MAINTENANCE MANUAL
SERVICE SECTION
FOR
DUAL FORMAT PCS™ RADIO

TABLE OF CONTENTS

INTRODUCTION

This service section contains the necessary information to align and troubleshoot the 800 MHz Dual Format PCS Radio. This manual includes steps for disassembly and procedures for replacing the PA module, surface mount components, integrated circuits and modules. Preventive maintenance checks are provided as well as battery service data. The tests and procedures in this manual are intended to be used by a qualified service technician.

ERICSSON

In order to perform many of the following alignments, tests and troubleshooting checks it will be necessary to (re) program the radio's personality EEPROM to tailor the operation of the radio to stipulated requirements. Instructions are offered which include the use of an IBM compatible personal computer and appropriate software. If the radio is functioning properly and has a preprogrammed personality, alignment procedures can be initiated directly.

If a radio is not working properly it is recommended to first test the radio in the Conventional mode. Any necessary repairs can be completed and the radio can then be tested in the Trunk mode using an available site. Conventional mode of operation should also be used when aligning the radio. From the Conventional mode, standard test equipment can be used to verify proper operation of all circuitry except the following:

- Data modulation circuitry in transmit mode
- Data demodulation circuitry in receive mode
- Trunked mode associated areas of the radio's memory

DISASSEMBLY PROCEDURE

TOOLS NEEDED

1. No. 10 TORX® screwdriver

CAUTION

ALWAYS remove the battery pack before disassembling the unit to avoid blowing the fuse or causing other component damage.

2. Flat Blade screwdriver
3. .050 hex tool (only needed for removal of BNC connector)

NOTE: TORX® is a Registered Trademark of Cam car Division of Textron Inc.

THINGS TO REMEMBER

1. The PA shield screw (F), is longer than the other screws securing the RF Board and should not be interchanged.
2. The shield, that covers L110, L111 and the BNC connection to the RF Board, has a clip that must make contact with Z401 for proper operation. If Z401 is replaced, the protective insulator on that side must be removed to make contact with the shield.
3. A rubber boot is placed over current shunt L106.

BATTERY REMOVAL

1. Ensure the ON/OFF switch on the battery pack is in the off position.
2. Press down on the battery release latch. Wiggle the battery pack from side to side to release it from the wedge in the casting.
3. Slide the battery pack out in the direction of the release latch. See Figure 1.

WARNING

Do not dispose of battery packs or batteries by burning. To do so may cause an explosion.

Figure 1 - Removing The Battery Pack

FRONT AND REAR COVER SEPARATION (See Figure 2)

1. Loosen the four screws (A) which hold the front and rear halves together using a #10 TORX screwdriver. These screws are captive in the rear assembly and should freely move out about 3/4 inch.

NOTE

Never interchange top and bottom screws. Because of length difference, Front Cap damage will result if these screws are interchanged.

2. Pry the front and rear halves apart at the bottom of the radio using a flat blade screwdriver or similar tool.

RF BOARD REMOVAL (See Figure 3)

1. Remove the friction fit RF shield (B) that covers most of the RF Board.
2. Remove the friction fit RF shield (C) that covers the BNC antenna connection to RF Board.
3. Remove the PA shield which covers the PA module.
4. If the center pin of the BNC connector is soldered to the RF Board Antenna contact J101, unsoldered it.
5. Remove the five TORX screws (#10 drive) at (E) and (F) that secure the RF Board to the rear casting.
6. Use a flat blade screwdriver to pry between the casting and the P801 connector housing to lift the RF Board out of the casting.

AUDIO/LOGIC BOARD REMOVAL (See Figure 4)

Remove the two M3-.5 x 4 (G) and the two M3-0.5 x 10 (H) TORX screws (#10 drive), that secure the Audio/Logic Board to the Front Cap assembly. This also removes the MOE connector under the board contacting the Control Frame.

CONTROL FRAME REMOVAL (See Figure 4)

1. Remove the M3-0.5 x 4 TORX screw (J) securing the control frame to the front radio half.
2. Unsolder the two wires at the speaker.

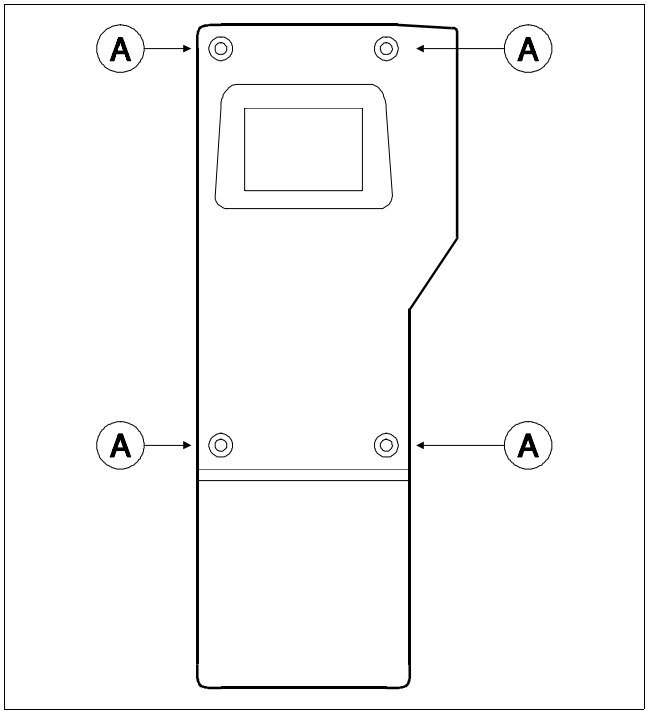


Figure 2 - Front And Rear Assembly Separation

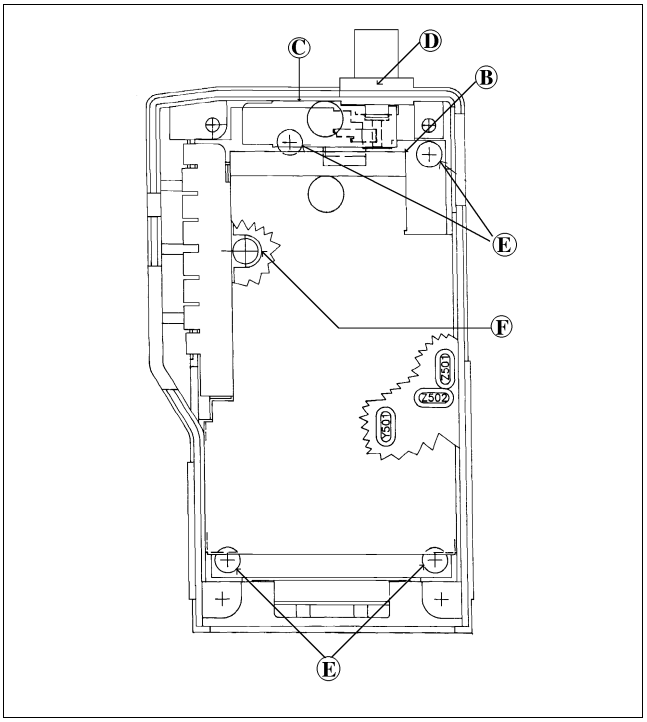


Figure 3 - RF Board Removal

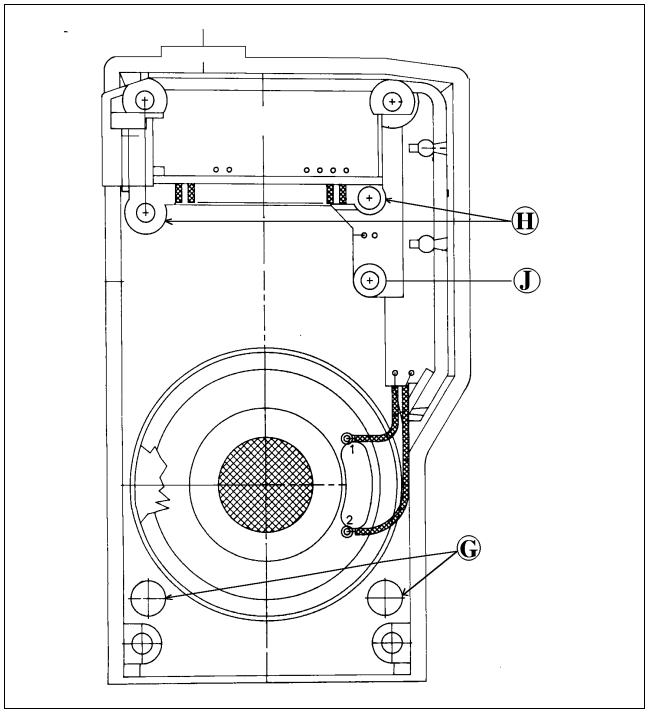


Figure 4 - Audio/Logic Board Removal

PERSONALITY PROGRAMMING

The PCS Dual Format Personal Radio is equipped with a 2048 x 8 bit serial personality EEPROM. All customer information such as frequencies, customer tones and customer options are stored in the EEPROM. The EEPROM contains all information to tailor the operation of the radio to the user's requirements. The EEPROM is programmed by using the following:

- An IBM compatible personal computer with MSDOS
- Interface Box 19D438367G2
- RS-232 Cable 19B235027P1 (computer to Interface Box)
- Programming Cable TQ-3336 (radio to Interface Box)
- Programming Software TQ-3346 - GEMARC-1
  or
  TQ-3373 - EDACS-2

Programming of the EEPROM is accomplished without opening the radio by communicating with the microprocessor through UDC connector on the side of the radio. To PC program the EEPROM, the radio must be placed into programming mode before communicating serially on the **MIC HI** and **PTT** lines. Software checks the status of the volume and channel switches at power up. If one of the volume switches (UP or DOWN) along with one of the channel switches (UP or DOWN) are pushed simultaneously at power up and then released, the radio enters PC programming mode. Power must be recycled OFF/ON to reset the radio to leave programming mode. Refer to the manual provided with TQ-3346 or TQ-3373 software packages for complete instructions on programming the Dual Format PCS radio.

