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EP450™
Portable Radio
Basic Service Manual

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HKLN4215A

EP450 Portable Radio
Basic Service Manual

VHF 146-174 MHz
UHF 403-440 MHz
UHF 438-470 MHz
UHF 465-495 MHz

Foreword

This manual is intended for use by service technicians familiar with similar types of equipment. It contains service information required for the equipment described and is current as of the printing date. Changes which occur after the printing date may be incorporated by a complete Manual revision or alternatively as additions.

> **Note:** Before operating or testing these units, please read the Product Safety and RF Exposure Compliance section.

Product Safety and RF Exposure Compliance

Caution

> Before using this product, read the operating instructions for safe usage contained in the Product Safety and RF Exposure booklet enclosed with your radio.

ATTENTION!

This radio is restricted to occupational use only to satisfy FCC RF energy exposure requirements. Before using this product, read the RF energy awareness information and operating instructions in the Product Safety and RF Exposure booklet enclosed with your radio (Motorola Publication part number 68P81095C98) to ensure compliance with RF energy exposure limits.

For a list of Motorola-approved antennas, batteries, and other accessories, visit the following web site which lists approved accessories: http://www.motorola.com/cgiss/index.shtml.

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Chapter 1 Model Charts and Test Specifications

1.1 Radio Model Information

The model number and serial number are located on a label attached to the back of your radio. You can determine the RF output power, frequency band, protocols, and physical packages. The example below shows one portable radio model number and its specific characteristics.

Table 1-1. Radio Model Number (Example: LAH65KDC9AA2AN)

	Type of Unit	Model Series	Freq. Band	Power Level	Physical Packages	Channel Spacing	Protocol	Feature Level	Model Revision	Model Package
LA **LA** = Motorola Internal Use →	**H** **H** = Portable →	**65**	**K** VHF (146-174 MHz) **Q** (403-440 MHz) **R** UHF (438-470 MHz) **S** UHF (465-495 MHz)	**D** 4 W or 5 W	**C** Non Display **H** Full Display	**9** Pro- gramma- ble	**AA** Conven- tional	**2** 16 CH **4** 64 CH	**A**	**N**

1.2   Model Chart for VHF 146-174 MHz

EP450, VHF, 146-174 MHz			
Model			**Description**
LAH65KDC9AA2AN			EP450, 146-174 MHz, 5 W, 16 Ch. Non-Display Model
	LAH65KDH9AA4AN		EP450, 146-174 MHz, 5 W, 64 Ch. Display Model
		Item	**Description**
X		PMUD1857_	EP450, 146-174 MHz, 5 W, 16 Ch. Non-Display Model
	X	PMUD1859_	EP450, 146-174 MHz, 5 W, 64 Ch. Display Model
X	X	PMLD4222_	EP450, Back Cover Kit. 146-174 MHz
X		PMLN4601_	Non-Display, Front Housing Kit, 16 Ch.
	X	PMLN4603_	Full Display, Front Housing Kit, 64 Ch.
X	X	NNTN4496_R	Ni-Cd Battery, 1100 mAH
X	X	NNTN4497_R	Li-Ion Battery, 1800 mAH
X	X	NNTN4851_	NiMH Battery, 1400 mAH
X	X	NNTN4970	Slim Li-Ion Battery, 1600 mAH
X	X	WPLN4138_R	Rapid 90-Min. Desktop Charger w/US Plug
X	X	WPLN4139_R	Rapid 90-Min. Desktop Charger w/Euro Plug
X	X	WPLN4142_R	Rapid 90-Min. Desktop Charger w/Argentina Plug
X	X	WPLN4140_R	Rapid 90-Min. Desktop Charger w/UK Plug
X	X	RLN5644	2.5" Belt Clip
X	X	NAD6502_R	Antenna, 146-174 MHz, 14cm
X	X	HKLN4212	E-Series Interactive User CD

X = Indicates compatibility with model(s)

1.3   VHF Test Specifications

General

	VHF
Channel Capacity:	16 or 64 Channels
Power Supply:	7.5 Volts ±20%
Dimensions (HxWxD) with Battery: High Capacity Li-Ion	130.5mm x 62mm x 45mm (5.12" x 2.44" x 1.77")
Weight: with Battery: High Capacity Li-Ion	397g (14.0 oz.)
Average Battery Life @ (5-5-90* Duty Cycle): High Capacity Li-Ion	17 hr low power/ 12 hr high power
Model Number:	LAH65KDC9AA2_N, LAH65KDH9AA4_N
Frequency Range:	146-174 MHz
Channel Spacing:	12.5/20/25 kHz
Temperature Range:	-30° to 60°C
Frequency Stability:	±2.5 ppm
FCC	ABZ99FT3045

*5% receive; 5% transmit; 90% standby.

Transmitter

	VHF	
RF Output Li-Ion @ 7.5 V:	Low 1 W	High 5 W
Frequency:	146-174 MHz	
Channel Spacing:	12.5/20/25 kHz	
Spurious/Harmonics:	-36 dBm < 1 GHz -30 dBm > 1 GHz	
FM Noise:	-40 dB (12.5 kHz) -45 dB (25 kHz)	
Modulation Limitation:	±2.5 kHz @ 12.5 kHz/ ±5 kHz @ 25 kHz	
Audio Response: (from 6 dB/oct. Pre-emphasis, 300 to 3000 Hz)	+1 to -3 dB	
Audio Distortion: @ 1000 Hz, 60% Rated Max. Dev.	3%	

Receiver

	VHF 12.5 kHz	VHF 25kHz
Channel Spacing:	12.5/20/25 kHz	
Sensitivity 12 dB EIA SINAD:	0.25 µV (typical)	
Adjacent Channel Selectivity:	-60 dB	-70 dB
Intermodulation:	-70 dB	
Freq. Stability (-30° C to +60° C):	0.00025%	
Spur Rejection:	-75 dB	
Image and 1/2 I-F Rejection:	-70 dB	
Audio Output @ <5% Distortion:	500 mW into 24Ω	

Specifications subject to change without notice. All electrical specifications and methods refer to EIA/TIA 603 standards.

1.4   Model Chart for UHF 403-440 MHz

EP450, UHF, 403-440 MHz			
Model			Description
LAH65QDC9AA2AN			EP450, 403-440 MHz, 4 W, 16 Ch. Non-Display Model
	LAH65QDH9AA4AN		EP450, 403-440 MHz, 4 W, 64 Ch. Display Model
		Item	Description
X		PMUE1972_	EP450, 403-440 MHz, 4 W, 16 Ch. Non-Display Model
	X	PMUE1974_	EP450, 403-440 MHz, 4 W, 64 Ch. Display Model
X	X	PMLE4288_	EP450, Back Cover Kit. 403-440 MHz
X		PMLN4601_	Non-Keypad, Front Housing Kit, 16 Ch.
	X	PMLN4603_	Full Keypad, Front Housing Kit, 64 Ch.
X	X	NNTN4496_R	Ni-Cd Battery, 1100 mAH
X	X	NNTN4497_R	Li-Ion Battery, 1800 mAH
X	X	NNTN4851_	NiMH Battery, 1400 mAH
X	X	NNTN4970	Slim Li-Ion Battery, 1600 mAH
X	X	WPLN4138_R	Rapid 90-Min. Desktop Charger w/US Plug
X	X	WPLN4139_R	Rapid 90-Min. Desktop Charger w/Euro Plug
X	X	WPLN4142_R	Rapid 90-Min. Desktop Charger w/Argentina Plug
X	X	WPLN4140_R	Rapid 90-Min. Desktop Charger w/UK Plug
X	X	RLN5644	2.5" Belt Clip
X	X	NAE6483_R	Antenna, 403-520 MHz, Whip
X	X	HKLN4212	E-Series Interactive User CD

X = Indicates compatibility with model(s)

1.5   Model Chart for UHF 438-470 MHz

EP450, UHF, 438-470 MHz			
Model		**Description**	
LAH65RDC9AA2AN		EP450, 438-470 MHz, 4 W, 16 Ch. Non-Display Model	
	LAH65RDH9AA4AN	EP450, 438-470 MHz, 4 W, 64 Ch. Display Model	
		Item	**Description**
X		PMUE1966_	EP450, 438-470 MHz, 4 W, 16 Ch. Non-Display Model
	X	PMUE1968_	EP450, 438-470 MHz, 4 W, 64 Ch. Display Model
X	X	PMLE4283_	EP450, Back Cover Kit. 438-470 MHz
X		PMLN4601_	Non-Display, Front Housing Kit, 16 Ch.
	X	PMLN4603_	Display, Front Housing Kit, 64 Ch.
X	X	NNTN4496_R	Ni-Cd Battery, 1100 mAH
X	X	NNTN4497_R	Li-Ion Battery, 1800 mAH
X	X	NNTN4851_	NiMH Battery, 1400 mAH
X	X	NNTN4970	Slim Li-Ion Battery, 1600 mAH
X	X	WPLN4138_R	Rapid 90-Min. Desktop Charger w/US Plug
X	X	WPLN4139_R	Rapid 90-Min. Desktop Charger w/Euro Plug
X	X	WPLN4142_R	Rapid 90-Min. Desktop Charger w/Argentina Plug
X	X	WPLN4140_R	Rapid 90-Min. Desktop Charger w/UK Plug
X	X	RLN5644	2.5" Belt Clip
X	X	NAE6483_R	Antenna, 403-520 MHz, Whip
X	X	HKLN4212	E-Series Interactive User CD

X = Indicates compatibility with model(s)

1.6   Model Chart for UHF 465-495 MHz

EP450, UHF, 465-495 MHz	
Model	**Description**

		Model / Item	Description
LAH65SDC9AA2AN			EP450, 465-495 MHz, 4 W, 16 Ch. Non-Display Model
	LAH65SDH9AA4AN		EP450, 465-495 MHz, 4 W, 64 Ch. Display Model
		Item	**Description**
X		PMUE1978_	EP450, 465-495 MHz, 4 W, 16 Ch. Non-Display Model
	X	PMUE1980_	EP450, 465-495 MHz, 4 W, 64 Ch. Display Model
X	X	PMLE4284_	EP450, Back Cover Kit. 465-495 MHz (1/4W)
X		PMLN4601_	Non-Display, Front Housing Kit, 16 Ch.
	X	PMLN4603_	Display, Front Housing Kit, 64 Ch.
X	X	NNTN4496_R	Ni-Cd Battery, 1100 mAH
X	X	NNTN4497_R	Li-Ion Battery, 1800 mAH
X	X	NNTN4851_	NiMH Battery, 1400 mAH
X	X	NNTN4970	Slim Li-Ion Battery, 1600 mAH
X	X	WPLN4138_R	Rapid 90-Min. Desktop Charger w/US Plug
X	X	WPLN4139_R	Rapid 90-Min. Desktop Charger w/Euro Plug
X	X	WPLN4142_R	Rapid 90-Min. Desktop Charger w/Argentina Plug
X	X	WPLN4140_R	Rapid 90-Min. Desktop Charger w/UK Plug
X	X	RLN5644	2.5" Belt Clip
X	X	NAE6483_R	Antenna, 403-520 MHz, Whip
X	X	HKLN4212	E-Series Interactive User CD

X = Indicates compatibility with model(s)

1.7   UHF Test Specifications

General

	UHF
Channel Capacity:	16 or 64 Channels
Power Supply:	7.5 Volts ±20%
Dimensions (HxWxD) with Battery: High Capacity Li-Ion	130.5mm x 62mm x 45mm (5.12" x 2.44" x 1.77")
Weight: with Battery: High Capacity Li-Ion	397g (14.0 oz.)
Average Battery Life @ (5-5-90* Duty Cycle): High Capacity Li-Ion	17 hr low power/ 12 hr high power
Model Numbers:	LAH65QDC9AA2_N LAH65QDH9AA4_N LAH65RDC9AA2_N LAH65RDH9AA4_N LAH65SDC9AA2_N LAH65SDH9AA4_N
Modulation Limitation:	±2.5 kHz @ 12.5 kHz/ ±5 kHz @ 25 kHz
Channel Spacing:	12.5/20/25 kHz
Temperature Range:	-30° to 60°C
Frequency Stability:	±2.5 ppm
FCC	ABZ99FT4057 403-440MHz ABZ99FT4056 438-470MHz ABZ99FT4058 465-495MHz

*5% receive; 5% transmit; 90% standby.

Transmitter

	UHF	
RF Output Li-Ion @ 7.5 V:	Low 1 W	High 4 W
Frequency:	403-440 MHz 438-470 MHz 465-495 MHz	
Channel Spacing:	12.5/20/25 kHz	
Freq. Stability: (-30° C to +60° C)	0.00025%	
Spurious/Harmonics:	-36 dBm < 1 GHz -30 dBm > 1 GHz	
FM Noise:	-40 dB (12.5 kHz) -45 dB (25 kHz)	
Audio Response: (from 6 dB/oct. Pre-emphasis, 300 to 3000 Hz)	+1 to -3 dB	
Audio Distortion: @ 1000 Hz, 60% Rated Max. Dev.	<3%	

Receiver

	UHF 12.5 kHz	UHF 25kHz
Channel Spacing:	12.5/20/25 kHz	
Frequency:	403-440 MHz 438-470 MHz 465-495 MHz	
Sensitivity 12 dB EIA SINAD:	0.25 μV (typical)	
Adjacent Channel Selectivity:	-60 dB	-70 dB
Intermodulation:	-70 dB	
Freq. Stability (-30° C to +60° C):	0.00025%	
Spur Rejection:	-75 dB	
Image and 1/2 I-F Rejection:	-70 dB	
Audio Output @ <5% Distortion:	500 mW into 24Ω	

Specifications subject to change without notice. All electrical specifications and methods refer to EIA/TIA 603 standards.

1.8 MIL Standards

Table 1-2. MIL STDS 810 C, D, E, and F: Applicable to UHF and VHF Specifications (8.2 and 8.4)

Military Standards 810 C, D, E, & F: Parameters/Methods/Procedures								
	810C		810D		810E		810F	
Applicable MIL-STD	Methods	Procedures	Methods	Procedures	Methods	Procedures	Methods	Procedures
Low Pressure	500.1	1	500.2	2	500.3	2	500.4	1
High Temperature	501.1	1,2	501.2	1,2	501.3	1,2	501.4	1,2
Low Temperature	502.1	1	502.2	1,2	502.3	1,2	502.4	1,2
Temperature Shock	503.1	1	503.2	1	503.3	1	503.4	1
Solar Radiation	505.1	1	505.2	1	505.3	1	505.4	1
Rain	506.1	1,2	506.2	1,2	506.3	1,2	506.4	1
Humidity	507.1	2	507.2	2,3	507.3	2,3	507.4	3
Salt Fog	509.1	1	509.2	1	509.3	1	509.4	1
Dust	510.1	1	510.2	1	510.3	1	510.4	1
Vibration	514.2	8,10	514.3	1	514.4	1	514.5	1
Shock	516.2	1,2,5	516.3	1,4	516.4	1,4	516.5	1

Chapter 2   Theory Of Operation

2.1   Introduction

This chapter provides a basic theory of operation for the radio components.

2.2   Major Assemblies

- Transceiver Board – contains all transmit, receive, and audio circuitry.
- Display (Display models only) – 8 characters (14 segments star burst) and 10 icons with back-lighting, liquid-crystal display (LCD).

Keypad Board (Display models only) –
Display model: a 2-button menu keypad with 2-way navigation button, and a 3 x 4 alphanumeric keypad.

Transceiver Board (Figure 2-1).
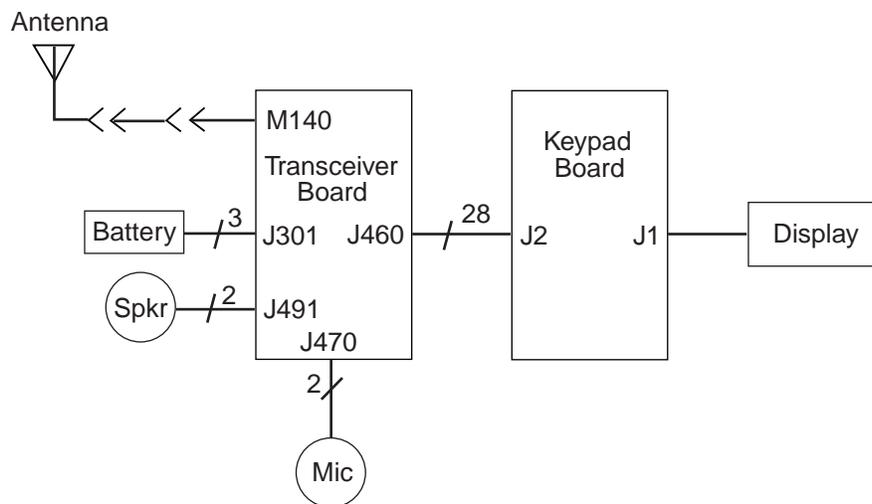
Figure 2-1. Major Assemblies Block Diagram

2.2.1   Receiver

Incoming RF signals from the antenna are first routed through the harmonic filter and antenna switch, part of the transmitter circuitry, before being applied to the receiver front end. The receiver front end consists of a preselector filter, RF amplifier, interstage filter, and a double-balanced first mixer (Figure 2-2).

The mixer output is applied to a diplexer network which matches the 44.85 MHz IF signal to the crystal filter, and terminates the mixer into 50 ohms at all other frequencies.

The receiver back-end is a dual conversion design. High IF selectivity is provided by a 4-pole fundamental mode 44.85 MHz crystal filter. The output is matched to an IF amplifier stage. The output of the IF amplifier is applied to the input of the receiver IFIC.

The IFIC is a low-voltage monolithic FM IF system incorporating a mixer/oscillator, two limiting IF amplifiers, quadrature detector, logarithmic received signal strength indicator (RSSI), voltage regulator and audio, and RSSI Op Amps. The second LO frequency, 44.395 MHz, is determined by a crystal oscillator. The second mixer converts the 44.85 MHz high IF frequency to 455 kHz.

Additional IF selectivity is provided by two ceramic filters. The first ceramic filter is a 4-pole filter used between the second mixer and IF amp. The second ceramic filter is a 6-pole filter and is used between the IF amp and the limiter input. For the second ceramic filter, a wider filter is used for 20/25 kHz channel spacing, and a narrower filter is used for 12.5 kHz channels.

A ceramic resonator provides phases vs. frequency characteristic required by the quadrature detector, with 90 degree phase shift occurring at 455 kHz. The output of the IFIC is the recovered audio signal which is fed to the audio IC for amplification and signal conditioning. The output of the audio IC is injecting into the audio PA which drives the 24 Ohm speaker.

2.2.2   Transmitter

- When the radio is transmitting, microphone audio is passed through the audio IC, where pre-emphasis and low-pass (splatter) filtering are done. The output of the audio IC is used to modu-late the TX VCO, which creates the modulated carrier. The modulated carrier is then amplified by the pre-driver and power amplifier circuit, which transmits the signal under dynamic power control
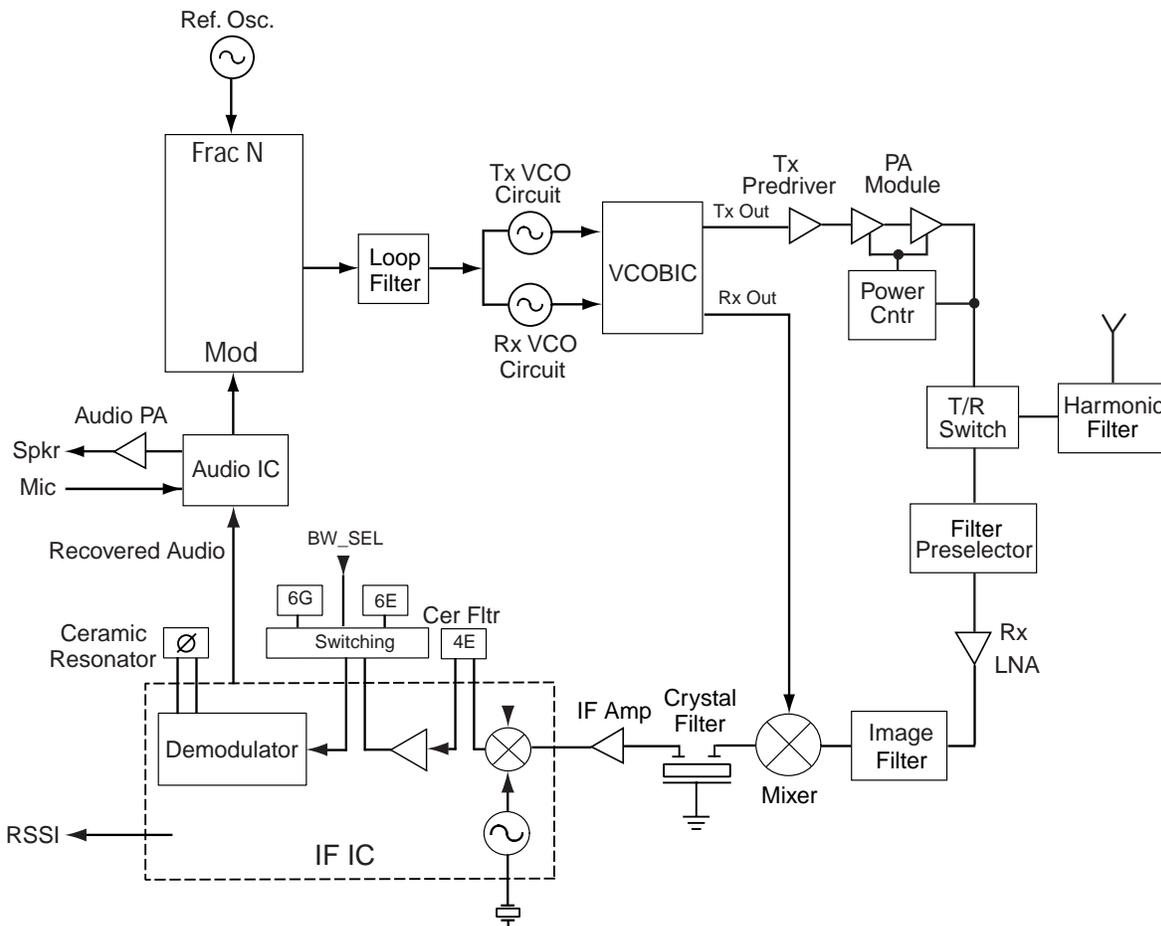
Figure 2-2. Transceiver Block Diagram

Chapter 3   Test Equipment, Service Aids, and Service Tools

3.1   Test Equipment

Table 3-1 lists test equipment required to service the EP450 Radios.

Table 3-1. Recommended Test Equipment

Motorola Part No.	Description	Characteristics	Application
R2600 series	System analyzer	This item will substitute for items with an asterisk (*)	Frequency/deviation meter and signal generator for wide-range troubleshooting and alignment
*R1074	Fluke 87 digital multi-meter	True RMS metering, 200 kHz frequency counter, 32-segment bar graph with backlit display	Digital voltmeter is recommended for AC/DC voltage and current measurements
	Fluke 85 RF probe	500 MHz, 30 VAC max	Use with Fluke 87 digital multi-meter for RF voltage measurements.
*R1377	AC voltmeter	1 mV to 300 mV, 10 mega-ohm input impedance	Audio voltage measurements
R1611	Dual channel 100 MHz oscillo-scope (Agillent)	Two-channel, 100 MHz bandwidth, 200 M sample rate/sec, 2 MB memory/ channel	Waveform measurements
S1339	RF millivolt meter	100 µV to 3V RF, 10 kHz to 1 GHz frequency range	RF level measurements
*R1013 or *R1370	SINAD meter or SINAD meter with RMS	Without RMS audio voltmeter or With RMS audio voltmeter	Receiver sensitivity measurements

3.2   Service Aids

Table 3-2 lists service aids recommended for working on the EP450 Radios. While all of these items are available from Motorola, most are standard shop equipment items, and any equivalent item capable of the same performance may be substituted for the item listed.

