument leaves the factory, the fuse for 115-volt operation is installed. An envelope containing the correct fuse for 230- volt operation is attached to a front handle of the 4815A. A marking on the rear panel, adjacent to the fuse holder, indicates the correct fuse rating for operating from either power source.

2-11. POWER CABLE.

2-12. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that instrument panels and cabinets be grounded. The 4815A is equipped with a detachable, three-conductor power cable which, when plugged into an appropriate receptacle, grounds panel and cabinet. The offset pin on the power cable three-prong connector is the ground pin.

2-13. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong adapter (-hp- Stock No. 1251-0048) and connect the green pigtail on the adapter to ground.

2-14. COOLING.

2-15. The temperature of surrounding air must not exceed 55°C (131°F). Clearance at the rear and sides of the cabinet should be provided to maintain adequate cooling. The clearances provided by the plastic feet in bench stacking and the filler strips used in rack mounting are adequate for the top and bottom cabinet surfaces.

2-16. BENCH OPERATION.

2-17. The RF Vector Impedance Meter has plastic feet and a fold away tilt stand for convenience in bench operation. The tilt stand permits inclining the instrument for ease in reading the meters. The plastic feet are shaped to provide clearance for air circulation and to make full width -hp- modular cabinet instruments such as the 4815A self-aligning when stacked.

2-18. RACK MOUNTING.

2-19. The 4815A can be rack mounted by adding mounting brackets to each end of the front panel. Additional support must be provided at the rear when the RF Vector Impedance Meter is subjected to vibration. The front panel mounting flanges and mounting hardware (-hp- Stock No. 5070-0706) are furnished with the instrument. Installation instructions are packed with the mounting hardware and shown in Figure 2-1.

CAUTION

Ambient temperature in rack operation should not exceed a maximum of 131°F (55° C).

2-20. IMPEDANCE PROBE.

2-21. The Model 4815A is shipped with the probe assembly in a separate wrapping inside the instrument shipping carton. To prepare the instrument for operation, connect probe to front panel mating connector;

install probe tip and ground assembly found in accessory kit. Also check for secure connections at the jumper between the rear-panel EXT OSC IN and INT OSC connectors.

2-22. REPACKAGING FOR SHIPMENT.

2-23. The original shipping carton and packing material should be used for reshipment. The Hewlett-Packard Sales/Service Office will also provide information and recommendations on materials to be used if the original packaging material is not available or reusable. Materials used should include: (1) a double-walled carton; (2) heavy paper or sheets of cardboard to protect all instrument surfaces; use extra material around projecting parts of the instrument, (3) at least four inches of tightly-packed shock-absorbing material surrounding the instrument. Close the carton securely with durable shipping tape.

NOTE

If the instrument is to be shipped to a -hp- Sales/Service Office for repair, attach a tag showing owner, model, complete serial number, and repairs required. Mark the shipping container FRAGILE to assure careful handling.

2-24. In any correspondence refer to the instrument by model number and full serial number.

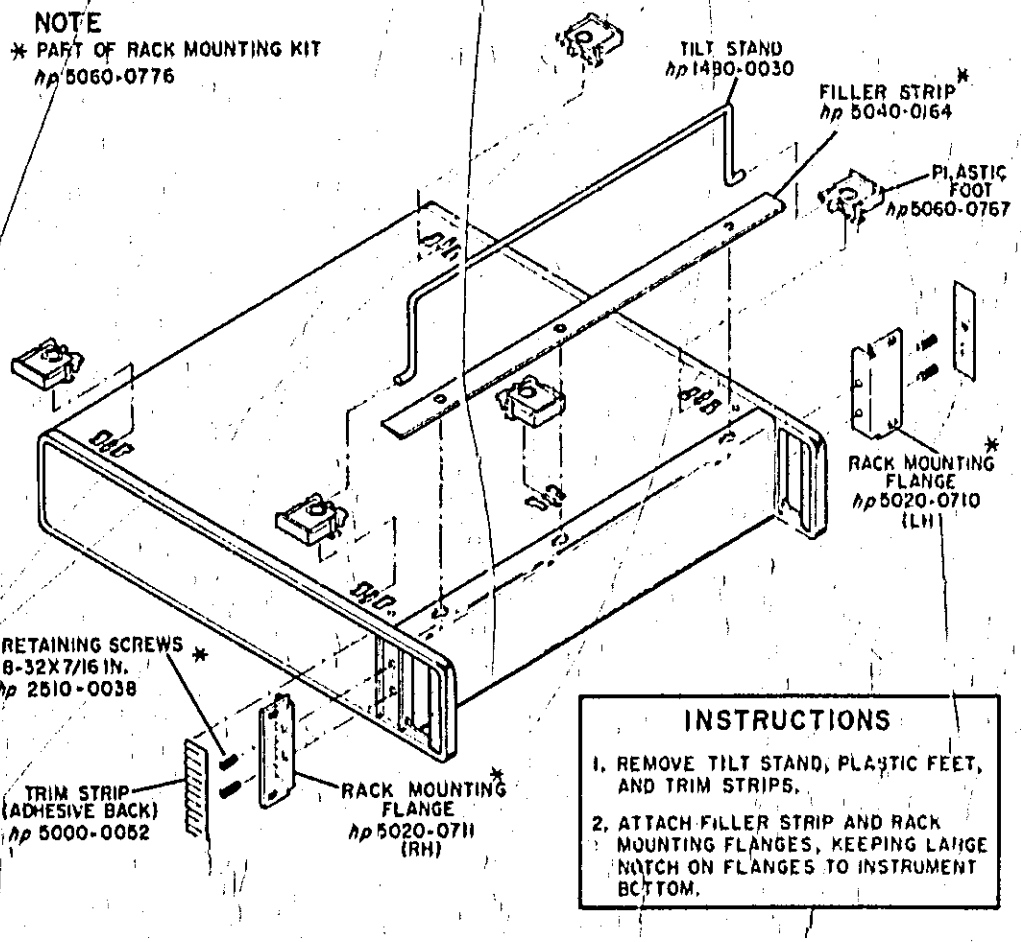


Figure 2-1. Preparations for Rack Mounting

OPERATION AND THEORY

SECTION III
OPERATION

3-1. INTRODUCTION.

3-2. The Model 4815A RF Vector Impedance Meter measures impedance directly by comparing the ratio of voltage and current injected into the circuit under test. An ALC circuit holds current constant so that impedance is directly proportional to voltage. Phase angle is measured by detecting the phase relation between voltage and current waveforms. An integral oscillator supplies test signals from 0.5 to 108 MHz.

3-3. Impedances to 100K ohms are measured in nine (9) ranges; phase angles from 0^0 to 360^0 are measured in two ranges, $0^0 \pm 90^0$ and $180^0 \pm 90^0$.

3-4. An automatic tuning process converts RF signals to a lower frequency for measurement. The front panel SEARCHING indicator is illuminated during periods of automatic tuning, and may flash while the test oscillator frequency is changed.

3-5. CONTROLS, CONNECTORS AND INDICATORS.

3-6. Figures 3-1 and 3-2 identify and briefly describe the purpose of each panel control, indicator and connector.

3-7. MAKING MEASUREMENTS.

3-8. GENERAL.

3-9. General instructions for making vector impedance measurements are given in Figure 3-3.

3-10. TEST PROBE.

3-11. Connection to the test circuit is made at the tip of the impedance probe attached to the front panel through a multi-coax connector. The 4815A meter readings include the effects of residual probe impedances; the test circuit appears to have 0.3 pF capacitance across it, and 1/2 ohm and 8 nH in series with it. The 4815A will indicate its own residuals so the effect on any reading may be quickly determined. With the probe center pin removed the residual capacitance is reduced to approximately 0.05 pF; the actual capacitance may be calculated from an on-scale magnitude OHMS meter reading and the test frequency. (0.05 pF would read approximately $30K\Omega \angle -90^0$ at 100 MHz.

3-12. ACTIVE CIRCUITS.

3-13. The main considerations when probing into active circuits are the method of grounding the probe, the injection of sampling pulses by the probe and the effects of source impedance of the probe on the test circuit.

3-14. GROUNDING. The metal barrel at the probe tip should be connected to the test circuit common as close to the test point as possible. The supplied slip-on, spring-loaded grounding assembly should be used when probing, or the accessory probe socket mounted close the the test point.

3-15. SAMPLING PULSE INJECTION. The signal from the probe is the same one that down-converts the RF test signal to the 5 kHz IF, where metering is accomplished. The pulses are 3 nano-seconds (ns) wide with a repetition rate of between 0.5 and 1 MHz, phase locked to the test frequency. Pulse amplitude is less than 75 milli-volts (mV) peak-to-peak from a 25 ohm source.

3-16. MEASURING IN THE PRESENCE OF OTHER SIGNALS. The probe will withstand voltages up to ±50 volts from tip to ground. Ac voltages of 0.5 v rms will overload probe. The process that converts the rf test signal to a lower frequency for measurement may also convert any ac circuit voltage to the measurement frequency and cause errors. Generally, if a single frequency is present, the OHMS meter will "beat" at certain test frequencies, and a very small change in frequency will remove the interference. The presence of noise, fm, or any other signal with a broad spectrum will increase the possibility of interference.

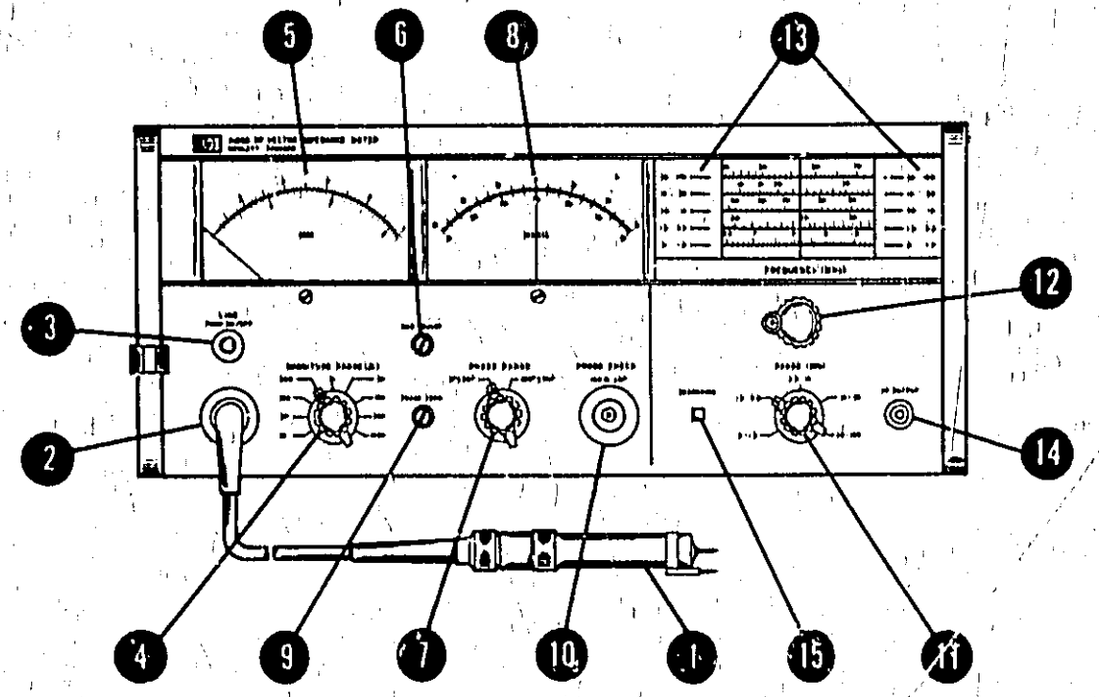
3-17. PROBE IMPEDANCE. To the circuit under test the probe is a controlled rf voltage with a source impedance of 25 ohms in series with 0.01 μF.

3-18. SWEPT FREQUENCY MEASUREMENTS.

3-19. Continuous phase and magnitude measurements may be made on test signals which change frequency, provided the rate of change of RF does not exceed 1MHz/s on any band. When the automatic tuning circuits reach the limit of their dynamic range the front panel SEARCHING indicator will flash momentarily and the Magnitude OHMS Meter will return toward zero, recovering when retuning is complete. The tuning process takes approximately 35 milliseconds. Meter indications are meaningless during a steady SEARCHING indication, the result of high sweep rate.

3-20. EXTERNAL OSCILLATOR

3-21. For certain measurements the use of an external oscillator is desirable; connection is made at the rear panel after the connection between the INT OSC and EXT OSC IN jacks is removed. Require-



1. Probe for connecting to circuit under test.

2. Connecting plug and jack.

3. LINE PUSH ON/OFF. Combination line power switch and power on indicator. Pushbutton glows when line power is applied. Pushbutton retainer unscrews for lamp replacement.

4. MAGNITUDE RANGE (Ω) determines full scale OHMS meter calibration.

5. Impedance magnitude OHMS meter.

6. MAG ADJUST screwdriver control makes small adjustments in Impedance Magnitude OHMS Meter sensitivity.

7. PHASE RANGE switch selects between 0° $\pm 90^{\circ}$ or 180° $\pm 90^{\circ}$ ranges.

8. Phase angle DEGREES meter indicates phase angle of the complex impedance vector. An on-scale reading on the OHMS meter is required for a meaningfull indication.

9. PHASE ZERO screwdriver adjustment corrects small DEGREES meter offsets when more accurate measurements at a particular frequency are desired.

10. PROBE CHECK 100Ω $\angle 0^{\circ}$ socket for a quick check of instrument accuracy and operation.

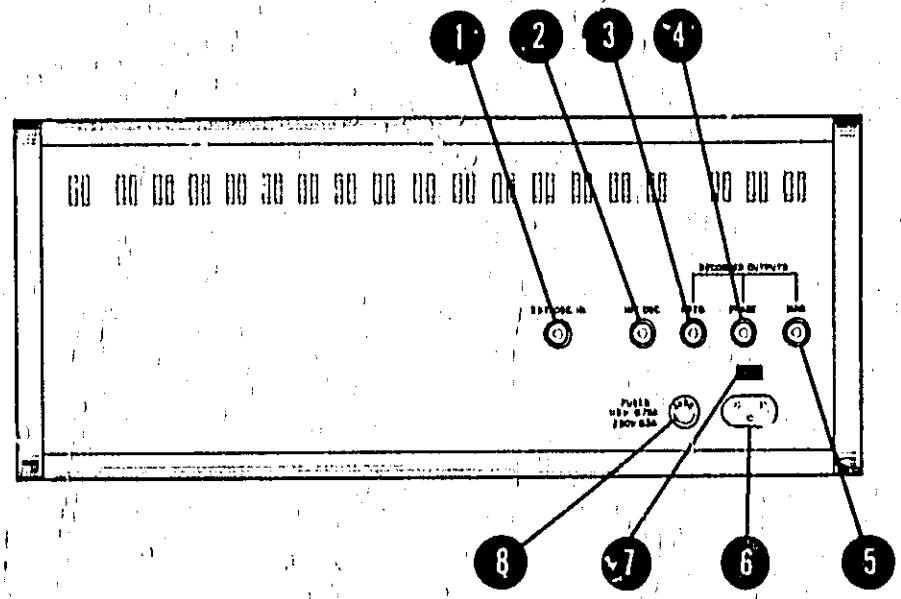
11, 12. RANGE (MHz) switch and frequency tuning control choose the test frequency.

13. Illuminated numerals indicate the frequency range selected by RANGE (MHz) switch, 11.

14. RF OUTPUT connector for monitoring with a frequency counter. Output level is 150 mV into 50Ω.

15. SEARCHING indicator lights when automatic tuning occurs.

Figure 3-1. Front Panel Features



1. EXT. OSC. IN. This connector is for applying an external test signal source, 0.5 - 108 MHz. Input level should be held at 100 mV ± 1 db. Front panel RANGE (MHz) switch should be set to range that includes frequency of external oscillator.

2. INT. OSC. Output of internal RF test oscillator.

NOTE

The 4815A is shipped with INT. OSC. and EXT. OSC. IN. connectors connected by RF couplings.

3. FREQ. - RECORDER OUTPUTS. Dc output 0 - 1 VDC (internal impedance 0 - 1 K ohms) proportional at frequency dial rotation. Zero volts DC is obtained at the low frequency extreme of dial rotation.

4. PHASE - RECORDER OUTPUTS. Dc output is 0 V ± 0.9 VDC, proportional to Phase Meter indication. Output is -0.9 V at -90°, 0 V at 0°, and +0.9 V at +90°. Internal impedance is 1K ohms.

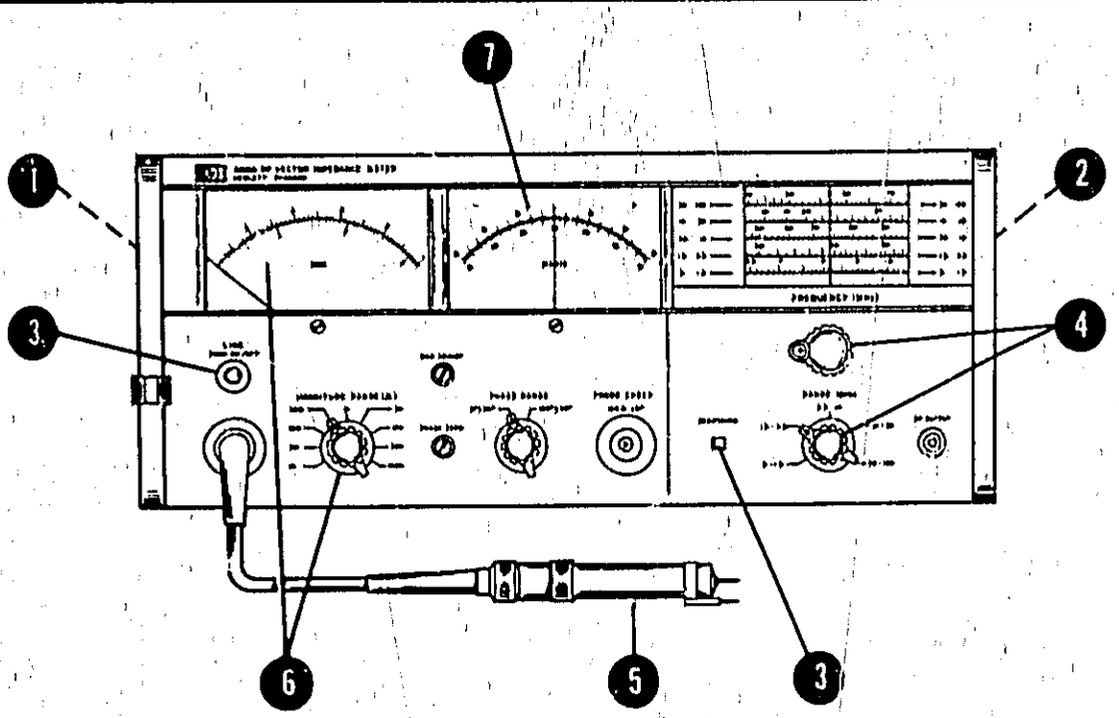
5. MAG. - RECORDER OUTPUTS. Dc output 0 - 1 VDC proportional to Magnitude Meter indication. Output is 1 volt with full scale deflection. Internal impedance is 1K ohms.

6. Power cord receptacle.

7. Power change-over switch, 115 - 230 VAC. Switch is operated by small blade screwdriver. Set nominal input line voltage before applying power to the 4815A.

8. Ac line fuse. Fuse should have rating indicated on panel adjacent to fuse holder.

Figure 3-2. Rear Panel Features



PREPARATION

1. Set rear-panel line switch to show nominal line voltage from which RF Vector Impedance Meter will operate. Check that fuse has rating marked adjacent to fuse holder.

2. Connect power cable to power source.

TURN-ON

3. Push LINE switch. Pushbutton should glow. SEARCHING light will flash momentarily. If light stays on, check for rear panel jumper between EXT OSC IN and INT OSC connectors.

TUNING

4. Set RANGE (MHz) and tuning control to test frequency. SEARCHING indicator will flash when automatic tuning takes place.

Z ∠θ MEASUREMENT

5. Place probe at the measurement point, using supplied adapters if convenient.

6. Adjust MAGNITUDE RANGE (Ω) switch for an on-scale reading on the OHMS meter.

NOTE

If a quick-check is desired, slide grounding clip away from probe tip and insert probe in PROBE CHECK 100Ω 0° jack. Adjust magnitude range to 100, phase range to 0° ±90°. OHMS and DEGREES meters should read 100Ω ±3% and 0° ±2°, respectively at a 1 MHz test frequency and 100Ω ±6% and 0° ±5° at 100 MHz.

7. With an on-scale OHMS meter indication, read the vector phase angle θ on the DEGREES meter.

Figure 3-3. General Operating Instructions

ments for the external oscillator are 0.5 - 108 MHz, at a level of 100 mv ±10%. Input impedance is 50 ohms. The signal at the front panel RF OUTPUT jack is at the frequency of the external oscillator. Stability of the oscillator must be good; maximum instantaneous rate of change of frequency is 1 MHz/s. Total harmonic distortion (THD) should be less than 5% when testing high Q circuits.

3-22. RECORDER OUTPUTS.

3-23. Dc voltages proportional to magnitude, phase angle and frequency are available at the rear panel. Dc levels are 1 volt for OHMS meter full scale, 1K source impedance; ±0.9 volts for ±90° DEGREES meter deflection, 1K source impedance; and 0 - 1 volt over the frequency dial rotation, 0 - 1K source impedance. The voltages may be used to drive recording, plotting or other equipment. Maximum recording rate is limited by rate of change of impedance magnitude in addition to the 1 MHz/s limitation of the automatic tuning circuits.

3-24. During the period of automatic tuning, when the SEARCHING indicator is lit, the analog outputs are held at values that existed just before retuning. After correct tuning is established the analog outputs are allowed to change. Very small transients will appear on a recording at the points where retuning occurred. With the exception of the small transients, recording traces will be continuous.

3-25. SLIDE RULE CALCULATOR.

3-26. As a user convenience a slide rule type VECTOR IMPEDANCE CALCULATOR (Figure 3-4) has been included with this manual. The simple instructions necessary to use the calculator are printed on the face of the rule.

3-27. The front side of the calculator is an aid in making the basic trigonometric calculations that convert impedance and phase (Z and θ) into series reactance and resistance (X_S and R_S).

3-28. The reverse side is a reactance-inductance-capacitance calculator. In addition to the usual calculating functions this side may be used to determine the full scale capacitance or direct reading inductance range of the 4815A at 1.592 or 15.92 MHz. A small vee (v) marking on the frequency scale marks these two points. For example, the calculator will indicate that a 1 mH inductor has 10 KΩ reactance at 1.592 MHz. At this frequency the 10K position of the MAGNITUDE RANGE Switch makes the Magnitude OHMS Meter direct-reading, 0 - 1 mH. The OHMS meter will also indicate reciprocal capacitance with 10 pF at full scale. Phase angles not near ±90° will indicate a lossy component is under test and the OHMS meter is not direct reading (the front side of the Vector Impedance Calculator can be used to make corrections, however).

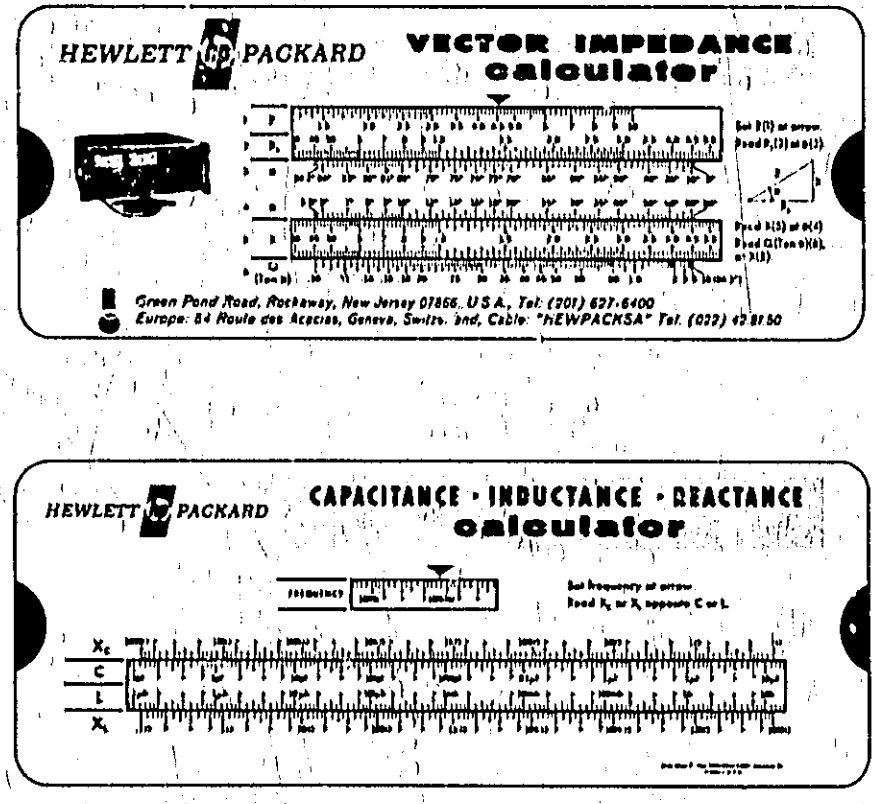


Figure 3-4. Vector Impedance Calculator

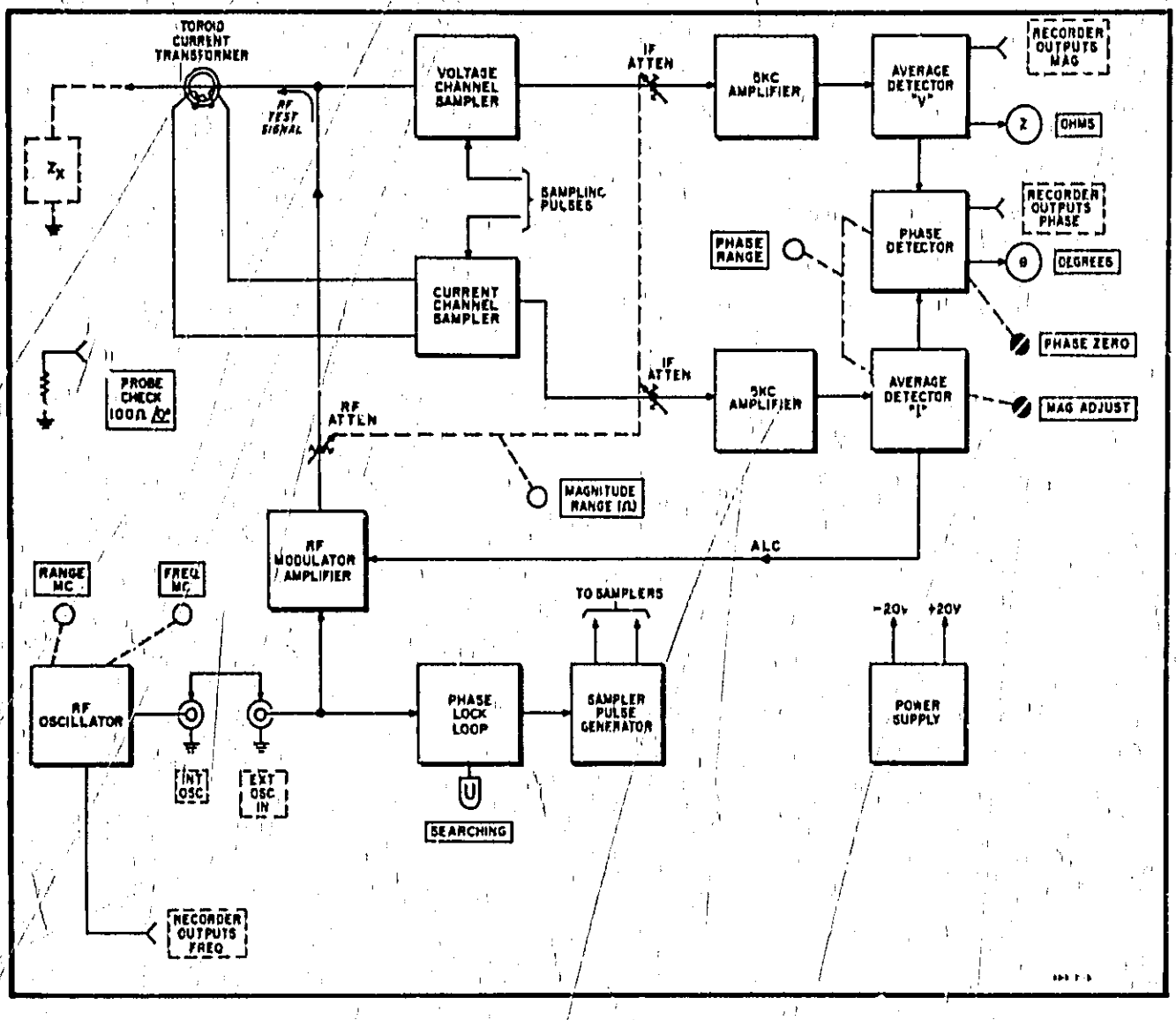


Figure 4-1. Simplified Overall Block Diagram.

SECTION IV
PRINCIPLES OF OPERATION

4-1. INTRODUCTION.

4-2. The 4815A RF Vector Impedance Meter measures complex vector impedance over a frequency range of 0.5 to 108 MHz. A small internally generated test signal is applied to the test circuit through a probe. The rf current through and voltage across the unknown are converted to two 5 kHz IF signals that retain both amplitude and phase information. The meter indications of magnitude, OHMS, and phase angle, DEGREES, are derived from the two IF signals.

4-3. OVERALL DESCRIPTION.

4-4. Referring to the 4815A Simplified Overall Block Diagram, Figure 4-1, a low-level RF test signal is injected into the external circuit. Connection is made at the probe tip through the center of a toroid current transformer. Output from the transformer is applied to a sampler where conversion from RF to IF is accomplished. The sampling process duplicates the RF waveform at a rate more convenient for measurement; in the 4815A the IF is 5 kHz. The current channel 5 kHz signal is amplified in a narrow-band system, detected and applied to a modulator system which controls the level of the RF test signal. The current channel and modulator form a closed-loop ALC system that holds the test signal constant.

4-5. With RF test current constant, the voltage across the external circuit is proportional to impedance magnitude, Z. A sampler transforms the probe-tip voltage to the 5 kHz IF, which is then amplified and detected in a system similar to the current channel. The detected output, porportional to impedance magnitude, is applied to the OHMS meter.

4-6. Ac signals from voltage and current channels are limited to remove amplitude variations and applied to a binary phase detector which operates the phase angle DEGREES meter.

4-7. Conversion of RF to IF signals in the probe is accomplished by sampling; amplitude samples of the RF waveforms are obtained on different occurrences of the waveforms, and at progressively earlier points. The result is a replica of the sampled waveform at a frequency convenient for measurement, 5 kHz in the RF Vector Impedance Meter. The sampling rate is controlled with a phase lock loop. The IF is phase compared to a reference, deriving a voltage that controls the frequency of a voltage-tuned oscillator (VTO), part of the phase lock loop. A sampling pulse generator, synchronized with the VTO, produces the necessary fast pulses for operation of the samplers.

4-8. RF test signals are generated in an internal oscillator and connected to an RF modulator through jacks on the rear panel. External oscillators may be simply substitued.

4-9. DETAILED DESCRIPTION.

4-10. Figures 4-3 through 4-11 describe the individual circuits of the 4815A in detail. Paragraphs 4-11 through 4-16 provide additional information on the phase lock loop.

4-11. PHASE LOCK LOOP.

4-12. The phase lock loop, with block diagram shown in Figure 4-2, automatically controls the sampling rate to hold the IF at 5 kHz. The same sampling process used in the probe generates a similar IF signal at the output of the lock-loop-sampler. The sampler is followed by high gain limiter-amplifier which delivers a constant output regardless of the input voltage.

When the loop is locked, the difference between the test signal frequency and a harmonic of the sampling frequency is exactly the 5 kHz reference oscillator frequency, or

$$n f_s = f_{rf} \pm 5 \text{ kHz}$$

where f_s = VTO frequency (sampling rate)

f_{rf} = test oscillator frequency

$n = 1, 2, 3, 4 \ldots$

and

$$0.5 \text{ MHz} < f_s < 1 \text{ MHz}$$

(The sampling rate, f_s, is controlled by a VTO operating between 0.5 and 1 MHz.).

4-13. The amplitude-limited IF is passed through a filter to attenuate harmonics generated in the limiting process, and phase-compared to the 5 kHz reference oscillator in a sampling phase detector. Output from the filter leads the 5 kHz input by 90° for operation of the sideband detector (described later). An equalizing low pass amplifier follows the detector, providing high dc gain to minimize loop phase error and controlled low pass characteristic for loop stability.

4-14. Overall gain of the phase lock loop is a function of the harmonic number, n. An attenuator, part of the VTO circuitry, adjusts the loop gain to an optimum value for each frequency range to maintain loop stability. When an external oscillator is used to sup-

ply the test signal, the RANGE (MHz) switch must be set to the position that includes the test frequency to maintain optimum loop gain.

4-15. When the loop is not locked, the low pass equalizing amplifier generates a voltage ramp which causes the VTO to search for a lock point. The ramp voltage changes slowly when the IF is near 5 kHz, and 100 times faster when the IF is far from 5 kHz. Reset of the ramp occurs when it reaches a predetermined level. The search discriminator, a frequency detector centered on 5 kHz disables the fast ramp when the IF approaches 5 kHz and allows the phase lock loop to capture the lock point. The tuning process is complete in less than 35 milliseconds.

4-16. A 5 kHz IF occurs when the sampling pulse harmonic is above or below the RF test frequency, causing a phase ambiguity if both lock points were allowed. The correct lock condition in the 4815A is when $nf_s = f_{rf} + 5$ kHz. This condition occurs first during search because the VTO tunes down in frequency, starting at 1 MHz. The relative phase between the two inputs to the sideband detector is different for the two possible lock points. The detector prevents the search from stopping at the improper lock point.

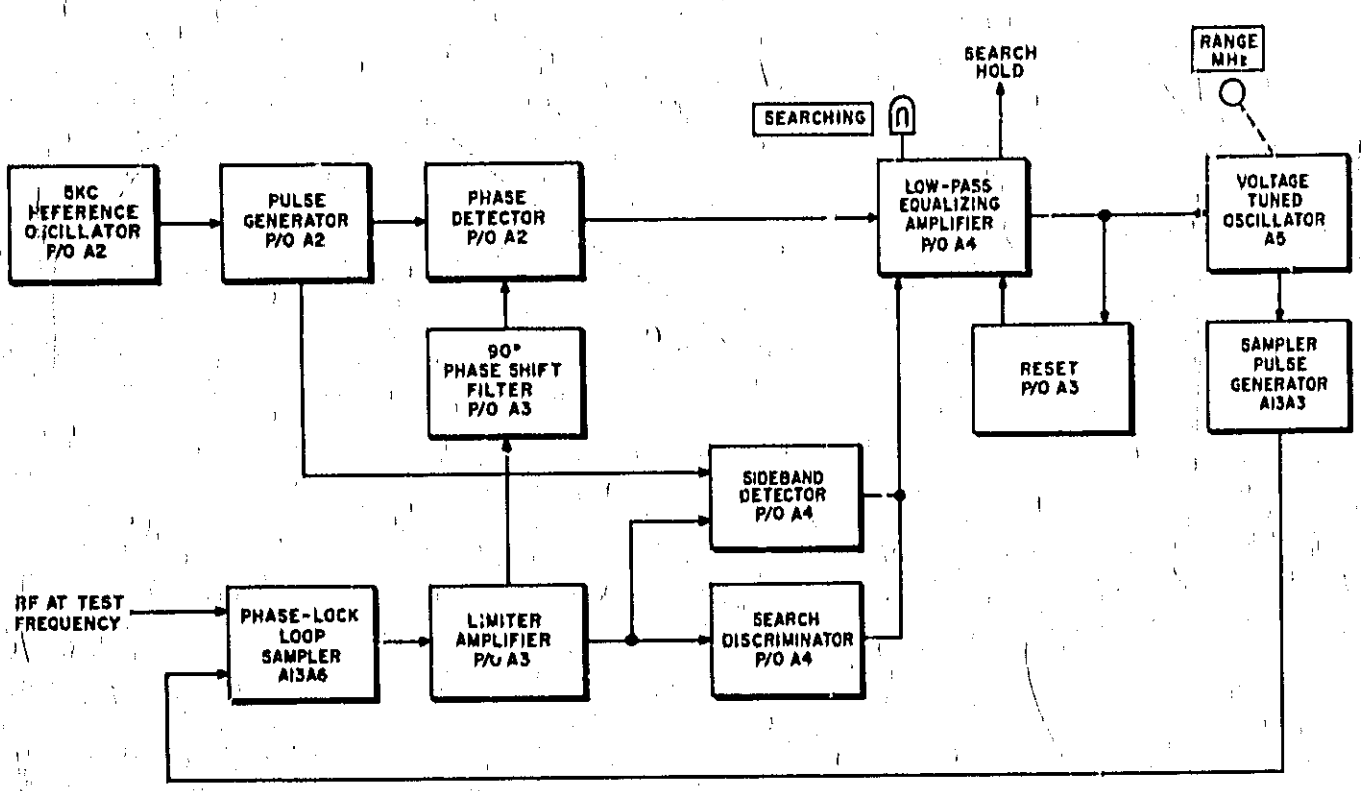
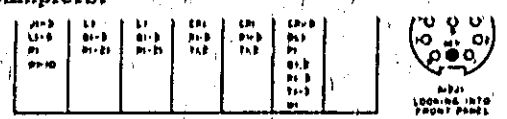


Figure 4-2. Phase Lock Loop Block Diagram

Sampling gate A16CR1-4 is normally reverse-biased by ac. A positive pulse to A16CR1-2 junction and a simultaneous negative pulse at A16CR3-4 junction let the diodes conduct briefly (about one nano-second). A16C1 charges toward the instantaneous rf voltage across A16R1 during this time. The pulses are so short that A16C1 can only charge about 25%. Positive feedback from A13A1Q3 raises the overall efficiency to between 80% and 100%. The A16C1 charge and A13A1 output voltage are maintained until the next sample is taken.

Sampling gate A16CR5-8 is normally reverse-biased by ac. A positive pulse to A16CR5-6 junction and a simultaneous negative pulse to A16CR7-8 junction let the diodes conduct briefly (about one nanosecond). A16C4 charges toward the instantaneous rf voltage at the output of A16DL1 during this time. The pulses are so short that A16C4 can only charge about 25%. Positive feedback from A13A2Q3 raises the overall sampling efficiency to between 80% and 100%. The A16C4 charge and A13A2 output voltage are maintained until the next sample is taken. A16DL1 allows sampling of both voltage and current at the same point of the rf waveform without interaction between samplers.



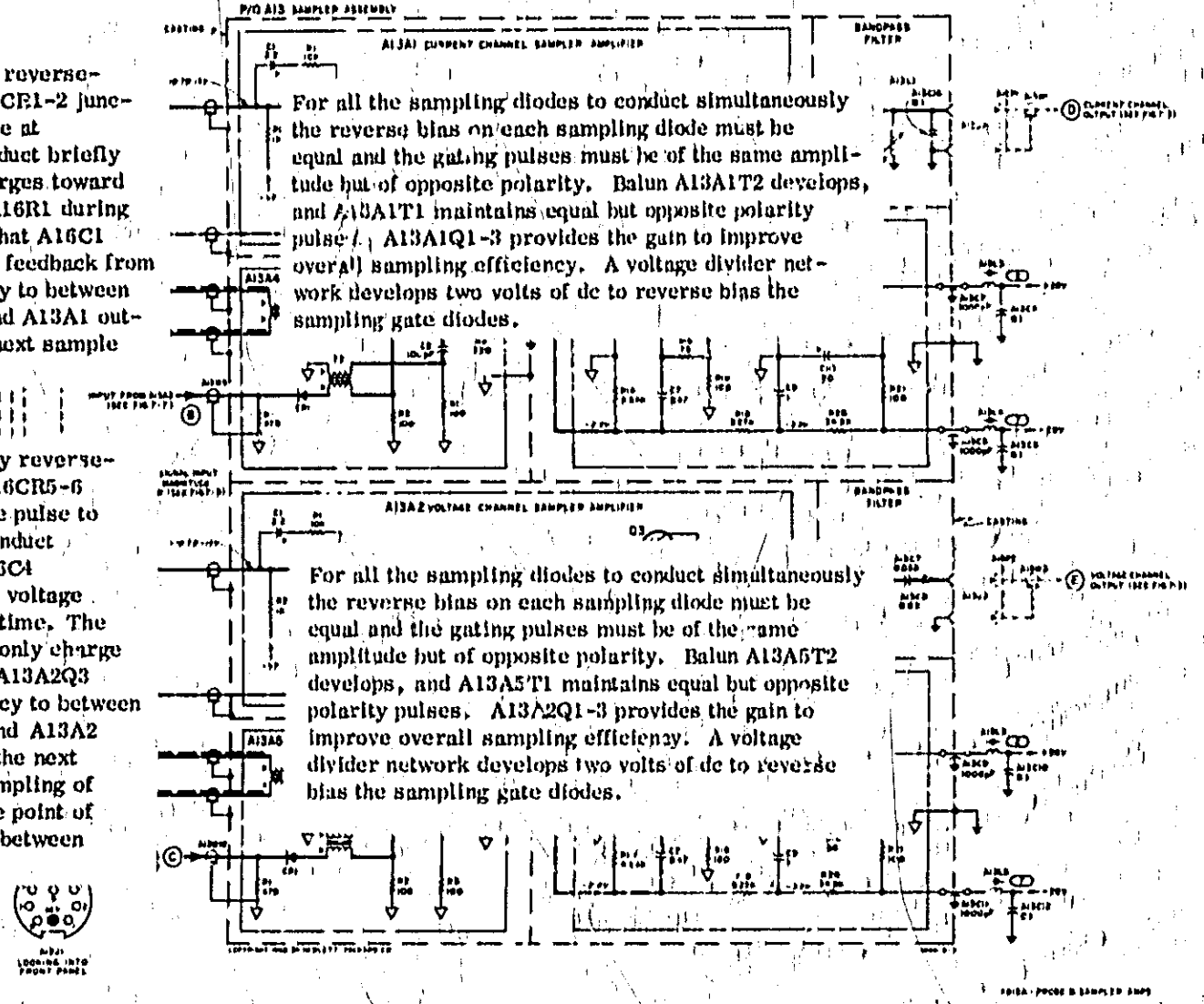


Figure 4-3. Probe and Sampler Circuits (sheet 1 of 2)

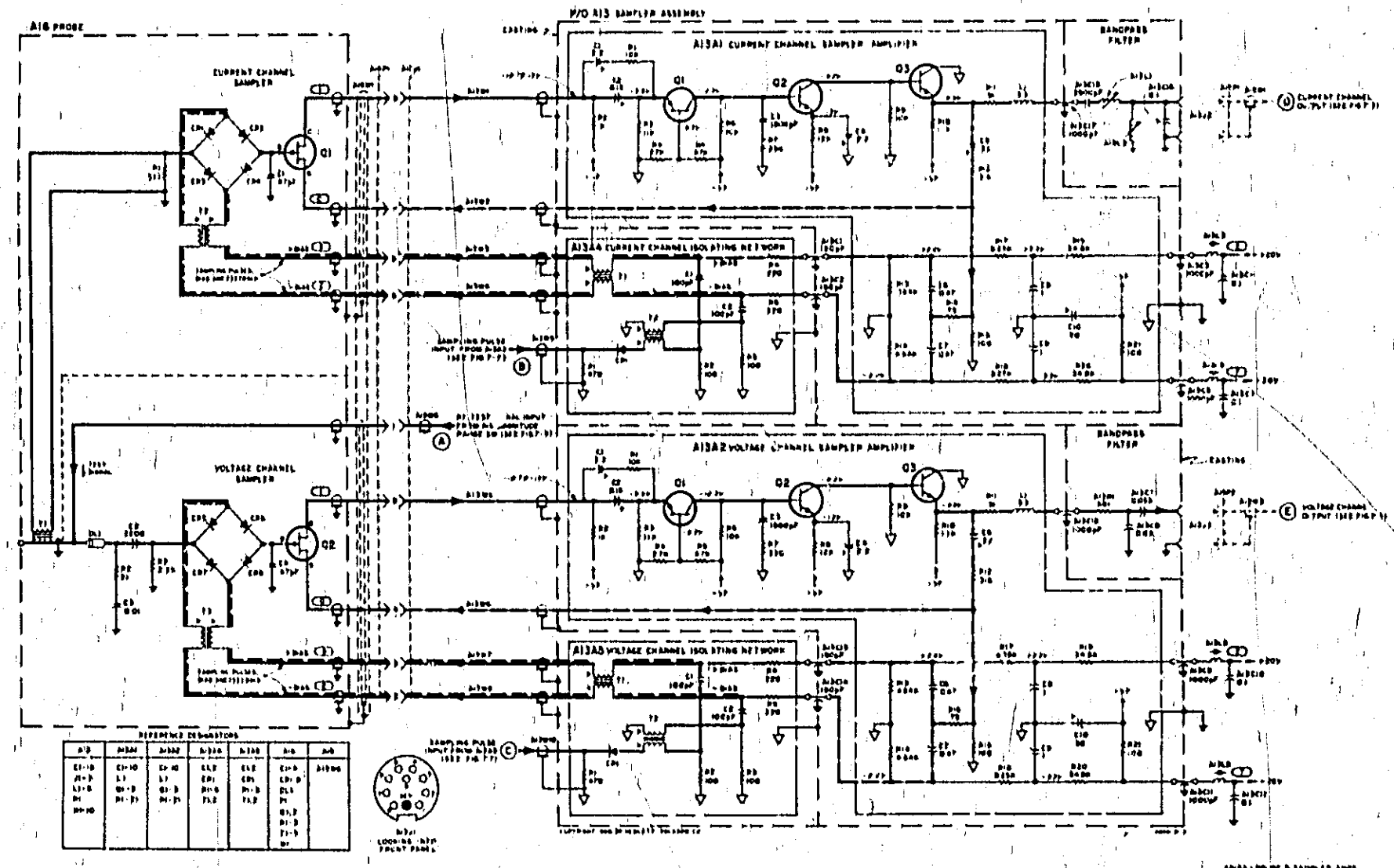


Figure 4-3. Probe and Sampler Circuits (sheet 2 of 2)

