OM2091-09007-00

Range Booster Amplifier
AM-4477

Operator and Organizational Maintenance Manual Including Repair Parts

June 1976

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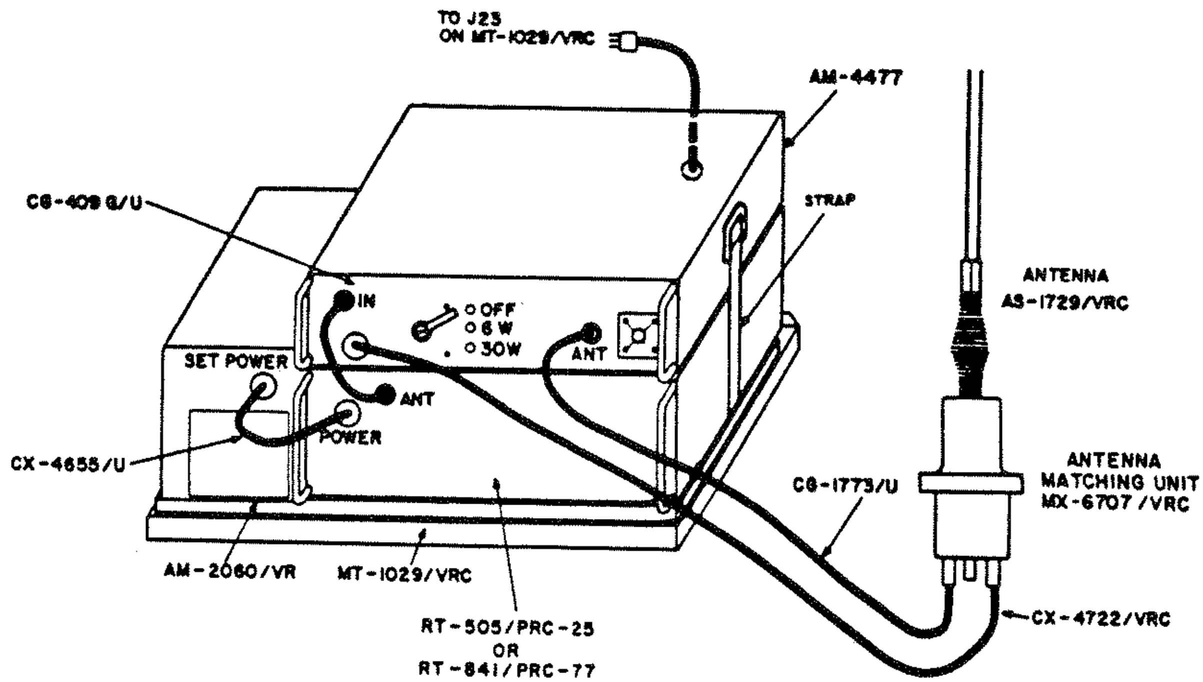


Figure 2–1. Interconnection Diagram

2-2 MANPACK INSTALLATION. – The manpack configuration consists of receiver-transmitter (RT-841/PRC-77 or RT-505/PRC-25), antenna AT-892/PRC-25 or AT-271A/PRC and Range Booster AM-4477. To prepare the system for operation, proceed as follows:

(a) Install batteries into the AM-4477 and receiver-transmitter battery boxes as required.

(b) Mount the AM-4477 on top of the receiver-transmitter as described in Paragraph 2-1a.

(c) Connect RF cable assembly CG-409 G/U between the IN connector of the AM-4477 and the ANT connector of the receiver-transmitter ANT jack.

(d) Install an appropriate whip antenna into AM-4477 antenna mount.

2-3 OPERATING INSTRUCTIONS

(a) CONTROLS AND CONNECTORS. – All controls and connectors are as listed in Table 2-1 and are shown in Figure 2-2.

Table 2-1. Range Booster AM-4477 Controls and Connectors

Control or Connector	Switch Position	Function
Function Switch		
	OFF	Turns off power
	6 W	Selects 6 watt power level
	30 W	Selects 30 watt power level
IN Connector		Input connection for RF drive signal.
ANT Connector		Output connector for a nominal 50-ohm vehicular antenna.
Multipin Connector		Connection for control voltages to vehicular antenna matching unit through cable assembly CX-4722/VRC.
Antenna mount		Base for 3 or 10 foot whip antenna.
Battery plug (in rear of unit)		Connection for 24 V dc battery.

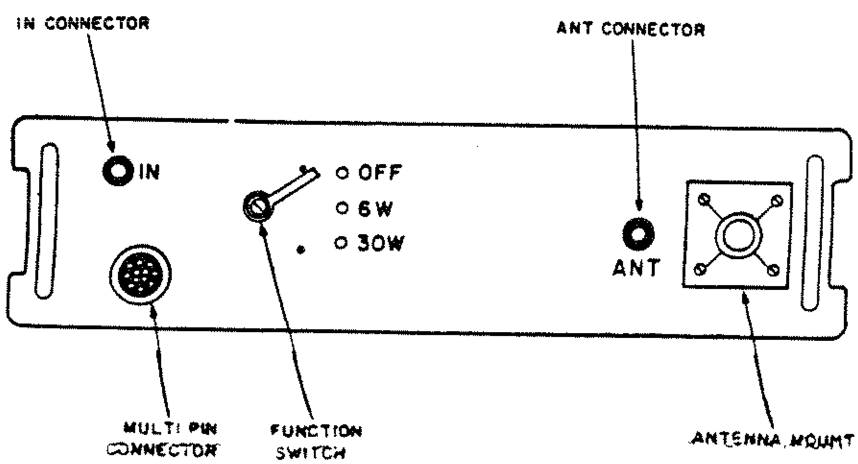


Figure 2–2. Front Panel Controls and Connectors

(b) OPERATION. (for all configurations)

(1) **Receiver-Transmitter.** – See Operator's Manual TM 11-5820-498-10 for Radio Set AN/VRC-53.

(2) **Amplifier – Power Supply.** (for vehicular configuration) – See Operator's Manual TM 11-5820-498-10 for Radio Set AN/VRC-53. Note that ANT. FREQ CONTROL has no effect upon operation and is not used with the AM-4477.

(3) **Range Booster AM-4477.**

(a) Set function switch to 6W or 30W position, depending upon transmitted power desired. The AM-4477 does not draw current until the push-to-talk switch is activated and the receiver-transmitter is in the transmit condition.

(b) With the function switch in the OFF position, the AM-4477 is bypassed. RF power from the receiver-transmitter enters and leaves the AM-4477 without amplification. In this situation, however, the control cable connected to multi-pin connector on the AM-4477 front panel must be transferred to ANTENNA CONTROL at rear of the AM-2060/VR and the ANT. FREQ CONTROL connector positioned as required.

CHAPTER 3

THEORY OF OPERATION

3-1 BLOCK DIAGRAM ANALYSIS. – The The AM-4477 is divided into the four basic functional sections described below as shown in the block diagram of figure 3-1.

(a) **T/R and Relay Assembly.** – This section consists of a transmit/receive unit and two transmit/receive relays. The radio set antenna connector is connected to the IN coaxial connector. In the receive mode direct connection exists through the T/R unit with the receive contacts of the deenergized relays connected to the antenna switch. When a whip antenna is used the antenna switch is activated by a plunger located in the whip antenna mount and connects the whip antennas through the matching switch, to a matching network assembly. When no whip antenna is used, the antenna switch connects the radio set to the ANT coaxial connector. This connector can be terminated with 50 ohms or connected to an external antenna matching unit. During transmission the RF signal energizes the T/R unit and relays connecting the radio set to the Automatic Tuning Detector and Phase Locking units. The antenna is also connected to the antenna filter output. The T/R unit also includes a voltage regulator which supplies a stabilized +17 volts to all circuits, as required, when in the transmit mode of operation.

(b) **Band Selector Assembly.** – This section consists of the ATD (Automatic Tuning Detector) and MD (Motor Driver) units and the stepping motor (SM) assembly with its associated switch sections. The 26-76 MHz frequency range of the AM-4477 is divided into 11 bands (see section 3-2b). The ATD Unit includes a tuned circuit for each band. The voltages developed across these circuits are rectified and directly coupled to a section on the stepping motor shaft. The stepping motor is an electromagnet-activated rotary switch with 11 positions corresponding to the 11 bands. When transmission starts on a new band, the MD Unit energizes the electromagnet of the stepping motor turning the rotary switch until it reaches the correct band position. When the output of the ATD Unit is sufficiently large it cuts off the MD Unit and stops the stepping motor. The stepping motor also rotates the switch sections of the antenna matching network and the antenna filter which select the correct matching circuit and filter for the particular frequency in use.

(c) **Phase Locking Circuit.**

(1) General (Fig. 3-1) – The Phase Locking (PL) circuit consists of a Voltage Controlled Oscillator (VCO) and an Isolation Amplifier (IA). The VCO operates from 26 to 76 MHz and is controlled by a dc voltage. Phase locking is accomplished by comparing the VCO output with the driving signal in the phase detector of the PL circuit. If a phase deviation exists, a dc correction voltage is developed at the input to the VCO. Phase locking is sufficiently fast to follow the frequency modulation of the driving signal, thus the VCO output assumes the same frequency and modulation as the driving signal. The amplified VCO signal produces the output of the AM-4477. The phase locking current prevents spurious frequencies present in the RF driving signal from reaching the AM- 4477 output.

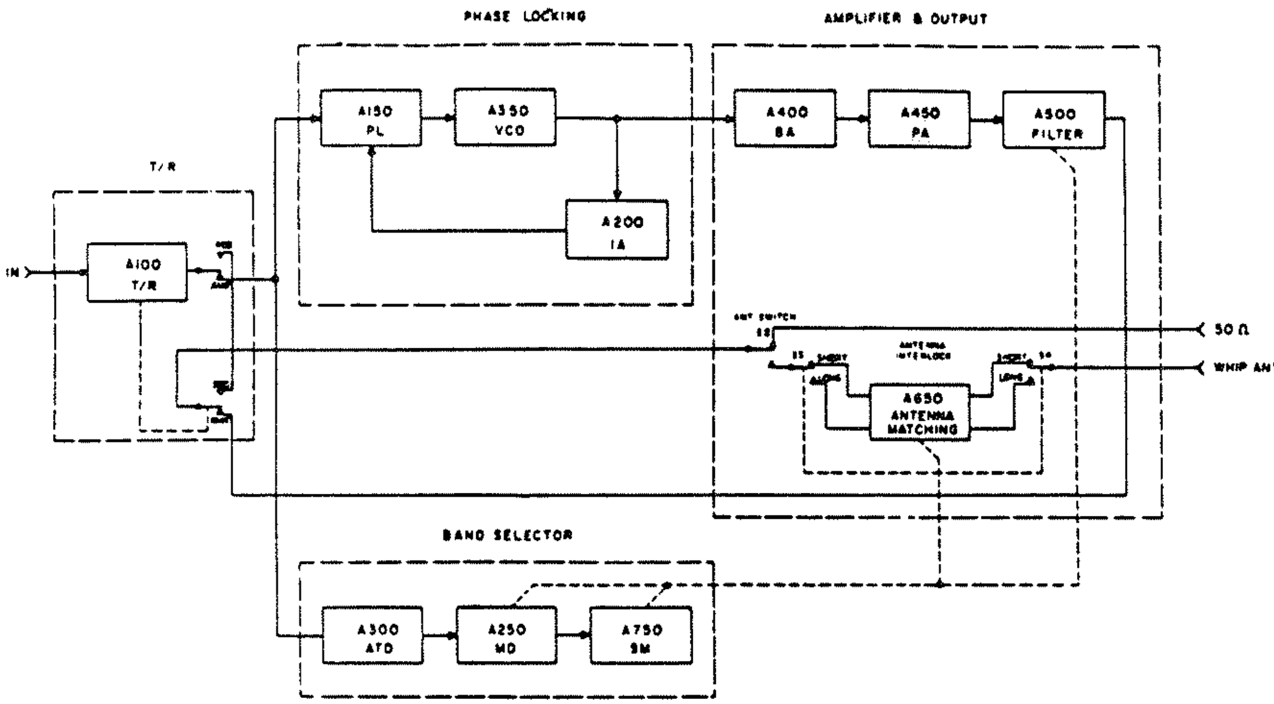


Figure 3–1. Functional Block Diagram

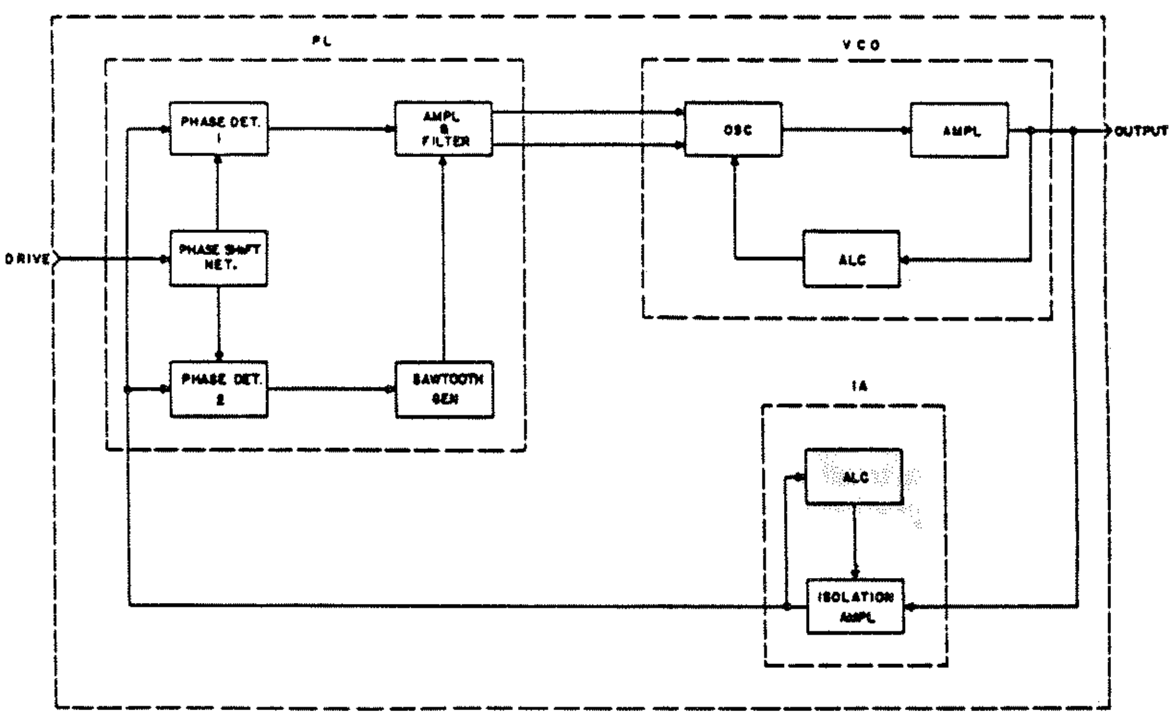


Figure 3–2. Phase Locking System, Block Diagram

For this reason the driving signal is not directly boosted in the broadband amplifier. The IA circuit prevents spurious frequencies, present in the RF driving signal, from reaching the output of the VCO through the feedback path of the VCO to the PL Unit.

(2) Detailed Description. (Fig. 3-2) – The RF signal from the transceiver is fed into a 90° phase shifting network which supplies two voltages 90° out of phase with the phase detectors. The other RF input signal to the two balanced phase detectors comes from the IA unit which amplifies the output signal of the VCO. If the two applied RF signals are of the same frequency the resultant dc voltage varies as the cosine of the phase difference (Fig. 3-9) If the RF signals are of different frequencies the phase detectors produce an ac voltage whose frequency is proportional to the difference between the signals. Phase detector 1 is connected to an amplifier whose dual output signal controls the VCO frequency. The amplifier includes RC loop filter networks. This filter limits amplification over the speech frequency range, yet its phase shift is too small to cause instability in the system. The two control inputs to the VCO vary the oscillator circuit capacitance and self-inductance. The reactance of a capacitive diode is varied by one of the control voltages. The reactance of a ferrite coil is varied by a direct current from an amplifier stage in the VCO circuit which is driven by the second control voltage. By varying both L and C in the oscillator circuit the range of 26 to 76 MHz can be covered without bandswitching. When transmission starts a stabilized voltage is first supplied. A sawtooth generator in the PL current applies a voltage to the VCO input which sweeps the VCO frequency through its entire frequency range of 26 to 76 MHz . When the system is locked to the radio set frequency the dc output from phase detector 1 is nearly zero. The 90° phase-shift network causes phase detector 2 to produce a maximum positive voltage, which disables the sawtooth generator. The sawtooth generator is coupled to the same amplifier which receives the output of phase detector 1. However, phase detector 1 counteracts the sawtooth signal and locks the VCO frequency long enough to permit phase detector 2 to disable the sawtooth generator. The VCO and IA circuits both contain ALC circuits which limit their outputs. This prevents overloading the output stage of the VCO and IA circuits and maintains the sinusoidal shape of the voltages needed for optimal functioning of the phase detectors.

