The low level amplifier is a class A amplifier stage. At rated output power a nominal input level of +2 dBm from the VCO buffer is amplified to a nominal level of +10 dBm (+9dBm for 2 Watt models). The bias to this stage is adjusted by the power control circuit for a variation in gain and output level required for power leveling and low transmitter output power settings.

The predriver is also a class A amplifier. At rated output power it amplifies a nominal signal level of +10 dBm to a nominal level of +17.5 dBm (+9 dBm to a nominal level of +14 dBm for 2 Watt models). This stage too has variable bias controlled by the power control circuit.

Bias to the low level amp(Q7) and predriver(Q8) is switched through Q12 in transmit mode. It is also filtered to suppress feedback on the positive bias line which may cause oscillations. In receive mode Q12 does not conduct and the collector of Q12 is pulled low , thus removing bias to Q7 and Q8. This turns off the transmitter.

The driver is a class C amplifier with a nominal gain of 10 dB (8dB for 2 Watt models). Its RF input signal, provided by the predriver is amplified to a nominal level of +27.5 dBm (+22dBm for 2 Watt models).

The final stage is a class C amplifier. It has a nominal gain of 10 dB (11.5 dB for 2 Watt models). Its RF input signal provided by the driver is amplified to a nominal level of +37.5 dBm (5.6 watts) for 5 watt models, and to 33.5 dBm (2.25 watts) for 2 Watt models.

## B. HARMONIC FILTER

The harmonic filter is a 7 pole elliptical lowpass filter. It attenuates the harmonics created by the power amplifier to levels more than 60 dB below the carrier. The input and output impedances of the filter are designed to be 50 ohms within the radio's band of operation (20 ohms in and 50 ohms out for 2 Watt models). The elements which make up the harmonic filter are C67, C68, C69, C70, C71, C72, C73, L24, L25, and L26.

## C. ANTENNA SWITCH

The antenna switch serves as a single-pole double-throw switch for RF signals.


Antenna Switch Functional Block Diagram

1. RECEIVE MODE

   In receive mode the receiver is connected to the antenna as shown(see figure). Q12 turns off bias to CR1 and CR13 which appear as open circuits to RF signals. Components C1, C2, C3, C5, and L1 then match the receiver to 50 ohms.

2. TRANSMIT MODE

   In transmit mode the transmitter is connected to the antenna port as shown(see figure). Q12 conducts turning on CR1 and CR13. Bias current is set by R52. Components C1, C2, C74, and L1 then match the output of the harmonic filter to 50 ohms.

## D. POWER CONTROL CIRCUIT

The power control circuit monitors the supply current in the power amplifier's final stages. This current is nearly proportional to the transmitter output power and is kept constant by the power control in order to level output power.

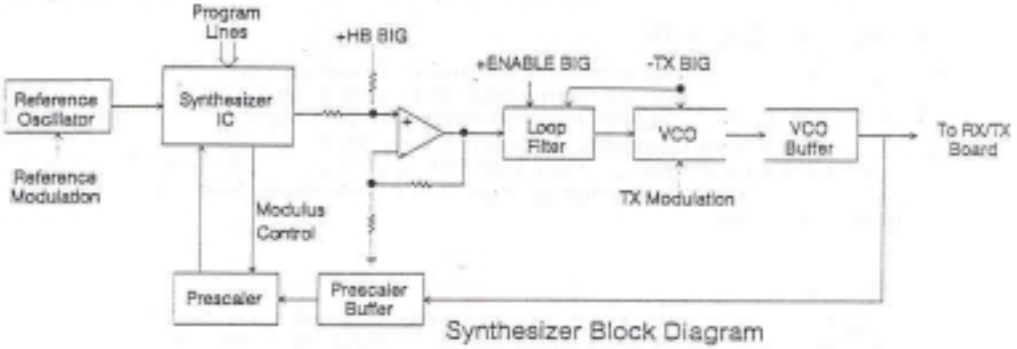
The power control is implemented in four steps.

1. Supply current is sensed in the final amplifier stages. A 100 milliohm resistor (R14) in the supply line develops a voltage at its terminals which is proportional to the supply current.
2. An error voltage is created with the current sense voltage and the PWR SET voltage. This is accomplished in a resistor bridge.
3. The error voltage is amplified using an operational amplifier (I3).
4. The amplified error voltage controls the supply current to the low level and predriver amplifier stages by means of an FET in the supply return path (Q9). This varies the gain of these stages.