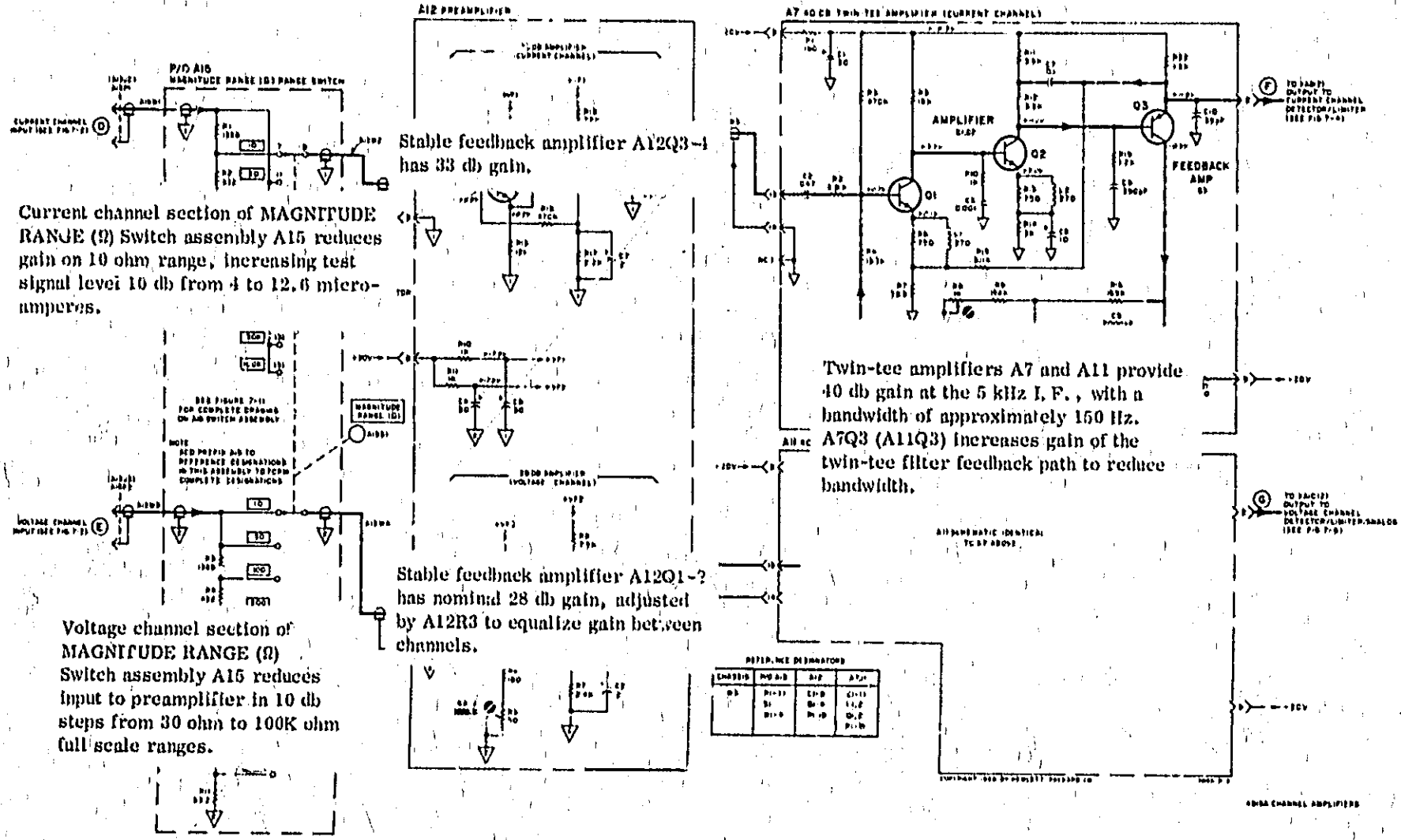


Figure 4-4. Channel Amplifiers (sheet 1 of 2)

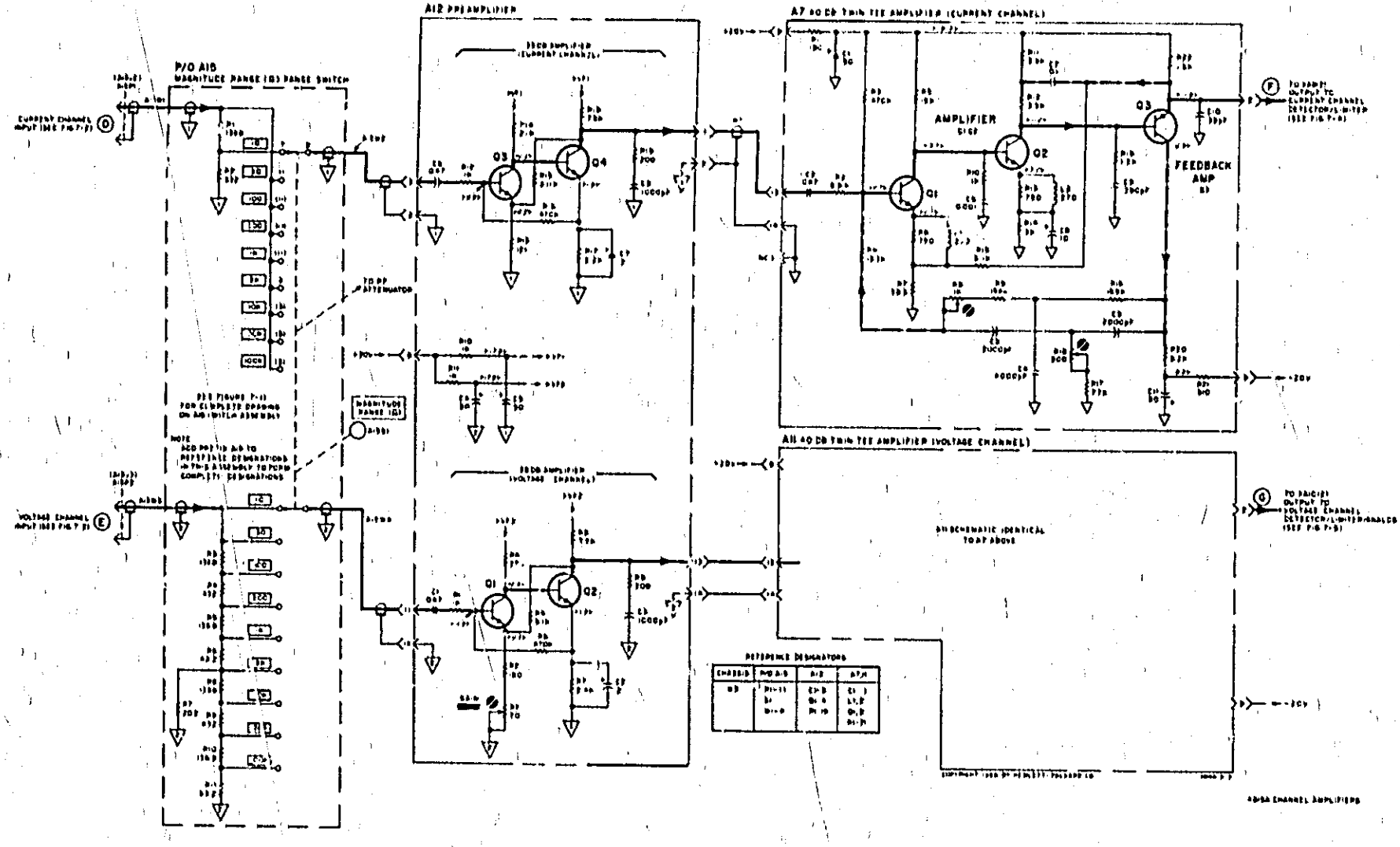


Figure 4-4. Channel Amplifiers (sheet 2 of 2)

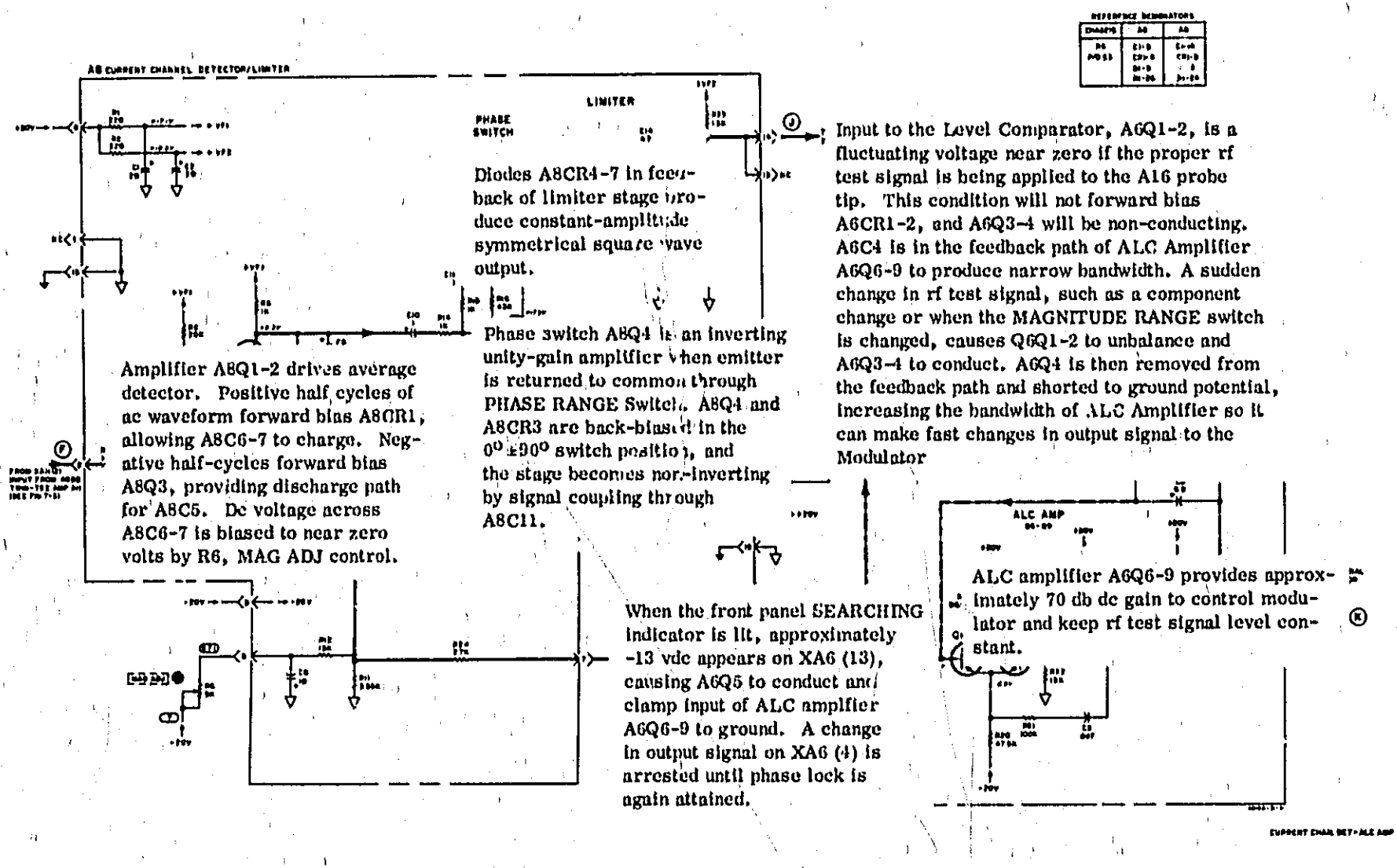


Figure 4-6. Current Channel Detector - ALC Amplifier (sheet 1 of 2)

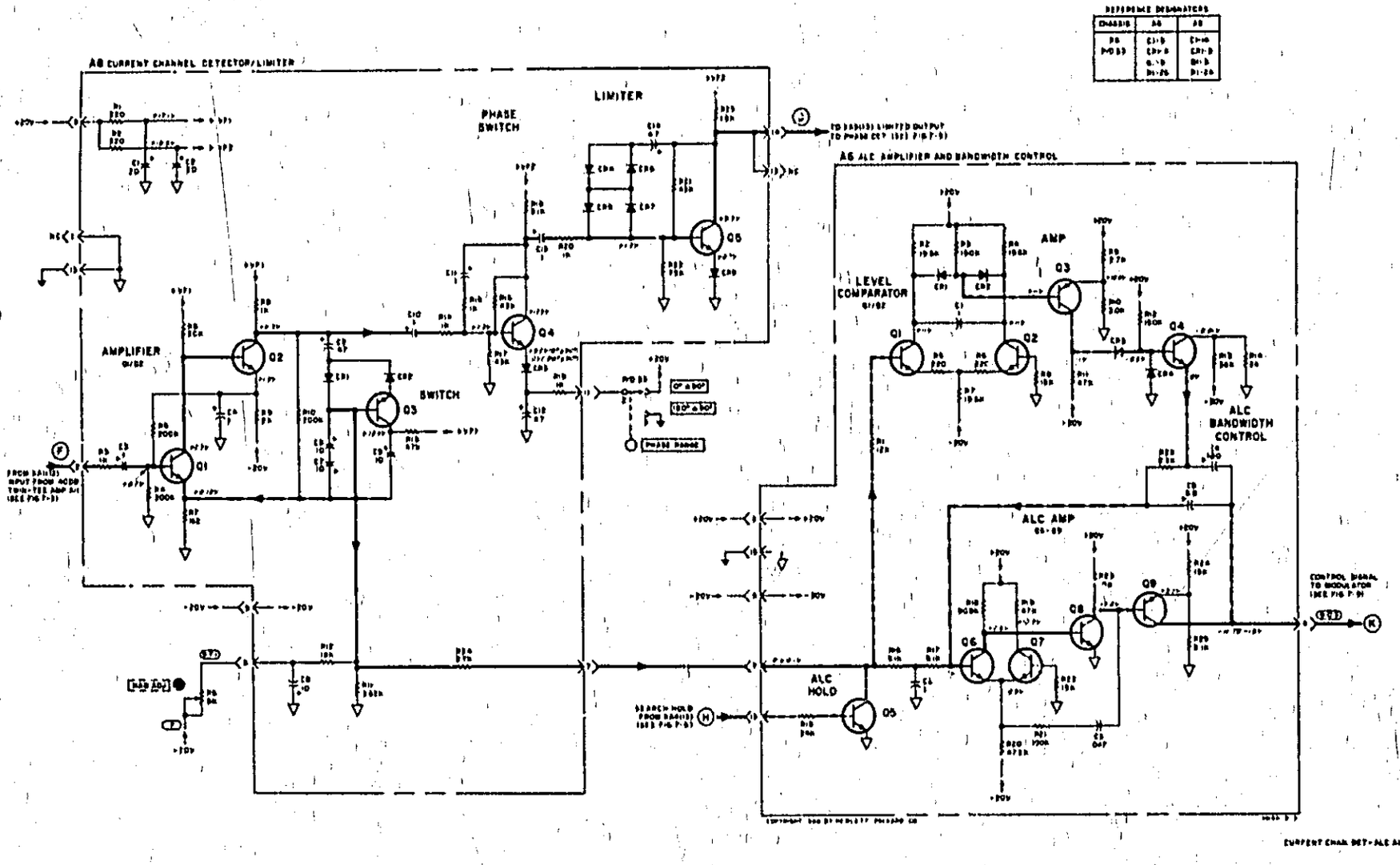


Figure 4-5. Current Channel Detector - ALC Amplifier (sheet 2 of 2)

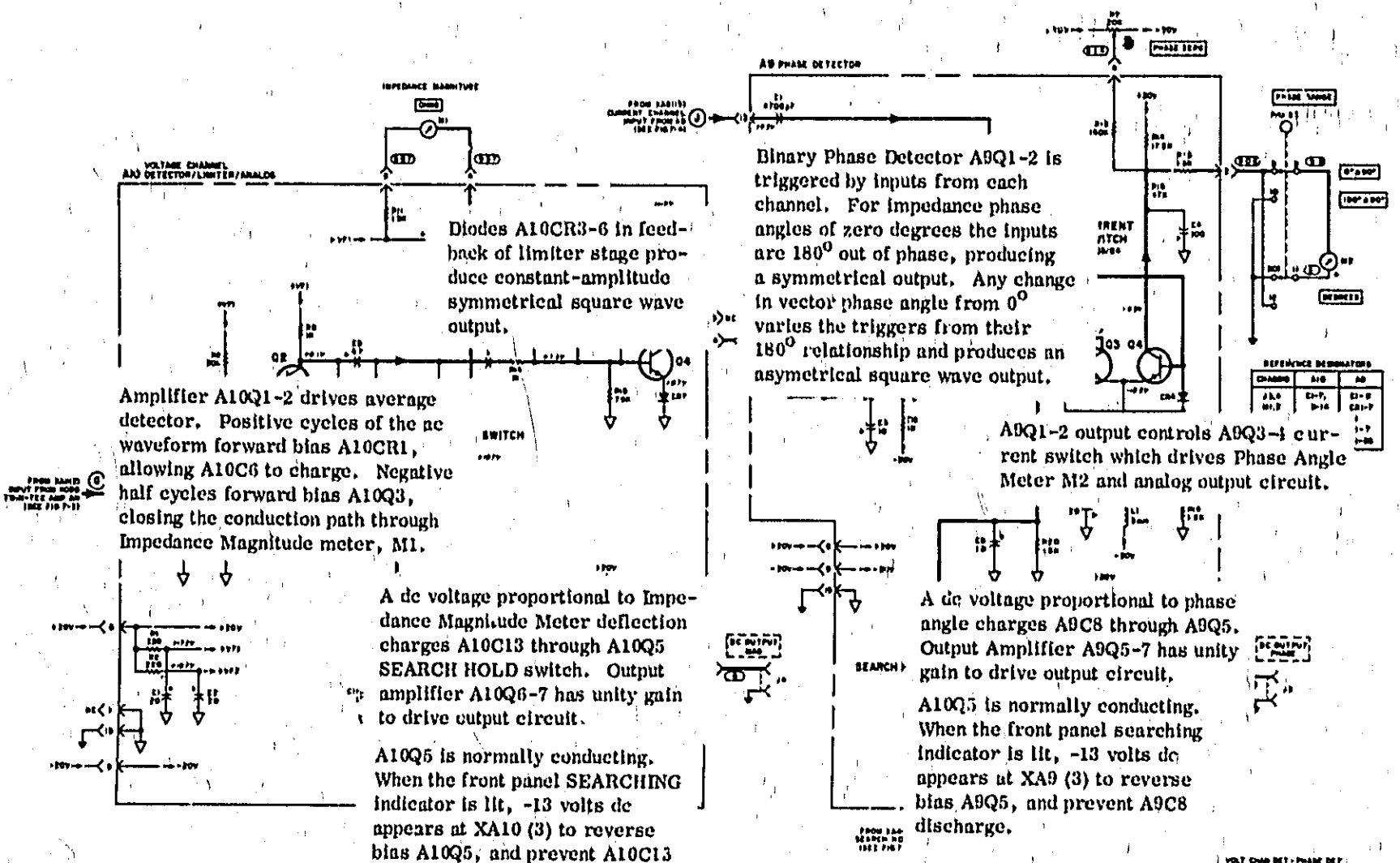


Figure 4-6. Voltage Channel Detector - Phase Detector (sheet 1 of 2)

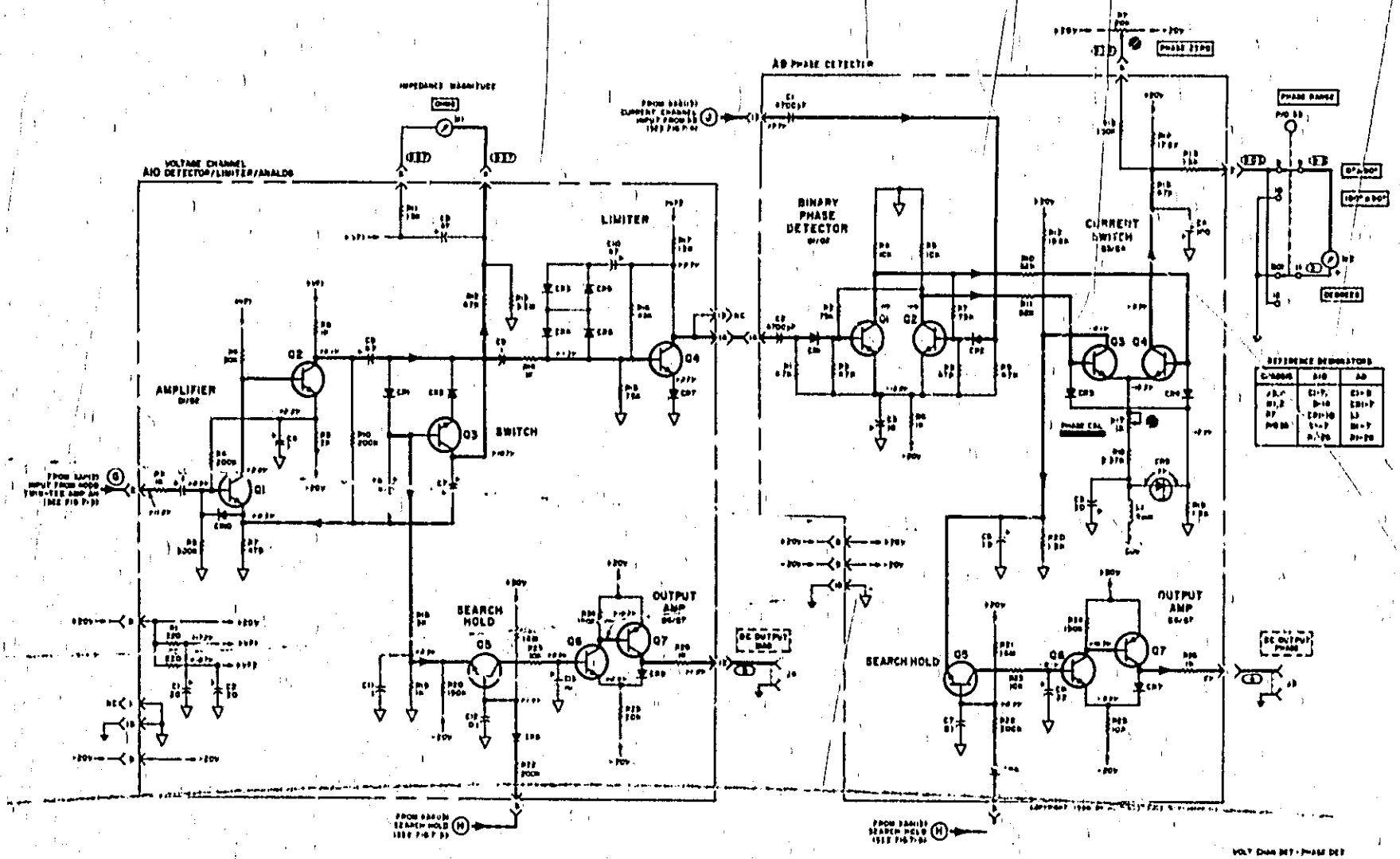
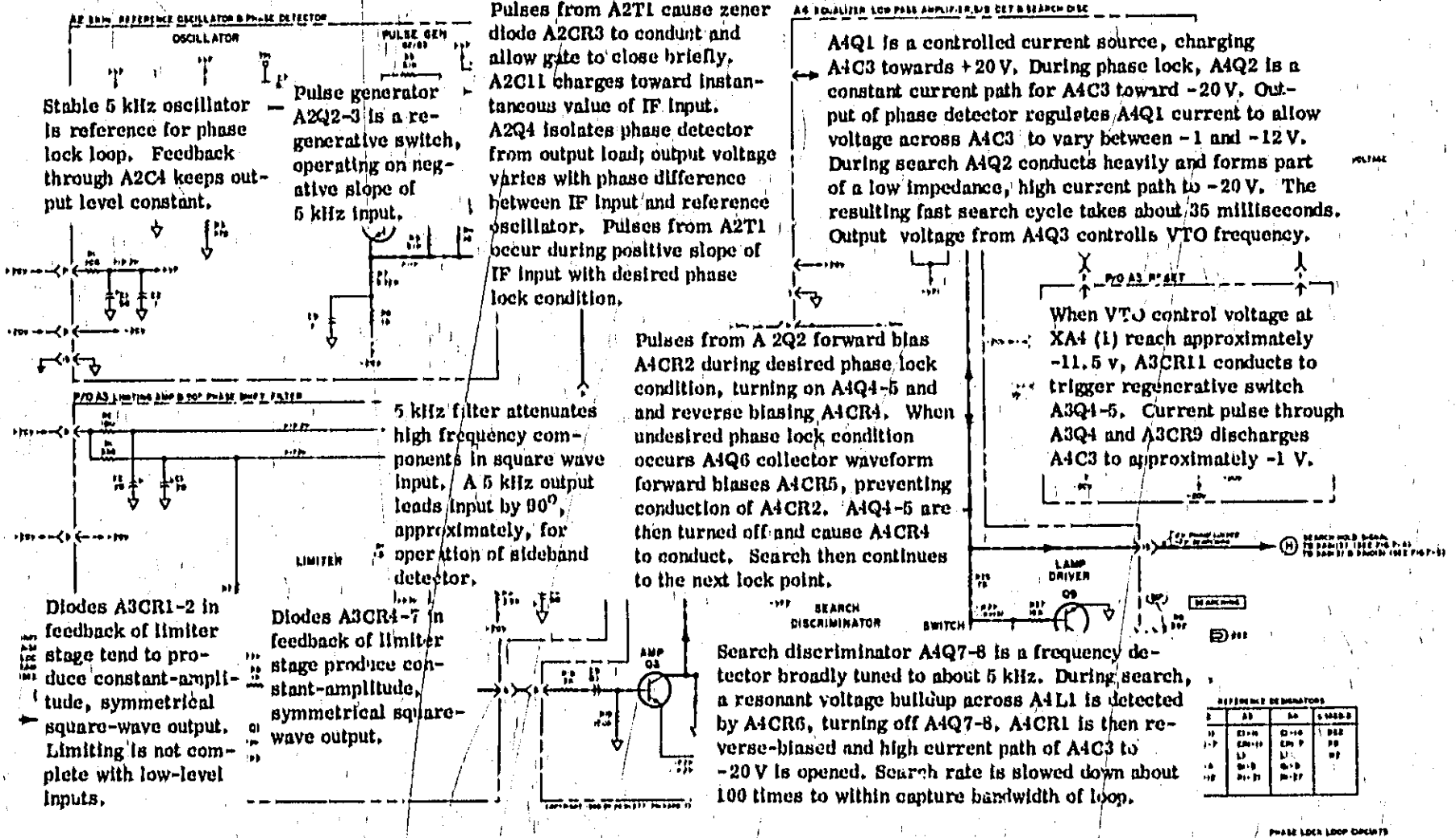


Figure 4-6. Voltage Channel Detector – Phase Detector (sheet 2 of 2)



Stable 5 kHz oscillator is reference for phase lock loop. Feedback through A2C4 keeps output level constant.

Pulse generator A2Q2-3 is a regenerative switch, operating on negative slope of 5 kHz input.

Sampling gate A2CR4-7 is normally reverse biased. Pulses from A2T1 cause zener diode A2CR3 to conduct and allow gate to close briefly. A2C11 charges toward instantaneous value of IF input. A2Q4 isolates phase detector from output load; output voltage varies with phase difference between IF input and reference oscillator. Pulses from A2T1 occur during positive slope of IF input with desired phase lock condition.

A4Q1 is a controlled current source, charging A4C3 towards +20 V. During phase lock, A4Q2 is a constant current path for A4C3 toward -20 V. Output of phase detector regulates A4Q1 current to allow voltage across A4C3 to vary between -1 and -12 V. During search A4Q2 conducts heavily and forms part of a low impedance, high current path to -20 V. The resulting fast search cycle takes about 35 milliseconds. Output voltage from A4Q3 controlls VTO frequency.

When VTO control voltage at XA4 (1) reach approximately -11.5 v, A3CR11 conducts to trigger regenerative switch A3Q4-5. Current pulse through A3Q4 and A3CR9 discharges A4C3 to approximately -1 V.

Pulses from A 2Q2 forward bias A4CR2 during desired phase lock condition, turning on A4Q4-5 and and reverse biasing A4CR4. When undesired phase lock condition occurs A4Q6 collector waveform forward biases A4CR5, preventing conduction of A4CR2. A4Q4-5 are then turned off and cause A4CR4 to conduct. Search then continues to the next lock point.

5 kHz filter attenuates high frequency components in square wave input. A 5 kHz output leads input by 90°, approximately, for operation of sideband detector.

Diodes A3CR1-2 in feedback of limiter stage tend to produce constant-amplitude, symmetrical square-wave output. Limiting is not complete with low-level inputs.

Diodes A3CR4-7 in feedback of limiter stage produce constant-amplitude, symmetrical square-wave output.

Search discriminator A4Q7-8 is a frequency detector broadly tuned to about 5 kHz. During search, a resonant voltage buildup across A4L1 is detected by A4CR6, turning off A4Q7-8. A4CR1 is then reverse-biased and high current path of A4C3 to -20 V is opened. Search rate is slowed down about 100 times to within capture bandwidth of loop.

Figure 4-7. Phase Lock Loop Circuits (sheet 1 of 2)

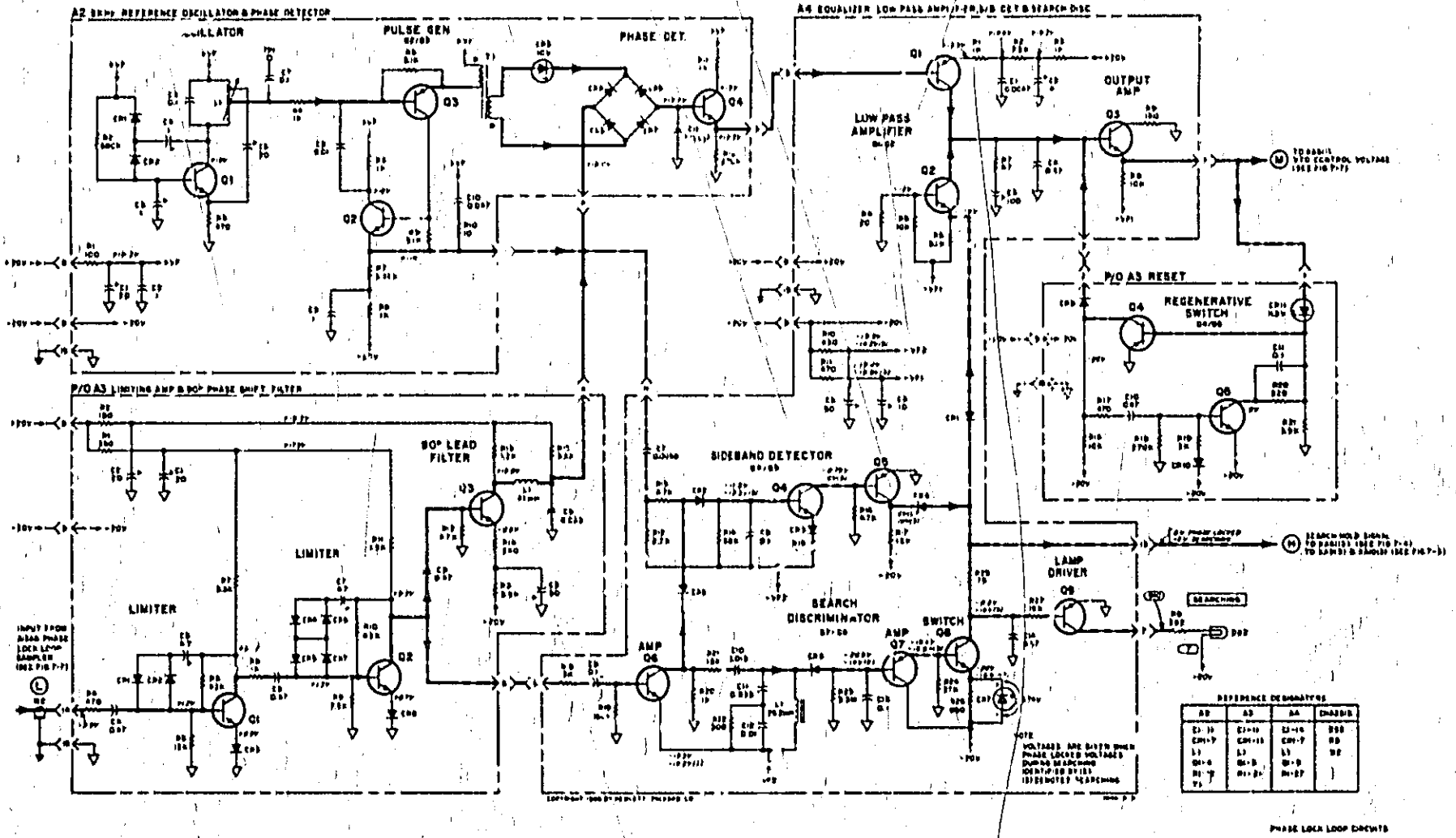


Figure 4-7. Phase Lock Loop Circuits (sheet 2 of 2)

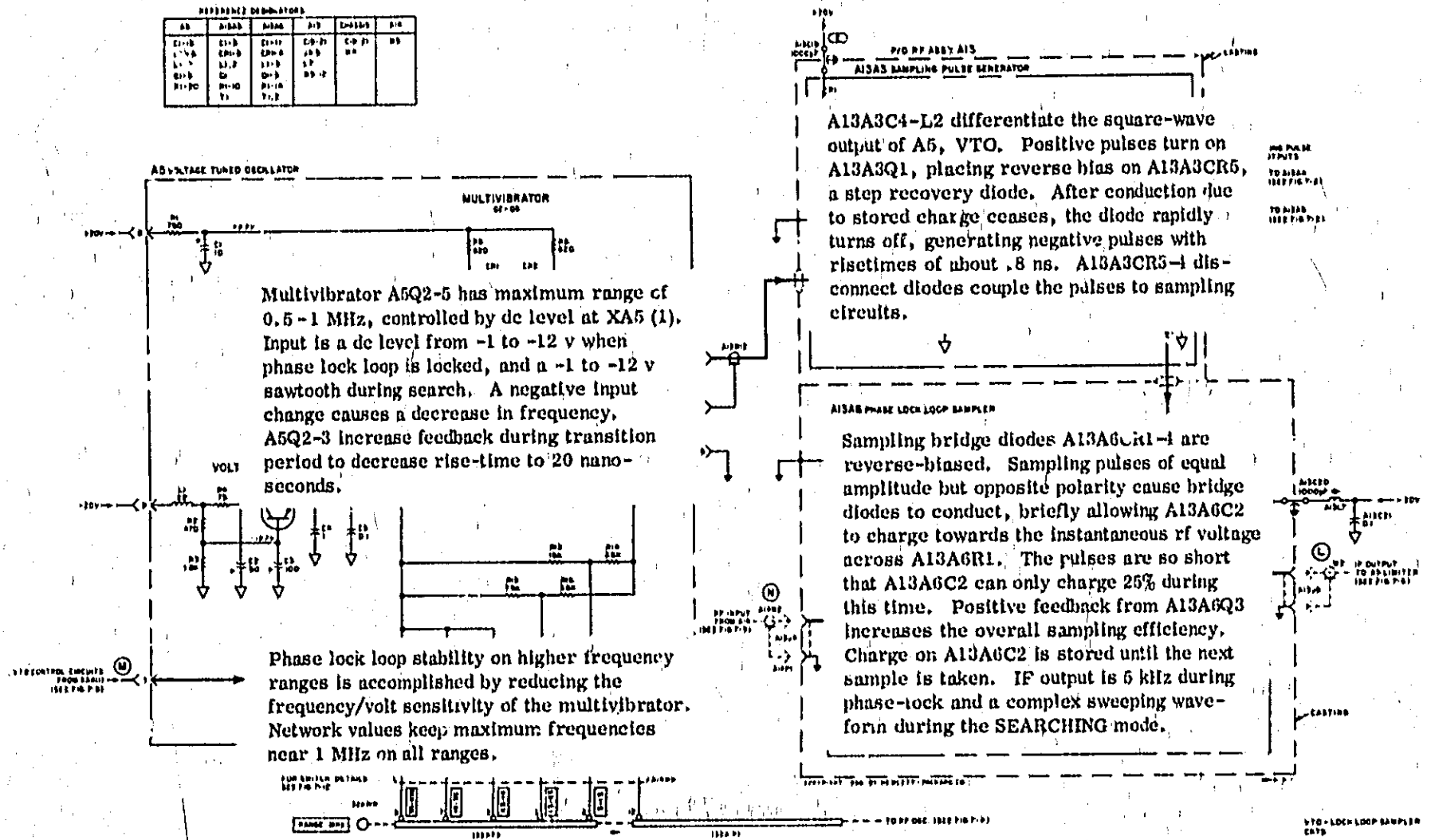


Figure 4-8. VTO - Lock Loop Sampler (sheet 1 of 2)

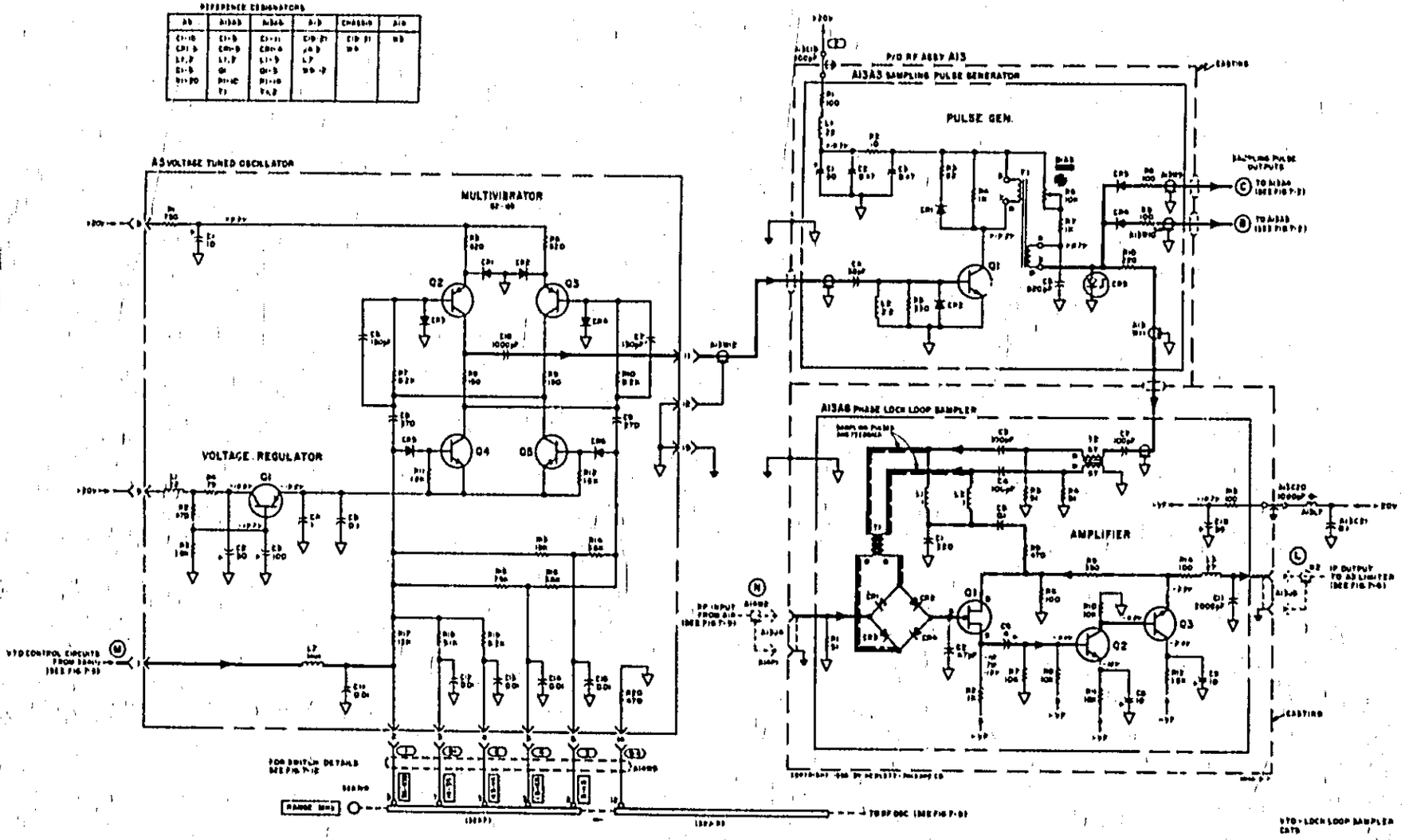


Figure 4-8. VTO – Lock Loop Sampler (sheet 2 of 2)

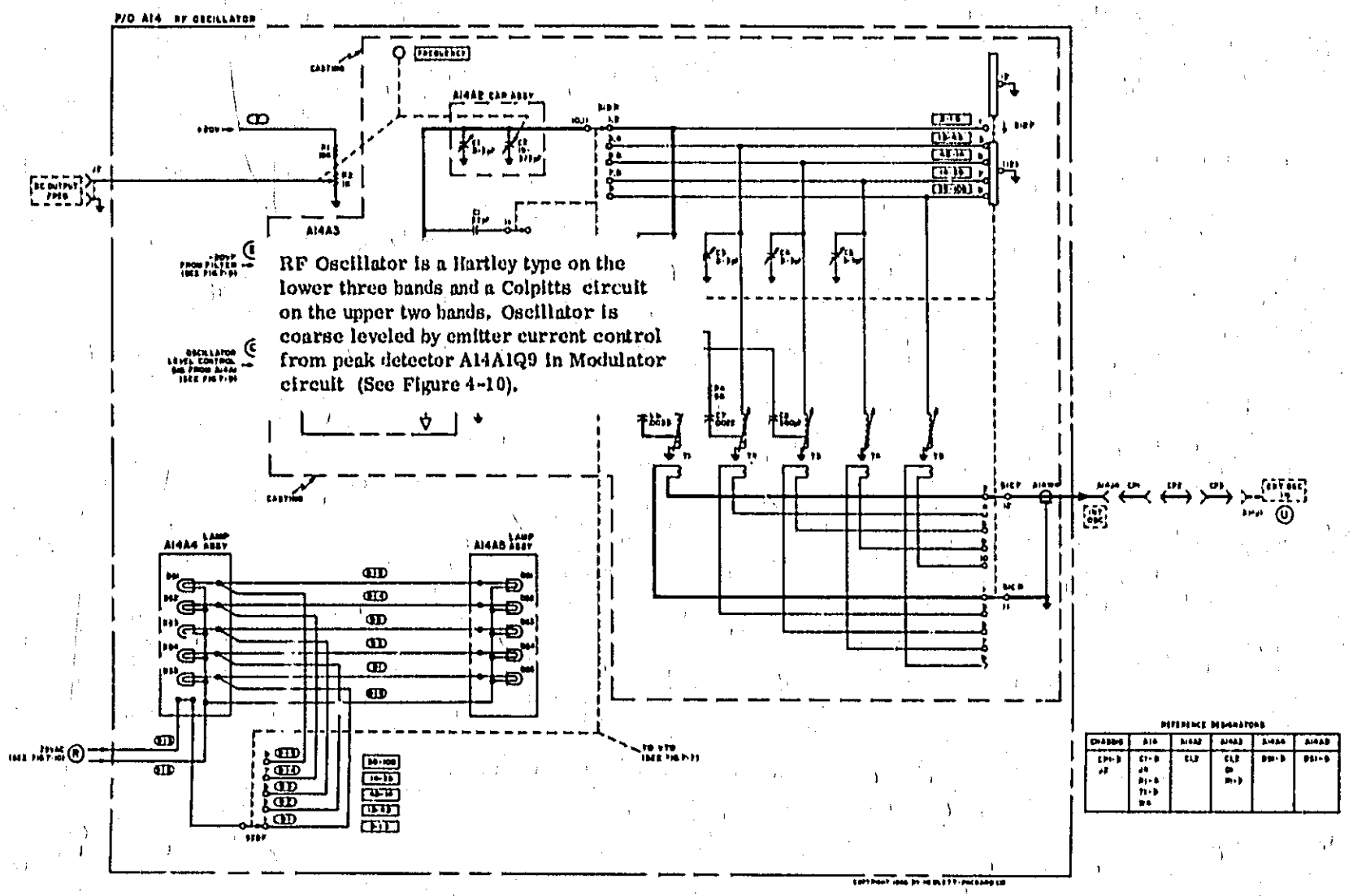


Figure 4-9. RF Oscillator (sheet 1 of 2)

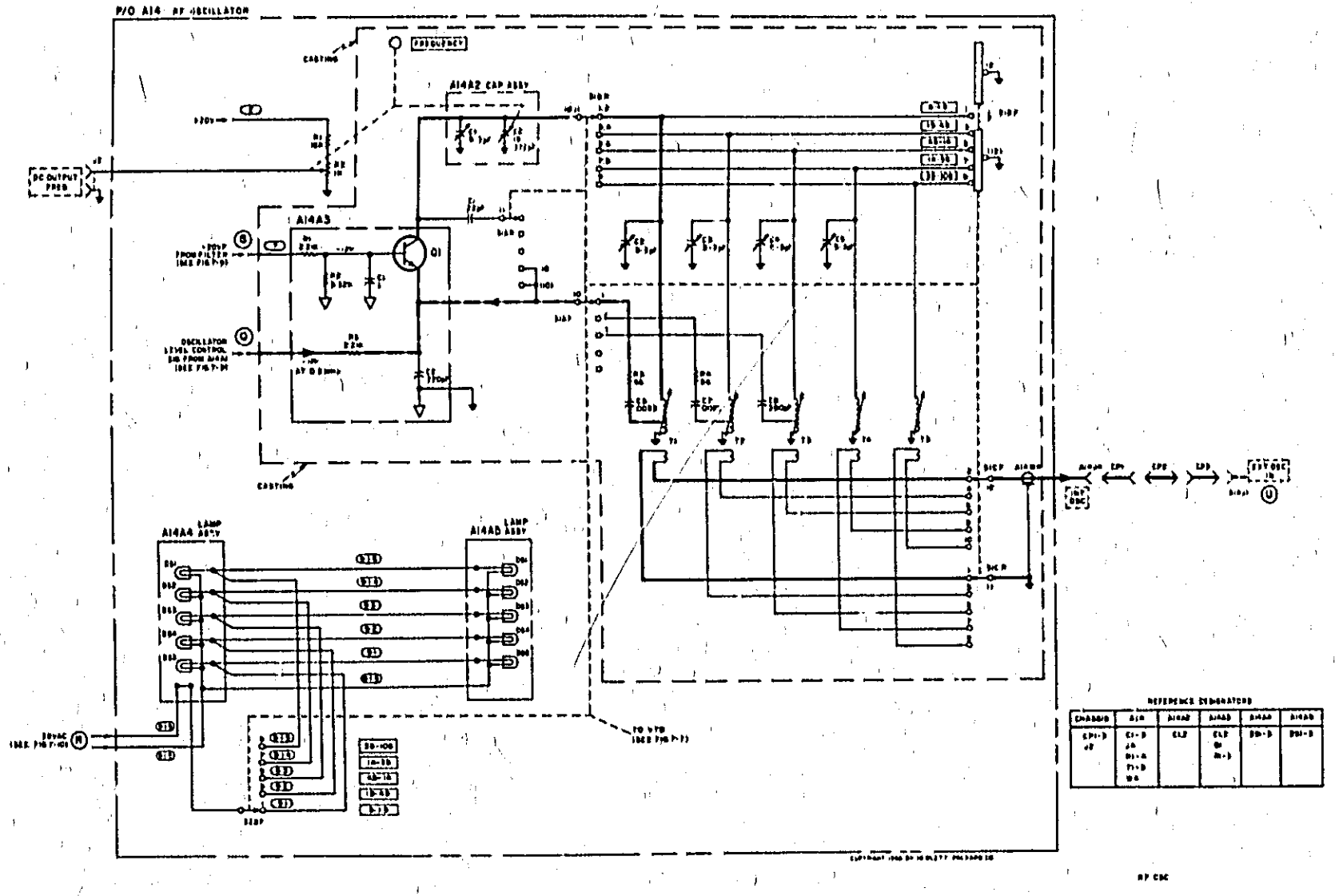


Figure 4-9. RF Oscillator (sheet 2 of 2)