(d) **Amplifier and Output Circuit.** – This section consists of the Broadband Amplifier (BA), the Power Amplifier assembly (PA), antenna filters, antenna matching networks and the antenna switches. The VCO signal is amplified to the 30 watt level in the BA and the PA circuits which consist of untuned broadband amplifiers. The signal is then applied to the antenna filter assembly, where the band selector stepping switch selects one of three low-pass filters used to block harmonic frequencies. The filtered signal passes through the transmit/receive relay to the antenna selector and matching switches in the antenna mount. If a whip antenna is used the signal is applied to the antenna matching network. The stepping switch selects the proper circuits for each band. If a whip antenna is not used the RF signal is applied directly to the ANT connector.

3-2 CIRCUIT ANALYSIS

(a) T/R Unit. (Fig. 3-3) – The T/R unit contains a circuit for energizing the transmit/receive relays and a dc voltage stabilizer. The circuits are incorporated in a two-module plug-in unit.

(1) Relay Circuit. – The circuit consists of transistors Q101, Q102, Q103 and Q104 with their associated components. The input RF radio signal is applied through the IN connector to pin b6. The signal then passes through a dual reflectometer (where it is slightly attenuated) to pin b5 and then to the contacts of transmit/receive relay K1. The reflectometer senses the forward and reflected power from b6 to b5. When b5 is terminated in 50 ohms (voltage standing wave ratio of 1.0) the reflected power will be zero. If b5 terminates in a high impedance, the reflected power will be almost as large as the forward power. Due to circuit losses, however, the reflected power will always be slightly less than the forward power. This difference prevents the relay circuit from being activated by high frequency power picked up by the antenna. Power input to the IN connector develops an RF voltage across diode CR102. The diode rectifies this voltage to a positive voltage which appears on the base of transistor Q102. Power from the antenna will similarly develop a positive voltage on the base of Q101. Transistors Q101 and Q102 form a balanced amplifier. Relays K1 and K2 are energized only when the base of Q102 is more positive than the base of Q101. Transistor Q102 draws collector current when its base becomes positive and the voltage drop across R114 exceeds 0.6 V causing Q103 (and thereby Q104) to draw current. The coils of relays K1 and K2 are connected in the collector circuit of Q104 (from b2 to +24 V) and, therefore, energized. Resistor R115 provides positive feedback across Q103 and Q104 and prevents intermediate voltages between zero and 24 V on the collector of Q104. Diode CR103 clips voltage spikes that may appear across the relay coils when the current is cut off. Diode CR105 prevents transmission in the event of low battery voltage.

(2) Reflectometer. – During transmission, pin b5 terminates in a 50 ohm load, and the transmitter output is connected to pin b6. The voltage on pin b6 is divided by R101, R102, R105 and R107. A fraction of the input voltage appears at the junction of R105 and R107 and is in phase with the input voltage. The load current flows through the primary of T101 which acts as current transformer. A voltage proportional to the current develops across load resistances R108 and R109 connected across the secondary. The voltage across R108 is in phase with the current, whereas the voltage of R109 is 180° out of phase with the current. The values of R105 and R107, as well as the winding ratio of T101, and the resistors across its secondary have been so chosen that, with a 50 ohm load, identical voltages are obtained on R107 and R108. Since there is no phase deviation, no RF voltage appears across diode CR101 and no rectified voltage is produced. This also applies to diode CR102, except that the voltages on R109 and R110 are 180° out of phase. As a result, the RF voltage on CR102 is a maximum and the rectified voltage on the base of Q102 is also a maximum. During reception the received signal is connected to b5 and the load (receiver-transmitter) to b6. The phase of the current through T101 is inverted, whereas the voltage divider phase is unchanged. The detector operation is reversed and the base of Q101 becomes positive.

(3) Voltage Stabilizer. – This circuit consists of transistor Q105 with its associated components. It is powered during transmission and supplies a stabilized +17 V to each unit in the AM-4477. The voltage stabilizer is fed by

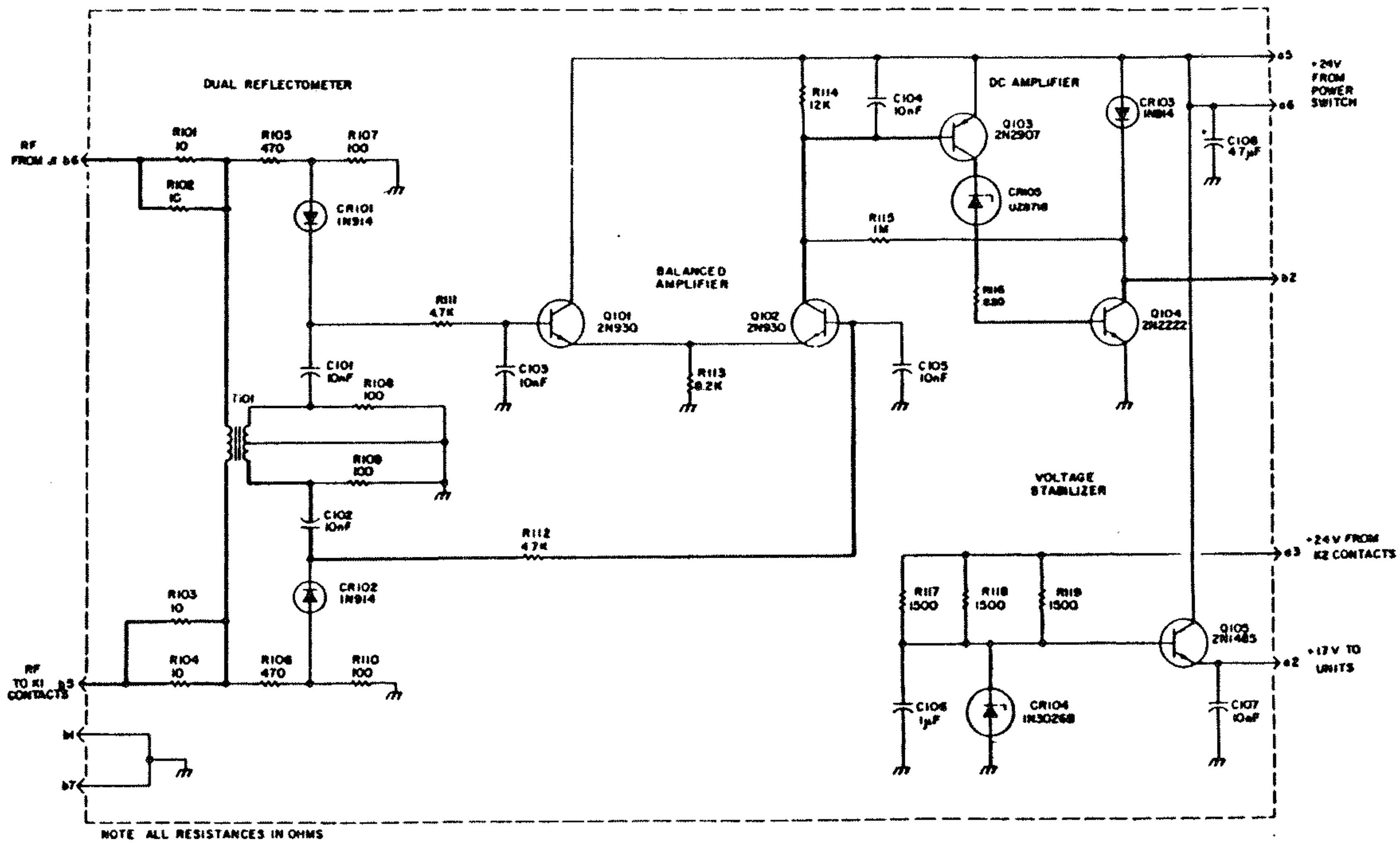


Figure 3–3. Transmit/Receive Unit A100, Schematic Diagram

+24 V through a set of contacts on relay K2. Zener diode CR104 furnishes +18 V to the base of Q105 whereby approximately +17 V is obtained from the emitter of Q105. The resistance in series with CR104 consists of three parallel-connected resistors for power handling. Capacitor C106 decouples CR104 to prevent low frequency noise on the +17 V line. Transistor Q105 is thermally connected to the bottom of the module case to effect good heat dissipation.

(b) **Automatic Tuning Detector.** (Fig. 3–4) – The Automatic Tuning Detector (ATD) circuit forms part of the automatic band selector system. It includes a frequency detecting circuit and diode logic. The circuit is incorporated in a three module plug-in unit.

The nominal frequency ranges for each band are given in Table 3-1. Band division is the same as that used for the antenna matching unit of Antenna AS-1729/VRC or AT-912/VRC, except that a 26 to 30 MHz band has been added,thus changing the number of bands.

Table 3–1 Frequency Band Grouping

Band No.	Frequency Range (MHz)	
	From	To
1	26	30
2	30	33
3	33	37
4	37	42
5	42	47.5
6	47.5	53
7	53	56
8	56	60
9	60	65
10	65	70.5
11	70.5	76

(1) Frequency Detector System. The system consists of 11 tuned circuits. The bandwidth of each circuit is adapted to the particular band it serves. The voltage across each circuit is rectified and directly connected to a switch contact attached to the stepping motor assembly. The switch section controls the band selector system by providing a positive voltage to disable the motor driver (MD) unit when the stepping motor has reached the correct band. All the tuned circuits are connected through resistors to pin a7, into which the RF signal from the radio set is applied when the transmit/receive relay is energized. The RF voltage will develop across the circuit which is in resonance, whereas, the other circuits having a low impednace, will develop low voltage drops across the series resistors only.

(2) Diode Logic Circuit. – The circuit consists of 11 diodes CR302 to CR322, (even numbers only), which connect the rectified dc voltages to a common reference line of 1 V fixed. This causes the line with the highest voltage to lock on to 1.5 V. The "cold" ends of the tuned circuits are commonly connected and decoupled to ground. They are, however, connected through a large resistor (R313) to the +17 V supply. This common line is negative with respect to the reference line, and causes all output lines to be negative except the one corresponding to the band used, which has locked on +1.5 V. When the transmitting frequency is near the limit between two bands the two tuned circuits will develop approximately the same voltage. The stepping motor will then stop at the first band reached. This overlapping range is about 10% above and below the normal bandwidth. The antenna filters and matching circuits will operate properly under this condition.

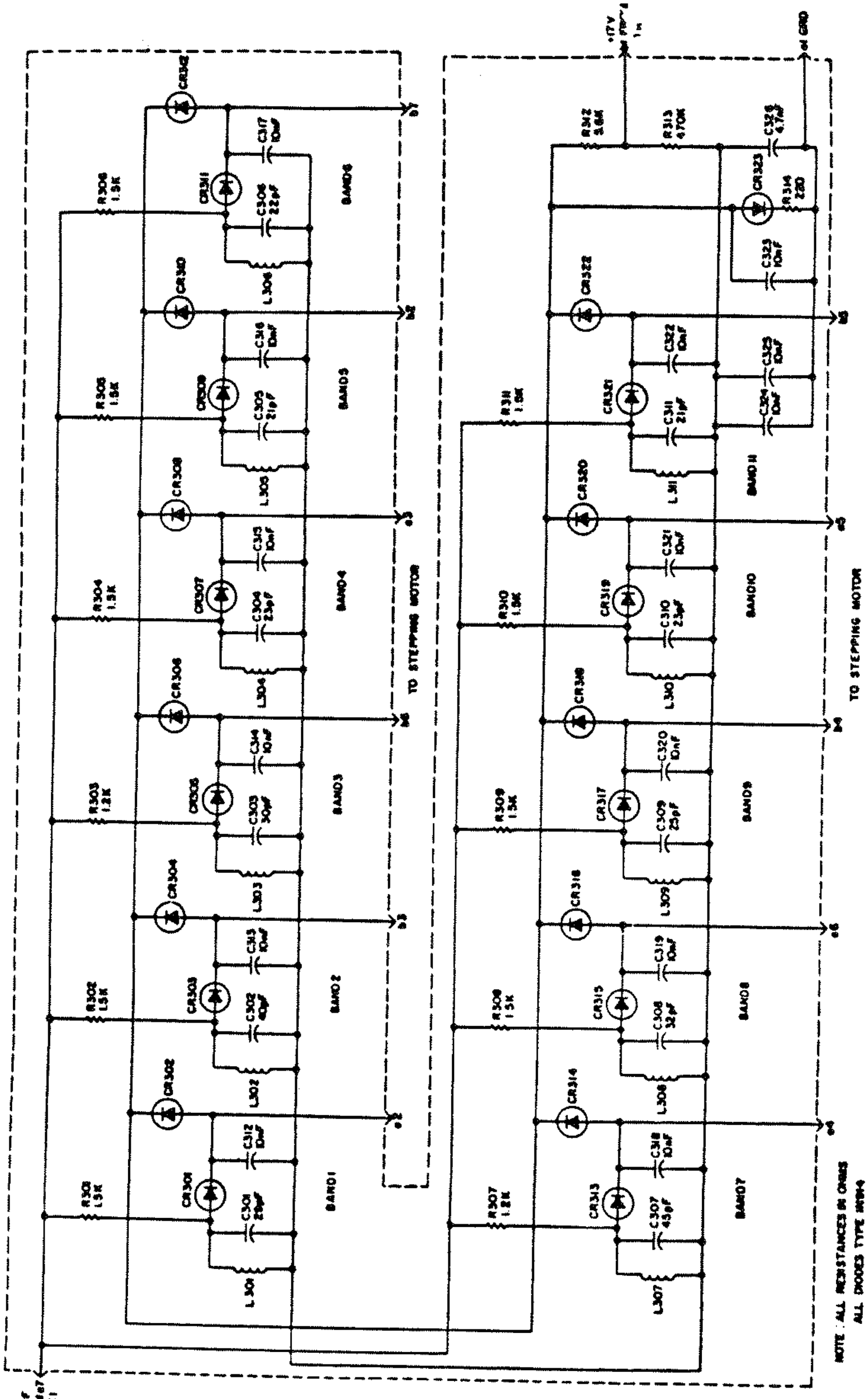


Figure 3–4. Automatic Tuning Detector Unit A300, Schematic Diagram

(c) Motor Drive. (Fig. 3–5) – This circuit is part of the automatic band selector system. It includes a dc amplifier for the stepping motor coil and a circuit for switching off the motor when it reaches the desired band. The circuits are incorporated in a two module plug-in unit.

(1) Direct Current Amplifier. – The circuit consists of transistor amplifiers Q254, Q255 and Q256 with their associated components. The stepping motor coil is connected to the collector circuit of Q256. The stepping motor commutation switch is connected between pins a4 and a3. When the electromagnet armature is not activated, the commutation switch is on. Pin a3 is positive since a4 is connected through Q253 and R253 to the +17 V reference. Similarly the bases of Q254 and Q255 are also positive. When transistor Q255 conducts heavily the base current flowing in Q256 causes the transistor to saturate. When current flows in the electromagnet coil the armature is activated and causes the band selector system to rotate one band forward. When the armature is nearly fully pulled forward the commutation switch opens and switches off the current flowing in the electromagnet through the amplifier. The armature then springs back to its initial position. The change-over shaft then remains stationary, the commutation switch reconnects, and the procedure is then repeated. The band selector switch will continue to rotate until no voltage appears on a4. Diode CR254 and resistor R266 limit the peak voltage on transistor Q256. The voltage on pin a4 is connected to the ALC line through R604 in the chassis assembly and cuts off the broadband amplifier as long as the stepping motor is in operation.

(2) Stopping Circuit. – This circuit consists of transistors Q251, Q252 and Q253 with their associated components. Pin a2 is connected to the rotor situated on the control section of the stepping motor. when the voltage on a2 exceeds +1 V (approximately), diode CR251 starts to conduct and transistor Q251 draws collector current. Diode CR251 protects the base-emitter junction of Q251 against a negative voltage from the ATD unit.

The collector voltage of Q251 is transferred to the base of Q252 through R258. When this voltage falls below the emitter voltage on Q252 (determined by R259, R260 and R253), Q252 is cut off. Consequently the base of Q253 becomes more positive than the emitter, and the transistor is also cut off. The voltage on pin a4 disappears and the stepping motor stops.