Varying the gain in the low level and predriver amplifiers varies the drive level to the driver and final. This has the desired effect on transmitter current and thus on transmitter power in the final stages.

### 4.3.3 SYNTHESIZER

The purpose of the synthesizer is to generate an RF signal either to downconvert a desired receive frequency to a fixed IF (16.9 MHz) or to drive the transmitter. The synthesizer is essentially a phase locked loop that locks the RF output of a voltage controlled oscillator (VCO) to a very stable lower frequency reference. The microcontroller determines the frequency that the synthesizer produces by programming the dividers contained within the synthesizer IC.



Synthesizer Block Diagram

A. VOLTAGE CONTROLLED OSCILLATOR (VCO)

Transistor Q4 provides the gain and an L-C resonant tank circuit provides the frequency selectivity and phase shift necessary to produce an oscillator. Frequency control of the oscillator is accomplished by the tuning tank circuit comprised of mechanically adjustable transformer T1 and varactors CR4 and CR5. CR4 is used to lock the VCO to the desired carrier frequency while CR5 is used in the transmit mode to modulate the carrier. The oscillator frequency range is 148-174 MHz in the transmit mode and 131.1-157.1 MHz in the receive mode (low side injection). The 16.9 MHz shift from transmit to receive is achieved by turning on PIN diode CR3, thus adding L4 to the tank circuit. Q5 and associated circuitry provide additional power supply filtering for the VCO. Diode CR6 gives the filter a rapid power up response while maintaining a very low cutoff frequency.

B. VCO BUFFER

The VCO buffer is a cascode configuration with bipolar transistor Q3 feeding common gate FET Q21. It isolates the VCO from the receiver/transmitter circuitry and provides enough power gain to supply a nominal level of +3dBm in receive and +0dBm in transmit.

C. PRESCALER BUFFER

Prescaler buffer Q2 provides isolation between the prescaler and receiver/transmitter circuitry and additional isolation between the prescaler and the VCO.

D. PRESCALER

Prescaler I11 is an emitter coupled logic device which divides down the RF signal provided by the prescaler buffer to a frequency which can be processed by the following CMOS dividers. The prescaler is of the dual modulus type which allows the divide value to be set by the synthesizer IC to either divide-by-40 (modulus control line high) or divide-by-41 (modulus control line low). This capability allows the RF signal frequency to be divided by integers that are not multiples of either 40 or 41.

E. SYNTHESIZER IC

Synthesizer chip I12 contains three programmable CMOS dividers, a sample-and-hold phase detector, and an amplifier which forms an on-chip reference oscillator when connected to the terminals of an external crystal (Y1). The first divider (divide-by-R) divides down the reference oscillator to a frequency which is used as a reference by the sample-and-hold phase detector. The second divider (divide-by-N) divides down the output of the prescaler to a frequency which is equal to the divided down reference frequency when the loop is locked. The third divider (divide-by-A) controls the modulus control line of the prescaler. The sample-and-hold phase detector provides a DC voltage that is proportional to the phase error between the divided down reference and the divided down carrier. This voltage is fed through the loop filter to the VCO and adjusts the VCO frequency in a direction to maintain phase and frequency lock between the two divided down signals.

F. REFERENCE OSCILLATOR

The reference oscillator provides the reference frequency from which the receiver and transmitter injection signals are synthesized. The oscillator frequency is controlled by crystal Y1 which operates in the parallel resonant mode across an amplifier built into the synthesizer IC. This crystal is compensated to plus or minus 5ppm by a temperature compensating circuit built around transistor Q1, thermistor RT1, and varactors CR1 and CR2. In addition, a method of modulation is provided to improve the synthesizer frequency response to low frequency modulation.

G. LOOP FILTER

The loop filter removes noise and unwanted frequency components from the output of the sample-and-hold phase detector which would otherwise modulate the VCO. It employs a multiple filter bandwidth design which allows fast response during frequency changes (such as in Channel Scan) without degrading the noise and spurious performance of the synthesizer during steady state receive or transmit conditions. The filter is switched to a wide bandwidth condition when the +ENABLE BIG line pulses high for approximately 4 msec during a frequency change. This allows the new frequency to be reached quickly. When the +ENABLE BIG line returns to the low state, the filter bandwidth changes to a narrow condition and provides for good noise and spurious performance. Finally, different filter bandwidths are used from transmit to receive to provide better hum and noise performance on transmit and better response time on receive. This is accomplished by changing the filter bandwidth to a narrower value when the -TX BIG line goes low during transmit.