Table 3-2. Service Aids

Motorola Part No.	Description	Application
RLN4460	Portable Test Set	Enables connection to the audio/accessory jack. Allows switching for radio testing.
RLN4510	Battery Interface	Regulates DC current and voltage between radio and power supply.
RVN4195	Customer Programming Software and Tuner Software on CD ROM	Program customer option and channel data.
AAPMKN4004	Programming Test Cable	Connects radio to RIB (RLN4008).
AAPMKN4003	Radio to Radio Cloning Cable	Allows a radio to be duplicated from a master radio by transferring programmed data from the master radio to the other.
RLN4008	Radio Interface Box	Enables communications between the radio and the computer's serial communications adapter.
5886564Z01	RF Adaptor	Adapts radio's antenna port to BNC cabling of test equipment.
0180305K08	Shop Battery Eliminator	Interconnects radio to power supply.
HSN9412	Wall-Mounted Power Supply	Used to supply power to the RIB (120 VAC).
3080369B71 or 3080369B72	Computer Interface Cable	Use B72 for the IBM PC AT or newer (9-pin serial port). Use B71 for older models (25-pin serial port). Connects the computer's serial communications adapter to the RIB (PLN4008).
6686533Z01	Knob Remover/Chassis Opener	Used to remove the front cover assembly.
HKN9216	IBM Computer Interface Cable	Connection from computer to RIB.
8180384N65	Housing Eliminator	Allows testing of the radio outside of the housing.
RLN5583	Flashing Adapter	Flashing/CPS cable for authorized service centers.

Table 3-3. Recommended Service Tools

Motorola Part No.	Description	Application
RSX4043	TORX screwdriver	Tighten and remove chassis screws
6680387A70	T6 TORX bit	Removable TORX screwdriver bit
R1453	Digital readout solder station	Digitally controlled soldering iron
RLN4062	Hot air workstation, 120 V	Tool for hot air soldering/desoldering of surface mounted integrated circuits

Table 3-3. Recommended Service Tools (Continued)

Motorola Part No.	Description	Application
0180386A78	Illuminated magnifying glass with lens attachment	Illumination and magnification of components
0180302E51	Master lens system	
0180386A82	Anti-static grounding kit	Used during all radio assembly and disassembly procedures
6684253C72	Straight prober	
6680384A98	Brush	
1010041A86	Solder (RMA type), 63/67, 0.5mm diameter, 1 lb. spool	
0180303E45	SMD tool kit (included with R1319A)	
R1319	ChipMaster (110 V)	Surface mount removal and assembly of surface mounted integrated circuits and/or rework station shields. Includes 5 nozzles.
R1321	ChipMaster (220 V)	
ChipMaster Nozzles:		
6680332E83	PLCC-28* nozzle	Soldering and Un-soldering IC's
6680332E82	PLCC-44* nozzle	
6680332E94	PLCC-52 nozzle	
6680332E96	PLCC-84 nozzle	
6680334E67	QFP-160 nozzle	
6680333E46	SOL-18 nozzle	
6680332E84	SOIC-20 nozzle	
6680332E87	SOL-20J nozzle	
6680333E45	SOL-24 nozzle	
6680333E55	TSOP-64 nozzle	

* Included with ChipMaster packages

Programming/Test Cable
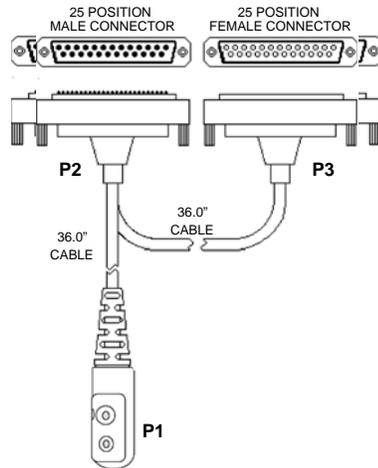
Figure 3-1. Programming/Test Cable
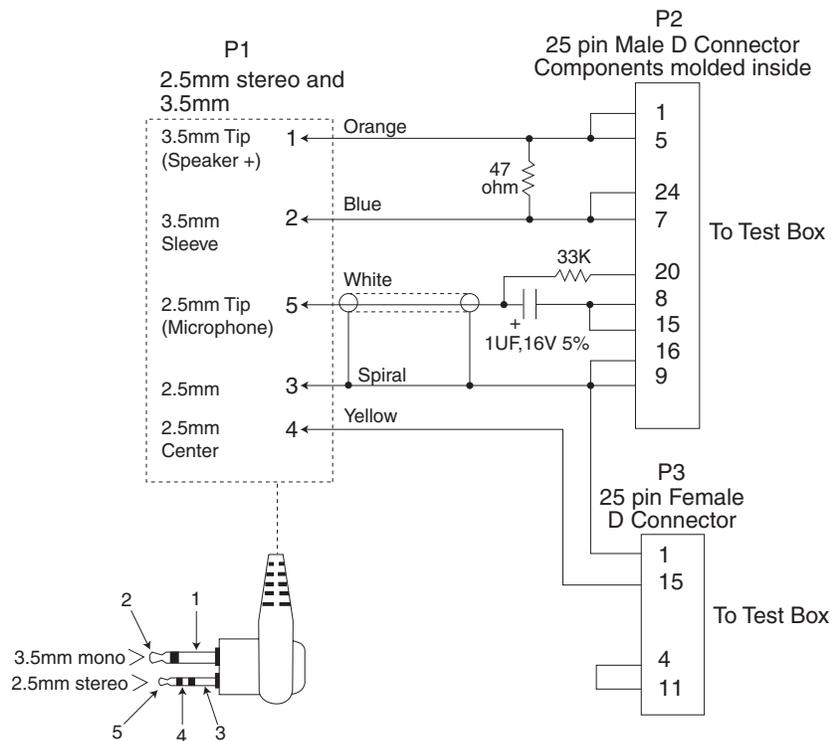
Figure 3-2. Wiring of the Connectors

Chapter 4   Performance Checks

4.1   General

These radios meet published specifications through their manufacturing process by utilizing high-accuracy laboratory-quality test equipment. The recommended field service equipment is as accurate as the manufacturing equipment with few exceptions. This accuracy must be maintained in compliance with the manufacturer's recommended calibration schedule.
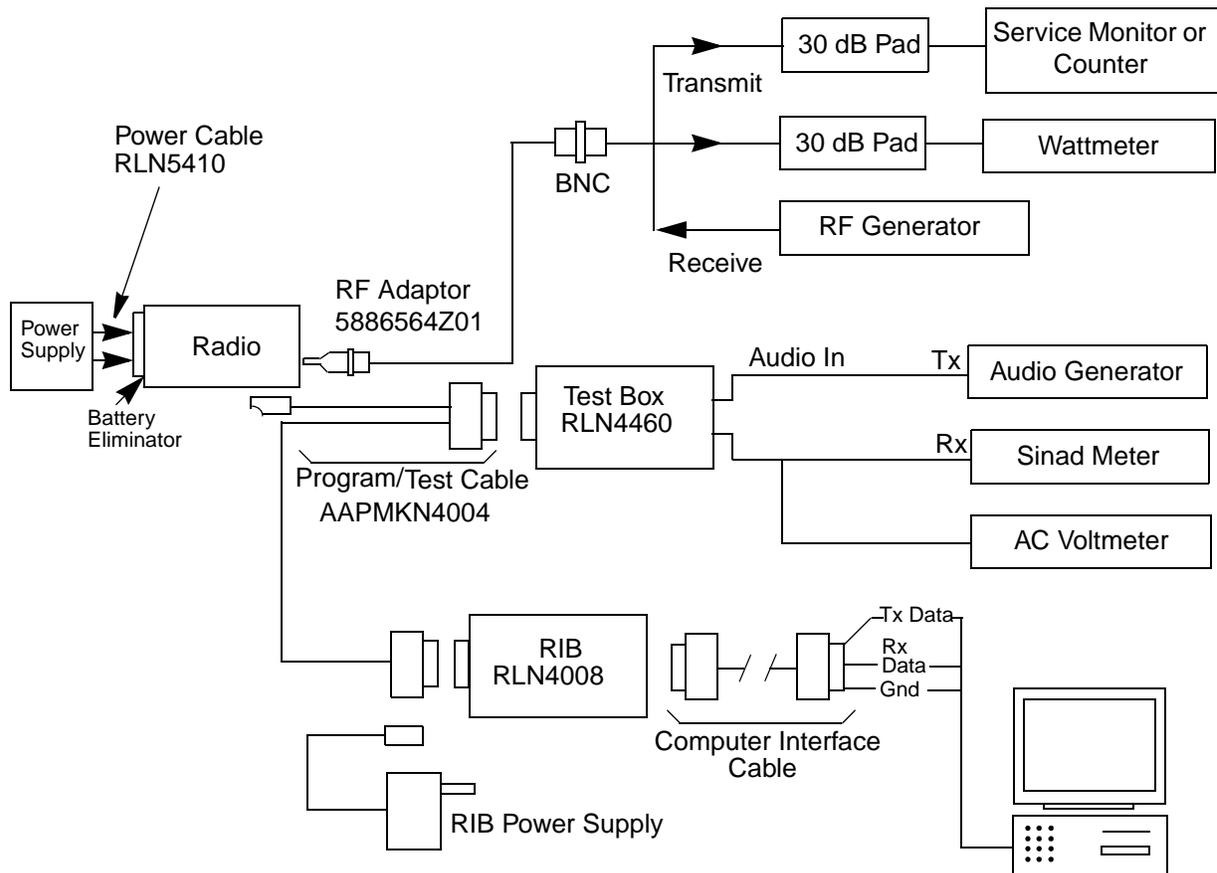
Figure 4-1. Radio Tuning Setup

4.2   Power-Up Self Test

Applying power to the radio by using the on/off volume control, starts a self-test routine which checks the RAM, EEPROM hardware and EEPROM checksum. Pressing and holding SB1 while turning on the radio causes the self-test routine to check for the ROM checksum as well. If these checks are successfully completed, the radio will generate the Self-Test Pass Tone. If the self-test is not successful, a Self-Test Fail Tone is heard.

Supply voltage can be connected from the battery eliminator. The equipment required for alignment procedures is connected as shown in the Radio Performance Checks Setup diagram (Figure 4-1).

Initial equipment control settings should be as indicated in Table 4-1 and should be the same for all performance checks and tuner alignment procedures.

Table 4-1. Initial Equipment Control Settings

Service Monitor	Test Set	Power Supply
Monitor Mode: Power Monitor	Spkr set: C	Voltage: 7.5 Vdc
RF Attenuation: -70	Spkr/load: Load	DC on/standby: Standby
AM, CW, FM: FM	PTT: OFF	Volt Range: 10 V
Oscilloscope Source: Mod Oscilloscope Horiz: 1 0 mSec/Div Oscilloscope Vert: 2.5kHz/Div Oscilloscope Trig: Auto Monitor Image: Hi Monitor BW: Nar Monitor Squelch: mid CW Monitor Vol: 1/4 CW		Current: 2.5 A

4.3   RF Test Mode

When the EP450 radio is operating in its normal environment, the radio's microcomputer controls the RF channel selection, transmitter key-up, and receiver muting, according to the customer code plug configuration. However, when the unit is on the bench for testing, alignment, or repair, it must be removed from its normal environment using a special routine, called RF TEST MODE. This mode allows bench testing of the radio at various test frequencies across the entire band, at both high and low transmit power (if applicable), at various channel spacings, and with different coded or carrier squelch types. Any customer specific programming in the radio will not be changed or affected by use of the RF Test Mode.
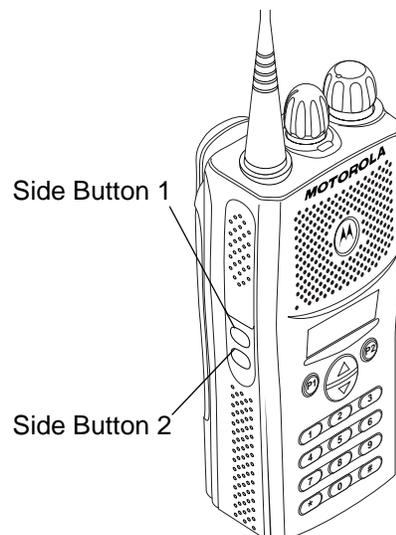
Figure 4-2. Side Button Locations

To enter test mode:

1. Turn the radio on.

Within ten seconds after the self test is complete (self test tone is heard), press SB2 (Side Button 2 in Figure 4-2) five times in succession. If the self test complete tone is not heard, see Error Codes information in Chapter 8. Entry into the test mode is indicated by a positive indicator tone followed by a good key chirp (GKC). Upon entering test mode, the radio is in the carrier squelch mode.

2. Press SB1 (Side Button 1) and scroll through and access test environments as shown in Table 4-2.

3. Press SB2 and scroll through the channel spacing available as shown in Table 4-3.

4. Turn the channel selector knob to change the test channel for that environment as shown in Table 4-4.

5. Press the PTT on a test channel to cause the radio to transmit at the test frequency for the channel.

Table 4-2. Test Environments

No. of Beeps	Description	Function
1 GKC*	Carrier Squelch	RX: unsquelch if carrier detected TX: mic audio
1 BKC*	Tone Private-Line	RX: unsquelch if carrier and tone (192.8 Hz) detected TX: mic audio + tone (192.8 Hz)
2 BKC	Digital Private-Line	RX: unsquelch if carrier and digital code (131) detected TX: mic audio + digital code (131)
3 BKC	Dual-Tone Multiple Frequency	RX: unsquelch if carrier detected TX: selected DTMF tone pair
5 BKC	Unsquelch Open	RX: constant unsquelch TX: mic audio
9 BKC	High-Speed Signal-ing	RX: unsquelch if carrier detected TX: 1500 Hz tone

* "BKC" means Bad Key Chirp (low-pitched tone), "GKC" means Good Key Chirp (high-pitched only).

Table 4-3. Test Channel Spacing

No. of BKC	Channel Spacing
1	25 kHz
2	12.5 kHz
3	20 kHz

Table 4-4. Test Frequencies

Channel Selector Switch Position	Test Channel	VHF R2 (MHz)	UHF R1 (MHz)	UHF R2 (MHz)	UHF R3 (MHz)
1 Low Power 8 High Power	TX#1 or #8 RX#1 or #8	146.625	403.625	438.625	465.625
2 Low Power 9 High Power	TX#2 or #9 RX#2 or #9	150.775	409.775	443.775	470.775
3 Low Power 10 High Power	TX#3 or #10 RX#3 or #10	155.275	415.275	448.275	475.275
4 Low Power 11 High Power	TX#4 or #11 RX#4 or #11	160.125	421.125	454.125	480.125
5 Low Power 12 High Power	TX#5 or #12 RX#5 or #12	164.475	427.475	459.475	485.475
6 Low Power 13 High Power	TX#6 or #13 RX#6 or #13	169.475	433.475	464.475	490.475
7 Low Power 14 High Power	TX#7 or #14 RX#7 or #14	173.875	439.875	469.875	494.875

Table 4-5. Receiver Performance Checks

Test Name	Communications Analyzer	Radio	Test Set	Comments
Reference Frequency	Mode: PWR MON 4th channel test frequency[*] Monitor: Frequency error Input at RF In/Out	TEST MODE, Test Channel 4 carrier squelch output at antenna	PTT to continuous (during the performance check)	Frequency error to be ±200 Hz VHF ±500 Hz UHF
Rated Audio	Mode: GEN Output level: 1.0m V RF 4th channel test frequency[*] Mod: 1 kHz tone at 3 kHz deviation Monitor: DVM: AC Volts	TEST MODE Test Channel 4 carrier squelch	PTT to OFF (center), meter selector to Audio PA	Set volume control to 3.24Vrms
Distortion	As above, except to distortion	As above	As above	Distortion <5.0%
Sensitivity (SINAD)	As above, except SINAD, lower the RF level for 12 dB SINAD.	As above	PTT to OFF (center)	RF input to be <0.30 µV (0.25 µV typical).
Noise Squelch Threshold (only radios with conventional system need to be tested)	RF level set to 1 mV RF	As above	PTT to OFF (center), meter selection to Audio PA, spkr/ load to speaker	Set volume control to 3.24 Vrms
	As above, except change frequency to a conventional system. Raise RF level from zero until radio unsquelches.	out of TEST MODE; select a conventional system	As above	Unsquelch to occur at <0.25 µV. Preferred SINAD = 6-9 dB

*. See Table 4-4

Table 4-6. Transmitter Performance Checks

Test Name	Communications Analyzer	Radio	Test Set	Comments
Reference Frequency	Mode: PWR MON 4th channel test frequency[*] Monitor: Frequency error Input at RF In/Out	TEST MODE, Test Channel 4 carrier squelch Output at antenna	PTT to continuous (during the performance check)	Frequency error to be ±200 Hz VHF ±500 Hz UHF
Power RF	As above	As above	As above	Refer to Maintenance Specifications
Voice Modulation	Mode: PWR MON 4th channel test frequency[*] atten to -70, input to RF In/Out Monitor: DVM, AC Volts Set 1 kHz Mod Out level for 0.025 Vrms at test set, 80m Vrms at AC/DC test set jack	As above	As above, meter selector to mic	Deviation: VHF, UHF $\geq$ 4.0 kHz but $\leq$ 5.0 kHz (25 kHz Ch Sp).
Voice Modulation (internal)	Mode: PWR MON 4th channel test frequency[*] atten to -70, input to RF In/Out	TEST MODE, Test Channel 4 carrier squelch Output at antenna	Remove modulation input	Press PTT switch on radio. Say "four" loudly into the radio mic. Measure deviation: VHF, UHF $\geq$ 4.0 kHz but $\leq$ 5.0 kHz (25 kHz Ch Sp)
DTMF Modulation	As above, 4th channel test frequency[*]	TEST MODE, Test Channel 4 DTMF Output at antenna	As above	Deviation: VHF, UHF $\geq$ 3.05 kHz but $\leq$ 3.45 kHz (25 kHz Ch Sp)
PL/DPL Modulation	As above 4th channel test frequency[*] BW to narrow	TEST MODE, Test Channel 4 TPL DPL	As above	Deviation: VHF, UHF $\geq$ 500Hz but $\leq$ 1000 Hz (25 kHz Ch Sp).

*. See Table 4-4

Notes:

Chapter 5 Radio Alignment Procedures

5.1   Introduction

This chapter provides an overview of the Commercial Series Customer Programming Software (CPS) and the Global Tuner as designed for use in a Windows® 98/NT4/2000/ME/XP environment. Both cover all the functions of the traditional Radio Service Software (RSS) package.

They are both available in the CPS Tuner (CD ROM) Kit (RVN4195).

5.2   CPS Programming Setup

Refer to online help files for the CPS Programming procedures. (See Figure 5-1 for CPS Programming Setup).
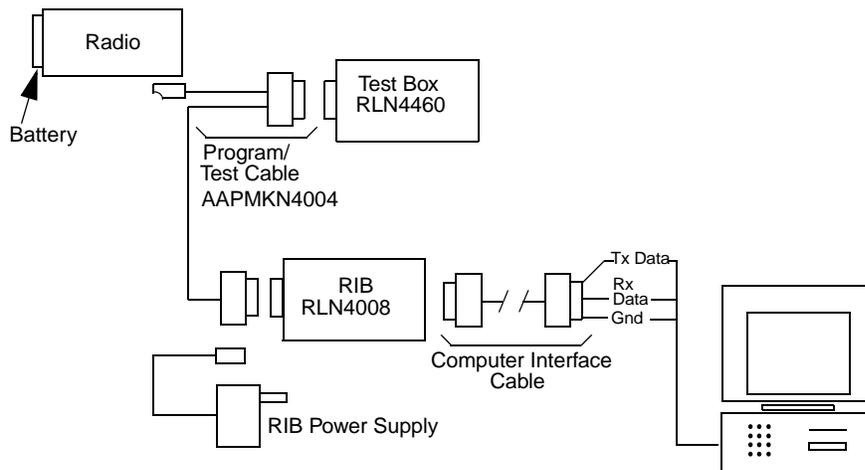
Figure 5-1. CPS Programming Setup

5.3   Radio Tuning Setup

A Windows 98/NT4/2000/ME/XP PC (personal computer) and Global Tuner are required to tune the radio. To perform the tuning procedures, the radio must be connected to the PC, RIB (Radio Interface Box) and Universal Test Set as shown in Figure 5-2 below. Refer to online help files for the tuning procedures.
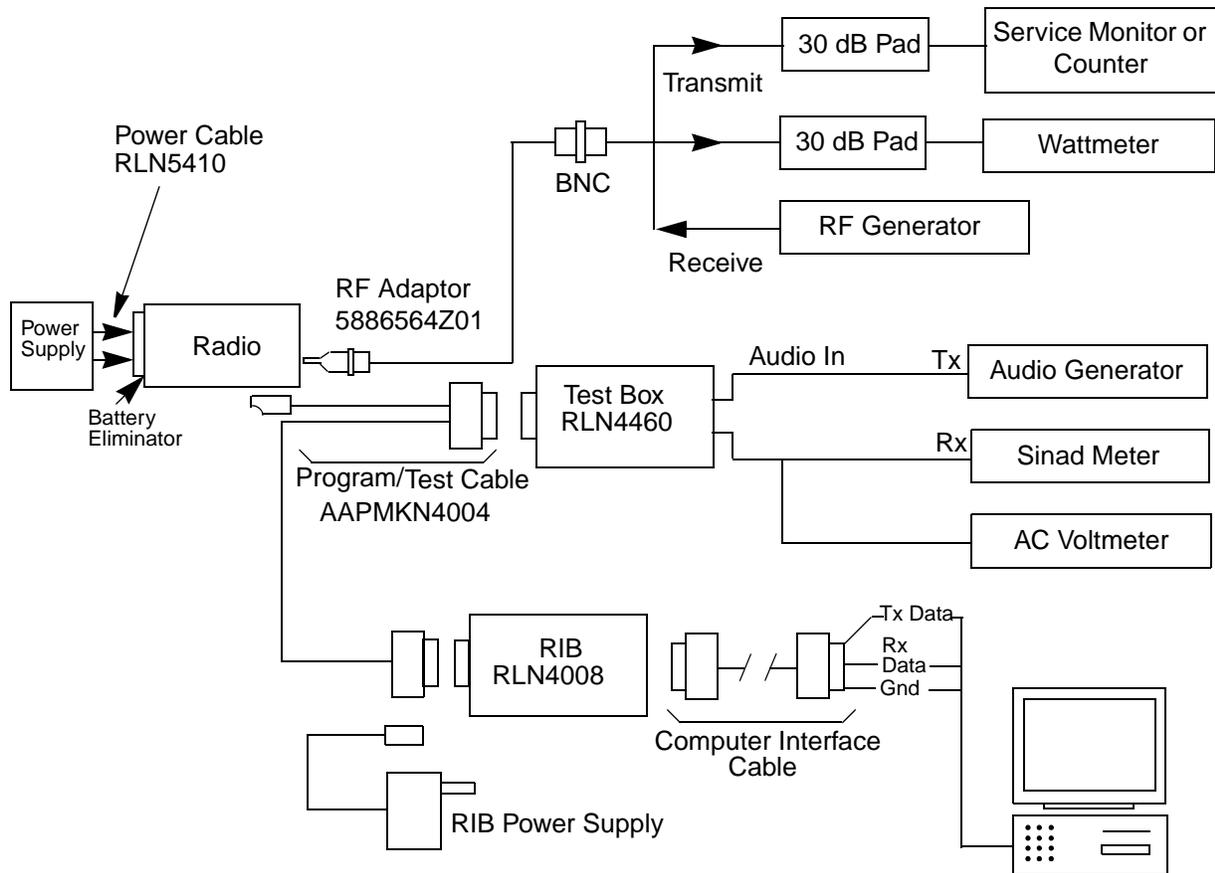
Figure 5-2. Radio Tuning Setup

5.3.1   Initial Test Equipment Control Settings

The initial test equipment control settings are listed in Table 5-1.