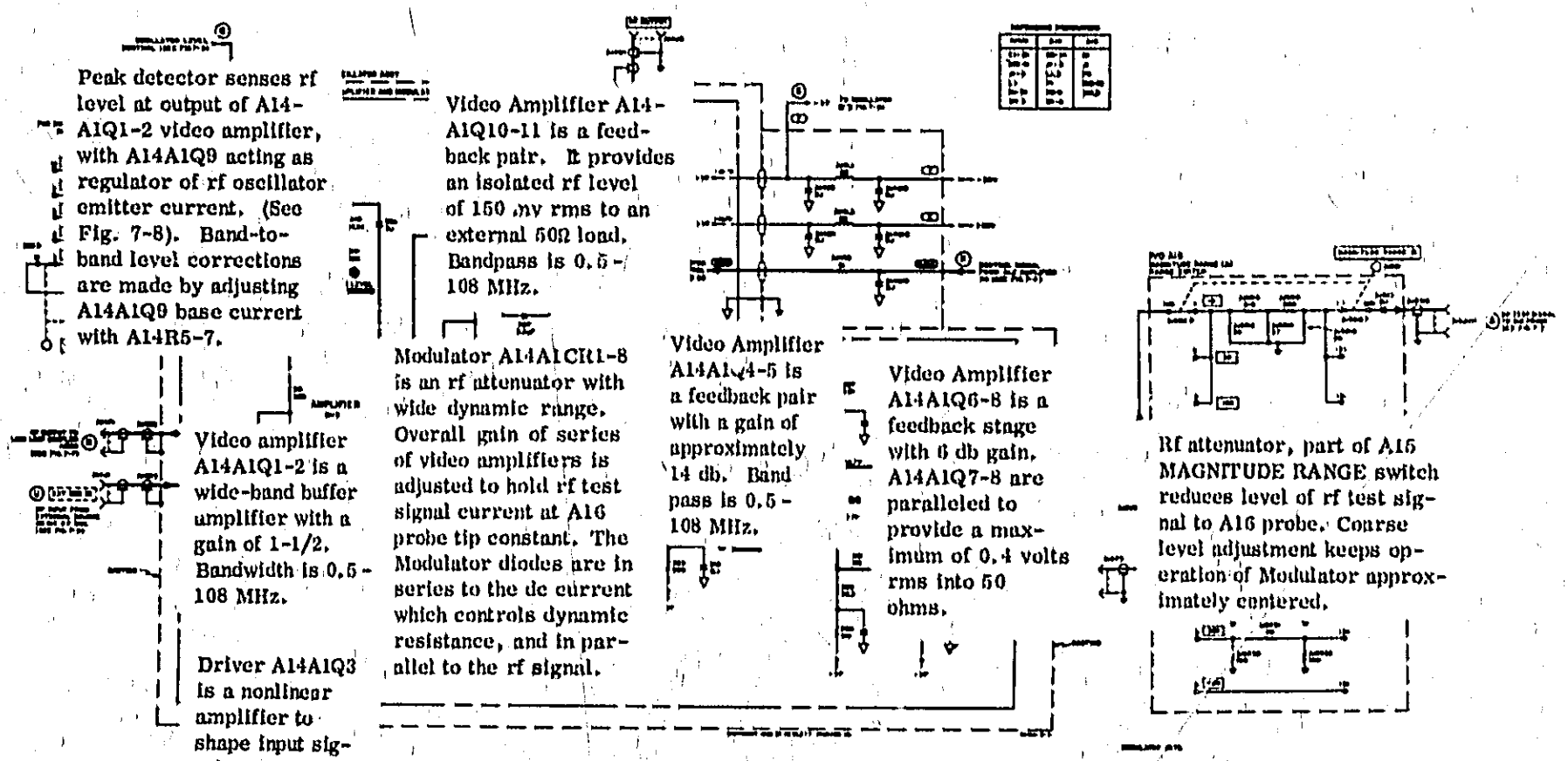


Figure 4-10. Modulator Circuits (sheet 1 of 2)

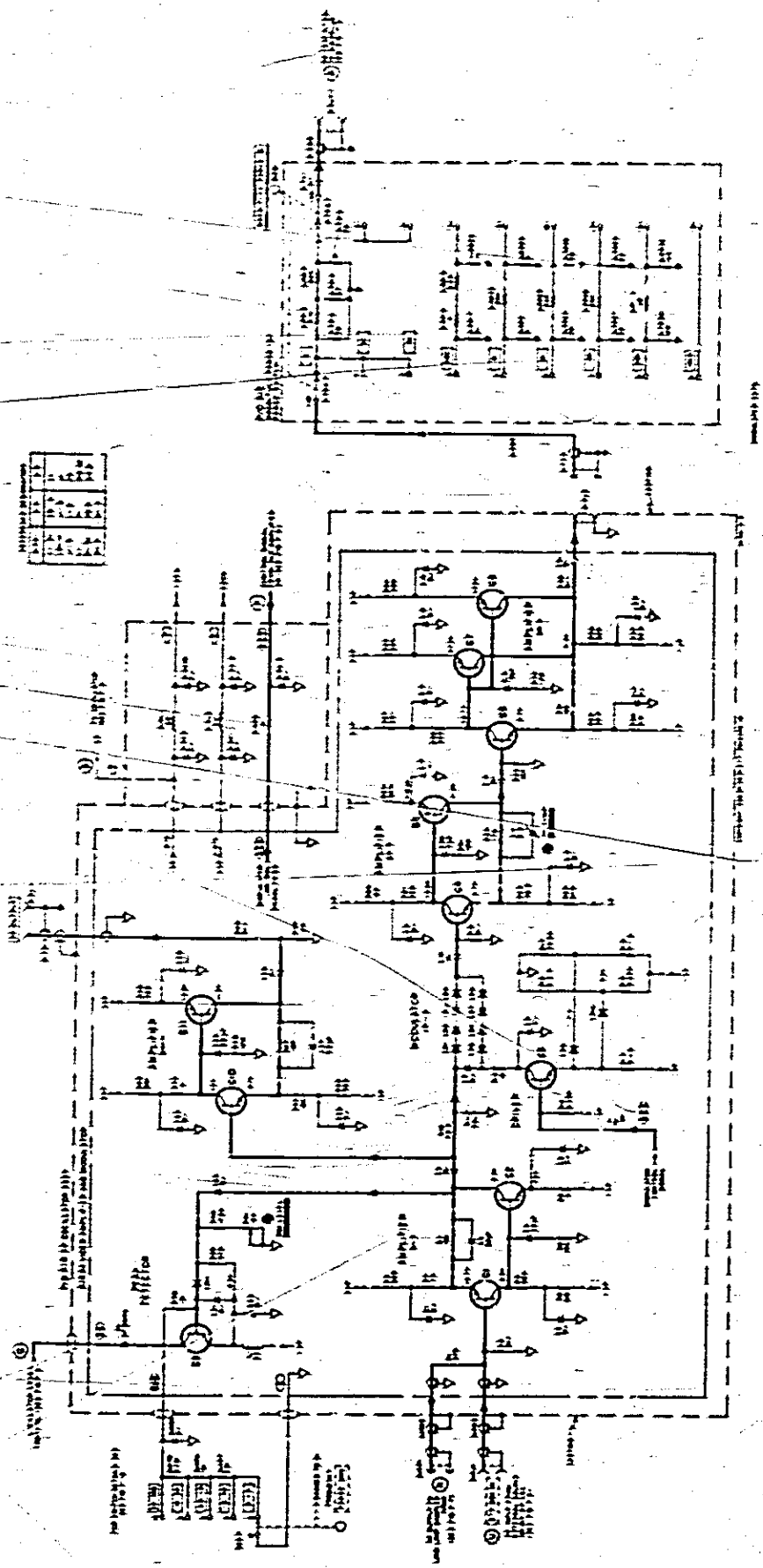


Figure 4-10. Modulator Circuits (sheet 2 of 2)

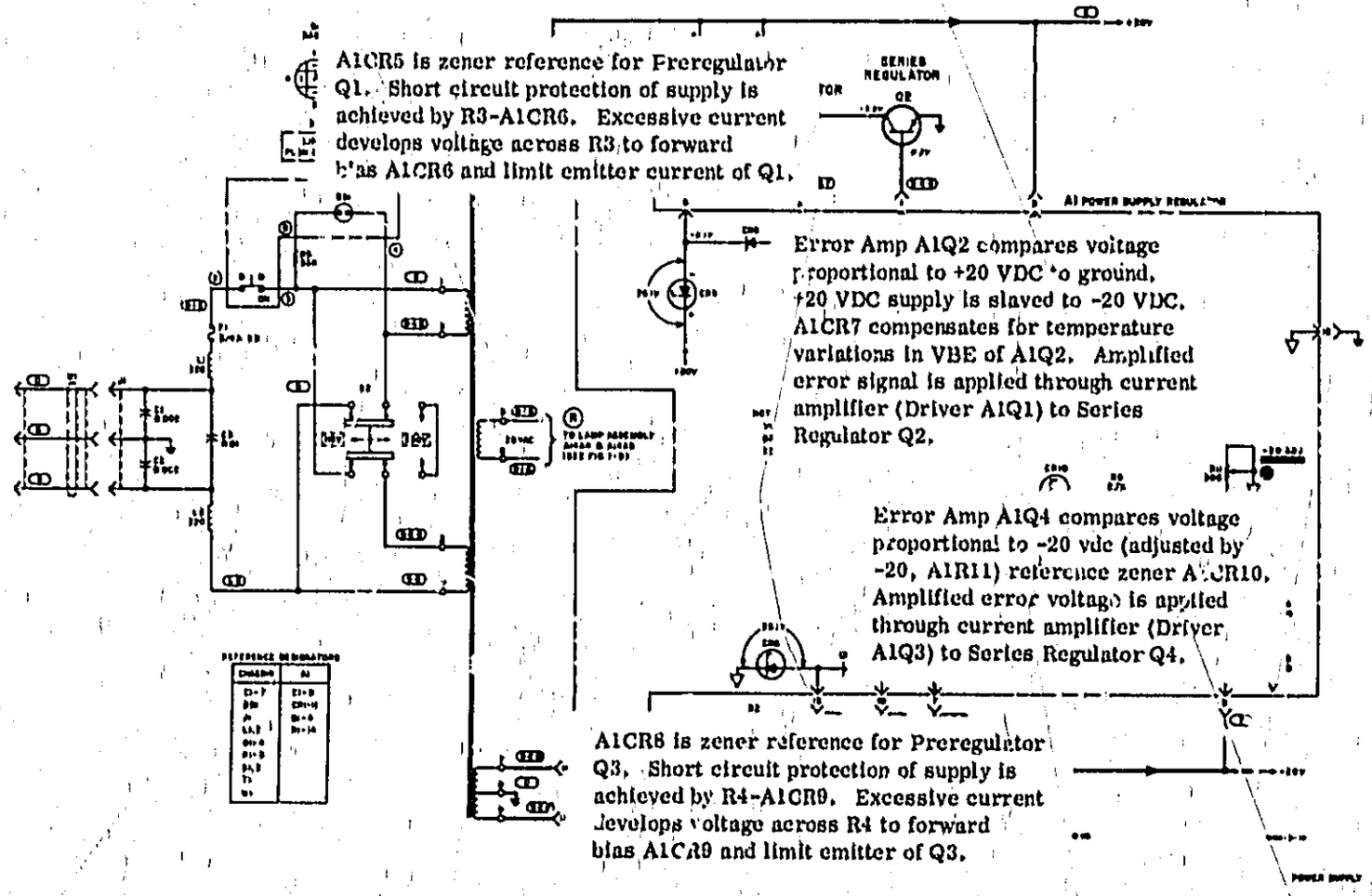


Figure 4-11. Power Supply (sheet 1 of 2)

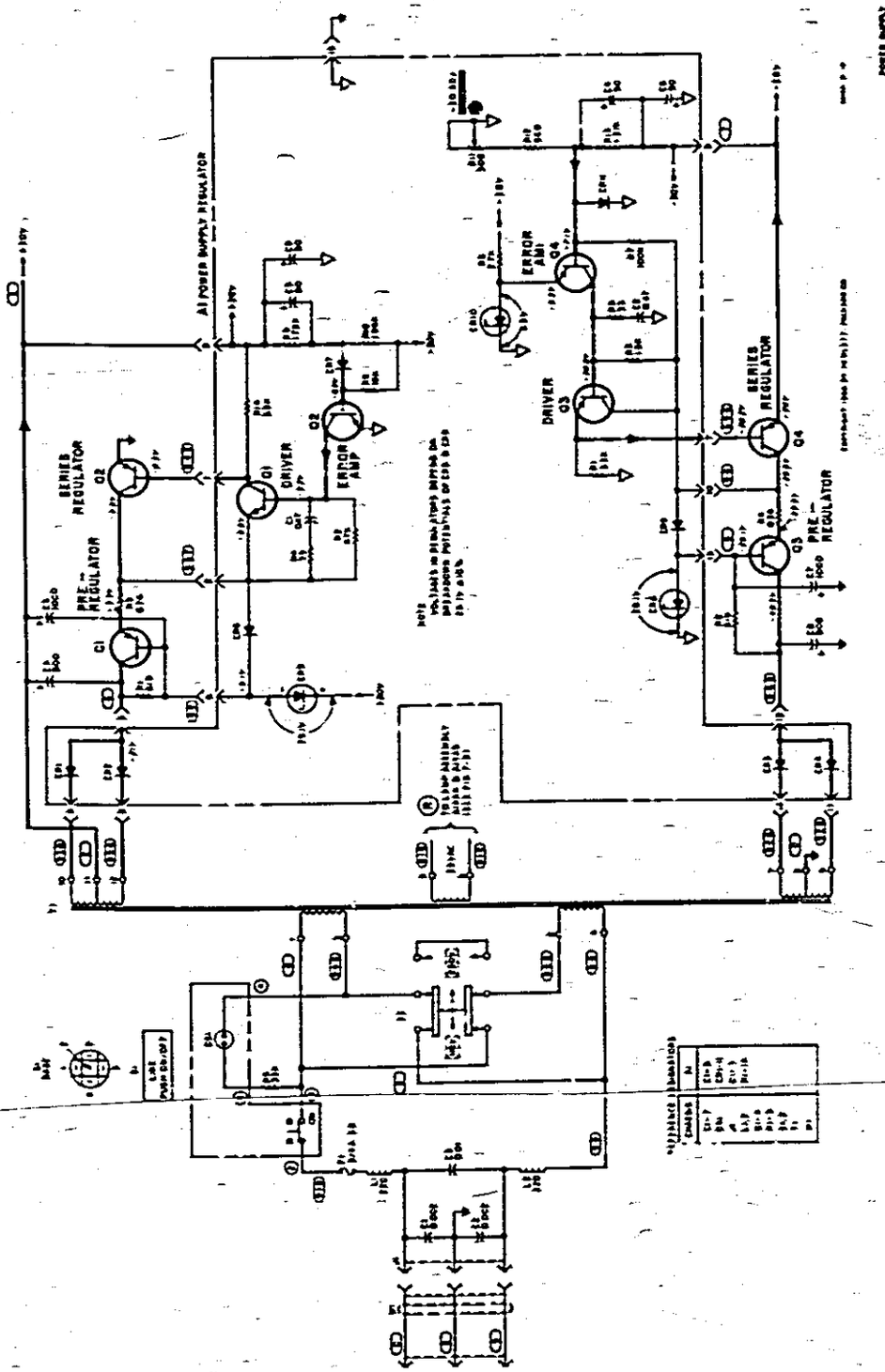


Figure 4-11. Power Supply (sheet 2 of 2)

MAINTENANCE

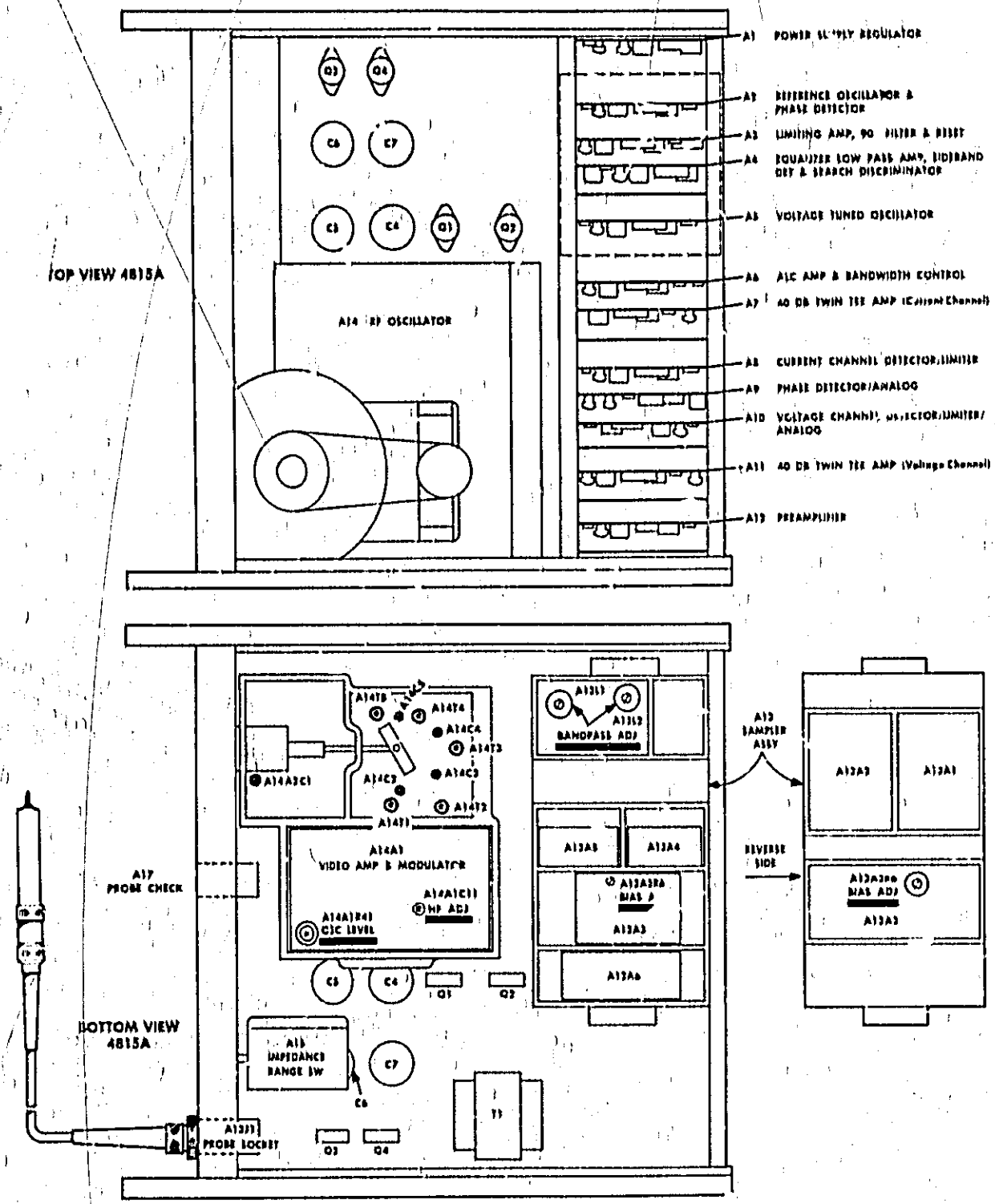


Figure 5-1. Location of Assemblies and Adjustments

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. Information required to maintain the 4815A RF Vector Impedance Meter is provided in this section. The type of information covered is briefly summarized in Paragraph 5-5.

5-3. Unless otherwise specified, test procedures assume the 4815A is connected to a 115 or 230 volt 50 to 400 cycle, approximately 50 watt source.

5-4. Most procedures require the use of other test equipment. Only those instructions that are pertinent to the procedure are given -- for full operating instructions refer to the Manual supplied with the instrument.

5-5. CONTENT — Summary.

a. Performance Checks. Table 5-3.

b. Adjustments. Internal adjustments are given in Paragraphs 5-12 to 5-25. Front panel adjustments are given in Section III.

c. Required test equipment. Instruments required to perform the operations outlined in this section are listed in Table 5-2. This table includes the type of instrument required, critical specifications, use, and recommended model. If the model listed is not available, equipment which meets or exceeds the critical specifications may be substituted.

d. Assembly and Component Identification.

(1) Figure 5-1 identifies the assemblies of the 4815A. Table 5-1 lists the assemblies numerically and indexes each to its schematic. Assemblies are identified by assembly number; for example, A12. Subassemblies of major assemblies carry two assembly numbers; for example A13A4 indicates the A4 subassembly of A13 assembly.

(2) Each board-mounted component is called out on an illustration of the board which also shows the etched wiring. Illustrations are located in Section VII, facing the schematic in which the assembly appears. The schematic designation of each board-mounted component is prefixed with the assembly number to form a complete designation.

e. Troubleshooting. Paragraphs 5-26 to 5-46.

f. Mechanical Assemblies. Paragraphs 5-52 to 5-59.

Table 5-1. 4815A Assemblies

Assy	Description	Schematic Figure
A1	Power Supply Regulator	7-10
A2	Reference Oscillator & Phase Det.	7-6
A3	Limiting Amp, 90° Filter & Reset	7-6
A4	Equalizer Low Pass Amp, Sideband Det & Search Discriminator	7-6
A5	Voltage Tuned Oscillator	7-7
A6	ALC Amp & Bandwidth Control	7-4
A7	40 dB Twin-Tee Amp (Curr. Chan.)	7-3
A8	Current Channel Detector/Limiter	7-4
A9	Phase Detector/Analog	7-5
A10	Voltage Channel Detector/Limiter/Analog	7-5
A11	40 dB Twin-Tee Amp (Volt. Chan.)	7-3
A12	Preamplifier	7-3
A13	Sampler Assy	7-2 7-7
A13A1	Current Channel Sampler Amp	7-2
A13A2	Voltage Channel Sampler Amp	7-2
A13A3	Sampling Pulse Gen	7-7
A13A4	Current Channel Isolating Network	7-2
A13A5	Voltage Channel Isolating Network	7-2
A13A6	Phase Lock Loop Sampler	7-7
A14	RF Oscillator	7-8
A14A1	Video Amp & Modulator	7-9
A14A2	Capacitor Assy	7-8
A14A3	Oscillator Circuit	7-8
A14A4	Lamp Assy	7-8
A14A5	Lamp Assy	7-8
A15	Impedance Range Switch	7-3 7-9 7-11
A16	Probe	7-2
A17	Probe Check	7-10

5-6. TEST EQUIPMENT REQUIRED.

5-7. The test equipment required to perform the operations outlined in this section are listed in Table 5-2. This table includes the type of instrument required, critical specifications, use, and recommended model. If the model recommended is not available, equipment which meets or exceeds the critical specifications may be substituted.

5-8. PERFORMANCE CHECKS.

5-9. Performance checks outlined in Table 5-3 can be used as an operating check for the instrument. These checks can also be used:

a. as part of an incoming inspection check of instrument specifications;

b. periodically, for instruments used in systems where reliability is of utmost importance;

c. as part of a troubleshooting procedure to locate operation problems, and

d. after any repairs or adjustments, before returning the instrument to regular service.

Table 5-2. Test Equipment Required

Instrument Type	Required Characteristics	Use	Instrument Recommended
Frequency Counter	5 kHz to 108 MHz, 0.1 V sensitivy	Performance Checks Calibration	-hp- 5245L, with 5253B plug-in
RF Millivoltmeter	3 mV to 1 V, 500 kHz to 108 MHz	Performance Checks Troubleshooting	-hp- 411A plus 11023A VHF probe tip
Coax tee	50Ω for use with -hp- 411A	Performance Checks	-hp- 1102A
Termination	50Ω Type N male	Performance Checks	-hp- 908A
Component Adapter	For use with -hp- 481EA probe	Performance Checks	-hp- 00601A
Adjustable Capacitor	0.7 - 3 pF	Performance Checks	-hp- Stock No. 0132-0005
Capacitor	0.001 μF ±0.1%	Performance Checks	General Radio 1409F
Capacitor	0.01 μF ±0.1%	Performance Checks	General Radio 1409L
Resistor	100Ω ±0.1%	Performance Checks	-hp- Stock No. 0698-4343
Resistor	1000Ω ±0.1%	Performance Checks	-hp- Stock No. 0698-3491
Inductor	250 μH; C_d approximately 8 pF; Q > 100	Performance Checks	-hp- 513A Q-Standard
Variable Transformer	Output 115 V ±20% or 230 V ±20%, Current: 2 amperes	Calibration Troubleshooting	General Radio Type W10 MT3A
DC Voltmeter	1 mV - 100 V range, Input impedance 10 MΩ Accuracy ±1% of FS 1Ω - 20 MΩ resistance range	Calibration Troubleshooting	-hp- 412A

Table 5-2. Test Equipment Required (cont'd)

Instrument Type	Required Characteristics	Use	Instrument Recommended
Oscilloscope	Input impedance: 10 megohms (with probe) Sensitivity: 1 mV/cm - 10 V/cm Passband: DC - 10 MHz	Calibration Troubleshooting	-hp- 140A plus 1401A plug-in
AC Voltmeter	Range - 1 MV - 30 V Frequency response: 10 Hz - 1 MHz Accuracy: ±3% of FS	Calibration Troubleshooting	-hp- 400D
VHF Signal Generator	Frequency, 100 MHz Output Range -50 to 0 dbm	Calibration	-hp- 608D
Sampling Oscilloscope	Sweep speeds to 100 ps/cm Bandwidth 3 gc Vertical sensitivity to 10 mV/cm	Troubleshooting Calibration	-hp- 185B plus 188A plug-in
Attenuator - qty 2	10 dB, General Radio connectors	Troubleshooting Calibration	General Radio 874-G10
Adapter (2 each)	General Radio coax to BNC female	Troubleshooting Calibration	General Radio 874-QBJ
Special test cable	2 cables, calibrated differential length special connectors one end, BNC another	Troubleshooting	-hp- 04815-61001
Delay line	400 ns	Troubleshooting Calibration	See Figure 5-10
Adapter	BNC to binding post	Calibration	-hp- 10110A
Cable Assembly	Shielded 50Ω terminated with BNC male connectors - both ends	Performance Checks Calibration	10503A
RF Adapter	BNC female - Male Type N	Performance Checks	-hp- Stock No. 1250-0780 (UG-201A/U)
Cable	bananna plugs to alligator clips	Calibration Troubleshooting	-hp- 11037A
Cable (special)	See Figure 5-6	Calibration	
Clip lead	2 - 3"; alligator clips	Calibration	

Table 5-3. Performance Checks

1. FREQUENCY

Specifications: 500 kHz to 108 MHz
Accuracy ± 2% of reading; ± 1% at 1.592 MHz and 15.92 MHz.
RF Monitor Output 150 mV into 50Ω.

a. Connect equipment to counter as shown in Figure 5-2.

b. Set counter controls to read frequency to at least four significant figures.

c. Set 4815A frequency to 1.592 MHz and 15.92 MHz (indicated by small 'vee' on scale). Counter should read between 1.576 and 1.607 MHz (or 15.76 and 16.07 MHz).

d. Check frequencies at low, middle and high end of each band as below. Check other frequencies of interest to ± 2% of reading.

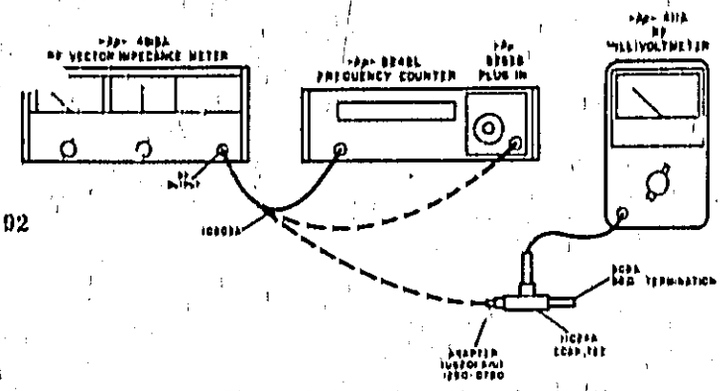


Figure 5-2. Connections for Testing Frequency and Output Level

Band	Low			Middle			High		
	Min, -2%	Dial Set	Max, +2%	Min, -2%	Dial Set	Max, +2%	Min, -2%	Dial Set	Max, +2%
0.5 - 1.5	0.490	0.50	0.510	0.889	0.90	0.918	1.4700	1.50	1.5300
1.5 - 4.5	1.470	1.5	1.530	2.450	2.5	2.550	4.410	4.5	4.590
4.5 - 14	4.410	4.5	4.590	7.840	8.0	8.160	13.72	14	14.28
14 - 35	13.62	14	14.38	19.60	20	20.40	34.40	35	35.60
35 - 108	34.40	35	35.60	58.80	60	61.20	100.84	108	110.16

e. Connect RF OUTPUT of 4815A -hp- 411A as shown in Figure 5-2.

f. RF Millivoltmeter should read >150 mV rms over range of 500 kHz to 108 MHz.

2. IMPEDANCE AND PHASE ACCURACY — Preliminary

a. Set 4815A controls as follows:
Probe in PROBE CHECK receptacle
MAGNITUDE RANGE (Ω) 100
PHASE RANGE 0^{o} ±90^{o}
FREQUENCY (MHz) approx 2 MHz

b. Adjust front panel screwdriver controls, MAG ADJUST and PHASE ZERO for meter indications of 1.0 (full scale) and 0^{o}.

c. Set frequency to 0.5 MHz, 100 MHz and any other frequency of interest. Meters should read within accuracy below (from Table 1-1).

Magnitude ± ~ % F.S. ± $\left(\frac{f}{30\ MHz} + \frac{Z}{25K\Omega}\right)$ % of reading

Phase angle ± $\left(3 + \frac{f}{30\ MHz} + \frac{Z}{50K}\right)$ degrees.

Table 5-3. Performance Checks (cont'd)

d. Set 4815A controls as follows:

Probe removed from PROBE CHECK receptacle	
FREQUENCY (MHz)	100
MAGNITUDE RANGE (Ω)	10K
PHASE RANGE	$0^{o} \pm 90^{o}$

e. Magnitude meter will read approximately 5KΩ (indicating 0.3 pF shunt C of probe); phase angle should read -90^{o} ±6.4°. Change PHASE RANGE to $180^{o} \pm 90^{o}$; meter should still indicate -90^{o} ±6.4°.

f. Install accessory 00601A (Component Mounting Adapter) and mount a small trimmer capacitor (-hp- Stock No. 0132-0005). See Figure 5-3. Adjust trimmer for OHMS Meter reading of .95 (95% of F. S.) (on 1K RANGE)

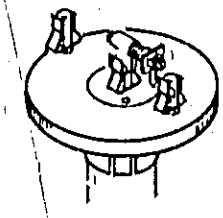


Figure 5-3. Test Component Installed for Checking High Impedance Ranges

g. Change frequency as follows and check OHMS Meter reading. Use counter to set frequency or add ± 2% to allowable magnitude error. Note: Read upper scale only; one division = 2%.

Frequency, MHz	MAGNITUDE RANGE (Ω)	Nominal	Magnitude Error	Phase angle Error
100	1K	0.95	set	±6°
31.62	3K	0.95	±5%	±1°
10	10K	0.95	±1.3%	±3.5°
3.162	30K	0.95	±5%	±3.9°
1	100K	0.95	±8%	±5°

NOTE: The procedures in steps 2a through 2g above check the range-to-range decading from 1K to 100K and the linearity of the probe voltage sampler.

3. IMPEDANCE MAGNITUDE CALIBRATION

NOTE

Impedance calibration consists of taking known capacitance and inductance standards and comparing the calculated impedance with the 4815A indication. The technique requires caution, however. The useful frequency range of large-value capacitors is limited by series inductance, negligible at 1 kHz but significant as series resonance is approached. For example, a test frequency of 1/5 the series resonant frequency causes a -1% magnitude error (without noticeably affecting the phase angle). Small value capacitors are difficult to standardize because of differing measuring terminal configurations and fringing effects. Inductors are more seriously frequency limited by series resistance and shunt capacity. The following procedures will check absolute magnitude calibration of the 4815A. Although substitutions can be made, care must be taken to avoid measurement situations that introduce unpredictable errors as indicated above. The 4815A calibration with capacitors requires correction for the predictable error due to series inductance of the standard (and probe inductance); if f = measuring frequency (MHz)

Table 5-3. Performance Checks (cont'd)

and f_r = series resonant frequency (MHz), the expected error will be $(\frac{f}{f_r})^2 \times 100\%$. f_r is measured by the 4815A by tuning for a minimum OHMS meter indication and 0^o phase angle. (an on-scale OHMS meter indication is kept while tuning).

a. Set 4815A controls as follows:
PHASE RANGE $0^o \pm 90^o$

b. Connect 4815A to precision components as shown in Figure 5-4, checking OHMS meter reading against readings below. MIN NOM and MAX values are derived from full scale reading + correction ± tolerance, where tolerance is from the formula $\pm(\frac{f}{30\ MHz} + \frac{Z}{25K})\% \pm 4\%$ of F. S. Use frequency counter to set test frequency or change figures in MIN and MAX columns to indicate an additional ± 2% from nominal.

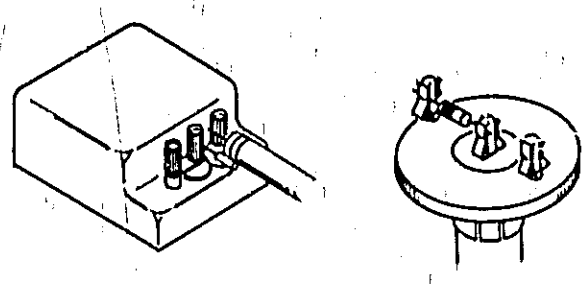


Figure 5-4. Connecting to Test Components

Test Component	MAGNITUDE RANGE (Ω)	FREQUENCY (MHz)	CORRECTION due to frequency	OHMS Meter reading USE UPPER SCALE ONLY MIN	NOM	MAX
GR Standard 1409L (0.01 μF ± 0.1%, (f_r = 6.4 MHz)	10	1.592	-6.3%	0.90	0.94	0.98
	30	0.5033	-0.6%	0.95	0.99	1.03
GR Standard 1409F (0.001 μF ± 0.1%) (f_r = 20 MHz)	100	1.592	-0.6%	0.95	0.99	1.03
	300	0.5033	nil (0.1%)	0.96	1.0	1.04
100Ω resistor -hp- stock no. 0698-4343 in comp. adapter	100	0.5	0%	.96	1.00	1.04
1000Ω resistor ± 0.1% -hp- stock no. 0698-3491	1K	0.5		0.96	1.00	1.04
-hp- 513A Q-Standard	1K	600 kHz	see below	-5%	++	+5%

Table 5-3. Performance Checks (cont'd)

Connect 4815A to 513A. Look for parallel resonance near 3.5 MHz (coil inductance resonating with distributed capacitance of coil + 4815A probe). Record frequency, f= _____ MHz.

Calculate $C_d' = \frac{1}{4\pi^2 f^2 L}$ (notations are those used in 513A Application Instructions, accompanying Q_s-Standard)

Record C_d' = _____ pF (approximately 10 pF)

Test frequency will be 0.6 MHz (where OHMS meter will read near full scale when measuring coil impedance) Calculate effective inductance of Q-Standard at 600 kHz:

$$L_e = \frac{L}{1 - \omega^2 L C_d'}$$ or the simplified expression $$L_e = L(1 + \omega^2 L C_d')$$

This is possible because $\omega^2 L C_d' \ll 1$

Record calculated L_e = _____ µH. This will be approximately 4% greater than L.

Calculate $X_L = 2\pi f L_e$ where f= 0.6 MHz.

Record X_L = _____ OHMS (approximately 980Ω)

$Z = X_L$ for purposes of 4815A testing, since series resistance of the high-Q coil is approximately 9Ω, very small compared to X_L.

Enter Z in space above marked ++. Tolerance of 5% is ± 4% for 4815A and ±1% due to accuracy of L calibration of 513A.

4. PHASE ANGLE CALIBRATION

Specification $\pm \left(3 + \frac{f}{30\ \text{MHz}} + \frac{Z}{50K} \right)$ degrees

a. Set 4815A controls as follows:
   Probe in PROBE CHECK receptacle
   MAGNITUDE RANGE (Ω) 100
   PHASE RANGE $0^o \pm 90^o$
   FREQUENCY (MHz) 2

b. Adjust PHASE ZERO front panel screwdriver adjust for 0^o reading.

c. DEGREES Meter should read $0^o \pm 6^o$ at any frequency between 0.5 MHz and 108 MHz.

d. Set 4815A controls as follows:
   Connect probe to 513A Q-Standard
   MAGNITUDE RANGE (Ω) 1K
   FREQUENCY (MHz) 0.6

e. DEGREES Meter should read $+90^o \pm 3^o$ in both positions of the PHASE RANGE Switch.

f. Set 4815A controls as follows:
   Connect probe to GR 1409F standard (0.001 µF)
   FREQUENCY (MHz) 0.5
   MAGNITUDE RANGE (Ω) 300

g. DEGREES meter should read $-90^o \pm 3^o$ in both positions of the PHASE RANGE switch.

5-10. INSTRUMENT COVER REMOVAL.

5-11. To remove either the top or bottom cover, remove the Phillips-head screws which secure the cover to the instrument. Slide the cover approximately 1/2 inch to the rear of the instrument and lift free. To replace cover, reverse the procedure.

CAUTION

DAMAGE MAY RESULT FROM THE DISASSEMBLY OF THE PROBE. Probe circuitry is covered with a fitted inner shield that cannot be removed without special tools.

5-12. ADJUSTMENT AND CALIBRATION PROCEDURES.

5-13. The following test and adjustment procedures should be performed only if it has been definitely determined by the Performance Checks given in Table 5-3 that the 4815A is not in specifications. Tolerances associated with adjustments are given as aids to making the adjustments. These tolerances do not constitute a basis for qualification or acceptance of an instrument since no allowance has been made for temperature or aging effects. Qualification and overall performance should only be based on the specifications listed in Table 1-1.

NOTE

Except where indicated, adjustments and tests are made at nominal line voltage. Access to adjustments on assembly boards A1 through A12 may require the use of the supplied plug-in extender.

CAUTION

Temporarily remove power to the 4815A while removing or replacing assembly boards.

5-14. MECHANICAL METER ADJUSTMENT. When a meter is properly zero-set, the pointer rests over the zero mark on the meter scale when the instrument is: 1) at the normal operation temperature, 2) in its normal operating position, and 3) turned off for at least one minute. Set the pointers as follows to obtain best accuracy and mechanical stability.

a. Turn the instrument off. Allow one minute for capacitors in metering circuits to discharge.

b. Rotate the meter mechanical adjustment screw clockwise until the meter pointer is to the left of zero and moving towards zero. Stop when the pointer is exactly over the zero mark. If the pointer overshoots, repeat step b.

c. When the pointer is exactly on zero, rotate the adjustment screw approximately 15 degrees counterclockwise. This frees the

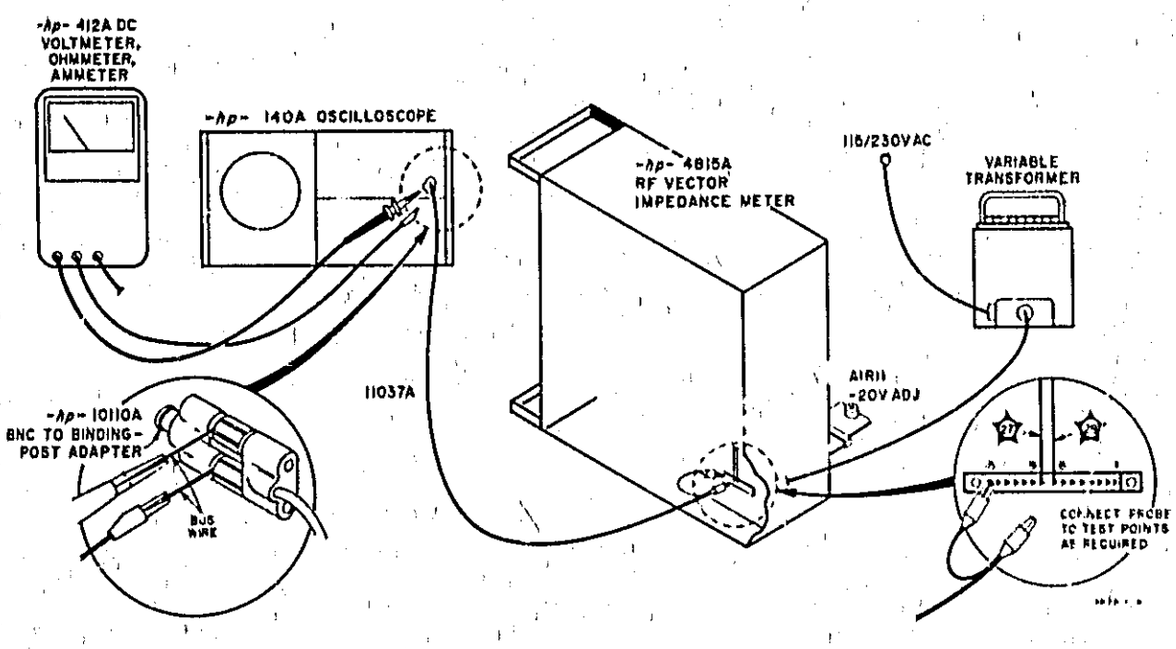


Figure 5-5. Setup for Power Supply Check

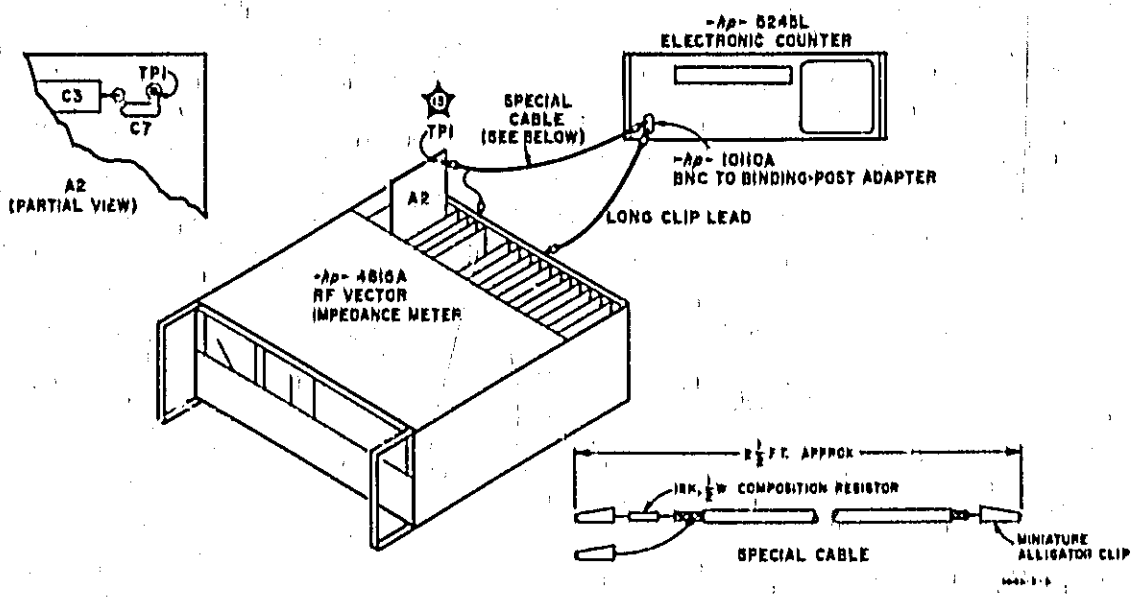


Figure 5-6. Setup for Reference Oscillator Adjustment

adjustment screw from the meter suspension. If the pointer moves during this step, repeat steps b and c.

5-15. POWER SUPPLY, A1.

a. Remove top and bottom cover plates. Rest 4815A on left side and make connections as shown in Figure 5-5.

b. Set Variable Transformer for output to agree with Line Voltage Switch position (115-vac or 230-vac). Turn on 4815A.

c. Connect DC Voltmeter and Oscilloscope to -20 V 17 XA1 (9).

d. Adjust A1R11 (-20 V ADJ) for -20.0 VDC ±1% (This adjustment can be made without extending the A1 assembly board).

e. Vary line voltage from 103 to 127 vac (or 206 to 254 vac).

f. DC Voltmeter reading should not change noticeably. Oscilloscope should show ripple below 1 mV peak-to-peak.

g. Connect DC Voltmeter and Oscilloscope to 12 XA1 (8).

h. Voltmeter should indicate between 19.4 and 20.6 vdc.

i. Vary line voltage from 103 to 127 vac (or 206 and 254 vac).

j. DC Voltmeter should not change noticeably. Oscilloscope should show ripple less than 1 mV, peak-to-peak.

k. Remove connections.

5-16. OSCILLATOR, A2.

a. Make connections as shown in Figure 5-6. Connect 13 to Frequency Counter using special cable illustrated.

b. Set counter controls to read period.

c. Adjust A2L1 for a period of 200.0 ±0.2 μs. Use extender board to gain access to adjustment.

d. With 4815A power turned off, remove cable and extender.

5-17. SAMPLER ASSEMBLY FILTER.

NOTE

The following procedure is a factory adjustment and not a necessary part of a normal calibration. The adjustments are extremely broad compared to overall channel bandwidth and will rarely require adjustment.

When adjustment is necessary:

a. Remove small cover plate on A13 Sampler Assembly.

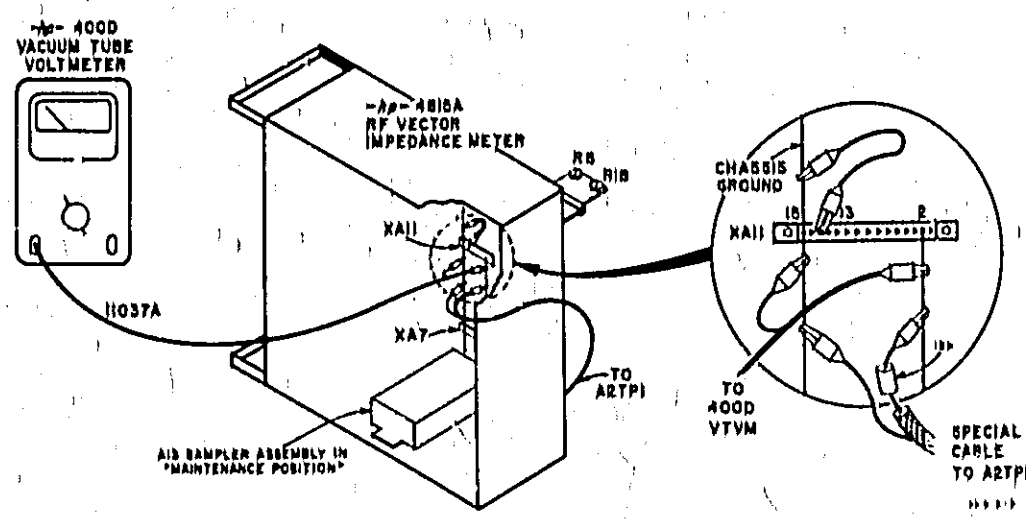


Figure 5-7. Setup for Bandpass Amplifier Adjustments

b. Disconnect A13C15 from A13C17.

c. Connect A2TP1, (12), to loose lead of A13C5 using special cable illustrated in Figure 5-6.

d. Connect an AC VTVM between loose lead of A13C5 and ground.

e. Place short across A13L2 and tune A13L1 for minimum voltmeter reading (< 6 mV rms).

f. Remove short across A13L2 and tune A13L2 for a maximum voltmeter reading, (<0.3 V rms).

g. Disconnect leads; reconnect A13C5. Reinstall cover plate.

5-18. BANDPASS AMPLIFIERS, A7/A11.

a. Place Voltage Channel Twin-Tee Amplifier, (A11) on board extender. Allow A13 Sampler Assembly to swing to the "maintenance position" by removing two screws near right-side frame.

b. Make connections as shown in Figure 5-7. Shielded cable to VTVM should be no longer than 3 ft to prevent amplifier instability.

c. Adjust A11R8 and A11R18 alternately for a voltmeter reading of less than 0.5 mV, rms.

d. Remove connections and extender.

e. Place Current Channel Twin-Tee Amplifier (A7) on board extender.

f. Repeat steps b through d above for A7 Assembly.