SERVICE NOTES

1. During service and alignment, the bench power supply should be set for 7.5 ±0.1 Vdc (unless otherwise noted). If a battery pack is used, it should be fully charged.
2. It is recommended not to repair but to replace the modules contained in this radio.
3. The personality information stored in the radio should be backed-up on the PC computer before any service procedure is performed.
4. This radio uses a 45.3 MHz IF as opposed to a 45 or 45.0125 MHz IF used by similar Ericsson GE products.
5. There are two 455 kHz IF filters (Z503 and Z504).
6. The Prescaler IC and the Synthesizer IC are contained in a single module (Prescaler Module). The RF line between the VCO and the Prescaler Module also supplies DC bias to the "prescaler output" stage in the VCO module.
7. This radio uses surface mount coils (wire wound) and extra caution should be taken not to jar these components.
8. The RF filters in this radio are fixed tuned and require no tuning.
9. This radio uses a 1.5 PPM oscillator and should not be replaced with 5 PPM oscillators.
10. The PA Module uses a 0 dBm input.
11. The Power Set has no potentiometer adjustments.
12. The transistor circuits for the Local Oscillator Buffer Q450, the VCO Buffer Q203 and the RF Amplifier Q401 are connected in series to preserve battery current. The voltage ("A") at the emitter of Q450 (4.1 Vdc) is applied to the collector of Q203. The voltage ("B") at the emitter of Q203 (2 Vdc) is applied to the collector of Q401.

ALIGNMENT PROCEDURES

This section describes the Transmitter and Receiver Alignment procedures for the 800 MHz RF Board. There are no adjustments on the Audio/Logic Board, therefore no alignments to be made. If a problem is suspected with the Audio/Logic Board, see the **TROUBLESHOOTING** section.

EQUIPMENT REQUIRED

1. Test Box TQ-0613 - requires UDC Programming cable TQ-3336
2. Test Cable 19B801406P62 - Connects the RF Board and the Audio/Logic Board together while the front and rear halves of the radio are separated.
3. Test Cable TQ-0652 - Allows using the Test Box and the PC Interface Box together to feed signals into the radio while communicating with the PC.

4. Computer Hardware and Software equipment - See the list located in the section **PERSONALITY PROGRAMMING**
5. Dummy Battery 19A705293P4
6. Adjustable Regulated Power Supply (5-9 Vdc)
7. RF Generator (806-869 MHz)
8. Wattmeter (4 watts)
9. Ammeter (2 amperes)
10. Distortion Analyzer
11. Frequency Counter

INITIAL ALIGNMENT

The following section describes the only adjustments that can be made without changing the Tracking Data and without using the Utility Software provided with the PC Programmer. For more information on adjusting Tracking Data and the use of the Utility Software, refer to the **FINAL ALIGNMENT** section on page 10. The following adjustments are to be made with the radio's Front and Rear Assemblies separated and with the following Test Equipment Setup.

Setup

1. Separate the Front Assembly and Rear Assembly as described in the DISASSEMBLY PROCEDURE section.
2. Connect the RF Board to the Audio/Logic Board using Test Cable 19B801406P62.
3. Connect the Dummy Battery to the Rear Cover and connect the Radio Programming Cable TQ-3336 to the UDC connector.
4. Set the power supply to 7.5 ±0.1 Vdc and connect the Dummy Battery supply leads to the power supply.
5. Program the radio with the LOW, MIDDLE and HIGH-side test channels listed in the table below. To fully test the transmitter, program a channel pair for each frequency (one at high power and one at low power).
6. Remove power from the radio and place the PC Programming cable on the TQ-0613 Test Box.
7. Connect the radio to the wattmeter and couple a small amount of the RF signal to the frequency counter.

Table 1 - Test Frequencies/Channels

RF BAND	TEST FREQUENCY (MHz)		
	LOW	MIDDLE	HIGH
806-824 MHz*	806.0125	813.0125	824.0125
851-869 MHz	851.0125	858.0125	869.0125

* Transmit only (RX channels are 45 MHz higher)

Transmitter Alignment

Reference Oscillator

1. Apply power to the radio and select any conventional transmit channel. Key the transmitter with either the radio's PTT switch or with the TQ-0613 Test Box.
2. Measure the TX frequency using the frequency counter. Do not apply any modulation.

NOTE

Reference Oscillator U202 is factory adjusted and should not normally need adjustment. Use a recently calibrated and stable frequency counter to determine if oscillator adjustment is needed. The test/alignment should be done at a room temperature of 25°C ±5°C.

3. Adjust Reference Oscillator U202 to obtain a TX frequency reading within ±100 Hz. If the ±100 Hz maximum error (at room temperature) can not be secured, Reference Oscillator replacement may be necessary.

Receiver Alignment

WARNING

Receiver testes use the balanced (bridge) speaker outputs, SPKR (+) and SPKR (-). Grounding of either diferential output may damage the audio power amp. Both have an output DC voltage with respect to ground of 1/2 the supply voltage. Test Box TQ-0613 RX AUDIO jacks are transformer isolated from the radio to allow feeding grounded test equipment.

Second Local Oscillator Frequency

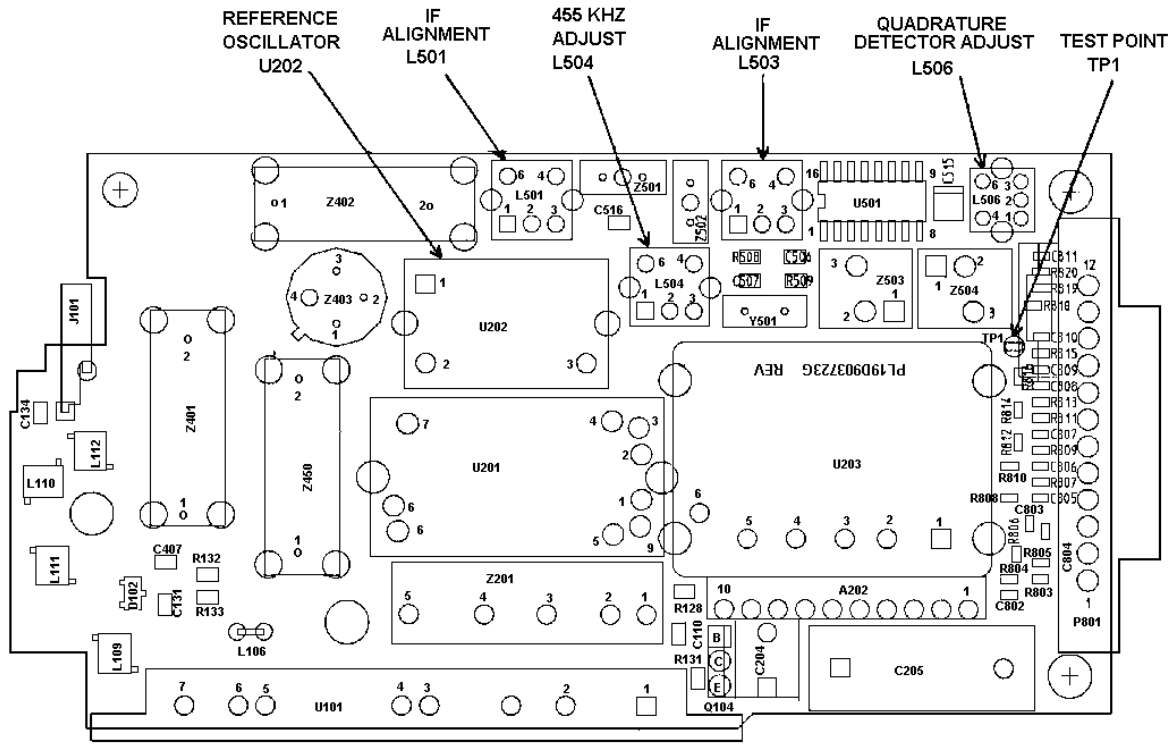
1. Check the Reference Oscillator alignment as outlined in the **Transmitter Alignment** section.
2. Select the Conventional channel programmed with 858.0125 MHz receive.
3. Set the RF signal generator to 858.0125 MHz and at a level between -20 and 0 dBm with no modulation. Apply this signal to the radio.
4. Monitor the frequency at TP1. Adjust L504 for 455 ±1 kHz.