A positive feed-back voltage across transistors Q252 and Q253 through R260 insures that the current will fall from full value to zero at a particular base voltage on Q252. The voltage provided by the RC network, consisting of CR253 and R261, prevents premature stopping of the motor. This positive voltage, at the base of Q252, maintains the transistor at cut-off as long as the commutation switch is closed, regardless of whether a disabling voltage is present at a2. Only when the switch opens does the disabling voltage – if any – become effective. Consequently, the last step of the adjustment sequence is normal even if the moving contact of the driving switch section touches the fixed contact of the desired band before the commutator opens.

The network consisting of CR252, R257 and C252 delays the start of the stepping motor when the disabling voltage disappears by causing the voltage at the base of Q252 to rise. Thus the motor is prevented from advancing one step when transmission is momentarily interrupted. In addition, capacitors C324, C325 and C326 in the ATD unit retain their negative voltage until

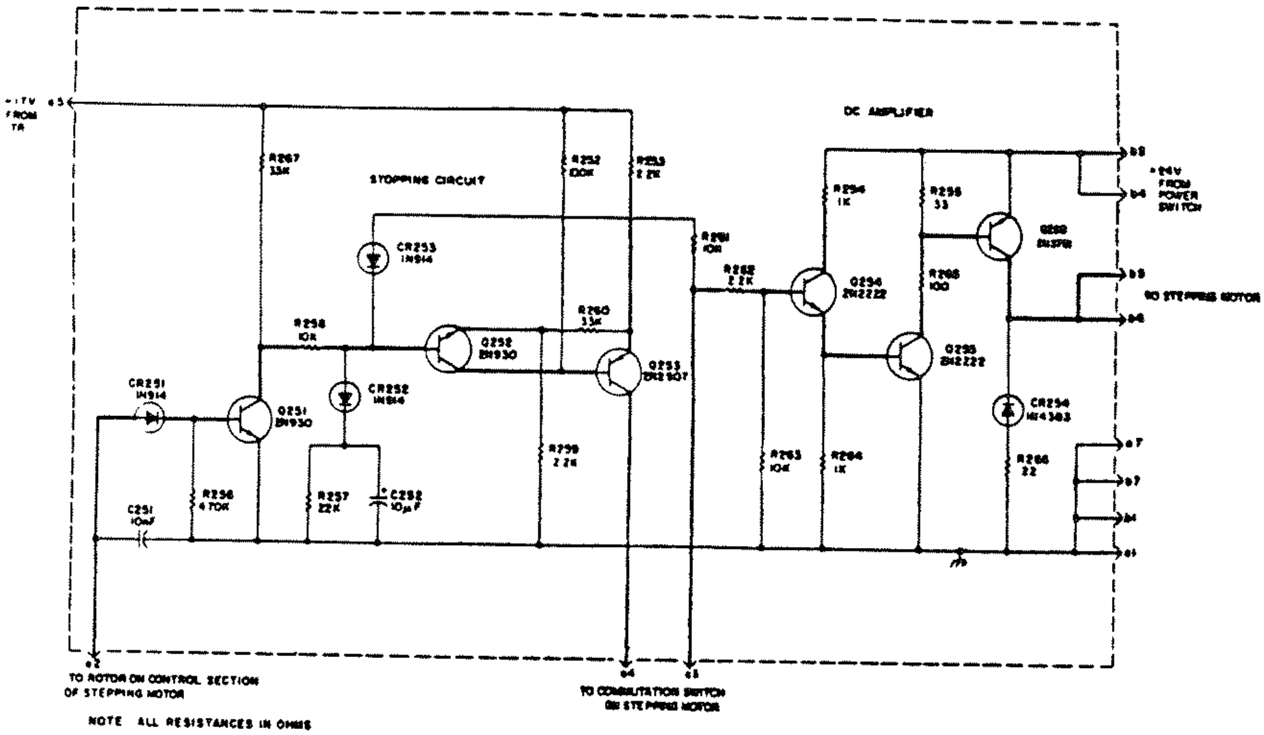


Figure 3–5. Motor Driver Unit A250, Schematic Diagram

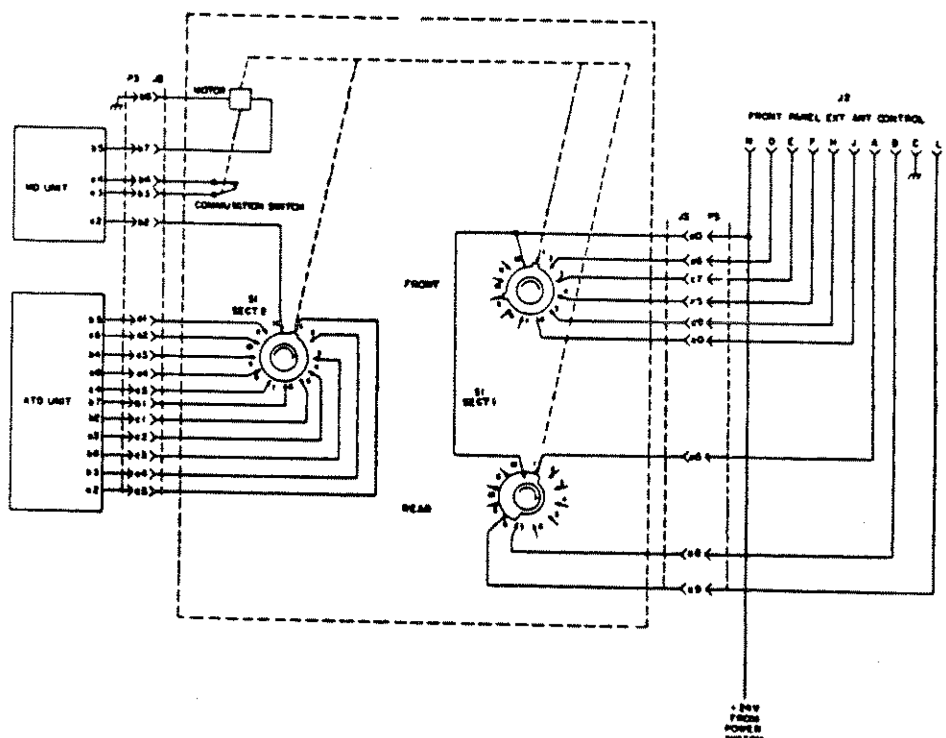


Figure 3–6. Stepping Motor Assembly A750, Schematic Diagram

they are charged by R313. This delay is not effective when the motor stops because diode CR252 does not conduct.

(d) **Stepping Motor Assembly.** (Fig. 3-6) – This assembly is part of the automatic band selector system. It contains a stepping motor, control section S1 sect 2, for the band selector system, and an additional control section S1 sect 1, for an external antenna matching unit. The assembly is mounted between the front panel and the chassis. All electrical connections are made through a 28-pin connector.

(1) Stepping Motor. – The circuit contains an electromagnet whose armature – through a pawl mechanism – activates a switch shaft and turns the sections of switch S1 one position forward each time current flows in the coil. When the current is switched off, the armature is returned to the start position by a spring, while the pawl mechanism with a detent keeps the switch shaft stationary. A commutation switch, mounted on the stepping motor, is normally closed but opens when the armature is almost fully attracted. The electromagnetic coil and commutation switch must be series-connected to +24 volts so that the motor can be self-stepping. The transistor amplifier, however, (Q254 to Q256, as described in paragraph 3-2c(1) above) is inserted to reduce the current through the commutation switch.

(2) Control Sections. – Control section S1 sect 2, serves as part of the automatic band selector system. The 11 fixed contacts are connected to the 11 band detectors of the ATD unit, whereas the moving contact is connected to pin a2 on the MD unit.

Control section S1 sect 1, (front and rear), connected to a multi-pin plug on the front panel, controls the external antenna matching unit. For each band several pins are connected to +24 volts as listed in Table 3-2 below. The other pins are free.

Table 3-2 Pin Connected to +24 V for each Band

Band No.	Frequency MHz		Pins with + 24 V
	From	To	
1	26	30	N, A, L
2	30	33	N, A, D
3	33	37	N, A, E
4	37	42	N, A, F
5	42	47.5	N, A, H
6	47.5	53	N, A, J
7	53	56	N, B, D
8	56	60	N, B, E, L
9	60	65	N, B, F, L
10	65	70.5	N, B, H, L
11	70.5	76	N, B, J, L

(e) Phase Lock Unit. (Fig. 3-7) – This unit forms a part of the phase locking system. It contains two phase detectors with their associated phase shifting networks, a dc amplifier with an audio filter and a sawtooth generator. The circuits are incorporated in a three module plug-in unit.

(1) Phase Detectors. – The phase detectors consist of transformer T151 with its associated components. Phase detector 1 includes diodes CR152 to CR155 and phase detector 2 includes diodes CR156 to CR159. The two detectors are commonly driven by transformer T151 whose primary is connected, through pin b6, to the Isolation Amplifier (IA) unit. The RF signal from the radio set is connected to pin a3 through a voltage divider (R601 and R602), in the chassis assembly. This voltage is supplied to the center taps of the transformer windings through a phase shift network consisting of C160, R167, L151 and R176. If the phase difference between the generated voltages E1 and E2 is 90° the vector diagram will be as in Figure 3-8b. The voltage at location A in the schematic will be the vector sum of E1 and E2a as shown by vector A. Similarly, the voltage at location B is the vector sum of E1 and E2b, except that E2 is shifted 180°. For a phase difference of 90° voltages A and B (whose values are represented by the lengths of the vectors) are equal. When the phase difference between E1 and E2 is not 90° – for instance 45° (Figure 3-8c)– the voltage at A will be larger than that at B. If the phase difference is above 90°, B will be larger than A. When voltage A is positive, capacitor Ca is charged to a positive value determined by the voltage at A, resistance R1 and the voltage drop across CR1. When voltage B is negative, Ca will discharge at a rate determined by the voltage at B, resistance R3 and the voltage drop across CR3. The voltage at C will effectively be:

$$V_C = (V_A - V_B)/2$$

The voltage at D will effectively be:

$$V_D = (V_B - V_A)/2$$

The voltage difference between C and D will thus be:

$$V_C - V_D = (V_A - V_B)/2 - (V_B - V_A)/2$$
$$= V_A - V_B$$

Thus the voltage between C and D is zero when the phase difference between E1 and E2 is 90°, positive when the angle is less than 90° and negative when it is greater than 90°. The output voltage variation with respect to the phase difference is shown in Figure 3-9.

In the actual phase detector, blocking capacitors C159 and C161 are in series with the transformer center tap to make the circuit floating. In phase detector 2, one output terminal is grounded and one is decoupled by C162. One output terminal of phase detector 1 is connected to voltage divider R165 and R166, providing 3 V, whereas the other output terminal is connected to the amplifier through pins a6 and a5. The series resistors connected to all diodes cause the diodes to function as mean value rectifiers and not as peak voltage rectifiers. As a result, the load on the IA unit is more constant and improves the IA waveshape. Moreover, the balance of the phase detectors is independent of harmonics of the RF input signal from the radio set.

(2) Phase Shift Network (Fig. 3-10) – This circuit is designed to maintain the phase difference between $E1_A$ and $E1_B$ at exactly 90° at all frequencies. The voltages are equal only at

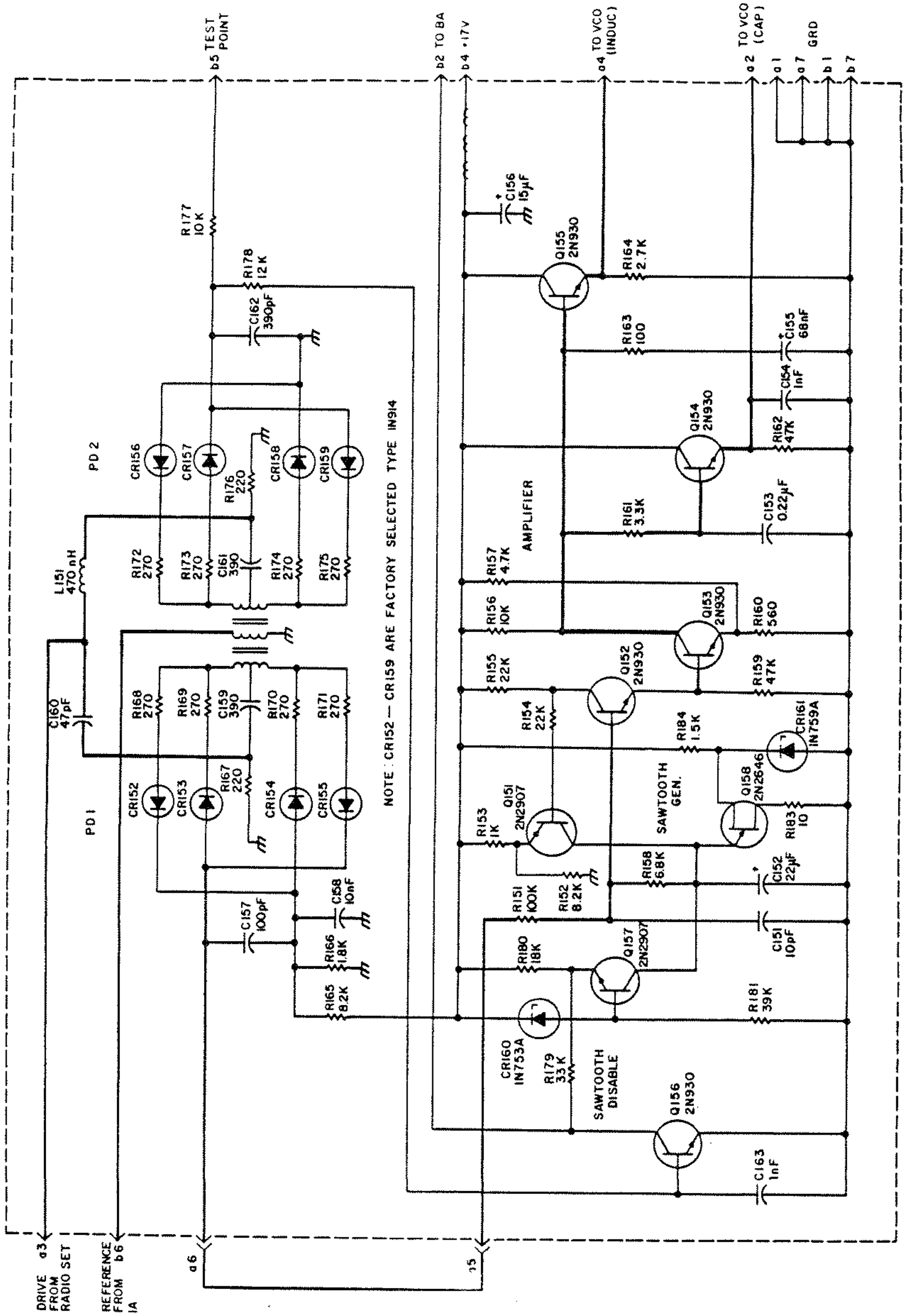


Figure 3–7. Phase Locking Unit A150, Schematic Diagram

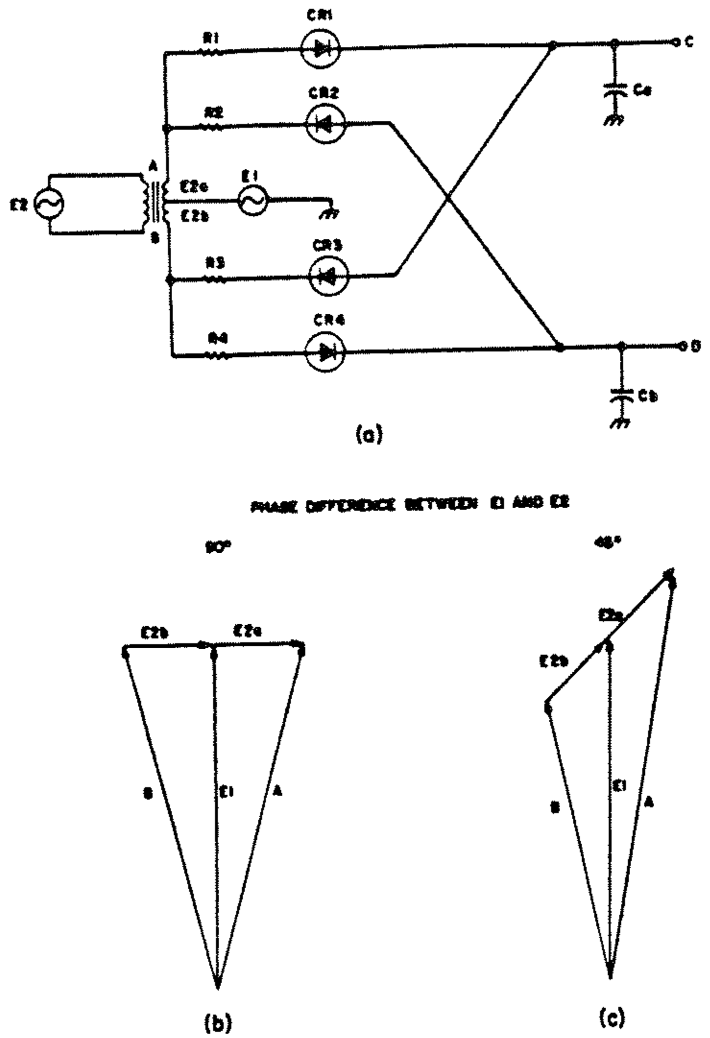


Figure 3–8. Phase Detector, Simplified Schematic Diagram

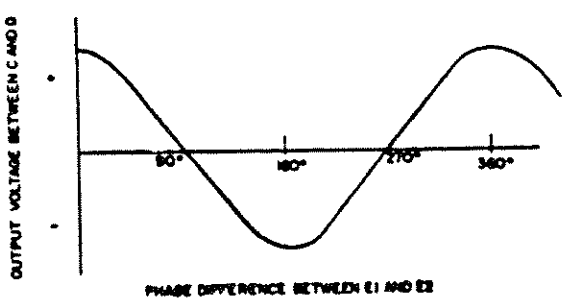


Figure 3–9. Phase Detector Output Voltage

the mean frequency, and will drop as much as half this value at the extreme frequencies. This does not affect circuit operation however. The impedance of the circuit is ohmic and equal to R at all frequencies. In the actual circuit R is 75 ohms, consisting of R167 and R176, in parallel with the input impedances of the respective phase detectors.