H. ACQUISITION AID BIT

The +HB BIG signal summed with the synthesizer IC phase detector output prior to the loop filter helps to keep the phase detector operating near the middle of its range. This bit is low for the lower half of either the receive or transmit band, and high for the upper half of either band.

### 4.3.4 SYSTEMS AREA

A variety of functions is included in the systems area.

A 5 volt precision voltage regulator provides power to the microprocessor and several other ICs in the radio. The -RESET signal from this circuit will prevent any radio functions if the battery voltage falls too low. The 8.2 volt regulator is used for synthesizer and VCO functions. An output signal will alert the processor if the battery voltage falls too low for proper operation.

Several special transmitter features are implemented by the microprocessor. These include repeater-talk-around, busy channel lockout, DTMF generation, ANI generation, sub-audible Code Guard generation, and time out timer.

Receive mode special features provided by the microprocessor include channel scan, priority scan, scan hold timer, battery saver, and tone and digital guard decoding.

Other functions performed by the microprocessor are synthesizer control and data loading, channel and hardware information storage, provision of a receiver front end tuning voltage, interpretation of the user switches, generation of display information, and remote and keypad programming mode.

A. MICROPROCESSOR

The microprocessor (I1) receives inputs from user switches and controls radio functions such as loading the synthesizer, adjusting the transmitter deviation, tuning the receiver, setting transmit power, time out functions, etc.

B. MICROPROCESSOR OSCILLATOR

The microprocessor oscillator consists of Y2, R82, C45, C44, R98, R99, and Q22. The frequency of oscillation can be altered slightly by Q22 to prevent interference when tuned to receive channels that are exact multiples of 4 MHz.

C. EEPROM

The EEPROM (I7) stores channel information and hardware compensation values. It is switched off to conserve energy by Q13 when not in use.

D. SIGNALING AND SWITCHING

The signaling D/A and switching network consists of RN1, I4, and I14. This circuitry allows the microprocessor to generate DTMF and ANI tones, transmit code guard, and various audio beeps heard in the speaker.

E. FRONT END TUNING AND POWER SET

The front end tuning and power set D/A converter is composed of a serial loaded register (I2) a resistor network (RN2) and amplifier (I3). In receive mode the voltage from RN2 is used to tune the front end filters on the Rx/Tx board. In transmit mode it is used to set the transmitter power.

F. 5V REGULATOR AND LOW VOLTAGE RESET

I8 provides a regulated 5 volt supply for the radio. An output signal from the regulator will force the microprocessor into a reset condition if the battery voltage drops below about 5 volts.

G. 8.2V REGULATOR AND LOW BATTERY SHUTDOWN

An 8.2 volt regulator is composed of I3, Q10, and associated circuitry. Regulator operation is monitored via Q11. The microprocessor will shut down radio operation if a low battery or 8.2 volt short circuit occurs. I14 is used to switch the regulator off during battery saver mode.

H. RECEIVE AUDIO

I9 is a .5 Watt audio amplifier. Muting is controlled by the microprocessor via Q16.

I. DEVIATION COMPENSATION

The transmit modulation deviation compensation network consists of R42 thru R45. At nigher transmitter frequencies less voltage is needed for VCO modulation, so this circuit attenuates the signal. Also, when guard tones are being transmitted, the deviation sensitivity is reduced by approximately 15% so that 5 KHz peak deviation is not exceeded.

J. CHANNEL SWITCH MULTIPLEXER

The channel switch multiplexer (I5) allows four lines to the microprocessor to be shared between two different functions. In receive mode, the channel selector switch position may be examined via I5. In transmit mode, I5 is used to disconnect the channel switch from the microprocessor so that these signals may be used for the deviation compensation circuitry.

K. SQUELCH THRESHOLD PRESET

Pin 11 of I5 is used to switch a resistor into the squelch circuit thus lowering the squelch threshold when the Squelch knob is in the "preset" position.

# SECTION V
# MAINTENANCE

## 5.1 INTRODUCTION

This maintenance section contains test and alignment procedures for an operational EPH Series radio. This section also contains troubleshooting and assembly/disassembly procedures. An understanding of the theory of operation is recommended before maintenance is attempted.