Quadrature Detector

1. Reduce the level of the RF Signal Generator to -50 dBm and modulate with a 1 kHz tone at 3 kHz deviation.
2. Adjust L506 for maximum audio output across RX AUDIO jacks on TQ-0613 Test Box.

IF Alignment

1. Reduce RF Signal Generator level to -100 dBm and continue to modulate with a 1 kHz tone at 3 kHz deviation.
2. Monitor the 1 kHz tone distortion across RX AUDIO jacks on TQ-0613 Test Box.
3. Tune L501 and L503 for minimum distortion. Should be less than 5%.



NOTE: RF BOARD 19D903723G1 SHOWN.
TEST POINTS AND TUNING CONTROLS
FOR RF BOARD 188D6460G1 SAME AS SHOWN.

Figure 5 - Location Of Test Points And Tuning Controls

RX Sensitivity

NOTE

There are no front-end filter or mixer adjustments.

1. Set RF Signal Generator level to -116.0 dBm (still modulated with 1 kHz tone at 3 kHz deviation).
2. Measure SINAD across the band at 851.0125, 858.0125 and 869.0125 MHz. It should be greater than 12 dB.

FINAL ALIGNMENT

Tracking Data

Tracking Data establishes individual radio parameters and tailors the operation of the unit across the band. The four parameters include High and Low RF Power, Modulation Level, Data Modulation and Receiver Squelch opening. This data is programmed into the personality EEPROM at the factory after the Front and Rear Assemblies are joined together.

Tracking data values are not used for each individual channel. Instead, the 806-824 MHz band is divided into 3 band segments and the 851-869 MHz band is also divided into 3 band segments. All channels within each band segment use the same tracking values.

Tracking Data should not normally be altered; however, it may be necessary to reprogram some of the values after aligning circuitry, or replacing modules or other components which obsolete the previously programmed values. Typical starting values for each parameter are listed in Table 2.

Digital values stored for the POWER SET analog voltage are one example of tracking information. As no two transmitter stages are exactly matched, the POWER SET DC voltage will be slightly different with any two radios to produce the same power output. Tracking Data allows the microprocessor to tailor the POWER SET line for the RF stage difference from unit-to-unit and across the band.

This section describes the Final Transmitter and Receiver Alignment. This section describes how to adjust the Tracking Data and must be made using the Utility Program provided with the TQ-3346/TQ-3373 Programming Software. In each procedure, brief instructions will be given on the use of the Utility Programming Software. LBI-38898 provides detailed instructions for operating the software and should be used as a reference for any software problems or questions. The following alignment procedures should be done with the radio assembled and with the Test Equipment Setup as shown in Figure 6.

Table 2 - Tracking Data Parameters

PARAMETERS	TYPICAL HEX VALUES		
Squelch Opening (All Bands)	B3		
NORMAL TX BAND	LOW 806-813 MHz	MEDIUM 813-821 MHz	HIGH 821-824 MHz
Power-High	7E	7F	7F
Power-Low	50	52	53
TX Modulation	27	26	1B
Data Modulation	28	27	1D
PARAMETERS	TYPICAL HEX VALUES		
TALKAROUND TX BAND	LOW 851-858 MHz	MEDIUM 858-866 MHz	HIGH 866-869 MHz
Power-High	76	78	72
Power-Low	54	54	57
TX Modulation	2D	2B	20
Data Modulation	**	**	**

** NOT USED

TX Power Settings

High Power Settings

1. From the Maintenance Screen shown in Figure 7, press **F1 Calib** to enter the Calibration Screen. The first screen to appear should be the "Tx High Power Calibration" window. If this window is not on the screen, then use the **F1 Next** or **F2 Prev** keys to toggle to the correct window.
2. Press **F4 Tx On** to key the transmitter.
3. Measure the transmitter power output.
4. With the Low Frequency value highlighted, increment or decrement the current value (Hex or Decimal) until the specified window for power is reached. See Table 3.
5. Measure the total radio current. Current should be less than the high power current specification given in the table. Retain the hex value for later programming of the personality.
6. Press the **F4 Tx Off** to turn the transmitter off.
7. Repeat this procedure for the remaining 5 frequencies.