(3) Amplifier. – The circuit consists of transistors Q152, Q153, Q154 and Q155 with associated components. The amplifier is directly coupled and thus amplifies the dc and low-frequency ac (below 0.2 Hz) inputs. The output of phase detector 1 is applied to the base of Q152 through R151.

Transistor Q152 functions as an emitter follower to ensure a high input impedance. The emitter of Q152 is directly connected to the grounded emitter amplifier Q153. Resistor R160 in the emitter circuit is unbypassed to produce negative feedback and stabilize the amplifier. Resistors R157 and R160 form a voltage divider that maintains a +1 V at the emitter of Q153 and thereby matches the input characteristic of the amplifier to the phase detector and the sawtooth generator. The amplified signal from the collector of Q153 is fed to output terminals a2 and a4 through the emitter followers Q155 and Q154, respectively. At the low-frequency inputs, the shunting effect of the three loop filters (see (4) below) has no effect, and the amplification of Q153 is determined by the 10:1 ratio between R156 and R160. The output voltages at a2 and a4 control the capacitive diode and the self-induction coil in the VCO circuit, respectively. Two control lines with the same dc voltage, but with different low frequency filtering, are needed because a phase shift occurs in the VCO self-induction coil at the high frequencies. Frequencies above 200 Hz cannot vary the self-induction coil and are only applied to the capacitive diode.

(4) Loop Filter. – The loop filter provides a frequency cutoff in the amplifier. Spurious components of the applied RF signal are prevented from modulating the VCO frequency. Cutoff must be achieved without a phase shift causing circuit instability. Ordinary low-pass networks cannot be used, as the phase shift of each approaches 90°. As seen in Figure 3-11, as the frequency increases the attenuation of each network approaches a constant value corresponding to the voltage output of divider R1 and R2. In addition, as the frequency increases, the phase shift returns to 0°. Three such networks are used. The first network (R151, R158, C152) is located in the amplifier input. While the VCO synchronizes to the input carrier frequency, C152 becomes part of the sawtooth generator as described later in paragraph (5).

The second network in the collector of Q153 consists of R156, R161 and C153. The voltage for pin a4 at the output of emitter follower Q154, is developed across C154, thereby achieving the sharp cutoff of the ordinary RC network. The third network consisting of R156, R163 and C155 affects only the control voltage of the capacitive diode in the VCO current.

These filter networks markedly attenuate the speech frequency range, but the modulation frequency response of the total phase locking system still remains flat and its amplification sufficiently high to allow the VCO frequency to follow the RF input signal accurately.

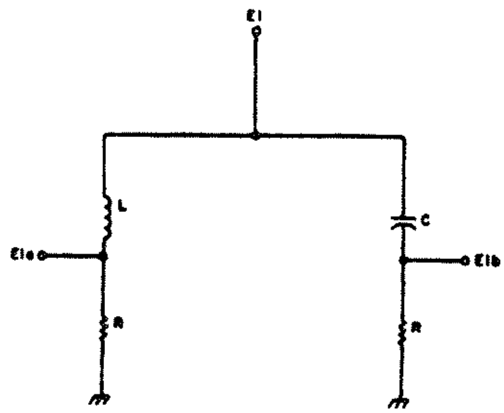


Figure 3–10. Phase Shift Network, Simplified Schematic Diagram

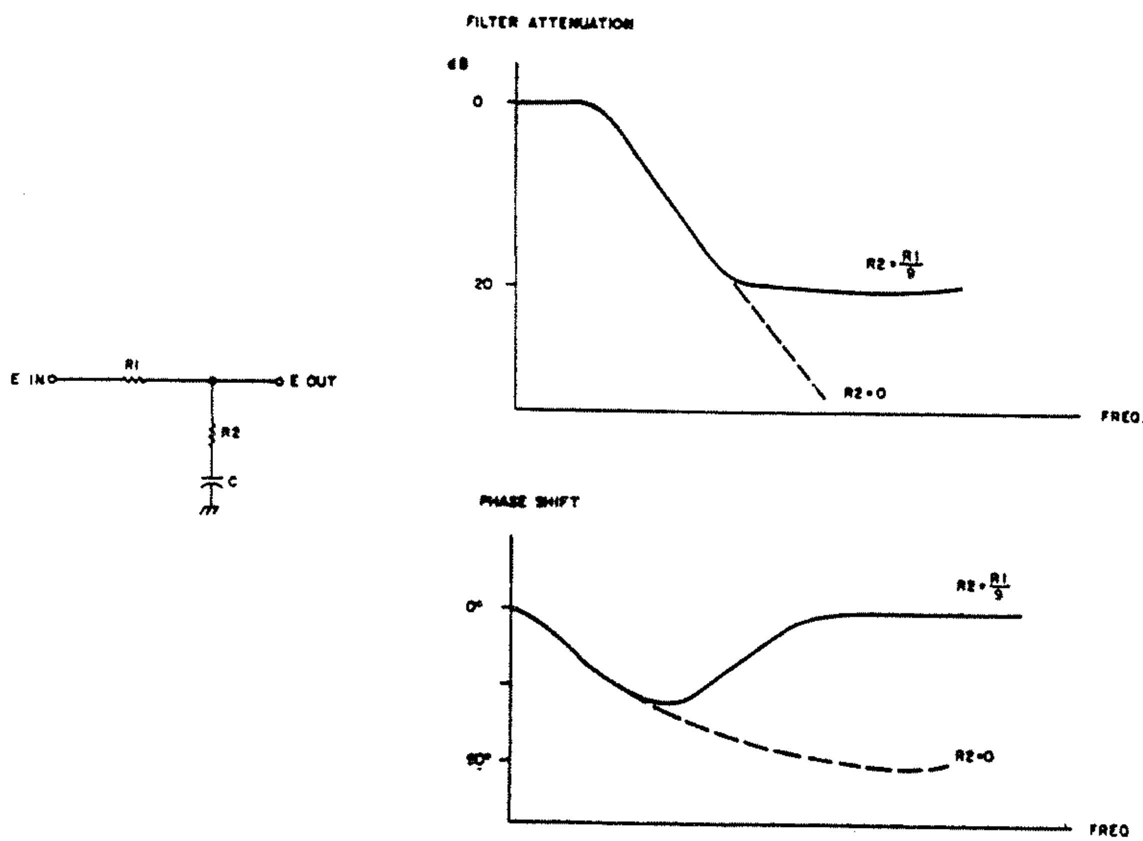


Figure 3–11. Loop Filter, Simplified Schematic Diagram and Curves

(5) Sawtooth Generator. – This circuit consists of transistors Q151, Q156, Q157, Q158 with their associated components. The sawtooth voltage is generated when capacitor C152 is charged by a constant current from current generator Q157. When the capacitor voltage reaches the trigger voltage of Q158 (about 9 volts) the UJT junction transistor conducts instantly discharging the capacitor. When the current in CR161 drops to a low value, it again cuts off and the sequence is repeated. The sawtooth voltage is applied to the amplifier input through R158 and the amplified sawtooth voltage sweeps the VCO frequency through its entire frequency range.

Transistor Q157 functions as current generator since the base is at +10.8 V. The emitter current flows through R180 which permits a current of about 300 μA to flow through the transistor. Transistor Q156 disables the sawtooth generator by cutting off the current generator. When the phase locking system locks, phase detector 2 furnishes a positive voltage through R178 to the base of Q156. The transistor saturates, a voltage division occurs between R179 and R180 and the emitter voltage on Q157 drops cutting off Q157. C152 stops charging and the system synchronizes. Pin b5 is a test point for the output of phase detector 2 of the PL unit. The voltage on pin b2 is connected through resistor R603 in the chassis assembly and the ALC line to the broadband amplifier and cuts off the amplifier when the system is not synchronized.

Transistor Q151 draws current when the current flow in emitter follower Q152 rises heavily. This happens when Q153 becomes saturated at which time R160 is effectively in parallel with R159. The collector current in Q151 quickly charges capacitor C152 until the trigger voltage of CR151 is reached. The transistor shortens the fall time of the sawtooth. During normal phase lock operation the voltage drop across R155 is less than the voltage across R153 thus Q151 is cut off.

(f) **VCO Unit.** (Fig. 3-12) – This unit forms part of the phase locking system, as shown in Figure 3-2. The unit contains a voltage-controlled oscillator, a buffer amplifier, an ALC circuit and a dc amplifier for a current-controlled inductor. The circuit is incorporated in a three module plug-in unit.

(1) Oscillator – The circuit consists of transistor Q353 with its associated components, forming an LC oscillator in which one of the windings of transformer T351 provides the inductance, and series-connected capacitors C355, C362 and C354 and diode CR351 provide the capacitance. The capacitors form a voltage divider which furnishes the positive feedback to the emitter of Q353 through capacitor C367.

The capacitance of diode CR351 varies with the dc voltage on control terminal a2 which is de-coupled for high frequencies. The other end of CR351 is raised to +3 V for the greatest possible capacity variation with the voltage available from the PL unit. The VCO frequency varies between 26 MHz and 76 MHz when the dc voltage at a2 and a4 varies from +3 V to +9 V.

(2) Buffer Amplifier. – This circuit (two-stage, untuned, transformer-coupled amplifier) consists of transistors Q354 and Q355 with their associated components. Both stages are class A grounded-emitter amplifiers, with unbypassed feedback resistors in the emitters. The driving signal for the amplifier is taken from the oscillator emitter and coupled through

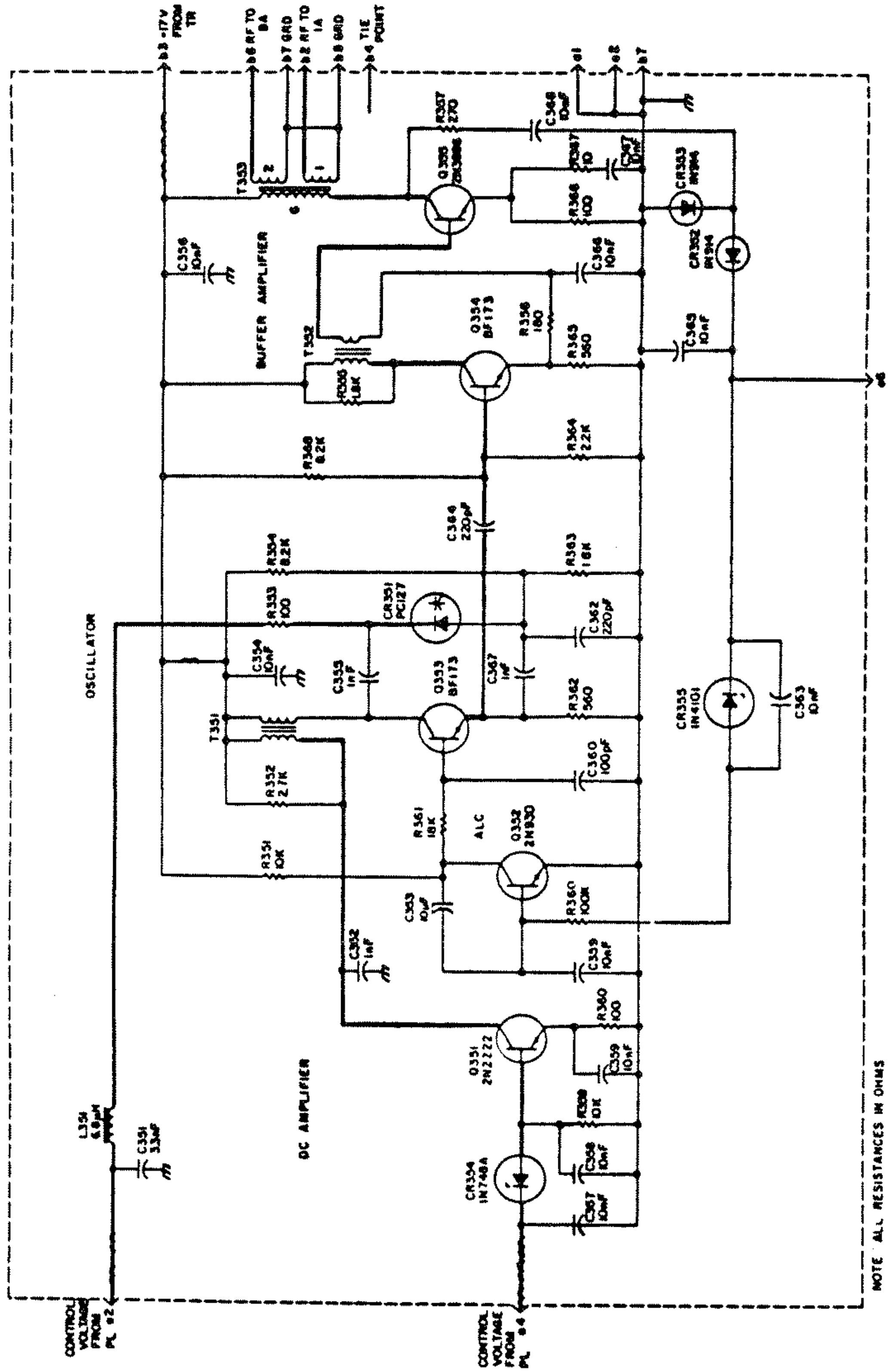


Figure 3–12. Voltage Controlled Oscillator Unit A350, Schematic Diagram

capacitor C364 to the base of Q354. Broadband transformer T352 is wound on a ferrite core and transfers the signal to the base of Q355. The dc base voltage on Q355 is obtained from the emitter of Q354. Two output signals are obtained from the two secondary windings on transformer T353. One, about 1.2 V, is applied to the BA unit through pins b6 and b7; the other is applied to the IA unit through pins b2 and b5.

(3) ALC circuit. – This circuit consists of transistor Q352 with its associated components. The high frequency collector voltage on Q355 is rectified in a voltage doubler which includes diodes CR352 and CR353. The rectified voltage is coupled through zener diode CR355 and resistor R360 to the base of regulating transistor Q352. When the rectified dc voltage exceeds the zener voltage (8.2 V), Q352 begins to draw collector current through resistor R351. This reduces the base voltage on oscillator transistor Q353, causing the oscillator output voltage to drop. In this manner the output level of the VCO unit is kept constant. Overdriving Q355 prevents any consequent waveshape distortion. Capacitor C353 limits the speed of the ALC system and prevents abrupt changes of the load on the VCO output from affecting the oscillator frequency through the ALC system.