5-19. PHASE DETECTOR, A9.

a. Insert 4815A probe into PROBE CHECK socket.

b. Set 4815A controls as follows:

MAGNITUDE RANGE (Ω)	100
PHASE RANGE	0^{o} $\pm 90^{o}$
FREQUENCY (MHz)	2

c. Adjust front-panel PHASE ZERO screwdriver control for a DEGREES meter reading of zero.

d. Place Phase Detector Assembly, A9, on the board extender.

e. Install Component Mounting Adapter accessory, 00601A, on probe and connect a 270 pF capacitor (-hp- Stock No. 0140-0015).

f. Set 4815A front panel controls as follows:

MAGNITUDE RANGE (Ω)	300
PHASE RANGE	0^{o} $\pm 90^{o}$
FREQUENCY (MHz)	2

g. Adjust A9R17 for a DEGREES meter reading of -90.0.

h. Change PHASE RANGE switch to 180^{o} $\pm 90^{o}$ DEGREES meter should read -90 ± 1^{o}.

i. Replace 270 pF capacitor with a 22 μH inductor, (-hp- Stock No. 9140-0115).

j. DEGREES meter should read $+90^{o} \pm 1^{o}$ in both positions of the PHASE RANGE switch. If not, check mechanical zero adjustment and steps a through c above.

k. Remove extender.

5-20. OSCILLATOR ASSEMBLY, A14.

5-21. MODULATOR.

a. Connect equipment as shown in Figure 5-8. Remove bottom cover plate on A14.

b. Set 4815A controls as follows:
MAGNITUDE RANGE (Ω) 30
Probe tip unconnected

c. Set 608D output frequency to 100 MHz and adjust output level for -23.5 db rf level across A14A1R18.

d. Adjust HF ADJ, A14A1C11, for 0 db rf level at A14J2.

e. Remove connections

f. Reconnect jumper between rear panel EXT. OSC. IN and INT. OSC. connectors.

g. Set 4815A frequency to 0.5 MHz.

h. Adjust OSC LEVEL, A14A1R41, for 95 mV rms across A14A1R2.

5-22. OSCILLATOR FREQUENCY

a. Remove bottom cover on A14. All adjustments are made from bottom. Refer to Figure 5-8 for location of adjustments.

NOTE

If the following procedures indicate calibration is consistently in error on all ranges, refer to Paragraph 5-55 for mechanical adjustment of the oscillator

b. Connect frequency counter to front panel RF OUTPUT connector. Set counter to rear frequency.

c. Set 4815A FREQUENCY (MHz) controls for 35.0 dial reading. Adjust A14T5 for 35.0 MHz output frequency.

d. Change 4815A controls for 100 MHz dial reading. Adjust A14A2C1 for 100.0 MHz output frequency.

e. Check dial tracking across 35 - 108 MHz band. Compromise adjustments may improve tracking.

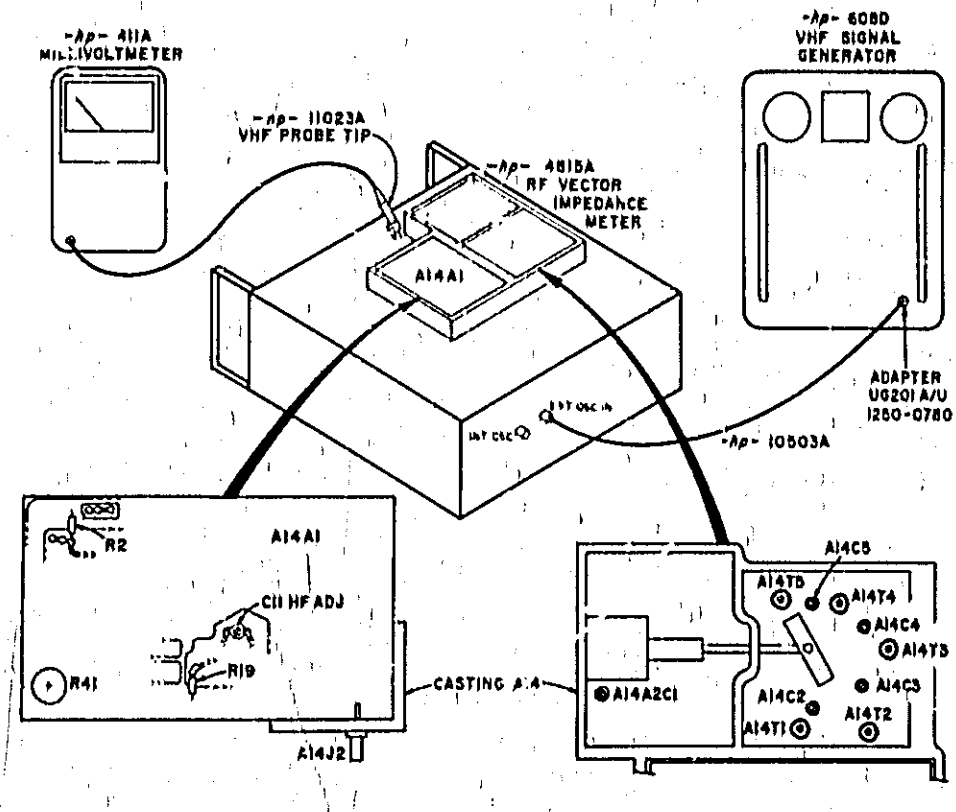


Figure 5-8. Setup for Modulator-Oscillator Adjustments

Table 5-4. Frequency Calibration Adjustments

Step	FREQUENCY (MHz)		Adjustments
	Range	Dial	
1	0.5 - 1.5	0.5	A14T1
2	0.5 - 1.5	1.5	A14C2
3	1.5 - 4.5	1.5	A14T2
4	1.5 - 4.5	4.5	A14C3
5	4.5 - 14	4.5	A14T3
6	4.5 - 14	14.0	A14C4
7	14 - 35	14.0	A14T4
8	14 - 35	35.0	A14C5

f. Set FREQUENCY (MHz) controls for dial readings as shown in steps 1-8 in Table 5-4. Adjust control indication for correct calibration.

g. Reinstall A14 Bottom Cover.

5-23. OTHER ADJUSTMENTS.

5-24. CHANNEL GAIN EQUALIZATION. A12R3 controls voltage channel gain and effectively centers the adjustment range of R6, the front panel MAG ADJ control. Readjustment of A12R3 is not required after initial factory adjustment is made.

5-25. PULSE GENERATOR & TIMING ADJUSTMENTS. Sampling of both voltage and current at the same point on the rf waveform is accomplished by control over the length of cables carrying the sampling pulses and by adjustment. Unless cables are replaced or phase error at 100 MHz exceeds 3° (See Table 5-3, Step 4c), adjustment is not necessary. The adjustment procedure is given in Paragraph 5-41 under Troubleshooting.

5-26. TROUBLESHOOTING.

5-27. The best approach to isolating trouble is to first ensure that the trouble is not a result of conditions external to the 4815A; then obtain all possible information from the controls and indicators and logically apply this information to locate the defective unit or component. Figure 3-1 (Front Panel Features), Figure 3-2 (Rear Panel Features), Figure 3-3 (General Operating Instructions), and component location figures and schematic diagrams can be used to understand operation and locate parts.

5-28. An initial setup for troubleshooting can be made by placing the probe into the PROBE CHECK 100Ω ∠0° socket, setting the MAGNITUDE RANGE (Ω) switch to 300 and oscillator frequency to 1 MHz. The OHMS meter should indicate near 100 and the DEGREES meter should indicate near 0°

5-29. With the initial setup as above, the SEARCHING indicator should not light. If it does, the phase lock circuits must first be made to operate before going further. If a phase locked condition exists and the OHMS meter indication is far from correct, check the IF channels, ALC amplifier and modulator. If only the DEGREES meter indication is incorrect, check the phase detector.

5-30. PROBE — Troubleshooting.

5-31. DISASSEMBLY OF THE PROBE PROVIDES NO USEFUL TROUBLESHOOTING INFORMATION, AND MAY ONLY CAUSE DAMAGE. Circuits in the probe are covered by a force-fitted shield that is removed with special tools. The following procedures will help locate failure within probe and adjacent circuits. Contact your Hewlett-Packard Sales and Service Office for information about probe replacement or repair.

5-32. Troubleshooting the probe consists of:

1. Direct substitution (when possible)
2. DC resistance checks
3. Specific test setups to raise the normally low-level signals in the sampler amplifiers (A13A1 and A13A2) to measurable levels.

5-33. Unbalance in pulse circuitry will generally cause normal or near-normal readings when measuring the 100Ω ∠0° PROBE CHECK at 0.5 MHz, with errors increasing with frequency. Resistance checks will help isolate failure in the probe. Following the procedures in Paragraph 5-41 will help locate failures in the 4815A pulse circuits.

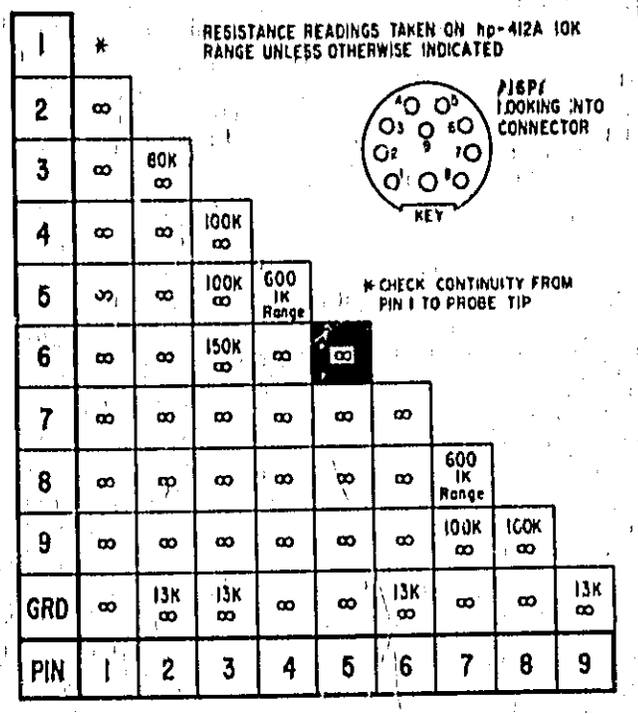
5-34. DC Resistance Checks. Table 5-5 lists normal probe connector - connector and connector-to-ground resistance readings taken on an -hp- 412A Multifunction Meter. Substitute meters should be expected to give different readings. Where polarity of test current affects readings, forward and reverse readings are given. To use Table 5-5, find the intersection between a row and a column, each including a desired connection number. The table illustrates, using pins 6 and 5, the resistance between these connections is infinity.

5-35. Operational Checks.

1. RF test current.

   a. Connect a 10KΩ fixed resistor and a 50KΩ adjustable resistor in series from chassis to A6 (4) (or white-orange-black wire entering feedthru at rear of A14 oscillator assembly).

Table 5-5. Resistance Chart for Probe, A16



1	*								
2	∞								
3	∞	80K ∞							
4	∞	∞	100K ∞						
5	∞	∞	100K ∞	600 1K Range					
6	∞	∞	150K ∞	∞	∞				
7	∞	∞	∞	∞	∞	∞			
8	∞	∞	∞	∞	∞	∞	600 1K Range		
9	∞	∞	∞	∞	∞	∞	100K ∞	100K ∞	
GRD	∞	13K ∞	13K ∞	∞	∞	13K ∞	∞	∞	13K ∞
PIN	1	2	3	4	5	6	7	8	9

b. Set FREQUENCY (MHz) to 0.5, MAGNITUDE (Ω) to 100K. Connect 4815A probe to oscilloscope vertical input using 10207A and 10206A adapters.

c. Set 50K variable resistor to minimum - probe tip signal level will be approximately 1.5 V p-p. The above test conditions shows modulator has capability of providing more than adequate test signal.

2. Voltage Channel

a. Complete preceding steps 1a and 1b. Adjust variable resistor for 1.0 V p-p (0.5 MHz) at probe tip.

b. Remove cover plate over A13A1 and A13A2 sampler amplifier assemblies.

c. Check signal level at A13A2Q3 emitter for approximately 4.5 V p-p, 5 kHz sine wave.

d. Check signal level at A13A2Q1 emitter for approximately 2 mV p-p. Voltage gain between test points is approximately 70 dB, mainly dependent upon h_{fe} of A13A2Q2.

3. Current Channel

a. Complete preceding steps 1a, 1b, 2a, and 2b.

b. Short probe tip to chassis.

c. Check signal level at A13A1Q3 emitter for approximately 0.75 V p-p, 5 kHz sine wave.

d. Check signal level at A13A1Q1 emitter for approximately 200 μV p-p. Voltage gain between test points is approximately 70 dB, dependent upon h_{fe} of A13A1Q2.

5-36. POWER SUPPLY — Troubleshooting.

NOTE

If either +20 V or -20 V supply voltages exceed 30 volts, disconnect load by lifting buss wire connections at A1 (8) and A1 (9). Install 100Ω 5 watt resistors as temporary loads until trouble is cleared.

a. A supply output voltage over 30 V indicate both preregulator and regulator circuits are not functioning.

b. Output voltages over 20 V but under approximately 29 V indicate preregulator is functioning and regulator is not.

c. Output voltages under 20 V are caused by preregulator, regulator, rectifier system or excessive load on supply causing preregulator to current limit.

5-37. PHASE LOCK LOOP — Troubleshooting.

5-38. Removing the connecting link between the rear-panel EXT. OSC. IN. and INT. OSC. connectors will cause the SEARCHING indicator to light. Reconnecting the link will cause the light to go out. (Excessive fm present upon an externally applied RF source will also cause SEARCHING indicator to light.)

a. Turn 4815A power on. If SEARCHING indicator does not flash briefly and extinguish, and yet meters read normally, check A4Q9 lamp driver circuit.

b. If SEARCHING indicator remains lit, connect oscilloscope with 10:1 divider probe between chassis and XA4 (1). Waveform should be a sawtooth with amplitude greater than 10 volts and period approximately 45 ms. If period is greater than 60 ms, check current path through A4CR1, A4R25 and A4Q8.

1) If sawtooth is normal, temporarily short XA4 (13) to chassis. Period should increase to over four seconds. If sawtooth runs only briefly and stops at a constant voltage less than 11.5 volts, and the SEARCHING lamp goes out, basic phase lock loop is functioning and the search discriminator and sideband detector should be checked.

2) Disconnect one end of A4CR4. If 4815A functions normally (except for the sense of the DEGREES meter) sideband detector is defective. If loop still will not lock, search discriminator is not operating. Reconnect A4CR4.

c. If sawtooth continues in b (1) above, check

1. VTO output at XA5 (11) - VTO may not be oscillating.

2. RF voltage at A14J4 (RF oscillator not operating.

3. IF waveform at XA3 (14) - will be a complex sweeping waveform during search, 5 kHz when locked.

4. A3 outputs at XA3 (4) and XA3 (6).

5. Collector waveform at A4Q6.

6. 5 kHz Reference oscillator, Pulse Generator and Phase Detector.

d. To check ability of loop to phase lock on all test frequencies, replace connecting link between EXT. OSC. IN and INT. OSC. rear-panel connectors. Connect voltmeter or oscilloscope to XA4 (1). If oscilloscope is used, direct-couple the vertical input.

e. Set 4815A FREQUENCY (MHz) to 0.5 Slowly increase frequency until voltage at XA4 (1) reaches -5.0 vdc and note frequency. Continue increasing frequency until DC level changes abruptly to a point more negative than -5.0 V. Decrease frequency slowly until another abrupt change occurs. The dial reading must be lower than noted previously.

f. Repeat e above on 1.5 - 4.5 MHz band, starting at 1.5 MHz.

g. Repeat e above on 4.5 - 14 MHz band, starting at 4.5 MHz.

h. Repeat e above on 14 - 35 MHz band, starting at 14 MHz.

i. Repeat e above on 35 - 108 MHz band, starting at 35 MHz.

NOTE

In step e above if second dial reading is not lower than the first, check VTO and A13CR11 - VTO may not be capable of tuning to 0.5 MHz. If, in steps f through i above, second dial reading is not lower than the first, check frequency range switch S2A and resistors A5R13-26.

5-39. IF CHANNELS — Troubleshooting.

a. Connect 1 KΩ, 1% resistor across input terminals of -hp- 400D; set meter to 10 mV range.

b. Set 4815A controls as follows:

MAGNITUDE RANGE (Ω)	1K
FREQUENCY (MHz)	0.5

Connect 4815A probe to VTVM as shown in Figure 5-9

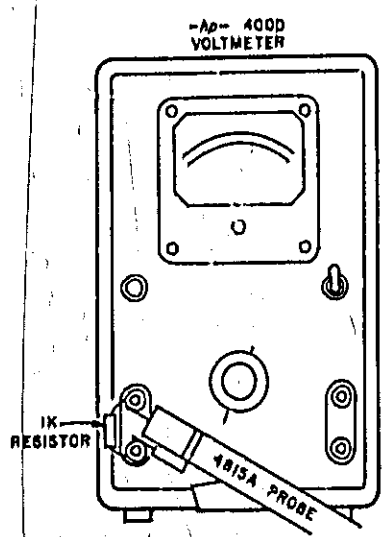


Figure 5-9. Setup for measuring RF Test Signal Level

1. VTVM should read approximately 4 mV and 4815A should indicate approximately 1000Ω $\angle 0^{\circ}$.

2. If VTVM reads high or low, check IF signal level at XA8 (2), which should be approximately 265 mV rms. If not, check ALC Amplifier and Modulator.

3. If VTVM reads correctly, and 4815A OHMS meter reads incorrectly, check gain in voltage channel amplifiers.

5-40. BANDWIDTH CONTROL — Troubleshooting.

a. Place probe in PROBE CHECK receptacle, set MAGNITUDE RANGE (Ω) switch to 1 K. Switch to 100 range. OHMS meter pointer will quickly rise to within 3% of full scale and then take a few seconds to move the remaining distance to full scale.

1. If meter action is fast acting to full scale, A6Q4 is shorted or saturated. Meter will bounce more than normal.

2. If meter action is slow acting all the way to full scale, A6Q4 is not conducting. With the probe still in PROBE CHECK receptacle, change MAGNITUDE RANGE (Ω) to 10K range or higher and check A6Q1-4 circuits by measuring circuit dc potentials.

5-41. PULSE GENERATOR AND TIMING ADJUSTMENTS.

NOTE

Timing adjustment need not be made unless cables carrying sampling pulses are replaced and/or phase error at 100 MHz exceeds 3 degrees.

a. Connect equipment as shown in Figure 5-10. Short cable of 04815-61001 Pulse Timing Cable Set is connected to A13J1 (2), the longer one to A13J1 (6).

b. Remove the two larger cover plates on A13 Sampler Assembly.

c. Turn on 4815A power and set FREQUENCY (MHz) to 0.8.

d. Adjust 188A controls as follows:

RESPONSE (both channels)	NORMAL
SENSITIVITY (both channels)	200 MV/CM
Vertical Presentation Switch	A & B

e. Adjust 185B controls as follows:

SCANNING	fully CW
TIME SCALE MAGNIFIER	X5
TIME SCALE	10 ns/cm
TRIGGER SLOPE	negative (-)

f. Adjust MODE and STABILITY controls on 185B for sharp, steady trace. See Figure 5-11(A).

g. Adjust A13A3 R6, BIAS ADJ, for maximum amplitude pulses. Pulses should be 750 mV ± 20%, peak, but within ±5% of each other.

h. Measure pulse width at 10% amplitude points using TIME SCALE MAGNIFIER and DELAY controls on 185B. Pulse width should be less than 2.5 nanoseconds.

i. Set 185B TIME SCALE MAGNIFIER to X100 and adjust DELAY control to center waveform peaks on

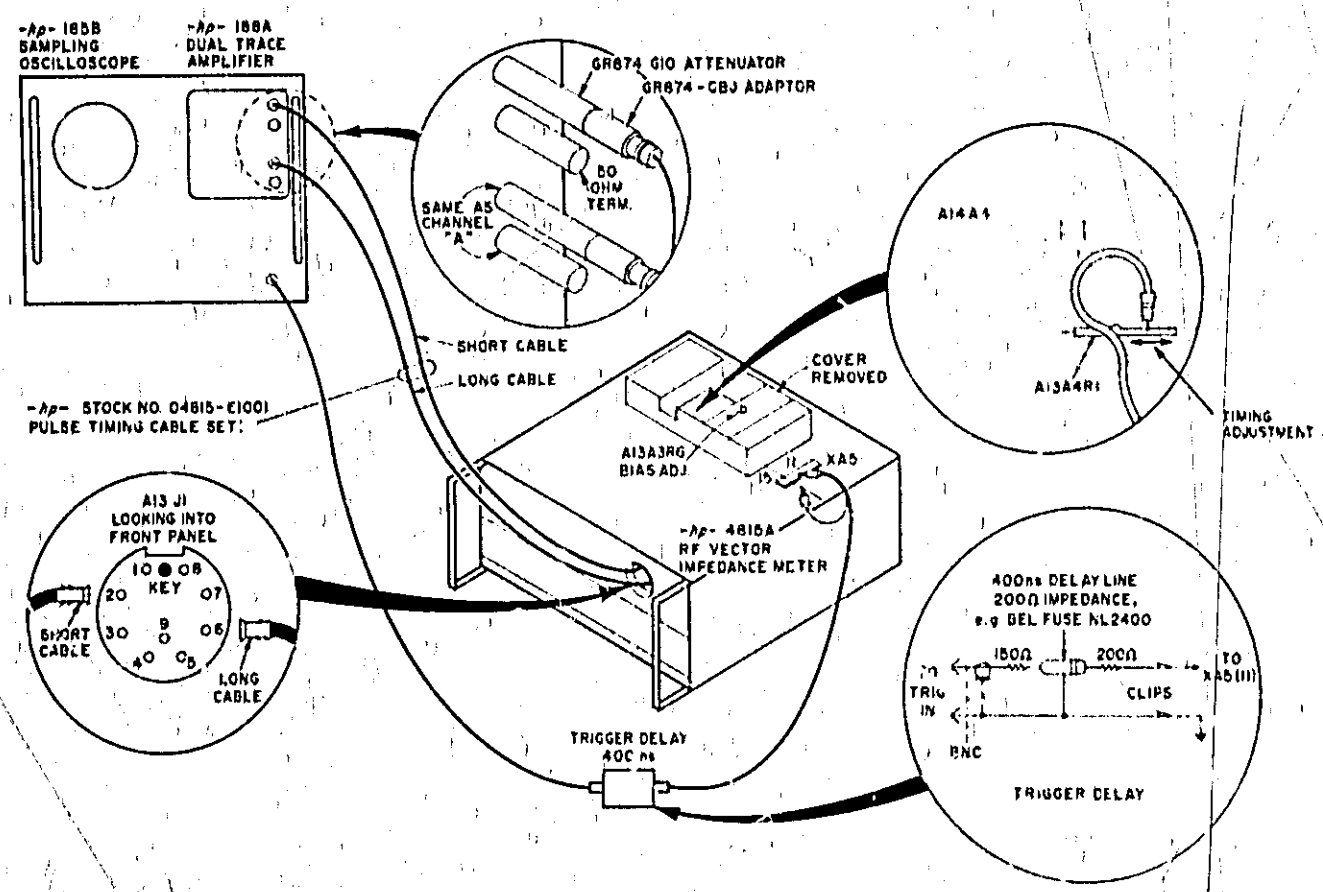


Figure 5-10. Setup for Pulse Generator and Timing Adjustments

CRT. Pulse peaks should not be separated by more than 100 picoseconds (See Figure 5-11 B). Adjust connection point of A13W9 (See Figure 5-10 for detail) until timing is correct. If A channel pulse app appears first in time, move connection point toward A13A4R1, a 470Ω resistor. If B channel pulse appears first, move connection point away from A13A4R1. Move connection only 1/16" at a time, resolder, check timing and readjust as necessary.

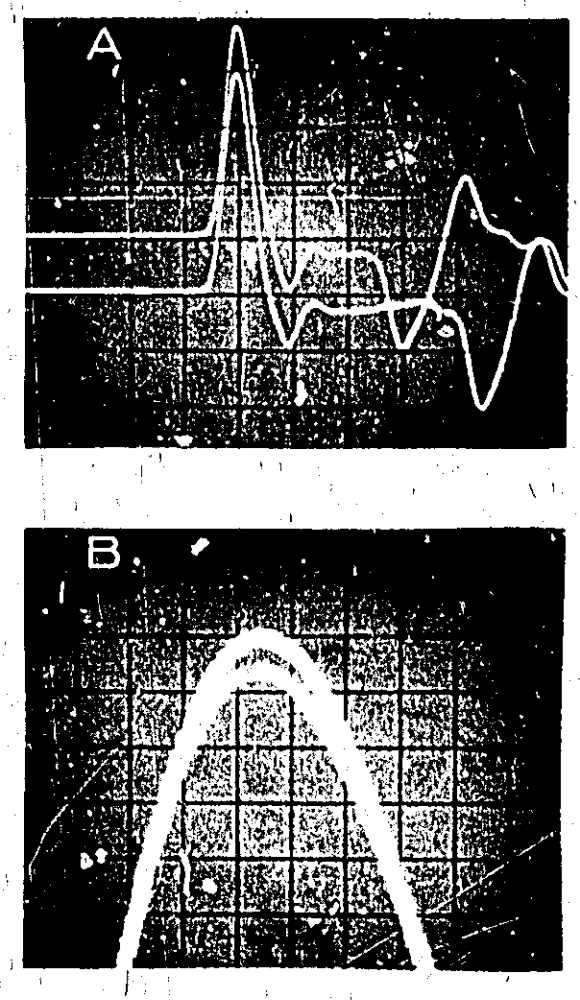


Figure 5-11. Pulse Timing Waveforms

5-42. TRANSISTORS.

5-43. INCIRCUIT TESTING. When checking a transistor stage, first determine if the emitter-base junction is forward-biased. Do not place an electronic voltmeter directly across the junction to measure the voltage difference; there could be sufficient loop current between the voltmeter leads to damage the transistor. Instead, measure each voltage separately with respect to a common point (e.g., chassis). If junction is not forward-biased, and power supply voltages are known to be correct, the base-emitter junction may be open.

5-44. If the emitter-base junction is forward-biased, check for amplifier action by short-circuiting base to emitter while observing collector voltage. The short eliminates base-emitter bias and should cause the transistor to stop conducting. Collector voltage will then shift to near the supply voltage in most circuits. Any difference is due to leakage current through the transistor, and in general, the smaller this current, the better the transistor. If collector voltage does not change, the transistor either has an emitter-collector short circuit or emitter-base circuit.

5-45. OUT-OF-CIRCUIT TESTING WITH OHMMETER. If a short or open circuit is suspected, remove the transistor from the circuit and use an ohmmeter to measure internal resistance. See Table 5-6 for typical measurement data.

CAUTION

Most ohmmeters can supply enough current or voltage to damage a transistor. Before using the ohmmeter, check ohmmeter open-circuit voltage and short-circuit current output ON THE RANGE TO BE USED. Open-circuit voltage must not exceed 1.5 volts and short-circuit current must be less than 3 mA. See Table 5-7 for safe resistance ranges for some common ohmmeters.

Table 5-6. Typical Data for Out-of-Circuit Transistor Resistance Measurements

Transistor Type		Connect Ohmmeter Pos lead to	Connect Ohmmeter Neg lead to	Measure Resistance (ohms)
PNP Germanium	Small Signal	emitter	base*	200-500
		emitter	collector	10K-100K
	Power	emitter	base*	30-50
		emitter	collector	several hundred
NPN Silicon	Small Signal	base	emitter	1K - 3K
		collector	emitter	very high (might read open)
	Power	base	emitter	200-1000
		collector	emitter	high, often greater than 1M

*To check collector, short collector to base; resistance should decrease.

5-46. Molded epoxy transistor type 2N3391 is used extensively in the 4815A. The component leads on this type are in-line and equally spaced; Figure 5-12 shows the lead information for properly installing the transistor. Other transistors used in the 4815A use a lead configuration that mates with etched circuit holes.

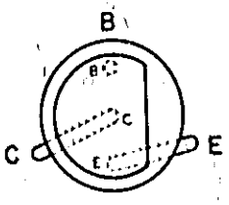


Figure 5-12. 2N3391 Top View

5-47. ETCHED CIRCUITS.

5-48. The etched circuit boards used in the 4815A RF Vector Impedance Meter are of the plate-through type consisting of metallic conductors banded to both sides of insulating material. The metallic conductors are extended through the component mounting holes by a plating process. Soldering can be done from either side of the board with equally good results. Table 5-8 lists recommended tools and materials. Following are recommendations and precautions pertinent to etched circuit repair work.

Table 5-7. Safe Ohmmeter Ranges for Transistor Resistance Measurement

Ohmmeter	Safe Range (s)	Open Ckt Voltage	Short Ckt Current	Color	Polarity
hp 412A	R x 1K R x 10K R x 100K R x 1M R x 10M	1.0V 1.0V 1.0V 1.0V 1.0V	1 ma 100 μa 10 μa 1 μa 0.1 μa	Red Black	+ −
hp 410C	R x 1K R x 10K R x 100K R x 1M R x 10M	1.3V 1.3V 1.3V 1.3V 1.3V	0.57 ma 57 μa 5.7 μa 0.5 μa 0.05 μa	Red Black	+ −
hp 410B	R x 100 R x 1K R x 10K R x 100K R x 1M	1.1V 1.1V 1.1V 1.1V 1.1V	1.1 ma 110 μa 11 μa 1.1 μa 0.11 μa	Black Red	+ −
Simpson 260	R x 100	1.5V	1 ma	Red Black	+ −
Simpson 260	R x 1K	1.5V	0.82 ma	Black Red	+ −
Triplett 630	R x 100 R x 1K	1.5V 1.5V	3.25 ma 325 μa	Varies with Serial Number	
Triplett 310	R x 10 R x 100	1.5V 1.5V	750 μa 75 μa		

a. Avoid unnecessary component substitution; it can result in damage to the circuit board and/or adjacent components.

b. Do not use a high-power soldering iron on etched circuit boards. Excessive heat may lift a conductor or damage the board.

c. Use a suction device (Table 5-3) or wooden toothpick to remove solder from component mounting holes. DO NOT USE A SHARP METAL OBJECT SUCH AS AN AWL OR TWIST DRILL FOR THIS PURPOSE. SHARP OBJECTS MAY DAMAGE THE PLATED-THROUGH CONDUCTOR.

d. After soldering, remove excess flux from the soldered areas and apply a protective coating to prevent contamination and corrosion. See Table 5-8 for recommendations.

5-49. ETCHED CIRCUIT REPAIR. A broken or burned section of conductor can be repaired by bridging the damaged section with a length of tinned copper wire. Allow adequate overlap and remove any varnish from etched conductor before soldering wire in place.

5-50. COMPONENT REPLACEMENT.

a. Remove defective component from board.

NOTE

Axial lead components, such as resistors and tubular capacitors, can be replaced without unsoldering. Clip leads near body of defective component, remove component and straighten leads left in board. Wrap leads of replacement component one turn around original leads. Solder wrapped connection, and clip off excess lead.

b. If component was unsoldered, remove solder from mounting holes with a suction desoldering aid (Table 5-8) or wooden toothpick.

c. Shape leads of replacement component to match mounting hole spacing.

d. Insert component leads into mounting holes, and position component as original was positioned. DO NOT FORCE LEADS INTO MOUNTING HOLES; sharp lead ends may damage plate-through conductor.

5-51. TRANSISTOR REPLACEMENT.

a. Do not apply excessive heat; See Table 5-8 for recommended soldering tools.

b. Use long-nose pliers as a heat sink between transistor and hot soldering iron. The instant solder is melted, use pliers to pull lead free of board.

c. When installing replacement transistor, ensure sufficient lead length to dissipate soldering heat by using about the same length of exposed lead as used for original transistor.

Table 5-8 Etched Circuit Soldering Equipment

Item	Use	Specification	Item Recommended
Soldering tool	Soldering Unsoldering	Wattage rating: 47-1/2 - 56-1/2 Tip Temp: 850 - 900°	Ungar #776 Handle with + Ungar #4037 Heating Unit
Soldering + Tip	Soldering Unsoldering	+ Shape: pointed	+ Ungar #PL111
De-soldering aid	To remove molten solder from connection	Suction device	Soldapullt by Edsyn Co, Arleta, California
Resin (flux) solvent	Remove excess flux from soldered area before application of protective coating	Must not dissolve etched circu' base board material or cone bonding agent	Freon Acetone Lacquer Thinner Isopropyl Alcohol (100% dry)
Solder	Component replacement Circuit board repair Wiring	Resin (flux) core, high tin content (60/40 tin/lead, 18 gauge (SWG) preferred	
Protective Coating	Contamination, corrosion protection after soldering	Good electrical insulation, corrosion-prevention properties	Krylon #1302++ Humiseal Protective Coating, Type 1B12 by Columbia Technical Corp., Woodside 77, New York

+ For working on 4815A Boards: for general purpose work, use Ungar #1237 Heating Unit (37.5W, tip temp of 750 - 800°) and Ungar #/L113 1/8" chisel tip.
++ Krylon, Inc., Norristown, Pennsylvania

5-52. MECHANICAL ASSEMBLIES.

5-53. OSCILLATOR DISASSEMBLY.

5-54. Disassembly of A14 Oscillator assembly is necessary to replace A14A3Q1 and other components in the compartment (see Figure 7-8 for circuitry under top cover casting).

a. Remove top and bottom covers.

b. Disconnect RF connector at A14J2.

c. Remove:
1) Right side cover and handle assembly
2) Adhesive-backed trim strip on right side
3) Two screws in top half of front panel. Part is not removable until side frame is loose.
4) Both FREQUENCY (MHz) knobs
5) Right side frame casting (held with 18 screws)
6) Dial window

d. Lift oscillator assembly and meter and trim assembly slightly up and towards rear of instrument. Oscillator will separate from extruded trim pieces - return meter and trim assembly to original position. At this point the oscillator assembly will have a small amount of freedom of movement in each direction.

e. Tilt A14 assembly up slightly to gain access to two screws holding range indicator assembly to casting. Remove screws and lay assembly to side.

f. Remove four flat-head screws and disc at top of frequency drum dial.

g. Rotate drum to counterclockwise extreme, unhook dial cord string and lay drum dial aside.

h. Remove stop collar at top of A14 assembly by removing long setscrew used as stop and two short setscrews. Shaft is undercut — loosen short setscrews several turns.

i. Remove 15 screws holding cover on oscillator assembly, lift cover straight up and lay aside. If red and orange wires to

A14R2 are removed, cover and drum dial can be removed from 4815A

CAUTION

If power is to be applied to 4815A for troubleshooting, be sure connections on range indicator assembly are not shorting to chassis.

NOTE

Unfastening 3 cable clamps will allo A14 to be placed on right side for trouble-shooting. A short BNC cable and adapter will allow reconnection to A14J2.

5-55. OSCILLATOR REASSEMBLY.

a. Install oscillator cover casting. Tighten screws after checking for tuning shaft binding. (Tuning shaft will not turn easily due to viscosity of oil in capacitor assembly.)

b. Install stop collar on capacitor tuning shaft. When stop collar is correctly set, counter-clockwise mechanical stop will coincide with collar stop EXACTLY. To accomplish this:

1) Turn the two short setscrews in and back off a full turn.

2) Turn long setscrew in and tighten. Collar should be free to rotate.

3) Rotate stop collar and capacitor tuning shaft to their counterclockwise stops. Tighten the single short setscrew.

4) Remove long setscrew, tighten remaining short setscrew, and reinstall long stop setscrew.

c. Install dial drum, frequency dial plate and 4 flat-head screws — leave screws loose.

d. Restring dial cords by following Figure 5-12. If dial cords have been completely removed during disassembly, refer to Paragraph 5-57 for complete restringing instructions.

e. Install range readout assembly. Before tightening screws, align readout to two vertical marks beyond dial calibration at either end of frequency scale.

f. Align frequency dial drum so two marks beyond scale calibration or under hairline when tuning capacitor is at counterclockwise stops.

g. List meter and trim assembly up slightly and to the rear. Place A14 so readout assembly is against trim and reinstall on front panel.

h. Install:

1) Dial window
2) Right side frame casting (held with 18 screws. Install top half of front panel before tightening screws.
3) Both FREQUENCY (MHz) knobs
4) Two screws in top half of front panel
5) Adhesive backed trim strip
6) Right side cover

i. Reconnect RF cable at A14J2.

5-56. REPLACING A14A2 CAPACITOR ASSEMBLY.

5-57. Assembly A14A2 is not field repairable. The part consists of a tuning capacitor mounted in an oil-filled cavity. When replacing the assembly leave the four mounting screws loose until top casting cover is installed as outlined in Paragraph 5-55. After rotating tuning shaft to check for binding, tighten screws.

5-58. DIAL CORD INSTALLATION.

5-59. DRUM DRIVE.

a. Gain access to oscillator assembly by completing procedures in Paragraph 5-54 steps a through d.

b. Turn frequency dial drum to counterclockwise stop. Attach dial string (-hp- Stock No. 04815-60730) to coil spring (-hp- Stock No. 1460-0290).

c. Refer to Figure 5-13 and detail (B) - hook spring onto drum, threading around pulleys and ending under fastening screw.

d. Make initial adjustment of tension by allowing spring to stretch only slightly. Increase tension as necessary until drive pulley slips only at band-edge stops.

e. Install oscillator by following Paragraph 5-55 steps g to i.

5-60. ANALOG DRIVE.

a. Set frequency dial drum to counterclockwise stop.

b. Loosen setscrews on pulley and position so slot is closest to right side frame.

c. Make a loop in dial string (-hp- Stock No. 04815-60720) 3-1/2" from one end, push through hole in drum and fasten under screw as shown in Figure 5-13 (B).

d. Thread long end of dial string through pulley as shown in Figure 5-13 (A) and finish by inserting coil spring (-hp- Stock No. 1460-0289) between ends.

e. Check operation of dial cord by turning frequency drum between stops. A small readjustment of the loop at Figure 5-13 (B) may be required. Tension can be adjusted by positioning mounting bracket for analog potentiometer.

f. Turn dial drum to counterclockwise stop. Use screwdriver to rotate A14R2 analog potentiometer to its counterclockwise stop and then clockwise a few degrees. Tighten setscrews.

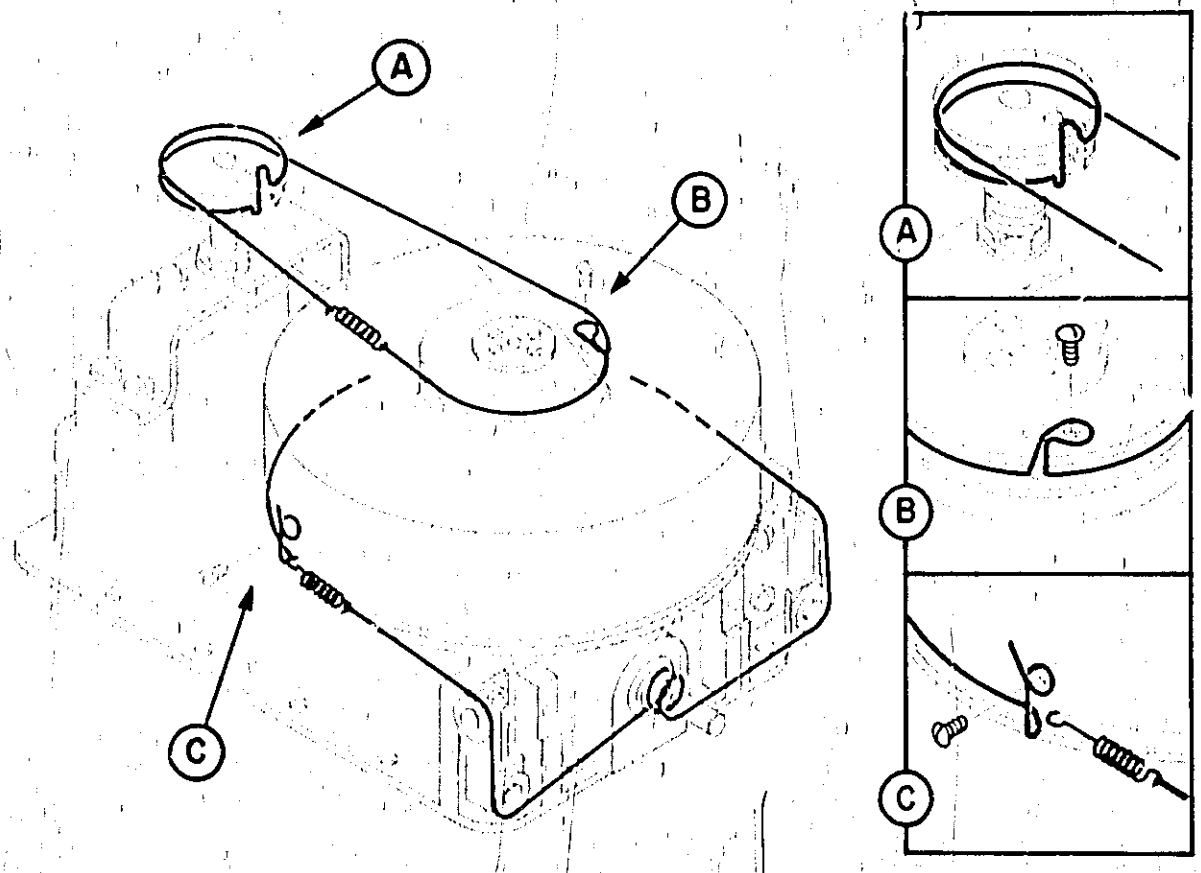


Figure 5-12. Dial Cord Arrangement

PARTS LIST

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alphanumerical order by reference designation and gives description and hp stock number for each part. Figures 6-1 and 6-2, associated with Tables 6-2 and 6-3, respectively, illustrate and identify components of the RF Oscillator Assembly, A14. Figure 6-3 and Table 6-4 illustrate and identify cabinet parts. Table 6-4 also lists miscellaneous mechanical parts.

6-3. ORDERING INFORMATION.

6-4. When ordering a replacement part listed in the tables:

a. Quote the Hewlett-Packard stock number for the part.

b. Address the order or inquiry to the nearest Hewlett-Packard sales and service office listed at the rear of this manual.

6-5. To order a part not listed in the tables:

a. Give a complete description of the part including its function and location.

b. Give the instrument model number and complete serial number from the rear serial plate.

c. Address the order or inquiry to the nearest Hewlett-Packard sales and service office listed at the rear of this manual.