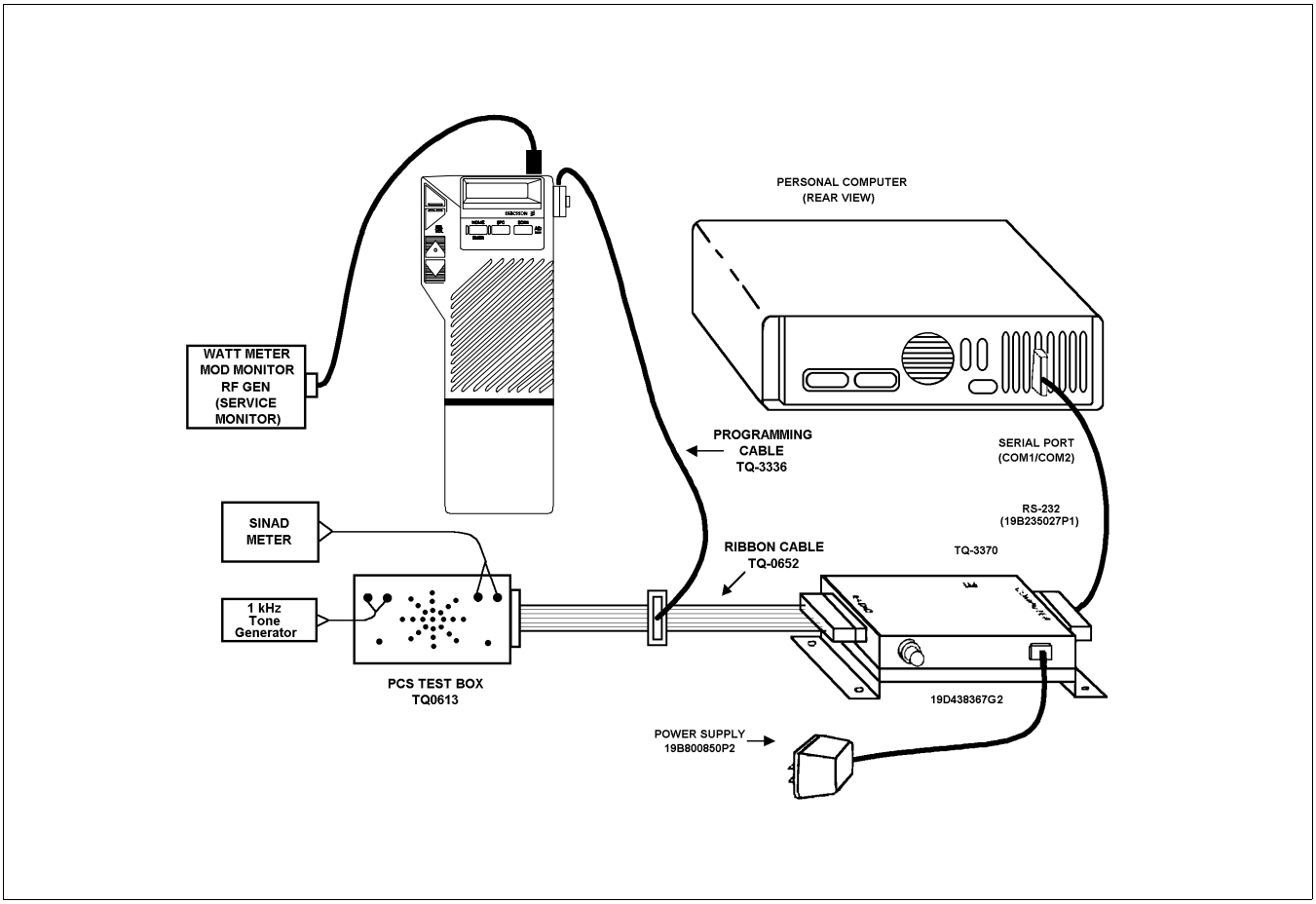


Figure 6 - Test Equipment Setup For Final Alignments

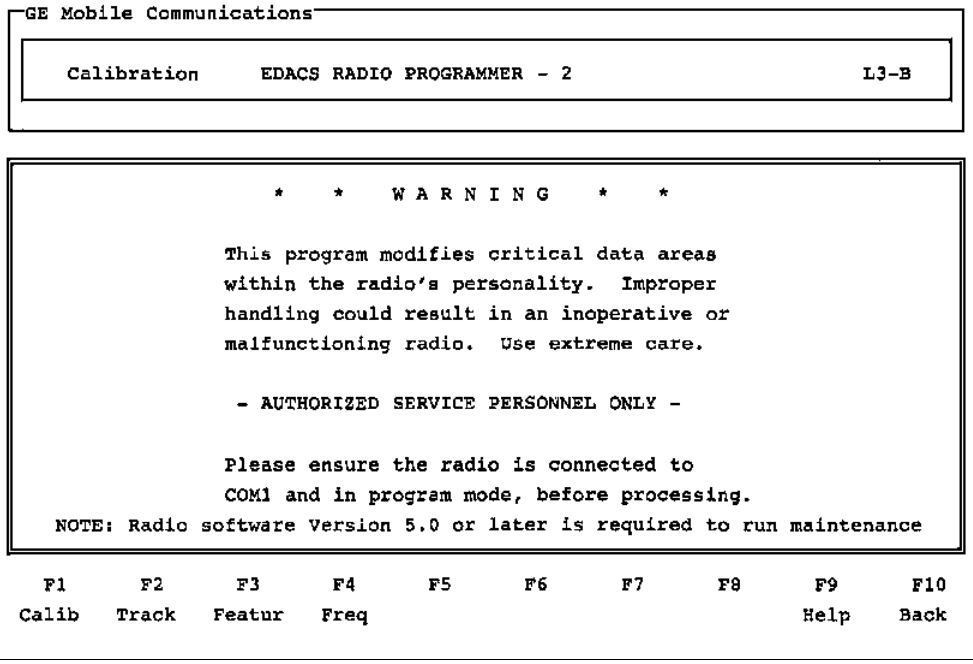


Figure 7 - Utility Program Maintenance Screen

Table 3 - High And Low Power Specifications

FREQUENCY	HIGH POWER		LOW POWER	
	Power (Watts)	I(Amps)	Power (Watts)	I(Amps)
TX Low	3.2 ±0.1	< 2.0	1.1 ±0.1	< 1.3
TX Mid	3.2 ±0.1	< 2.0	1.1 ±0.1	< 1.3
TX High	3.2 ±0.1	< 2.0	1.1 ±0.1	< 1.3
TX Low Talkaround	2.5 ±0.1	< 2.0	1.1 ±0.1	< 1.3
TX Mid Talkaround	2.5 ±0.1	< 2.0	1.1 ±0.1	< 1.3
TX High Talkaround	2.5 ±0.1	< 2.0	1.1 ±0.1	< 1.3

Low Power Settings

1. Using the **F1 Next** or **F2 Prev** keys, toggle to the "Tx Low Power Calibration" window.
2. Press **F4 Tx On** to key the transmitter.
3. Measure the transmitter power output.
4. With the Low Frequency value highlighted, increment or decrement the current value (Hex or Decimal) until the specified window for power is reached. See Table 3.
5. Measure the total radio current. Current should be less than the low power current specification given in the table. Retain the hex value for later programming of the personality.
6. Press the **F4 Tx Off** to turn the transmitter off.
7. Repeat this procedure for the remaining 5 frequencies.

Tx Modulation Calibration

1. Using the **F1 Next** or **F2 Prev** keys, toggle to the "Tx Modulation Calibration" window.
2. Feed a 200 mV rms, 1 kHz tone across the TX AUDIO jacks on TQ-0613 Test Box.

NOTE

The MIC HI input line to the PCS is also the RX DATA line from the computer. To allow simultaneous communication with the computer while feeding in a 1 kHz tone, the audio generator impedance must be 600 ohms or greater. Insert a resistor in series with the generator output if necessary, i.e. a 560 ohm resistor when using a 50 ohm generator. Also, higher audio signal levels exceeding 200 mV rms may confuse the radio as being data.

3. With the Low Frequency value highlighted, press **F4 Tx On** to key the transmitter.
4. Summed with the 1 kHz input tone, the radio will be generating 75 Hz low speed data (Channel Guard tone). Measure the deviation. Modulation Monitor should be set for 15 kHz low pass filter and no high pass filter.
5. Increment or decrement the value (hex or digital) until the deviation specifiations are met. See Table 4. The deviation test window is 0.20 kHz wide. Each step is typically 0.14 kHz, depending on the VCO modulation sensitivity.

Table 4 - TX Deviation Specifications

FREQUENCY	DEVIATION (kHz)
TX Low	4.5 ±0.1
TX Mid	4.5 ±0.1
TX High	3.6 ±0.1
TX Low Talkaround	4.5 ±0.1
TX Mid Talkaround	4.5 ±0.1
TX High Talkaround	3.6 ±0.1

6. Press **F4 Tx Off** to turn the transmitter off.
7. Repeat steps 3-6 for each frequency.

Data Modulation

NOTE

The personality map has data deviation bytes reserved for Tx Low Talkaround, Tx Mid Talkaround and Tx High Talkaround. These EEPROMS locations are presently not used and do not have to be programmed.

1. Using the **F1 Next** or **F2 Prev** keys, toggle to the "Data Modulation Calibration" window.
2. With the Low Frequency highlighted, press **F4 Tx On** to key the transmitter.
3. Measure the data deviation. The Modulation Monitor should be set for 15 kHz low pass filter and no high pass filter.
4. Increment or decrement the current value (Hex or Decimal) until the specified window for data deviation is reached. See Table 5.

Table 5 - Data Deviation Specifications

FREQUENCY	DEVIATION (kHz)
TX Low	3.0 ±0.1
TX Mid	3.0 ±0.1
TX High	2.4 ±0.1

5. Press **F4 Tx Off** to turn the transmitter off.
6. Repeat steps 2-6 for each frequency.

Squelch Calibration

It is recommended to use the procedure described in the section below **Conventional Method Of Adjustment,** but if it becomes necessary to adjust the squelch using the Utility Program, keep in mind the following note:

NOTE

In normal radio operation, when software detects the first quick burst of the squelch opening, the hysteresis adds a fixed number of steps to the squelch value to loosen the squelch and keep it open. PC Programming mode does not use the hysteresis software routine. Therefore, without this routine, the test below must detect the point when the audio just begins to bubble or chatter.

1. Using the **F1 Next** or **F2 Prev** keys, toggle to the "Squelch Calibration" window.
2. The **Chan Field** should read "Low". Use the TAB key as a toggle switch to change the frequency of the **Chan field**.
3. Press F4 to toggle the RX Audio on.
4. Move down to the **Value Field** and change the value to "E2" (226). This will keep the receiver audio open.
5. With the RF generator at -117.0 dBm, modulated with a 1 kHz tone at 3 kHz deviation, reduce generator RF level until 8-10 dB SINAD is found across the RX AUDIO jacks on the TQ-0613 Test Box.
6. Decrement this value field until the RX audio turns completely off. Increment the value field one step and check for occasional bursts of receiver audio. Repeat until the point is reached that the audio just begins to chatter.

Conventional Method Of Adjustment

1. With the radio on a Conventional Channel, press and hold the **SHFT/CLR** button.
2. Use the **VOLUME** buttons to adjust the squelch. Pressing the **VOLUME UP** button will loosen the squelch to allow opening on weaker signals. Pressing the **VOLUME DOWN** button will tighten the squelch to allow stranger signals to open the squelch.

TROUBLESHOOTING

This section provides a guide to troubleshooting the Dual Format PCS radio. The following procedures will assist in determining if the problem is in the RF circuits (Transmitter, Receiver or Synthesizer) or the Control circuits. The test set-up should be the same as that used in Alignment section of this manual.

DOCUMENTATION TO HELP IN TROUBLESHOOTING

- RX and TX block diagrams with RF gains and levels
- Synthesizer block diagram
- Interconnection diagrams (located on pages 20 and 21)
- Outline diagrams
- Schematic diagrams
- Parts lists
- IC data

Table 6 - Basic Troubleshooting

SYMPTOM	POSSIBLE CAUSE
Completely inoperative (no audio and no LCD indication)	1. Dead battery pack. 2. Control circuit problem - troubleshoot Front Assembly. 3. Blown fuse.
At power-up, radio	
1. beeps once every 130 seconds and the BT indicator is on.	The battery is weak.
2. displays an "E3"	The Synthesizer is not locked - check the LOCK detect line, synthesizer loading and VCO tuning voltage.
3. displays an "E9"	The radio is not programmed - see TQ-3346 or TQ-3373 software and programming manual.
Receiver inoperative or weak	1. Squelch levels programmed too high - press monitor button twice and hold to disable squelch. 2. Defective antenna. 3. RF Board problem - troubleshoot Rear Assembly.
Transmitter inoperative or low range	1. Power levels programmed low - check RF output power and reporgram unit if necessary. 2. Weak battery. 3. Defective antenna. 4. RF Board problem - troubleshoot Rear Assembly.
TX and RX inoperative on some channels only	1. Programming incorrect - reprogram the unit using TQ-3346 or TQ-3373. 2. Synthesizer problem - check LOCK detect (high=lock), VCO tuning voltage and modulus control line.
TX and RX inoperative on all channels	1. Programming incorrect - reprogram the radio using TQ-3346 or TQ-3373. 2. Synthesizer problem - check LOCK detect (high=lock), VCO tuning voltage and modulus control line. 3. Control circuit problem - troubleshoot Front assembly.
Trunk Mode Problem	1. Modem circuitry problem - check U702 on the Audio/Logic Board.

FRONT ASSEMBLY

Inoperative Radio

Power Supplies

1. DC power should be the first area to check if the radio is completely dead. Verify that the battery is not defective.

2. Next check for 7.5 Vdc battery voltage (**B+**) on the Audio/Logic Board. **B+** from the battery is routed from the RF Board to the Audio/Logic Board through connector J801 pin 4. If **B+** is not present on the Audio/Logic Board then trace the **B+** line back through the 4 amp fuse to the battery. **B+** on the Audio/Logic Board is also routed from J901 pin 15 to the Control Assembly.