## 5.2 TEST EQUIPMENT REQUIRED

A. RF Signal Generator: HP8640B or equivalent

B. Distortion Analyzer: HP334A or equivalent

C. RF Voltmeter (optional): Boonton 92C or equivalent

D. RF Power Meter: HP435B with 30 dB pad or equivalent

E. Service Monitor: Cushman 4000 Radio Communications Test Set or equivalent

F. Digital Multimeter: Fluke 8012A or equivalent

G. Programmer: Companion radio with keyboard display.
(for non-keyboard/display units only)

H. Computer: IBM PC or compatible, with 256K memory and an RS-232 serial port
LAA0705 or LAA0725 programming cable
EPH frequency programming software
EPH RX/TX tuning software

I. Portable Tool Kit: LAA0600, P/N 050-02567-0000.
This tool kit consists of the following parts:

| | |
|---|---|
| Antenna Adaptor Key | 047-06754-0000 |
| Battery Eliminator | 071-05087-0000 |
| Spline Wrench .48 | 071-06119-0000 |
| Spanner | 076-01451-0000 |
| Accessory Test Cable | 155-02260-0000 |
| RF Cable Assembly | 155-02268-0000 |
| Audio Cable Assembly | 155-02269-0000 |

J. Test Cable Kit: LAA0608, P/N 050-02767-0000.
This cable kit consists of the following parts:

| | |
|---|---|
| Eight-pin interconnect cable | 155-02528-0000. |
| Ten-pin interconnect cable | 155-02564-0000. |
| Twelve-pin interconnect cable | 155-02565-0000. |
| RF Output interconnect cable | 155-02566-0000. |
| Local Oscillator cable | 155-02567-0000. |

# 5.3 OVERHAUL

## 5.3.1 VISUAL INSPECTION

This section contains instructions to assist in determining, by inspection, the condition of EPH assemblies. Defects resulting from wear, physical damage, deterioration, or other causes can be found by these inspection procedures. To aid inspection, detailed procedures are arranged in alphabetical order.

A. CAPACITORS, FIXED

Inspect capacitors for case damage, body damage, and cracked, broken, or charred insulation. Check for loose, broken, or corroded terminal studs, lugs, or leads. Inspect for loose, broken, or improperly soldered connections. On chip caps be especially alert for hairline cracks in the body and broken terminations.

B. CAPACITORS, VARIABLE

Inspect trimmers for chipped and cracked bodies, damaged dielectrics and damaged contacts.

C. CHASSIS

Inspect the chassis for deformation, dents, punctures, badly worn surfaces, damaged connectors, damaged fastener devices, loose or missing hardware, component corrosion, and damage to the finish.

D. CONNECTORS

Inspect connectors for broken parts, and other irregularities. Inspect for cracked or broken insulation and for contacts that are broken, deformed, or out of alignment. Also, check for corroded or damaged plating on contacts and for loose, improperly soldered, broken, or corroded terminal connections.

E. COVERS AND SHIELDS

Inspect covers and shields for punctures, deep dents, and badly worn surfaces. Also, check for damaged fastener devices, corrosion and damage to finish.

F. FLEX CIRCUITS

Inspect flex circuits for punctures, and badly worn surfaces. Check for broken traces, especially near the solder contact points.

G. FUSE

Inspect for blown fuse and check for loose solder joints.

H. INSULATORS

Inspect insulators for evidence of damage, such as broken or chipped edges, burned areas, and presence of foreign matter.

I. JACKS

Inspect all jacks for corrosion, rust, deformations, loose or broken parts, cracked insulation, bad contacts, or other irregularities.

J. POTENTIOMETERS

Inspect all potentiometers for evidence of damage or loose terminals, cracked insulation or other irregularities.

K. RESISTORS, FIXED

Inspect the fixed resistors for cracked, broken, blistered, or charred bodies and loose, broken, or improperly soldered connections. On chip resistors be especially alert for hairline cracks in the body and broken terminations.

L. RF COILS

Inspect all RF coils for broken leads, loose mountings, and loose, improperly soldered, or broken terminal connections. Check for crushed, scratched, cut or charred windings. Inspect the windings, leads, terminals and connections for corrosion or physical damage. Check for physical damage to forms and tuning slug adjustment screws.

M. TERMINAL CONNECTIONS SOLDERED

1. Inspect for cold-soldered or resin joints. These joints present a porous or dull, rough appearance. Check for strength of bond using the points of a tool.
2. Examine the terminals for excess solder, protrusions from the joint, pieces adhering to adjacent insulation, and particles lodged between joints, conductors, or other components.
3. Inspect for insufficient solder and unsoldered strands of wire protruding from conductor at the terminal. Check for insulation that is stripped back too far from the terminal.
4. Inspect for corrosion at the terminal.