REFERENCE DESIGNATORS

A = assembly	E = misc electronic part	P = plug	V = vacuum, tube, neon bulb, photocell, etc.
B = motor	F = fuse	Q = transistor	W = cable
BT = battery	FL = filter	R = resistor	X = socket
C = capacitor	J = jack	RT = thermistor	Y = crystal
CP = coupler	K = relay	S = switch	
CR = diode	L = inductor	T = transformer	
DL = delay line	M = meter	TB = terminal board	
DS = device signaling (lamp)	MP = mechanical part	TP = test point	

ABBREVIATIONS

A = amperes	H = henries	NRFR = not recommended for field replacement	SECT = section(s)
A.F.C. = automatic frequency control	HEX = hexagonal	SEMICON = semiconductor
AMPL = amplifier	HG = mercury	OBD = order by description	SI = silicon
B.F.O. = beat frequency oscillator	HR = hour(s)	OH = oval head	SIL = silver
BE CU = beryllium copper	IF = intermediate freq	OX = oxide	SL = slide
BH = binder head	IMPG = impregnated	P = peak	SPL = special
BP = bandpass	INCD = incandescent	PC = printed circuit	SST = stainless steel
BRS = brass	INCL = include(s)	PF = picofarads = 10^{-12} farads	SR = split ring
BWO = backward wave oscillator	INS = insulation(ed)		STL = steel
CCW = counter-clockwise	INT = internal	PH BRZ = phosphor bronze	TA = tantalum
CER = ceramic	K = kilo = 1000	PHIL = Phillips	TD = time delay
CMO = cabinet mount only	LIN = linear taper	PIV = peak inverse voltage	TGL = toggle
COEF = coefficient	LK WASH = lock washer	P/O = part of	TI = titanium
COM = common	LOG = logarithmic taper	POLY = polystyrene	TOL = tolerance
COMP = composition	LPF = low pass filter	PORC = porcelain	TRIM = trimmer
CONN = connector	M = milli = 10^{-3}	POS = position(s)	TWT = traveling wave tube
CP = cadmium plate	MEG = meg = 10^{6}	POT = potentiometer	U = micro = 10^{-6}
CRT = cathode-ray tube	MET FILM = metal film	PP = peak-to-peak	VAR = variable
CW = clockwise	MET OX = metallic oxide	PT = point	VDCW = dc working volts
DEPC = deposited carbon	MFR = manufacturer	PWV = peak working voltage	W/ = with
DR = drive	MINAT = miniature	RECT = rectifier	W = watts
ELECT = electrolytic	MOM = momentary	RF = radio frequency	WIV = working inverse voltage
ENCAP = encapsulated	MTG = mounting	RH = round head	WW = wirewound
EXT = external	MY = "mylar"	RIV = reverse inverse voltage	W/O = without
F = farads	N/C = normally closed	RMO = rack mount only	
FH = flat head	NE = neon	RMS = root-mean square	
FIL H = fillister head	NI PL = nickel plate	RWV = reverse working voltage	* = optimum value selected at factory, average value shown (part may be omitted)
FXD = fixed	N/O = normally open	S-B = slow-blow	
GE = germanium	NPO = negative positive zero (zero temperature coefficient)	SCR = screw	
GL = glass		SE = selenium	
GND = ground(ed)			

Table 6-1. Reference Designation Index

Reference Designation	Stock No.	Description	Note
		CHASSIS COMPONENTS	
C1, 2	0150-0023	C: fxd, cer, 0.002 μF, 20%, 1000 vdcw	
C3	0150-0012	C: fxd, cer, 0.01 μF, 20%, 1000 vdcw	
C4	0180-0047	C: fxd, elect, 500 μF, 75 vdcw	
C5	0180-0056	C: fxd, elect, 1000 μF, 500 vdcw	
C6	0180-0047	C: fxd, elect, 500 μF, 75 vdcw	
C7	0180-0056	C: fxd, elect, 1000 μF, 50 vdcw	
CP1	1250-0076	Adapter - right angle, BNC jack, BNC plug	
CP2	1250-0216	Straight adapter - RF connector, BNC	
CP3	1250-0076	Adapter - right angle, BNC jack, BNC plug	
DS1	2140-0052	Lamp, glow, (part of S1)	
DS2	2140-0043	Lamp, indicator, min, 6 v	
F1	2110-0033	Fuse - cartridge, 3/4A, 250 v, (115 v op'n)	
F1	2110-0067	Fuse: 3/10A, 250 v, (230 v op'n)	
J1	1251-0148	Receptacle - line cord	
J2, 3, 4	1250-0001	Jack receptacle - blkhd mtg, BNC	
L1, 2	9140-0174	Coil: fxd, RF, 220 μH,	
M1	1120-1195	Meter - magnitude, ohms	
M2	1120-1194	Meter - phase	
Q1	1850-0038	Transistor, PNP, Ge, 2N301	
	1200-0043	Insulator, transistor	
Q2	1850-0038	Transistor, PNP, Ge, 2N301	
	1200-0043	Insulator, transistor	
Q3	1850-0038	Transistor, PNP, Ge, 2N301	
	1200-0043	Insulator, transistor	
Q4	1850-0038	Transistor, PNP, Ge, 2N301	
	1200-0043	Insulator, transistor	
R1, 2	0757-0158	R: fxd, met flm, 619 ohms, 1%, 1/2 w	
R3, 4	0812-0022	R: fxd, ww, 0.56 ohms, 5%, 3 w	
R5	0757-0960	R: fxd, met flm, 33K ohm, 2%, 1/8 w	
R6	2100-0026	R: var, comp, lin, 5K ohm, 10%, 2 w	
R7	2100-0060	R: var, comp, lin, 20K ohm, 20%, 2 w	
R8	0757-0809	R: fxd, met flm, 332 ohm, 1%, 1/2 w	
S1	3101-0100	Switch - push ON/OFF (includes DS1)	
S2	3101-0033	Switch - slide, DPDT, 115 v - 230 v	
S3	3100-1844	Switch - phase range	
T1	9100-1746	Transformer - power	
W1	8120-0078	Cable power, 3 wire NEMA, 7-1/2 ft	
W2	04815-60240	Cable assembly; includes P2	
XA1-12	1251-0135	Connector, 15 contact printed circuit mount	
XQ1-4	1200-0044	Socket, transistor	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A1	**04815-60360**	**POWER SUPPLY REGULATOR ASSY**	
	04815-20360	A1 printed circuit board blank	
A1C1, 2	0160-0174	C: fxd, cer, 0.47 μF, -20 + 80%, 25 vdcw	
A1C3-6	0180-0058	C: fxd, elect, 50 μF, -10 + 75%, 25 vdcw	
A1CR1-4	1901-0028	Diode, Si	
A1CR5	1902-0228	Diode, Si, breakdown, 26.1 v, 5%, 1.5 w	
A1CR6	1901-0028	Diode, Si	
A1CR7	1901-0040	Diode, Si	
A1CR8	1902-0228	Diode, Si, breakdown, 26.1 v, 5%, 1.5 w	
A1CR9	1901-0028	Diode, Si	
A1CR10	1902-0057	Diode, Si, breakdown, 6.49 v, 400 mw	
A1CR11	1901-0040	Diode, Si	
A1Q1	1854-0071	Transistor - NPN, Si, 2N3391	
A1Q2-4	1853-0016	Transistor - PNP, Si, 2N3638	
A1R1	0757-0936	R: fxd, met flm, 3.3K ohm, 2%, 1/8 w	
A1R2	0757-0940	R: fxd, met flm, 4.7K ohm, 2%, 1/8 w	
A1R3	0757-0930	R: fxd, met flm, 1.8K ohm, 2%, 1/3 w	
A1R4, 5	0683-3305	R: fxd, comp, 33 ohm, 5%, 1/4 w	
A1R6	0757-0954	R: fxd, met flm, 18K ohm, 2%, 1/8 w	
A1R7	0757-0972	R: fxd, met flm, 100K ohm, 2%, 1/8 w	
A1R8	0757-0934	R: fxd, met flm, 2.7K ohm, 2%, 1/8 w	
A1R9	0757-0278	R: fxd, met flm, 1.78K ohm, 1%, 1/8 w	
A1R10	0698-0083	R: fxd, met flm, 1.96K ohm, 1%, 1/8 w	
A1R11	2100-1611	R: var, ww, 250 ohm, 10%, 1.5 w	
A1R12	0757-0918	R: fxd, met flm, 560 ohm, 2%, 1/8 w	
A1R13	0757-0734	R: fxd, met flm, 1.21K ohm, 1%, 1/4 w	
A1R14	0757-0936	R: fxd, met flm, 3.3K ohm, 2%, 1/8 w	
A2	**04815-60370**	**REFERENCE OSCILLATOR & PHASE DETECTOR ASSY**	
	04815-20370	A2 printed circuit board blank	
A2C1	0180-0058	C: fxd, elect, 50 μF, -10 + 100%, 25 vdcw	
A2C2	0160-0127	C: fxd, cer, 1.0 μF, 20%, 25 vdcw	
A2C3	0170-0069	C: fxd, poly, 0.1 μF, 2%, 50 vdcw	
A2C4, 5	0180-0230	C: fxd, tant, 1 μF, 20%, 50 vdcw	
A2C6	0180-0049	C: fxd, elect, 20 μF, 50 vdcw	
A2C7	0150-0121	C: fxd, cer, .1 μF, -20 + 80%, 50 vdcw	
A2C8	0160-0161	C: fxd, my, .01 μF, 10%, 200 vdcw	
A2C9	0160-0127	C: fxd, cer, 1.0 μF, 20%, 25 vdcw	
A2C10	0160-0138	C: fxd, my, .047 μF, 5%, 200 vdcw	
A2C11	0160-0155	C: fxd, my, 3300 pF, 10%, 200 vdcw	
A2CR1,2	1901-0040	Diode, Si	
A2CR3	1902-0025	Diode, Si, breakdown, 10 v, 400 mw	
A2CR4-7	1901-0040	Diode, Si	
A2L1	04815-60140	Coil, reference oscillator	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A2Q1, 2	1854-0071	Transistor, NPN, Si, 2N3391	
A2Q3	1853-0016	Transistor, PNP, Si, 2N3638	
A2Q4	1854-0071	Transistor, NPN, Si, 2N3391	
A2R1	0757-0900	R: fxd, met flm, 100 ohm, ±2%, 1/8 w	
A2R2	0683-6845	R: fxd, comp, 680K ohm, 5%, 1/4 w	
A2R3	0757-0916	R: fxd, met flm, 470 ohm, ±2%, 1/8 w	
A2R4	0757-0924	R: fxd, met flm, 1000 ohm, ±2%, 1/8 w	
A2R5	0757-0941	R: fxd, met flm, 5100 ohm, ±2%, 1/8 w	
A2R6	0757-0924	R: fxd, met flm, 1000 ohm, ±2%, 1/8 w	
A2R7	0757-0743	R: fxd, met flm, 3.32K ohm, ±1%, 1/4 w	
A2R8	0757-0924	R: fxd, met flm, 1000 ohm, ±2%, 1/8 w	
A2R9	0757-0941	R: fxd, met flm, 5.1K ohm, ±2%, 1/8 w	
A2R10	0683-1005	R: fxd, comp, 10 ohm, ±5%, 1/4 w	
A2R11	0757-0924	R: fxd, met flm, 1K ohm, ±2%, 1/8 w	
A2R12	0683-2745	R: fxd, comp, 270K, ±5%, 1/4 w	
A2T1	04815-60130	Transformer - pulse	
A3	**04815-60380**	**LIMITING AMP, 90° FILTER & RESET ASSY**	
	04815-20380	A3 printed circuit board blank	
A3C1, 2	0180-0049	C: fxd, elect, 20 µF, 50 vdcw	
A3C3	0180-0033	C: fxd, elect, 50 µF, -10 +100%, 6 vdcw	
A3C4	0160-0174	C: fxd, cer, 0.47 µF, -20 + 80%, 25 vdcw	
A3C5	0180-0100	C: fxd, tant, 4.7 µF, 10%, 35 vdcw	
A3C6	0160-0174	C: fxd, cer, 0.47 µF, -20 + 80%, 25 vdcw	
A3C7	0180-0100	C: fxd, tant, 4.7 µF, 10%, 35 vdcw	
A3C8	0160-0174	C: fxd, cer, 0.47 µF, -20 + 80%, 25 vdcw	
A3C9	0160-0180	C: fxd, my, 0.033 µF, 5%, 200 vdcw	
A3C10	0160-0174	C: fxd, cer, 0.47 µF, -20 + 80%, 25 vdcw	
A3C11	0150-0121	C: fxd, cer, 0.1 µF, -20 + 80%, 50 vdcw	
A3CR1-9	1901-0040	Diode, Si	
A3CR10	1910-0016	Diode, Ge	
A3CR11	1902-3180	Diode, Si, breakdown, 11.8 v, ±2%	
A3L1	04815-60170	Inductor, 41 mH	
A3Q1-3	1854-0071	Transistor, NPN, Si, 2N3391	
A3Q4	1853-0016	Transistor, PNP, Si, 2N 638	
A3Q5	1854-0071	Transistor, NPN, Si, 2N3391	
A3R1	0757-0912	R: fxd, met flm, 330 ohm, ±2%, 1/8 w	
A3R2	0757-0906	R: fxd, met flm, 180 ohm, ±2%, 1/8 w	
A3R3	0757-0938	R: fxd, met flm, 3.9K ohm, ±2%, 1/8 w	
A3R4	0757-0916	R: fxd, met flm, 470 ohm, ±2%, 1/8 w	
A3R5	0757-0951	R: fxd, met flm, 13K ohm, ±2%, 1/8 w	
A3R6	0757-0963	R: fxd, met flm, 43K ohm, ±2%, 1/8 w	
A3R7, 8	0757-0942	R: fxd, met flm, 5.6K ohm, ±2%, 1/8 w	
A3R9	0757-0945	R: fxd, met flm, 7.5K ohm, ±2%, 1/8 w	
A3R10	0757-0963	R: fxd, met flm, 43K ohm, ±2%, 1/8 w	
A3R11	0757-0928	R: fxd, met flm, 1.5K ohm, ±2%, 1/8 w	
A3R12	0757-0940	R: fxd, met flm, 4.7K ohm, ±2%, 1/8 w	
A3R13	0757-0926	R: fxd, met flm, 1.2K ohm, ±2%, 1/8 w	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A3R14	0757-0909	R: fxd, met flm, 510 ohm, ±2%, 1/8 w	
A3R15	0757-0937	R: fxd, met flm, 3.6K ohm, ±2%, 1/8 w	
A3R16	0757-0948	R: fxd, met flm, 10K ohm, ±2%, 1/8 w	
A3R17	0757-0916	R: fxd, met flm, 470 ohm, ±2%, 1/8 w	
A3R18	0683-2745	R: fxd, comp, 270K ohm, ±5%, 1/4 w	
A3R19	0757-0935	R: fxd, met flm, 3.0K ohm, ±2%, 1/8 w	
A3R20	0757-0922	R: fxd, met flm, 820 ohm, ±2%, 1/8 w	
A3R21	0757-0938	R: fxd, met flm, 3.9K ohm, ±2%, 1/8 w	
A4	**04815-60390**	**EQUALIZER LOW PASS AMP, SIDEBAND DET & SEARCH DISCRIM ASSY**	
	04815-20390	A4 printed circuit board blank	
A4C1	0160-0157	C: fxd, my, .0047 μF, ±10%	
A4C2	0180-0114	C: fxd, elect, 4 μF, -10 + 100%, 25 vdcw	
A4C3	0180-0098	C: fxd, tant, 100 μF, ±20%, 20 vdcw	
A4C4	0160-0174	C: fxd, cer, 0.47 μF, -20 + 80%, 25 vdcw	
A4C5	0180-0058	C: fxd, elect, 50 μF, -10 + 75%, 25 vdcw	
A4C6	0180-0059	C: fxd, elect, 10 μF, -10 + 100%, 25 vdcw	
A4C7	0160-0159	C: fxd, my, 0.0068 μF, 10%	
A4C8, 9	0150-0121	C: fxd, cer, 0.1 μF, -20 + 80%, 50 vdcw	
A4C10	0160-0194	C: fxd, my, 0.015 μF, 10%	
A4C11	0160-0163	C: fxd, my 0.033 μF, 10%	
A4C12	0160-0161	C: fxd, my, 0.01 μF, ±10%	
A4C13	0150-0121	C: fxd, cer, 0.1 μF, -20 + 80%, 50 vdcw	
A4C14	0160-0174	C: fxd, cer, 0.47 μF, -20 + 80%, 25 vdcw	
A4CR1-6	1901-0040	Diode, Si	
A4CR7	1902-0062	Diode, breakdown, 3.74 v, ±10%, 400 mw	
A4L1	04815-60180	Coil assembly-discriminator, 26.2 mH	
A4Q1	1853-0016	Transistor, PNP, Si, 2N3638	
A4Q2, 3	1854-0071	Transistor, NPN, Si, 2N3391	
A4Q4, 5	1853-0016	Transistor, PNP, Si, 2N3638	
A4Q6	1854-0071	Transistor, NPN, Si, 2N3391	
A4Q7	1853-0016	Transistor, PNP, Si, 2N3638	
A4Q8	1854-0071	Transistor, NPN, Si, 2N3391	
A4Q9	1853-0016	Transistor, PNP, Si, 2N3638	
A4R1	0757-0924	R: fxd, met flm, 1.0K ohm, ±2%, 1/8 w	
A4R2	0757-0945	R: fxd, met flm, 7.5K ohm, ±2%, 1/8 w	
A4R3	0757-0924	R: fxd, met flm, 1.0K ohm, ±2%, 1/8 w	
A4R4	0757-0955	R: fxd, met flm, 20K ohm, ±2%, 1/8 w	
A4R5	0757-0948	R: fxd, met flm, 10K ohm, ±2%, 1/8 w	
A4R6	0757-0947	R: fxd, met flm, 9.1K ohm, ±2%, 1/8 w	
A4R7	0683-0475	R: fxd, comp, 4.7 ohm, ±5%, 1/4 w	
A4R8	0757-0948	R: fxd, met flm, 10K ohm, ±2%, 1/8 w	
A4R9	0757-0904	R: fxd, met flm, 150 ohm, ±2%, 1/8 w	
A4R10	0757-0915	R: fxd, met flm, 430 ohm, ±2%, 1/8 w	
A4R11	0757-0916	R: fxd, met flm, 470 ohm, ±2%, 1/8 w	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A4R11	0757-0916	R: fxd, met flm, 470 ohm, ±2%, 1/8 w	
A4R12	0757-0934	R: fxd, met flm, 2.7K ohm, ±2%, 1/8 w	
A4R13	0757-0940	R: fxd, met flm, 4.7K ohm, ±2%, 1/8 w	
A4R14	0757-0968	R: fxd, met flm, 68K ohm, ±2%, 1/8 w	
A4R15	0757-0924	R: fxd, met flm, 1.0K ohm, ±2%, 1/8 w	
A4R16	0757-0940	R: fxd, met flm, 4.7K ohm, ±2%, 1/8 w	
A4R17	0757-0928	R: fxd, met flm, 1.5K ohm, ±2%, 1/8 w	
A4R18	0757-0935	R: fxd, met flm, 3.0K ohm, ±2%, 1/8 w	
A4R19	0757-0976	R: fxd, met flm, 150K ohm, ±2%, 1/8 w	
A4R20	0757-0924	R: fxd, met flm, 1.0K ohm, ±2%, 1/8 w	
A4R21	0757-0928	R: fxd, met flm, 1.5K ohm, ±2%, 1/8 w	
A4R22	0757-0911	R: fxd, met flm, 300 ohm, ±2%, 1/8 w	
A4R23	0683-3355	R: fxd, comp, 3.3M ohm, ±5%, 1/4 w	
A4R24	0757-0958	R: fxd, met flm, 27K ohm, ±2%, 1/8 w	
A4R25	0757-0897	R: fxd, met flm, 75 ohm, ±2%, 1/8 w	
A4R26	0757-0920	R: fxd, met flm, 680 ohm, ±2%, 1/8 w	
A4R27	0757-0952	R: fxd, met flm, 15K ohm, ±2%, 1/8 w	
A5	**04815-60400**	**VOLTAGE TUNED OSCILLATOR ASSY**	
	04815-20100	A5 printed circuit board blank	
A5C1	0180-0032	C: fxd, elect, 10 µF, -10 + 75%, 12 vdcw	
A5C2	0180-0058	C: fxd, elect, 50 µF, -10 + 75%, 25 vdcw	
A5C3	0180-0061	C: fxd, elect, 100 µF, -10 + 75%, 15 vdcw	
A5C4	0160-0127	C: fxd, cer, 1.0 µF, 20%, 25 vdcw	
A5C5	0150-0121	C: fxd, cer, 0.1 µF, 50 vdcw	
A5C6, 7	0160-0183	C: fxd, mica, 130 pF, ±5%, 300 vdcw	
A5C8, 9	0140-0210	C: fxd, mica, 270 pF, ±5%, 300 vdcw	
A5C10	0150-0050	C: fxd, cer, 1000 pF, 600 vdcw	
A5C11-15	0150-0093	C: fxd, cer, 0.01 µF, 100 vdcw	
A5CR1-4	1901-0040	Diode, Si	
A5CR5, 6	1901-0179	Diode, Si	
A5L1	9140-0115	Inductor, 22 µH	
A5L2	9140-0239	Inductor, 1 mH	
A5Q1-3	1853-0016	Transistor, PNP, Si, 2N3638	
A5Q4, 5	1854-0005	Transistor, NPN, Si, 2N708	
A5R1	0757-0921	R: fxd, met flm, 750 ohm, ±2%, 1/8 w	
A5R2	0757-0916	R: fxd, met flm, 470 ohm, ±2%, 1/8 w	
A5R3	0757-0930	R: fxd, met flm, 1.8K ohm, ±2%, 1/8 w	
A5R4	0757-0897	R: fxd, met flm, 75 ohm, ±2%, 1/8 w	
A5R5, 6	0757-0919	R: fxd, met flm, 620 ohm, ±2%, 1/8 w	
A5R7	0757-0946	R: fxd, met flm, 8.2K ohm, ±2%, 1/8 w	
A5R8, 9	0757-0904	R: fxd, met flm, 150 ohm, ±2%, 1/8 w	
A5R10	0757-0946	R: fxd, met flm, 8.2K ohm, ±2%, 1/8 w	
A5R11, 12	0757-0930	R: fxd, met flm, 1.8K ohm, ±2%, 1/8 w	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A5R13	0757-0952	R: fxd, met flm, 15K ohm, ±2%, 1/8 w	
A5R14	0757-0937	R: fxd, met flm, 3.6K ohm, ±2%, 1/8 w	
A5R15	0757-0945	R: fxd, met flm, 7.5K ohm, ±2%, 1/8 w	
A5R16	0757-0937	R: fxd, met flm, 3.6K ohm, ±2%, 1/8 w	
A5R17	0757-0951	R: fxd, met flm, 13K ohm, ±2%, 1/8 w	
A5R18	0757-0947	R: fxd, met flm, 9.1K ohm, ±2%, 1/8 w	
A5R19	0757-0943	R: fxd, met flm, 6.2K ohm, ±2%, 1/8 w	
A5R20	0757-0916	R: fxd, met flm, 470 ohm, ±2%, 1/8 w	
A6	**04815-60410**	**ALC AMPLIFIER & BANDWIDTH CONTROL ASSY**	
	04815-20410	A6 printed circuit board blank	
A6C1, 2	0160-0127	C: fxd, cer, 1.0 μF, 20%, 25 vdcw	
A6C3	0160-0174	C: fxd, cer, 0.47 μF, -20 + 80%, 25 vdcw	
A6C4	0180-0113	C: fxd, tant, 100 μF, -15 + 20%, 30 vdcw	
A6C5	0180-0116	C: fxd, tant, 6.8 μF, 10%, 35 vdcw	
A6CR1-3	1901-0040	Diode, Si	
A6Q1, 2	1854-0071	Transistor, NPN, Si, 2N3391	
A6Q3	1853-0016	Transistor, PNP, Si, 2N3638	
A6Q4	1855-0062	Transistor, Field, Effect, N Channel, Type A	
A6Q5	1853-0016	Transistor, PNP, Si, 2N3638	
A6Q6-8	1854-0071	Transistor, NPN, Si, 2N3391	
A6Q9	1853-0016	Transistor, PNP, Si, 2N3638	
A6R1	0757-0950	R: fxd, met flm, 12K ohm, 2%, 1/8 w	
A6R2	0698-3157	R: fxd, met flm, 19.6K ohm, 1%, 1/8 w	
A6R3	0757-0976	R: fxd, met flm, 150K ohm, 2%, 1/8 w	
A6R4	0698-3157	R: fxd, met flm, 19.6K ohm, 1%, 1/8 w	
A6R5, 6	0757-0908	R: fxd, met flm, 220 ohm, 2%, 1/8 w	
A6R7	0698-3157	R: fxd, met flm, 19.6K ohm, 1%, 1/8 w	
A6R8	0757-0952	R: fxd, met flm, 15K ohm, 2%, 1/8 w	
A6R9	0757-0934	R: fxd, met flm, 2.7K ohm, 2%, 1/8 w	
A6R10	0757-0935	R: fxd, met flm, 3.0K ohm, 2%, 1/8 w	
A6R11	0757-0964	R: fxd, met flm, 47K ohm, 2%, 1/8 w	
A6R12	0757-0976	R: fxd, met flm, 150K ohm, 2%, 1/8 w	
A6R13	0757-0961	R: fxd, met flm, 36K ohm, 2%, 1/8 w	
A6R14	0683-2405	R: fxd, comp, 24 ohm, 5%, 1/4 w	
A6R15	0757-0957	R: fxd, met flm, 24K ohm, 2%, 1/8 w	
A6R16, 17	0757-0941	R: fxd, met flm, 5.1K ohm, 2%, 1/8 w	
A6R18	0757-0464	R: fxd, met flm, 90.9K ohm, 1%, 1/8 w	
A6R19	0757-0964	R: fxd, met flm, 47K ohm, 2%, 1/8 w	
A6R20	0757-0457	R: fxd, met flm, 47.5K ohm, 1%, 1/8 w	
A6R21	0757-0972	R: fxd, met flm, 100K ohm, 2%, 1/8 w	
A6R22	0757-0952	R: fxd, met flm, 15K ohm, 2%, 1/8 w	
A6R23	0757-0948	R: fxd, met flm, 10K ohm, 2%, 1/8 w	
A6R24	0757-0952	R: fxd, met flm, 15K ohm, 2%, 1/8 w	
A6R25	0757-0941	R: fxd, met flm, 5.1K ohm, 2%, 1/8 w	
A6R26	0757-0932	R: fxd, met flm, 2.2K ohm, 2%, 1/8 w	
A6R27	0757-0976	R: fxd, met flm, 150K ohm, 2%, 1/8 w	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A7	**04815-60250**	**40 DB TWIN-TEE AMPLIFIER ASSY (Current Channel)**	
	04815-20250	A7 printed circuit board blank	
A7C1	0180-0058	C: fxd, elect, 50 μF, 25 vdcw	
A7C2	0160-0174	C: fxd, cer, 0.47 μF, 25 vdcw	
A7C3	0160-2301	C: fxd, mica, 2000 pF, ±1%, 100 vdcw	
A7C4	0160-2302	C: fxd, mica, 4000 pF, ±1%, 100 vdcw	
A7C5	0160-2301	C: fxd, mica, 2000 pF, ±1%, 100 vdcw	
A7C6	0150-0050	C: fxd, cer, 0.001 μF, 600 vdcw	
A7C7	0150-0121	C: fxd, cer, 0.1 μF, -20 + 80%, 50 vdcw	
A7C8	0180-0032	C: fxd, elect, 10 μF, 12 vdcw	
A7C9	0140-0200	C: fxd, mica, 390 pF, 2%, 300 vdcw	
A7C10	0140-0190	C: fxd, mica, 30 pF, ±5%, 300 vdcw	
A7C11	0180-0058	C: fxd, elect, 50 μF, 25 vdcw	
A7L1, 2	0140-0075	Coil, fxd, 270 μH	
A7Q1, 2	1854-0071	Transistor, NPN, Si, 2N3391	
A7Q3	1853-0016	Transistor, PNP, Si, 2N3638	
A7R1	0757-0906	R: fxd, met flm, 180 ohm, ±2%, 1/8 w	
A7R2	0757-0439	R: fxd, met flm, 6.81K ohm, ±1%, 1/8 w	
A7R3	0683-4745	R: fxd, comp, 470K ohm, ±5%, 1/4 w	
A7R4	0757-0239	R: fxd, met flm, 13.3K ohm, ±1%, 1/8 w	
A7R5	0757-0952	R: fxd, met flm, 15K ohm, ±2%, 1/8 w	
A7R6	0757-0921	R: fxd, met flm, 750 ohm, ±2%, 1/8 w	
A7R7	0698-3435	R: fxd, met flm, 38.3 ohm, ±1%, 1/8 w	
A7R8	2100-0755	R: var, ww, 1K ohm, ±5%	
A7R9	0811-1650	R: fxd, ww, 15.4K ohm, ±1%, 1/4 w	
A7R10	0757-0924	R: fxd, met flm, 1K ohm, ±2%, 1/8 w	
A7R11, 12	0757-0938	R: fxd, met flm, 3.9K ohm, ±2%, 1/8 w	
A7R13	0757-0921	R: fxd, met flm, 750 ohm, ±2%, 1/8 w	
A7R14	0757-0935	R: fxd, met flm, 3.0K ohm, ±2%, 1/8 w	
A7R15	0757-0438	R: fxd, met flm, 5.11K ohm, ±1%, 1/8 w	
A7R16	0811-1651	R: fxd, ww, 15.9K ohm, ±1%, 1/4 w	
A7R17	0811-1649	R: fxd, ww, 7.7K ohm, ±1%, 1/4 w	
A7R18	2100-0898	R: var, ww, lin, 500 ohm, ±5%	
A7R19	0757-0926	R: fxd, met flm, 1.2K ohm, ±2%, 1/8 w	
A7R20	0757-0946	R: fxd, met flm, 8.2K ohm, ±2%, 1/8 w	
A7R21	0757-0923	R: fxd, met flm, 910 ohm, ±2%, 1/8 w	
A7R22	0757-0929	R: fxd, met flm, 1.6K ohm, ±2%, 1/8 w	
A8	**04815-60430**	**CURRENT CHANNEL DETECTOR/LIMITER ASSY**	
	04815-20430	A8 printed circuit board blank	
A8C1, 2	0180-0049	C: fxd, elect, 20 μF, 50 vdcw	
A8C3, 4	0180-0230	C: fxd, tant, 1 μF, 20%, 50 vdcw	
A8C5	0180-0100	C: fxd, tant, 4.7 μF, 10%, 35 vdcw	
A8C6, 7	0180-0032	C: fxd, elect, 10 μF, -10 + 75%, 12 vdcw	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A8C8	0180-0059	C: fxd, elect, 10 μF, -10 + 100%, 25 vdcw	
A8C9	0180-0032	C: fxd, elect, 10 μF, -10 + 75%, 12 vdcw	
A8C10, 11	0180-0230	C: fxd, tant, 1 μF, 20%, 50 vdcw	
A8C12	0180-0100	C: fxd, tant, 4.7 μF, 10%, 35 vdcw	
A8C13	0180-0230	C: fxd, tant, 1 μF, 20%, 50 vdcw	
A8C14	0180-0100	C: fxd, tant, 4.7 μF, 10%, 35 vdcw	
A8CR1-8	1901-0040	Diode, Si	
A8Q1-5	1854-0071	Transistor, NPN, Si, 2N3391	
A8R1, 2	0757-0908	R: fxd, met flm, 220 ohm, ±2%, 1/8 w	
A8R3	0757-0924	R: fxd, met flm, 1.0K ohm, ±2%, 1/8 w	
A8R4, 5	0683-2045	R: fxd, comp, 220K ohm, ±5%, 1/4 w	
A8R6	0757-0955	R: fxd, met flm, 20K ohm, ±2%, 1/8 w	
A8R7	0757-0405	R: fxd, met flm, 162 ohm, ±1%, 1/8 w	
A8R8	0757-0924	R: fxd, met flm, 1.0K ohm, ±2%, 1/8 w	
A8R9	0757-0739	R: fxd, met flm, 2.0K ohm, ±1%, 1/4 w	
A8R10	0683-2045	R: fxd, comp, 200K ohm, ±5%, 1/4 w	
A8R11	0757-0434	R: fxd, met flm, 3.65K ohm, ±1%, 1/8 w	
A8R12	0757-0954	R: fxd, met flm, 18K ohm, ±2%, 1/8 w	
A8R13	0757-0940	R: fxd, met flm, 4.7K ohm, ±2%, 1/8 w	
A8R14, 15	0757-0924	R: fxd, met flm, 1.0K ohm, ±2%, 1/8 w	
A8R16, 17	0757-0963	R: fxd, met flm, 43K ohm, ±2%, 1/8 w	
A8R18	0757-0941	R: fxd, met flm, 5.1K ohm, ±2%, 1/8 w	
A8R19, 20	0757-0924	R: fxd, met flm, 1.0K ohm, ±2%, 1/8 w	
A8R21	0757-0963	R: fxd, met flm, 43K ohm, ±2%, 1/8 w	
A8R22	0757-0945	R: fxd, met flm, 7.5K ohm, ±2%, 1/8 w	
A8R23	0757-0928	R: fxd, met flm, 1.5K ohm, ±2%, 1/8 w	
A8R24	0757-0934	R: fxd, met flm, 2.7K ohm, ±2%, 1/8 w	
A9	**04815-60440**	**PHASE DETECTOR/ANALOG ASSY**	
	04815-20440	A9 printed circuit board blank	
A9C1, 2	0150-0075	C: fxd, cer, 4700 pF, -20 + 100%, 500 vdcw	
A9C3	0180-0059	C: fxd, elect, 10 μF, -10 + 100%, 25 vdcw	
A9C4	0180-0098	C: fxd, tant, 100 μF, 20%, 20 vdcw	
A9C5	0180-0049	C: fxd, elect, 20 μF, -10 + 75%, 50 vdcw	
A9C6	0180-0101	C: fxd, tant, 1.8 μF, 10%, 35 vdcw	
A9C7	0150-0121	C: fxd, cer, 0.1 μF, +20 + 80%, 50 vdcw	
A9C8	0180-0228	C: fxd, tant, 22 μF, 10%, 15 vdcw	
A9CR1-4	1901-0040	Diode, Si	
A9CR5	1902-0033	Diode, Si, breakdown, 6 v	
A9CR6, 7	1901-0040	Diode, Si	
A9L1	9140-0072	Coil -RF, 5 mH, 10%, 100 ma	
A9Q1-6	1854-0071	Transistor, NPN, Si, 2N3391	
A9Q7	1853-0016	Transistor, PNP, Si, 2N3638	
A9R1	0757-0940	R: fxd, met flm, 4.7K ohm, 2%, 1/8 w	

Table 6-1. Reference Designation Index (Cont'd

Reference Designation	Stock No.	Description	Note
A9R2	0757-0969	R: fxd, met flm, 75K ohm, 2%, 1/8 w	
A9R3	0757-0940	R: fxd, met flm, 4.7K ohm, 2%, 1/8 w	
A9R4, 5	0757-0948	R: fxd, met flm, 10K ohm, 2%, 1/8 w	
A9R6	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A9R7	0757-0969	R: fxd, met flm, 75K ohm, 2%, 1/8 w	
A9R8, 9	0757-0940	R: fxd, met flm, 4.7K ohm, 2%, 1/8 w	
A9R10, 11	0757-0967	R: fxd, met flm, 62K ohm, 2%, 1/8 w	
A9R12	0698-3157	R: fxd, met flm, 19.6K ohm, 1%, 1/8 w	
A9R13	0757-0976	R: fxd, met flm, 150K ohm, 2%, 1/8 w	
A9R14	0698-3136	R: fxd, met flm, 17.8K ohm, 1%, 1/8 w	
A9R15	0757-0929	R: fxd, met flm, 1.6K ohm, 2%, 1/8 w	
A9R16	0757-0940	R: fxd, met flm, 4.7K ohm, 2%, 1/8 w	
A9R17	2100-0755	R: var, ww, lin, 1K ohm, 20%, 1.5 w	
A9R18	0698-3150	R: fxd, met flm, 2.37K ohm, 1%, 1/8 w	
A9R19, 20	0757-0930	R: fxd, met flm, 1.8K ohm, 2%, 1/8 w	
A9R21	0683-1665	R: fxd, comp, 1.6M ohm, 5%, 1/4 w	
A9R22	0683-2045	R: fxd, comp, 200K ohm, 5%, 1/4 w	
A9R23	0757-0948	R: fxd, met flm, 10K ohm, 2%, 1/8 w	
A9R24	0757-0976	R: fxd, met flm, 150K ohm, 2%, 1/8 w	
A9R25	0757-0948	R: fxd, met flm, 10K ohm, 2%, 1/8 w	
A9R26	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A10	**04815-60450**	**VOLTAGE CHANNEL DETECTOR/LIMITER/ANALOG ASSY**	
	04815-20450	A10 printed circuit board blank	
A10C1, 2	0180-0049	C: fxd, elect, 20 μF, 50 vdcw	
A10C3, 4	0180-0230	C: fxd, tant, 1 μF, 20%, 50 vdcw	
A10C5	0180-0100	C: fxd, elect, 4.7 μF, 35 vdcw	
A10C6, 7	0180-0114	C: fxd, elect, 4 μF, 25 vdcw	
A10C8	0180-0097	C: fxd, elect, 47 μF, 35 vdcw	
A10C9	0160-0127	C: fxd, cer, 1 μF, 20%, 25 vdcw	
A10C10	0180-0100	C: fxd, elect, 4.7 μF, 35 vdcw	
A10C11	0160-0127	C: fxd, cer, 1 μF, 20%, 25 vdcw	
A10C12	0150-0121	C: fxd, cer, 0.1 μF, -20 + 80%, 50 vdcw	
A10C13	0180-0032	C: fxd, elect, 10 μF, 12 vdcw	
A10CR1-10	1901-0040	Diode, Si	
A10Q1-6	1854-0071	Transistor, NPN, Si, 2N3391	
A10Q7	1853-0016	Transistor, PNP, Si, 2N3638	
A10R1, 2	0757-0908	R: fxd, met flm, 220 ohm, 2%, 1/8 w	
A10R3	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A10R4, 5	0683-2045	R: fxd, comp, 220K ohm, 5%, 1/4 w	
A10R6	0757-0955	R: fxd, met flm, 20K ohm, 2%, 1/8 w	
A10R7	0757-0415	R: fxd, met flm, 475 ohm, 1%, 1/8 w	
A10R8	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A10R9	0757-0739	R: fxd, met flm, 2K ohm, 1%, 1/4 w	
A10R10	0683-2045	R: fxd, comp, 200K ohm, 5%, 1/4 w	
A10R11	0757-0928	R: fxd, met flm, 1.5K ohm, 2%, 1/8 w	
A10R12	0757-0940	R: fxd, met flm, 4.7K oh, 2%, 1/8 w	
A10R13	0683-3355	R: fxd, comp, 3.3M ohm, 5%, 1/4 w	
A10R14	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A10R15	0757-0945	R: fxd, met flm, 7.5K ohm, 2%, 1/8 w	
A10R16	0757-0963	R: fxd, met flm, 43K ohm, 2%, 1/8 w	
A10R17	0757-0928	R: fxd, met flm, 1.5K ohm, 2%, 1/8 w	
A10R18	0757-0935	R: fxd, met flm, 3K ohm, 2%, 1/8 w	
A10R19	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A10R20	0757-0976	R: fxd, met flm, 150K ohm, 2%, 1/8 w	
A10R21	0683-1655	R: fxd, comp, 1.6M ohm, 5%, 1/4 w	
A10R22	0683-2045	R: fxd, comp, 200K ohm, 5%, 1/4 w	
A10R23	0757-0948	R: fxd, met flm, 10K ohm, 2%, 1/8 w	
A10R24	0757-0976	R: fxd, met flm, 150K ohm, 2%, 1/8 w	
A10R25	0757-0955	R: fxd, met flm, 20K ohm, 2%, 1/8 w	
A10R26	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A11	**04815-60250**	**40 DB TWIN-TEE AMPLIFIER ASSY (Voltage Channel)**	
		A11 same as A7-use A11 prefix	
A12	**04815-60460**	**PREAMPLIFIER ASSY**	
	04815-20460	A12 printed circuit board blank	
A12C1	0160-0174	C: fxd, cer, 0.47 μF, 25 vdcw	
A12C2	0180-0111	C: fxd, elect, 2 μF, 25 vdcw	
A12C3	0150-0050	C: fxd, cer, 1000 pF, 600 vdcw	
A12C4, 5	0180-0058	C: fxd, elect, 50 μF, 25 vdcw	
A12C6	0160-0174	C: fxd, cer, 0.47 μF, 25 vdcw	
A12C7	0180-0111	C: fxd, elect, 2 μF, 25 vdcw	
A12C8	0150-0050	C: fxd, cer, 1000 pF, 600 vdcw	
A12Q1-4	1854-0071	Transistor, NPN, Si, 2N3391	
A12R1	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A12R2	0757-0906	R: fxd, met flm, 180 ohm, 2%, 1/8 w	
A12R3	2100-1769	R: var, ww, lin, 50 ohm, 10%, 1 w	
A12R4	0757-0958	R: fxd, met flm, 27K ohm, 2%, 1/8 w	
A12R5	0757-0941	R: fxd, met flm, 5.1K ohm, 2%, 1/8 w	
A12R6	0683-4745	R: fxd, comp, 470K ohm, 5%, 1/4 w	
A12R7	0757-0933	R: fxd, met flm, 2.4K ohm, 2%, 1/8 w	
A12R8	0757-0945	R: fxd, met flm, 7.5K ohm, 2%, 1/8 w	
A12R9	0757-0907	R: fxd, met flm, 200 ohm, 2%, 1/8 w	
A12R10-12	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A12R13	0757-0403	R: fxd, met flm, 121 ohm, 1%, 1/8 w	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A12R14	0757-0958	R: fxd, met flm, 27K ohm, 2%, 1/8 w	
A12R15	0757-0438	R: fxd, met flm, 5.11K ohm, 1%, 1/8 w	
A12R16	0683-4745	R: fxd, comp, 470K ohm, 5%, 1/4 w	
A12R17	0757-0932	R: fxd, met flm, 2.2K ohm, 2%, 1/8 w	
A12R18	0757-0945	R: fxd, met flm, 7.5K ohm, 2%, 1/8 w	
A12R19	0757-0907	R: fxd, met flm, 200 ohm, 2%, 1/8 w	
A13	**04815-60300**	**SAMPLER ASSY**	
A13C1, 2	0160-2300	C: fxd, cer, feedthru, 150 pF, 20%, 500 vdcw	
A13C3	0150-0005	C: fxd, cer, feedthru, 1000 pF, 20%, 500 vdcw	
A13C4	0150-0121	C: fxd, cer, .1 μF, -20 + 80%, 50 vdcw	
A13C5	0150-0005	C: fxd, cer, feedthru, 1000 pF, 20%, 500 vdcw	
A13C6	0150-0121	C: fxd, cer, .1 μF, -20 + 80%, 50 vdcw	
A13C7	0160-0180	C: fxd, my, 0.033 μF, ±5%, 200 vdcw	
A13C8	0170-0027	C: fxd, my, .02 μF, 5%, 200 vdcw	
A13C9	0150-0005	C: fxd, cer, feedthru, 1000 pF, 20%, 500 vdcw	
A13C10	0150-0121	C: fxd, cer, .1 μF, -20 + 80%, 50 vdcw	
A13C11	0150-0005	C: fxd, cer, feedthru, 1000 pF, 20%, 500 vdcw	
A13C12	0150-0121	C: fxd, cer, .1 μF, -20 + 80%, 50 vdcw	
A13C13, 14	0160-2300	C: fxd, cer, feedthru, 150 pF, 20%, 500 vdcw	
A13C15	0160-2359	C: fxd, poly, 2500 pF, 1%, 50 vdcw	
A13C16	0170-0069	C: fxd, poly, 0.1 μF, 2%, 50 vdcw	
A13C17-20	0150-0005	C: fxd, cer, feedthru, 1000 pF, 20%, 500 vdcw	
A13J1		Connector, multi-coax NSR	
	5040-0265	Insulator, connector, p/o A13	
		Individual connectors are part of wire assemblies A13W1-8, A15W6	
		Mechanical parts: (mounted on front panel); not p/o A13	
	5020-3257	Body, receptacle	
	5020-3258	Nut, hex, 1-1/8 across flats	
	5020-3259	Nut, knurled	
A13J2-5	1250-0829	Connector, RF, min	
A13L1	04815-60160	Inductor, var, 400 mH, ±5%	
A13L2	04815-60160	Inductor, var, 10.1 mH, ±5%	
A13L3-7	9170-0016	Bead, ferrite	
A13R1	0757-0729	R: fxd, met flm, 681 ohm, 1%, 1/4 w	
A13W1, 2	04815-60490	Cable assy W1 includes A13J1 (8); W2 includes A13J1 (7)	
A13W3, 4	04815-60470	Cable assy W3 includes A13J1 (9); W4 includes A13J1 (6)	
A13W5, 6	04815-60500	Cable assy W5 includes A13J1 (5); W6 includes A13J1 (4)	
A13W7, 8	04815-60480	Cable assy W7 includes A13J1 (3); W8 includes A13J1 (2)	
A13W9, 10	04815-60580	Cable assy	
A13W11	04815-60510	Cable assy	
A13W12	04815-60520	Cable assy	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A13A1	**04815-60340**	**CURRENT CHANNEL SAMPLER AMPLIFIER ASSY**	
	04815-20340	A13A1 printed circuit board blank	
A13A1C1	0180-0155	C: fxd, elect, 2.2 μF, 20%, 20 vdcw	
A13A1C2	0180-0218	C: fxd, elect, 0.15 μF, 10%, 35 vdcw	
A13A1C3	0160-0298	C: fxd, my, 1500 pF, 10%, 200 vdcw	
A13A1C4	0180-0155	C: fxd, elect, 2.2 μF, 20%, 20 vdcw	
A13A1C5	0185-0228	C: fxd, elect, 22 μF, 10%, 15 vdcw	
A13A1C6, 7	0160-0174	C: fxd, cer, 0.47 μF, 25 vdcw	
A13A1C8, 9	0160-0127	C: fxd, cer, 1 μF, 20%, 25 vdcw	
A13A1C10	0180-0058	C: fxd, elect, 50 μF, 25 vdcw	
A13A1L1	9140-0111	Inductor, fxd, 3.3 μH	
A13A1Q1	1853-0016	Transistor, PNP, Si, 2N3638	
A13A1Q2, 3	1854-0071	Transistor, NPN, Si, 2N3391	
A13A1R1	0757-0948	R: fxd, met film, 10K ohm, 2%, 1/8 w	
A13A1R2	0757-0924	R: fxd, met film, 1K ohm, 2%, 1/8 w	
A13A1R3	0757-0949	R: fxd, met film, 11K ohm, 2%, 1/8 w	
A13A1R4	0757-0934	R: fxd, met film, 2.7K ohm, 2%, 1/8 w	
A13A1R5	0757-0940	R: fxd, met film, 4.7K ohm, 2%, 1/8 w	
A13A1R6	0757-0948	R: fxd, met film, 10K ohm, 2%, 1/8 w	
A13A1R7	0757-0912	R: fxd, met film, 330 ohm, 2%, 1/8 w	
A13A1R8	0757-0950	R: fxd, met film, 12K ohm, 2%, 1/8 w	
A13A1R9	0757-0948	R: fxd, met film, 10K ohm, 2%, 1/8 w	
A13A1R10	0757-0738	R: fxd, met film, 1.1K ohm, 1%, 1/4 w	
A13A1R11	0757-0899	R: fxd, met film, 90 ohm, 2%, 1/8 w	
A13A1R12	0698-3444	R: fxd, met film, 316 ohm, 1%, 1/8 w	
A13A1R13, 14	0698-3155	R: fxd, met film, 4.64K ohm, 1%, 1/8 w	
A13A1R15	0757-0897	R: fxd, met film, 75 ohm, 2%, 1/8 w	
A13A1R16	0757-0401	R: fxd, met film, 100 ohm, 1%, 1/8 w	
A13A1R17, 18	0757-0441	R: fxd, met film, 8.75K ohm, 1%, 1/8 w	
A13A1R19, 20	0757-0123	R: fxd, met film, 34.8K ohm, 1%, 1/8 w	
A13A1R21	0757-0900	R: fxd, met film, 100 ohm, 2%, 1/8 w	
A13A2	**04815-60340**	**VOLTAGE CHANNEL SAMPLER AMPLIFIER ASSY**	
		A13A2 same as A13A1 -use A13A1 prefix	
A13A3	**04815-60330**	**SAMPLING PULSE GENERATOR ASSY**	
	04815-20330	A13A3 printed circuit board blank	
A13A3C1	0180-0058	C: fxd, elect, 50 μF, -10 + 75%, 25 vdcw	
A13A3C2, 3	0160-0174	C: fxd, cer, 0.47 μF, 25 vdcw	
A13A3C4	0140-0192	C: fxd, mica, 68 pF, 5%, 300 vdcw	
A13AC5	0140-0151	C: fxd, mica, 820 pF, 2%, 300 vdcw	
A13A3CR1, 2	1901-0040	Diode, Si	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A13A3CR3, 4	1901-0179	Diode, Si	
A13A3CR5	1901-0331	Diode, step recovery	
A13A3L1	9140-0115	Inductor, fxd, 22 μH	
A13A3L2	9140-0142	Inductor, fxd, 2.2 μH	
A13A3Q1	1854-0035	Transistor, NPN, Si	
A13A3R1	0757-0893	R: fxd, met ox: 51 ohm, 2%, 1/4 w	
A13A3R2	0683-1005	R: fxd, comp, 10 ohm, 5%, 1/4 w	
A13A3R3	0757-0898	R: fxd, met flm, 82 ohm, 2%, 1/8 w	
A13A3R4	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A13A3R5	0757-0912	R: fxd, met flm, 330 ohm, 2%, 1/8 w	
A13A3R6	2100-0765	R: vnr, ww, 1K ohm, 5%, 1 w n, 1/5 w	
A13A3R7	0760-0008	R: fxd, met flm, 430 ohm, 5%, 1 w	
A13A3R8, 9	0757-0900	R: fxd, met flm, 100 ohm, 2%, 1/8 w	
A13A3R10	0757-0908	R: fxd, met flm, 220 ohm, 2%, 1/8 w	
A13A3T1	0415-60010	Transformer-pulse	
A13A4	**04815-60320**	**CURRENT CHANNEL ISOLATING NETWORK ASSY**	
	04815-20320	A13A4 printed circuit board blank	
A13A4C1, 2	0150-0073	C: fxd, cer, 100 pF, 10%, 500 vdcw	
A13A4CR1	1901-0179	Diode, si	
A13A4R1	0757-0916	R: fxd, met flm, 470 ohm, 2%, 1/8 w	
A13A4R2, 3	0757-0900	R: fxd, met flm, 100 ohm, 2%, 1/8 w	
A13A4R4, 5	0757-0908	R: fxd, met flm, 220 ohm, 2%, 1/8 w	
A13A4T1, 2	04815-60060	Transformer, balun	
A13A5	**04815-60310**	**VOLTAGE CHANNEL ISOLATING NETWORK ASSY**	
	04815-20310	A13A5 printed circuit board blank	
A13A5C1, 2	0150-0073	C: fxd, cer, 100 pF, 10%, 500 vdcw	
A13A5CR1	1901-0179	Diode, Si	
A13A5R1	0757-0916	R: fxd, met flm, 470 ohm, 2%, 1/8 w	
A13A5R2, 3	0757-0900	R: fxd, met flm, 100 ohm, 2%, 1/8 w	
A13A5R4, 5	0757-0908	R: fxd, met flm, 220 ohm, 2%, 1/8 w	
A13A5T1, 2	04815-60060	Transformer, balun	
A13A6	**04815-60350**	**PHASE LOCK LOOP SAMPLER ASSY**	
	04815-20350	A13A6 printed circuit board blank	
A13A6C1	0150-0111	C: fxd, cer, 200 pF, 5%, 300 vdcw	
A13A6C2	0150-0042	C: fxd, TI DIOX, 4.7 pF, 5%, 500 vdcw	
A13A6C3, 4	0150-0073	C: fxd, cer, 100 pF, 10%, 500 vdcw	
A13A6C5	0150-0121	C: fxd, cer, 0.1 μF, 50 vdcw	
A13A6C6	0180-0114	C: fxd, elect, 4 μF, 25 vdcw	
A13A6C7	0150-0073	C: fxd, cer, 100 pF, 10%, 500 vdcw	
A13A6C8, 9	0180-0059	C: fxd, elect, 10 μF, 25 vdcw	
A13A6C10	0180-0058	C: fxd, elect, 50 μF, 25 vdcw	
A13A6C11	0150-0093	C: fxd, cer, 0.01 μF, +80 -20%, 100 vdcw	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A13A6CR1-64	1901-0179	Diode, Si	
A13A6L1, 2	9140-0158	Inductor, fxd, 1 μH	
A13A6L3	9140-0107	Inductor, fxd, 27 μH	
A13A6Q1	1855-0004	Transistor, field effect, P channel U112	
A13A6Q2	1854-0071	Transistor, NPN, Si, 2N3391	
A13A6Q3	1853-0016	Transistor, PNP, Si, 2N3638	
A13A6R1	0757-0893	R: fxd, met flm, 51 ohm, 2%, 1/8 w	
A13A6R2	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A13A6R3, 4	0757-0893	R: fxd, met flm, 51 ohm, 2%, 1/8 w	
A13A6R5	0757-0916	R: fxd, met flm, 470 ohm, 2%, 1/8 w	
A13A6R6	0757-0900	R: fxd, met flm, 100 ohm, 2%, 1/8 w	
A13A6R7, 8	0757-0948	R: fxd, met flm, 10K ohm, 2%, 1/8 w	
A13A6R9	0757-0912	R: fxd, met flm, 330 ohm, 2%, 1/8 w	
A13A6R10	0757-0948	R: fxd, met flm, 10K ohm, 2%, 1/8 w	
A13A6R11	0757-0954	R: fxd, met flm, 18K ohm, 2%, 1/8 w	
A13A6R12	0757-0930	R: fxd, met flm, 1.8K ohm, 2%, 1/8 w	
A13A6R13, 14	0757-0900	R: fxd, met flm, 100 ohm, 2%, 1/8 w	
A13A6T1, 2	04815-60060	Transformer, balun	
A14	**C4815-60120**	**RF OSCILLATOR ASSY**	
A14C1	0160-2358	C: fxd, mica, 22 pF, 1%, 100 vdcw	
A14C2-5, 15	0132-0003	C: var, poly, 0.7 to 3.0 pF, 1000 min, 350 vdcw	
A14C6	0160-0155	C: fxd, my, 0.0033 μF, 10%, 200 vdcw	
A14C7	0160-0154	C: fxd, my, 0.0022 μF, 10%, 200 vdcw	
A14C8	0140-0037	C: fxd, mica, 390 pF, 5%, 500 vdcw	
A14C9-13	0150-0121	C: fxd, cer, 0.1 μF, 50 vdcw	
A14C14	0170-0055	C: fxd, my, 0.1 μF, 20%, 200 vdcw	
A14J2	1250-0001	Connector, RF, BNC bulkhead mtg	
A14L1, 2	9140-0179	Inductor, fxd, 22 μH	
A14R1	0757-0954	R: fxd, met flm, 18K ohm, 2%, 1/8 w	
A14R2	2100-0789	R: var, lin, 1K ohm, 20%, 2 w	
A14R3, 4	0683-5605	R: fxd, comp, 56 ohm, 5%, 1/4 w	
A14R5	0686-2755	R: fxd, comp, 2.7M ohm, 5%, 1/2 w	
A14R6	0686-1055	R: fxd, comp, 1M ohm, 5%, 1/2 w	
A14R7	0686-2055	R: fxd, comp, 2M ohm, 5%, 1/2 w	
A14R8	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A14S1	3100-1856	Switch, osc. range, rf section does not include detent and shaft	
A14S2	3100-1836	Switch, osc. range	
A14T1	04815-60670	Coil assy, oscillator, 0.5 - 1.5 MHz	
A14T2	04815-60680	Coil assy, oscillator, 1.5 - 4.5 MHz	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A14T3	04815-60690	Coil assy, oscillator, 4.6 - 14 MHz	
A14T4	04815-60700	Coil assy, oscillator, 14 - 35 MHz	
A14T5	04815-60710	Coil assy, oscillator, 35 - 108 MHz	
A14W1	04815-60560	Cable assy, includes center conductor p/o A14J3	
A14W2	04815-60550	Cable assy, rf, includes A14P1	
A14W3	04815-60540	Cable assy, rf, includes center conductor p/o A14J1	
A14W4	04815-60620	Cable assy, coax. NRFR. Includes center conductor part of A14J4. Does not include, but requires:	
	1250-0817	Connector, rf pc board	
	0362-0026	Crimp sleeve (assembled with Thomas & Betts tool WT231)	
A14W5	04815-60570	Cable assy, multi-wire	
A14A1	**04815-60290**	**VIDEO AMPLIFIER & MODULATOR ASSY**	
	04815-20290	A14A1 printed circuit board blank	
A14A1C1, 2	0150-0121	C: fxd, cer, 0.1 μF, 50 vdcw	
A14A1C3	0150-0059	C: fxd, cer, 3.3 pF, NPO, 600 vdcw	
A14A1C4	0140-0145	C: fxd, mica, 22 pF, 5%, 500 vdcw	
A14A1C5-10	0150-0121	C: fxd, cer, 0.1 μF, 50 vdcw	
A14A1C11	0121-0060	C: var, cer, 2 - 8 pF, NPO, 300 vdcw	
A14A1C12-15	0150-0121	C: fxd, cer, 0.1 μF, 50 vdcw	
A14A1C16	0160-0333	C: fxd, mica, 15 pF, ±0.5 pF, 300 vdcw	
A14A1C17-25	0150-0121	C: fxd, cer, 0.1 μF, 50 vdcw	
A14A1C26	0140-0145	C: fxd, mica, 22 pF, 5%, 500 vdcw	
A14A1C27	0150-0059	C: fxd, cer, 3.3 pF, NPO, 600 vdcw	
A14A1C28, 29	0150-0121	C: fxd, cer, 0.1 μF, 50 vdcw	
A14A1C30	0150-0074	C: fxd, cer, 7 pF ±0.5, 500 vdcw	
A14A1C31	0150-0121	C: fxd, cer, 0.1 μF, 50 vdcw	
A14A1CR1-8	1901-0179	Diode, Si	
A14A1CR9, 10	1901-0040	Diode, Si	
A14A1CR11	1901-0179	Diode, Si	
A14A1L1	9140-0179	Inductor, fxd, 22 μH	
A14A1Q1	1853-0034	Transistor, PNP, Si,	
A14A1Q2	1854-0092	Transistor, NPN, Si, 2N3563	
A14A1Q3	1854-0071	Transistor, NPN, Si, 2N3391	
A14A1Q4	1854-0092	Transistor, NPN, Si, 2N3563	
	1205-0037	Dissipator, heat	
A14A1Q5	1853-0034	Transistor, PNP, Si,	
	1205-0037	Dissipator, heat	
A14A1Q6	1854-0092	Transistor, NPN, Si, 2N3563	
	1205-0037	Dissipator, heat	
A14A1Q7, 8	1853-0015	Transistor, PNP, Si, 2N3640	
	1205-0037	Dissipator, heat	
A14A1Q9	1854-0071	Transistor, NPN, Si, 2N3391	
A14A1Q10	1854-0092	Transistor, NPN, Si, 2N3563	
A14A1Q11	1853-0034	Transistor, PNP, Si,	
A14A1R1	0757-0415	R: fxd, met flm, 475 ohm, ±1%, 1/8 w	
A14A1R2	0757-0394	R: fxd, met flm, 51.1 ohm, 1%, 1/8 w	
A14A1R3	0757-0818	R: fxd, met flm, 825 ohm, 1%, 1/2 w	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A14A1R4	0757-0398	R: fxd, met flm, 75 ohm, 1%, 1/8 w	
A14A1R5	0757-0421	R: fxd, met flm, 825 ohm, 1%, 1/8 w	
A14A1R6	0757-0418	R: fxd, met flm, 619 ohm, 1%, 1/8 w	
A14A1R7	0757-0404	R: fxd, met flm, 130 ohm, 1%, 1/8 w	
A14A1R8	0757-0401	R: fxd, met flm, 100 ohm, 1%, 1/8 w	
A14A1R9	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A14A1R10	0757-0316	R: fxd, met flm, 42.2 ohm, 1%, 1/8 w	
A14A1R11	0757-0397	R: fxd, met flm, 68.1 ohm, 1%, 1/8 w	
A14A1R12	0757-0441	R: fxd, met flm, 8.25K ohm, 1%, 1/8 w	
A14A1R13	0757-0280	R: fxd, met flm, 1K ohm, 1%, 1/8 w	
A14A1R14	0757-0438	R: fxd, met flm, 5.11K ohm, 1%, 1/8 w	
A14A1R15	0757-0430	R: fxd, met flm, 2.21K ohm, 1%, 1/8 w	
A14A1R16	0757-0441	R: fxd, met flm, 8.25K ohm, 1%, 1/8 w	
A14A1R17	0757-0123	R: fxd, met flm, 34.8K ohm, 1%, 1/10 w	
A14A1R18	0757-0438	R: fxd, met flm, 5.11K ohm, 1%, 1/8 w	
A14A1R19	0757-0394	R: fxd, met flm, 51.1 ohm, 1%, 1/8 w	
A14A1R20	0757-0406	R: fxd, met flm, 182 ohm, 1%, 1/8 w	
A14A1R21	0757-0421	R: fxd, met flm, 825 ohm, 1%, 1/8 w	
A14A1R22	0757-0316	R: fxd, met flm, 42.2 ohm, 1%, 1/8 w	
A14A1R23	0757-0819	R: fxd, met flm, 909 ohm, 1%, 1/2 w	
A14A1R24	0698-3439	R: fxd, met flm, 176 ohm, 1%, 1/8 w	
A14A1R25	0757-0422	R: fxd, met flm, 909 ohm, 1%, 1/8 w	
A14A1R26	0757-0401	R: fxd, met flm, 100 ohm, 1%, 1/8 w	
A14A1R27	0757-0282	R: fxd, met flm, 221 ohm, 1%, 1/8 w	
A14A1R28	0757-0421	R: fxd, met flm, 825 ohm, 1%, 1/8 w	
A14A1R29	0698-3435	R: fxd, met flm, 38.3 ohm, 1%, 1/8 w	
A14A1R30	0757-0168	R: fxd, met flm, 619 ohm, 1%, 1/2 w	
A14A1R31	0757-0405	R: fxd, met flm, 162 ohm, 1%, 1/8 w	
A14A1R32	0757-0401	R: fxd, met flm, 100 ohm, 1%, 1/8 w	
A14A1R33, 34	0757-0919	R: fxd, met flm, 620 ohm, 2%, 1/8 w	
A14A1R35	0757-0394	R: fxd, met flm, 51.1 ohm, 1%, 1/8 w	
A14A1R36	0757-0818	R: fxd, met flm, 825 ohm, 1%, 1/2 w	
A14A1R37	0757-0399	R: fxd, met flm, 82.5 ohm, 1%, 1/8 w	
A14A1R38	0686-1055	R: fxd, comp. 1M ohm, 5%, 1/2 w	
A14A1R39	0757-0416	R: fxd, met flm, 475 ohm, 1%, 1/8 w	
A14A1R40	0698-3136	R: fxd, met flm, 17.8K ohm, 1%, 1/8 w	
A14A1R41	2100-0396	R: var, ww, lin, 10K ohm, 20%, 1.5 w	
A14A1R42	0757-0410	R: fxd, met flm, 301 ohm, 1%, 1/8 w	
A14A1R43	0757-0280	R: fxd, met flm, 1K ohm, 1%, 1/8 w	
A14A1R44	0757-0906	R: fxd, met flm, 180 ohm, 2%, 1/8 w	
A14A1R45	0698-3404	R: fxd, met flm, 383 ohm, 1%, 1/2 w	
A14A1R46, 47	0757-0401	R: fxd, met flm, 100 ohm, 1%, 1/8 w	
A14A1R48	0757-0727	R: fxd, met flm, 562 ohm, 1%, 1/4 w	
A14A1R49	0757-0394	R: fxd, met flm, 51.1 ohm, 1%, 1/8 w	
A14A1R50, 51	0757-0401	R: fxd, met flm, 100 ohm, 1%, 1/8 w	

