MAINTENANCE MANUAL
SERVICE SECTION
FOR
TMX-8210 & TMX-8510
TWO-WAY MOBILE RADIOS

TABLE OF CONTENTS

TEST PREPARATION (NON-SCANNING OPERATION)

In order to test either the TMX-8510 or the TMX-8210 radio, it is necessary to disable the channel scanning mode normal to all GE-MARC radios. Also, the capability to select the operating frequency and operating mode is necessary. All this needs to be accomplished without removing circuit boards from the radio, which would interrupt the signal flow from board to board. This is accomplished using the TMX-8510 Handset with both TMX-8510 and TMX-8210 radios.

TEST MODE SELECTION

Built into the software for both the TMX-8510 and the TMX-8210 radio is a Test Operating Mode. This software is normally disabled before shipment to the customer. It is necessary to enable this Test Operating Mode by writing to the radio personality PROM from the GE TQ2310 Suitcase Programmer. This function is menu selectable.

OPERATION WITH HANDSET

Either the TMX-8210 or the TMX-8510 radio may be operated in the test mode with the TMX-8510 Handset. Connect the radio and system for testing as shown in Figure 1. The following selections may now be made from the handset.

- Frequency Selection
- TX Mode/RX Mode
- Open/Mute TX Audio Paths
- Open/Mute RX Audio Paths
- Modulate TX with Busy/Signalling Tones
- Test Microprocessor Ports
- Select Direct Mode Operation
- Erase Personality PROM

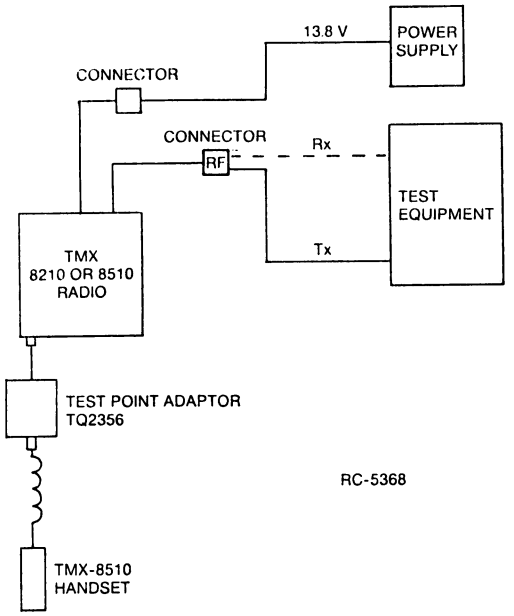


Figure 1 - Radio and System Connections

TEST MODE COMMANDS

The tests described in this section are an integral part of the TMX-8210 and TMX-8510 operational software. These tests are controlled by a TMX-8510 Handset through the serial data link normally used by the two-way radio to communicate with the handset. The data link uses 11 bits ASCII (1 start, 8 data and 2 stop bits) no parity and operates at a 300 baud rate.

To enter the Test Mode, push and hold the CL (CANCEL/MON) key and the STO key.

Defining the Test Functions:

Each function has a two digit index number in parentheses next to the title of the function. The two-digit number preceded by "S" enables the function. Wait until the display is updated before pushing the next button (approximately 1/2 second).

Default Conditions:

The radio, upon entering the Service Shop Tests, will revert to the following default condition to avoid undefined conditions.

Frequency: 815.0125 MHz (TX)
Channel 730

Volume: Set at 2 (Range 0-3)

All audio paths will be muted.

Special Keys (CL, VOL, STO, E, RCL and S):

The handset has six special keys. When in the test mode, their function is as follows:

CL - Start and end key for channel number

E - Turns the transmit circuit off

S - Invokes a new function

RCL - Resets to default conditions

STO - Exits test mode

VOLUME - Ramps volume up/down

Frequency Select:

Select a frequency by entering "CL" followed by a channel number (10 - 1528) followed by "CL". A channel number can be entered with or without leading zeroes. Receive audio is on.

Example: For Channel 12: CL 12 CL or CL 012 CL or CL 0012 CL

NOTE

Channel 10 is 806.0125 MHz and Channel 1528 is 824.9875 MHz. A one MHz frequency increase or decrease corresponds to a channel number increase or decrease of 80. Channel spacing is 12.5 KHz.