Table 5-1. Initial Equipment Control Settings

Service Monitor	Test Set	Power Supply
Monitor Mode: Power Monitor	Speaker set: A	Voltage: 13.2 Vdc
RF Attenuation: -70	Speaker/load: Speaker	DC on/standby: Standby
AM, CW, FM: FM	PTT: OFF	Volt Range: 20 V
Oscilloscope Source: Mod Oscilloscope Horizontal: 10 mSec/Div Oscilloscope Vertical: 2.5 kHz/Div Oscilloscope Trigger: Auto Monitor Image: Hi Monitor BW: Nar Monitor Squelch: mid CW Monitor Volume: 1/4 CW		Current: 20 A

5.4   Transmitter Alignment Options

Note: **When checking the RF power output of the radio with a test set, always use a pad of at least 30 dB attached to the radio end of the RF cable. This will avoid an RF mismatch and ensure a stable RF reading that will not change with varying lengths of connecting cable.**

5.4.1   Reference Oscillator Warp

This is an important operation which affects all deviation values such as **DTMF, MDC-1200 Signaling** etc. The frequency will drift if not warped properly. Perform this operation prior to all other transmit tuning operations in order to **minimize heating** and because of the **impact of warp on signaling operations**.
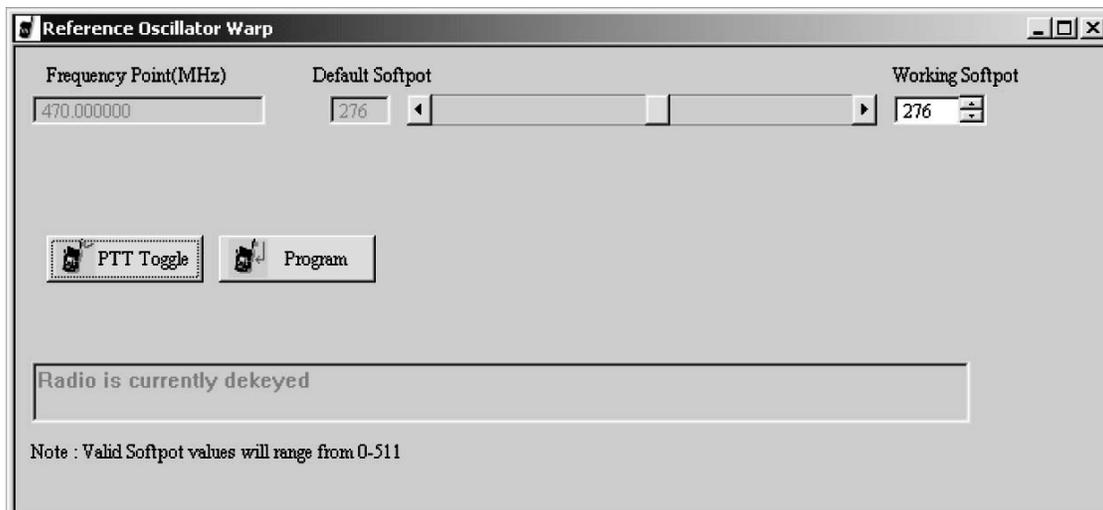
Figure 5-3. Reference Oscillator Warp Window

1. Under **Tx Align** menu, select **Reference Oscillator Warp** (Figure 5-3).

2. There is only 1 frequency point shown which is always the last non-0 transmit frequency point, which will normally be F7.

3. Click on the slider thumb and press **PTT Toggle** to key up the radio at the corresponding frequency point.

4. Monitor the transmit frequency.

5. Adjust the slider, spin or edit control (press **ENTER** to confirm selection/send a softpot value) until the frequency is as close as possible to the indicated transmit frequency. (Refer to Table 5-2).

6. Dekey the radio by pressing **PTT Toggle**.

7. Program the warp value into the radio by pressing the **Program** button.

8. Exit the Reference Oscillator Warp function.

Table 5-2. Reference Oscillator Specifications

RF Band	Target
VHF (146-174)	±174 Hz
UHF Band 1 (403-440)	±440 Hz
UHF Band 2 (438-470)	±470 Hz
UHF Band 3 (465-495)	±495 Hz

5.4.2 Modulation Balance Attenuation

Note: **When using test box RLN4460:**
- **Inject the signal into the radio via the METER IN terminal and**
- **Set the METER IN selector switch to "VOL".**
- **Inject the signal into the radio via the AUDIO IN terminal.**
- **Set the METER OUT toggle switch to the "MIC PORT" position**
- **Set the METER OUT selector switch to "MIC".**
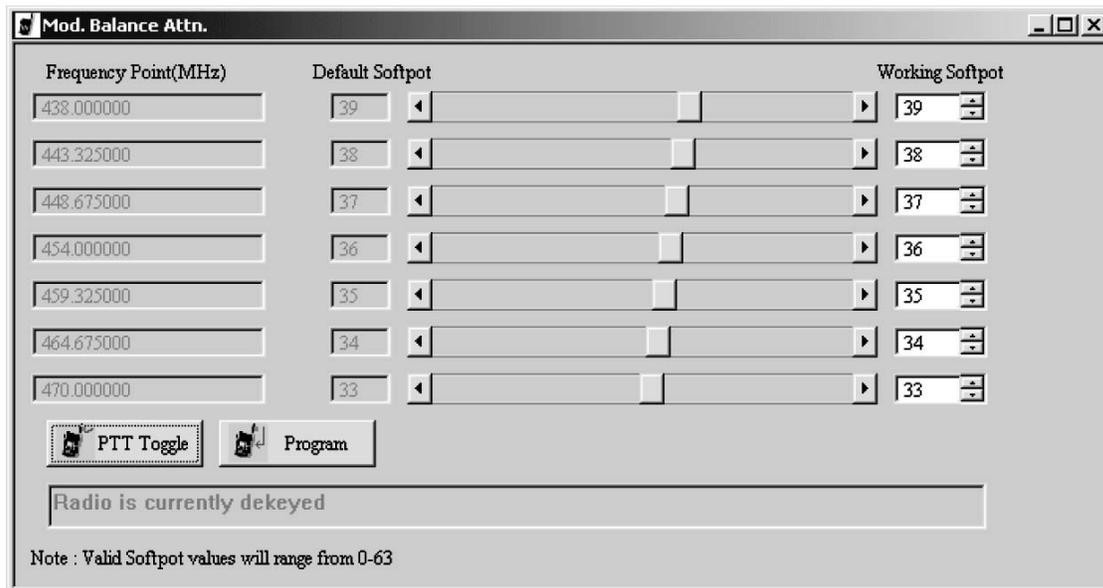
Figure 5-4. Modulation Balance Window

Compensation alignment balances the **modulation sensitivity** of the **VCO** and reference modulation (synthesizer low frequency port) lines. The compensation algorithm is critical to the operation of signaling schemes that have very low frequency components (Digital Private-Line) and could result in distorted waveforms if improperly adjusted. To perform Modulation Balance tuning, follow the following steps.

1. Under the **Tx Align** menu, select **Mod Balance Attn** (Figure 5-4).

2. Begin with the lowest frequency (i.e. the first frequency point from the top). Pressing **PTT Toggle** without selecting any slider control at the corresponding frequency point will key the radio up at the first frequency point.

3. Inject **80 Hz** at an amplitude of **1.78 V**.

4. Record the deviation obtained. Typical values should range from **[(1.70-2.30 kHz. Modulation is only tuned in the 25 kHz channel spacing mode**.

5. Inject **3 kHz.** Set the amplitude to **1.5 V**.

6. Change the modulation balance attenuation setting until the **Tx** deviation is as recorded in step 4.

7. Inject **80 Hz** at an amplitude of **1.78 V**.

8. Check the deviation again. If the Tx deviation changes, record the reading and repeat steps 5-8 until the Tx deviation remains the same.

9. Press **PTT Toggle** to dekey the radio. Choose the next frequency, key up and repeat steps 3 to 8 until all seven tuning points are done.

10. Program the softpot value by pressing the **Program** button.

11. Exit the Modulation Balance Function.

5.4.3 Transmit Power Tuning

Note: **The maximum available power level given in the table below must not be exceeded. There are separate alignment procedures for High and Low power.**

Note: **When checking the RF power output of the radio with a test set, always use a pad of at least 30 dB attached to the radio end of the RF cable. This will avoid an RF mismatch and ensure a stable RF reading that will not change with varying lengths of connecting cable**
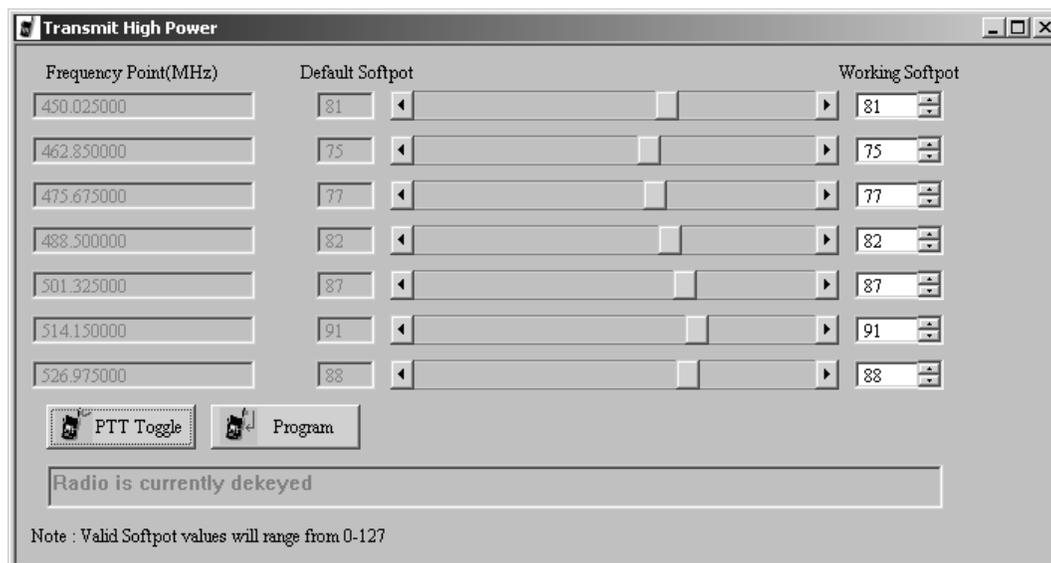
Figure 5-5. Transmit Power Window (High Power)

Table 5-3. Transmit High/Low Power Level

RF Band (MHz)	Model Number	High Power(W)	Low Power (W)
16 Channel VHF 146-174	H65KDC9AA2AN	5.2-5.5	1.1-1.3
64 Channel VHF 146-174	H65KDH9AA4AN	5.2-5.5	1.1-1.3
16 Channel UHF 1 403-440	H65QDC9AA2AN	4.2-4.5	1.1-1.3
64 Channel UHF 1 403-440	H65QDH9AA4AN	4.2-4.5	1.1-1.3
16 Channel UHF 2 438-470	H65RDC9AA2AN	4.2-4.5	1.1-1.3
64 Channel UHF 2 438-470	H65RDH9AA4AN	4.2-4.5	1.1-1.3
16 Channel UHF 3 465-495	H65SDC9AA2AN	4.2-4.5	1.1-1.3
64 Channel UHF 3 465-495	H65SDH9AA4AN	4.2-4.5	1.1-1.3

5.4.3.1 To Perform Transmit High Power Tuning, do the following:

1. Under the **Tx Align** menu, select **Transmit Power**, then select **High** (Figure 5-5).
2. Press **PTT Toggle**. This will key the radio up at 1st test frequency (F1).
3. Adjust the high power level to be as defined by Table 5-3. Move the slider/spin control or keying in values in the edit control (press **ENTER** to confirm your selection after typing in the softpot value).
4. Press **PTT Toggle** to dekey the radio, go to the next frequency point by selecting the slider, typing in the edit control box (press **ENTER** to confirm selection after typing in the softpot value) or toggling the softpot value using the spin control.
5. Press **PTT Toggle** again to key up the radio at the selected frequency point.
6. Repeat steps 3-5 for the remaining test frequencies (F2-7)
7. Press **Program** to store the softpot values into the radio's codeplug.
8. Exit the Transmit High Power function.
9. If the radio uses only high power channels, proceed to adjust modulation. If low power channels are used, perform Transmit Low Power Tuning as defined.

5.4.3.2 To Perform Transmit Low Power Tuning, do the following: -

1. Under the **Tx Align** menu, select **Transmit Power**, and then select **Low**.
2. Press **PTT Toggle**. This will key the radio up at 1st test frequency (F1).
3. Adjust the power level to be as defined by **country power level specifications** by moving the slider/spin control or keying in values in the edit control (press **ENTER** to confirm your selection after typing in the softpot value).
4. Press **PTT Toggle** to dekey the radio, go to the next frequency point by selecting the slider, typing in the edit control box (press **ENTER** to confirm your selection) or toggling the softpot value using the spin control.
5. Press **PTT Toggle** again to key up the radio at the selected frequency point.
6. Repeat steps 3-5 for the remaining test frequencies (F2-F7).
7. Press **Program** to store the softpot values into the radio's codeplug.
8. Exit the Transmit Low Power function.

5.4.4 VCO Attenuation

Note: **Modulation Balance Tuning must be done first. The Transmit Deviation Limit softpot sets the maximum deviation of the carrier. Tuning is performed for all (12.5 kHz, 20 kHz and 25 kHz) channel bandwidths. Tuning for 25 kHz channels must be done first for all frequency points. Tuning for 12.5 and 20 kHz channels determines only the offset to the previously tuned deviation for 25 kHz tuning channel spacing. For 12.5, and 20kHz channels, only the last non-0 transmit frequency point (normally F7) is used for tuning. The 30 kHz channel bandwidths that use 5.0 kHz maximum system deviation are covered by the 25 kHz tuning.**

When using test box RLN4460:

- Set the METER OUT toggle switch to the "MIC PORT" position
- Set the METER OUT selector switch to "MIC".
- Inject a 1 kHz tone with the levels given below for each radio model to AUDIO IN.
- Measure the level at the radio input at the AC/DC meter.
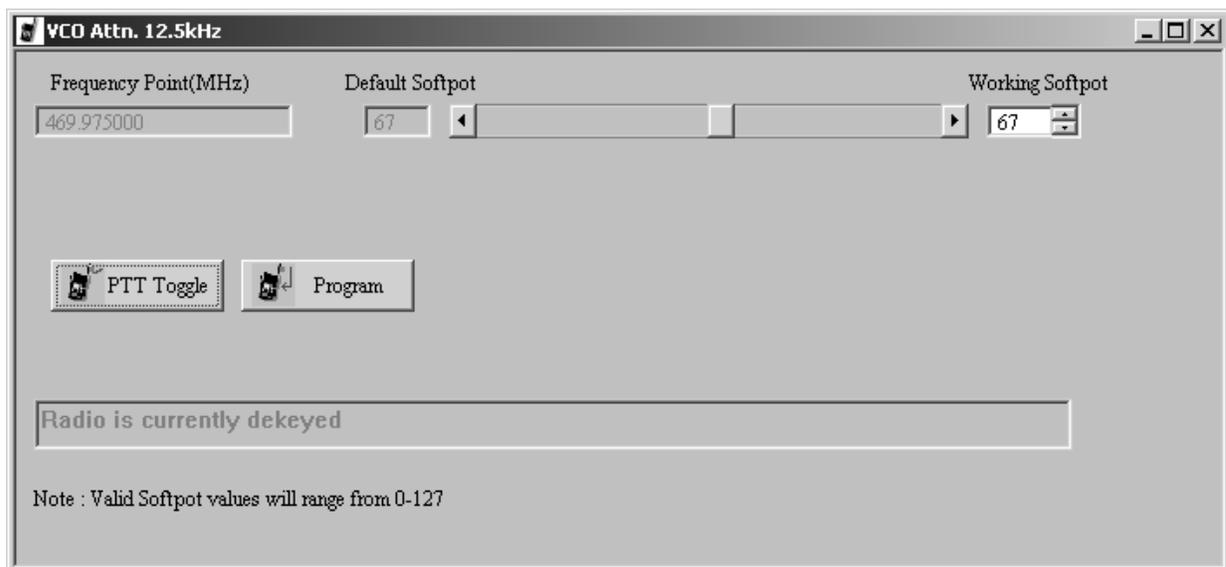
Figure 5-6. VCO Attenuation Window (12.5 kHz)

5.4.4.1 VCO Attenuation 25 kHz

1. Under the **Tx Align** menu, select **VCO Attenuation 25 kHz** (Figure 5-6).

2. Begin with the lowest frequency. Select the thumb of the slider at the lowest frequency point and then press the **PTT Toggle** button to key up the radio at the corresponding frequency point. The spin control can also be toggled via its up/down arrow buttons. The softpot value can also be typed into the edit control (press **ENTER** to confirm your selection/send a softpot value).

3. **Inject 1 kHz** at an appropriate level until **2.3 V rms** is measured at the AC/DC METER (radio input) if using test box **RLN4460**.

4. Record the deviation obtained.

5. Adjust the slider; adjust the spin control or key in softpot values (press **ENTER** to confirm) for the frequency point until the deviation is within the range **specified in** Table 5-4.

6. Dekey the radio (Press the **PTT Toggle** button). Choose the next frequency, key up and repeat steps 3 to 6 until all seven tuning points are done.

7. Program the softpot value by pressing the **Program** button.

8. Exit the VCO Attn. 25 kHz function.

5.4.4.2 VCO Attenuation 12.5 kHz

Note: **Tuning of Modulation Balance Attenuation and VCO Attenuation for 25 kHz channel bandwidth must be done first.**

1. Under the **Tx Align** menu, select **VCO Attenuation 12.5 kHz**.

2. Press **PTT Toggle** to key up the radio at the last non-0 transmit frequency point (normally F7).

3. Inject **1 kHz** at an appropriate level until **2.3 V rms** is measured at the AC/DC METER (radio input) if using test bo**x RLN4460**.

4. Record the deviation obtained.

5. Adjust the slider, adjust the spin control or key in softpot values (press **ENTER** to confirm) for the frequency point until the deviation is within the range **specified in** Table 5-4.

6. Press **PTT Toggle** to dekey the radio.

7. Program the softpot value by pressing the **Program** button.

8. Exit the VCO Attenuation 12.5 kHz function.

5.4.4.3 VCO Attenuation 20 kHz

Note: **Tuning of Modulation Balance Attn. and VCO Attn. for 25 kHz channel bandwidth must be done first.**

1. Under the **Tx Align** menu, select **VCO Attenuation 20 kHz**.

2. Press **PTT Toggle** to key up the radio at the last non-0 transmit frequency point (normally F7).

3. Inject **1 kHz**: at an appropriate level until **2.3V rms** is measured at the AC/DC METER (radio input) if using test box **RLN4460**.

4. Record the deviation obtained.

5. Adjust the slider; adjust the spin control or key in softpot values (press **ENTER** to confirm) for the frequency point until the deviation is within the range **specified in** Table 5-4.

6. Press **PTT Toggle** to dekey the radio.

7. Program the softpot value by pressing the **Program** button.

8. Exit the VCO Attn. 20 kHz function.

Table 5-4. Deviation Specifications

Band	Channel Spacing	Deviation (kHz)
UHF/VHF	25 kHz	4.40 - 4.60
UHF/VHF	12.5 kHz	2.20 - 2.30
UHF/VHF	20 kHz	3.40 - 3.60

5.4.5 DTMF Deviation Tuning

This tuning option controls the **Dual Tone Multi-Frequency** deviation. Please note that **Modulation Balancing** and **VCO Attenuation** have to be performed prior to this tuning operation. Not doing so will result in the **wrong deviation value being obtained** while tuning the DTMF.
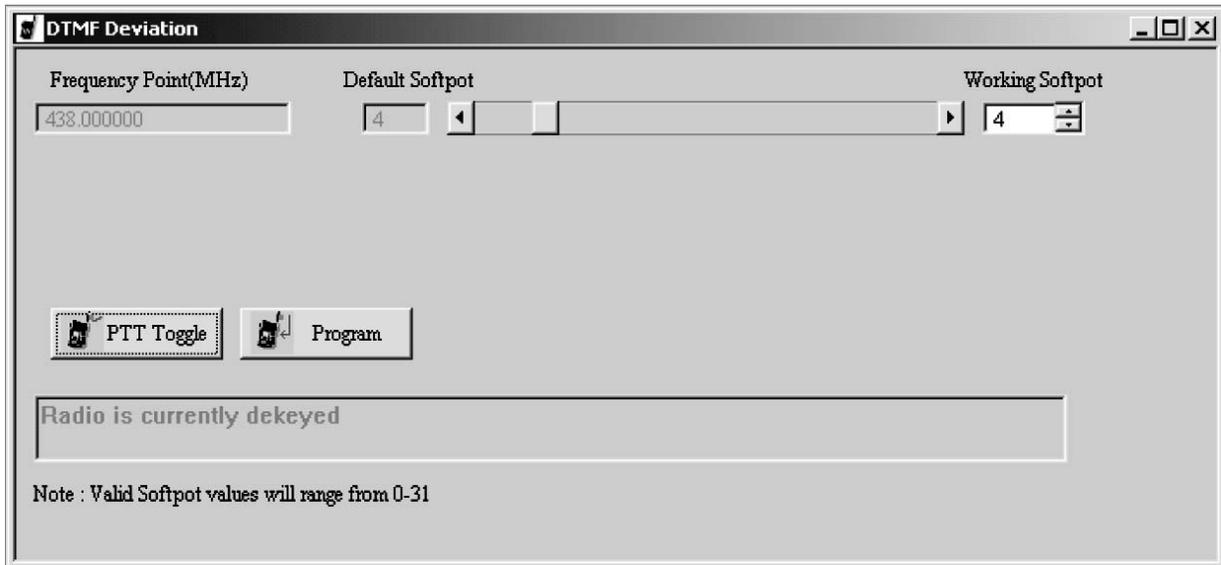
Figure 5-7. DTMF Deviation Tuning Window

1. Under **Tx Align**, select **DTMF Deviation** (Figure 5-7).
2. Press **PTT Toggle** to key the radio. Monitor the deviation obtained.
3. Adjust the slider, spin or edit control (press **ENTER** to confirm your selection/send a softpot value) until a deviation of **3.1-3.4 kHz** is obtained.
4. Press **PTT Toggle** again to dekey the radio.
5. Program the softpot value into the radio by pressing **Program**.
6. Exit the DTMF Deviation function.

5.4.6   MDC-1200 Deviation Tuning

This tuning option controls the MDC-1200 Signaling deviation. Please note that Modulation Balancing and VCO Attenuation have to be performed prior to this tuning operation. Not doing so will result in the wrong deviation value being obtained while tuning this feature.
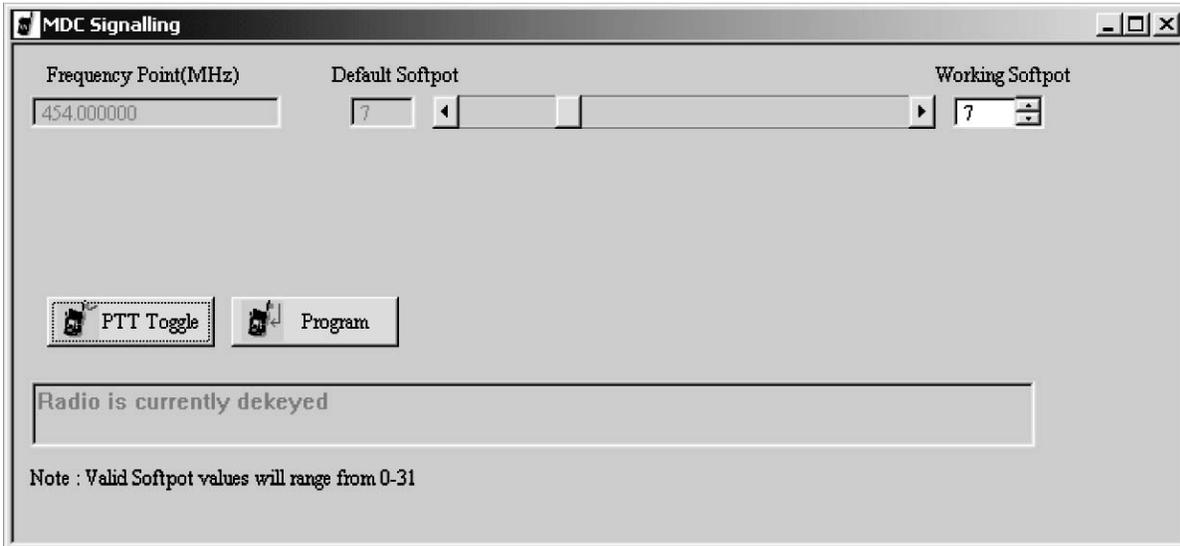
Figure 5-8. MDC-1200 Deviation Tuning Window

1. Under the **Tx Align**, select **MDC-1200 Signaling** (Figure 5-8).

2. Press **PTT Toggle** to key the radio up. Monitor the deviation obtained.

3. Adjust the slider, spin or edit control (press **ENTER** to confirm the selection/send a softpot value) until a deviation of **3.3-3.7 kHz** is obtained.