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A14A2	**04815-60110**	**CAPACITOR ASSY**	
A14A2	04815-60110	Not recommended for field repair	
A14A3	**04815-60280**	**OSCILLATOR CKT ASSY**	
	04815-20280	A14A3 printed circuit board blank	
A14A3C1	0150-0121	C: fxd, cer, .1 μF, -20 + 80%, 50 vdcw	
A14A3C2	0160-2324	C: fxd, mica, 220 pF, 5%, 500 vdcw	
A14A3Q1	1854-0092	Transistor, NPN, Si, 2N3563	
A14A3R1	0757-0430	R: fxd, met flm, 2.21K ohm, 1%, 1/8 w	
A14A3R2	0757-0433	R: fxd, met flm, 3.32K ohm, 1%, 1/8 w	
A14A3R3	0757-0430	R: fxd, met flm, 2.21K ohm, 1%, 1/8 w	
A14A4, 5	**04815-60270**	**LAMP ASSY**	
	04815-20270	A14A4, 5 printed circuit board blank	
DS1 thru 5	2140-0037	Lamp, indicator, 28 v	
A15	**04815-60070**	**IMPEDANCE RANGE SWITCH ASSY**	
A15C1	0170-0055	C: fxd, my, 0.1 μF, 20%, 200 vdcw	
A15R1	0698-4188	R: fxd, met flm, 1368 ohm, .5%, 1/8 w	
A15R2	0698-4187	R: fxd, met flm, 632 ohm, .5%, 1/8 w	
A15R3	0698-4186	R: fxd, met flm, 1368 ohm, .5%, 1/8 w	
A15R4	0698-4186	R: fxd, met flm, 432 ohm, .5%, 1/8 w	
A15R5	0698-4185	R: fxd, met flm, 136.8 ohm, .5%, 1/8 w	
A15R6	0698-4183	R: fxd, met flm, 43.2 ohm, .5%, 1/8 w	
A15R7	0698-3524	R: fxd, met flm, 20.2 ohm, .5%, 1/8 w	
A15R8	0698-4188	R: fxd, met flm, 1368 ohm, .5%, 1/8 w	
A15R9	0698-4186	R: fxd, met flm, 432 ohm, .5%, 1/8 w	
A15R10	0698-4185	R: fxd, met flm, 136.8 ohm, .5%, 1/8 w	
A15R11	0698-4184	R: fxd, met flm, 63.2 ohm, .5%, 1/8 w	
A15R12	0757-0894	R: fxd, met flm, 56 ohm, 2%, 1/8 w	
A15R13	0757-0917	R: fxd, met flm, 510 ohm, 2%, 1/8 w	
A15R14	0683-2705	R: fxd, comp, 27 ohm, 5%, 1/4 w	
A15R15	0757-0922	R: fxd, met flm, 820 ohm, 2%, 1/8 w	
A15R16	0757-0894	R: fxd, met flm, 56 ohm, 2%, 1/8 w	
A15R17	0757-0893	R: fxd, met flm, 51 ohm, 2%, 1/8 w	
A15R18	0757-0924	R: fxd, met flm, 1K ohm, 2%, 1/8 w	
A15R19	0757-0943	R: fxd, met flm, 6.2K ohm, 2%, 1/8 w	
A15R20, 21	0757-0893	R: fxd, met flm, 51 ohm, 2%, 1/8 w	
A15R22	0757-0933	R: fxd, met flm, 2.4K ohm, 2%, 1/8 w	
A15R23	0757-0893	R: fxd, met flm, 51 ohm, 2%, 1/8 w	
A15R24	0757-0894	R: fxd, met flm, 56 ohm, 2%, 1/8 w	
A15R25	0757-0922	R: fxd, met flm, 820 ohm, 2%, 1/8 w	

Table 6-1, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A15R26	0757-0894	R: fxd, met flm, 56 ohm, 2%, 1/8 w	
A15R27	0757-0695	R: fxd, met ox, 62 ohm, 2%, 1/8 w	
A15R28	0757-0909	R: fxd, met flm, 240 ohm, 2%, 1/8 w	
A15R29	0757-0895	R: fxd, met ox, 62 ohm, 2%, 1/8 w	
A15R30	0757-0900	R: fxd, met flm, 100 ohm, 2%, 1/8 w	
A15R31	0757-0896	R: fxd, met flm, 68 ohm, 2%, 1/8 w	
A15R32	0757-0900	R: fxd, met flm, 100 ohm, 2%, 1/8 w	
A15S1	3100-1845	Switch	
A15MP1	2390-0007	Screw, machine, binder hd w/ext lockwasher 6-32 x 5/16	TQ5
A15MP2	186A-55A-1	Plate, clamping	
A15MP3	186A-55A	Shield, Switch	
A15MP4	2320-0001	Nut, machine, 6-32 x 5/16 hex	TQ5
A15W1	04815-60200	Cable assy includes P1	
A15W2	04815-60190	Cable assy	
A15W3	04815-60200	Cable assy includes P2	
A15W4	04815-60190	Cable assy	
A15W5	04815-60210	Cable assy includes P3	
A15W6	04815-60220	Cable assy includes A13J1 (1)	
A16	**04815-60010**	**PROBE ASSY**	
A16	04815-60010	Probe assy. Not field repairable. Contact your Hewlett-Packard sales and service office for information. Addresses are on the last page of this manual.	
A17		**PROBE CHECK**	
A17R1	0698-4349	R: fxd, met flm, 99.6 ohm, 5%, 1/8 w	
		Mechanical Parts:	
	1250-0048	Pin, center contact	
	10206-60001	Contact, ground	
	04815-20500	Plug, insulator, "teflon"	
	04815-20520	Plug, end	
	04815-20530	Housing	
	04815-40001	Plug, end cap, nylon	
		MISCELLANEOUS MECHANICAL PARTS	
	0370-0050	Knob, spinner	
	0370-0275	Knob, crank	
	1410-0033	Bushing, knob	Frequency tuning knob
	2410-0001	Screw, mach, SS, 6-32x5/8 OH	
	0370-0112	Knob, MAGNITUDE RANGE (Ω), PHASE RANGE, RANGE (MHz)	
	1200-0043	Insulator, transistor (for Q1-4)	
	1200-0081	Bushing, transistor mounting (for Q1-4)	
	1400-0084	Fuseholder	
	5040-0234	Lamp holder (for DS2)	
	5040-0235	Lamp holder base (for DS2)	
	5060-0049	Plugin extender board	

Table 6-2. Legend for Figure 6-1

Ref. No.	Stock No.	Description	Qty
1	04815-20590	Pulley, pot	1
2	3030-0022	Screw, set, sh, 6-32 x .125	2
3	1460-0290	Spring, coil	1
4	04815-60720	String assembly, pot	1
5	2950-0030	Nuts - hex, brs, 3/8 x 9/16 x 32 in., NI P	1
6	2190-0022	Washer, lock, internal, .375 ID	1
7	2300-0007	Screw, bh, ss, 6-32 x .312	24
8	04815-00200	Bracket - pot, mtg.	1
9		A14R2 (See Table 6-1)	1
10	0360-0014	Terminal	1
11	2420-0001	Nut, hex, snp, 6-32, .312 wd	1
12	2370-0002	Screw, fh, ss, 6-32 x .375	4
13	61B-40D-4	Plate, frequency dial	1
14	04815-20610	Drum	1
15	7124-0324	Label, frequency scale	1
16	2200-0003	Screw, mach, rh, ss, 4-40, .250 lg	6
17	1460-0289	Spring, coil	1
18	04815-60730	String assembly, drum	1
19	3030-0002	Screw, set, 8-32 x .375	1
20	3030-0005	Screw, set, 8-32 x .125	2
21	1480-0137	Roll pin, .125 dia. x .625	2
22	5020-0305	Hub, dial	1
23	1410-0015	Bearing, ball	2
24	3030-0033	Screw, set, 6-32 x .1875	1
25	04815-20480	Casting, top	1
26	04815-60650	Bracket, pulley, right side	1
27	04815-20630	Bushing, drive	1
28	04815-60610	Shaft and pulley assembly	1
29	04815-60640	Bracket, pulley, left side	1
30	04815-20650	Shaft, drum	1
31	0510-0005	Tru - arc, .250 dia.	2
32	04815-20570	Gasket, upper	1
33	2190-0003	Washer, lock, helical, No. 4	4
34		A14A4, 5 (See Table 6-1)	2
35	7124-0323	Label, readout, right	1
36	2550-0008	Screw, mach, bh, ss, 8-32 x .5	2
37	2190-0017	Washer, lock, helical, No. 8	2
38	3050-0001	Washer, brass, .375 od, .172 id.	2
39	04815-40030	Read out, molded	1
40	7124-0322	Label, readout, left	1
41	0510-0054	Tru - arc, 250 dia, compression type	1
41	0510-0005	Tru - arc, .250 dia. (for use on grooved shafts)	1
42	2190-0183	Washer - ss, .255 id, .445 od, .005 thk	

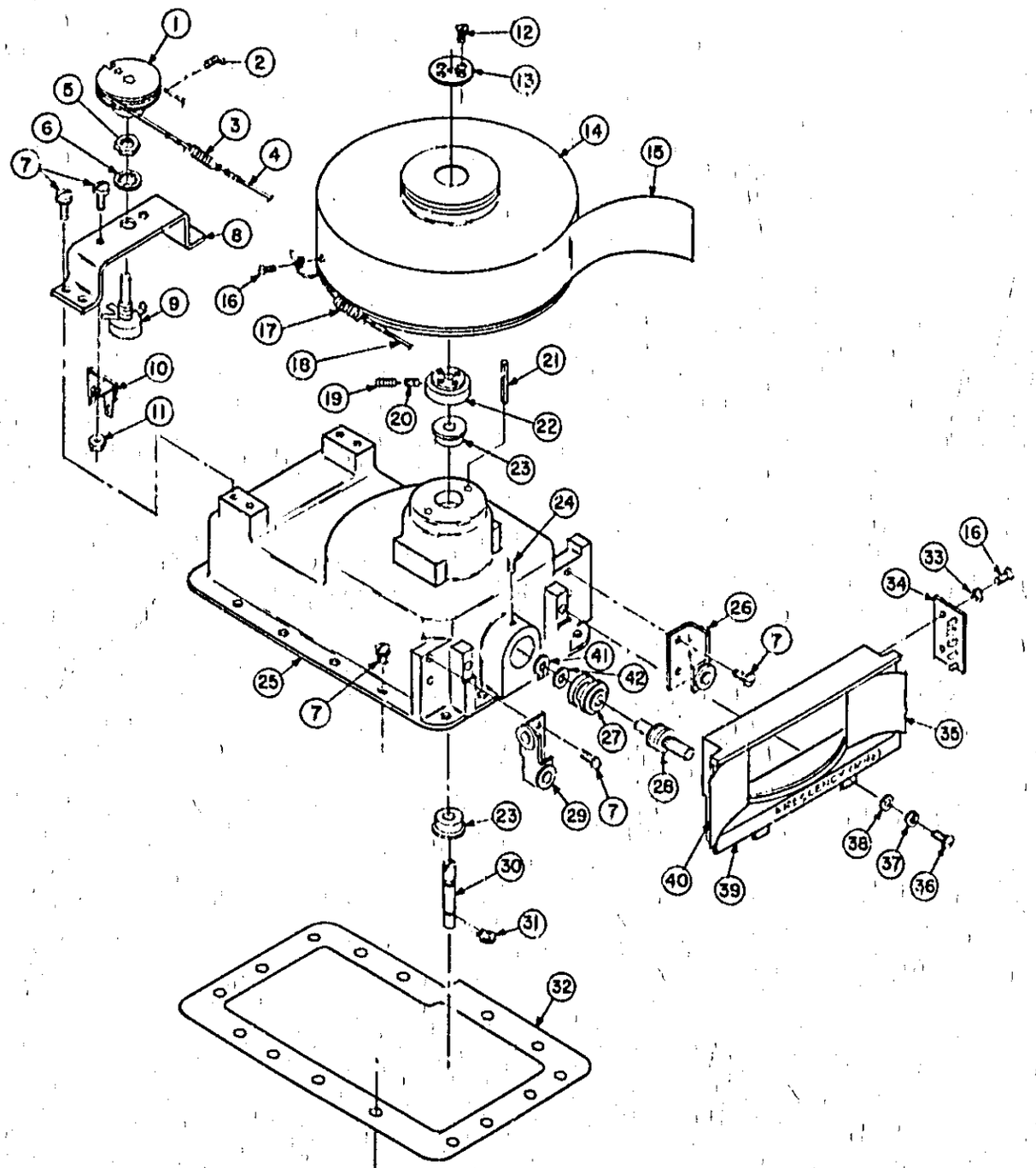


Figure 6-1. RF Oscillator Assembly A14 - Top

Table 6-2. Legend for Figure 6-2

Ref. No.	Stock No.	Description	Qty
1	6A-88	Washer, compression	1
2	5040-0210	Coupler, flex	1
3	3030-0005	Screw, set, sh, 8-32 x .125	4
4		A14A2 (See Table 6-1)	1
5	2390-0007	Screw, bh, ss, 6-32 x .312	22
6	2200-0003	Screw, mach, rh, ss, 4-40, .250 lg	4
7	2190-0003	Washer, lock, helical, No. 4	4
8		A14A3 (See Table 6-1)	1
9	0520-0002	Screw, mach, rh, 2-56, .250 lg	4
10	0360-0002	Terminal, lug copper, flat type	3
11	2190-0014	Washer, lock, internal, No. 2	9
12	0610-0001	Nut, hex, 2-56, .188 wd, .063 thk	1
13		A14T1 (See Table 6-1)	1
14		A14T2 (See Table 6-1)	1
15		A14T3 (See Table 6-1)	1
16		A14S1 (See Table 6-1)	1
17	0520-0071	Mach, screw, brs, 2-56 x 5/16, rh, sd	2
18		A14T4 (See Table 6-1)	1
19		A14T5 (See Table 6-1)	1
20	0360-0045	Terminal, lug bronze, flat type	1
21	0360-1104	Terminal, feedthru	3
22	0360-1105	Terminal, standoff	3
23		A14W4 (See Table 6-1)	1
24		A14W3 (See Table 6-1)	1
25		A14W2 (See Table 6-1)	1
26		A15W5 (See Table 6-1)	1
27	2190-0006	Washer, lock, helical, No. 6	9
28	3050-0100	Washer, brass, .4375 od, .147 id	9
29	2390-0008	Screw, mach, stl, 6-32 x 3/8 in, BD, HD, SD	9
30	1400-0017	Clamp, cable	1
31	1250-0817	Connector, pc board	1
32	0362-0007	Sleeve, crimp	1
33	1400-0031	Clamp, cable	1
34	2190-0022	Washer, lock, internal, .375 id	3
35		A14J2 (See Table 6-1)	1
36		A14W1 (See Table 6-1)	1
37	1250-0295	Nut, clamp	3
38	1250-0294	Washer, flat	3
39	1250-0293	Gasket, clamp	1
40	1250-0292	Washer, clamp	3
41	04815-20490	Casting, base	1
42		A14A1 (See Table 6-1)	1
43	2950-0030	Nut, mach, 3/8 x 32	2
44	1400-0015	Clamp, cable	1
45	0360-0042	Solder, lug-brs, .144, mtg. hole, 90 deg bend	1

Table 6-2. Legend for Figure 6-2 (Cont'd)

Ref. No.	Stock No.	Description	Qty
46	3030-0022	Screw, set, sh, 6-32 x .125	4
47	1430-0064	Gear, miter	2
48	0510-0005	Tru-arc, .250 dia	2
49	04815-20760	Shaft, osc. range	1
50	1410-0003	Bushing, .250 id	1
51	5020-0237	Coupler, .25 id	1
52		A1482 (See Table 6-1)	1
53	3050-0017	Washer, .375 , dx, .26 id	as reqd
54	3050-0161	Washer, spring, .26 id	1
55	04815-20540	Plate, support	1
56	04815-20580	Gasket, lower	1
57	04815-00160	Cover, bottom	1
58	0362-0021	Unlring (red)	3

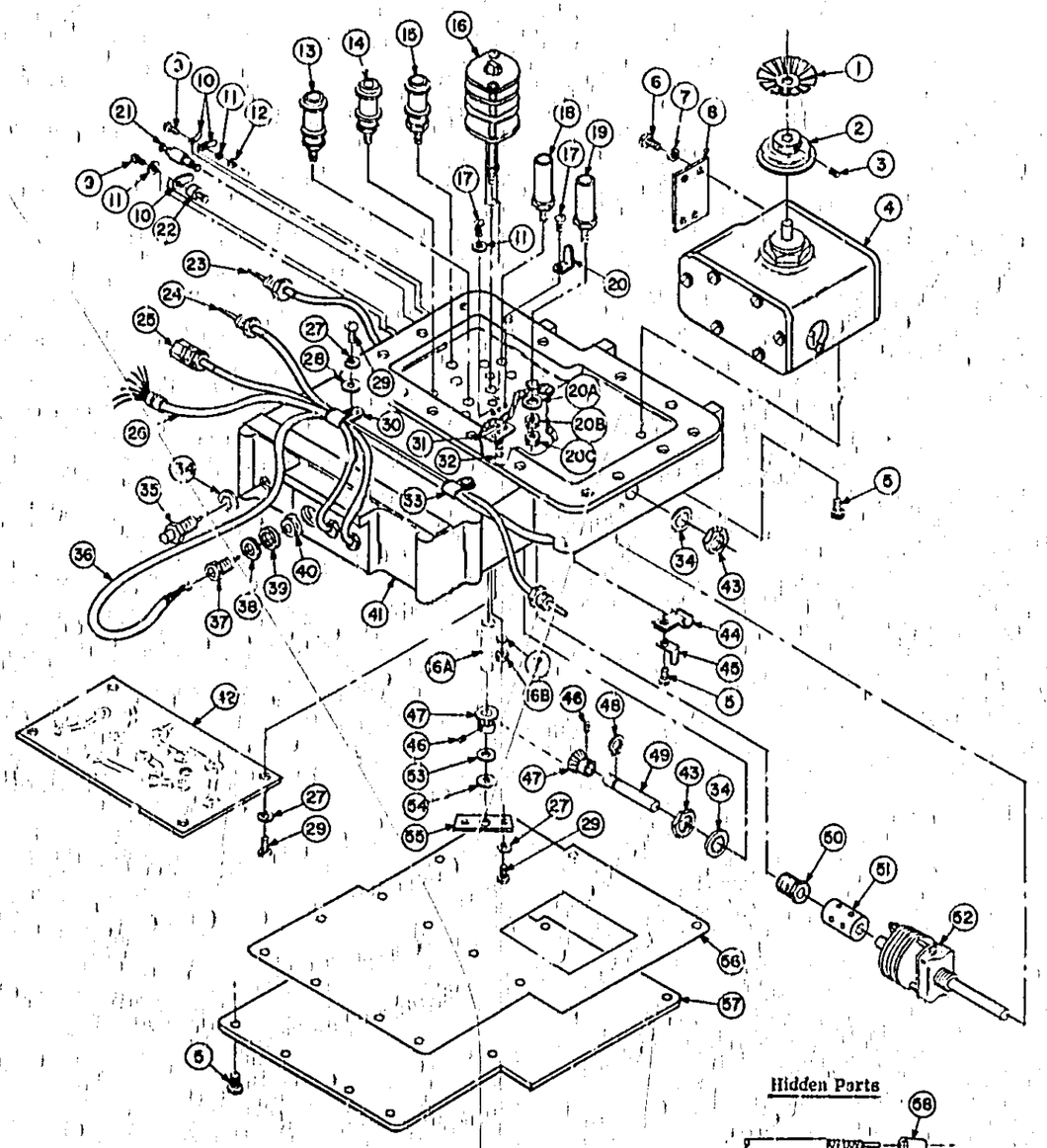


Figure 6-2. RF Oscillator Assembly A14 - Bottom

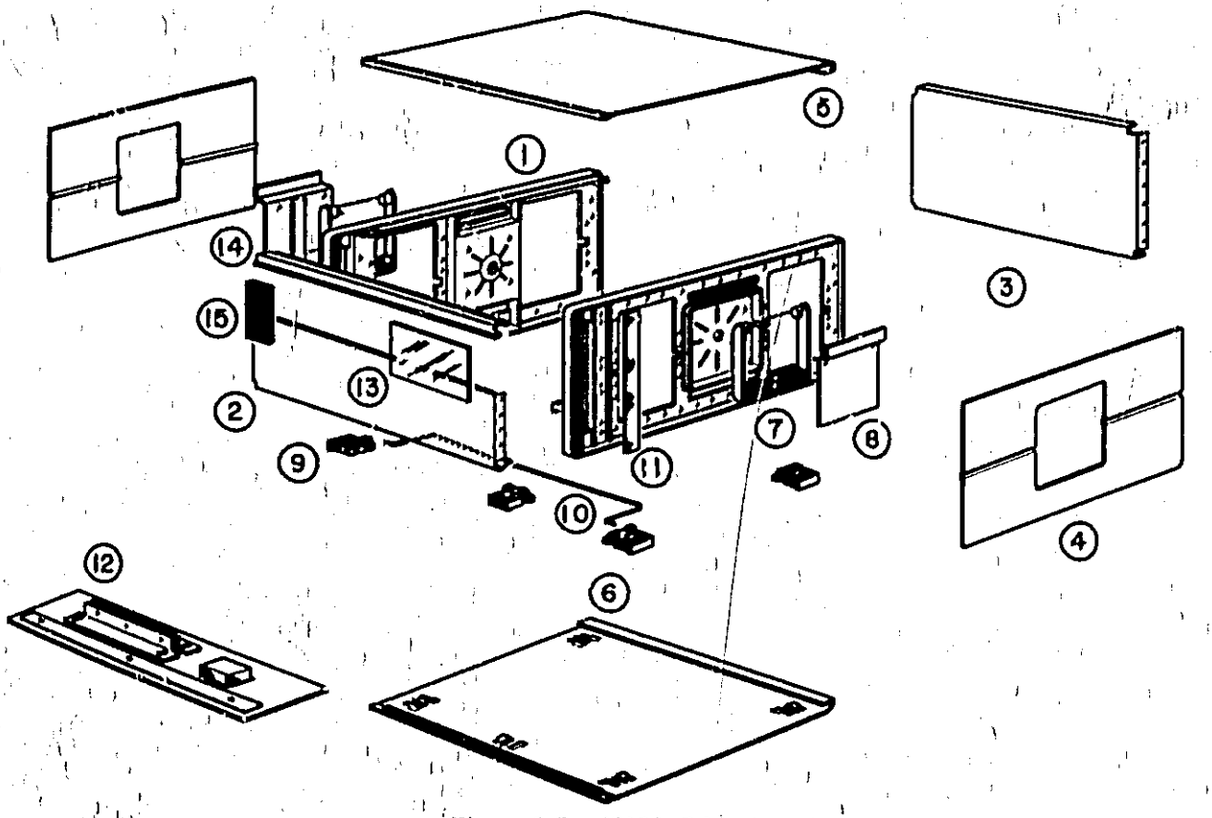


Figure 6-3. 4815A Cabinet Parts

Table 6-4. Legend for Figure 6-3

REF NO.	STOCK NO.	DESCRIPTION	QTY
1	04815-20060	Side frame	2
2	04815-00030	Panel, Front	1
	2530-0011	Screw-Mach. 8-32x3/8 flt. hd. sd.	4
3	04815-00040	Panel, Rear	1
	2515-0017	Screw-Mach. ss 8-32x1/4 lg. p. hd., ph. dr., w/lw	4
4	5000-0742	Cover, Side	2
	2370-0020	Screw-Mach. ss 6-32x3/16 100° f. hd	8
5	04815-00320	Cover, top	1
	2370-0017	Screw-Mach. fh ss, 6-32x5/8 p.dr.	4
6	5060-0752	Cover, Bottom	1
	2370-0017	Screw-Mach. fh ss, 6-32x5/8 p. dr.	4
7	5060-0763	Handle Assy - Side	2
8	5060-0765	Retainer - Handle Assy	2
	2550-0013	Screw-Mach. bh ss 8-32x.313	4
	2190-0017	Washer, Lock Split Ring No. 8	4
9	5060-0767	Foot Assy	5
10	1490-0030	Stand, Tilt	1
11	5000-0052	Plate, Fluted Alum.	2
12	5060-0776	Kit - Rack Mounting	1
13	04815-20660	Window Readout	1
14	04815-00180	Panel, Front Strip	1
	2210-0002	Screw-Mach. ss 4-40 x .250 fh sd	2
15	04815-00230	Sub Panel	1

SCHEMATIC DIAGRAMS

SECTION VII
CIRCUIT DIAGRAMS

7-1. INTRODUCTION.

7-2. This Section contains schematic diagrams of the Model 4815A. The diagrams represent the circuits electrically and are not wiring diagrams, although wire colors are given where practical. Figures 7-11 and 7-12 show combination schematic and wiring diagrams for the two major switch assemblies in the 4815A. Refer to page 7-2 for general notes and explanations of symbols used in the circuit diagrams.

7-3. Each schematic diagram has a box labelled Reference Designations which lists all the reference designations that appear on the diagram. In addition, a Semiconductor Reference table is included, showing Stock Number and JEDEC type (if any exists) for all diodes and transistors in the diagram. The table is arranged by reference designator.

7-4. ASSEMBLY AND COMPONENT IDENTIFICATION.

7-5. Figure 5-1 on page 5-0 identifies the assemblies in the 4815A. Components mounted on circuit board assemblies are called out on an illustration which also shows the etched wiring. Illustrations face the schematic in which the assembly appears.

7-6. WAVEFORMS.

7-7. Waveforms at certain test points are included with schematic diagrams for troubleshooting. Unless otherwise indicated waveforms are taken under the following conditions:

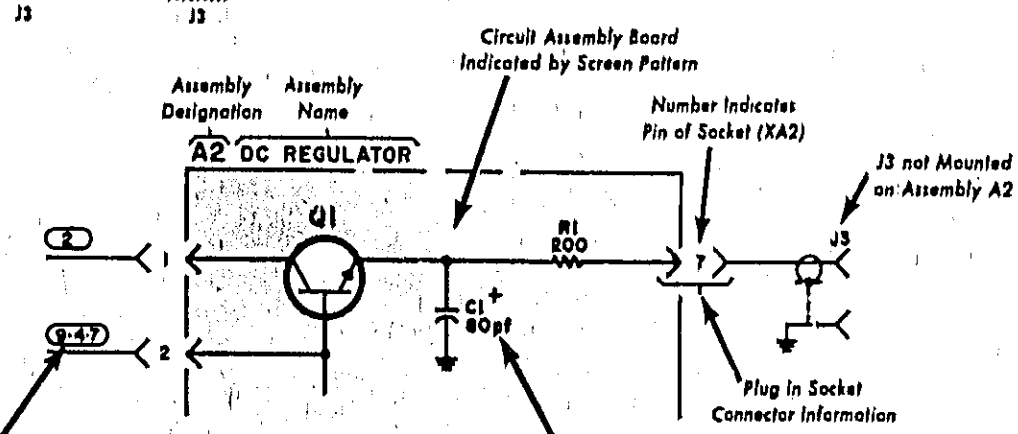
FREQUENCY (MHz) set to 0.5
RANGE (MHz) set to 0.5 - 1.5
MAGNITUDE RANGE (Ω) set to 100
PHASE RANGE set to $0^{\circ} \pm 180^{\circ}$
Probe is inserted in PROBE CHECK 100Ω 0° receptacle.

When direct coupling the oscilloscope yields useful waveform information, the zero voltage reference is identified on the waveform with a — 0 VDC marking. Bandwidth of the test oscilloscope will affect some fast risetime waveforms. The waveforms in this manual were taken with a Hewlett-Packard Model 140A Oscilloscope with Model 1401A plug-in.

REFERENCE DESIGNATION

Reference designations on assembly boards (printed circuit boards) are abbreviated. Add assembly number to abbreviation for complete description.

Assembly	Abbreviation	Complete Designations
A5	C1	A5C1
A13A1	R8	A13A1R
Chassis (no prefix)	J3	J3



Wire Color. Color code same as resistor code. First number identifies ground color, second number identifies wider strip. Third number identifies narrower strip. E.g., 947 denotes white, yellow, violet wire (MIL-STD-681).

Value selected for best value shown is average or most commonly selected value.

REFERENCE DESIGNATORS

CHASSIS	A2
J3	C1 Q1 R1

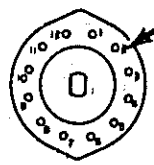
← *Reference Designation Index*

SYMBOLS

Resistance in ohms, capacitance in microfarads, inductance in microhenries unless otherwise noted.

- Screwdriver adjustment.
- Knob control
- Encloses front panel designation
- Encloses rear panel designation
- Circuit assembly borderline
- Other assembly borderline
- Heavy line with arrows indicates path and direction of main signal.
- Heavy dashed line with arrows indicates path and direction of main feedback.
- Indicates main path of auxiliary signal
- Powerline (chassis) ground
- Etched circuit board common ground
- Waveform test point
- 9-1-8 Denotes wire color using standard color code (e.g. 9-1-8 ... white-brown-grey)
- Voltage regulator (breakdown) diode.
- Step recovery diode
- Field effect transistor with P-material base

SWITCH DESIGNATION



A3S51 BR (2)

A3S51 Switch S51 within assembly A3

B 2nd wafer from front (A = first, etc.)

R Rear of wafer (F = front)

(2) Terminal location 2

Figure 7-1 shows the complete block diagram of the Model 4815A RF Vector Impedance Meter. Screened areas indicate circuits on the same schematic diagram. The figure number for the corresponding schematic (Figures 7-2 through 7-10) is indicated within the screened area.

Where signal paths leave a screened area, a circled letter, eg, (D) is placed on the diagram and corresponding schematics for reference. Also included are plugin board connection numbers and plug/jack combinations for all signal path connections.