The channel number may be determined as follows:

$$\text{Ch. No.} = 10 + (F_c - 806.0125)/.0125$$

Transmit (01):

ON (S01)
OFF (E)

The carrier is ON/OFF at the specified frequency. This function overrides the PTT switch. Receive audio is OFF.

Receive ON (02):

(S02)

The receive audio path is unmuted.

Receive OFF (03):

(S03)

The receive audio path is muted.

Microphone ON (04):

(S04)

The microphone audio path is unmuted.

Microphone OFF (05):

(S05)

Busy Tone (06):

(S06)

The radio continuously transmits the 3051.6 Hz standard busy tone. This function overrides the alternate busy tone function.

Alternate Busy Tone (07):

(S07)

The radio continuously transmits 2918.7 Hz alternate busy tone. This function overrides the busy tone function.

Transmitted Tone (08):

(S08) Tone (01 - 41)

This function transmits the selected GE-MARC tone (1 to 41).

NOTE

Any key causes reset to the default conditions.

Manual Channel Increment (09):

(S09)

This function increments the channel number and loads the synthesizer. The receive audio is ON.

Across Band Switching (10):

(S10)

This function continuously toggles the synthesizer between the first and last channels in the band (806.025 MHz and 825.9875 MHz).

NOTE

Any key causes reset to the default conditions.

Tone Set Select (11):

(S11) Tone set number (01-99)

This function selects the tone sequence from the tone set number. The tone set must be programmed in the personality PROM. This is used in conjunction with S13 and S14.

DTMF Tone (12):

(S12) Tone Pair (0-9, *, #)

This function transmits the DTMF tone associated with the appropriate key depression (0-9, *, #).

NOTE

Any key causes reset to the default conditions.

Key and DTMF tone combinations are as follows:

Key	Low Tone (Hz)	High Tone (Hz)
1	697	1209
2	697	1336
3	697	1477
4	770	1209
5	770	1336
6	770	1477
7	852	1209
8	852	1336
9	852	1477
*	941	1209
0	941	1336
#	941	1477

Call Decode (13):

(S13)

This function looks for the tone sequence selected by the tone set function. The three note alert tone is sounded and all handset indicators are displayed if the sequence is detected.

NOTE

Any key causes reset to the default conditions.

Call Encode (14):

(S14)

This function initiates a call using the tone sequence selected by the tone set function. The three note alert tone is sounded if the attempt is successful. The call is attempted at one second intervals.

NOTE

Any key causes reset to the default conditions.

Alert Tones (15):

(S15)

This function sounds the call initiated alert and the channels busy/ error tone.

NOTE

Any key causes reset to the default conditions.

PTT Enable (16):

(S16)

This function will turn the transmit circuit ON/OFF when the PTT switch is pushed/released. This function is disabled whenever another function activates the transmit circuit.

Personality PROM Check (17):

WARNING

The personality PROM is cleared by this function.

(S17)

This function writes FF and 00 to all locations in the personality PROM and reads the PROM to verify its operation. A "PROM OK" message will appear if the check is passed.

NOTE

Any key causes reset to the default conditions.

Relay Switch (18):

(S18)

This function toggles the relay line at a 1000 Hz rate for board level testing.

NOTE

Any key causes reset to the default conditions.

Port Check (19):

(S19)

This function is used at board level test to check the operation of the port pins. The port pins will toggle at the rate indicated as follows:

Pin	Rate
1	20 KHz
2	10 KHz
3	5 KHz
4	2500 Hz
5	1250 Hz
6	625 Hz
7	312 Hz
8	156 Hz
12	78 Hz
13	39 Hz

NOTE

Any key causes reset to the default conditions

Software Revision (20):

(S20)

This test displays the micro-processor software revision.

NOTE

Any key causes reset to the default conditions.

Direct Mode (21):

(S21)

This test pulls the band switch line of the VCO low. A channel can then be loaded in order to test the transmit circuit at the high end of the band (CH3610 thru CH5310).

NOTE

Any key causes reset to the default conditions.

Checksum Test (22):

(S22)

This test performs a checksum test on the program memory. If the test passes, PROM OK is displayed. If the test fails, BAD PROM is displayed.

TEST DESCRIPTIONS

Self Test: (Automatically performed each power ON cycle)

- Verifies that the synthesizer will lock in the proper amount of time at various frequencies across the band.
- Verifies that the personality PROM is programmed.
- Verifies that illegal tones are not in the personality PROM.