4. Press **PTT Toggle** again to dekey the radio.

5. Program the softpot value into the radio by pressing the **Program**.

6. Exit the MDC-1200 Deviation function.

5.5   Receiver Tuning

The following sub-sections contain the procedures to tune the radio receiver. These procedures include:

- Rated Volume
- Squelch Tuning Front End Filter Tuning

5.5.1   Rated Volume Tuning

> **Note:** **When using test box RLN4460, the received audio output is taken from the AC/DC METER OUT terminals with the METER OUT rotary switch set to RX. The rated audio tuning procedure automatically configures the radio for 25 KHz. This means that a 3 kHz (for 25 kHz channel spacing) deviation must always be used, irrespective of the radio channel bandwidth.**
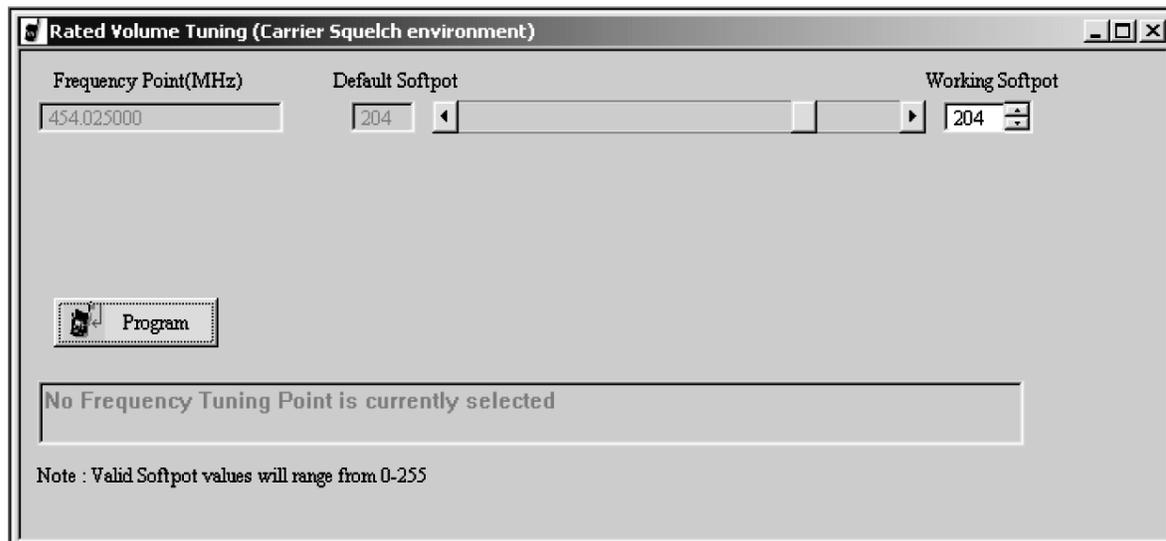
Figure 5-9. Rated Volume Tuning Window

Perform the rated volume tuning procedure as follows:

1. Under the **Rx Align** menu, select **Rated Volume** (Figure 5-9).

2. Inject a -47 dBm RF signal modulated with **1 kHz** tone at **3 KHz** (for 25 kHz channel spacing).

3. Adjust the softpot value by using the slider, keying in the edit box (press **ENTER** to confirm the selection or send a softpot value), or via the spin controls. Repeat this until **500 mW (3.24 V)** audio power is obtained. Rated Audio tuning is only done for 25 kHz channel spacing.

4. Press **Program** to commit the softpot value into the radio.

5. Exit the rated volume tuning function.

5.5.2   Squelch Tuning

Note: **1. Squelch tuning can only be accomplished after reference oscillator warping.**

2. When using the test box RLN4460, the received audio output is taken from the AC/ DC METER OUT terminals with the METER OUT rotary switch set to RX. It is recommended that Rated Volume Tuning be performed so the correct 10 dB SINAD level can be obtained.

3. This tuning method is performed for multiple squelch tuning channels and multiple channel spacings.
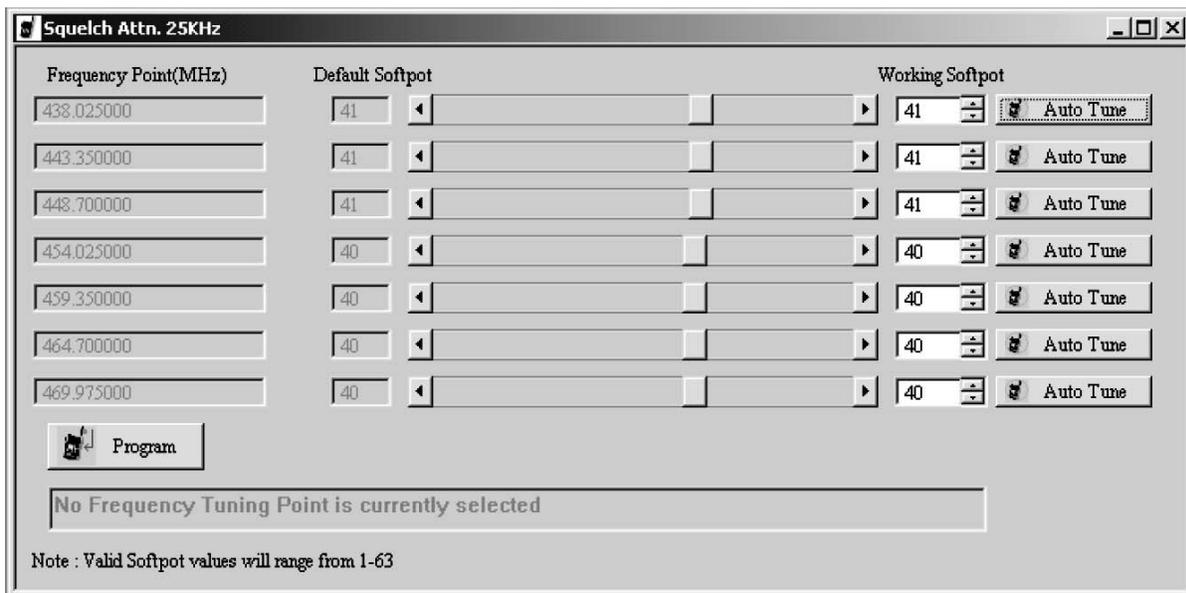
Figure 5-10. Squelch Tuning Window

5.5.2.1 Manual Squelch Tuning

Perform the squelch tuning procedure as follows:

1.   Under the **Rx Align** menu, select **Squelch Attenuation**. Select **Squelch Attenuation 12.5 kHz** or **Squelch Attenuation 25 kHz** Channel Spacing variations (Figure 5-10).

2.   Apply an RF signal modulated with a 1 kHz tone at 60% rated deviation listed in Table 5-5 for current frequency point (F1 being the first) of 10 dB SINAD. That is, adjust the reference signal level until 10 dB SINAD is obtained at the SINAD meter. Squelch tuning can either be done manually (see Manual Squelch Tuning for procedure) or by Auto Squelch (see Manual Squelch Tuning for procedure). To obtain 10 dB, unmute the radio first by dragging the corresponding slider value to 1.

Table 5-5. Squelch Deviation Values

Channel Spacing	Rated System Deviation	Signal Generator Deviation
25 kHz	5.0 kHz	3.0 kHz
12.5 kHz	2.5 kHz	1.5 kHz
20 kHz	4.0 kHz	2.4 kHz

3. Set softpot to its maximum value to mute the radio.

4. Adjust the softpot value by using the slider, keying in the edit box or using the spin controls. Press **ENTER** to confirm the selection or use the spin controls. Do this until the radio is totally unmuted. Verify the squelch closing by inputting a signal level of **4 dB** lower than that of the **10 dB** SINAD level.

5. Repeat Steps 2 through 4 of Manual Squelch Tuning, for frequency points F2-F7.

6. Press **Program** to commit the softpot values into the radio.

7. Exit the Squelch Tuning function.

5.5.2.2 Auto Tune

> **Note:** **Proceed with caution since this procedure automatically programs the softpot value into your radio.**

When you press the **Auto Tune** button, the radio automatically returns an optimum squelch value.

After you press the button, the radio may need time to produce an optimal setting for the squelch attenuation. The following steps describe the auto tune process:

1. Select current frequency point (F1 being the first), then press **Auto Tune**.

2. Repeat Steps 3-4 of the Manual Squelch Tuning section for frequency points F2-F7.

> **Note:** **Auto Tune will automatically update your radio's codeplug. Please be careful when using it.**

5.5.3   RSSI System Level Tuning
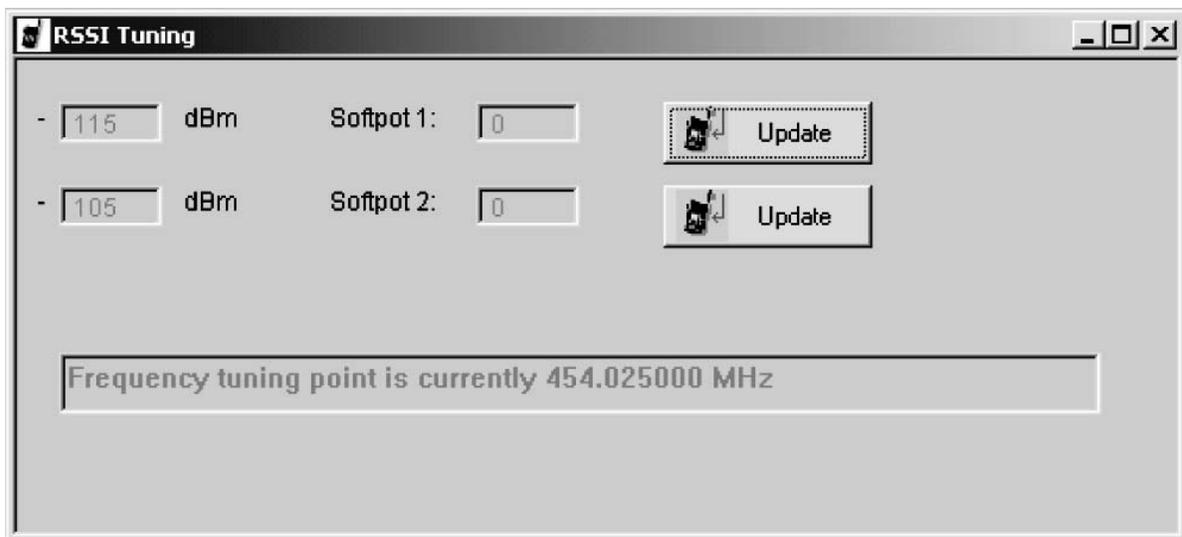
Figure 5-11. RSSI Tuning

1. Under the **Rx Align** menu, select **RSSI Tuning** (Figure 5-11).

2. Inject an on channel signal to the radio at **-47 dBm** at the frequency listed. Modulate the signal with a 1 kHz tone at 60% deviation (3 kHz) to verify that the radio is receiving the desired frequency. RSSI tuning is only done at 25 kHz channel spacing.

3. Change the level to the defined dBm level in the softpot box. (**-115 dBm or -105 dBm**).

4. Press the **Update** button for the soft spot to be tuned to the RSSI value correlating to the applied level. The programmed RSSI value will be displayed.

5. Adjust the input level to reflect the next soft spot value. Repeat steps 3 and 4 to tune the next value.

5.5.4   RSSI Display Tuning

1. Under the **Rx Align** menu, select **RSSI Display Tuning**.

2. Inject an on channel signal to the radio at **-47 dBm** at the frequency listed. Modulated the signal with a 1 kHz tone at 60% deviation (3 kHz) to verify the radio is receiving the desired frequency. RSSI tuning is only done at 25 kHz channel spacing.

3. Change the level to that which is needed to produce 12 SINAD (**approximately -119 dBm**).

4. Press the **Update** button for the soft spot to be tuned to the RSSI value correlating to the applied level. The programmed RSSI value will be displayed.

5. Adjust the input level to **-90 dBm**.

6. Press the **Update** button for the soft spot to be tuned to the RSSI value correlating to the applied level. The programmed RSSI value will be displayed.

5.6   Utilities

5.6.1   Program Serial No.

The Program Serial No. option under the Utilities heading allow the radio serial number to be programmed. However, the serial number of a particular radio can only be programmed if it was originally blank. If the serial number of the radio was not blank, then access to the screen will be denied.

5.7   Radio-to-Radio Cloning

1. Cloning is the process of copying the content of one radio (source radio) into another radio (destination radio). Radio content refers to system-type features such as frequency, squelch type options, trunking, etc.

Note: **The source radio's serial number cannot be blank.**

Radio functionality inherent in one radio cannot be cloned to another radio that does not contain the same functionality. Tuning and alignment information are not transferable and are not affected by cloning.

1. Signaling Identification Numbers (IDs) are duplicated in the cloning process. Unique IDs may be assigned with the CPS.

Note: **Unsuccessful cloning attempts generates a continuous tone and may be an indication that the destination radio's codeplug is corrupted.**

Procedure:

1. Turn source and target radios off.

2. Connect cloning cable (AAPMKN4003) to the side connector of both radios.

3. Turn on the destination radio.

4. Press and hold the two side buttons at the same time on the source radio and then power up the source radio (Figure 5-12). Both radios produce a "clone-entry" tone.

5. Release both side buttons, 1 and 2.

6. When cloning is completed, the source radio produce's a "clone-exit" tone and both the source and destination radios reset.

7. Turn both radios off.

8. Disconnect the cloning cable from both radios and turn them on for normal operation.
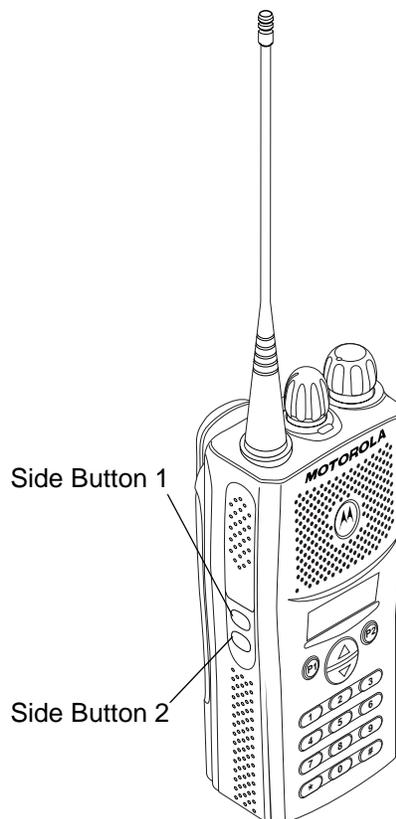
Figure 5-12. Side Button Locations

Notes:

Chapter 6 Display Model Disassembly and Re-assembly

6.1   Introduction

This section provides details about the following:

- Preventive maintenance (inspection and cleaning)
- Safe handling of CMOS and LDMOS devices
- Disassembly and re-assembly of the radio
- Repair procedures and techniques

6.2   Preventive Maintenance

The radios do not require a scheduled preventive maintenance program; however, yearly verification of technical parameters and periodic visual inspection and cleaning is recommended.

6.2.1 Inspection

Check that the external surfaces of the radio are clean, and that all external controls and switches are functional. It is not recommended to inspect the interior electronic circuitry.

6.2.2 Cleaning Procedures

The following procedures describe the recommended cleaning agents and the methods to be used when cleaning the external and internal surfaces of the radio. External surfaces include the front cover, housing assembly and battery case. These surfaces should be cleaned whenever a periodic visual inspection reveals the presence of smudges, grease, and/or grime.

> **Note:**   Internal surfaces should be cleaned only when the radio is disassembled for service or repair.

The only recommended agent for cleaning the external radio surfaces is a 0.5% solution of a mild dishwashing detergent in water. The only factory recommended liquid for cleaning the printed circuit boards and their components is isopropyl alcohol (70% by volume).

> **CAUTION: The effects of certain chemicals and their vapors can have harmful results on certain plastics. Avoid using aerosol sprays, tuner cleaners, and other chemicals.**

Cleaning External Plastic Surfaces

Apply the 0.5% detergent-water solution sparingly with a stiff, non-metallic, short-bristled brush to work all loose dirt away from the radio. Use a soft, absorbent, lintless cloth or tissue to remove the solution and dry the radio. Make sure that no water remains entrapped near the connectors, cracks, or crevices.

Cleaning Internal Circuit Boards and Components

Isopropyl alcohol (70%) may be applied with a stiff, non-metallic, short-bristled brush to dislodge embedded or caked materials located in hard-to-reach areas. The brush stroke should direct the dislodged material out and away from the inside of the radio. Make sure that controls or tunable components are not soaked with alcohol. Do not use high-pressure air to hasten the drying process since this could cause the liquid to collect in unwanted places. After completing the cleaning process, use a soft, absorbent, lintless cloth to dry the area. Do not brush or apply any isopropyl alcohol to the frame, front cover, or back cover.

> **Note:** Always use a fresh supply of alcohol and a clean container to prevent contamination by dissolved material (from previous usage).

6.3   Safe Handling of CMOS and LDMOS Devices

Complementary metal-oxide semiconductor (CMOS) devices are used in this family of radios, and are susceptible to damage by electrostatic or high voltage charges. Damage can be latent, resulting in failures occurring weeks or months later. Therefore, special precautions must be taken to prevent device damage during disassembly, troubleshooting, and repair.

Handling precautions are mandatory for CMOS circuits and are especially important in low humidity conditions. DO NOT attempt to disassemble the radio without first referring to the following CAUTION statement.

CAUTION: This radio contains static-sensitive devices. Do not open the radio unless you are properly grounded. Take the following precautions when working on this unit:

- Store and transport all CMOS devices in conductive material so that all exposed leads are shorted together. Do not insert CMOS devices into conventional plastic "snow" trays used for storage and transportation of other semiconductor devices.

- Ground the working surface of the service bench to protect the CMOS device. We recommend using the Motorola Static Protection Assembly (part number 0180386A82), which includes a wrist strap, two ground cords, a table mat, and a floor mat.

- Wear a conductive wrist strap in series with a 100k resistor to ground. (Replacement wrist straps that connect to the bench top covering are Motorola part number RSX-4015.)

- Do not wear nylon clothing while handling CMOS devices.

- Do not insert or remove CMOS devices with power applied. Check all power supplies used for testing CMOS devices to be certain that there are no voltage transients present.

- When straightening CMOS pins, provide ground straps for the apparatus used.

- When soldering, use a grounded soldering iron.

- If at all possible, handle CMOS devices by the package and not by the leads. Prior to touching the unit, touch an electrical ground to remove any static charge that you may have accumulated. The package and substrate may be electrically common. If so, the reaction of a discharge to the case would cause the same damage as touching the leads.

6.4   Disassembling and Re-assembling the Radio — General

Since these radios may be disassembled and re-assembled with the use of only four (board to casting) screws, it is important to pay particular attention to the snaps and tabs, and how parts align with each other.

The following tools are required for disassembling the radio (see 3.2 for a list of service aids):

- Knob remover/chassis opener
- Penknife-size screwdriver
- TORX™ T6 screwdriver
- Scribe

If a unit requires more complete testing or service than is customarily performed at the basic level, send this unit to a Motorola Authorized Service Center. See Appendix B for a list of authorized service centers.

The following disassembly procedures should be performed only if necessary:

- Chassis Disassembly
- Speaker Disassembly
- PTT Disassembly

6.4.1   Radio Disassembly — Detailed

6.4.1.1 Front Cover From Chassis Disassembly

1. Turn off the radio.
2. Remove the battery (Figure 6-1):

    a. Slide the battery latch into the unlock position. Disengage by pushing downward and holding the latch towards the front of the radio.

    b. With the battery latch disengaged, slide the battery down from the top of the radio about 1/2 in. Once the battery is free from the battery rails, lift it directly away from the radio.

    c. Remove the battery from the radio.
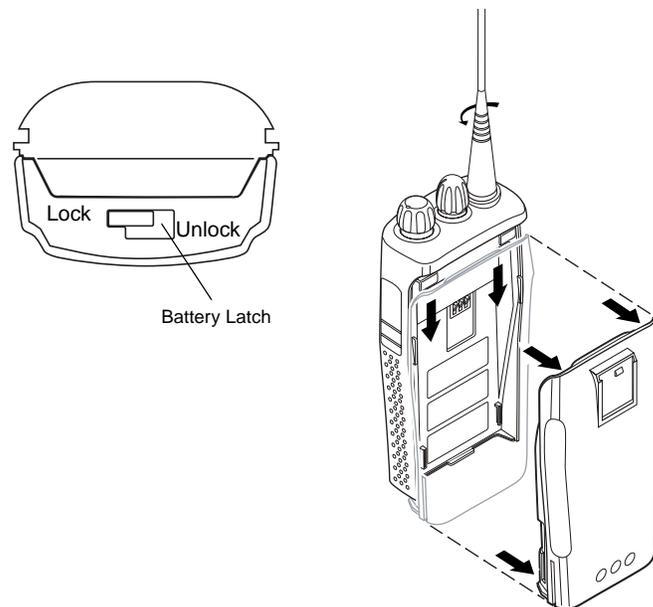
Figure 6-1. Battery Removal

3. Remove the antenna.

4. Pry off the volume and channel selector knobs from their shafts using the knob removal/chassis opener tool (Motorola part # 6686533Z01). (Figure 6-2.)
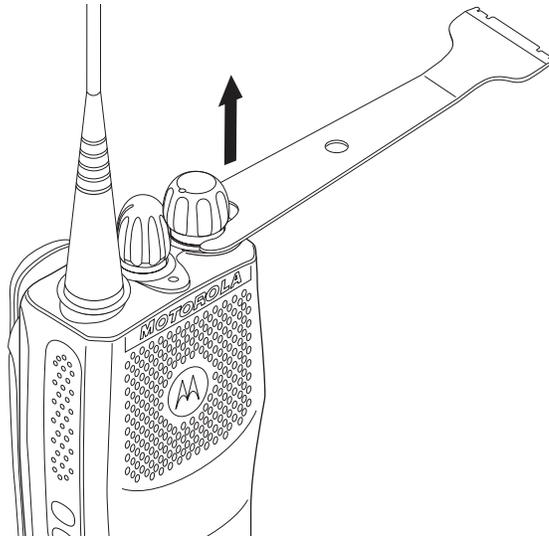
Figure 6-2. Antenna and Knob Removal

Note:　Both knobs slide on and off. However the knobs are designed to fit very tightly on the shaft.

5. Separate the chassis from the front housing assembly by using the knob remover/chassis opener too. Place the broad side of the opener into the slots located at the base of the radio (Figure 6-3). Press the handle on the opener downwards. This pressing action forces the thin inner plastic wall toward the base of the radio, releasing the two chassis base tabs..