N. WIRING/COAXIAL CABLE

Inspect wiring in chassis for breaks in insulation, conductor breaks, cut or broken lacing and improper dress in relation to adjacent wiring or chassis.

### 5.3.2 CLEANING

A. Using a clean, lint-free cloth lightly moistened with soap and water only, remove the foreign matter from the equipment case and unit front panel. Wipe dry using a clean, dry, lint-free cloth.

B. Using a hand controlled dry air jet (not more than 15psi), blow the dust from inaccessible areas. Care should be taken to prevent damage by the air blast.

C. Clean the receptacles and plugs with a hand controlled dry air jet (not more than 25psi), and a clean, lint-free cloth lightly moistened with soap and water only. Wipe dry with a clean, dry, lint-free cloth.

### 5.3.3 REPAIR

This section describes the procedure along with any special techniques for replacing damaged or defective components.

#### A. CONNECTORS

When replacing a connector, refer to the appropriate PC board assembly drawing and follow the notes to insure correct mounting and mating of each connector.

#### B. CRYSTAL

The use of any other than a BENDIX/KING crystal is considered an unauthorized modification.

#### C. DIODES

Use long nose pliers as a heat sink under normal soldering conditions. Note the diode polarity before removal.

#### D. INTEGRATED CIRCUITS

Refer to Appendix A for removal and replacement instructions.

#### E. WIRING/COAXIAL CABLE

When repairing a wire that has broken from it's terminal, remove all old solder and pieces of wire from the terminal, restrip the wire to the necessary length and resolder the wire to the terminal. Replace a damaged wire or coax with one of the same type, size and length.

## 5.4 DISASSEMBLY/ASSEMBLY

### 5.4.1 BATTERY REMOVAL

To remove the battery pack, turn the radio off. Press up the metal tab on the side of the case while turning the pack approximately 30°. Remove the pack from the radio.

### 5.4.2 UNIT DISASSEMBLY

1. Remove the four screws from the radio rear cover (the side opposite the speaker grill).
2. Remove the two screws holding the heat sink shield to the rear cover and remove the heat sink shield.
3. Loosen the PTT housing screw and separate the front cover from the main frame.

A. OPTIONS BOARD AND KEYBOARD

A. Disconnect the zero force insertion connector (J 10) from the options board, by sliding the connector sleeve toward the top of the radio. This allows the flex cable to be unplugged.

B. Remove the five screws that secure the options board to the keyboard and the front cover, unplug the keyboard.

B. RX/TX BOARD

A. Unfasten the three retaining clip screws that secure the RX/TX board to the main frame.

B. Carefully remove the antenna coax from the RX/TX connector.

C. Lift up on the RX/TX board until it is disconnected from the systems board.

C. SYNTHESIZER AND VCO

Remove the screw and unsolder the 5 tabs that secure the Synthesizer shield to the systems board. Remove the shield halves from both sides of the systems board.

D. TOP PLATE AND SWITCH BOARD

A. Remove the channel select, volume, and the squelch knobs.

B Remove the retaining fasteners from the channel select switch, volume control, and the squelch control.

C. Remove the bezel and inlay, retaining the channel select stop pins.

D. Remove the retaining fasteners from the talk around, scan, and priority switches.

E. Unfasten the four screws that secure the top frame assembly to the main frame (the screws are located on the side of the frame, two screws beside the channel select switch and two screws below the PTT housing).

F. Unsolder the audio jack wire from systems board location E13.

### 5.4.3 ASSEMBLY

To assemble the unit complete the disassembly procedure in reverse order.

## 5.5 TEST AND ALIGNMENT PROCEDURES

### 5.5.1 TEST SET-UP

The radio should be supplied with 10.5 VDC power from an external power supply, and the manual controls shall be set as follows:

| | |
|---|---|
| Channel Selector: | Channel 1 |
| On/Off Volume: | On, Volume minimum |
| Squelch/Monitor: | Unsquelched, Fully Clockwise |
| High / Low power: | High power |
| Scan: | Off |
| Priority: | Off |
| Battery Saver: | Off |

The radio should be mounted in a suitable fixture containing an adaptor for supplying DC power from an external power supply.

Refer to Figures 5-2 and 5-3 for Transmitter and Receiver test setup. These figures show the interface between test equipment and the radio.

### 5.5.2 SYNTHESIZER

A. VCO ADJUSTMENT

1. The radio should be programmed with 148 and 174 MHz.
2. Set the radio to receive on 148 MHz.
3. Connect a digital voltmeter between TPE16 and ground.
4. Adjust T1 for a reading of 2.0 VDC with the synthesizer locked.
5. Set the radio to receive at 174 MHz. The voltage at TPE16 should be less than 7.6 VDC.