(4) DC Amplifier –This circuit consists of transistor Q351 with its associated components. It supplies the direct current which varies the self-induction of the secondary winding of T351. The self-induction is maximum when no direct current is present, and decreases linearly as the current increases up to 60 mA. The control voltage on pin a4 is coupled through zener diode CR354 (3.9 V) to the base of Q351. When the control voltage exceeds 4.5 V, Q351 begins to draw collector current. This collector current is determined by the control voltage on the base of Q351 and by the emitter resistor R359. It can vary up to 60 mA with 10 V at a4. All capacitors are used to provide high frequency decoupling.

(g) IA Unit (Fig. 3-13) – This unit forms a part of the phase locking system. It contains a two-stage amplifier with ALC circuit and is incorporated in a single module plug-in unit.

(1) Amplifier – The circuit consists of transistors Q202, Q203 and Q204 with their associated components. The input stage operates as a class A grounded emitter amplifier. The autotransformer T201 attached to collector, drives the output stage which include Q203 and Q204. The output is a complementary-symmetrical transformerless circuit that operates class AB and produces an undistorted output signal at pin a6 of about 2 volts. The signal is applied to the phase detectors in the PL unit. The IA unit prevents signals at the phase detectors from reaching the VCO output, as they would then be amplified in the broadband amplifier chain (BA and PA) and would cancel the spurious-eliminating property of the phase locking system.

(2) ALC Circuit – This circuit consists of transistor Q201 with its associated components. The output voltage of the amplifier is rectified in a voltage doubler consisting of diodes CR201 and CR202. The rectified dc voltage is supplied through zener diode CR203 and resistor R211 to the base of Q201. When the rectified voltage exceeds the zener voltage (3.9 V), Q201 conducts, thus forming a voltage divider consisting of the transistor collector impedance and resistor R208 and thereby

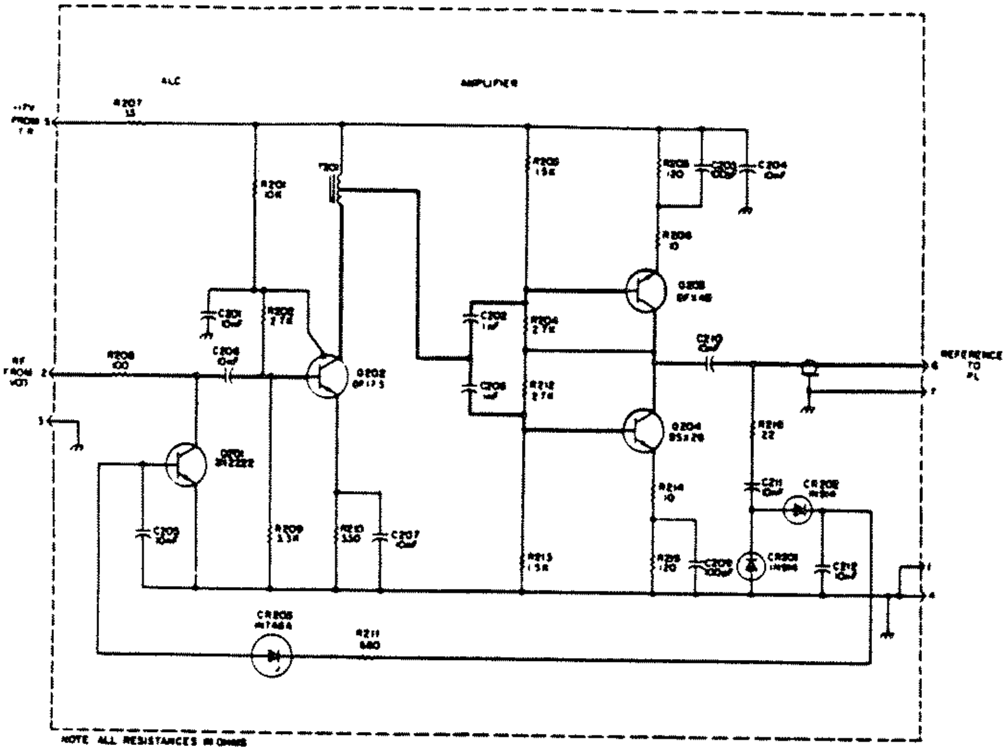


Figure 3–13. Isolation Amplifier Unit A200, Schematic Diagram

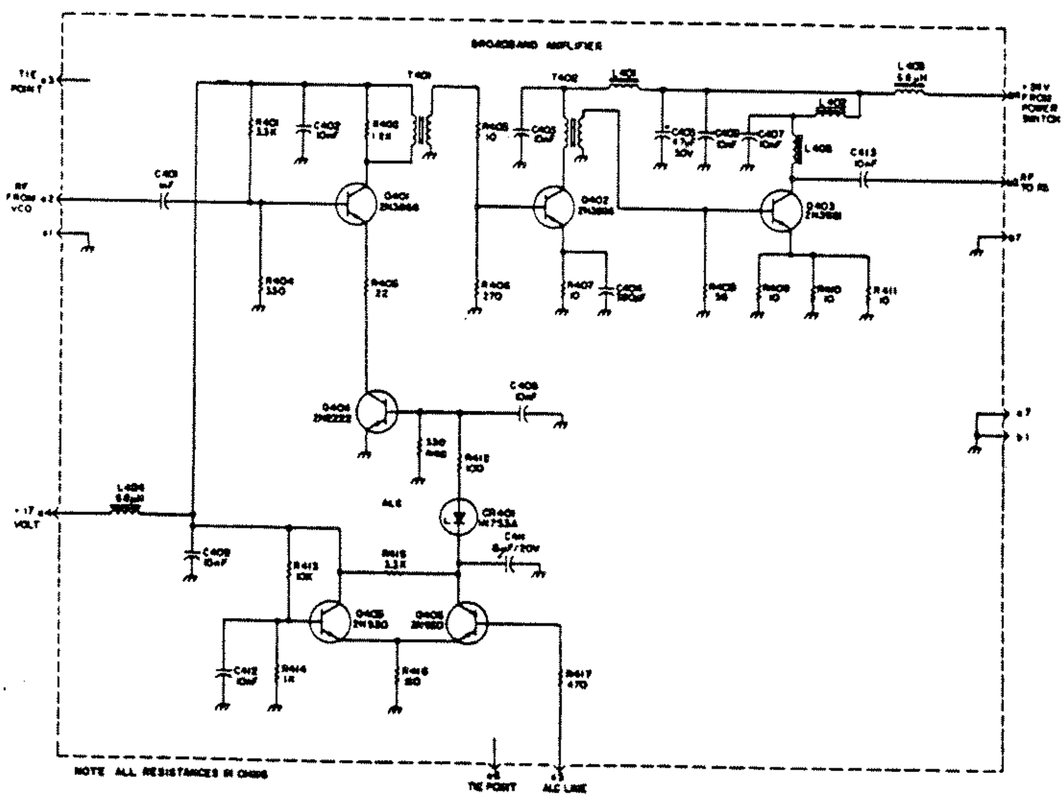


Figure 3–14. Broadband Amplifier Unit A400, Schematic Diagram

reducing the input signal to the amplifier. Thus the output signal is kept constant preventing any overdrive of the IA output stages.

(h) **Broadband Amplifier (BA) Unit** (Fig. 3-14) – This unit forms part of the broadband amplifying chain which amplifies the VCO signal up to 30 W. The unit consists of a three-stage broadband amplifier with variable amplification, and a dc voltage amplifier. The circuit is incorporated in a three-module plug-in unit.

(1) Broadband Amplifier – This circuit consists of transistors Q401, Q402, Q403 and Q404 with their associated components. The input signal from the VCO unit is applied through pin a2 and capacitor C401 to the base of Q401. The transistor is biased class A by voltage divider resistors R401 and R404 at the base and by emitter resistor R405. Transistor Q404 operates as a variable emitter resistor for both direct current and high frequency. The amplification of Q401 is varied by changes in the base current of Q404. The broadband transformer in the collector of Q401 couples the signal through damping resistor R403 to the base of Q402. This stage operates class B since the base is grounded. Collector current is determined by the excitation at the base and by emitter resistor R407. This stage and the subsequent stages of the amplifying chain are powered by an unstabilized 24 V supply. The supply voltage is connected as soon as the AM-4477 is turned on but no current is drawn unless there is excitation. The output of Q402 is coupled, through transformer T402, to the base of Q403. This transistor operates class B with an unbypassed emitter resistance consisting of resistors R409, R410 and R411. The output signal from the collector is fed through pin b6 to the Power Amplifier. The current flow to the last two stages is filtered by inductors L401, L402 and L403 and decoupled for high frequency (C403, C406, C407) and low frequency (C405). The output power on b6, in the 30 W position, is about 2 W at 76 MHz, dropping to about 0.5 W at 26 MHz. Without attenuation, the power averages between 3 to 6 W across the frequency range. (The unit cannot withstand a short-circuit from b6 to ground during operation).

(2) DC Voltage Amplifier – The circuit consists of transistors Q405 and Q406, with associated components, that form a balanced dc voltage amplifier. Input terminal a5 is connected from the current limiting circuit in the PA assembly through R417 to the base of Q406. The base of Q405 is maintained at +1.5 V by a voltage divider R413 and R414. Both transistors have a common emitter resistor (R416). Any current increase in one transistor, will raise the common emitter voltage and thereby decrease the current in the other transistor. The collector of Q406 is connected through resistor R415 to +17 V and through zener diode CR401 and resistor R412 to the base of the ALC transistor Q404.

When the voltage on pin a5 is below +1.5 V Q406 does not draw collector current. The current in R415 thus passes through CR401 and R412 to the base of Q404 causing it to saturate. Consequently, the negative feedback to Q401 is minimum thus providing maximum amplification. If the voltage on pin a5 exceeds 1.5 V Q406 begins to draw current, reducing the current in the base circuit of Q404. The resistance of Q404 thus increases and amplification in the BA amplifier drops due to the negative feedback. If the base current in Q404 ceases entirely the amplifier will be cut off.

The dc voltage amplification in the balanced stage is very high so that the entire procedure takes place with a very small change of the dc voltage at a5. Capacitor C411 on the collector of Q406 ensures a suitable time constant in the ALC circuit.

(i) **Power Amplifier (PA)** (Fig. 3-15) – The PA assembly contains the last two stages of the Range Booster and a current regulating circuit. The assembly is mounted on an aluminium plate and is secured to the front panel to provide a suitable thermal path. All connections to the unit are made through plugs.

(1) Power Amplifier. – This circuit consists of transistors Q451, Q452 and Q453 with their associated components. It is a two-stage broadband amplifier with an output stage consisting of two transistors in parallel. The input signal from the BA unit is coupled through a coaxial plug to a T network attenuator consisting of R451, R452 and R453 having an attenuation of 2 dB and an impedance of 50 ohms. The network improves isolation between the broadband amplifying stages thereby improving stability. The attenuated signal is connected to matching transformer T451 which reduces the impedance to 3 ohms so as to match the input impedance of driver transistor Q451.

Transformer T451 is specially designed and consists of four transmission lines with a characteristic impedance of 12 ohms. The lines are made of copper strips on both sides of a thin, double-sided printed circuit. The transmission lines are connected in series at the input side and in parallel at the transistor side, thereby achieving an impedance transformation of 16:1. The printed circuit is placed between two grooved ferrite blocks to accommodate the individual transmission lines. The transformer forms a short circuit for dc so that the base of Q451 is at ground potential. The collector load of the transistor consists of two attenuators similar to the one at the input of the unit. The two output transistors Q452 and Q453 are similarly coupled to the driver transistor. Matching transformers T452 and T453 are identical with T451.

The output transistors operate in parallel but the attenuators introduce a certain isolation between them. The collector circuit is untuned the same as the driver stage. Current is supplied through RF chokes L451 and L452, which are connected to +24 V through the current limiting circuit. The signal is coupled from transistor Q452 to the common output transformer T454 through capacitors C454, C455 and C456; and from transistor Q453 through capacitors C462 and C463. Resistor R478, located between the collectors, suppresses parasitic oscillations in the output stage and has no attenuating effect on the signal since its voltage is in phase.

Output transformer T454 is constructed the same way as the input transformers. The transformer contains three transmission lines from each output transistor which establish an impedance transformation of 9:1 from collector to output. The two paralleled outputs of the transformer are connected through a coaxial plug to the input of the antenna filter. The wiring of the output transformer is a flexible printed circuit with teflon insulation. It is folded and placed in grooves in a number of stacked ferrite blocks so as to minimize losses in the transformer.

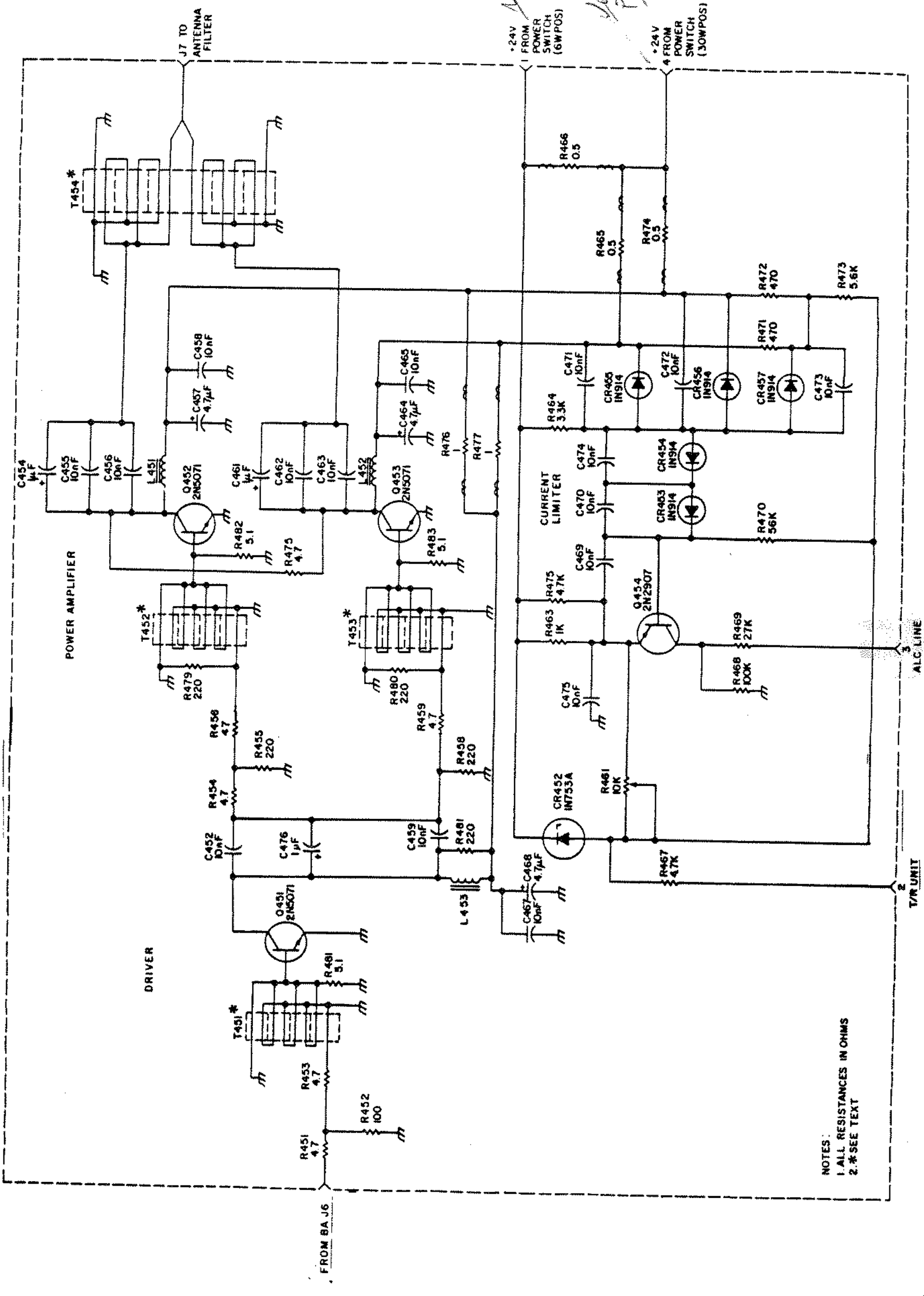


Figure 3—15. Power Amplifier Assembly A450, Schematic Diagram

The current leads for all three transistors are decoupled for both high frequency (C467, C458, C465) and low frequency (C468, C457, C464).