Knob Remover/
Chassis Opener
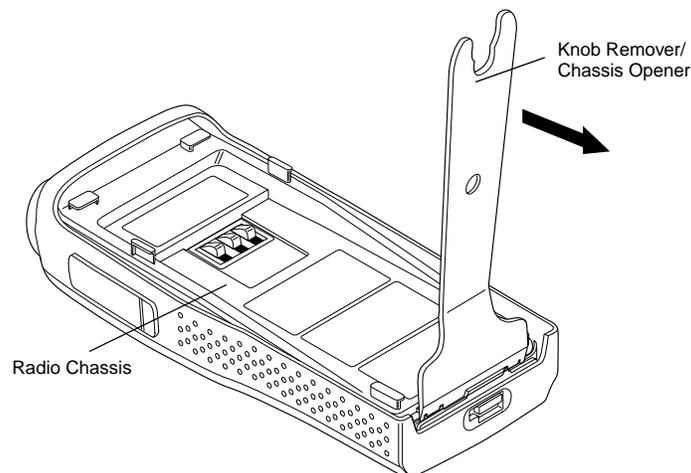
Radio Chassis

Figure 6-3. Chassis Removal

⚠ **CAUTION: Marring the front cover O-ring sealing area will prevent the radio from sealing properly. If the O-ring is damaged, replace it with a new one.**

6. Pull the chassis assembly out of the front cover only until the volume and channel selectors shaft just clear the top of the case. (Figure 6-4).

> **Note:** The speaker wire assembly microphone wire assembly and keypad flex cable connector connecting the front housing assembly and the chassis prevent the two units from being completely separated

7. Rotate the bottom of the chassis up about 20° to disconnect the keyboard flex cable connector. Push down 2 end tabs to release flex connector at the bottom of the chassis.

Radio Chassis
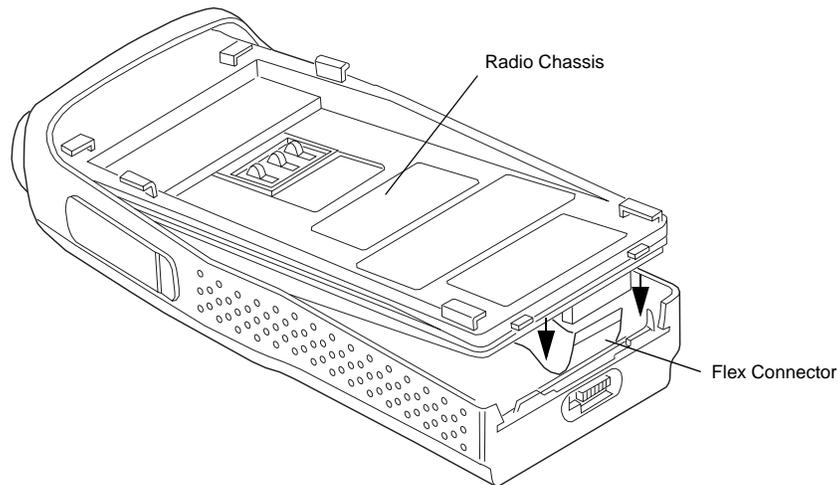
Flex Connector

Figure 6-4. Keyboard Flex Connection

8. Rotate the chassis counterclockwise out of the housing and position next to the housing. Take care not to damage the speaker and microphone wires that are still connected to the chassis (Figure 6-5).

Speaker Connector

Microphone Connector
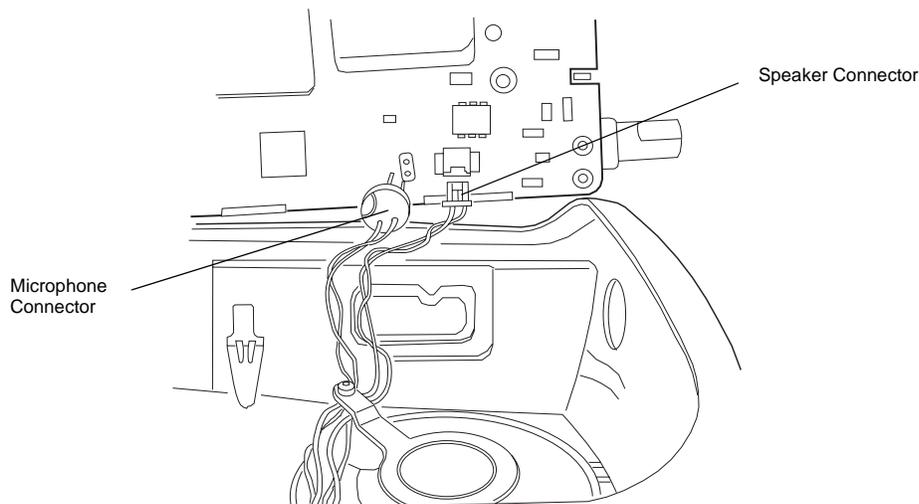
Figure 6-5. Microphone and Speaker Connections

9. Unplug the speaker wire assembly from the 2-pin connector on the chassis.

10. Unplug the microphone wire assembly from the socket on the chassis.

11. Move the chassis away from the housing and place on a clean work surface.

6.4.1.2 Dust Cover Disassembly

1. Gently pry the top of the dust cover away from the body of the radio. (See Figure 6-6).
2. Rotate the dust cover 90° in a counterclockwise direction to allow the key to be removed.
3. Separate the dust cover away from the body of the radio. The dust cover key is fragile; apply only light pressure to the key while removing the dust cover.
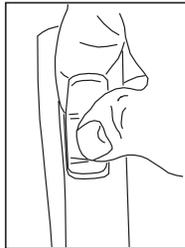
a. Pry dust cover from body.
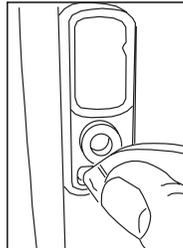
b. Rotate dust cover 90° to allow key to be removed.
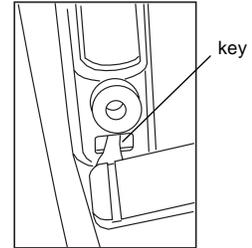
c. Separate dust cover from body.

Figure 6-6. Dust Cover Disassembly

6.4.1.3 Speaker and Microphone Disassembly

> **Note:** The speaker is held in place with a retainer bracket. Be careful not to damage the speaker when removing the retainer bracket.

1. Remove the screw from the speaker retainer using a T6 Torx screwdriver (Figure 6-7.
2. Lift the retainer off the speaker, sliding end of retainer out of corner slot on the housing.
3. Lift the speaker out from the front housing.
4. Carefully lift microphone assembly out of housing.
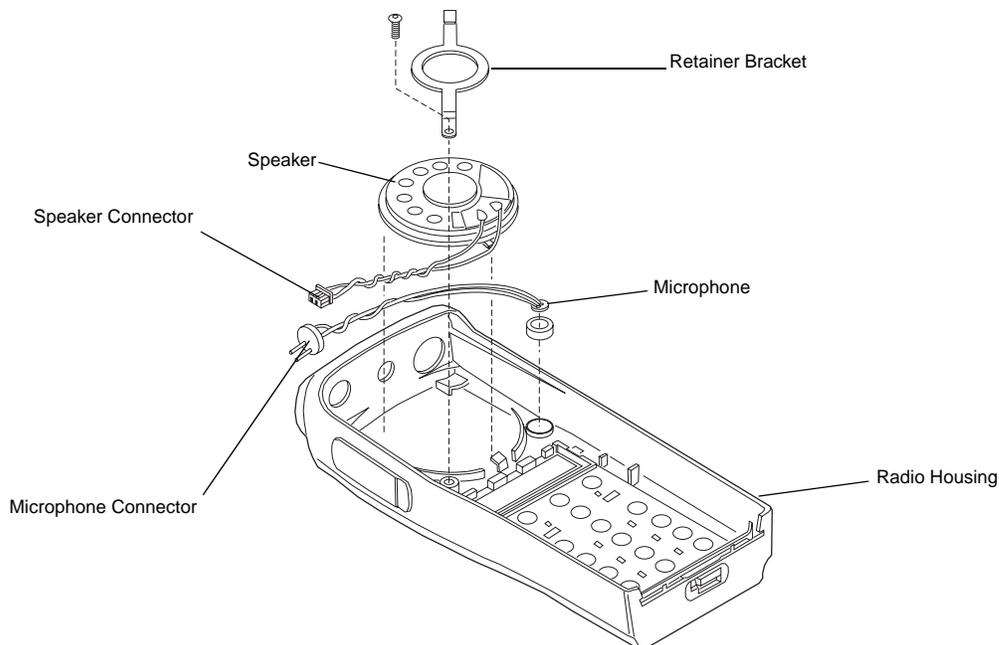
Figure 6-7. Removal Speaker-Microphone Assembly

6.4.1.4 Keyboard Removal

1. Carefully pry the four keypad retainer locking tabs free from the housing use a scribe.

Note: Use care when removing the keypad retainer to prevent damage to the keyboard flex cable.

2. Lift the keypad retainer up from the bottom and slide the top tabs out.

3. Slide keypad retainer out of chassis carefully to prevent damage to flex cable.

⚠ **CAUTION: Refer to the CMOS CAUTION paragraph (6.3) before removing the main board. Be sure to use Electrostatic Discharge protection when handling circuit boards.**

4. Lift LCD keypad board out of housing (Figure 6-8).

5. Lift keypad out of housing.

Keypad Retainer

Flex Cable

Keypad Board
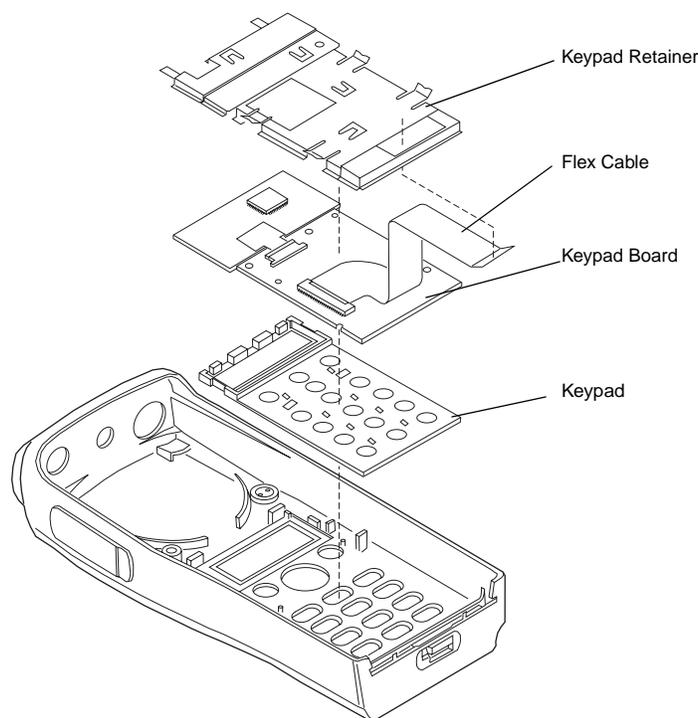
Keypad

Figure 6-8. Keypad Removal

6.4.1.5 PTT Disassembly

1. If required, the PTT (Figure 6-9 can be disassembly using a small screwdriver, as follows:

    a.   Insert the tip of a small screwdriver underneath the PTT and unsnap the top tab.

    b.   Pry the PTT away from the radio housing.

    c.   Inspect the two hooks. If bent or broken, the PTT must be replaced.

    d.   Remove the PTT seal.
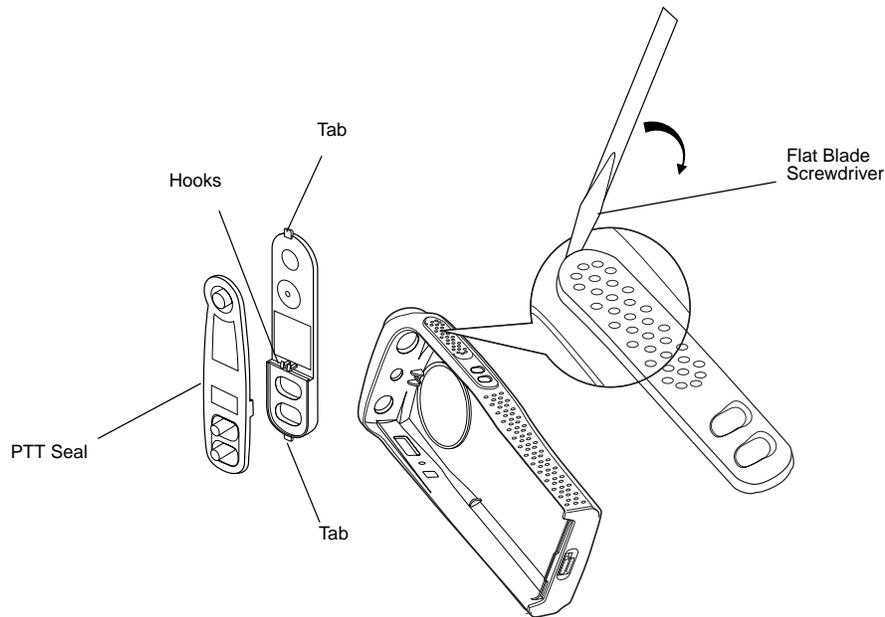
Figure 6-9. PTT Removal

6.4.1.6 Chassis Disassembly

> ⚠ **CAUTION: Refer to the CMOS CAUTION paragraph (see 3.3) before removing the main board. Be sure to use Electrostatic Discharge protection when handling circuit boards.**

1. Remove the O-ring.

2. Use a Torx™ screwdriver with a T6 bit to remove the four screws (Figure 6-10) holding the main board to the chassis.

.
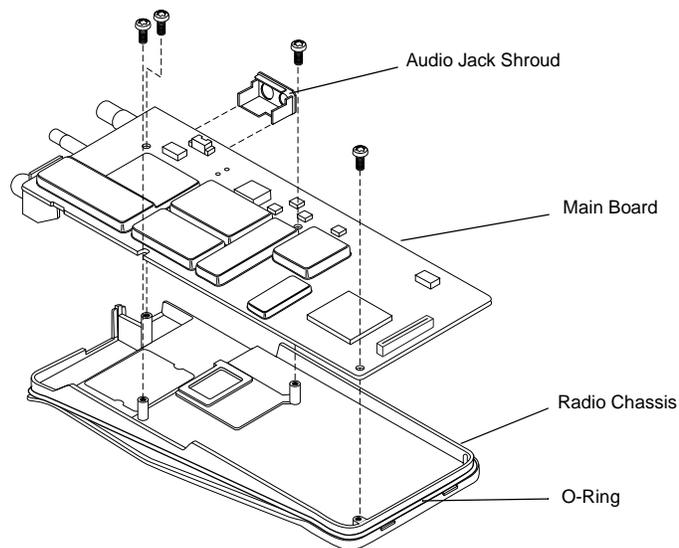
Figure 6-10. Removal of Main Board from Chassis

3. The audio jack shroud can be removed from the main board.

4. Lift the main board from the chassis (Figure 6-10).

5. Remove the battery contact seal.

6.4.2   Radio Re-assembly - Detailed

6.4.2.1 Dust Cover Re-assembly

1. Insert the tail of the dust cap into the bottom hole of the audio jacks housing opening (Figure 6-11).

2. Press the dust cap until the tail is fully into the hole.

> **Note:** Make sure the dust cap is placed between the keypad retainer mounting post and the side wall of the radio.

3. Twist the dust cap counter-clockwise until the cap is seated properly onto the recess.

4. Press the cap again to ensure it fully covers the opening for the audio jack.

.

1   2   3   4
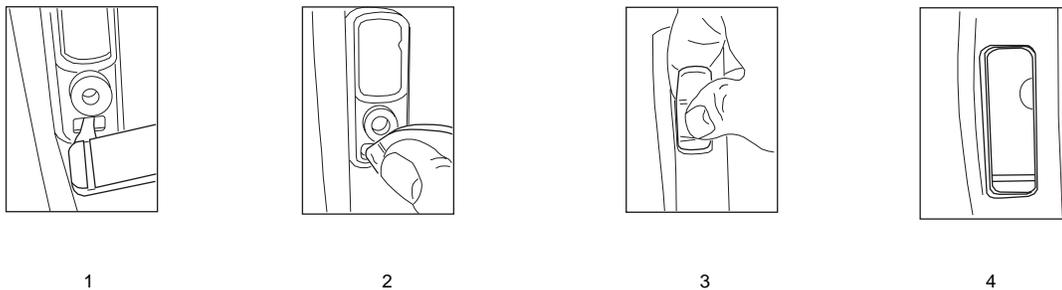
Figure 6-11. Dust Cap Re-assembly

6.4.2.2 Microphone and Speaker Re-assembly

1. Check that the mic and speaker felts are in position and not damaged. If damaged replace felts.

2. Insert the microphone sub-assembly into the microphone boot.

3. 3. Insert the Boot and microphone sub-assembly into the microphone recess in the housing and route wires as shown in Figure 6-12.
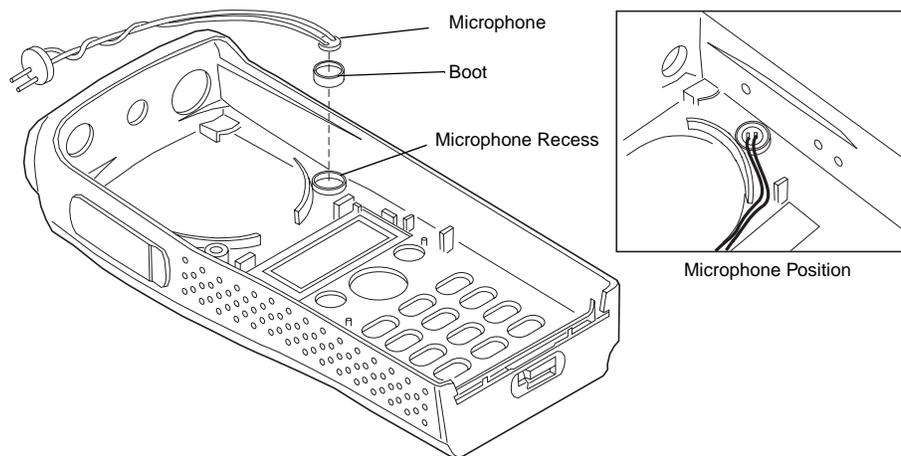
Figure 6-12. Microphone Re-assembly

4. Locate the speaker tab and align it with the tab opening in the front housing (Figure 6-13).

5. Insert the speaker tab into the speaker recess in the housing. Ensure the speaker is seated flush in the housing.

Note: Make sure the speaker and microphone wires are routed tightly between the speaker basket and the housing post.

6. Insert one end of the speaker retainer into the slot in the front housing (See Figure 6-13).
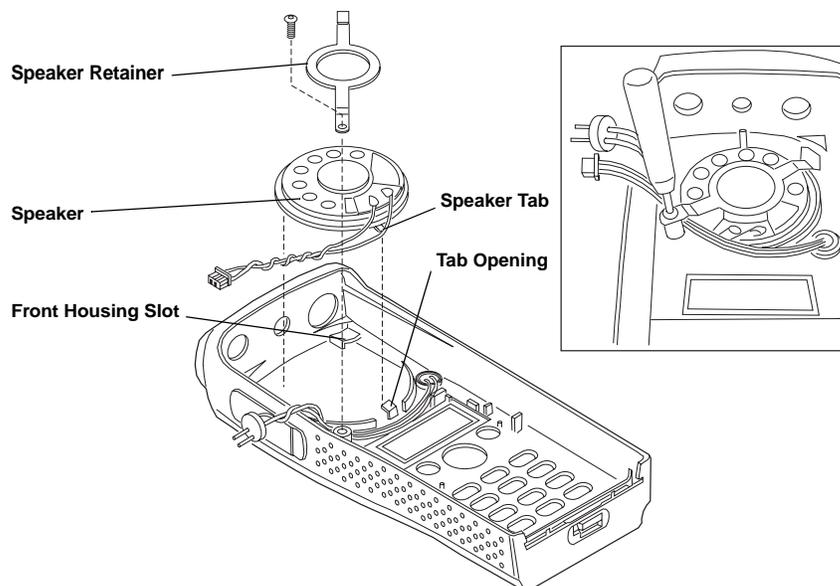
Figure 6-13. Speaker Re-assembly

Note: When fastening the speaker retainer screw, make sure the wires are out of the way to prevent pinching by the retainer.

7. Install the retainer screw using a T6 Torx screwdriver. Torque to 2.3 - 2.5 lb/in.

6.4.2.3 Keypad and LCD/Keyboard Re-assembly

1. Attach the flex cable from the LCD module to the keyboard, if not already attached (Figure 6-15).

2. Remove protective mylar from window and from keypad, if present.

3. Install the new keypad into the housing. Use the two housing posts for keypad alignment (Figure 6-14).

Full Keypad

Housing Posts
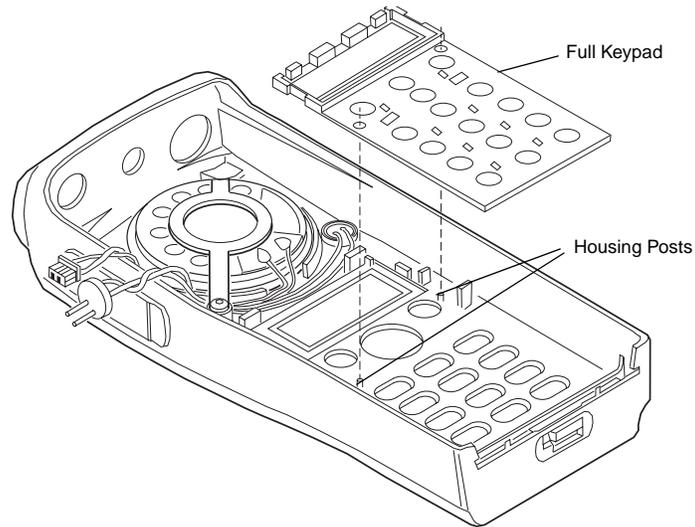
Figure 6-14. Keypad Re-assembly

4. Remove mylar from LCD if present.

⚠ **CAUTION:** Make sure the microphone and speaker wires are not trapped under the LCD module.

5. Install the LCD/Keypad sub-assembly into the housing (Figure 6-15).

Flex Cable from LCD Module

Flex Cable to Main PC Board
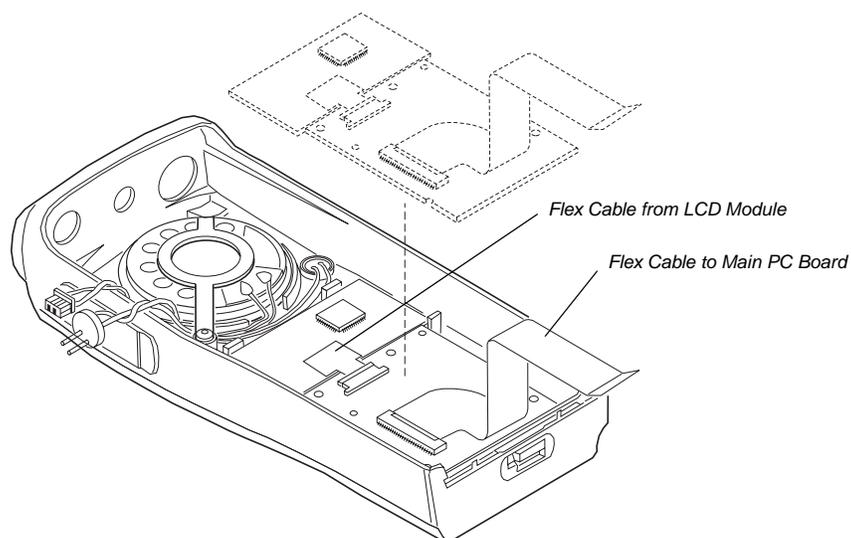
Figure 6-15. LCD/Keypad Board Re-assembly

6. Attach the flex cable into the connector on the keypad board, if not already connected.

7. Bend the flex cable as shown (Figure 6-15)

6.4.2.4 Keyboard Retainer Re-assembly

1. Insert the flex cable through the slot at the bottom of the keyboard retainer (Figure 6-16).
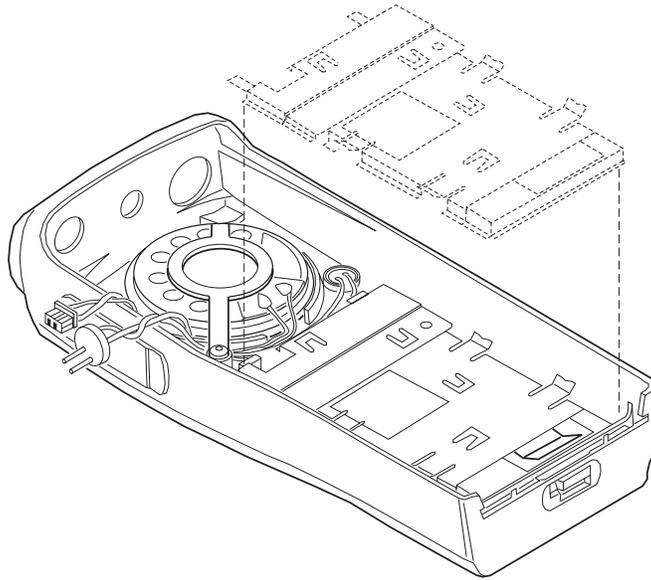
Figure 6-16. Keyboard Retainer Re-assembly

2. Insert the two top tabs of the keyboard retainer into the two tab retainers located on each side of the speaker in the front housing (Figure 6-16).