B. REFERENCE OSCILLATOR ADJUSTMENT

1. Connect a service monitor to the output of the transmitter.
2. Set the radio for any valid transmit frequency and set the service monitor to receive on this frequency.
3. Key the transmitter and adjust C6 on the systems board to obtain the frequency selected within 200 Hz.

C. DEVIATION ADJUSTMENT

1. Connect the antenna output to the RF input jack of the service monitor.
2. Connect the modulation output of the service monitor to the Mic high input of the radio. Connect the digital multimeter to monitor this input voltage.
3. Adjust the audio output level of the modulation output to 0.15 VRMS at a frequency of 1 kHz.
4. Set the service monitor to receive this transmitter frequency.
5. Adjust R3 on the systems board to the center of its range.
6. Key the transmitter and adjust R40 on the systems board to obtain a deviation reading of 4.75 kHz on the service monitor.
7. Check the deviation reading on all of the other transmit frequencies. On any frequency where the deviation is greater than 5 kHz, adjust to reduce the deviation to 5 kHz.

D. REFERENCE MODULATION ADJUSTMENT

1. Adjust the modulation output level from the service monitor to 0 volts.
2. Key the transmitter and observe the resulting waveform on the service monitor display.
3. Adjust R3 on the systems board to obtain the flattest waveform possible. A droop of up to 30% is allowable.
4. Return the modulation output level from the service monitor to 0.15 VRMS, and readjust the deviation if necessary.

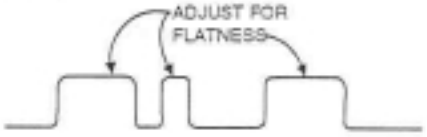



FIGURE 5-1 REFERENCE MODULATION ADJUSTMENT

5.5.3 TRANSMITTER

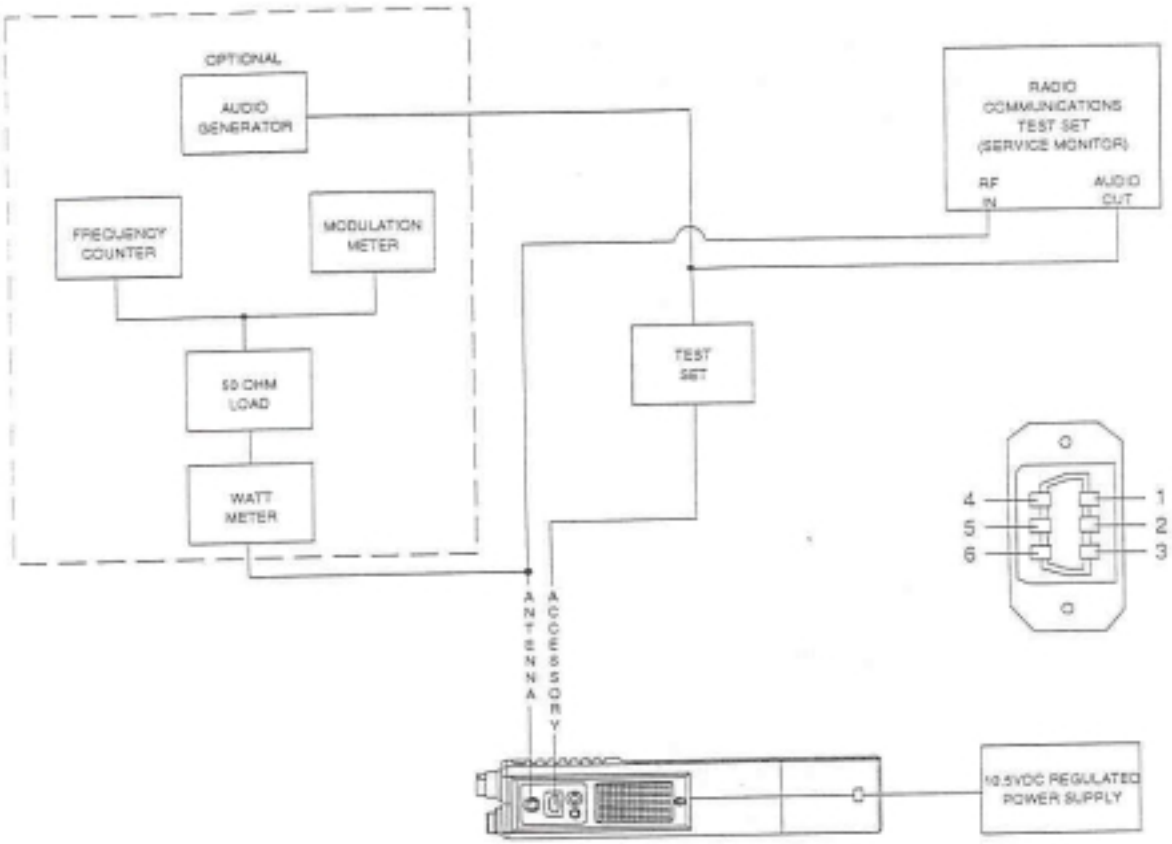
NOTE: Adjustments of the high and low transmitter power settings, as well as the receiver tuning slope, can be made using a computer, EPH RX/TX Tuning software, and a programming cable. Specific instructions are provided in the EPH RX/TX Tuning software manual.