(2) Current Limiter. This circuit consists of transistor Q454 with its associated components. In the 30 W position terminal 4 is connected to a +24 V potential. Current for the two output transistors flows through current-sensing resistors R465 and R474. The voltage drop across these resistors is coupled through diodes CR455 and CR456 to resistor R464. The mean value of the voltage-drops across the current-sensing resistors is established by resistors R471 and R472. This voltage is coupled through diode CR457 to R464. The diodes function as a logic circuit and ensure that the voltage across R464 will be the largest of the three voltages present. Resistor R473 adds a small voltage drop across R471 and R472, so that with the same current in the two output transistors, diode CR457 conducts and determines the voltage on R464. The voltage is fed through diodes CR453 and CR454 which conduct due to the presence of a constant current from resistor R470 to the base of dc amplifier Q454. The emitter voltage of Q454 is determined by zener diode CR452 and the voltage divider consisting of resistors R461, R463 and R475. When the base voltage of Q454 is below the emitter voltage (less than 0.6 V), Q454 begins to draw collector current. The collector is connected through resistor R468 to ground, and through resistor R469 and terminal 3 to the ALC line. When Q454 causes the ALC voltage to exceed +1.5 V, BA amplification begins to drop, reducing the drive to the PA. The system stabilizes at this point of operation.

The threshold value for current limiting can be adjusted by potentiometer R461, located on the upper circuit board of the PA, which varies the dc emitter voltage on Q454. The voltage also depends on the value of NTC resistor R475, which is fitted into a metal block in thermal contact with the heat sink. When the block is heated by the output transistors (after lengthy transmissions), the value of R475 decreases, and the current in the stage is reduced. This limits the rise in temperature to a permissible value, and thermal stability is maintained. The current in driving transistor Q451 is fed through resistors R476 and R477 to sensing resistors R465 and R474 and has a small effect on the current limiting process.

Diode CR456 conducts during normal operation keeping the total current of the PA unit constant. When one output transistor cuts off, current limiting diode CR455 (or CR456) takes over and limits the current rise in the other transistor to about 65% of the adjusted total current, resulting in a slight increase in the transistor load. The decoupling capacitors in the current limiting circuit prevent high frequency voltages across the diodes from effecting the limiting process. Resistor R467 is connected to pin b2 of the T/R unit through terminal 2. This junction is at +24 V during reception, and at zero volts during transmission, so that current flows in zener diode CR452 during transmission only.

(j) **Antenna Filter Assembly A500 (Fig. 3-17)** – This unit includes three low-pass filters with their switch sections and is mounted between the front panel and the chassis. Connections to the unit are through two coaxial connectors and

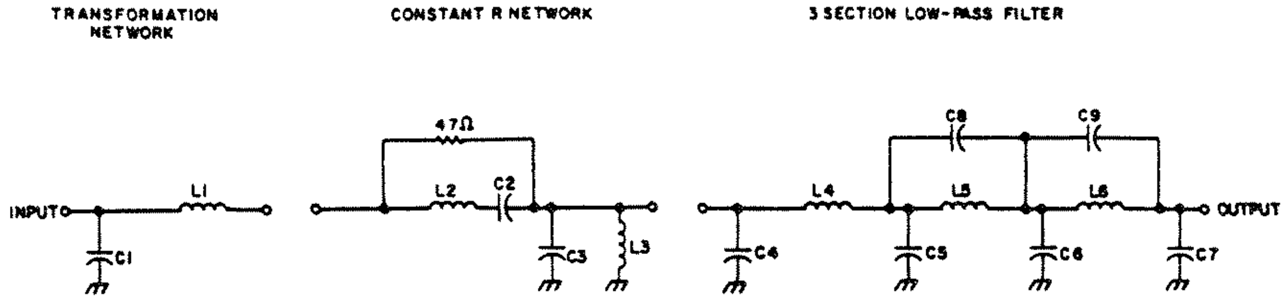


Figure 3–16. Antenna Filter, Simplified Schematic Diagram

a soldered terminal.

Low-Pass Filters. – The three LP filters are similarly constructed, but have different cutoff frequencies. The bandpass and cutoff frequencies are given in Table 3-3:

Table 3-3

Filter	Used with Band	Bandpass Frequency	Cutoff Frequency
1	1, 2, 3	26–37 MHz	42 MHz
2	4, 5, 6	37–53 MHz	61 MHz
3	7, 8, 9, 10, 11	53–76 MHz	87 MHz

The basic diagram of the filters is shown in Figure 3-16. The filter assembly can be divided into a transformer section, a constant R-section, and three low-pass filter sections.

The transformer section matches the output impedance of the amplifier to that of the filter. The complete transformer is used only in filter No. 1. In filter No. 2 only a coil (L507) is used, whereas no transformer is used in filter No. 3.

The constant R-section consists of a series-tuned circuit (L2, C2) and a parallel-tuned circuit (L3, C3) which are tuned to the center frequency in the bandpass of the filter. At this tuned frequency the series circuit acts as a short-circuit and the parallel circuit as a high impedance. There is maximum coupling of the center frequency, but the LC ratios of the circuits cause little attenuation over the entire bandpass. At frequencies either much above or below the bandpass the series circuit will have a high impedance, so that the 47 ohm resistor is coupled into the circuit while the parallel circuit acts as a short-circuit. Consequently, the filter has a resistive input impedance of 47 ohms and is independent of the antenna impedance. This

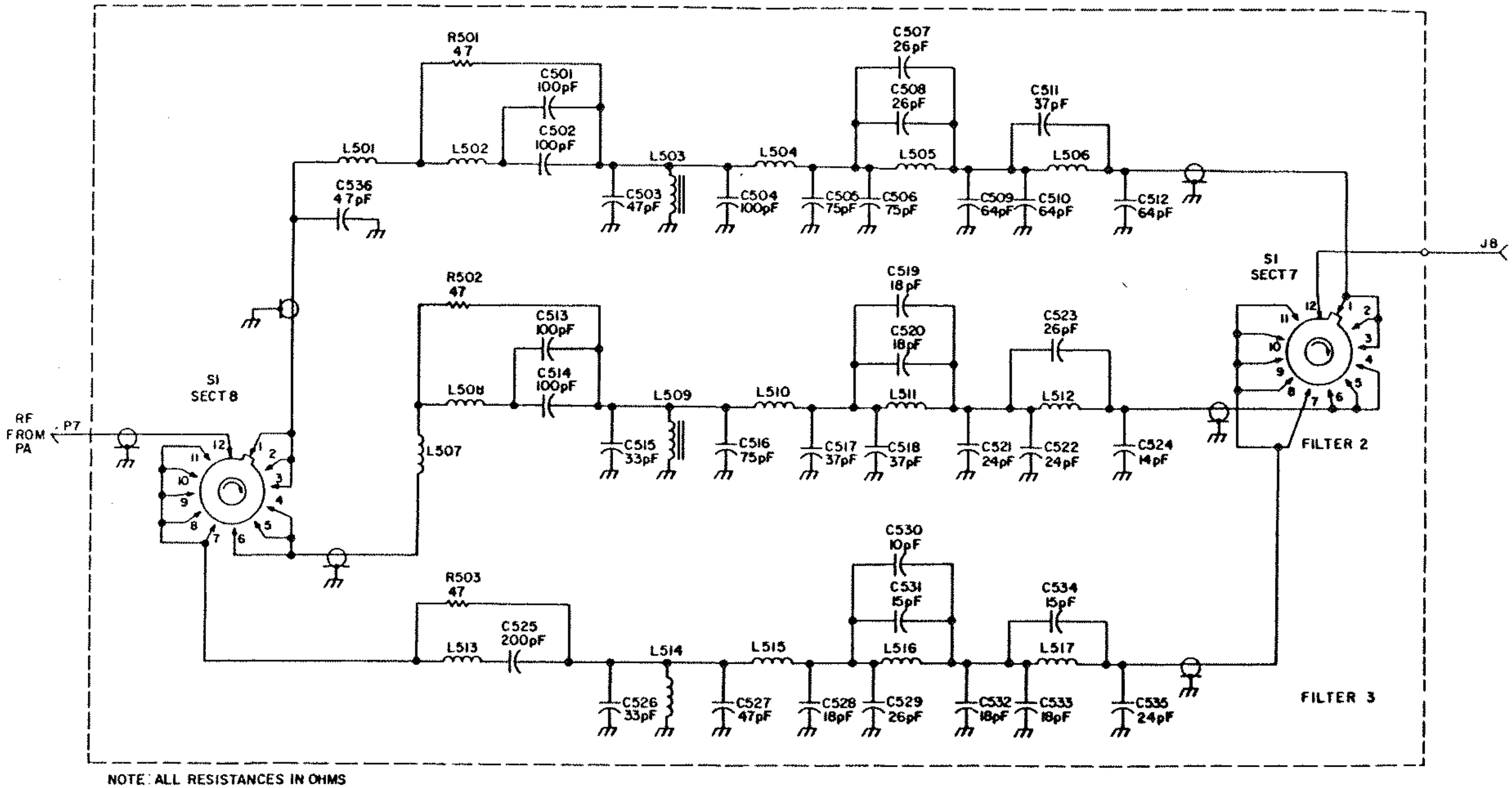


Figure 3–17. Antenna Filter Assembly A500, Schematic Diagram

load on the output amplifier improves amplifier stability, particularly at low frequencies. The low-pass filter consists of three pi-sections. The last two sections have parallel capacitors across their coils and function as wavetraps for two frequencies above the cutoff frequency. These traps, and the ratio between the other components, give the filter a sharp cutoff characteristic, which attenuates by at least 50 dB harmonics of the transmitting frequency.

The complete diagram of the Antenna Filter Assembly is shown in Figure 3-17. Two parallel capacitors are often used since the high frequency current is at times too high for one capacitor. Ferrite cores around the shielded cables, in the input and output to the switch sections, prevent stray currents on the shield from reducing the isolation between input and output.

(k) **Antenna Matching Assembly A650** (Fig. 3-18) – The assembly includes matching sections for the long and short whip antennas (10 feet and 3 feet respectively). The unit is mounted between the front panel and chassis. Connections to the unit are through two coaxial connectors and two soldered terminals.

(1) Matching Circuits for Three-foot Antenna. – The circuits are shown at upper part of Figure 3-18. They are selected by two rotary switches actuated by the stepping motor. The basic diagram of the matching circuits is shown in Figure 3-19. The circuits transform the antenna impedance to 50 ohms with the highest possible accuracy within the frequency range of each circuit. A VSWR of 3:1, or less, is obtained over the entire range.

The three-foot whip antenna is shorter than 1/4 wavelength over the entire frequency range and, therefore, displays a capacitive impedance on all bands. The matching circuits introduce a coil in series with the antenna. The series circuit then formed resonates at the center of the selected band. A tapped parallel circuit across the input maintains a low VSWR over a band of frequencies. A bandpass filter effect is obtained, with a flat VSWR curve over the desired frequency range. The effect is shown in the curve of Figure 3-19.

The parallel compensating circuits are used for bands 1–6, whereas bands 7–11 use only a series coil and a parallel capacitor at the transmitter end of the circuit. This parallel capacitor is composed of several parallel-connected mica capacitors to withstand the large RF current in these circuits. Bands 7–9 have a common shunt capacitor, as do bands 10 and 11.

(2) Matching Circuits for Ten-Foot Antenna. – These circuits are shown at the bottom of Figure 3-18. Both input and output circuits are selected by two switch sections actuated by the stepping motor. The ten-foot antenna is 1/4 wavelength at 26 MHz, 1/2 wavelength at 45 MHz, and 3/4 wavelength at 70 MHz. It is, therefore, inductive from 26 to 45 MHz and capacitive from 45 to 70 MHz. A VSWR of 3:1, or less is obtained over the entire band.

All matching circuits are L-sections. Bands 1–3 have a common L-section, consisting of coil L651 and capacitor C651, which reduces the antenna impedance. The capacitor also provides a parallel tuning of the inductive impedance of the antenna. Band 4 also uses an L-section consisting of L652 and C652. On band 5, only series coil L653 is connected since the necessary parallel capacity is inherent in the antenna mount and the wiring.

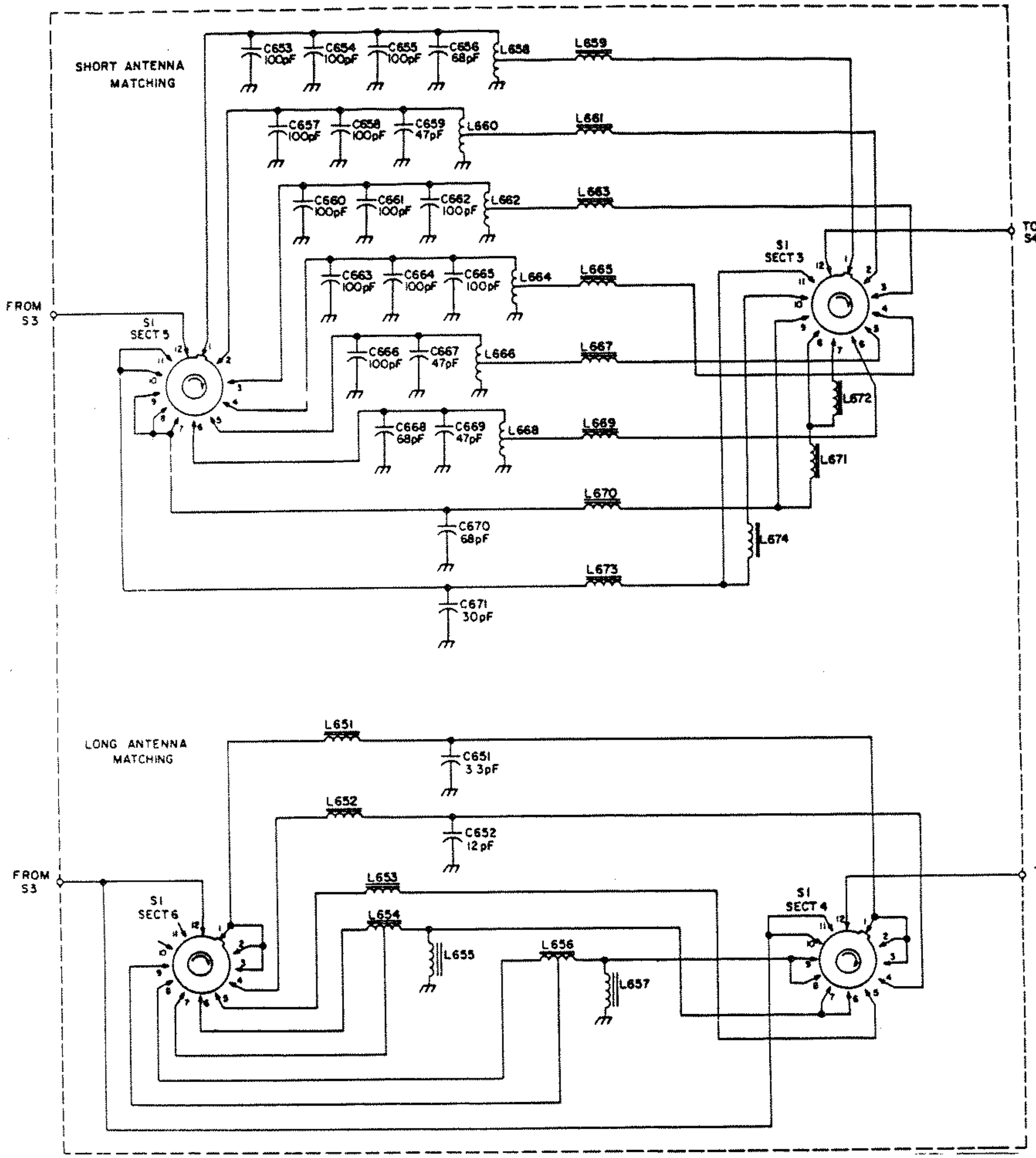


Figure 3–18. Antenna Matching Network A650, Schematic Diagram

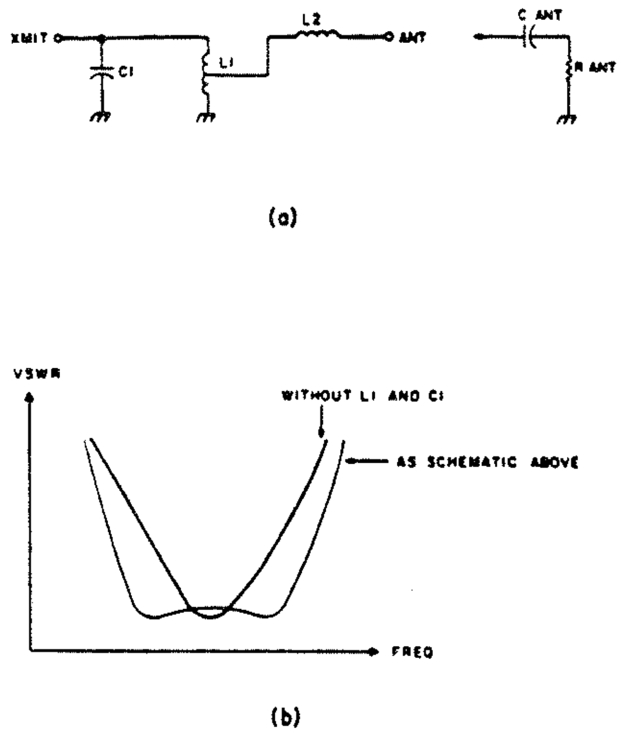


Figure 3–19. Antenna Matching Network, (a) Simplified Schematic Diagram, (b) VSWR Curve

Bands 6 and 7 are combined on the output side, while the series coil is tapped. The parallel reactance for these bands is a coil since the antenna itself is capacitive. Bands 8 and 9 are connected in the same manner as bands 6 and 7. No matching circuit is used for bands 10 and 11.