3. Press the four keypad retainer locking tabs into the housing.

4. Push the speaker and microphone wires into the top left hand corner of the housing.

6.4.2.5 Chassis Assembly/Re-assembly

1. Replace the battery contact seal (if necessary) surrounding the battery contact (Figure 6-17).

2. Remove the old Interface Pad from the chassis by scraping off the pad and adhesive with a straight razor. Use rubbing alcohol and a cloth to completely remove the adhesive from the chassis surface. With the chassis clean and dry, add a new Interface Pad to the chassis.

3. Place the main circuit board straight down on top of the chassis with the frequency and volume switches facing down (Figure 6-17).

   Note: Be sure the battery contact seal protrudes through the chassis and is not pinched under the chassis.

4. Use the T6 Torx screwdriver to fasten the screws holding the main board to the chassis. Tighten to 3.7 - 3.9 in/lb.

5. Replace the O-ring by positioning it in the top groove by the volume/frequency switches. Stretch the O-ring to place it into the retaining groove at the bottom end of the chassis.

6. Check that the O-ring is not twisted and being held by the top and bottom chassis groves.

.

Frequency &
Volume Switches

Audio Jack Shroud
(Replace after Plugging
in Speaker and Mic)

Main Board

Interface Pad

Flex Cable Connector

Radio Chassis

Battery Contact Seal

O-Ring
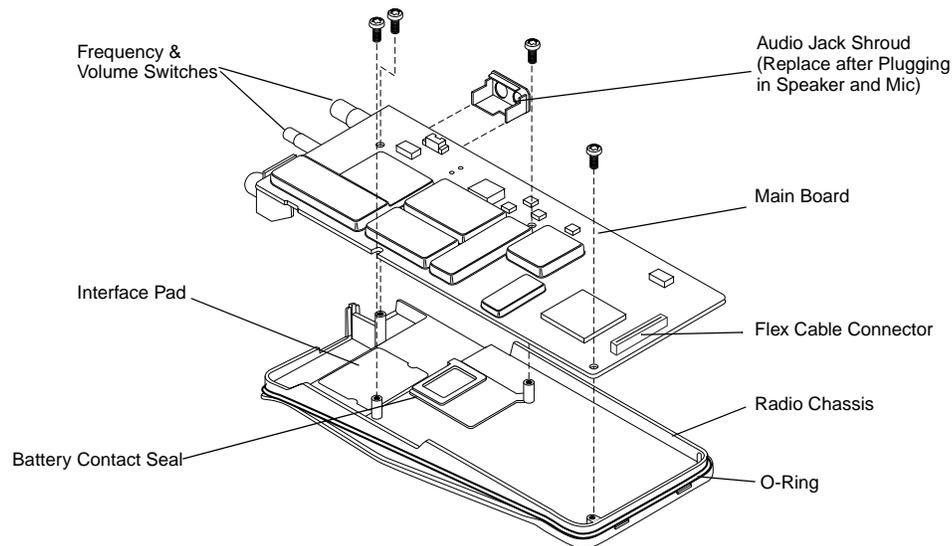
Figure 6-17. Main Board onto Chassis Re-assembly

6.4.2.6 Chassis and Front Cover Re-assembly

1.   Dress and connect the speaker wires..

Note: Care should be taken when dressing the speaker and microphone wires to avoid pinching them between the speaker magnet and shield, or between the accessory connector and housing.

Note: Ensure that the plug orientation is correct with the exposed pins in the wire casing facing upward and fully plugged in.

a.   Connect the speaker wire assembly into the 2-pin connector on the main board and bend the wires at the board connector so the wires are positioned toward the top of the radio (Figure 6-18).

b.   Connect the microphone wire assembly into the two hole socket on the main board and bend the wires at the board connector so the wires are positioned toward the top of the radio (Figure 6-18).

c.   Slide the audio jack shroud onto accessory connector (Figure 6-17).

Microphone
Connector

Speaker Connector

Shroud
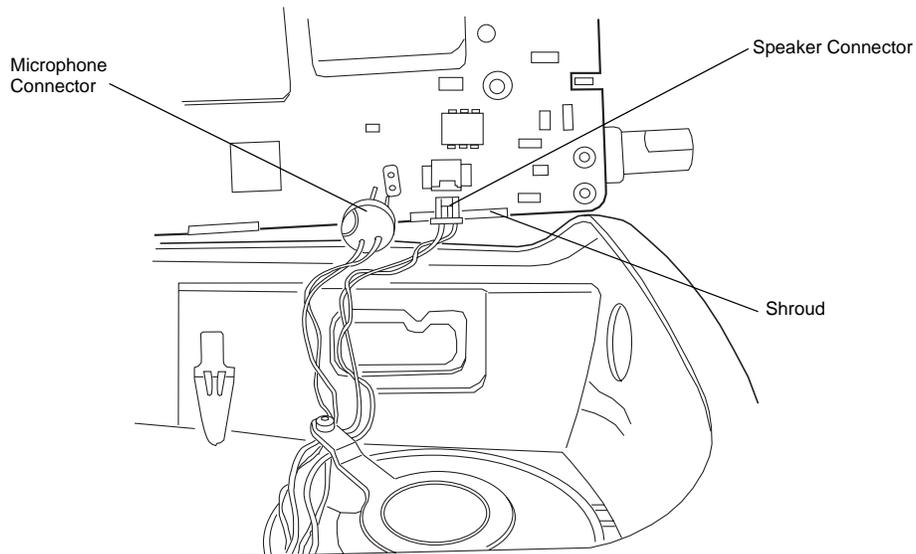
Figure 6-18. Microphone and Speaker Wires Re-assembly

2. Position the radio (Figure 6-19), and reconnect the flex connector from the keyboard into the connector located on the bottom of the main board, pushing up the 2 end tabs.

3. Slide the volume potentiometer and frequency switch shafts into their respective holes in the front cover. Look through the accessory connector opening to make certain that the wires are not pinched, between shroud and housing.

Radio Chassis

End Tabs

Flex Cable Connector
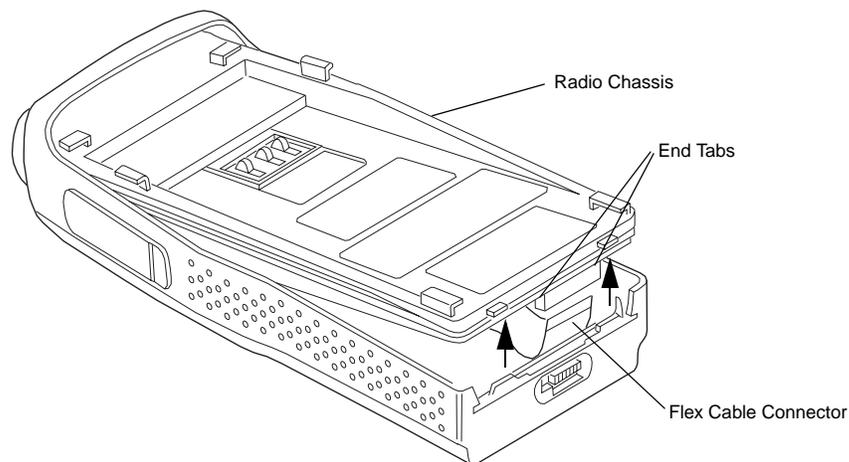
Figure 6-19. Keyboard Flex Cable Connection

4. Push the topside of the board chassis upward until it touches the housing end. Before snapping the board into the housing, perform the following checks:

    a. Open the dust cap and ensure the wires are not pinched between the shroud and housing.

    b. Ensure the O-ring is seated in the groove.

    c. Ensure that the bottom side of the dust cap is fully pressed into the housing before the snapping the board into place.

5. Snap chassis assembly completely into the top of the front cover (Figure 6-20) until it settles in place.
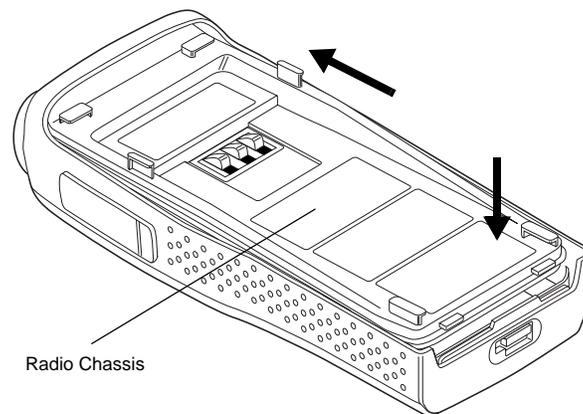
Figure 6-20. Fastening the Chassis

6. Make sure the 0-ring is properly seated. If the O-ring seal is pinched, separate the chassis from the housing using the knob removal/chassis opener and dress O-ring properly.

7. Snap the bottom of the chassis into the front cover.

8. Check that O-ring is visible at the corners.

9. After closing the radio, verify that the O-ring is not visible; if visible, re-assemble properly.

10. Re-assemble the knobs, antenna, and battery.

6.4.2.7 PTT Re-assembly

1. Place the PTT seal over the ridge around the top hole. Press down to seat the seal around the ridge.

2. Place the bottom tab in the slot inside the front housing PTT opening. Slightly slide down the PTT and bow it by placing one finger under the middle of the PTT, so that the top tab can be aligned and inserted into the top slot (Figure 6-21a).

3. Press the PTT assembly against the front cover opening (Figure 6-21b).
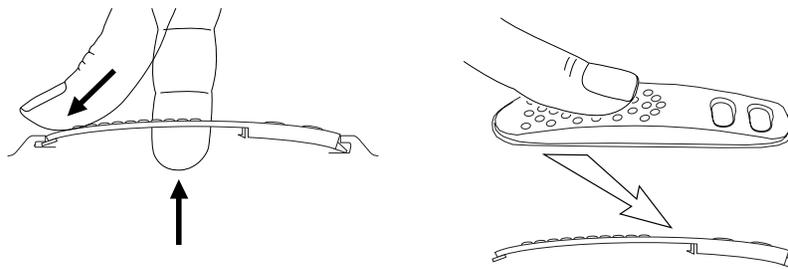
a. Place bottom tab into bottom slot.
Place top tab into top slot.

b. Push down on PTT toward bottom
of radio so hooks do not get crushed.

Figure 6-21. PTT Re-assembly

6.5   Mechanical View and Parts List

6.5.1   EP450 Display Exploded View and Parts List
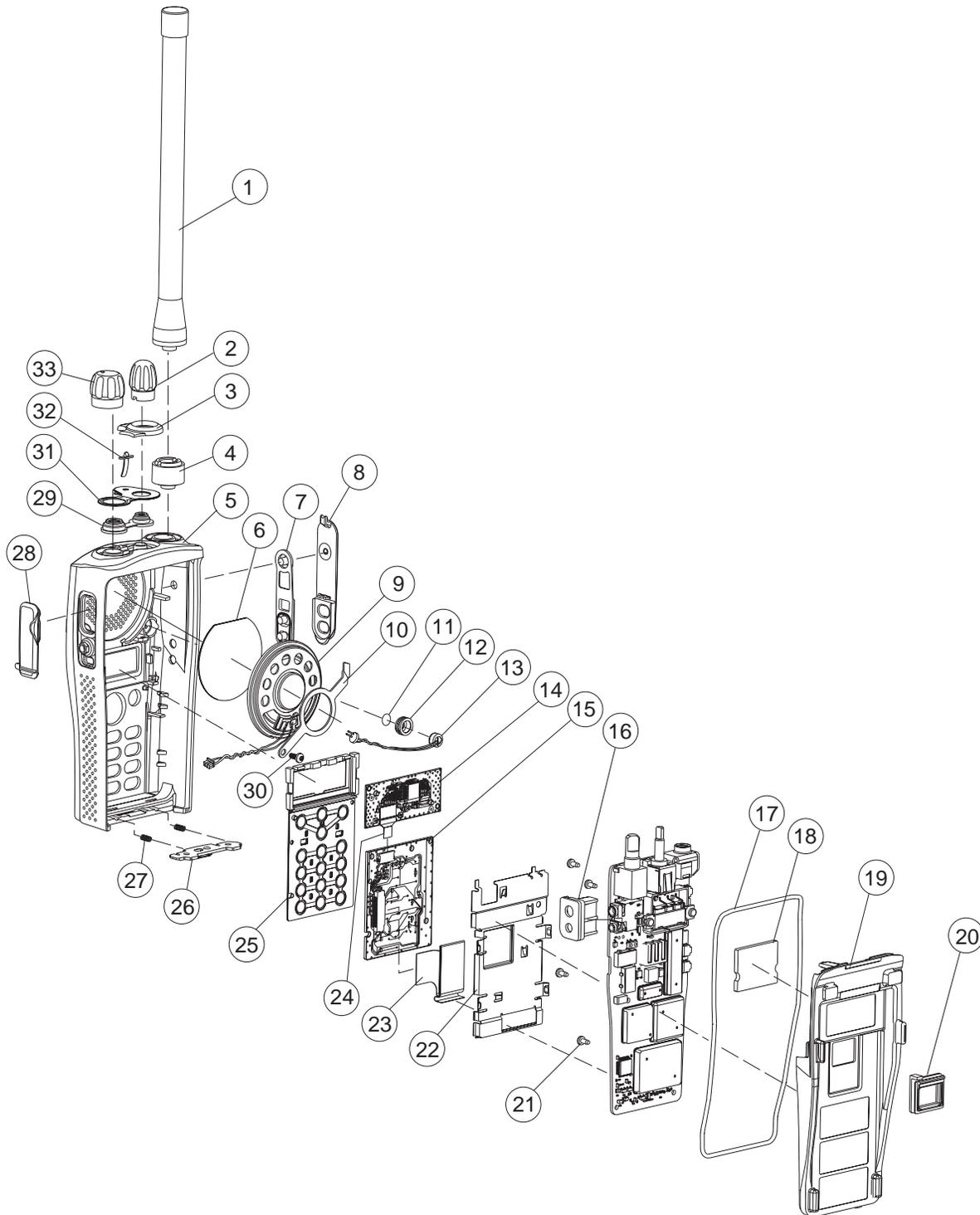
Figure 6-22. EP450 Display Radio Exploded View

Item	Motorola Part Number	Description
1	See Section 6	Antenna
2	3680530Z02	Knob, Frequency
3	1386440Z01 1386440Z02	Escutcheon, Top; 4 Ch. Escutcheon, Top; 16 Ch.
4	5886627Z01	Antenna Adaptor/Seal (Optional)
5	1586391Z03	Housing, Full, with Lens
6	3586621Z01	Speaker, Felt
7	3886489Z01	PTT, Rubber
8	4586439Z01	PTT, Plastic
9	5085738Z08	Speaker
10	4286620Z01	Retainer Speaker
11	3586621Z02	Felt, Microphone
12	0780608V01	Boot, Microphone
13	5085880L01	Microphone
14	5104949J16	Display, LCD Module
15	0104017J18	Keypad Board Assy
16	1586437Z01	Shroud, Audio Jack
17	3286431Z02	Seal, Main O-ring
18	7586436Z01	Pad, PA Interface
19	2786389Z01	Chassis
20	3286435Z01	Seal, Battery Contact Block
21	0304726J05	Screws, Chassis; 4 Used
22	4286648Z01	Plate, Retainer
23	0909059E19	Connector, 28-pin
24	0986632Z02	9 Pin Connector
25	7586654Z03	Keypad, Full
26	5586445Z02	Latch Assembly
27	4105944K01	Spring, Latch; 2 Used
28	3886441Z01	Cap, Dust
29	3286432Z01	Seal, Control Shaft
30	0386434Z01	Screw, Speaker Retainer
31	3386443Z01	Label, Escutcheon Seal
32	6186446Z02	Lightpipe
33	3680529Z01	Knob, Volume

Item	Motorola Part Number	Description
NON-REFERENCED ITEMS		
	3386625Z01	Nameplate, Motorola
		Nameplate, EP450

Notes:

Chapter 7 Non-Display Model Disassembly and Re-assembly

7.1 Introduction

This section provides details about the following:

- Preventive maintenance (inspection and cleaning)
- Safe handling of CMOS and LDMOS devices
- Disassembly and re-assembly of the radio
- Repair procedures and techniques

7.2 Preventive Maintenance

The radios do not require a scheduled preventive maintenance program; however, periodic visual inspection and cleaning is recommended.

7.2.1 Inspection

Check that the external surfaces of the radio are clean, and that all external controls and switches are functional. It is not recommended to inspect the interior electronic circuitry.

7.2.2 Cleaning Procedures

The following procedures describe the recommended cleaning agents and the methods to be used when cleaning the external and internal surfaces of the radio. External surfaces include the front cover, housing assembly and battery case. These surfaces should be cleaned whenever a periodic visual inspection reveals the presence of smudges, grease, and/or grime.

> **Note:** **Internal surfaces should be cleaned only when the radio is disassembled for service or repair.**

The only recommended agent for cleaning the external radio surfaces is a 0.5% solution of a mild dishwashing detergent in water. The only factory recommended liquid for cleaning the printed circuit boards and their components is isopropyl alcohol (70% by volume).

⚠ **CAUTION: The effects of certain chemicals and their vapors can have harmful results on certain plastics. Avoid using aerosol sprays, tuner cleaners, and other chemicals.**

Cleaning External Plastic Surfaces

Apply the 0.5% detergent-water solution sparingly with a stiff, non-metallic, short-bristled brush to work all loose dirt away from the radio. Use a soft, absorbent, lintless cloth or tissue to remove the solution and dry the radio. Make sure that no water remains entrapped near the connectors, cracks, or crevices.

Cleaning Internal Circuit Boards and Components

Isopropyl alcohol (70%) may be applied with a stiff, non-metallic, short-bristled brush to dislodge embedded or caked materials located in hard-to-reach areas. The brush stroke should direct the dislodged material out and away from the inside of the radio. Make sure that controls or tunable components are not soaked with alcohol. Do not use high-pressure air to hasten the drying process since this could cause the liquid to collect in unwanted places. After completing the cleaning process, use a soft, absorbent, lintless cloth to dry the area. Do not brush or apply any isopropyl alcohol to the frame, front cover, or back cover.

> **Note:** Always use a fresh supply of alcohol and a clean container to prevent contamination by dissolved material (from previous usage).

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Complementary metal-oxide semiconductor (CMOS) devices are used in this family of radios, and are susceptible to damage by electrostatic or high voltage charges. Damage can be latent, resulting in failures occurring weeks or months later. Therefore, special precautions must be taken to prevent device damage during disassembly, troubleshooting, and repair.

Handling precautions are mandatory for CMOS circuits and are especially important in low humidity conditions. DO NOT attempt to disassemble the radio without first referring to the following CAUTION statement.

CAUTION: This radio contains static-sensitive devices. Do not open the radio unless you are properly grounded. Take the following precautions when working on this unit:

- Store and transport all CMOS devices in conductive material so that all exposed leads are shorted together. Do not insert CMOS devices into conventional plastic "snow" trays used for storage and transportation of other semiconductor devices.

- Ground the working surface of the service bench to protect the CMOS device. We recommend using the Motorola Static Protection Assembly (part number 0180386A82), which includes a wrist strap, two ground cords, a table mat, and a floor mat.

- Wear a conductive wrist strap in series with a 100k resistor to ground. (Replacement wrist straps that connect to the bench top covering are Motorola part number RSX-4015.)

- Do not wear nylon clothing while handling CMOS devices.

- Do not insert or remove CMOS devices with power applied. Check all power supplies used for testing CMOS devices to be certain that there are no voltage transients present.

- When straightening CMOS pins, provide ground straps for the apparatus used.

- When soldering, use a grounded soldering iron.

- If at all possible, handle CMOS devices by the package and not by the leads. Prior to touching the unit, touch an electrical ground to remove any static charge that you may have accumulated. The package and substrate may be electrically common. If so, the reaction of a discharge to the case would cause the same damage as touching the leads.

7.4   Disassembling and Re-assembling the Radio — General

Since these radios may be disassembled and re-assembled with the use of only four (board to casting) screws, it is important to pay particular attention to the snaps and tabs, and how parts align with each other.

The following tools are required for disassembling the radio (see 3.2 for a list of service aids):

*   knob remover/chassis opener
*   penknife-size screwdriver
*   TORX™ T6 screwdriver

If a unit requires more complete testing or service than is customarily performed at the basic level, send this unit to a Motorola Authorized Service Center. See Appendix B for a list of authorized service centers.

The following disassembly procedures should be performed only if necessary:

*   Chassis Disassembly
*   Speaker Disassembly
*   PTT Disassembly

7.4.1   Radio Disassembly — Detailed

7.4.1.1 Front Cover From Chassis Disassembly

1. Turn off the radio

2. Remove the battery (Figure 7-1):

   a.   Slide the battery latch into the unlock position. Disengage by pushing downward and holding the latch towards the front of the radio.

   b.   With the battery latch disengaged, slide the battery down from the top of the radio about 1/2 in. Once the battery is free from the battery rails, lift it directly away from the radio.

   c.   Remove the battery from the radio.
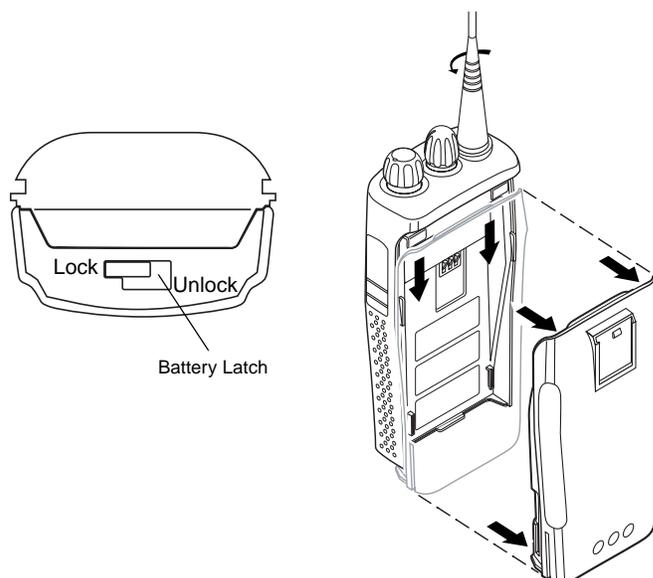
Figure 7-1. Battery Removal

3. Remove the antenna.

4. Pry off the volume and channel selector knobs from their shafts using the knob removal/chassis opener tool (Motorola part # 6686533Z01). (Figure 7-2)
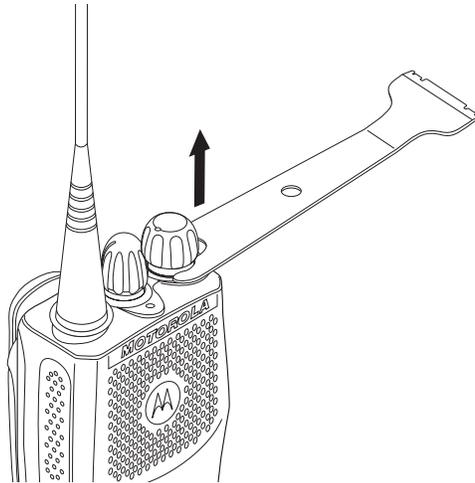
Figure 7-2. Antenna and Knob Removal

Note: Both knobs slide on and off. However the knobs are designed to fit very tightly on the shaft.