3. A single 5 volt regulator U801 supplies all circuitry on the board (except OP Amp U301 and Audio PA U603. There should be a regulated +5 volts at U801 pin 1, that is stable within $\pm$.1 Vdc during each operating mode (transmit, receive, standby and program).

Table 7 - Current Consumption (typical)

OPERATING MODE	BATTERY CURRENT
Receive Standby	90 mA
Receive Full Audio	270 mA
Transmit at 3 watts	2.0 Amps
Transmit at 1 watt	1.3 Amps
Programming	100 mA

Reset Logic

1. U801 also provides reset signal for Modem U702. Check for a reset signal at U801-5 which is normally high and goes low during reset. Invertor Q804 inverts the signal and provides a +5V to the Modem at reset. Trigger the scope with B+ and observe the collector of Q804. The collector should rise to +5 Vdc at power up, remain there for 20 mS, and then switch LOW.

2. Modem U702 provides the reset signal for the Microprocessor and the Audio Signal Processor (ASP). The active high reset signal (RESOUT) at U703-43 is inverted by Q703 and sent to the low reset inputs of the microprocessor (U701-30) and the ASP (U804-9). Monitor Q703 collector as the unit is powered and check for reset signal.

Microprocessor And Clock

NOTE

Microprocessor U701 was changed with the G2 Audio/Logic board. The microprocessor operation is the same but with a different pin out.

To check the operation of the microprocessor:

1. First, check R752 (the end away from C751) under the microprocessor. At this point you will observe a 4V p-p 11.0592 MHz clock from the modem IC (U702-15) to the Microprocessor clock input (U701-52 for G1 boards and U701-39 for G2 boards). Use an oscilloscope or a frequency counter with a high input impedance. Suspect Y701 if this clock is in error.
2. If the 11.0592 MHz buffered clock is present, the **ALE** output line at U701-55 for G1 boards and U701-50 for G2 boards, should then run continuously at 1.8432 MHz (.54 µs period on a scope). The **PSEN** output (U701-54 for G1 boards and U701-49 for G2 boards) should also run continuously at the same frequency. However, the PSEN line rests at 5 volts when 12 Vdc is applied to the radio.

Transmit Audio Failures

Internal Microphone Audio Failure

With no external option connected to the UDC:

1. Check J901-11 for an internal microphone bias of 2.2 Vdc. Access to this point can easily be measured on R833 on the bottom of the board (end away from R834).
2. Average speech into the microphone should produce 12 mV rms at the same point.

External Microphone Audio Failure

1. There should be approximately 2.2 Vdc bias at UDC connector J-902 pin 4 with an external mic connected and 2.5 Vdc bias without an external mic connected. Make this measurement at the same point as mentioned previously for an internal microphone.
2. If the internal mic is operating normally then suspect micro switch problem or open run on the Control Frame.

Complete Mic Audio Failure

If both internal and external microphones are not functioning, suspect U804 or U301. See Table 8 for the correct levels.

Table 8 - Tx Audio Mic Test Points And Levels

TEST LOCATION	LEVELS
R833 (end away from R834) on bottom of board	- 2.2 Vdc with Mic connected - 2.5 Vdc without Mic connected - 12 mv RMS (34 mV P-P) for 2.5 kHz deviation (1 kHz tone)
U804 pin 60 and deviation control set at one half output	- 1.5V P-P Limited Mic - 0.3V P-P CG Tone- - 1.2V P-P Data
U301.1 pin 1 (3.0 kHz) deviation	- 0.6V P-P Typical

Transmit Channel Guard or Low-Speed Data Problems

Connect a scope to R741 and R742 common connection on bottom of board. While transmitting tone channel guard, a 4 step waveform should be present, alternating between 1.4 Vdc and 3.6 Vdc (2.2 Vp-p).

This waveform is filtered by the ASP. A pure 2.4 Vp-p sine wave should be at U804-37. Observe 0.3 Vp-p at U804-60 and 0.15 Vp-p at J801-5 (TX MOD) typically with deviation set at one half.

Receive Audio Failures

Verify that the discriminator audio from the RF Board is present at J801 pin 10. Typical signal level should be 500 mV rms (1.4V P-P) with 3 kHz deviation.

Squelch Circuit

Nearly all the Squelch circuitry is contained within the ASP. There should be a DC voltage on U804-52 between 2.5 Vdc and 4.5 Vdc (proportional to receiver noise). Please see Table 9 for the correct Squelch levels.

Check the squelch opening Tracking Data parameters using the PC Programmer and Utility Manual LBI-38898. Higher numbers should make squelch open at lower signal levels, and lower numbers should make squelch open at higher signal levels. Below Hex 80, the squelch will not open at all.

Table 9 - Squelch Test Points And Levels

TEST LOCATION	LEVELS
U804-43 at 3 kHz deviation	- 340 mV rms (960 mV P-P)
U804 pin 52	- No RF signal: 2.5 Vdc bias with rectified noise peaking to 4.5 Vdc). Full Quieting: 2.5 Vdc.
U804 pin 23	- 5 Vdc No signal - 0 Vdc Signal Detected
U804 pin 55	- 3.0 Vdc Noise - 2.5 Vdc Full Quieting
U804 pin 53	- 3.5 Vdc Noise - 2.5 Vdc Full Quieting

Table 10 - RX Audio Test Points And Levels

TEST LOCATION	LEVELS
J801-10 at 3 kHz deviation	- 500 mV rms (1.41V P-P)
U804 pin 45 at 3 kHz deviation	- 340 mV rms (960V P-P)
U804 pin 28 at 3kHz deviation (GE-MARC Only)	- 340 mV rms (960V P-P)
U804 pin 27 at max volume with 1 kHz tone and 3 kHz deviation	- 200 mV rms (570 mV P-P)
U603 pin 7	- 21 mV rms (60 mV P-P) 500 mW output into 16 ohms
U603 pin 1(+) and 3(-) (bridge output)	- 2.83 V rms for 500 mW output into 16 ohms

Audio Path

DET Audio enters the ASP on pin 44. Pin 44 is the (-) input to a OP Amp buffer within ASP U804. The audio level will not be measurable at pin 44 since this input is at "virtual ground" for the Op Amp. RX audio for EDACS and Conventional modes never loops out and back into the ASP. RX audio for GE-MARC systems loops out of the ASP at pin 45 and is sent to Busy Tone Band Pass Filter U601.1 and Busy Tone Notch Filter U602. The Notched Audio reenters the ASP on pin 28. All RX audio leaves ASP on pin 27 where it is sent to Audio PA U603. See Table 10 for RX Audio test points and there levels.

Speaker Amp

1. If the speaker is inoperative and audio is present at ASP pin 27, check U603 pin 2 for battery power from Q605.
2. Using a scope, check U603's differential outputs on pins 1 and 3. Connect the scope ground to the radio ground and measure each pin separately. Observe 3.8 Vdc or 1/2 supply voltage. 4 Vp-p of signal will be at each pin at full power output.

NOTE

The Audio amplifier drives a balanced load only. A prolonged short on either speaker (+) or speaker (-) will result in damage to the audio amplifier or speaker.

Low Speed Tone/Data Decode Problems

Filtering and limiting of Channel Guard and trunked low-speed data occurs in ASP U804. Channel Guard signals and trunked low-speed data are decoded by Microprocessor U701.

1. Channel the radio to a conventional test channel that has CG decode programmed. Apply an on frequency RF signal from a signal generator.
2. Modulate the signal from a signal generator with a CG tone. Set CG deviation to 0.750 kHz.
3. Monitor U804 pin 37. The CG tone should be present at a level of 350 mV P-P. The pin is biased to 2.5 Vdc. If the signal or the DC bias is incorrect, suspect ASP U804.
4. Check pins 34 and 35 for a dc level of 2.5 Vdc.
5. Monitor U804 pin 22 for a 0-5 Volt square-wave at the CG frequency. This is the Audio Signal Processor output that is applied to the Microprocessor for decoding.

LCD/Backlight Failure

LCD:

1. Since the LCD driver board is connected to the Audio/Logic board through the Control Assembly, check all associated connections and runs on the Control Assembly.
2. Be sure the LCD assembly is intact and that it is not broken or cracked.
3. Check for +5 volts at P1-2.
4. Monitor **IIC DATA** and **IIC CLK** (P1-4 and P2-2 respectively) for active LOW serial data. These lines normally rest at 5 Vdc.
5. Check voltage divider R6 and R7 for proper LCD reference voltages. Voltage divider R6 and R7 should provide 2 Vdc at U1 pin 12.

Backlight:

1. Using the PC Programmer, make sure the radio is programmed for Backlighting.
2. Check for **B+** at P2-2.
3. Measure the DC voltage P1-3 while pressing a key on the keypad. P1-3 should be at 0 Vdc when backlight is off and at +5 Vdc when backlight is on. This voltage originates from ASP U804-14.

Keypad Failure

Keypad Scanning

Each of the 3 key's in the SCAN version connect to an individual input to the microprocessor. The SYSTEM version has 12 keys which connect to shift registers U780 and U781 on the Keypad Board. These same three lines which were used with the SCAN keypad are now used to serially clock the data out of the shift registers.