(l) **Complete Schematic Diagram.** – A complete schematic diagram of the AM-4477 is found on page 4-9, and shows all electronic components of the unit. Units or components not previously covered will now be described.

(1) Signal Path. – The input connector (shown at the extreme left hand side of the diagram), is connected through a coaxial cable to pin b6 of the T/R unit. After passing through the dual reflectometer of the T/R unit, the RF drive signal reaches pin b5 which is connected to one of the contacts of relay K1. The relays are shown in the static receive position. In this position the signal passes from relay K1 to relay K2 and then to microswitch S2 at the antenna mount (at the lower right of schematic). The microswitch is activated by a plunger in the antenna mount which is depressed when the antenna is installed. Switch S2 selects either the coaxial output connector (ANT socket) or the antenna matching circuits and is activated by the short or the long antenna. Microswitches S3 and S4 are activated by the long antenna only; the two switches select the matching circuits for either the short or long antennas. In the transmit condition relays K1 and K2 are energized. The RF drive signal is coupled through one set of contacts on K1, through C601, and on to the

ATD unit. Coupling to the PL unit is obtained through voltage divider R601 and R602. The other set of relay contacts grounds the line between the two relays, thereby increasing the isolation between the input and output circuits of the booster. During transmission K2 connects the antenna switch assembly to the output of the antenna filter reflectometer.

(2) Power Distribution Circuits – The power supply is connected through the battery connector at the bottom of the case. The terminal pin connections are as follows:

Pin Designation	Connection
A	Ground
B	+24 V
C	Control Line

The AM-4477 is not protected against a reverse polarity connection.

The battery connector is connected (through an RF filter) to plug P11. This plug is inserted in the test socket, on the chassis, when the cover (which holds the plug-in units) is fitted.

The +24 V line (battery plug pin B) is connected to test socket pins B and D, pin A is ground. Pin B is connected through the power switch to the PA assembly. In the 6 W position, point 1 on the PA assembly is connected while for the 30 W position point 4 is used. Test socket pin D supplies +24 V through the power switch to the plug-in units in both the 6 W and 30 W positions. Pin D also connects +24 V to the antenna control socket.

The +17 V stabilizer in the T/R unit is activated through a set of contacts on relay K2, which connects +24 V to pin a3 of the T/R unit. The same set of contacts in receive position are used to discharge the capacitors on the +17 volt

Table 3-4 Test Socket Pin Connections

Pin Designation	Connection
A	Ground
B	+24 V to PA assembly
C	Pin M of EXT. ANT socket
D	+24 V to plug-in units
E	+17 V from T/R unit
F	+17 V to plug-in units
H	VCO control voltage to self-inductance coil
J	VCO control voltage to capacitive diode
K	VCO voltage regulation
L	IA voltage regulation
M	BA voltage regulation
N	BA output voltage
P	ATD stop voltage

line through diode CR601. This voltage is connected from the test socket to all plug-in units, but is again filtered before reaching the VCO unit.

(3) Test Circuit. – Several test points are present which permit rapid localizing of defective plug-in units. The test socket is used with standard test equipment. Details of the voltages measured are given in Chapter 4. Table 3-4 identifies the circuits connected to the individual pins of the test socket.

(m) Adapter Box CY-250 – This box is required when the AM-4477 is fed from a vehicular electrical system. It replaces the normal battery box, and includes a rear connector to allow connection to the power source using a cable assembly. The box protects the AM-4477 against pulses above 33 volts which appear at the input. These pulses are grounded by zener diode CR1.

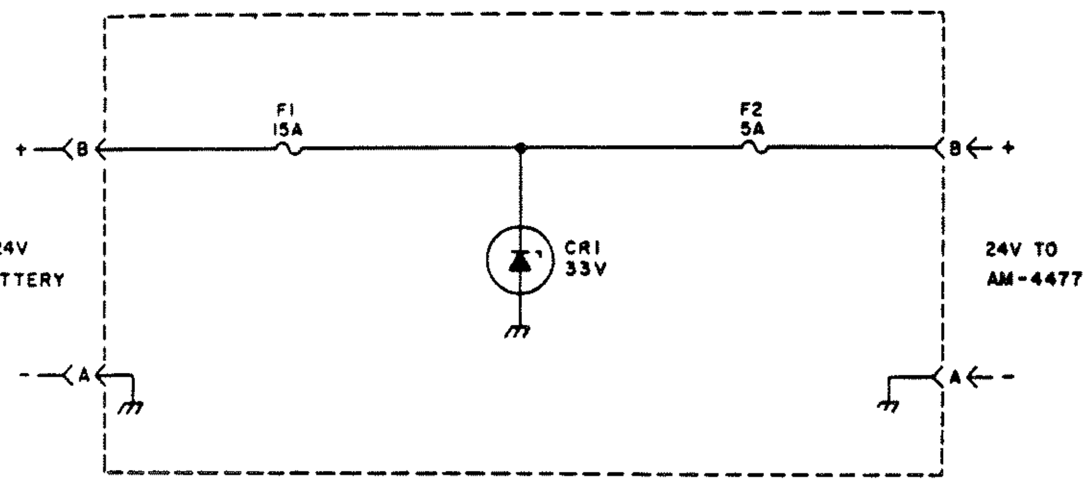


Figure 3–20. Adapter Box CY-250

CHAPTER 4

MAINTENANCE

4-1 TROUBLESHOOTING

(a) **Introduction.** – The procedures presented in this section are used in troubleshooting to (a) localize failures in replaceable units; (b) replace defective unit, and (c) check AM-4477 to ensure that the failure has been eliminated. The check list in Table 4-1 serves as a simple final test for the AM-4477.

(b) **Operational Check.** – The following troubleshooting procedure should first be used. The checks listed below should be made without removing the AM-4477 from its case. The following test equipment is necessary:

- Radio Set AN/PRC-25 or AN/PRC-77 (an RF signal generator with 2 W output may be used);
- Coaxial cable CG-409G/U
- RF wattmeter, Bird Model 611 or equivalent.

Procedure

(1) Connect transceiver to AM-4477 IN connector using coaxial cable CG-409G/U.
(2) Connect wattmeter to ANT connector.
(3) Switch wattmeter to its lowest scale.
(4) Perform procedure listed in Table 4-1 in the order given. When a normal indication is not obtained, stop test and proceed to paragraph 4-1(c).

Table 4-1 Operational Checklist

Action	Normal Indication	Probable Cause of Trouble
Set function switch to OFF position; Key RF source on 31 MHz	2 W	a. Defective interconnecting cable b. Defective radio set or RF generator c. Fault in AM-4477
Set function switch to 6 W position; Key RF source on 31 MHz	6 W	a. Defective battery b. Faulty AM-4477
Set function switch to 30 W position Key RF source on 31 MHz	30 W	a. Weak battery b. Faulty AM-4477
Key RF source on the following frequencies: 35, 40, 45, 50, 55, 58, 63, 68, 75 MHz	30 W	Faulty AM-4477

The AM-4477 is tested with a 50-ohm load as in a vehicular installation. The whip antenna matching sections can only be tested by communicating with another radio set at a distance of at least 100 meters. If the matching sections do not function properly, higher echelon repair is required.

(c) **Preparation for Troubleshooting.** – If the operational checks indicate a defective unit then remove the AM-4477 chassis from its case. Remove the cover which holds the plug-in units, as well as the silicone-rubber insert. It is now possible to replace plug-in units without further disassembly. In addition to the equipment used above the following equipment is required for troubleshooting:

(1) VTVM, Hewlett-Packard Model HP 410C or equivalent.

(2) Multimeter, Simpson Model 270 or equivalent (current measurements).

(3) 24 Volt, 4 amp power source (a stabilized power supply or a large 24 volt battery are recommended).

(d) **Procedure.** –

(1) Connect output of transceiver to IN connector using coaxial cable, CG-409G/U.

(2) Connect wattmeter to AM-4477 ANT connector.

(3) Follow the sequence in Table 4-2; when an abnormal indication is obtained.

(4) Set transmitter to 75 MHz.

Replace the unit suggested in the corrective measures column as given in Table 4-4. If the fault is not remedied return the original part or unit and replace the next item listed. Continue this procedure until the fault is corrected. Continue to perform the remaining steps listed in the table to ensure that no other faults are present.

(e) **Troubleshooting Chassis Wiring.** – This procedure localizes trouble in the wiring and components of the chassis assembly, by resistance measurement with a multimeter. Trouble can also be localized in the multiconductor cables and to a limited extent in the front panel assembly. Before measuring resistances, remove all external connections to the AM-4477 as well as the seven plug-in units. The normal resistance values and the connecting leads are shown in figure 4-1. If an incorrect reading results, the AM-4477 must be disassembled further for repair; this includes opening the hinged chassis, removing the coaxial plug under the printed board of the PA assembly, and removing the chassis bottom plate. Disassembly and assembly of these parts must be performed carefully and according to the instructions in paragraph 4-2; otherwise the AM-4477 may be damaged and high echelon repair will be necessary.

4-2 REPAIRS.

(a) **Introduction.**

(1) Range Booster AM-4477 may be repaired only by qualified personnel provided with suitable tools and test equipment. An inexperienced operator who tries to repair the AM-4477 may damage the set such that it may need overhaul.

(2) Sometimes components or wiring may have to be removed for access to the faulty part; if so, draw a sketch of the wires to be removed and their location in the AM-4477.

(3) Avoid dropping solder into the AM-4477; the tiniest bit of solder may cause short circuits. When soldering diodes, use long-nose pliers, held around the wire between the

Table 4-2 Troubleshooting Chart

Step	Indication	Possible Cause of Fault	Check or Corrective Measure
1	No output of 1.5 watts at ANT connector with function switch at OFF	a. Defective Relay K_1 and/or K_2 b. Defective coax cable c. Defective Antenna switch	a. Replace relays K_1 and/or K_2 b. Replace coax cable c. Higher echelon repair required
2	No 6 W output with function switch in 6 W position	a. Short circuit in plug-in unit or chassis wiring b. Motor jamming c. Short circuit in wiring between motor and ATD	a, b, and c require higher echelon repair (To verify motor jamming perform checks at 75, 68, 63, 58, 55, 50, 45, 40 and 31 MHz and measure voltage at point P).
3	Output level too high with function switch in 6 W position	AGC circuit of BA unit not operating properly	Replace BA unit.
4	Output level too low with function switch in 30 W position	Faulty BA unit	Replace BA unit.
5	No output with function switch in 30 W position	a. Faulty plug-in unit(s) b. Booster does not key c. AGC wire to PA open or short circuited	(a) Measure voltages and/or currents at test points given Table 4-3 below. Replace most probable faulty plug-in unit as suggested in Table 4-4 (b) Check test point Em for incorrect readings at test points noted. Repeat test as necessary. (c) Higher echelon repair required.
6	No output with function switch in 6 W position	Faulty plug-in unit(s)	Same procedure as in Step 5 above.

Table 4-3 Test Point Readings

Test Pt.	Normal Reading 30 W	Normal Reading 6 W
B-B*	3.2 A	
B-D	450 mA	
E	+17 V	
E-F	180 mA	
H		8 – 8.5 V
J		8 – 8.5 V
K		9.3 – 9.5 V
M	.75 – .79 V	
N	4 – 4.25 V	
P		1.1 V
L		50 mV

* Using special Test fixture.

Table 4-4 Probable Defective Unit vs Incorrect Test Point Readings

Incorrect Test Point Reading	Probable Defective Unit: T/R	PL	IA	VCO	BA	MD	ATD
6W		H J	H L	H J K L		P	P
30W	E**	E-F M	E-F	E-F	E-F B-D M N	B-D M	

** See step 5(b). Table 4-2

point of solder and the diode, as a heat sink.

(4) Never change the location of components or wiring, as this may affect circuit operation.

(5) Take special care when disassembling and assembling mechanical parts; tighten screws well.

(b) **Disassembly.** To troubleshoot and repair the AM-4477, the set must be partially disassembled. Never disassemble the AM-4477 more than is necessary for repair.

(1) Removal of Case. – Position AM-4477 with front panel downward. Remove the four screws that join the front panel to the case. Hold battery plug downward with the thumb, and lift off case.

(2) Removal of Cover of Plug-in Units. Loosen carefully the two retaining springs on each side of chassis using a screwdriver. Bend springs backward, and lift off cover carefully.

(3) Opening Hinged Chassis. – Remove the two screws, that are flush with the chassis, from side plate opposite hinge. Lift the chassis (about 5 cm) and disconnect the coaxial plug from the PA; plug is located under upper circuit plate of PA and should be separated using a pair of bent tweezers or long-nose pliers. (Be sure not to damage the snap lock of the coaxial plug). The hinged chassis can now be swung all the way up.

(4) Removal of Chassis Bottom Plate. – Remove the six retaining screws and pry plate off with a screwdriver . This gives access to chassis wiring.

(5) Removal of Relay Clamp Strap. – Remove all plug-in units, and unscrew the strap retaining screws. Remove strap and replace relays. Pin-connections of the relays are symmetrical, so relay orientation is unimportant.

(c) **Assembly.**

(1) Replacement of Chassis Bottom Plate. Ease the plate into position, being careful not to dislodge the spring sections. Position plate with all screw holes correctly aligned, insert screws and tighten them well.

(2) Closing Hinged Chassis. Close chassis sufficiently to permit connection of coaxial cable to PA. Connect coaxial plug and press it firmly until the snap lock engages with a click. When closing the chassis fully, ensure that all pins and guide springs engage side plates of antenna filter assembly, antenna matching unit, and step motor unit. When chassis is fully closed, the screw holes of side plate are aligned. Insert screws and tighten them well.

(3) Replacement of Cover for Plug-in Units. – Remove silicon rubber insert from cover and position it in place. Install cover, make sure side sections and multipin plug are properly engaged; then replace the four springs.

(4) Replacement of Case. – Position AM-4477 with front panel downward. Slide case over AM-4477, pressing it down until it meets the rubber gasket at both sides. Insert the four screws and tighten until gasket is sealed. Normal tightening should not cause side lugs of case to meet front panel. Do not tamper with the screw at the bottom of the case; it is used for vacuum-testing a sealed AM-4477.

4-3. **ILLUSTRATIONS** – The illustrations on the following pages are provided to assist in the maintenance (and troubleshooting) of the AM-4477.