5. Separate the chassis from the front housing assembly by using the knob remover/chassis opener too. Place the broad side of the opener into the slots located at the base of the radio (Figure 7-3). Press the handle on the opener downwards. This pressing action forces the thin inner plastic wall toward the base of the radio, releasing the two chassis base tabs..

Knob Remover/
Chassis Opener
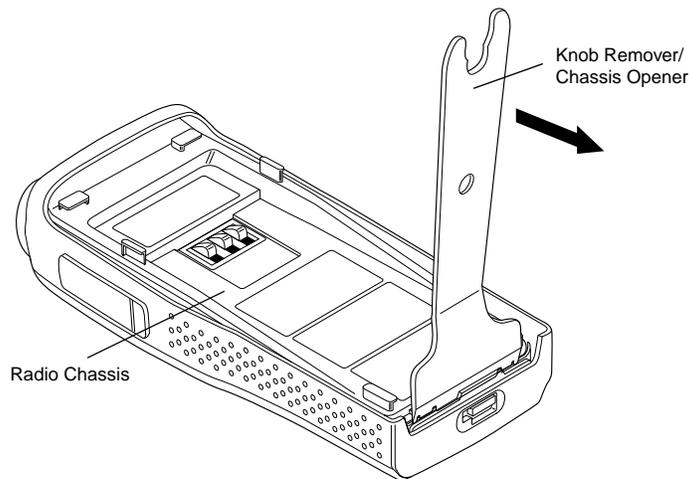
Radio Chassis

Figure 7-3. Chassis Removal

⚠ **CAUTION: Marring the front cover O-ring sealing area will prevent the radio from sealing properly. If the O-ring is damaged, replace it with a new one.**

Note: The speaker wire assembly microphone wire assembly and keypad ribbon connector connecting the front housing assembly and the chassis prevent the two units from being completely separated

6. Pull the chassis assembly out of the front cover only until the volume and channel selectors shaft just clear the top of the case. (Figure 7-4).

Rotate the chassis counterclockwise out of the housing and position next to the housing. Take care not to damage the speaker and microphone wires that are still connected to the chassis (Figure 7-4).

Speaker Connector

Shroud

Microphone
Connector
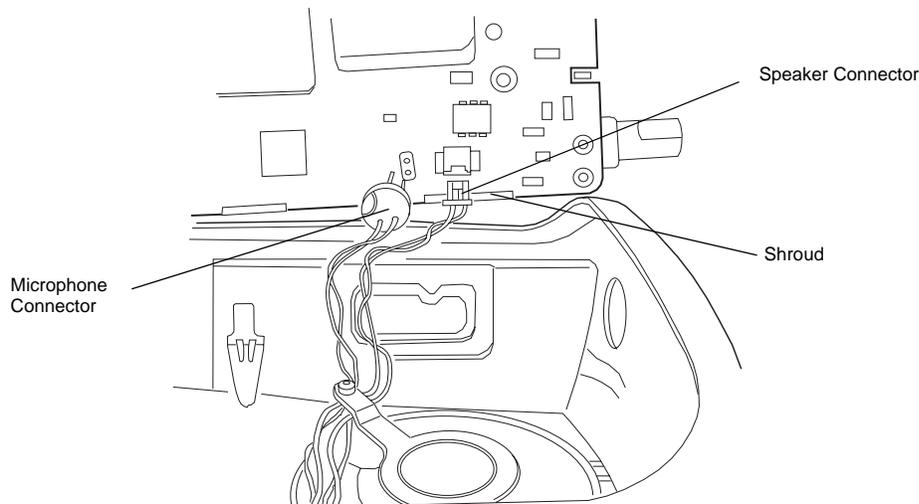
Figure 7-4. Microphone and Speaker Connections

7. Unplug the speaker wire assembly from the 2-pin connector on the chassis.

8. Unplug the microphone wire assembly from the socket on the chassis.

9. Move the chassis away from the housing and place on a clean work surface.

7.4.1.2 Dust Cover Disassembly

1. Gently pry the top of the dust cover away from the body of the radio. (See Figure 7-5).

2. Rotate the dust cover 90° in a counterclockwise direction to allow the key to be removed.

3. Separate the dust cover away from the body of the radio. The dust cover key is fragile; apply only light pressure to the key while removing the dust cover.

key
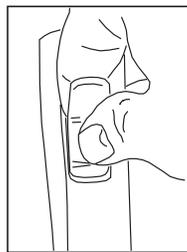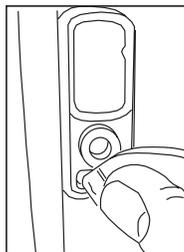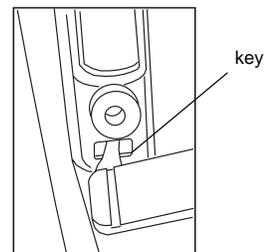
a. Pry dust cover from body.   **b**. Rotate dust cover 90° to allow key to be removed.   **c**. Separate dust cover from body.

Figure 7-5. Dust Cover Disassembly

7.4.1.3 Speaker and Microphone Disassembly

> **Note:** The speaker is held in place with a retainer bracket. Be careful not to damage the speaker when removing the retainer bracket.

1. Remove the screw from the speaker retainer using a T6 Torx screwdriver (Figure 7-6).
2. Lift the retainer off the speaker, sliding end of retainer out of corner slot on the housing.
3. Lift the speaker out from the front housing.
4. Carefully lift microphone assembly out of housing.
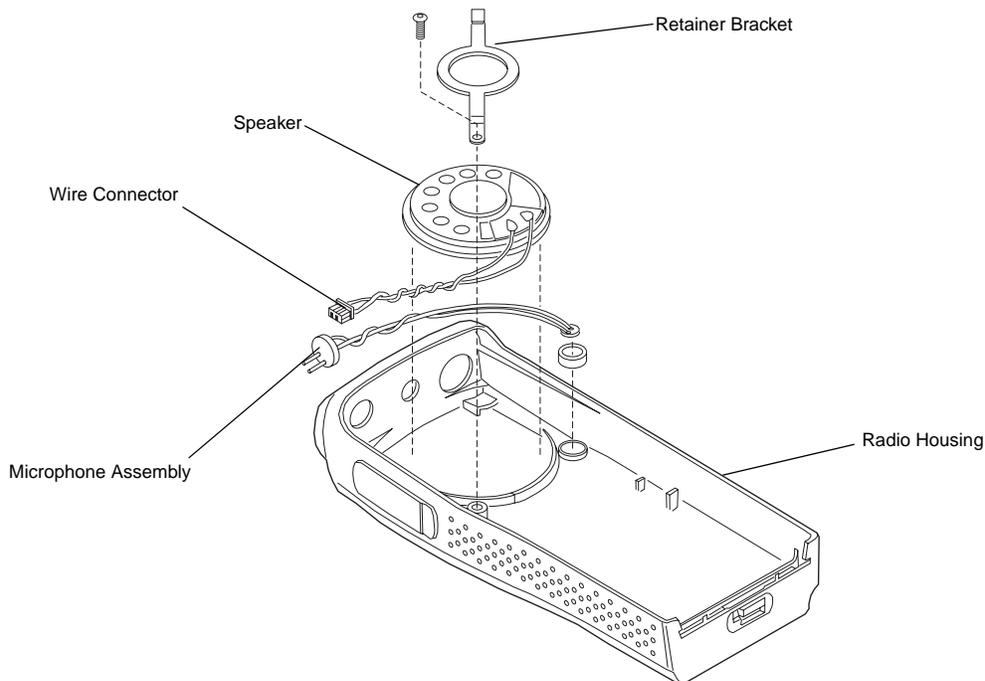
Figure 7-6.   Removal Speaker-Microphone Assembly

7.4.1.4 PTT Disassembly

1. If required, the PTT (Figure 7-7) can be disassembly using a small screwdriver, as follows:
   a. Insert the tip of a small screwdriver underneath the PTT and unsnap the top tab.
   b. Pry the PTT away from the radio housing.
   c. Inspect the two hooks. If bent or broken, the PTT must be replaced.
   d. Remove the PTT seal.
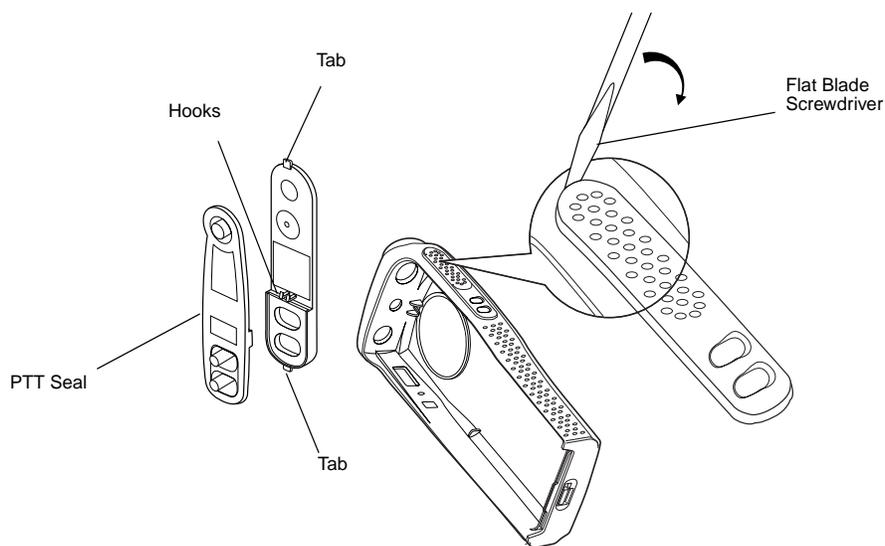
Figure 7-7. PTT Removal

7.4.2   Chassis Disassembly

⚠ **CAUTION: Refer to the CMOS CAUTION paragraph (7.3) before removing the main board. Be sure to use Electrostatic Discharge protection when handling circuit boards.**

1. Remove the O-ring.

2. Use a Torx™ screwdriver with a T6 bit to remove the four screws (Figure 7-8) holding the main board to the chassis.
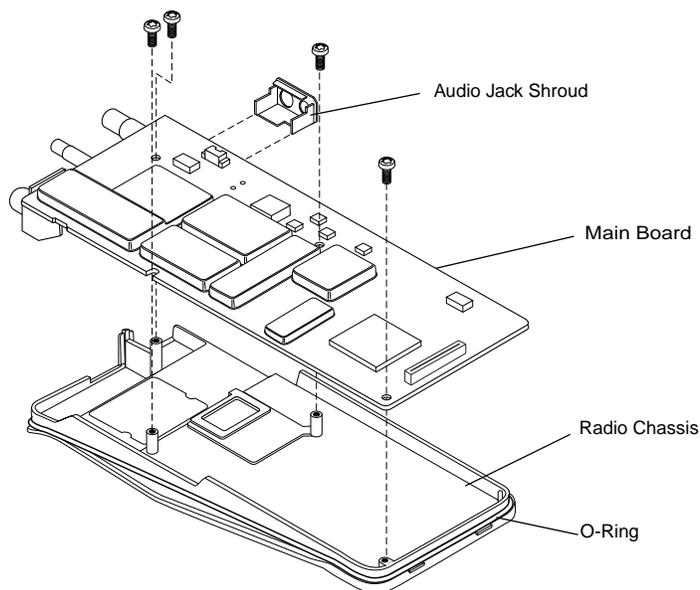
Figure 7-8. Removal of Main Board from Chassis

3. The audio jack shroud can be removed from the main board.

4. Lift the main board from the chassis.

5. Remove the battery contact seal.

7.4.3   Radio Re-assembly - Detailed

7.4.3.1 Dust Cover Re-assembly

1. Insert the tail of the dust cap into the bottom hole of the audio jacks housing opening (Figure 7-9).
2. Press the dust cap until the tail is fully into the hole.
3. Twist the dust cap counter-clockwise until the cap is seated properly onto the recess.
4. Press the cap again to ensure it fully covers the opening for the audio jack.

1   2   3   4
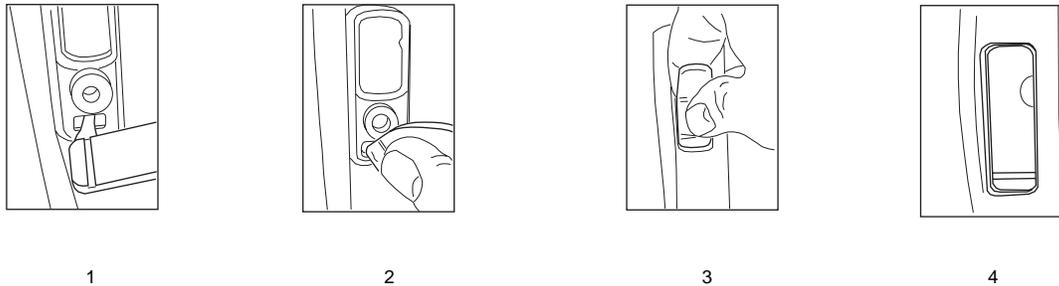
Figure 7-9. Dust Cap Re-assembly

7.4.3.2 Microphone and Speaker Re-assembly

1. Check that the speaker felt is in position and is not damaged. If damaged replace felt.
2. Insert the microphone sub-assembly into the microphone boot.
3. Insert the Boot and microphone sub-assembly into the microphone recess in the housing and route the wires as shown in Figure 7-10.
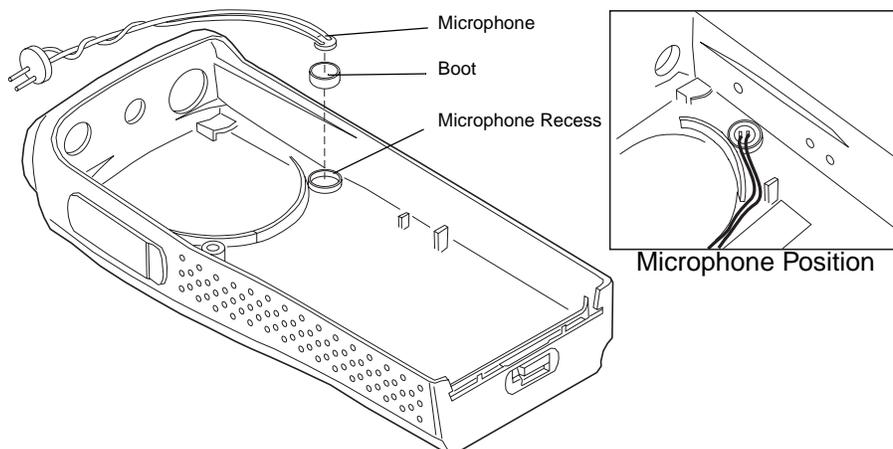
Figure 7-10. Microphone Re-assembly

4. Locate the speaker tab and align it with the tab opening in the front housing (Figure 7-11).
5. Insert the speaker tab into the speaker recess in the housing. Ensure the speaker is seated flush in the housing

.

> **Note:** Make sure the speaker and microphone wires are routed tightly between the speaker basket and the housing post

6. Insert one end of the speaker retainer into the slot in the front housing (See Figure 7-11)..

Speaker Retainer

Speaker Tab

Speaker

Tab Opening

Front Housing Slot
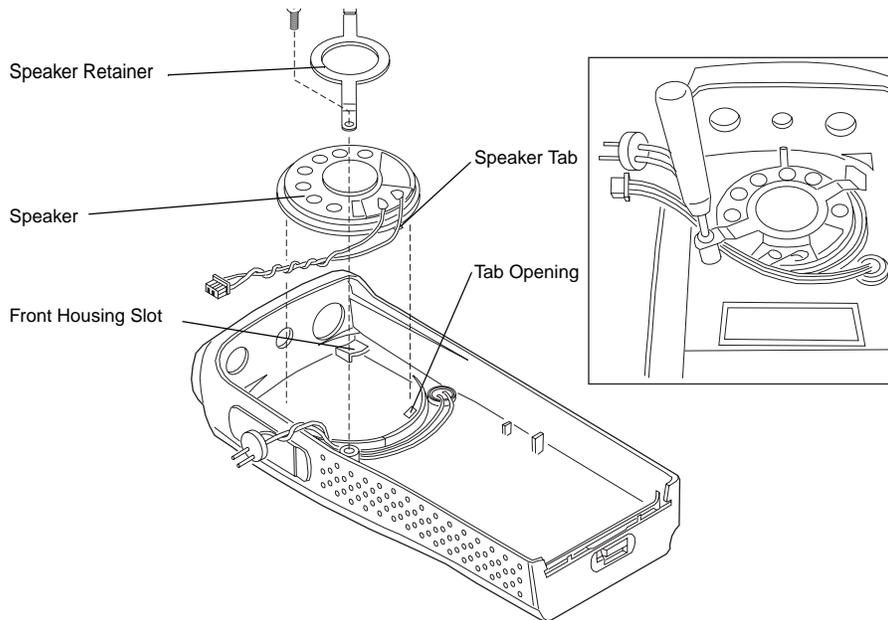
Figure 7-11. Speaker Re-assembly

> **Note:** When fastening the speaker retainer screw, make sure the wires are out of the way to prevent pinching by the retainer.

7. Install the retainer screw using a T6 Torx screwdriver. Torque to 2.3 - 2.5 lb/in.

7.4.3.3 Chassis Assembly/Re-assembly

1. Replace the battery contact seal (if necessary) surrounding the battery contact (Figure 7-12).

2. Remove the old Interface Pad from the chassis by scraping off the pad and adhesive with a straight razor. Use rubbing alcohol and a cloth to completely remove the adhesive from the chassis surface. With the chassis clean and dry, add a new Interface Pad to the chassis.

3. Place the main circuit board straight down on top of the chassis with the frequency and volume switches facing down.

> **Note:** Be sure the battery contact seal protrudes through the chassis and is not pinched under the chassis.

4. Use the T6 Torx screwdriver to fasten the screws holding the main board to the chassis. Tighten to 3.7 - 3.9 in/lb.

5. Replace the O-ring by positioning it in the top groove by the volume/frequency switches. Stretch the O-ring to place it into the retaining groove at the bottom end of the chassis.

6. Check that the O-ring is not twisted and is being held by the top and bottom chassis groves.

7. Replace the audio jack shroud.

.
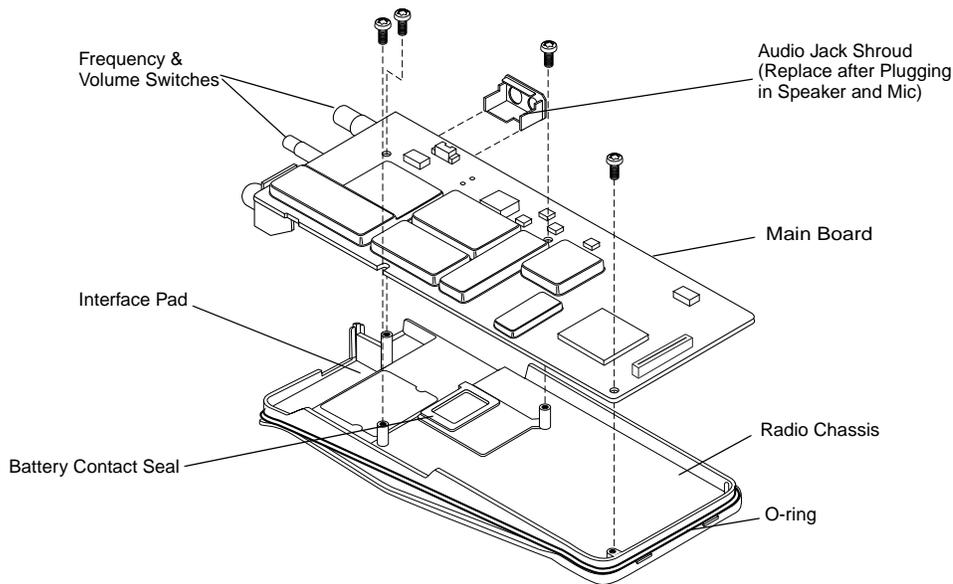
Figure 7-12. Installation of Main Board onto Chassis

7.4.3.4 Chassis and Front Cover Re-assembly

8.   Dress and connect the speaker wires.

Note: Care should be taken when dressing the speaker and microphone wires to avoid pinching them between the speaker magnet and shield, or between the accessory connector and housing.

Note: Ensure that the plug orientation is correct with the exposed pins in the wire casing facing upward and fully plugged in.

   a.   Connect the speaker wire assembly into the 10-pin connector on the main board and bend the wires at the board connector so the wires are positioned toward the top of the radio (Figure 7-13).

   b.   Connect the microphone wire assembly into the two hole socket on the main board and bend the wires at the board connector so the wires are positioned toward the top of the radio (Figure 7-13).

   c.   Slide the audio jack shroud onto accessory connector (Figure 7-12).

9.   Slide the volume potentiometer and frequency switch shafts into their respective holes in the front cover. Look through the accessory connector opening to make certain that the wires are not pinched.

10.   Push the topside of the board chassis upward until it touches the housing end. Before snapping the board into the housing, perform the following checks.:

   a.   Open the dust cap and ensure the wires are not pinched between the shroud and housing.

   b.   Ensure the O-ring is seated in the groove.

11.   c. Ensure that the bottom side of the dust cap is fully pressed into the housing before the snapping the board into place

.
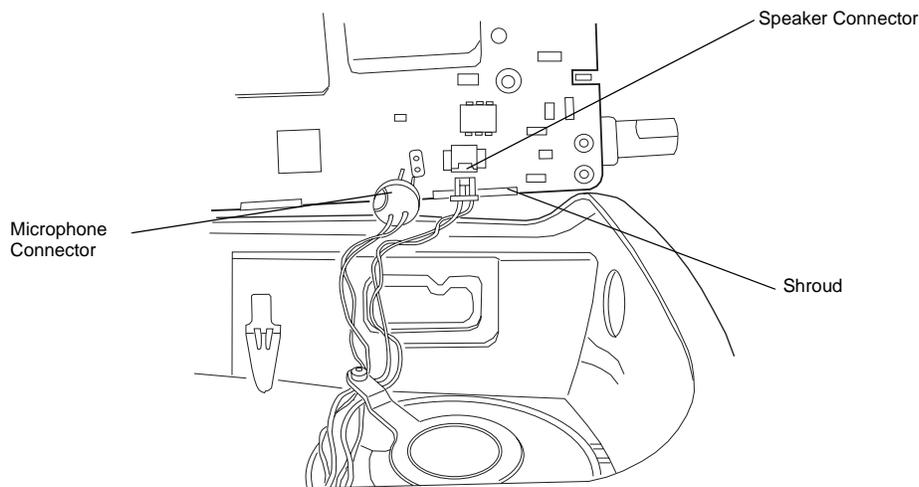
Figure 7-13. Microphone and Speaker Wires Re-assembly
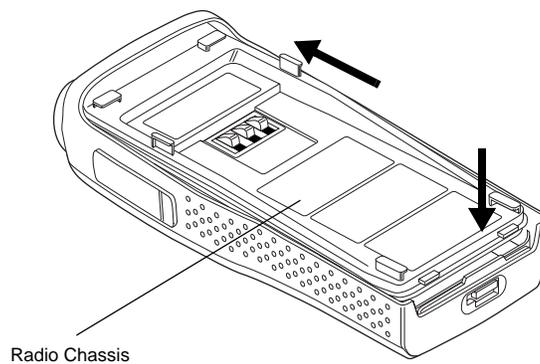
Figure 7-14. Fastening the Chassis

12. Snap chassis assembly completely into the top of the front cover (Figure 7-14) until it settles in place.

13. Make sure the O-ring is properly seated. If the O-ring seal is pinched, separate the chassis from the housing using the knob removal/chassis opener and dress O-ring properly.