SCAN Keypad

On the bottom of the Audio/Logic Board, measure the keypad lines at J802 of the ribbon cable. These three lines should normally rest at +5 Vdc with a key push grounding a line.

SYSTEM Keypad

At power up, the radio software first tries scanning the keypad to determine if the shift registers are present or not. If the registers are found, the microprocessor starts scanning the keyboard. The keyboard is scanned every 20 to 50 mS depending on the radio mode of operation. A high speed digital storage scope is needed to observe the **DATA**, **LOAD** and **CLK** lines on J802.

CLK will have 15 active high pulses, each 5 µs wide repeating every 20-50 ms. **LOAD** will have 1 active low pulse, 1 µs wide repeating every 20-50 ms. **DATA** will have 2 active low pulses, 1 ms wide repeating every 20-50 ms. Pushing a key will add an active low pulse to the **DATA** line.

REAR ASSEMBLY

The troubleshooting information that follows assumes a problem has been narrowed down to the Rear Assembly. The following troubleshooting guide will cover the Transmitter, Receiver and Synthesizer circuitry.

Transmitter

Inoperative Or Low Power

Power sources and regulated power supplies should be one of the first areas to check before troubleshooting any transmitter problem. The radio's power source (battery or bench power supply), is especially critical when troubleshooting a portable radio. Current consumption is an excellent troubleshooting tip when troubleshooting a dead or weak transmitter. See Table 4 for details.

1. Check for battery power (**B+**) at P801-4.
2. Regulator U801 supplies a regulated 5.4 volts to all circuits requiring a stable reference voltage. Check for **B+** at U801 pin 6 and check for a regulated 5.4 Vdc at pin 4.
3. Check that the microprocessor is enabling the TX Switch circuit and that it is operating properly when the PTT switch is pressed. There should be approximately 7.4 Vdc at Q104 pin 2 when the PTT switch is pressed.
4. Battery voltage (7.5 Vdc) should be present at the Power Amplifier module pins 3 and 4. If current consumption is normal for both high and low power modes, the problem may be the Tx/Rx switch or the low pass filter. If there is a problem with the low pass filter, the receiver will also be weak. A shorted or open pin diode (D101 and D102) may cause transmitter and/or receiver problems.
5. If low RF Power is a symptom, check the operation of the Power Control circuit (see the Power Control section)
6. If the Power Control circuit is working properly, then check the Gain of Buffer Amplifier and Power Amplifier Module (see the Block Diagram in LBI-38856).

Excessive Power Output

Short battery life and possible damage to the PA module may result if this problem occurs in the power controlling circuit. See the **Power Control** Section below.

Power Control

TX PWR set voltage from the microprocessor should be present at R107 (see the Schematic), and should range from .5 to 5 Vdc. There should be between 3.5 and 7.5 Vdc at the collector of the Buffer Amplifier Q109. Check VCO module U203 and VCO buffer Q203 for low RF drive. Check for 3.7 Vdc at U101 pin 1.

1. Check programming.
2. Check regulated supplies to the Synthesizer when the PTT is pressed.
3. See the **Synthesizer Troubleshooting** section.

Frequency Error

If transmit frequency error exists (greater than 1.5 PPM) and the synthesizer stays locked, Reference Oscillator U202 alignment or replacement is necessary. See **ALIGNMENT PROCEDURES**. The microprocessor will not enable a transmission if the synthesizer is not locked.

Modulation

Problems can be caused by failures in the audio circuits in the Front Assembly or the modulating circuitry of the RF Board.

1. Insure modulating audio (TX MOD) is present on P801 pin 5. A level of 600 mV p-p should produce 3 kHz deviation. Improper modulation from 300-3000 Hz, points to a VCO modulation problem.
2. If improper low-frequency (Channel Guard) modulation exists, first check P801 pin 5 for the tone. If it is not present, see the **FRONT ASSEMBLY** troubleshooting section.

Modulation Distortion

Check TX AUDIO for an undistorted signal to the RF Board. The audio signal on P801 pin 5 should appear undistorted at maximum deviation and it should be riding on a 2.5 Vdc bias from U804 from the Audio/Logic Board.

1. If TX AUDIO distortion is minimal and transmitter distortion is excessive, suspect the VCO on the RF Board.
2. If TX AUDIO is distorted, suspect a defective microphone, mic amps, modulation limiting or pre-emphasis circuitry. See the **FRONT ASSEMBLY** troubleshooting section.

Receiver Troubleshooting

Inoperative

1. Momentarily press, and then press and hold the Monitor Button. If receiver noise is heard, it can be assumed that most of the receiver's circuitry is good.
2. If the Synthesizer will not lock, the radio should display an "E3" message. If an "E3" message is displayed, see the **Synthesizer Troubleshooting** section.
3. Check P801-10 **DET AUDIO** for signal and/or noise. With an RF input modulated with 1 kHz tone at 3 kHz deviation, **DET AUDIO** should be 960 mV p-p. If the 1 kHz tone is present, troubleshoot the audio circuits in the Front Assembly. Noise only levels on **DET AUDIO** should be approximately 2 Vp-p.
4. Check for 1 Vdc at the collector of RF Amp Q401. Check for 2.8 Vdc at the collector of IF Amp Q502. Check for 5.3 Vdc at U501 pin 4. Insure **SW_B+** is low in receive mode.
5. Insure mixer injection from the VCO is present at Z450 pin 1. Check the VCO output with a frequency counter at Z450-1. The VCO should be running at 45.3 MHz below the RX frequency. VCO output power level is typically -3 dBm into 50 ohms.
6. To eliminate a problem in the Mixer/Limiter/Detector circuits, follow the procedure below:

    a. Check for the following DC voltages (typical) at:

        U501 pin 1 - 5.4 Vdc
        U501 pin 2 - 4.7 Vdc
        U501 pin 4 - 5.3 Vdc
        U501 pin 6 - 5.1 Vdc
        U501 pin 8 - 5.3 Vdc

    b. Connect a frequency counter to TP1 to monitor the IF. Use an appropriate high impedance probe.

c. Couple a 45.3 MHz signal (no modulation) from an HF signal generator to U501 pin 16. Adjust the signal generator level to achieve accurate counting of the IF; the signal generator should be set 10 dBm above the lowest level which gives stable counting of the 455 kHz IF. See the **ALIGNMENT PROCEDURES** if the 2nd IF is in error by more than 90 Hz.

d. Modulate the HF signal generator and observe the **DET AUDIO** at P801 pin 10.

Low Sensitivity

Low receiver sensitivity in conjunction with low transmit power indicates excessive loss in the low pass filter-T/R switch circuitry. Capacitor C407 can be removed to inject a signal directly into the Receiver input at Z401 to verify that the problem exists before this point. Also verify that mixer injection drive to Z403 pin 1 is correct.

Check DC voltages on transistors Q401, Q501, Q502, Q503 and Q504. Refer to the schematic diagram for the Transmit/Receive Board 19D903725 sheet 3 for nominal DC voltages. LBI-38856 provides a block diagram that gives typical signal levels in the receiver to help in tracing receiver problems to the particular stage involved.

Squelch Problem

A squelch circuit problem (assuming good signal and/or noise is present at P801 pin 10) indicates a problem with the Audio Signal Processor chip on the Audio/Logic Board. Troubleshooting should begin at the discriminator output and signal trace to the Audio Processor. Check the operation of the noise rectifier to be sure the noise is being converted into the proper DC voltage.

See **TROUBLESHOOTING** the Front Cover Assembly for details on receiver audio failures. Check Tracking Data.

Excessive Distortion

If the measured distortion exceeds the rated specification signal trace starting at the discriminator output and through the audio stages until the fault is isolated. Signal tracing with an oscilloscope proves very useful in locating the trouble areas.

Synthesizer Troubleshooting

Each time the channel is changed, the PTT Button is pressed or the PTT is released, the Synthesizer IC within Prescaler Module U201 is serially loaded with new TX and RX data. If the synthesizer does not lock or stay locked, the following will be observed:

- an "E3" error message will be displayed
- the **SYN LOCK DET** line at P801 pin 11 will be low or pulsing to flag the Microprocessor of the unlocked condition

If the above condition occurs, the Microprocessor will continue to try to reload the Prescaler Module with data until the synthesizer locks.