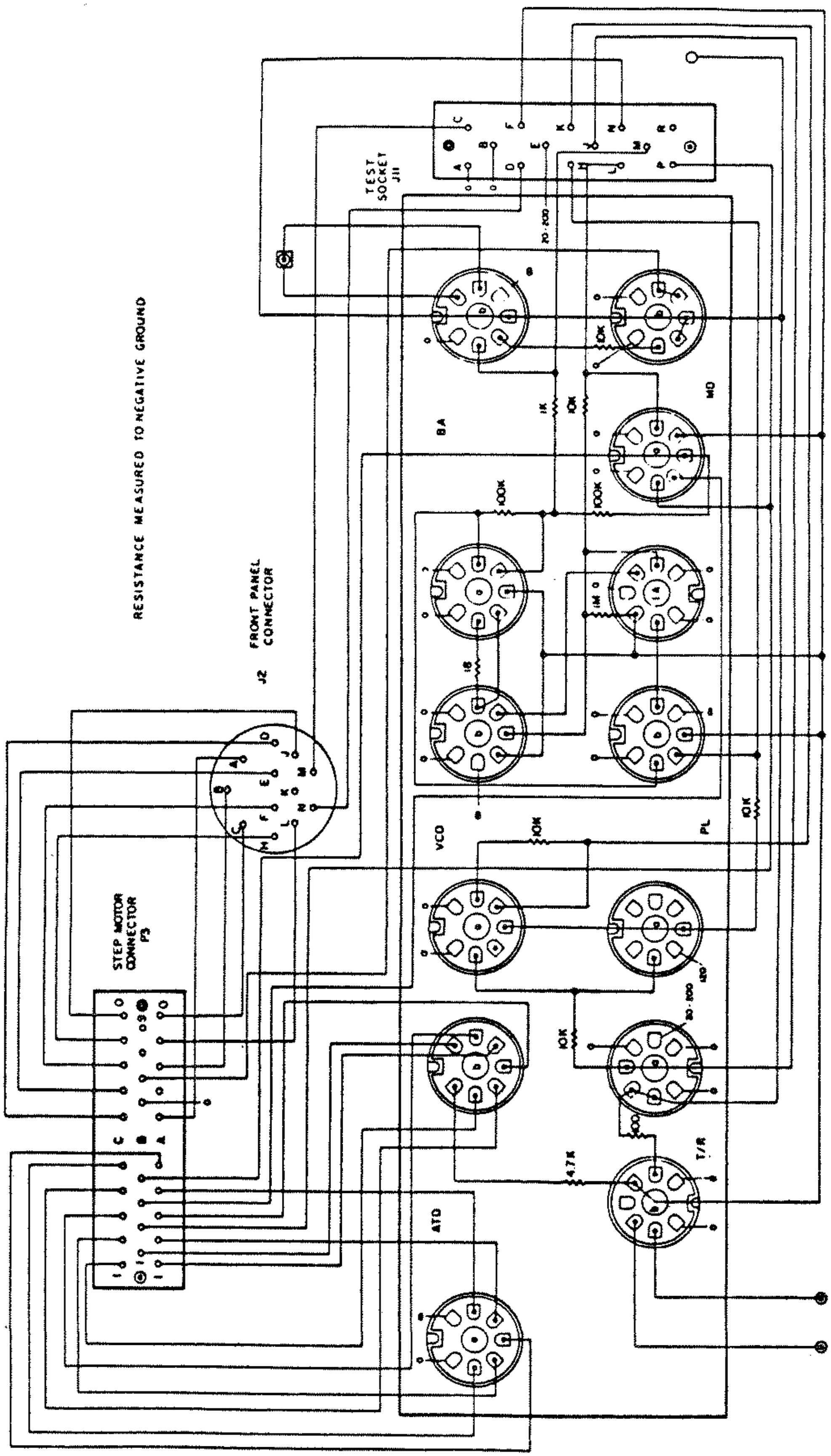


Figure 4–1. Resistance Measurements

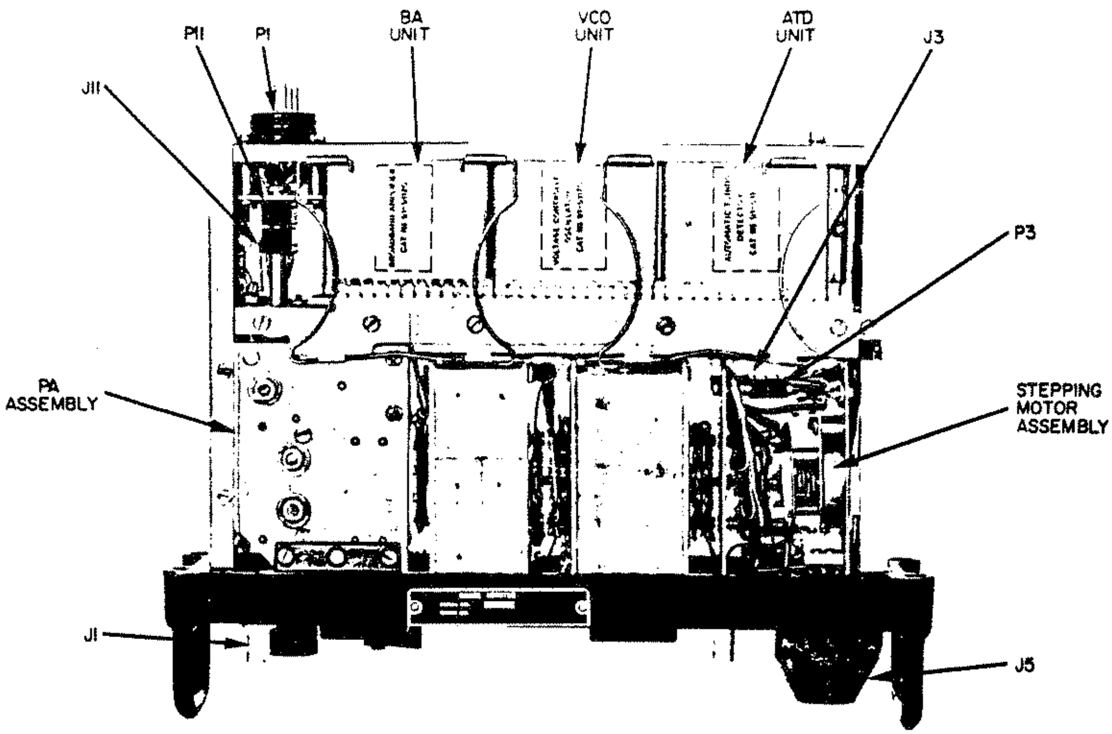


Figure 4–2. AM-4477 Removed from Case, Top View

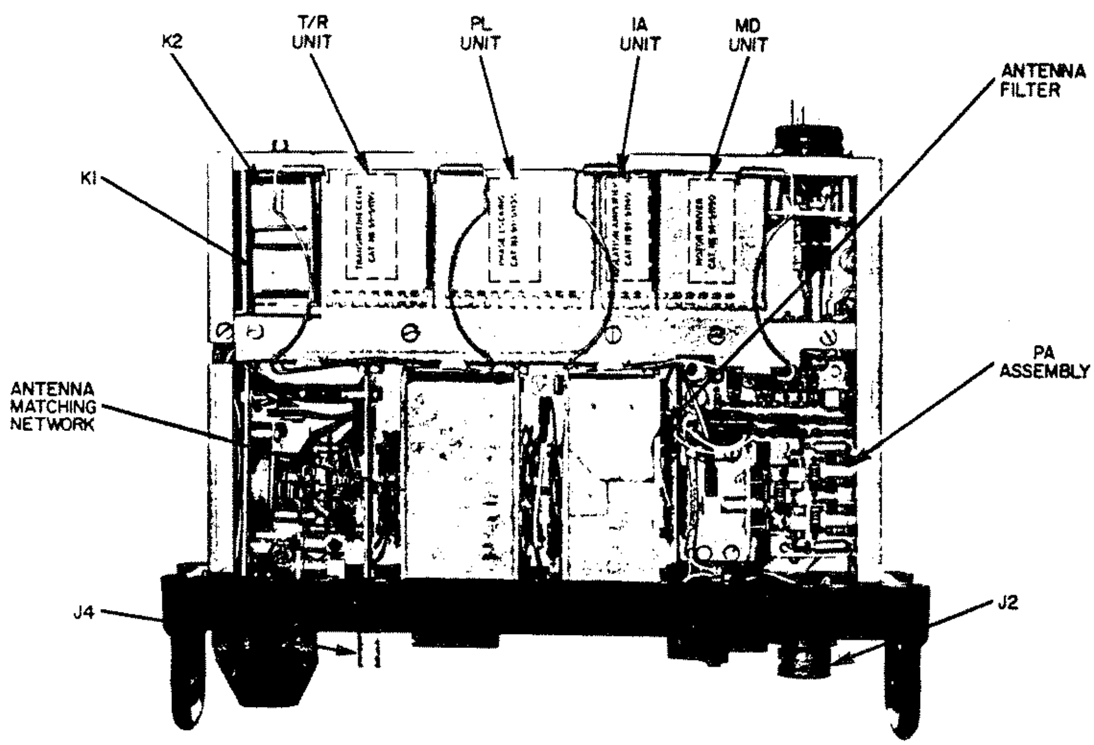
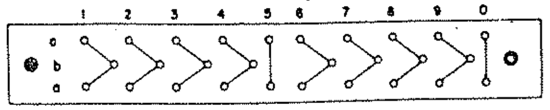


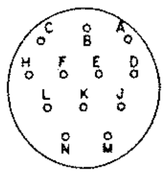
Figure 4–3. AM-4477 Removed from Case, Bottom View

NOTES:

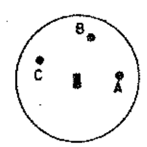
1. SWITCH S2 ACTIVATED BY INSTALLING ANTENNA (SHORT OR LONG) IN WHIP ANTENNA MOUNT.
2. SWITCHES S3 AND S4 ACTIVATED BY INSTALLING LONG ANTENNA IN WHIP ANTENNA MOUNT.
3. POWER SWITCH SHOWN IN 30W POSITION SEEN FROM REAR.
4. ALL RESISTANCES IN OHMS
5. ~ SIGNIFIES FERRITE BEAD
6. PLUG P3 (PIN SIDE)



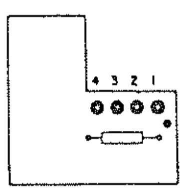
7. ANTENNA CONTROL CONNECTOR J2 (RECEPTACLE SIDE)



8. BATTERY CONNECTOR P1 (PIN SIDE)

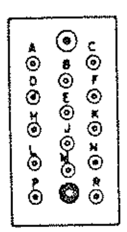


9. POWER AMPLIFIER JACKS



(FOR PARTS REPLACEMENT, JACKS ARE NUMBERED J401, J402, J403, J404)

10. TEST SOCKET J9 (RECEPTACLE SIDE)



LEGEND:

- ——— +24V
- -·-·-·- +17V REGULATED
- ——— MAIN TRANSMIT SIGNAL (AND RECEIVE AS REQUIRED)
- ━━━ MAIN RECEIVE SIGNAL ONLY

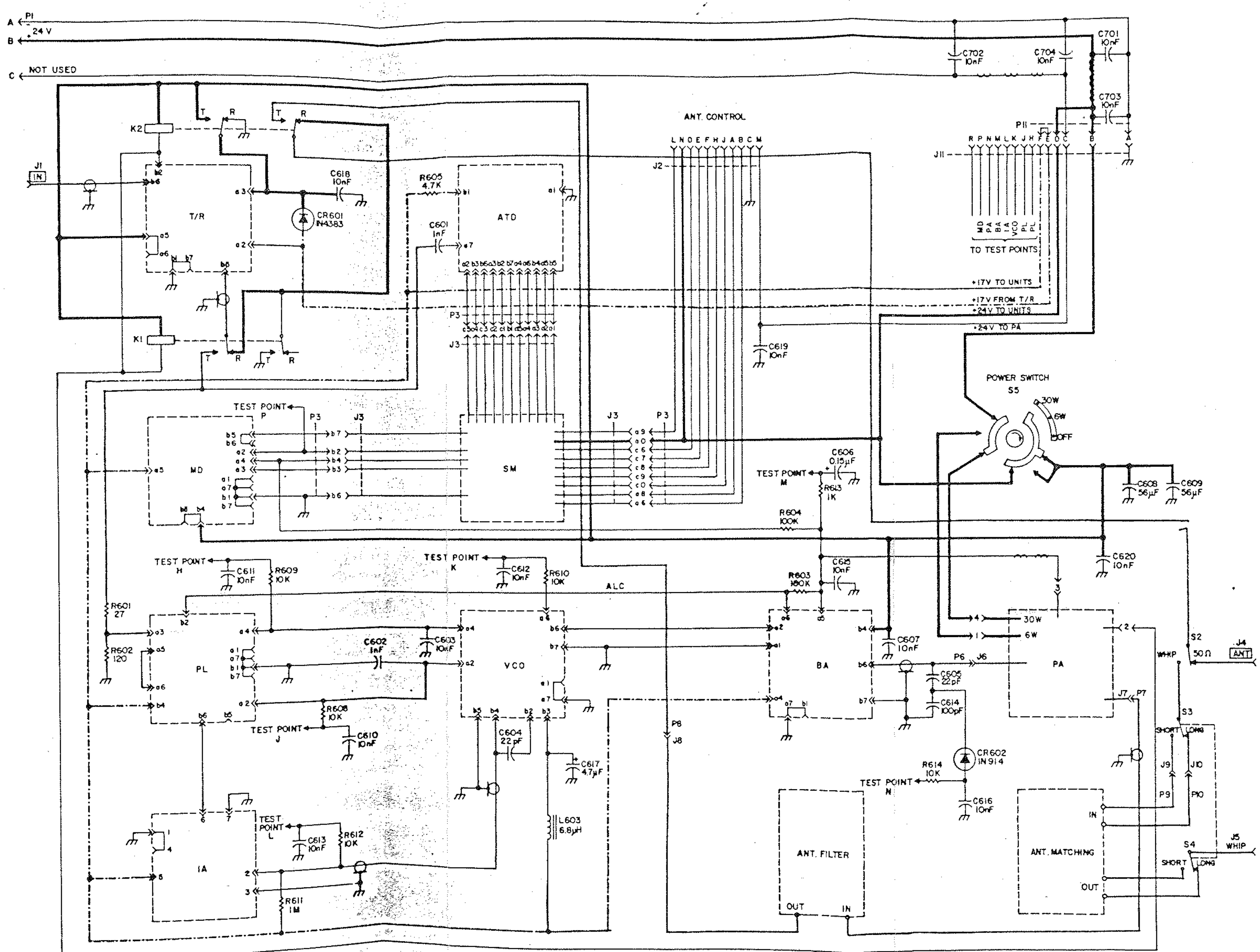


Figure 4–4. Complete Schematic Diagram

5-2. Electrical Repair Parts List.

REF. DES.	DESCRIPTION	QTY.	MFR. CAT. NO.
C101	Capacitor, ceramic: 10nF, 50V	79	911200103
C102 -C105	See C101		
C106	Capacitor, tantalum: 1μF, 50V	5	911201101
C107	See C101		
C108	Capacitor, tantalum: 4.7uF, 50V	6	911201102
C151	Capacitor, ceramic: 10pF, 400V	1	911200301
C152	Capacitor, tantalum 22uF, 15V	1	911201800
C153	Capacitor, tantalum 0.22μF, 100V	1	911201203
C154	Capacitor, ceramic: 1nF, 50V	10	911200101
C155	Capacitor, tantalum: 68nF, 100V	1	911201201
C156	Capacitor, tantalum: 15μF, 20V	2	911201002
C157	Capacitor, mica: 100pF, 100V	1	911201713
C158	See C101		
C159	Capacitor, mica: 390pF, 100V	3	911201709
C160	Capacitor, ceramic: 47pF, 400V	1	911200200
C161, C162	See C159		
C163	See C154		
C201	See C101		
C202	See C154		
C203	Capacitor, ceramic: 100pF, 25V	4	911200401
C204 -C207	See C101		
C208	See C154		
C209	See C203		
C210 -C212	See C101		
C251	See C101		
C252	Capacitor, tantalum: 10μF, 20V	1	911201001
C301	Capacitor, ceramic: 29pF, 400V	1	911200605
C302	Capacitor, ceramic: 40pF, 400V	1	911200608
C303	Capacitor, ceramic: 30pF, 400V	1	911200606
C304	Capacitor, ceramic: 23pF, 400V	2	911200603
C305	Capacitor, ceramic: 21pF, 400V	2	911200601
C306	Capacitor, ceramic: 22pF, 400V	1	911200602
C307	Capacitor, ceramic: 45pF, 400V	1	911200609
C308	Capacitor, ceramic: 32pF, 400V	1	911200607
C309	Capacitor, ceramic: 25pF, 400V	1	911200604
C310	See C304		
C311	See C305		
C312 -C325	See C101		
C326	Capacitor, ceramic: 4.7nF, 25V	1	911200700
C351	Capacitor, ceramic: 3.3nF, 50V	1	911200102
C352	See C154		
C353	See C106		
C354	See C101		
C355	See C154		
C356 -C359	See C101		
C360	See C203		
C361	See C154		
C362	Capacitor, ceramic: 220pF, 25V	2	911200402
C363	See C101		
C364	See C362		
C365 -C369	See C101		
C401	See C154		
C402 C403	See C101		
C404	Capacitor, ceramic: 390pF, 400V	3	911200800
C405	See C108		
C406 -C409	See C101		
C411	See C156		
C412 C413	See C101		
C452, C453	See C101		
C454	See C106		
C455, C456	See C101		
C457	See C108		
C458, C459	See C101		
C461	See C106		
C462, C463	See C101		
C464	See C108		
C465	See C101		
C467	See C101		
C468	See C108		
C469 -C475	See C101		
C476	See C106		