14. Snap the bottom of the chassis into the front cover.

15. Check that O-ring is visible at the corners.

16. After closing the radio, verify that the O-ring is not visible; if visible, re-assemble properly.

17. Re-assemble the knobs, antenna, and battery.

7.4.3.5 PTT Re-assembly

1. Place the PTT seal over the ridge around the top hole. Press down to seat the seal around the ridge.

2. Place the bottom tab in the slot inside the front housing PTT opening. Slightly slide down the PTT and bow it by placing one finger under the middle of the PTT, so that the top tab can be aligned and inserted into the top slot (Figure 7-15a).

3. Press the PTT assembly against the front cover opening (Figure 7-15b).

a. Place bottom tab into bottom slot. Place top tab into top slot.

b. Push down on PTT toward bottom of radio so hooks do not get crushed.
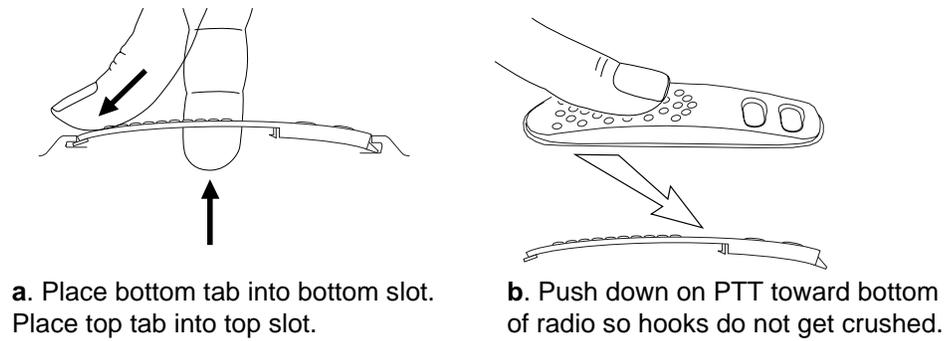
Figure 7-15. PTT Re-assembly

7.5 Mechanical View and Parts List

7.5.1 EP450 Non-Display Exploded View and Parts List
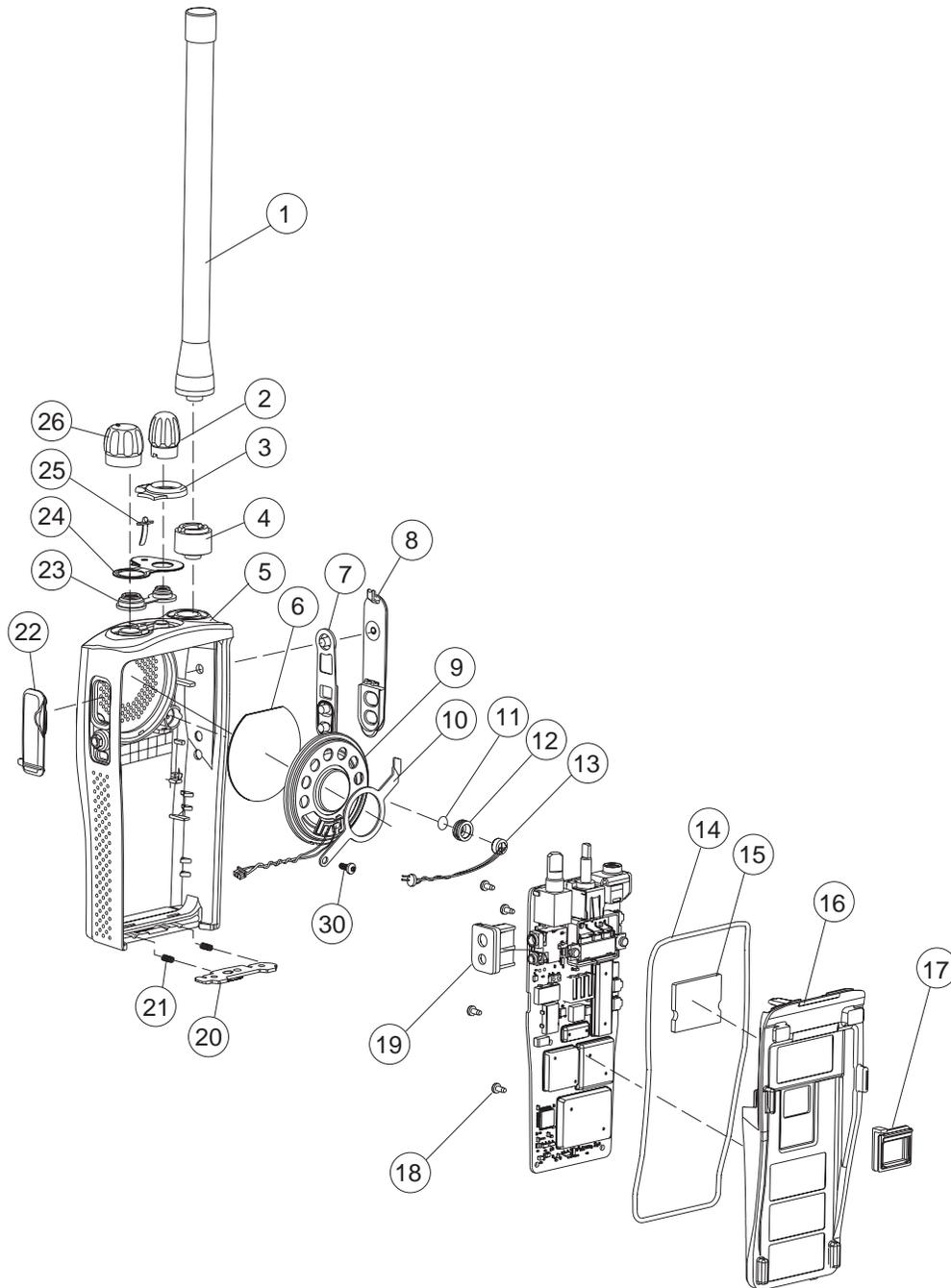
Figure 7-16. EP450 Non-Display Radio Exploded View

Item	Motorola Part Number	Description
1	See Section 6	Antenna
2	3680530Z02	Knob, Frequency
3	1386440Z02	Escutcheon, Top; 16 Ch.
4	5886627Z01	Antenna Adaptor / Seal
5	1586391Z01	Housing, ELP+, Plain
6	3586621Z01	Felt, Speaker
7	3886489Z01	PTT, Rubber
8	4586439Z01	PTT, Plastic
9	5085738Z08	Speaker
10	4286620Z01	Retainer, Speaker
11	3586621Z02	Felt, Microphone
12	0780608V01	Boot, Microphone
13	5085880L01	Microphone
14	3286431Z02	Seal, Main O-ring
15	7586436Z01	Pad, PA Interface
16	2786389Z01	Chassis
17	3286435Z01	Seal, Battery Contact Block
18	0304726J05	Screws, Chassis; 4 Used
19	1586437Z01	Shroud, Audio Jack
20	5586445Z02	Latch Assembly
21	4105944K01	Spring, Latch; 2 Used
22	3886441Z01	Cap, Dust
23	3286432Z01	Seal, Control Shaft
24	3386443Z01	Label, Escutcheon Seal
25	6186446Z02	Lightpipe
26	3680529Z01	Knob, Volume
27	0386434Z01	Screw, Speaker Retainer
NON-REFERENCED ITEMS		
	3386625Z01	Nameplate, Motorola
		Nameplate, EP450

Chapter 8   Troubleshooting Tables

8.1   Power-Up Error Codes

During radio power-up, the radio performs dynamic tests to determine if the radio is working properly. Problems detected during these tests are presented as an error code on the radio's display. The presence of an error code should prompt a user that a problem exists and that a service technician should be contacted. Use Table 8-1 to aid in understanding particular operational error codes.

Table 8-1. Power-Up Error Code Display

Error Code	Possible Causes	Corrective Action
RAM ERR	RAM Test Failure	Retest radio by turning if off and tuning it on again. If message reoccurs, replace main board or send radio to depot.
ROM ERR	ROM checksum is wrong	Reprogram FLASH memory and retest. If message reoccurs, replace main board or send radio to depot.
EPRM ERR	EEPROM Hardware Error – Codeplug structure mismatch or non-existence of code-plug or, EEPROM Checksum Error – Codeplug checksum is wrong	Reprogram codeplug with correct codeplug and retest. If message reoccurs, replace main board or send radio to depot.

8.2   Operational Error Codes

During radio operation, the radio performs dynamic tests to determine if the radio is working properly. Problems detected during these tests are presented as an error code on the radio's display. The presence of an error code should prompt a user that a problem exists and that a service technician should be contacted. Use Table 8-2 to aid in understanding particular operational error codes.

Table 8-2. Operational Error Code Display

Error Code	Possible Causes	Corrective Action
SYN UNLK	Synthesizer Out-of-Lock	Verify codeplug and reprogram if necessary. If message reoccurs, replace main board or send radio to depot.

8.3   Troubleshooting Table for Receiver

Table Table 8-3 lists the possible causes of, and corrections for, receiver problems.

Table 8-3. Receiver Troubleshooting Table

Symptom	Possible Causes	Corrective or Test (Measurements at Room Temperature)
Radio Dead; Display Does Not Turn On	1. Dead Battery.	Replace with charged battery.
	2. Blown Fuse	Send radio to depot.
	3. On/Off Switch	
	4. Regulators	
	5. Regulator fault	
Radio Dead; Display Turns On	Transceiver Board	Send radio to depot.
No Receive Audio, or Receiver Does Not Unmute	Programming	1. Does the transmitted signal match the receiver configuration (PL, DPL, etc.)? 2. With the monitor function enabled, can the radio be unmuted?
Audio Distorted or Not Loud Enough	Synthesizer Not On Frequency	Check synthesizer frequency by measuring the transmitter frequency; realign it off by more than ±150 Hz (VHF), ±500 Hz (UHF)
RF Sensitivity Poor	1. Synthesizer Not on Frequency	Check synthesizer frequency by measuring the transmitter frequency; realign it off by more than ±150 Hz (VHF), ±500 Hz (UHF)
	2. Antenna Switch/Connector	Send radio to depot.
	3. Receiver Front End Tuning	Check RF front-end tuning for optimum sensitivity using the tuner.
Radio Will Not Turn Off	Transceiver Board	Send radio to depot.

8.4   Troubleshooting Table for Transmitter

Table Table 8-4 lists the possible causes of, and corrections for, transmitter problems.

Table 8-4. Transmitter Troubleshooting Table

Symptom	Possible Causes	Corrective or Test (Measurements at Room Temperature)
No RF Power Out	1. Tx Power Level or Frequency	Check Tx power level and frequency programming (from tuner).
	2. No Injection To Power Amplifier	Send radio to depot.
	Antenna Switch/Connector	
No Modulation; Distortion Modulation	1. Programming	Check deviation and compensation settings using the tuner.
	2. Transceiver Board	Send radio to depot.
Bad Microphone Sensitivity	1. Check Deviation and Compensation	Realign if necessary.
	2. Microphone	Send radio to depot.
No/Low Signaling (PL, DPL, MDC)	1. Programming	Check programming.
	2. Transceiver Board	Send radio to depot.
Cannot Set Deviation Balance	RF Board	Send radio to depot.

Notes:

Appendix A   Accessories

Antennas

NAD6502_R	VHF Heliflex Antenna 14cm (146-174 MHz)
HAD9742	VHF Stubby Antenna, 9cm (146-162 MHz)
HAD9743	VHF Stubby Antenna, 9cm (162-174 MHz)
NAE6522_R	UHF Heliflex Stubby Antenna 9cm (438-470 MHz)
NAE6483_R	Flexible Whip Antenna (403-520 MHz)
8505816K26	UHF Heliflex Stubby (470-520 MHz)

Carrying Accessories

RLN5498	Hard Leather Case, Full DTMF with Belt Loop
RLN5496	Hard Leather Case, Full DTMF with 3 inch Swivel Belt Loop
RLN5497	Hard Leather Case, Full DTMF (attaches to D-Shaped Rings on case)
RLN5644	2.5 inch Spring Action Belt Clip
NTN5243	Shoulder Strap for Hard Leather Cases (attaches to D-Shaped Rings on case)
HLN9985	Waterproof Bag
RLN5383	Nylon Case with Belt Loop Non-Display models
HLN9701	Leather Case with Belt Loop
RLN5384	Leather Case with 2-1/2 inch Swivel Belt Loop Non-Display models
RLN5385	Leather Case with 3 inch Swivel Belt Loop Non-Display models

Chargers

WPLN4137	Desktop Rapid Charger Base Only w/NA LA Manual
WPLN4138_R	Rapid 90-Min. Desktop Charger w/US plug
WPLN4139_R	Rapid 90-Min. Desktop Charger w/Euro plug
WPLN4142_R	Rapid 90-Min. Desktop Charger w/Argentina plug
WPLN4140_R	Rapid 90-Min. Desktop Charger w/UK plug
WPLN4161	Rapid 90-Min. Multi-Unit Charger w/US plug
WPLN4162	Rapid 90-Min. Multi-Unit Charger w/Euro plug
WPLN4163	Rapid 90-Min. Multi-Unit Charger w/UK plug
WPLN4164	Rapid 90-Min. Multi-Unit Charger w/Argentina plug

Batteries

NNTN4496_R	High Capacity Ni-Cd, 1100 mAH
NNTN4497_R	Ultra High Capacity Li-lon, 1800 mAH
NNTN4851_R	High Capacity NiMH, 1400 mAH
NNTN4970	High Capacity Li-Ion, 1600 mAH

Audio Accessories

HMN9752	Earpiece with Volume Control, 1-Wire (plastic earloop) (Beige)
HMN9727	Earpiece without Volume Control, 1-Wire (plastic earloop) (Beige)
RLN4894	Earpiece without Volume Control, 1-Wire (plastic earloop) (Black)
HMN9754	Earpiece with Microphone & PTT Combined, 2-Wire (Beige)
RLN4895	Earpiece with Microphone & PTT Combined, 2-Wire (Black)
RLN5198_P	Earpiece with Microphone & PTT Combined (Black) including Low Noise Kit, 2-Wire Surveillance Kit w/Clear Comfortable Acoustic Tube (includes NTN8371)
BDN6720	Flexible Ear Receiver (RX only)
PMLN4443	Flexible Ear Receiver with Microphone & PTT Combined
HMN9036	Earbud with Microphone & PTT Combined, 2-Wire (Black)
PMLN4294	Earbud with Microphone & PTT Combined
PMLN4442	Earbud with Microphone & PTT Combined
HLN9132	Earbud Single Wire Receive Only (Black)
NTN8370	Extreme Noise Kit
5080384T72	Replacement Noise Attenuating Plug for NTN8370
NTN8371	Low Noise Kit
RLN4760	Small Custom Clear Earpiece, Right Ear
RLN4763	Small Custom Clear Earpiece, Left Ear
RLN4761	Medium Custom Clear Earpiece, Right Ear
RLN4764	Medium Custom Clear Earpiece, Left Ear
RLN4762	Large Custom Clear Earpiece, Right Ear
RLN4765	Large Custom Clear Earpiece, Left Ear
BDN6646	Standard 95 dB Ear Microphone with PTT Interface Module
BDN6706	Standard 95 dB Ear Microphone with VOX & PTT Interface Module
0180358B38	Ring PTT Switch for Ear Microphone System
0180300E83	Body PTT Switch for Ear Microphone System
RLN5500	Accessory Retainer
RLN5317	2-Wire Comfort Earpiece wMic & PTT (Beige)
RLN5318	2-Wire Comfort Earpiece w/Mic & PTT (Black)
TDN9327	Portable Radio Hanger
TDN9373	Portable Radio Hanger

Headsets

RLN5411	Ultra-Lite Breeze Behind the Head Headset
PMMN4001	Ultra-Lite Earset with Mic and PTT
HMN9013	Lightweight Headset w/o In-line PTT
RMN4016	Lightweight Headset with In-line PTT
RLN5238	Lightweight Headset with In-line PTT, NFL Style
HMN9021	Medium Weight Over the Head Dual Muff Headset
HMN9022	Medium Weight Behind the Head Dual Muff Headset

BDN6647   Medium Weight Single Speaker Headset

BDN6648   Heavy Duty Dual Muff Headset with Noise Canceling Microphone

5080371E66   Replacement Ear Pad for BDN6647

RMN5015   Heavy Duty Dual Muff Racing Headset
                         (requires RKN4090 Headset Adapter Cable)

REX4648   Ear Pad and Windscreen Kit

RKN4090   Adapter Cable for use with RMN5015 Racing Headset

RMN4051   2-Way Hard Hat Mount, Black, Noise Reduction Rating (22db)
                         (requires RKN4094 Adapter Cable)

RMN4055   Receive-Only Headband Style Headset with 3.5mm Right Angle Plug

HLN9133   VOX Adapter Kit (for use with Headsets only)

RKN4094   In-Line PTT Adapter for use with headsets RMN4051, RMN4052, and
                         RMN4053 only)

PMLN4445   Ultra-Light Headset with Boom Microphone

Remote Speaker Microphones

HMN9030   Remote Speaker Microphone

RLN4904   Mic Jacket for HMN9030 Remote Speaker Microphone

HKN9094   Replacement Cord for HMN9030

PMMN4008   Remote Speaker Microphone

Manuals

HKLN4212   E-Series User Guide

HKLN4215   E-Series Basic Service Manual

HKLN4216   E-Series Detailed Service Manual

Appendix B   Warranty, Service Support, and Replacement Parts

1.1   Scope of Manual

This manual is intended for use by service technicians familiar with similar types of equipment. It contains service information required for the equipment described and is current as of the printing date. Changes which occur after the printing date may be incorporated by a complete Manual revision or alternatively as additions.

Notes: Before operating or testing these units, please read the Product Safety and RF Exposure Compliance section in the front of this manual.

1.2   Warranty

Motorola offers long term support for its products. This support includes full exchange and/or repair of the product during the warranty period, and service/ repair or spare parts support out of warranty. Any "return for exchange" or "return for repair" by an authorized Motorola Dealer must be accompanied by a Warranty Claim Form. Warranty Claim Forms are obtained by contacting an Authorized Motorola Dealer.

1.2.1   Warranty Period and Return Instructions

The terms and conditions of warranty are defined fully in the Motorola Dealer, Distributor, or Reseller contract. These conditions may change from time to time and the following notes are for guidance purposes only.

In instances where the product is covered under a "return for replacement" or "return for repair" warranty, a check of the product should be performed prior to shipping the unit back to Motorola. This is to ensure that the product has been correctly programmed or has not been subjected to damage outside the terms of the warranty.

1.2.2   After Warranty Period

After the Warranty period, Motorola continues to support its products in two ways.

1. Motorola's Radio Products Services Division (RPSD)* offers a repair service to both end users and dealers at competitive prices.
2. Radio Products Services Division (RPSD) supplies individual parts and modules that can be purchased by dealers who are technically capable of performing fault analysis and repair.

* The Radio Products Services Division (RPSD) was formerly knows as the Accessories and Aftermarket Division (AAD)

1.3   Replacement Parts Ordering

1.3.1   Basic Ordering Information

When ordering replacement parts or equipment information, the complete identification number should be included. This applied to all components, kits, and chassis. If the component part number is not known, the order should include the number of the chassis or kit of which it is a part, a sufficient description of the desired component to identify it.

1.3.2 Motorola Online

Motorola online users can access our on-line catalog at:

https://businessonline.motorola.com

1.3.3 Mail Orders

Send written orders to the following addresses:

International Orders:

Motorola, Inc.
Customer Care and Services
Division*
Attention: Order Processing
2200 Galvin Dr.
Elgin, IL 60123
U.S.A.

1.3.4 Telephone Orders

Radio Products Services Division (RPSD)*
(United States and Canada)
7:00 AM to 7:00 PM (Central Standard Time)
Monday through Friday (Chicago, U.S.A.)
1-800-422-4210
1-847-538-8023 (International Orders)

1.3.5 Fax Orders

Radio Products Services Division (RPSD)
(United States and Canada)
1-800-622-6210
1-847-576-3023 (International)

USFGMD
(Federal Government Orders)
1-800-526-8641 (For Parts and Equipment Purchased Orders)

1.3.6 Parts Identification

Radio Products Services Division (RPSD)
(United States and Canada)
1-800-422-4210, menu 3
1-847-538-0021(International) (voice)

* The Radio Products Services Division (RPSD) was formerly known as the Accessories and
Aftermarket Division (AAD)

1.4   Technical Support

Technical support is available to assist the dealer/distributor in resolving any malfunction which may be encountered. Initial contact should be by telephone wherever possible. When contacting Motorola Technical Support ("contact us" MOL at https://businessonline.motorola.com), be prepared to provide the product **model number** and the unit's **serial number**.

Motorola de Colombia Service Center

Carrera 7 No. 71-52
Torre B, Piso 13
Oficina 1301
Bogotá – Colombia
1-571-376-6990

Motorola de Mexico Service Center

Bosques de Alisos #125
Col. Bosques de las Lomas
CP 05120 Mexico D. F.
1-525-257-6700

Glossary of Terms

Term	Definition
ALC	Automatic Level Control: a circuit in the transmit RF path that controls RF power amplifier output, provides leveling over frequency and voltage, and protects against high VSWR (voltage standing wave ratio).
ASFIC	Audio Signalling Filter Integrated Circuit
BKC	Bad Key Chirp
CD	Compact Disk
CMP	Compression
CPS	Customer Programming Software
CSQ	Carrier Squelch
DTMF	Dual-Tone Multifrequency
DPL	Digital Private-Line™
EEPROM	Electronically Erasable/Programmable Read-Only Memory: used by the radio to store its personality
Firmware	Software, or a software/hardware combination of computer programs and data, with a fixed logic configuration stores in a read-only memory. Information cannot be altered or reprogrammed.
FGU	Frequency Generation Unit
GaAs	Gallium Arsenide: a type of crystalline material used in some semiconductors.
GKC	Good Key Chirp
ISW	Inbound Signalling Word: data transmitted on the control channel from a sub-scriber unit to the central control unit.
LH DATA	Longhorn Data: a bidirectional 0-5V, RS-232 line protocol that uses the micro-controller's integrated RS-232 asynchronous serial communications interface (SCI) peripheral.
LLE	Low Level Expander: slight amount of volume expansion; used to improve the signal to noise ratio.
MCU	Micro Controller Unit
MRTI	Motorola Radio-Telephone Interconnect: a system that provides a repeater connection to the Public Switched Telephone Network (PSTN). The MRTI allows the radio to access the telephone network when the proper access code is received.
OMPAC	Over-Molded Pad-Array Carrier: a Motorola custom package, distinguished by the presence of solder balls on the bottom pads.
PC Board	Printed Circuit Board
PL	Private-Line® tone squelch: a continuous sub-audible tone that is transmitted along with the carrier.

Term	Definition
PLL	Phase-Locked Loop: a circuit in which an oscillator is kept in phase with a reference, usually after passing through a frequency divider.
PTT	Push-To-Talk: the switch located on the left side of the radio; when pressed, causes the radio to transmit.
RAM	Random Access Memory: the radio's RAM is loaded with a copy of the EEPROM data.
Registers	Short-term data-storage circuits within the microcontroller.
RESET	Reset line: an input to the microcontroller that restarts execution.
RF PA	Radio Frequency Power Amplifier
RIB	Radio Interface Box
ROM	Read Only Memory
RSSI	Received Signal-Strength Indicator: a dc voltage proportional to the received RF signal strength.
RPT/TA	Repeater/Talk Around
Softpot	A computer-adjustable electronic attenuator
Software	Computer programs, procedures, rules, documentation, and data pertaining to the operation of a system.
SPI (clock and data lines)	Serial Peripheral Interface: how the microcontroller communicates to modules and ICs through the CLOCK and DATA lines.
Squelch	Muting of audio circuits when received signal levels fall below a pre-determined value.
Standby Mode	An operating mode whereby the radio is muted but still continues to receive data
TOT	Time-Out Timer: a timer that limits the length of a transmission.
TPL	Tone Private-line
µC	Microcontroller
UHF	Ultra High Frequency
µP	Microprocessor
VCO	Voltage-Controlled Oscillator: an oscillator whereby the frequency of oscillation can be varied by changing a control voltage.
VCOBIC	Voltage-Controlled Oscillator Buffer Integrated Circuit
VHF	Very High Frequency
VSWR	Voltage Standing Wave Ratio