1. Insure **5.4_Reg Vdc** from U801 is within ±0.1 Vdc. Be sure that **5.4 Vdc** is present at A202 pin 9 and within ±0.1 Vdc. Be sure B+ 7.5 Vdc is present at P801 pin 4.
2. Monitor **SYN EN**, **SYN DATA** and **SYN CLK** on P801 pins 2, 3 and 6 respectively for pulse activity when a channel is changed. If signals are not present, suspect a defective Microprocessor.
3. Check for 1.8 to 3.5 Vdc (typical) loop voltage at A202 pin 10. Check for 5.4 Vdc at A202 pin 9. Check for B+ (7.5 Vdc) at A202 pin 7. Check for 2-4 Vdc at A202 pin 8. If the voltages at A202 pins 7, 9 and 10 are correct and 2-4 Vdc is not present at pin 8, suspect A202.
4. Using a frequency counter with a high impedance probe or amp, check for a 12.8 MHz (±20 Hz at 25 °C) signal from Reference Oscillator U202 at pin 2. Replace this module if this signal is not present and pin 3 is at 5.4 Vdc.
5. Insure the SYN BANDSWITCH line is at the correct logic level as shown below:

Table 11 - BANDSWITCH Voltage Levels

TEST POINT	TX at 806-824 MHz	TX at 851-869 MHz
Q204 pin 2	4.7 Vdc	5.4 Vdc
U203 pin 1	5.4 Vdc	-2.0 Vdc*

* measured with a Digital Voltmeter with >1M ohm load

If the signals are not correct at Q204 pin 2 suspect the Microprocessor. If the inverted signals at U203 pin 1 are correct on both bands and the synthesizer will not lock on one band only, replace VCO module U203.

6. If the **SYN LOCK DET** is low and not pulsing, temporarily pull it high by connecting P801 pin 11 to 5.4 REG Vdc. If the radio operates normally on all test TX and RX channels, replace U201, the output on pin 1 is defective.
7. Check the VCO output with a frequency counter at U203 pin 5. The VCO should be running at 45.3 MHz below the RX frequency. VCO output power level is typically -3.0 dBm at U203 pin 5.
8. If the synthesizer lock problem can not be narrowed to a problem in the Rear Assembly, reprogram the inoperative channels and test the unit again. Also see the **TROUBLESHOOTING** procedures for the Front Assembly.

COMPONENT REPLACEMENT

SURFACE MOUNT COMPONENTS

Surface mount components should always be replaced using a temperature controlled soldering system. The soldering tools may be either a temperature controlled soldering iron or a temperature controlled hot-air soldering station. A hot-air system is recommended for the removal of components on the multi-layered boards used in the Dual Format PCS radio. With either soldering system, a temperature of 700°F (371°C) should be maintained.

The following procedures outline the removal and replacement of surface mount components. If a hot-air soldering system is employed, see the manufacture's operating instructions for detailed information on the use of your system.

CAUTION

Avoid applying heat to the body of any surface mount component using standard soldering methods. Heat should be applied only to the metallized terminals of the components. Hot-air systems do not damage the components since the heat is quickly and evenly distributed to the external surface of the component.

CAUTION

The CMOS Integrated Circuit devices used in this equipment can be destroyed by static discharges. Before handling one of these devices, service technicians should discharge themselves by touching the case of a bench test instrument that has a 3-prong power cord connected to an outlet with a known good earth ground. When soldering or desoldering a CMOS device, the soldering equipment should have a known good earth ground.

SURFACE MOUNT REMOVAL

1. Grip the component with tweezers or small needlenose pliers.
2. Alternately heat the metallized terminal ends of the surface mount component with the soldering iron. If a hot-air system is used, direct the heat to the terminals of the component. Use extreme care with the soldering equipment to prevent damage to the printed wire board (PWB) and the surrounding components.
3. When the solder on all terminals is liquefied, gently remove the component. Excessive force may cause the PWB pads to separate from the board if all solder is not completely liquefied.
4. It may be necessary to remove excess solder using a vacuum de-soldering tool or Solderwick®. Again, use great care when de-soldering or soldering on the printed wire boards. It may also be necessary to remove the epoxy adhesive that was under the surface mount component and any flux on the printed wire board.

SURFACE MOUNT COMPONENT REPLACEMENT

1. "Tin" one terminal end of the new component and the corresponding pad of the PWB. Use as little solder as possible.
2. Place the component on the PWB pads, observing proper orientation for capacitors, diodes, transistors, etc.
3. Simultaneously touch the "tinned" terminal end and the "tinned" pad with the soldering iron. Slightly press the component down on the board as the solder liquefies. Solder all terminals, allowing the component time to cool between each application of heat. Do not apply heat for an excessive length of time and do not use excessive solder.

With a hot-air system, apply hot air until all "tinned" areas are melted and the component is seated in place. It may be necessary to slightly press the component down on the board. Touch-up the soldered connections with a standard soldering iron if needed. Do not use excessive solder.

4. Allow the component and the board to cool and then remove all flux from the area using alcohol or another GE approved flux remover.

CAUTION

Some chemicals may damage the internal and external plastic parts of the radio.

SURFACE MOUNTED INTEGRATED CIRCUIT REPLACEMENT

Soldering and de-soldering techniques of the surface mounted IC's are similar to the above outlined procedures for the surface mounted chip components. Use extreme care and observe static precautions when removing or replacing the defective (or suspect) IC's. This will prevent any damage to the printed wire board or the surrounding circuitry.

The hot-air soldering system is the best method of replacing surface mount IC's. The IC's can easily be removed and installed using the hot-air system. See the manufacturers instructions for complete details on tip selection and other operating instructions unique to your system.

If a hot-air system is not available, the service technician may wish to clip the pins near the body of the defective IC and remove it. The pins can then be removed from the PWB with a standard soldering iron and tweezers, and the new IC installed following the Surface Mount Component Replacement procedures. It may not be necessary to "tin" all (or any) of the IC pins before the installation process.

MODULE REPLACEMENT

The modules, all of which are located on the RF Board, are very reliable devices. Before replacing any of the modules, check the associated circuitry thoroughly to insure there is not a problem elsewhere. If replacement is necessary, follow the below procedures.

All of the component lead holes on the RF Board for the modules are plated through from the top to the bottom of the board. This allows for easy removal and replacement of the modules as long as appropriate soldering techniques are observed. Always observe static precautions when handling the board during module replacement.

To remove a module, position the RF Board in a work vice (face down, chip components up) and remove the solder from the plated-through points at the appropriate pins. If a hot-air system is employed, use an appropriate tip that will localize the heat on the pins and not on surrounding chip components. Solderwick or a vacuum de-soldering iron will also remove the solder if a hot-air station is not available. When all solder has been removed or liquefied, the module should drop out.

To install a module, clean any solder from the plated through holes and clean all flux from the board. Next, install the replacement module making sure that all pins align in the proper holes. Re-solder the pins to the board. Clean the flux from the board using an approved solvent and clip any excess lead length.

PREVENTATIVE MAINTENANCE

As preventative maintenance to insure that the radio is always operable, regularly schedule the following checks to be made on each radio.

1. Check the condition of and clean electrical connections such as antenna, battery and battery charging contacts.
2. Check RF power output.
3. Check the transmit frequency.
4. Check the transmit modulation.
5. Check the receiver sensitivity.
6. Check receiver audio.

BATTERY INFORMATION

Rechargeable battery packs available for use with the Dual Format PCS radio include a High Capacity and Extra High Capacity. All of the battery packs are sealed at the factory and are not serviceable other than regular cleaning of the contacts. Chargers are available with nominal charge times of 1 hour (rapid) and 14 hours (standard).

CHARGING THE BATTERY PACKS

New battery packs from the factory should be fully charged before being placed into service. This applies to batteries that have been stored for long periods of time. A fully charged battery pack should provide an open terminal voltage of about 7.5 Vdc (typically 9 Vdc). A fully discharged battery should read no less than 6 Vdc.

Rechargeable batteries in some applications can develop a condition of reduced capacity, sometimes called "Memory Effect". This condition may occur when:

1. The battery is continuously overcharged for long periods of time.
2. A regularly performed duty cycle allows the battery to expend only a limited portion of its capacity.

If the nickel-cadmium battery is only sparingly or seldom used and is left on continuous charge for one or two months at a time, it could experience reduced capacity. This would severely reduce the life of the battery between charges. On the first discharging cycle, the output voltage could be sufficiently lowered to reduce the battery's hours of useful service.

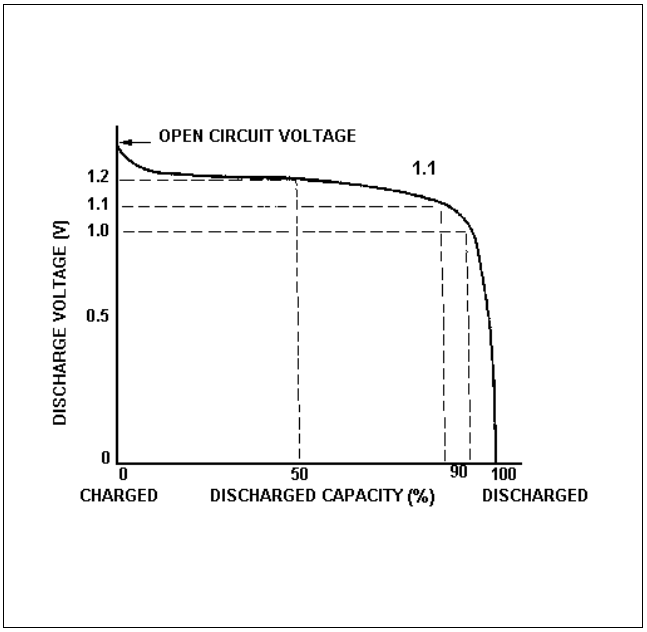


Figure 8 - Typical Ni-Cad Cell Discharge Curve

The most common method of causing this limited capacity is regularly performing short duty cycles; when the battery is operated so that only a portion (< 50%) of its capacity is expended. This type of operation can cause the battery to become temporarily inactive and show a severe decrease in the ability to deliver at full rated capacity.