A. HIGH POWER ADJUSTMENT

1. Connect the RF power meter and 50 ohm load to the RF output side connector.
2. Set the radio to the highest available transmit frequency with high power enabled.
3. Key the transmitter and record the output power.
4. Adjust the transmitter high power setting using a computer, EPH RX/TX Tuning software, and a programming cable.
5. Repeat the above steps until 5 watts is obtained.
6. Retest at frequencies near midband and 148 MHz. Increase the output power if below 5 Watts.

B. LOW POWER ADJUSTMENT

1. Connect the RF power meter and 50 ohm load to the RF output side connector.
2. Set the radio to the lowest available transmit frequency with low power enabled.
3. Key the transmitter and record the output power.
4. Adjust the transmitter low power setting using a computer, EPH RX/TX Tuning software, and a programming cable.
5. Repeat the above steps until 1.5 Watts is obtained.
6. Retest at frequencies near midband and 174 MHz. Adjust the output power if below 1.4 or above 2.45 Watts.



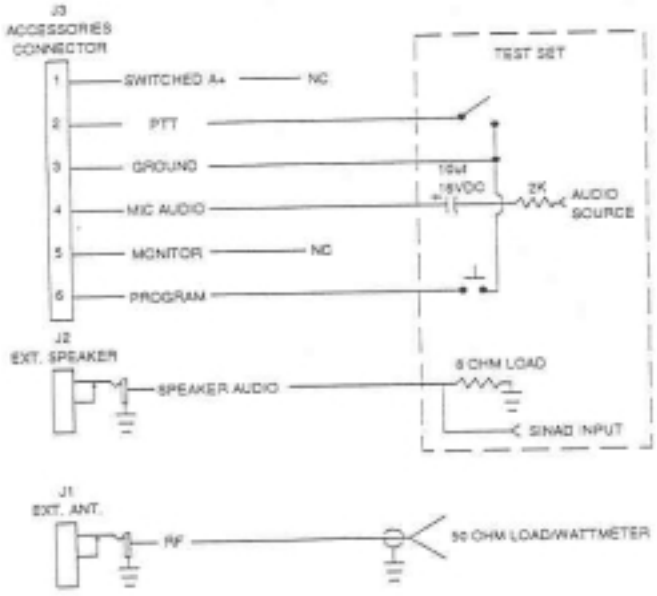
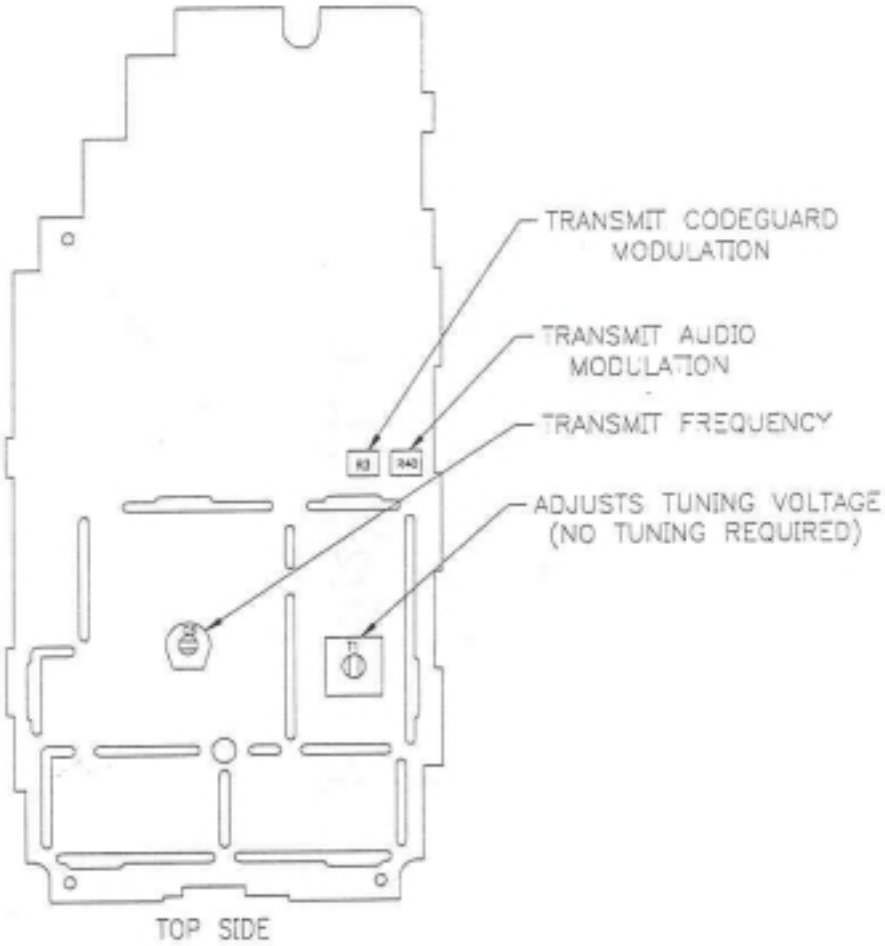
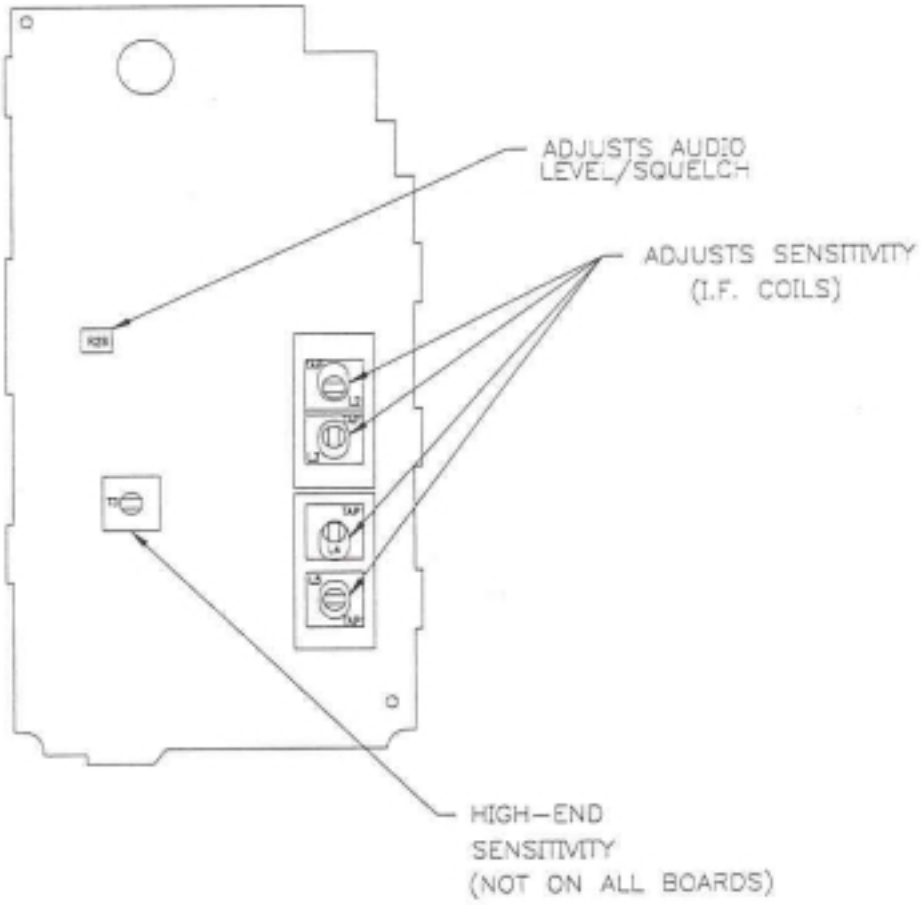




FIGURE 5-2 TRANSMITTER TEST SET-UP




SYSTEMS BOARD ADJUSTMENTS




RX/TX BOARD ADJUSTMENTS