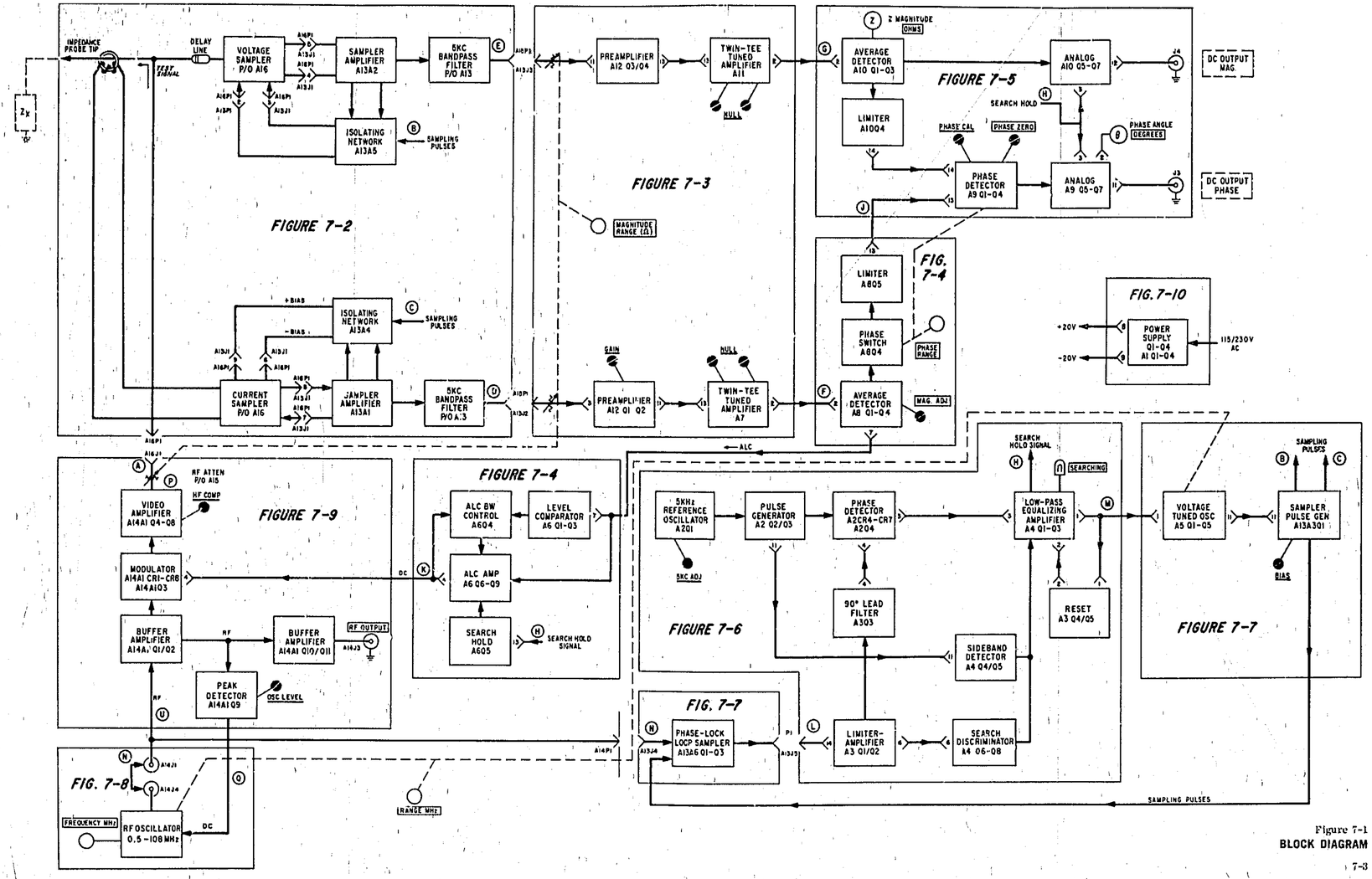
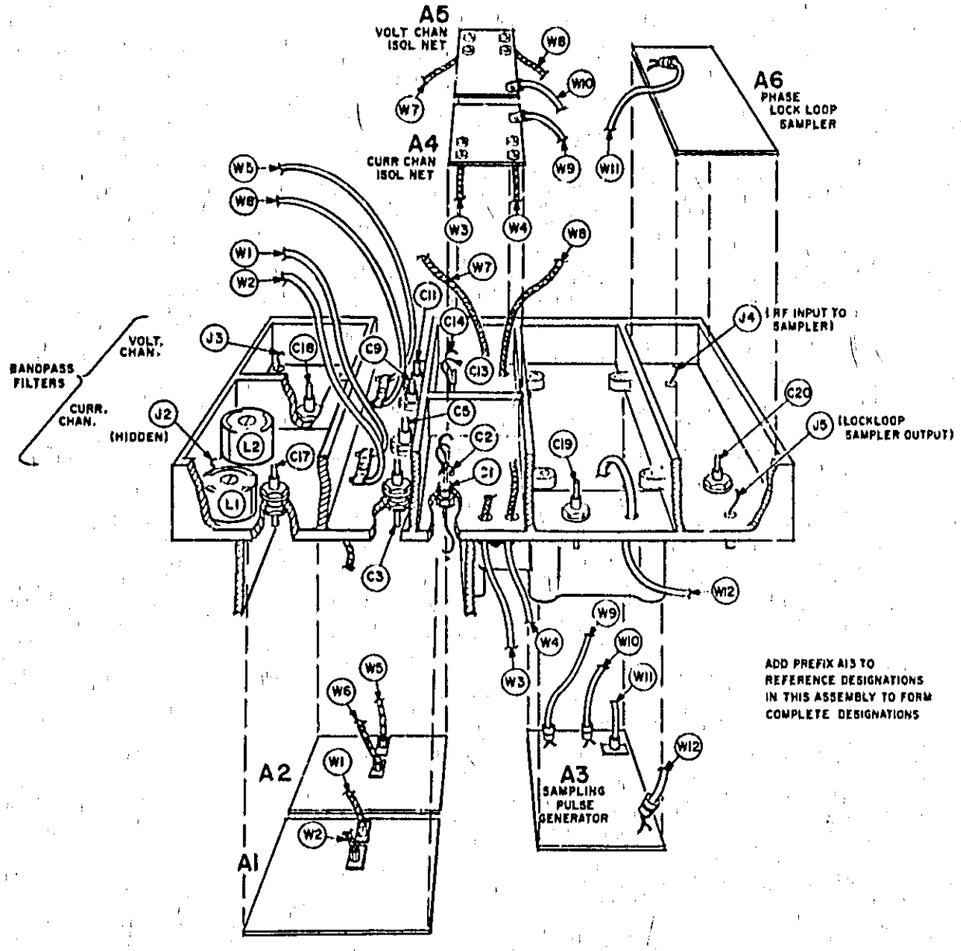
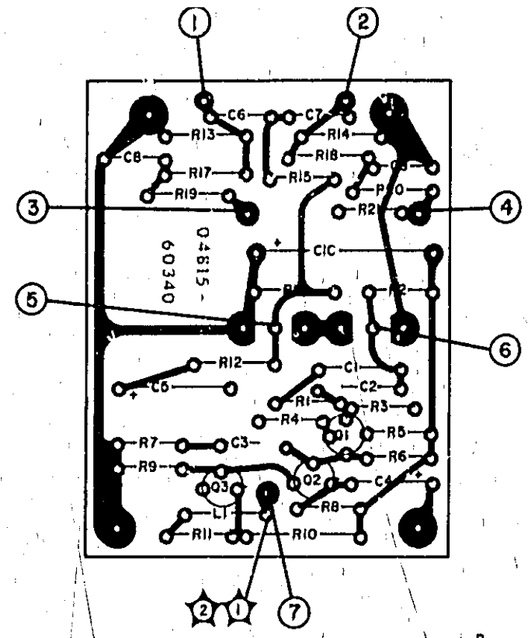


Figure 7-1
BLOCK DIAGRAM



EXPLODED VIEW OF A13



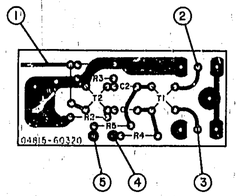
A13A1
A13A2

Connections, A13A1 Current Channel Sampler Amplifier

Connection No.	Code	Connection
1	Jumper	to A13C1, feedthru
2	Jumper	to A13C2, feedthru
3	P. C. board circuit soldered directly to A13C3, feedthru (hidden)	
4	P. C. board circuit soldered directly to A13C5, feedthru (hidden)	
5	Coaxial cable A13W6	to A13J1 (7)
6	Coaxial cable A13W5	to A13J1 (8)
7	P. C. board circuit soldered directly to A13C17, feedthru (hidden)	

Connections, A13A2 Voltage Channel Sampler Amplifier

Connection No.	Code	Connection
1	Jumper	to A13C13, feedthru
2	Jumper	to A13C14, feedthru
3	P. C. board circuit soldered directly to A13C9, feedthru (hidden)	
4	P. C. board circuit soldered directly to A13C11, feedthru (hidden)	
5	Coaxial cable A13W6	to A13J1 (4)
6	Coaxial cable A13W5	to A13J1 (5)
7	P. C. board circuit soldered directly to A13C18, feedthru (hidden)	

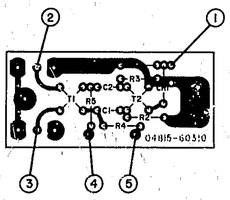


A13A4

COMPONENT SIDE
CIRCUIT ONLY SIDE

Connections, A13A4 Current Channel Isolating Network

Connection No.	Code	Connection
1	Center cond. of coax cable (pulse timing adjustment)	A13W9 to A13A3
2	Coaxial cable A13W4	to A13J1 (6)
3	Coaxial cable A13W3	to A13J1 (9)
4	Jumper	to A13C1 feedthru
5	Jumper	to A13C2 feedthru



A13A5

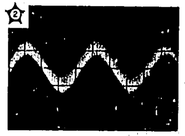
COMPONENT SIDE
CIRCUIT ONLY SIDE

Connections, A13A5 Voltage Channel Isolating Network

Connection No.	Code	Connection
1	Center cond. of coax cable A13W10	to A13A3
2	Coaxial cable A13W8	to A13J1 (2)
3	Coaxial cable A13W7	to A13J1 (3)
4	Jumper	to A13C14, feedthru
5	Jumper	to A13C13, feedthru

WAVEFORMS

Vert: 5 mV/cm ac coupled
Sweep: 50 μs/cm
Sync: INT



Vert: 2 mV/cm ac coupled
Sweep: 50 μs/cm
Sync: INT

SEMICONDUCTOR REFERENCE

Assy	Ref. Des.	-hp- Stock No.	JEDEC (if any)
A13A1 and A13A2	Q1	1853-0016	2N3638
	Q2, 3	1854-0071	2N3391
A13A4 and A13A5	CR1	1901-0179	
A16	CR1-8	1901-0183	
	Q1, 2 not field replaceable	1855-0004	

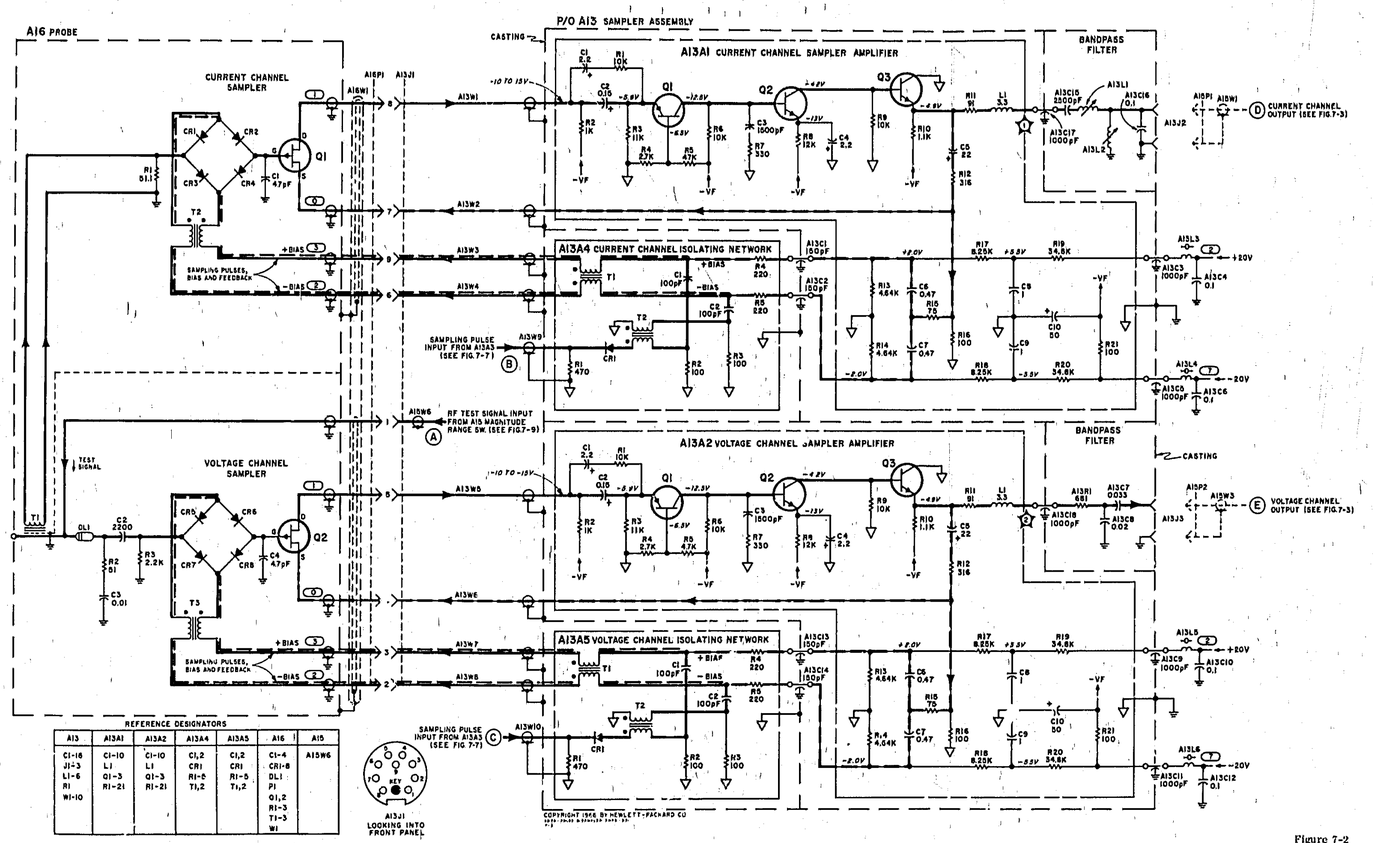
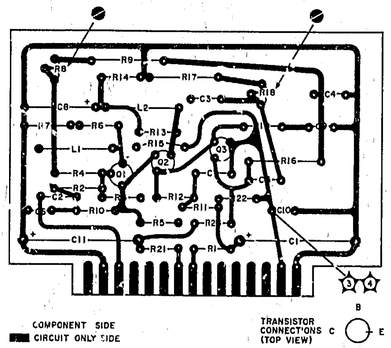
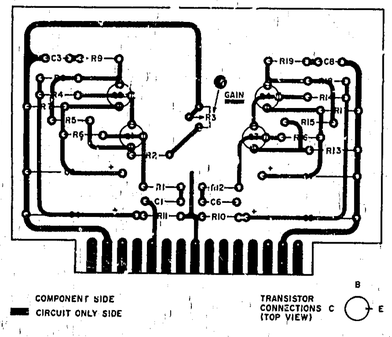


Figure 7-2
PROBE & SAMPLER AMPS
7-5/7-6

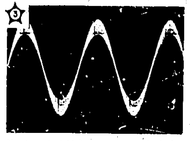


A7, A11



A12

WAVEFORMS



Vert: 0.2 V/cm, ac coupled
Sweep: 50 μs/cm
Sync: INT

Vert: 0.5 V/cm, ac coupled
Sweep: 50 μs/cm
Sync: INT

SEMICONDUCTOR REFERENCE

Assy	Ref. Des.	-hp- Stock No.	JEDEC (If any)
A7/A11	Q1, 2 Q3	1854-0071 1853-0016	2N3391 2N3638
A12	Q1-4	1854-0071	2N3391

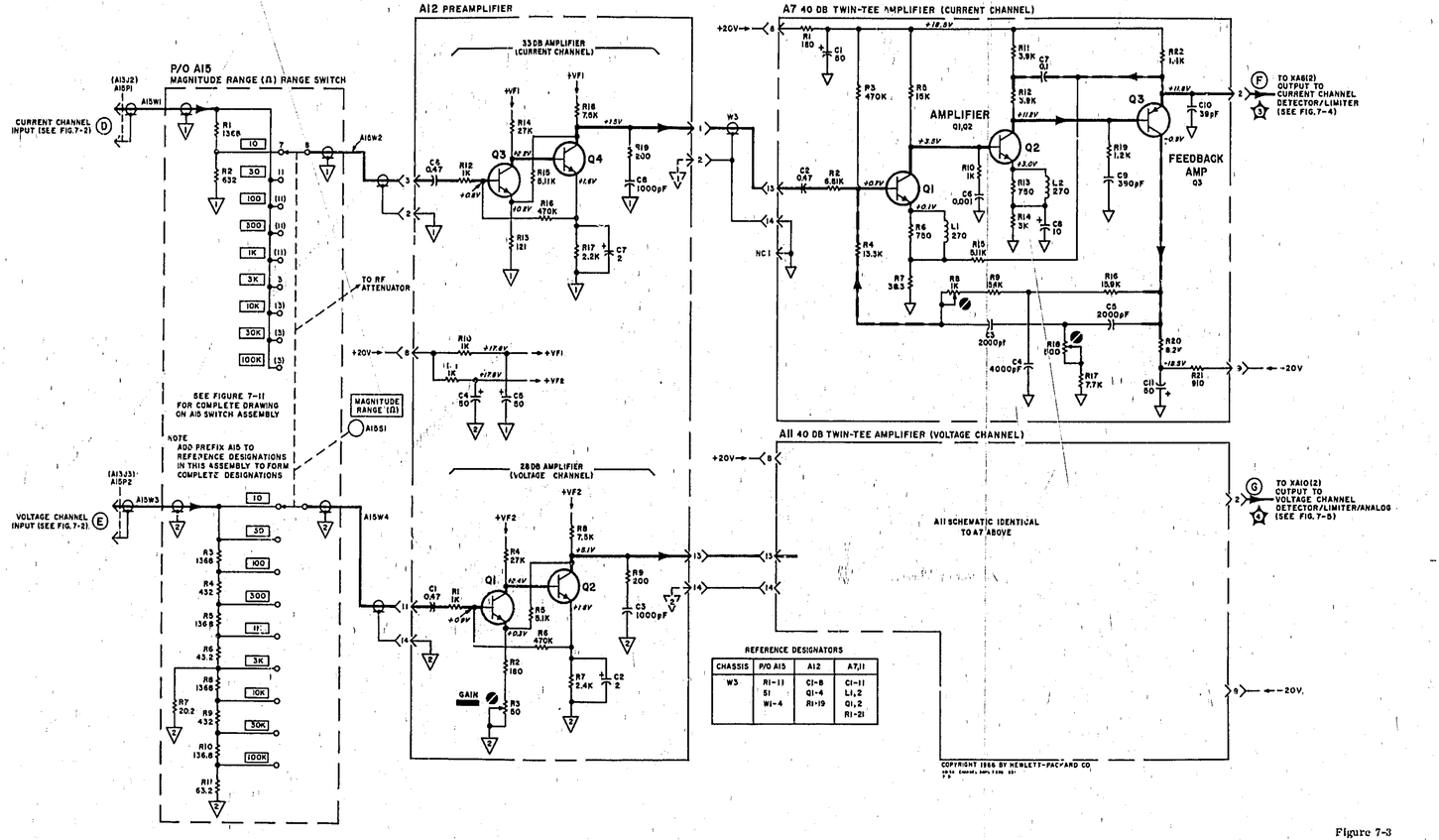
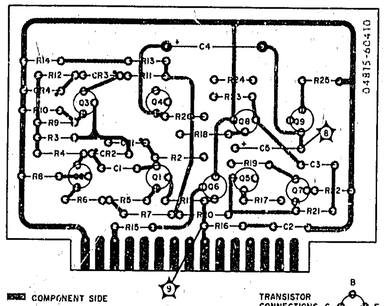
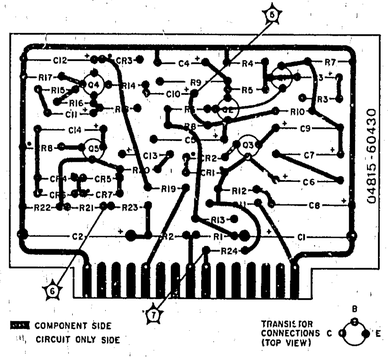


Figure 7-3
CHANNEL AMPLIFIERS
7-7/7-8

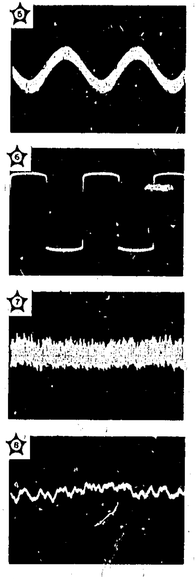


A6



A8

WAVEFORMS



Vert: 0.5 V/cm ac coupled
Sweep: 50 μsec/cm
Syn: EXT + on A2TP1

Vert: 0.5 V/cm ac coupled
Sweep: 50 μs/cm
Syn: INT +

Vert: 0.5 V/cm ac coupled
Sweep: 0.2 s/cm
Syn: INT

Vert: 50 mV/cm
Sweep: 0.2 s/cm
Sync: INT

SEMICONDUCTOR REFERENCE

Assy	Ref. Des.	-hp- Stock No.	JEDEC (If any)
A6	CR1-4	1901-0040	
	Q1, 2	1854-0071	2N3391
	Q3	1853-0016	2N3638
	Q4	1854-0071	2N3391
	Q5	1853-0016	2N3638
	Q6-8	1854-0071	2N3391
	Q9	1853-0016	2N3638
A8	CR1-8	1901-0040	
	Q1-5	1901-0071	

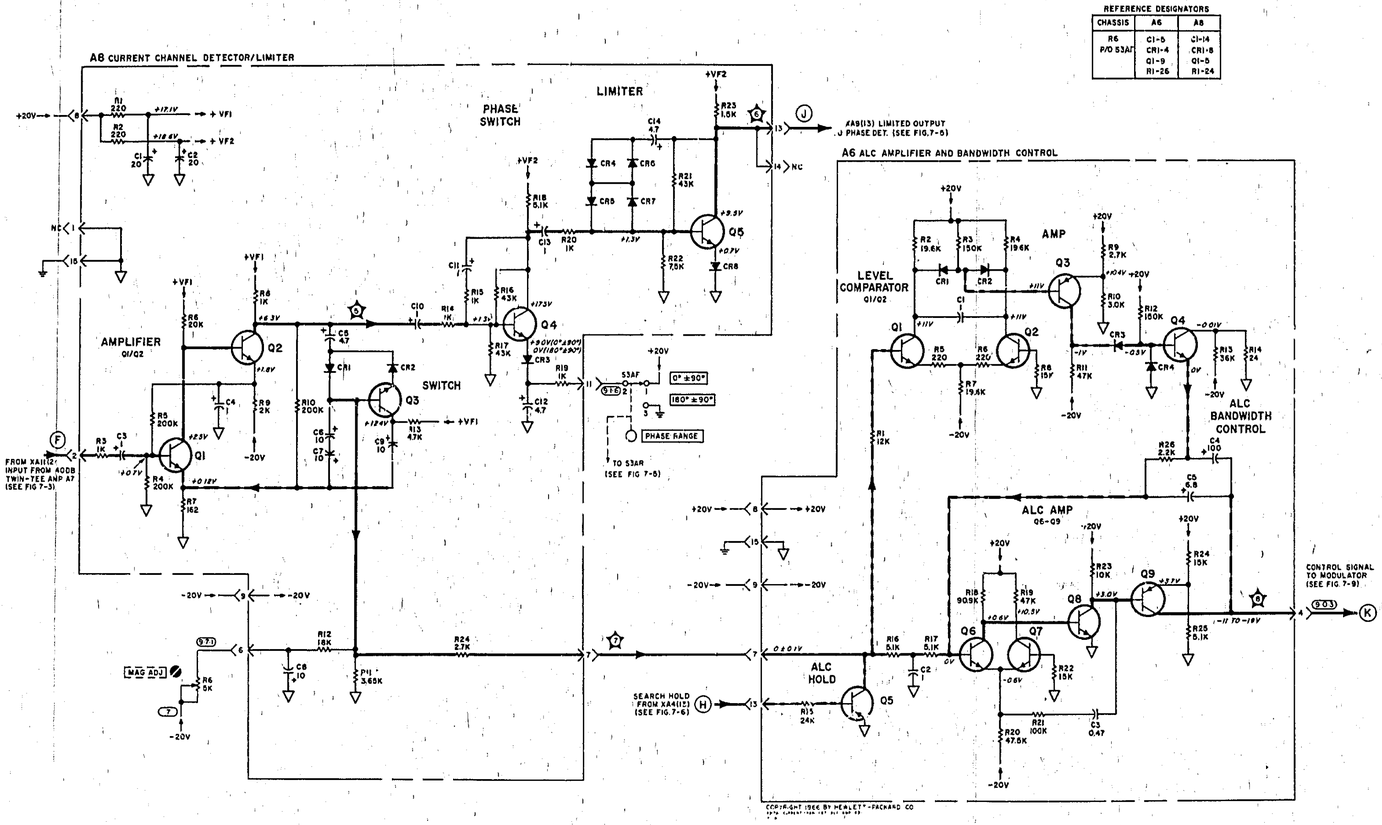
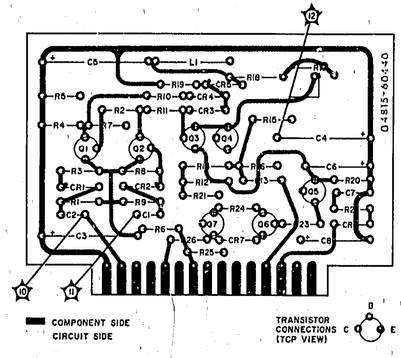
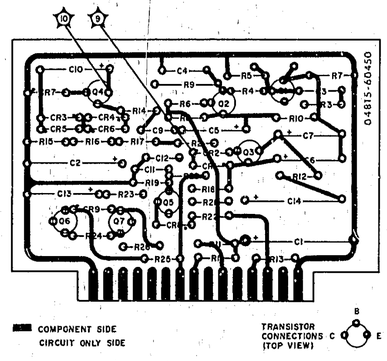
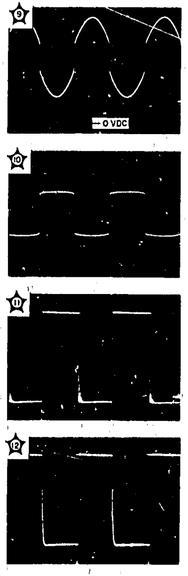


Figure 7-1
CURRENT CHAN. DET.-ALC AMP
7-9/7-10





WAVEFORMS



Vert: 1 V/cm dc coupled
Sweep: 50 μs/cm
Sync: EXT + on A2TP1

Vert: 1 V/cm ac coupled
Sweep: 50 μs/cm
Sync: EXT + on A2TP1

Vert: 1 V/cm ac coupled
Sweep: 50 μs/cm
Sync: EXT + on A2TP1

Vert: 1 V/cm ac coupled
Sweep: 50 μs/cm
Sync: EXT + on A2TP1

SEMICONDUCTOR REFERENCE

Assy	Ref. Des.	-hp- Stock No.	JEDEC (If any)
A9	CR1-4	1901-0040	
	CR5	1902-0033	
	Q1-6	1854-0071	2N3391
	Q7	1853-0016	2N3638
A10	CR1-10	1901-0040	
	Q1-6	1854-0071	2N3391
	Q7	1853-0016	2N3638

REFERENCE DESIGNATORS

CHASSIS	A10	A9
J3,4	C1-7,	C1-8
M1,2	9-14	CR1-7
R7	CR1-10	L1
53AR	Q1-7	Q1-7
	R1-26	R1-26

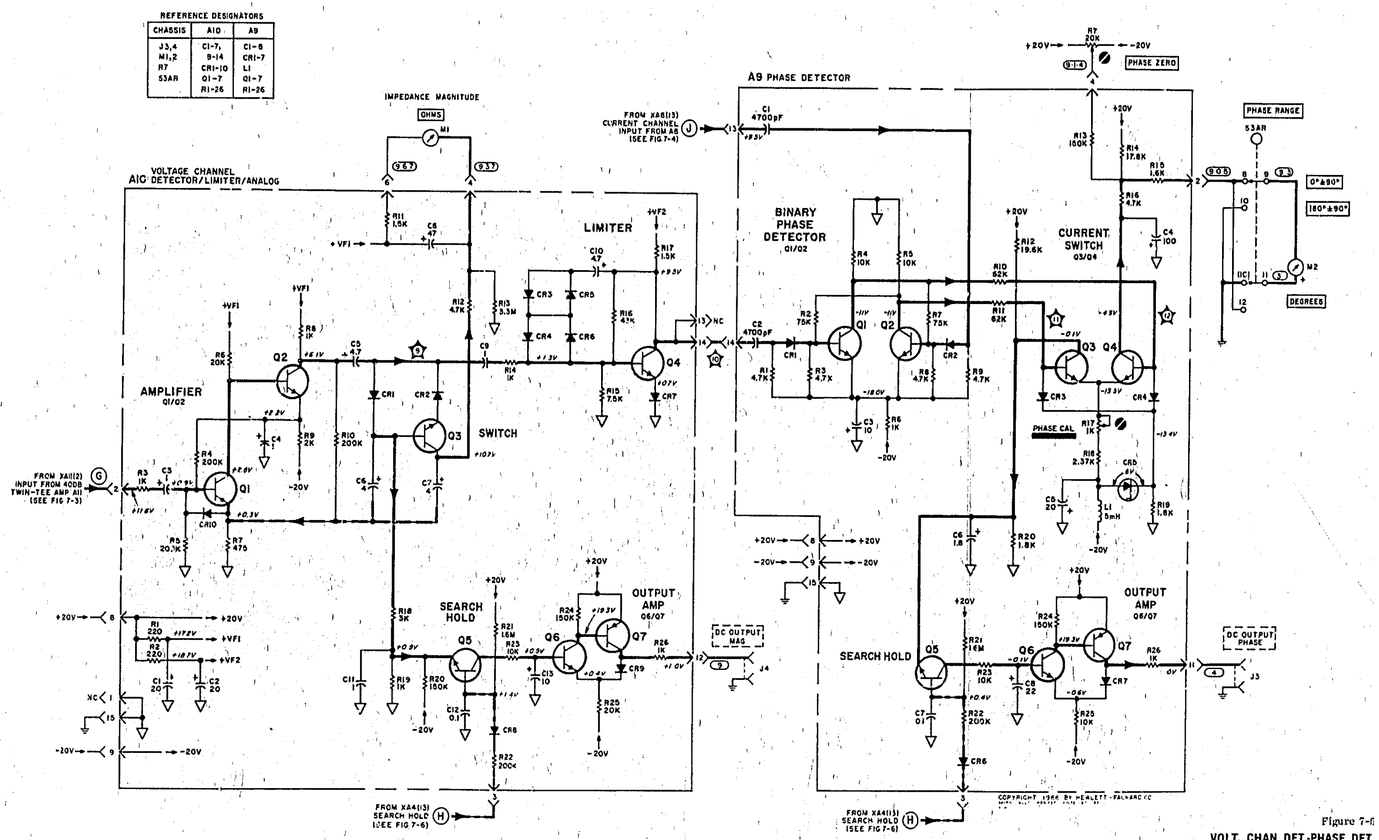
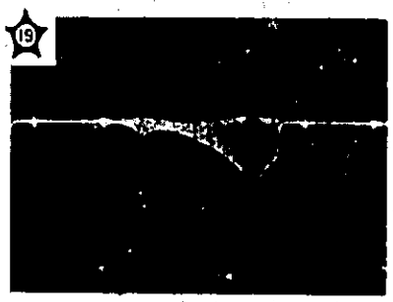


Figure 7-6
VOLT. CHAN DET.-PHASE DET.

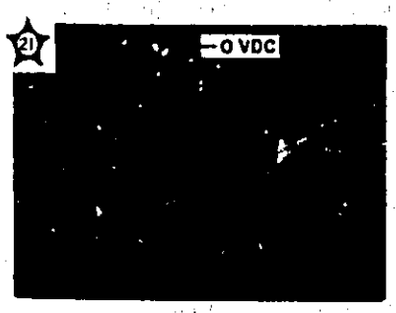
Normal circuit waveforms during search for a phase lock condition are non-repetitive and completed within 35 milliseconds, making observation difficult. To observe searching waveforms connect a 2 μF, 20 V capacitor (or larger) from A3 (4) to chassis and temporarily short A4 (13) to chassis. The following waveforms were taken under these conditions of no phase lock and slow search speed. Refer to paragraph 7-7 for front panel control settings.

WAVEFORMS

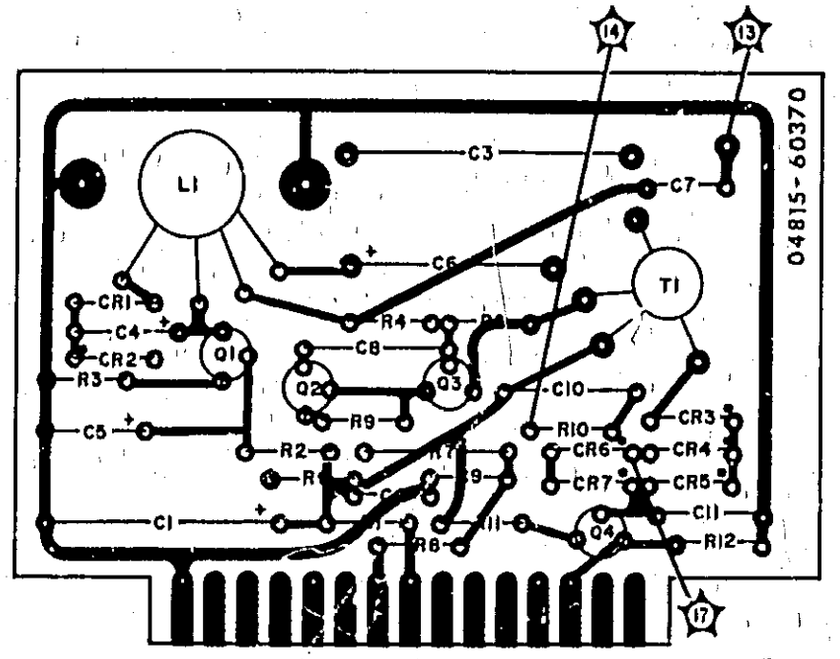


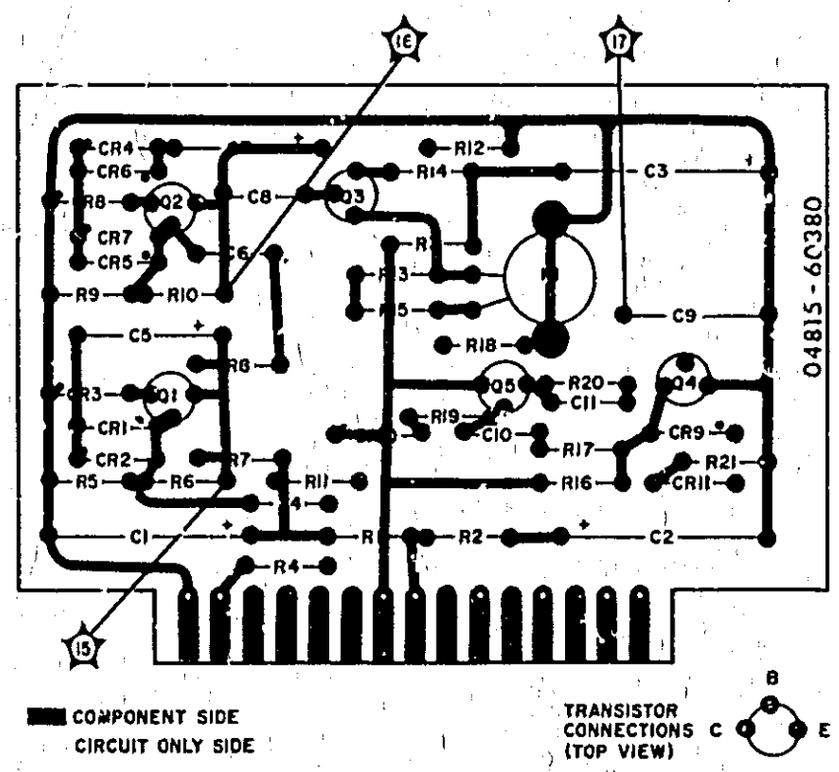
Vert: 2 V/cm, ac coupled
Sweep: 1 sec/cm
Sync: EXT + on XA4 (1)

Vert: 2 V/cm, ac coupled
Sweep: 1 sec/cm
Sync: EXT + on XA4 (1)



Vert: 2 V/cm, dc coupled
Sweep: 1 sec/cm
Sync: INT +

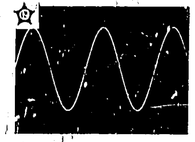




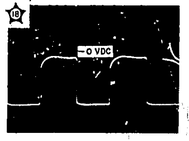
WAVEFORMS

Waveforms on this page were taken during normal phase-locked operation. For waveforms during searching, refer to foldout portion of page 7-12.

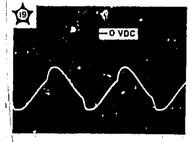
Vert: 0.2 V/cm, ac coupled
Sweep: 50 µs/cm
Sync: EXT + on A2TP1



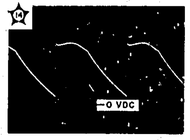
Vert: 0.5 V/cm, ac coupled
Sweep: 50 µs/cm
Sync: EXT + on A2TP1



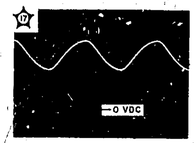
Vert: 5 V/cm, dc coupled
Sweep: 50 µs/cm
Sync: EXT + on A2TP1



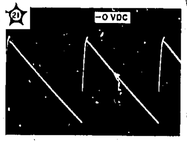
Vert: 5 V/cm, dc coupled
Sweep: 50 µs/cm
Sync: EXT + on A2TP1

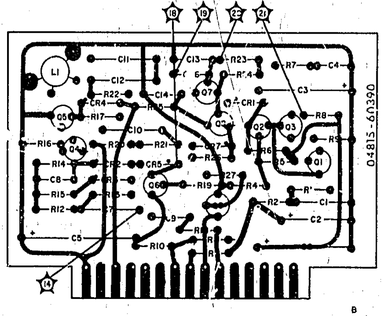


Vert: 5 V/cm, dc coupled
Sweep: 50 µs/cm
Sync: EXT + on A2TP1



Vert: 2 V/cm, dc coupled
Sweep: 10 ms/cm
Sync: INT +





COMPONENT SIDE
CIRCUIT ONLY SIDE

TRANSISTOR CONNECTIONS (TOP VIEW)

A4

SEMICONDUCTOR REFERENCE

Assy	Ref. Des.	-hp- Stock No.	JEDEC (If any)
A2	CR1, 2	1901-0040	
	CR3	1902-0025	
	CR4-7	1901-0040	
	Q1, 2	1854-0071	2N3391
	Q3	1853-0016	2N3638
	Q4	1854-0071	2N3391
A3	CR1-9	1901-0040	
	CR10	1910-0016	
	CR11	1902-0067	
	Q1-3	1854-0071	2N3391
	Q4	1853-0016	2N3638
	Q5	1854-0071	2N3391
A4	CR1-6	1901-0040	
	CR7	1902-0062	
	Q1	1853-0016	2N3638
	Q2, 3	1854-0071	2N3391
	Q4, 5	1853-0016	2N3638
	Q6	1854-0071	2N3391
	Q7	1853-0016	2N3638
	Q8	1854-0071	2N3391
	Q9	1853-0016	2N3638

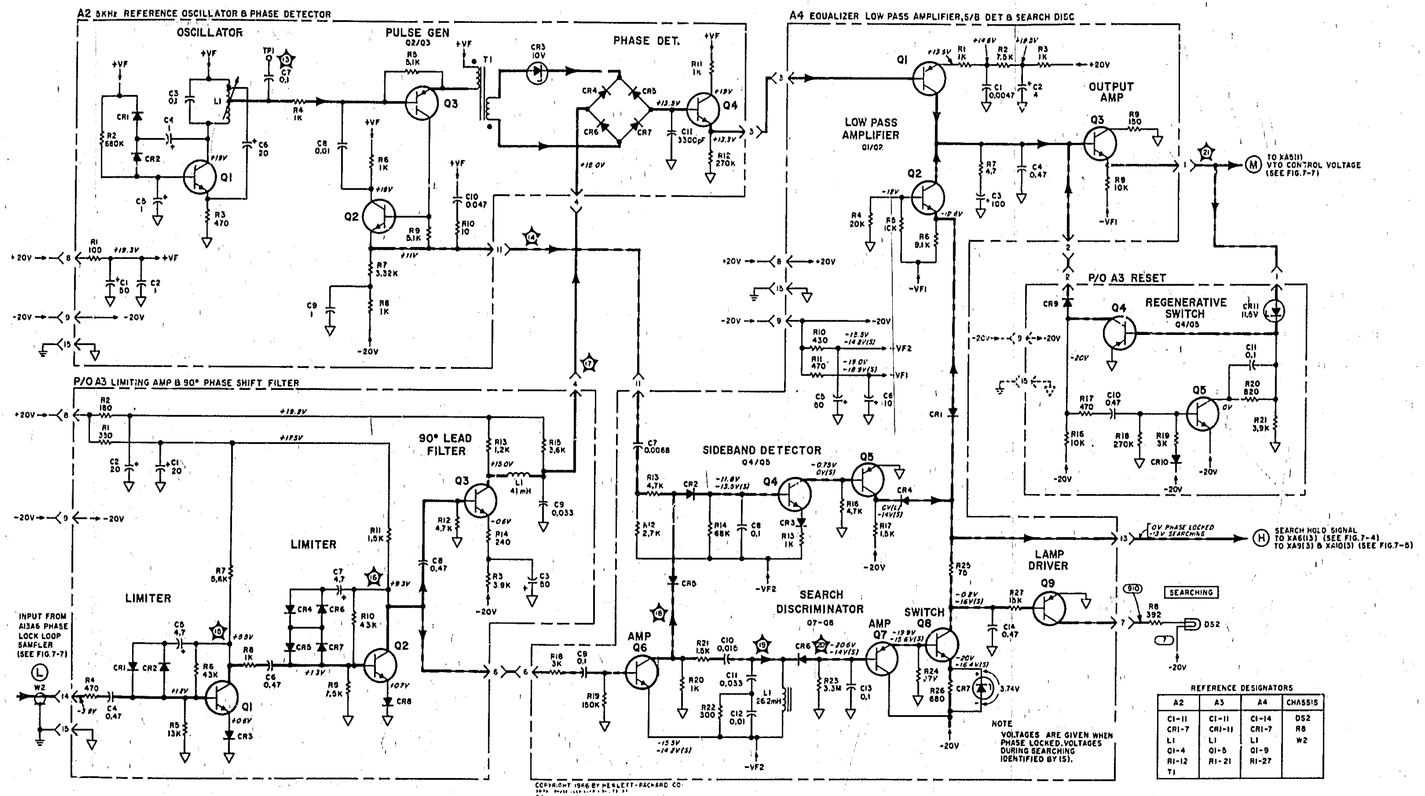


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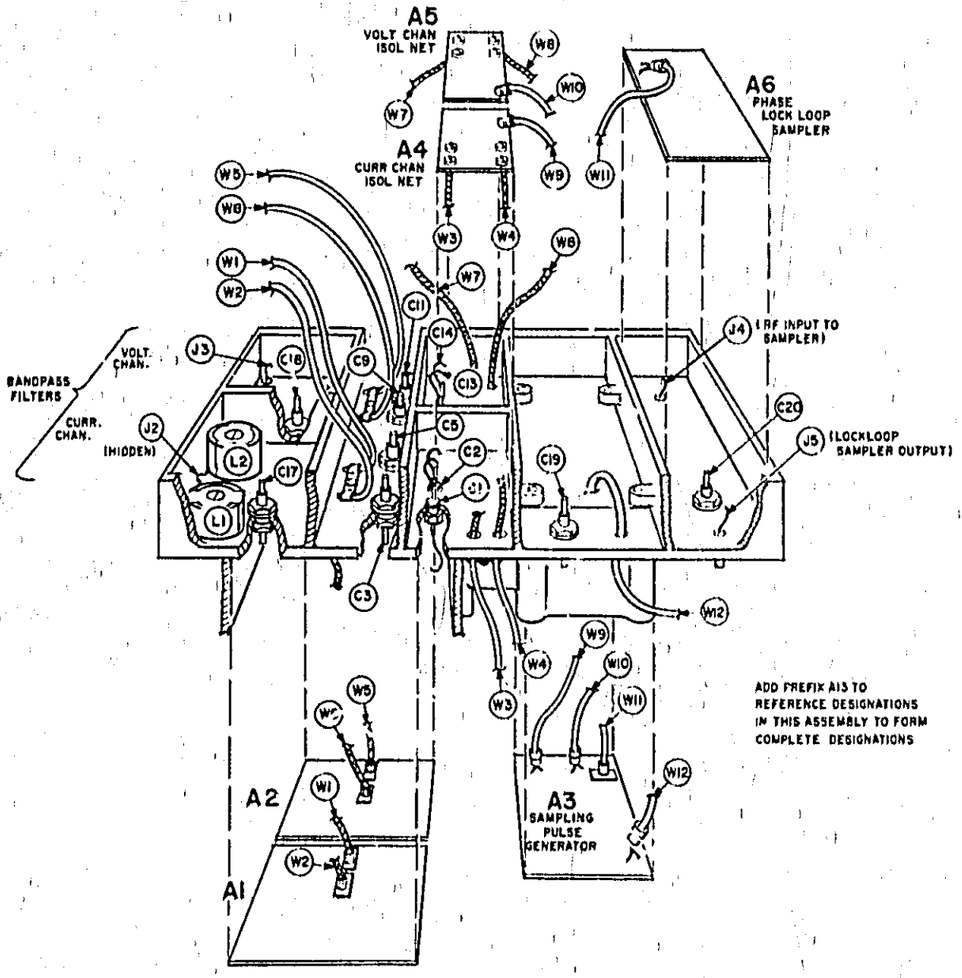
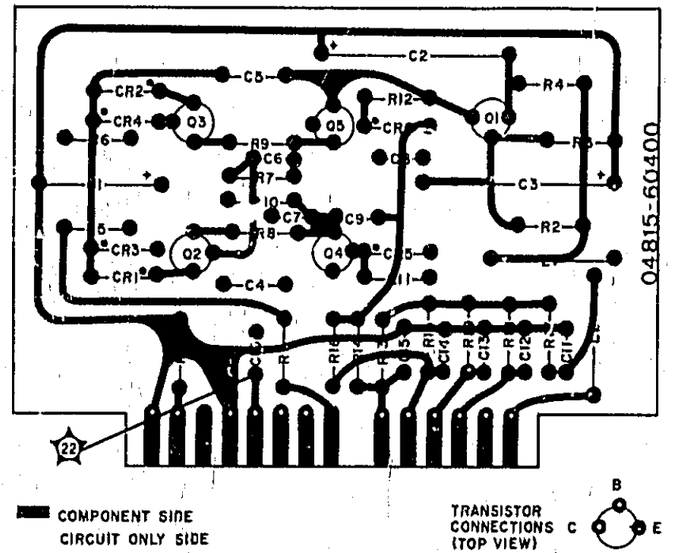
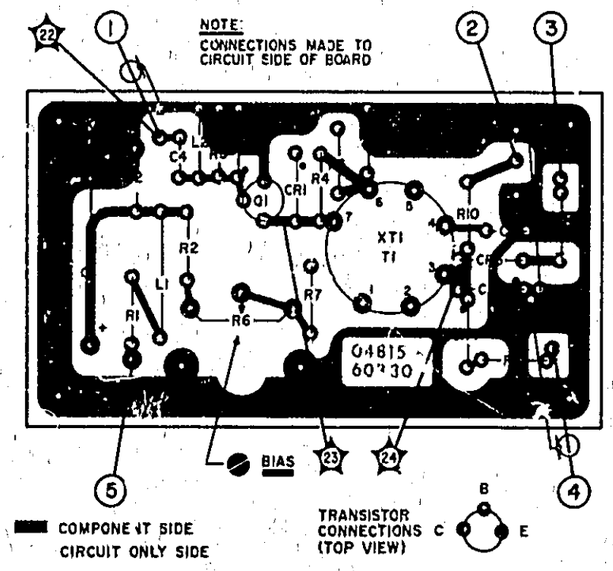
Figure 7-6
PHASE LOCK LOOP CIRCUITS



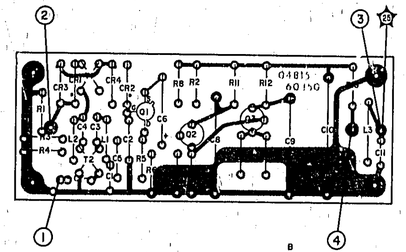
EXPLODED VIEW OF A13



A5



A13A3



Connections, A13A6 Phase Lock Loop Sampler

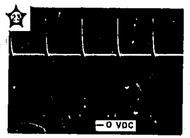
Connection Number	Code	Connection
1	Coaxial wire A13W11	sampling pulse input from A13A3
2	Jumper	to A13J4, RF input from A14
3	Jumper	to A13J5, IF output to A3
4	A13C20 soldered directly to etched circuit (+20 VDC)	

Connections, A13A3 Sampling Pulse Generator

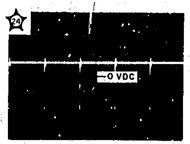
Connection Number	Code	Connection
1	Coaxial wire A13W12	VTO input from AX5 (11) and (12)
2	Coaxial wire A13W11	sampling pulse output to A13A6
3	Coaxial wire A13W9	sampling pulse output to A13A4
4	Coaxial wire A13W10	sampling pulse output to A13A5
5	Red wire	to A13C19 feedthru in casting well (+20 VDC)
Note - Connections to A13A6 are made on the circuit side only of the board		

WAVEFORMS

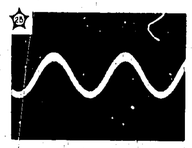
Vert: 5 V/cm, ac coupled
Sweep: 1 μs/cm
Sync: INT



Vert: 5 V/cm, dc coupled
Sweep: 1 μs/cm
Sync: INT



Vert: 0.1 V/cm, dc coupled
Sweep: 1 μs/cm
Sync: INT



Vert: 5 mV/cm, ac coupled
Sweep: 50 μs/cm
Sync: INT

SEMICONDUCTOR REFERENCE

Assy	Ref. Des.	-hp- Stock No.	JEDEC (If any)
A5	CR1-4 CR5, 6 Q1-3 Q4, 5	1901-0040 1901-0179 1853-0016 1854-0005	 2N3638 2N708
A13A3	CR1, 2 CR3, 4 CR5 Q1	1901-0040 1901-0079 1901-0055 1851-0035	
A13A6	CR1 CR2 CR3 CR4 Q1 Q2 Q3	1901-0040 1901-0179 1901-0040 1901-0179 1855-0004 1854-0071 1853-0016	 2N3391 2N3638

REFERENCE DESIGNATORS

A5	A13A3	A13A6	A13	CHASSIS	A14
C1-15 CR1-6 L1,2 Q1-5 R1-20	C1-5 CR1-5 L1,2 Q1 R1-10 T1	C1-11 CR1-4 L1-3 Q1-3 R1-14 T1,2	C19-21 J4,5 L7 W9-12	C19-21 W4	W5

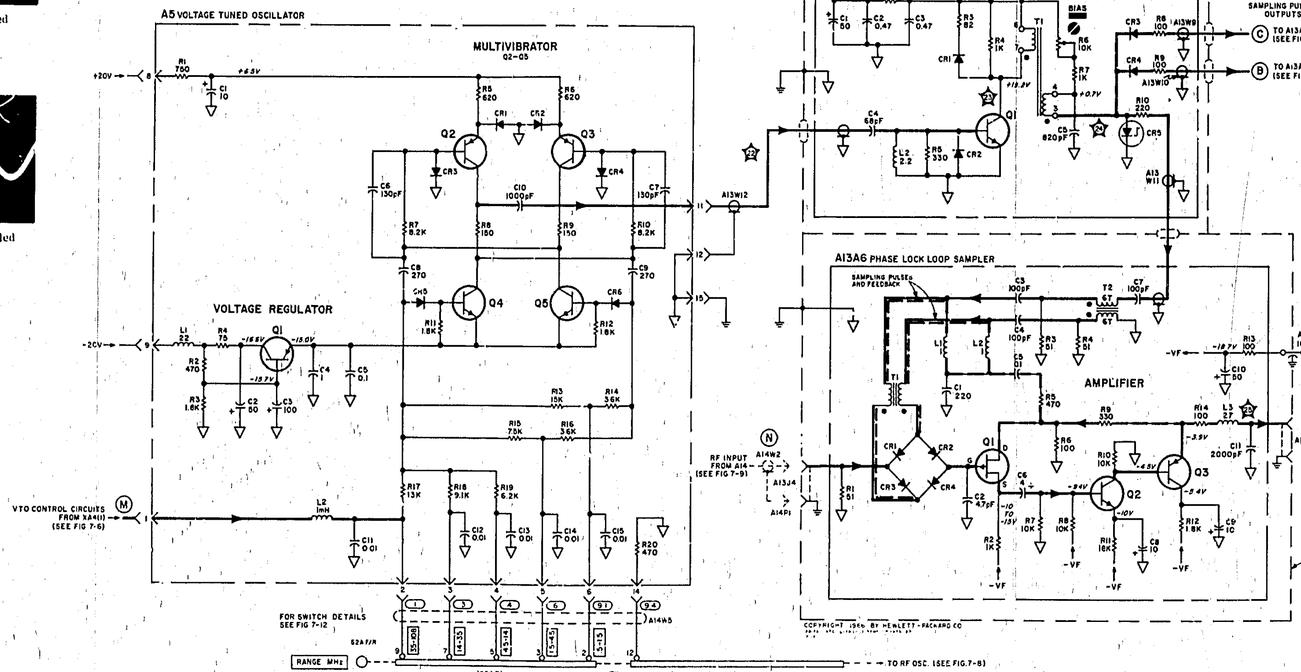
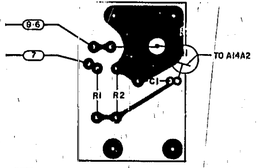
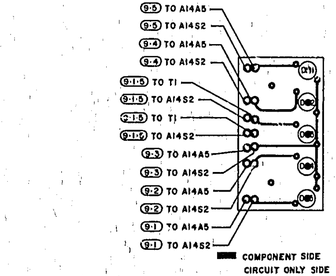


Figure 7-7
VTO-LOCK LOOP SAMPLER CKTS.