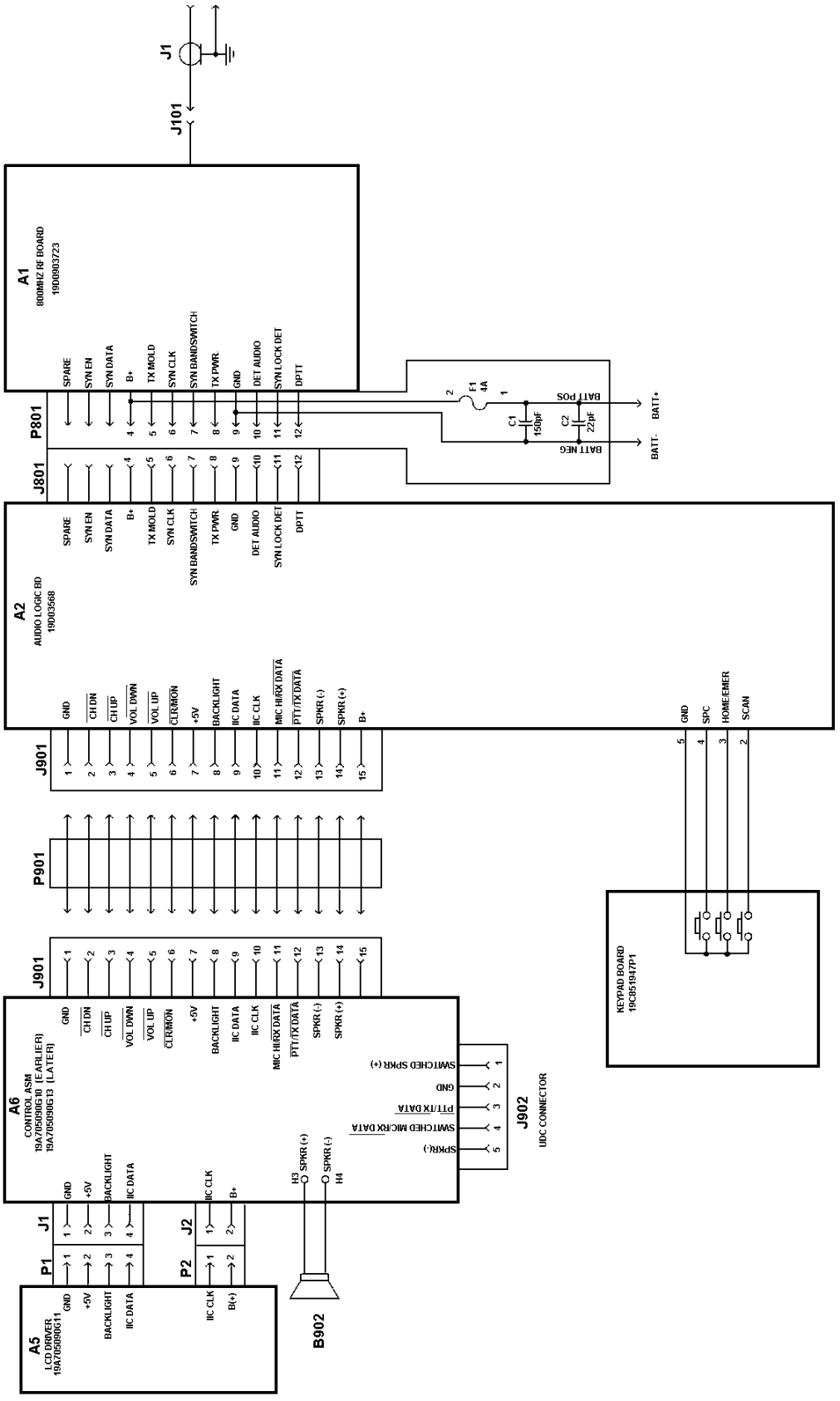
Any rechargeable battery showing signs of reduced capacity, should be carefully checked before being returned under warranty or scrapped. If reduced capacity is suspected, the following procedure may restore capacity:

1. Discharge the multicell battery at the normal discharge rate until the output voltage is approximately 1 volt per cell. For PCS radio batteries this equals about 6.2 volts output when the **BT** low battery indicator turns on.

   Refer to the typical Ni-Cad cell discharge curve in Figure 8. Note the flatness of the discharge voltage from 0%-90%. Discharging below the knee of the curve does not give added service. Experience shows that discharging below 1.0 Volt ("knee") is not necessary for reconditioning a cell.
2. Complete a full charge cycle using an appropriate Ericsson charger.
3. This procedure should be repeated again. Performing the rated discharge and charge cycle at least twice should sufficiently restore the battery.

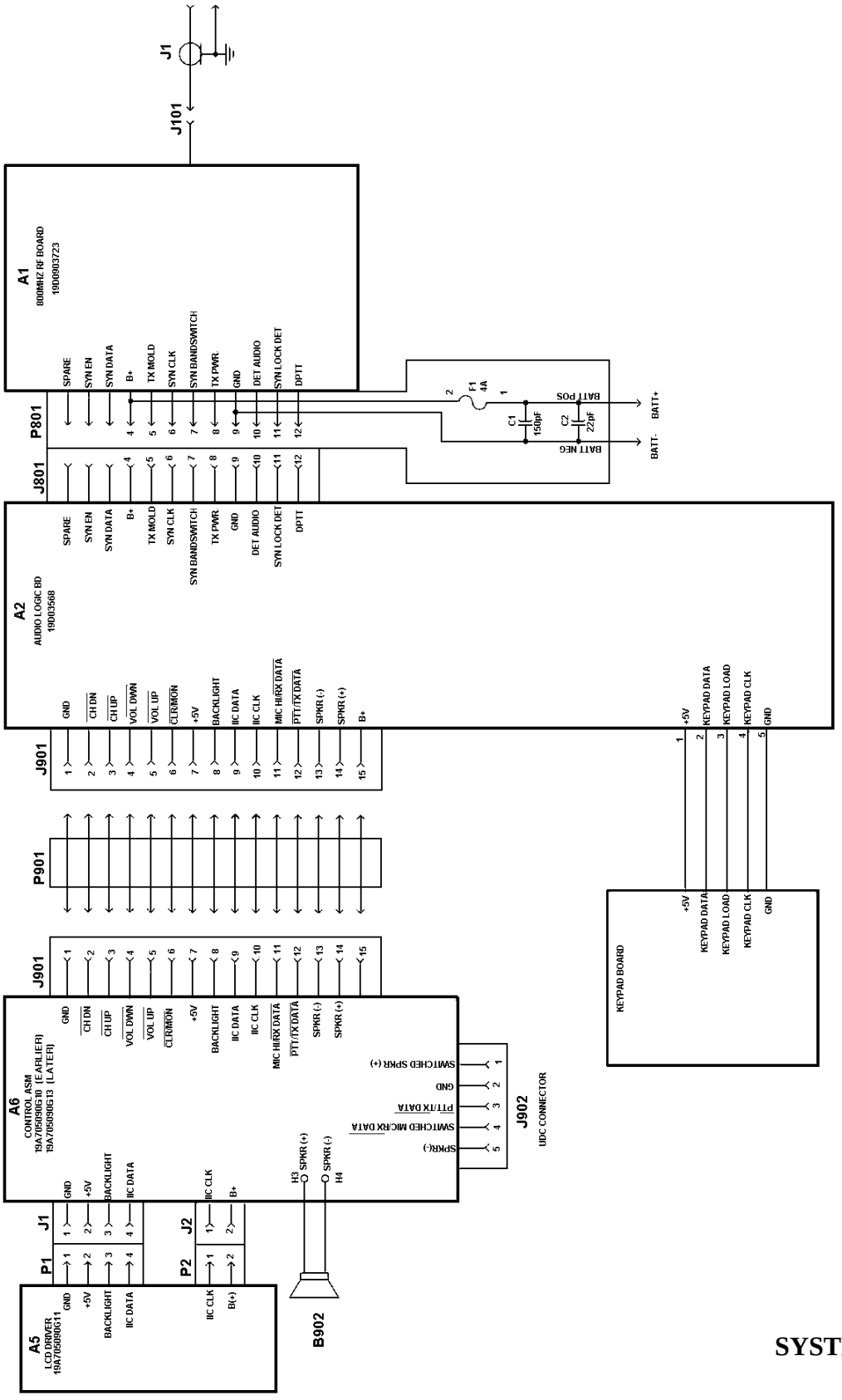
RECHARGEABLE BATTERY PACK DISPOSAL

The product that you have purchased contains a rechargeable battery. The battery is recyclable. At the end of its useful life, under various state and local laws, it may be illegal to dispose of this battery into the municipal waste stream. Check with your local solid waste officials for details in your area for recycling options or proper disposal. Call Toll Free 1-800-8-BATTERY for information and/or procedures for returning rechargeable batteries in your state.



SCAN RADIO

(19D903831, Rev. 3)



SYSTEM RADIO

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