7-15/7-16



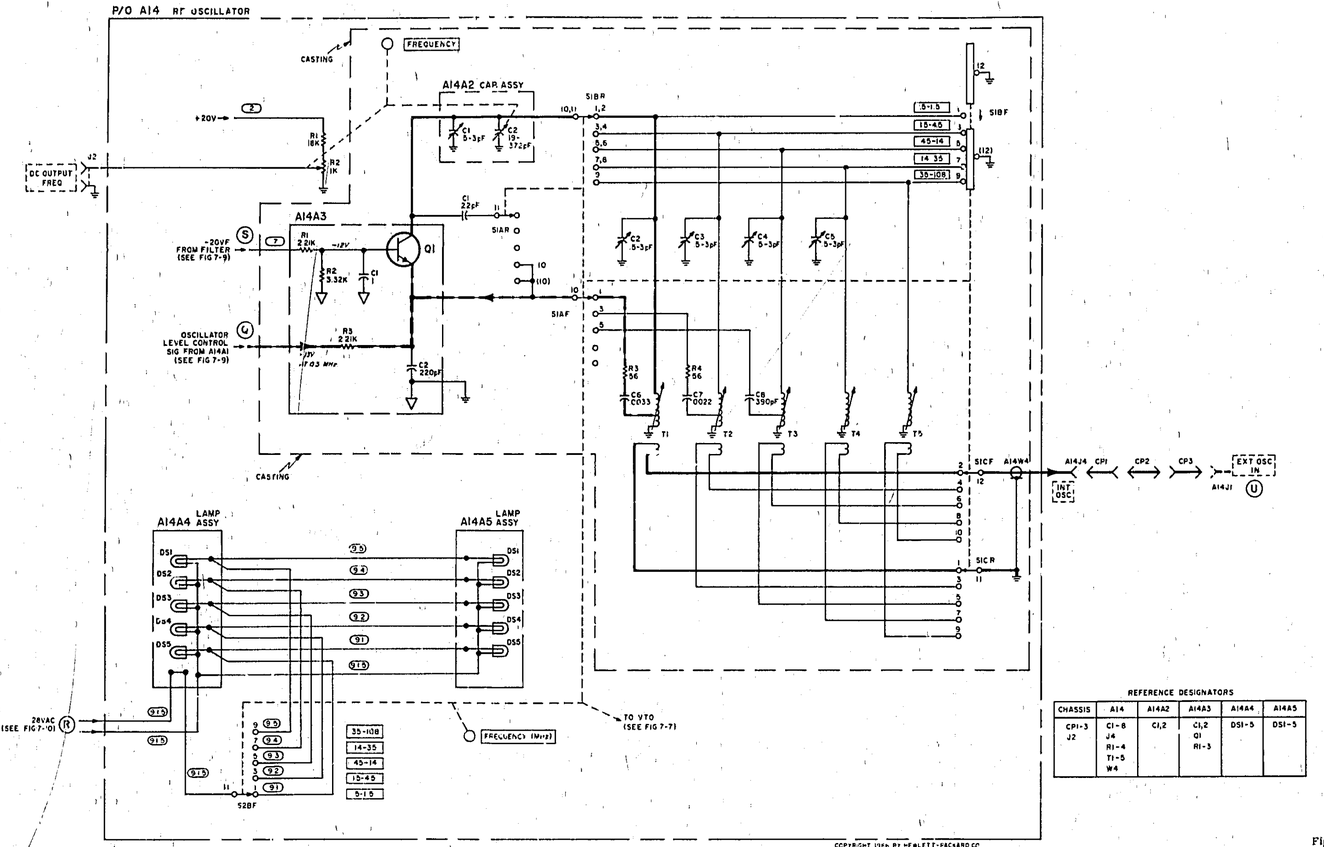
A14A3



A14A4
A14A5

SEMICONDUCTOR REFERENCE

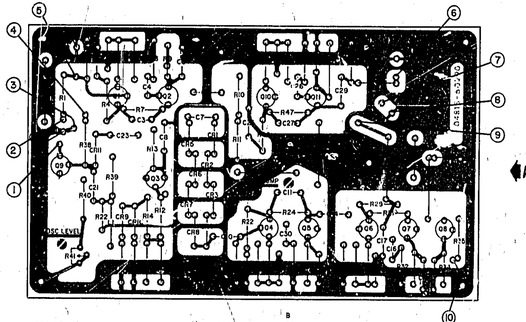
Assy	Ref. Des.	-hp- Stock No.	JEDEC (if any)
A14A3	Q1	1854-0092	2N3563



REFERENCE DESIGNATORS

CHASSIS	A14	A14A2	A14A3	A14A4	A14A5
CP1-3 J2	C1-8 J4 R1-4 T1-5 W4	C1,2	C1,2 Q1 R1-3	DS1-5	DS1-5

Figure 7-8
RF OSC

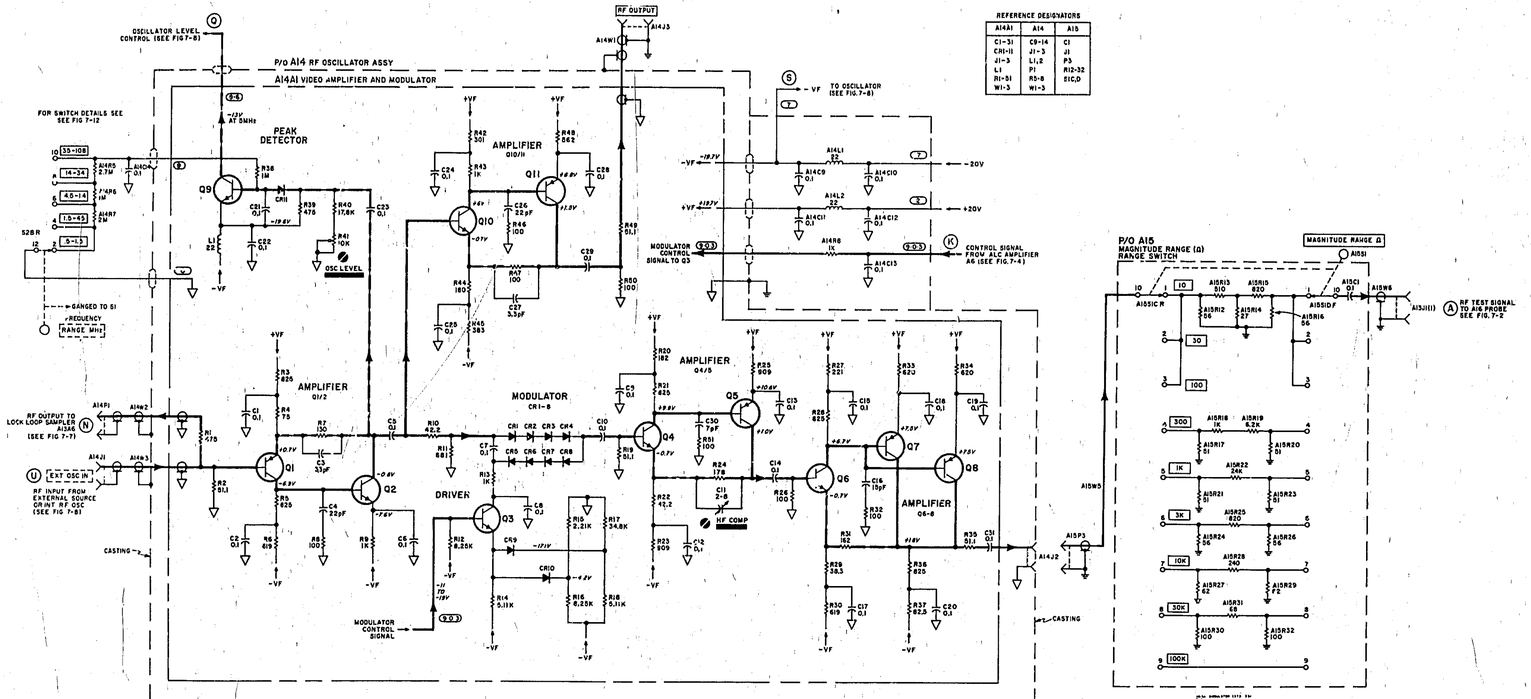


Connections, A14A1 Video Amplifier and Modulator

Connection Number	Code	Connection
1	white - blue wire	oscillator level control signal to RF Oscillator
2	Coaxial cable A14W2	RF output to lock loop sampler A13A6
3	black wire	ground wire to S2 BR (1)
4	white - black - blue (9-1-6 wire)	to S2 BR (1)
5	Coaxial cable A14W3	RF input from A14J1 EXT OSC IN
6	Coaxial cable A14W1	to RF output jack (front panel), A14J3
7	red wire	+ VF from filter in adjacent compartment
8	black wire	chassis grd. from solder lug in adjacent compartment
9	violet wire	−VF from filter in adjacent
10	C31 (0.01 μF ceramic)	to A14J1

SEMICONDUCTOR REFERENCE

Assy	Ref. Des.	-hp- Stock No.	JEDEC (If any)
A14A1	CR1-8	1901-0179	
	CR9, 10	1901-0040	
	CR11	1901-0179	
	Q1	1853-0015	2N3640
	Q2	1854-0092	2N3563
	Q3	1854-0071	2N3391
	Q4	1854-0092	2N3563
	Q5	1853-0015	2N3640
	Q6	1854-0092	2N3563
	Q7, 8	1853-0015	2N3640
	Q9	1854-0071	2N3391
	Q10	1854-0092	2N3563
	Q11	1853-0015	2N3640

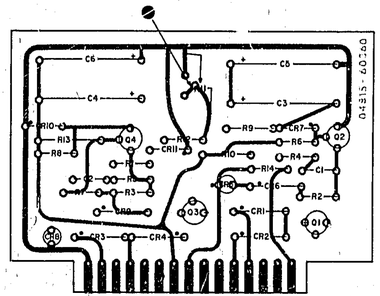


REFERENCE DESIGNATORS

A14A1	A14	A15
C1-31	C9-14	C1
CR1-11	J1-3	J1
J1-3	L1,2	P3
L1	P1	R12-32
R1-51	R5-8	S1C,D
W1-3	W1-3	

Figure 7-9
MODULATOR CKTS.

7-19/7-20

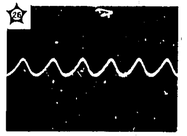


COMPONENT SIDE
CIRCUIT ONLY SIDE

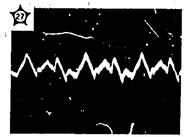
TRANSISTOR CONNECTIONS (TOP VIEW)

A1

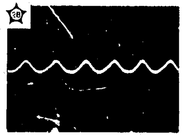
WAVEFORMS



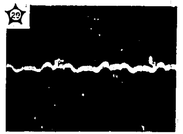
Vert: 10 mV/cm, ac coupled
Sweep: 5 ms/cm
Sync: Line



Vert: 0.2 mV/cm, ac coupled
Sweep: 5 ms/cm
Sync: Line



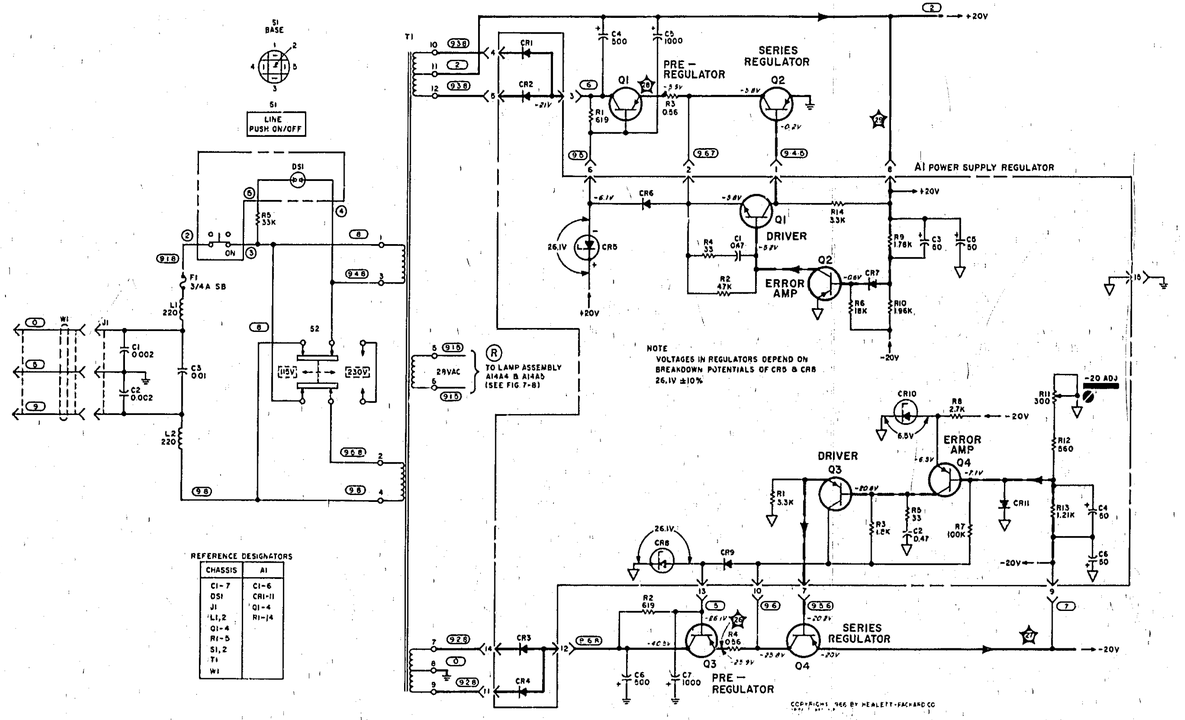
Vert: 10 mV/cm, ac coupled
Sweep: 5 ms/cm
Sync: Line



Vert: 0.2 mV/cm, ac coupled
Sweep: 5 ms/cm
Sync: Line

SEMICONDUCTOR REFERENCE

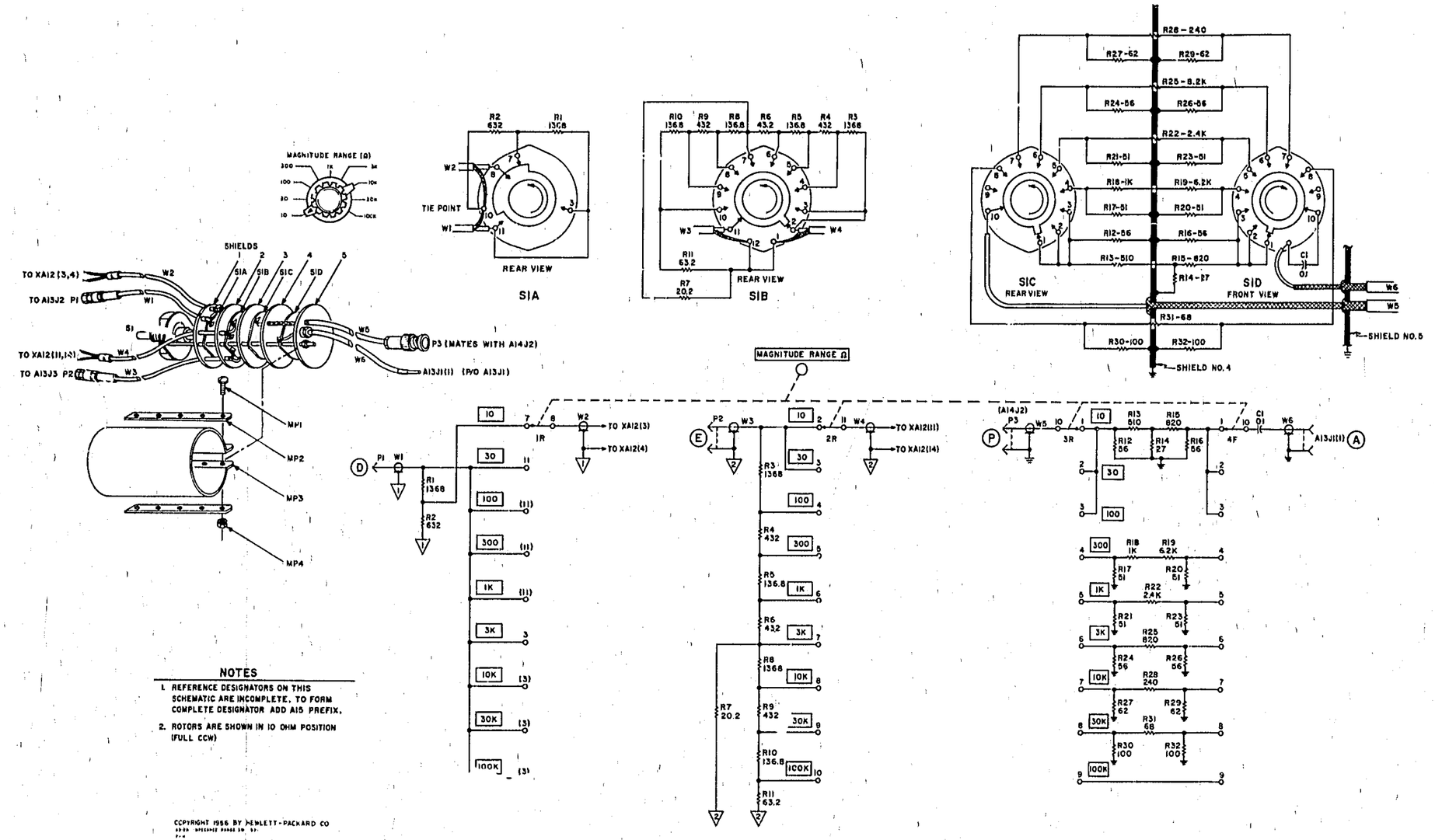
Assy	Ref. Des.	-hp- Stock No.	JEDEC (If any)
Chassis	Q1-4	1850-0038	2N301
A1	CR1-4	1901-0028	
	CR5	1902-0228	
	CR6	1901-0028	
	CR7	1901-0040	
	CR8	1901-0228	
	CR9	1901-0028	
	CR10	1902-0057	
	CR11	1901-0040	
	Q1	1854-0071	2N3391
	Q2-4	1853-0016	2N3638



REFERENCE DESIGNATORS

CHASSIS	A1
C1-7	C1-6
DS1	CR1-11
J1	Q1-4
L1,2	R1-14
Q1-4	
R1-5	
S1,2	
T1	
W1	

Figure 7-10
POWER SUPPLY



NOTES

1. REFERENCE DESIGNATORS ON THIS SCHEMATIC ARE INCOMPLETE. TO FORM COMPLETE DESIGNATOR ADD A15 PREFIX.
2. ROTORS ARE SHOWN IN 10 OHM POSITION (FULL CCW)

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Figure 7-11
IMPEDANCE RANGE SWITCH

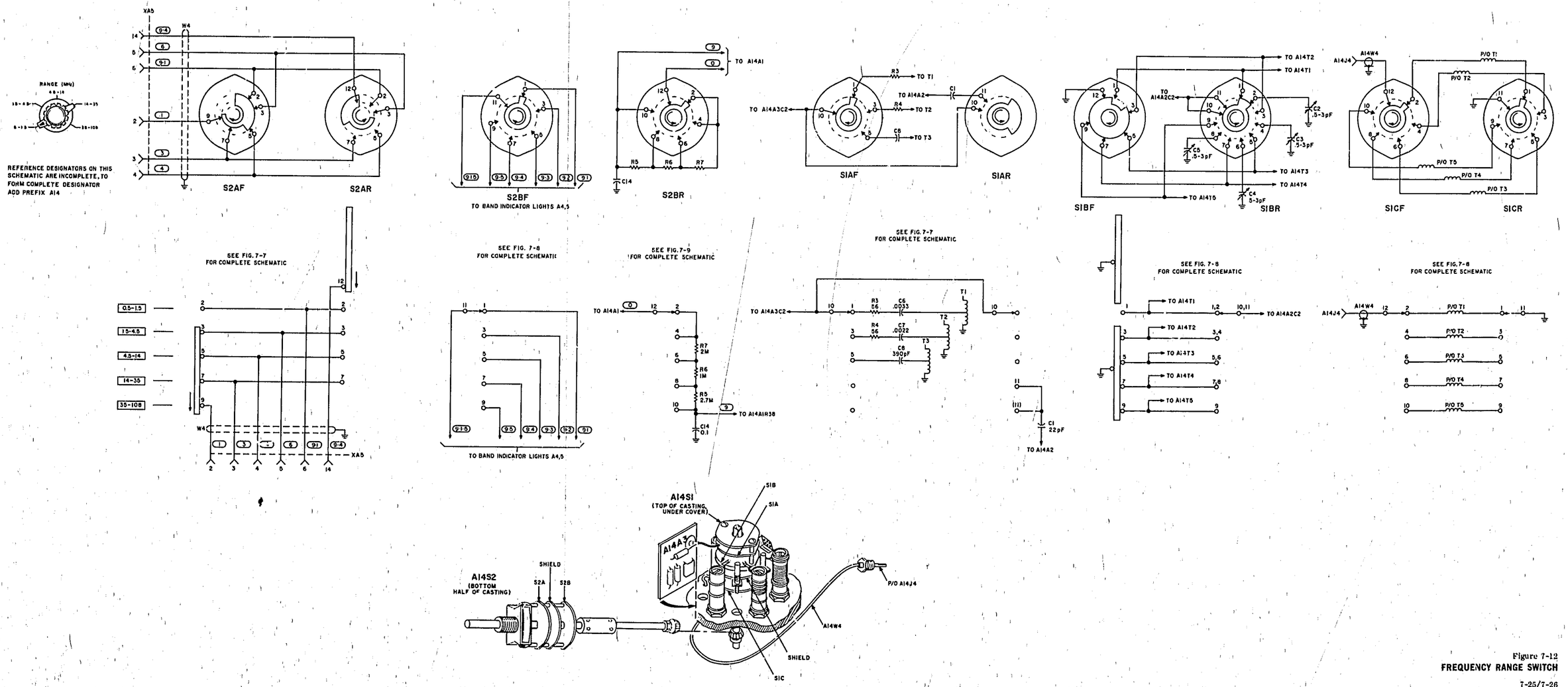


Figure 7-12
FREQUENCY RANGE SWITCH

7-25/7-26

MANUAL CHANGES

MANUAL CHANGES
RF VECTOR IMPEDANCE METER
Model 4815A
Manual HP Part No. 04815-90011

Make all corrections in the manual according to errata below, then check the following table for your power supply serial number and enter any listed change(s) in the manual.

SERIAL	MAKE CHANGES
631-00106, -00110, -00111, -00115	1
652	1
701	1, 2
717	1 thru 4
723	1 thru 5
734	1 thru 6
742	1 thru 7
801	1 thru 8
812	1 thru 9
840	1 thru 10
850	1 thru 11
910	1 thru 12
914	1 thru 13
927	1 thru 14
1038	1 thru 15
1130	1 thru 16

SERIAL		MAKE CHANGES
Prefix	Number	
1205A	01876-02120	1 thru 17
1205A	02121-02435	1 thru 18
1205A	02436 02610	1 thru 19
1205A	02611-02910	1 thru 20
1602A	02911-02940	1 thru 21
1606A	02941-03150	1 thru 22
1639A	03151-03270	1 thru 23
1709A	03271-03480	1 thru 24
1805A	03481-03510	1 thru 25
1810A	03511 - 03860	1 thru 26
1902A	03861-4250	1 thru 27
2005A	4251-4380	1 thru 28
2041A	04381-4480	1 thru 29
2107A	4480-up	1 thru 30

ERRATA:

Figure 7-8: Value of A14A3C7 should be 0.1 (0.1μF).
Figure 7-3: A12Q4 collector voltage should be 5.1V.
Figure 7-4: A6 component identification (9) should be (7).
Figure 6-12: GE manufactured device shown. Lead configuration differs with manufacturer. Refer to manufacturers case outline drawings.
Table 6-1, Page 6-15: Reverse description of A14S1 and A14S2.
Table 5-3: Under IMPEDANCE AND PHASE ACCURACY, step f, last sentence to read: "Adjust trimmer for OHMS Meter reading of 0.95 on X1K range (95% of F. S.)". Under PHASE ANGLE CALIBRATION, step d, add: FREQUENCY (MHz) –0.6.
Page 3-5: Add Part No. of slide rule calculator (P/N 5952-2516) to paragraph 3-26.
Pagagraph 5-25: Change sentence to read: A12R3 controls voltage channel gain.
Paragraph 5-39: Change b1 to read: should indicate approximately 1000Ω ∠0°.
Table 6-1, Page 6-6: Change Part No. of A5L2 from 9140-0239 to 9100-1798.

CHANGE 1:

Figure 7-8: Delete A14A2C1 from A14A2. Add A14C15 in parallel with A14C1.
Table 6-1, Page 6-15: Add A14C15, 0132-0003, C: var, 0.7 - 3pF.

Figure 5-1, 5-8: Delete location information for A14A2C1. Add location information for A14C15 as shown in following figure.

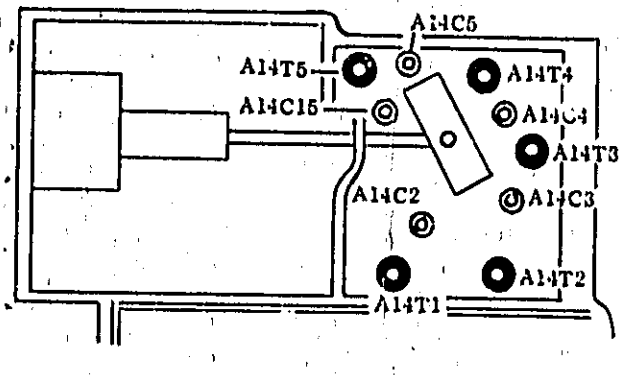


Table 1-1: Change RF Monitor output from 150mV min to 100mV minimum.
Table 5-3: Part 1 (FREQUENCY) step f change to read: RF Millivoltmeter should read more than 100mV over range - - - .
Paragraph 5-22d: Change A14A2C1 to A14C15.

CHANGE 2:

Table 6-1, Figure 7-10: Change Stock No. of Q1-Q4 from 1850-0038 to 1850-0098. Delete 2N301 from description.

CHANGE 3:

Table 6-1, Page 6-13: Add A13A1C11, C: fxd, cer, 0.1μF, –20 + 80%, 50 vdcw, Stock No. 0160-0121.
Figure 7-2: Add A13A1C11 from base of A13A1Q1 to common. Add A13A2C11 from base of A13A2Q1 to common.

CHANGE 4:

Paragraph 1-13: Add sentence: "Additional pin receptacles (HP Part No. 1250-0928) are provided for this adapter".
Paragraph 1-15: Delete last sentence and replace with: "The threaded end of the center pin is tightened in the probe tip using the (HP Part No. 8710-0906) Hex-Nut Driver. CAUTION: Do not overtighten the center pins".
Figure 1-2: Change Stock No. of Probe Center Pin from 04815-20010 to 04815-20770. Add: Stock No. 1250-0928 Pin Receptacle. Add: Stock No. 8710-0906 1/8 Hex-Nut Driver.
Table 6-1, Pages 6-16, 6-22: Change Stock No. 0362-0007 to 0362-0026, crimp sleeve.
Table 6-1, Page 6-20: Change item Ref. No. 41 from Stock No. 0510-0054 to 0510-0005, Tru-arc, .250 dia. Page 6-23 delete Stock No. 0362-0021, Uniring (red).

CHANGE 5:

Figure 7-7: Change A13A6C11 from 2000pF to 0.01μF.
Table 6-1, Page 6-14: Delete A13A6C11. Add: A13A6C11 0160-0093, C: fxd, cer, 0.01μF, –20% + 80% 100 vdcw.
Figure 7-2: Replace A13A1R7 with jumper; replace A13A2R7 with jumper.
Table 6-1, Page 6-13: Delete A13A1R7.

CHANGE 6:

Table 6-1: Change Stock No. of L1, 2 from 9140-0174 to 9100-2503.

ERRATA:

Table 6-1: Change Stock No. of A13A6CR1 and A13A6CR3 from 1901-0040 to 1901-0179.

CHANGE 7:

Table 6-1: Change Stock No. of A14A1Q1, A14A1Q5, and A14A1Q11 from 1853-0015 to 1853-0034. Delete JEDEC No. 2N3640 in description column for above transistors.
Figure 7-9: In Semiconductor Reference Table, change Stock No. of Q1, Q5, and Q11 from 1853-0015 to 1853-0034. Delete JEDEC No. 2N3640 for above transistors.

ERRATA:

Table 6-1, Page 6-19: Add the following to Probe Check: 2190-0883 Washer, flat, Bakelite.

CHANGE 8:

Table 6-1, Page 6-7: Delete: A6R12, A6R13, A6R14, and A6CR4. Add: A6R27 0757-0976 R: fxd, met film, 150K ohms, 2%, 1/8W. Change: A6Q4 from 1854-0071 Transistor NPN, Si. 2N3391 to 1855-0062 Transistor, field effect, N channel, type A.
Figure 7-4: Delete A6Q4 stage and A6 circuit board layout, and substitute attached changes. Q4 stage may be pasted directly over original schematic.

CHANGE 9:

Table 6-1, Page 6-14: Change the following.
a. A13A3CR5 from 1901-0055 to 1901-0331 Diode, step recovery.
b. A13A3R1 from 0757-C900 to 0757-0893 R: fxd, met ox 51Ω, 2% 1/4W.
c. A13A3R6 from 2100-0092 to 2100-0765 R: var ww 1kΩ 5% 1W
d. A13A3R7 from 0757-0924 to 0760-0008 R: fxd met film 470Ω 5% 1W
e. A13A3T1 from 04815-66001 to 04815-80010.
f. Delete A13A3XT1 1200-0083 Socket, minature 7 pin.

Figure 7-7: Change A13A3R1 from 100Ω to 51Ω; A13A3R6 from 10kΩ to 1kΩ; A13A3R7 from 1kΩto 470Ω.

CHANGE 10:

Table 6-1, Page 6-13: Change the following:

a. A13A1C3 from 0160-0298 to 0160-0155 Cap Fxd 3300pF.
b. A13A1R7 from 0757-0192 to 0757-0407, Res Fxd 200 ohm.
c. A13A1R19, 20 from 0757-0123 to 0757-0957, Res. Fxd, 24.0k ohms

Figure 7-2, Page 7-5/7-6: Change the following:
a. A13A1C3 and A13A2C3 to 3300pF.
b. A13A1R7 and A13A2R7 to 200 ohms.
c. A13A1R19, 20 and A13A2R19, 20 to 24.0k ohms.

CHANGE 11:

Figure 7-6, Page 7-13: Change A2CR3 from 10V to 20V.
Table 6-1, Page 6-3; Change A2CR3 to Stock No. 1902-0182, Diode, Si, Breakdown, 20.5V. 400mW.

CHANGE 12:

Page 7-17/18, Figure 7-8: Add to the schematic A14A2C3 a 1pF capacitor in parallel with A14A2C2. NOTE: This capacitor was added to correct for a slight decrease in

circuit capacitance as a result of casting changes. Field repairs within Capacitor Assembly A14A2 are not recommended, and the above addition is a schematic change only.

CHANGE 13:

Page 6-3, Table 6-1: Change Stock No. and Description of A1Q2-4 to read: 1853-0099 Transistor, PNP, Si.
Page 6-6, Table 6-1: Change Stock No. and Description of A5Q1-3 to read: 1853-0099 Transistor, PNP, Si.
Page 7-15/16, Figure 7-7: Change the Semiconductor reference for A5Q1-3 to show Stock No. 1853-0099 and delete the JEDEC number.
Page 7-21/22, Figure 7-10: Change the Semiconductor reference for A1Q2-4 to show Stock No. 1853-0099 and delete the JEDEC number.

CHANGE 14:

Page 5-11, Paragraph 5-21: Add the following steps to the Modulator Adjustment Procedure:
i. Reset 4815A frequency to 108MHz.
j. Adjust HF GAIN ADJ A14A1C3 for 95mV rms across A14A1R2.
Page 6-16, Table 6-1: Change Stock No. and Description of A14A1C3 to read: 0121-0448 C: var cer, 2.5-6pF, 63vdcw NO33.
Page 7-3 (Block Diagram): Add screwdriver adjustment HF GAIN ADJ to Buffer amplifier A14A1Q1/Q2.
Page 7-19/20, Figure 7-9: Show A14A1C3 as variable capacitor 2.5 to 6.0pF. Label it HF GAIN ADJ.

CHANGE 15:

Page 6-2, Table 6-1: Change Stock No. of J1 to 1251-2357. Change Stock No. of S2 to 3101-1234. Change Stock No. of S1 to 3101-1390. Change Stock No. and Description of C1, C2 to read: 0160-2108 C, fxd, disc cer. 0.002μF 250Vac.
Change Stock No. and Description of C3 to read: 0150-0123 C, fxd disc, cer. 0.01μF 250Vac.
Change Stock No. and Description of W1 to read: 8120-1348 W, Cable Assembly.
NOTE: Change 15 makes this model conform to I. E. C. safety requirements for power wiring.

CHANGE 16:

Page 6-6, Table 6-1: Change Stock No. of A5Q2, Q3, to 1853-0016.
Page 6-8, Table 6-1: Change Stock No. of A7L1, L2 to 9100-1642.
Page 6-9, Table 6-1: Change Stock No. of A9L1 to 9100-1670.

CHANGE 17:

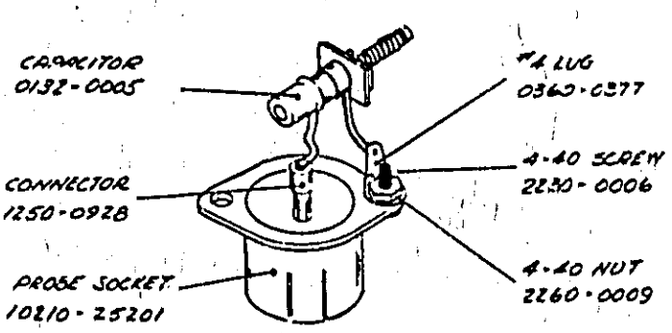
The standard colors for this instrument are now mint gray (for front surfaces) and olive gray (for all other external surfaces). Option X95 designates use of the former color scheme of light gray and blue gray. Option A85 designates use of light gray for front surfaces with olive gray used for all other external surfaces. New part numbers are shown on Page 5.

CHANGE 18:

Add to the reference designation index under A14— RF Oscillator Assembly on Page 6-15, a new resistor, A14R9, HP Part No. 0686-7505, 75Ω, 5%, 1/2W, quantity 1; and one two-lug terminal strip, HP Part No. 0360-0417. On Figure 7-8 of the schematic, A14R9 is connected in series with the wire connected from terminal 11 of oscillator range switch A14S2 to lamp assembly board A14A4.

ERRATA:

Substitute the test fixture illustrated below for the one shown in Figure 5-3 on Page 5-5. The substitute test fixture is composed of probe socket 10210-25201 from Accessory Kit 00600A and the additional parts shown below.



ERRATA:

Change the part number of A15C1 in the Impedance Range Switch Assembly and of A14C14 in the RF Oscillator Assembly to 0160-0168.

Make the following corrections to the Figure 7-3 portion of the Figure 7-1 block diagram on Page 7-3:
Change the designation of "Preamplifier A12 Q3/Q4" to "Preamplifier A12 Q1/Q2" and vice versa.
Delete the gain control from the current channel preamplifier and add one to the Q1/Q2 voltage channel preamplifier at the top of the page.
Change the output connector pin number of the Q3/Q4 current channel preamplifier from 11 to 1.

On Page 6-12, Table 6-1: Change the part number of A13L3-L7 to 9170-0894.

The part number of the 10206A probe adapter described in Paragraph 1-10 and shown in Figure 1-2 has been changed from 10206-23201 to 04815-20811.

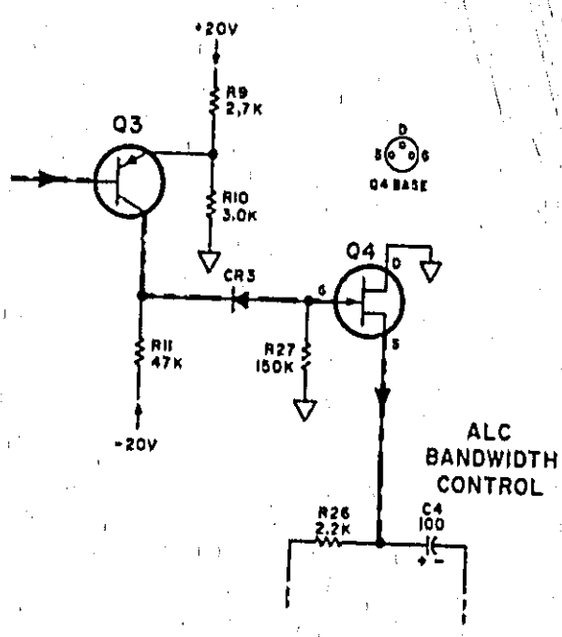
On Page 6-19: Change the part number of the plug-in extender board to 5060-2693.

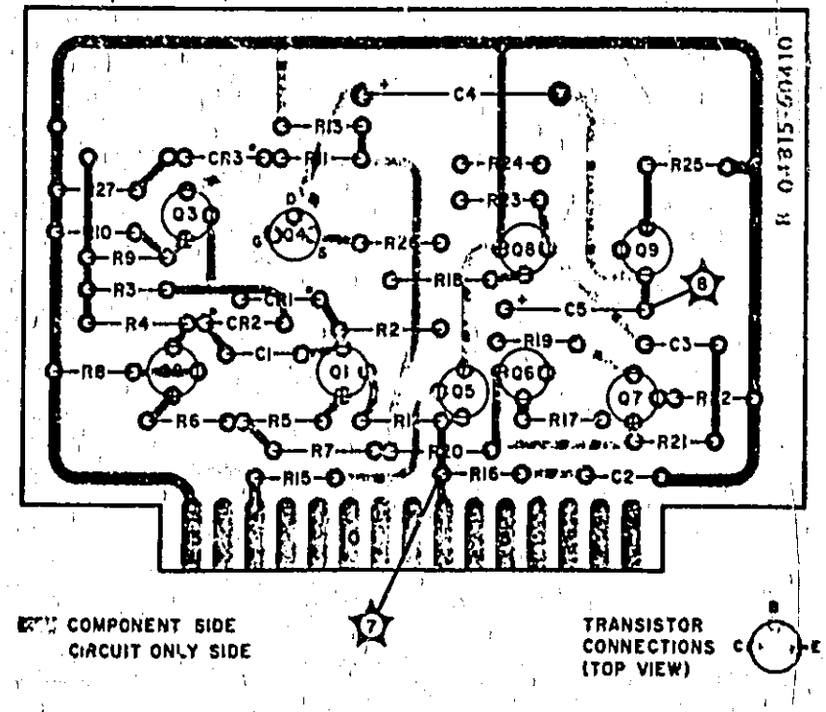
CHANGE 19:

To Table 6-1 on Page 6-4, add capacitor A3C12, 0.02μF, 100V, 0160-0818. Also add this capacitor to the schematic; it is connected in parallel with A3CR9 in the regenerative switch circuit on Figure 7-6.

CHANGE 20:

To Table 6-1 on Page 6-19, add resistor A15R34, 62kΩ, 5% 1/2W, 0686-6235. On Figure 7-3 of the schematic, A15R34 is connected across A15R3 in the magnitude range switch assembly.





Model 4815A serials prefixed 801 and above
A6 ALC Amplifier and Bandwidth Control
Revised Schematic and Component Locator

DESCRIPTION	HP PART NUMBER		
	Standard	Option A85	Option X95
Cover, Top	5060-8589	5060-8589	
Cover, Bottom	5060-8713	5060-8713	
Cover, Side	5000-8717	5000-8717	
Retainer	5060-8735	5060-8735	Refer to Manual Parts List
Rack Mount	5060-8741	5060-0776	
Front Panel (lower)	04815-00324	04815-00030	
Front Panel (upper)	04815-00323	04815-00180	

CHANGE 21:

The following changes eliminate all germanium transistors from the ±20V power supply and replace them with silicon transistors.

In Table 6-1, under Chassis Components on page 6-2, add diodes CR1 and CR2, qty. 2, HP Part No. 1901-0327.

On Power Supply schematic, Figure 7-10, (page 7-21/7-22), connect CR1 and CR2 as follows:

CR1: Connect CR1 cathode to Q2 emitter and CR1 anode to Q2 base.

CR2: Connect CR2 cathode to Q4 emitter and CR2 anode to Q4 base.

In Table 6-1, under Chassis Components on page 6-2, make the following changes:

Ref. Des.	Stock No.	Description
Q1 through Q4	1853-0059	Si PNP 2N3791
R1, 2	0811-2114	fxd,ww,560Ω,5%,2W
R3, 4	0811-1831	fxd,ww,2Ω,5%,3W

In Table 6-1, under A1 Power Supply Regulator Assy, on page 6-3, make the following changes:

Ref. Des.	Stock No.	Description
A1C1	0160-0127	fxd,cer.,1μF,20%,25V
A1C2	0160-0263	fxd,cer.,0.22μF,20%,50V
A1CR6, CR9	1901-0460	Stabistor, 15V, 150mA
A1R1, R14	0683-5125	fxd, comp,5.1kΩ,5%,1/4W
A1R2	0698-3150	fxd,film,2.37kΩ,1%,1/8W
A1R4,R5	0683-0475	fxd,comp,4.7Ω,5%,1/4W

In Table 6-1, under Miscellaneous Parts on page 6-19, add heat sink (qty. 2), HP Part No. 1205-0030 (associated with breakdown diodes A1CR5 and A1CR8).

CHANGE 22:

In table 6-1, under A1 Power Supply Regulator Assy, add heat dissipators (qty. 2) HP Part No. 1205-0033. The heat dissipators provide better cooling for diodes A1CR5 and A1CR8.

In table 6-1, under A14A1 Video Amplifier and Modulator Assy, add the following:

A14A1C32: capacitor, 27pF, 10%, HP Part No. 0140-0005.

A14A1C33: capacitor, 0.1μF, 50V, HP Part No. 0150-0121.

On Figure 7-9, under A14A1: connect A14A1C32 from emitter of Q4 to ground and connect A14A1C33 from –VF end of A14A1R23 to ground.

ERRATA:

Change the first sentence of paragraph 3-26 to read "As a user convenience a slide rule type Vector Impedance Calculator (5952-2516) has been shipped with the Model 4815A." (Slide rules are not shipped with separate manual orders.)

CHANGE 23:

The prefix number has been changed to 1639A. This is the only change.

CHANGE 24:

On page 6-8 of the parts list and the Figure 7-3 schematic, change A7R21 (in series with –20V input to A7 board) to 909Ω 1% 1/8W, HP Part No. 0757-0422.

ERRATA:

On page 6-8 change the HP Part No. of R18 in the A7 Twin-Tee Amplifier Assembly to 2100-1772. The resistor has not been changed; just its part number has.

In Figure 7-5, and on page 6-10, change the designation of A10C8 to A10C14.

CHANGE 25:

Change capacitors C3, 5, 9, 11, 17-20 in the A13 Sampler Assy. to HP Part No. 0160-4671 on page 6-12.

In Figure 7-7 and Table 6-1, delete capacitor A5C10, HP Part No. 0160-0050. Connect new resistor R21 (10Ω ±5%, 1/4W, HP Part No. 0683-1005) in its place.

In table 6-1 and applicable schematics, make the following changes: change resistors A13A3R4 and R5 to 100Ω, 2%, 1/8W, HP Part No. 0757-0900. Delete resistor A13A3R3, HP Part No. 0757-0898. Inser. jumper (No. 22 wire) in its place. Change diodes A13A3CR1 and CR2 to HP Part No. 1901-0050. Change fuse F1 (Chassis Components) from HP Part No. 2110-0067 to HP Part No. 2110-0044.

CHANGE 26:

The prefix number has been changed to 1810A. This is the only change.

CHANGE 27:

In the replaceable parts list, change the HP Part No. from 1400-0084 to fuseholder body 2100-0564 and fuseholder carrier 2100-0565. Change the HP Part Number for fuseholder nut from 2950-0131 to 2100-0569.

CHANGE 28:

In Table 6-1, page 6-2, delete R5; change HP Part No. of S1 to 3101-2287. In Figure 7-10, page 7-21, change S1 to show two switch sections; one section breaks the ac line between F1 and T1, pin 1 (as shown), the other section breaks the ac line between L2 and T1, pin 4.

The Model 4815A is C.S.A. certified for laboratory equipment.

CHANGE 29:

In the replaceable parts list, page 6-15 add capacitor A14C16 HP Part Number 0160-3872. On the schematic located on pages, 4-17, and 7-17/7-18 insert the capacitor A14C16 so it is in parallel with capacitor A14C5.

In the replaceable parts list, page 6-2 add four Ferrite Beads HP Part Number 9170/0894. On the Schematic diagram located on page 7-21/7-22 indicate Ferrite beads are inserted at the bases of Q1, Q2, Q3, and Q4.

In the replaceable parts list, page 6-2 change the fuse F1 (115V op'n) HP Part Number 2110-0033 to HP Part Number 2110-0063.

CHANGE 30:

Delete from the parts list and the Schematic capacitor A14C16, added by Change 29.

▶ ERRATA:

Add the following to paragraphs 1-9 and 2-19:

"Rack Mounting Kit, HP P/N 5060-0776, is no longer a furnished accessory, but is still available as option 908."

On page 1-2, change the part numbers for the probe accessories as follows:

Component Mounting Adaptor	00600-60001
Probe Ground Assembly	5060-0418
Probe to BNC Adaptor	10207-60001
Probe Adaptor	04815-20801
Probe Center Pins	04815-20770
Probe Socket	10210-25201

3/1/82