THEORY OF OPERATION

POWER DISTRIBUTION

Refer to Figure 2 - Power Distribution Block Diagram for an understanding of the distribution of regulators used in the TMX-8210 and TMX-8510 radios. Note that the receive circuit has an 8 volt regulator. The synthesizer has a separate 8.8 volt regulator and a 5 volt regulator. The transmit circuit uses another 8 volt regulator. The transmit circuit regulator output is switched to the exciter along with a variable power set voltage to the power amplifier control stage. The last two power amplifier stages in the power modules are operated directly from A+. All of these regulators are located on the RF Board. Only Regulator U103 (TX 8 volt supply) and Q105 (power set output transistor) are mounted for heat sinking.

A single 5 volt regulator is used to power the Logic Board. The input voltage is derived from the 8 volt TX regulator. This allows moderate power dissipation in the U105 regulator. The power on reset circuitry for the Logic board microprocessor is part of the regulator chip. This reset signal prevents scrambled operation due to low voltage transients during automobile starting. The A+ lead is also actively filtered by Q703 and associated ciruitry and fed to the Audio Board.

The Audio Board uses the filtered A+ directly for the on board audio amplifier. A fixed 8 volt regulator provides bias for the other circuitry.

This block diagram along with the schematic diagrams for the three circuit boards should allow identification and testing for all voltages.

SIGNAL FLOW

Figure 3 - Signal Flow Diagram shows the signal flow paths for the TMX-8210 and TMX-8510 radios. Note that all of the radio boards are involved in both transmit and receive modes.

Receive:

The RF enters the RF Board through Jack J401 and discriminator audio exits the RF Board through J702-4 (VOL HI). This audio is routed to the Audio Board by way of the Logic Board. The Audio is processed by filtering circuits on the Audio Board and diverted into two paths. One path is limited and fed to the microprocessor for tone decoding. The other is the voice path which is filtered and fed to the front connector of the radio and ultimately to the handset or AUDIOSET™ (handheld controller). Two mute circuits on the Audio Board interrupt the voice signal. Both mutes are processor controlled.

Transmit:

Transmit audio orginates in either the AUDIOSET™ Handheld Controller or the Handset and enters the radio through front connector J701, Pin 4. This signal is routed to the Audio Board through the Logic Board. The TX audio input port, on the Audio Board, is at J703-8. After processing, the audio is fed to J703-11 and then J702-8, the Synthesizer modulation input. Again, the processed audio signal traverses the Logic Board enroute to the RF Board. The Audio Path may be muted by the two muting circuits located on the Audio Board. The modulated synthesizer output is amplified and PIN diode switched to the output jack J401.

RECEIVER OPERATION (Refer to the Schematic Diagram in LBI-31655)

RF is coupled from J401 to Z401/Z402 through receive PIN diode D401. DC voltage is coupled from the $\overline{\text{DPTT}}$ line of the processor through resistor R401 and inductors L401, L403 and L404 to the PIN switch. Thus, bias current flows through D401 while the $\overline{\text{DPTT}}$ line is high in the receive state. The DC path to ground is completed by inductor L101 and parallel resistors R101 and R114.

Filters Z401 and Z402 are fixed tuned three pole dielectric resonators. Their bandwidth is greater than 20 MHz and covers the 851 MHz to 870 MHz band. Therefore, no tuning is required for these filters. All RF selectivity is provided by these two filters. About 2 dB of passband ripple is typical for this filter pair. Approximately 50 ohms impedance levels exist at all ports of these filters.

RF amplifier transistor Q401 is a low noise bipolar transistor biased with DC feedback. This allows a stable operating point of about 10 milliamps, while allowing direct emitter grounding. Input matching is obtained with stripline W404. The amplifier load is primarily mixer diodes D402 and D403. Striplines W405 and capacitor C404 provide a low Q match to the mixer.

Shottky diodes D402 and D403 along with striplines W406, W407 and W408 and capacitors C406 and C407 form a balanced diode mixer circuit. The local oscillator drive level is typically +8 dBm. The IF signal produced at the mixer output is fed to 1st IF amplifier transistor Q501. Inductor L501 and capacitor C501 provide RF filtering to this amplifier.

The first IF amplifier transistor Q501 is a junction FET operated in the

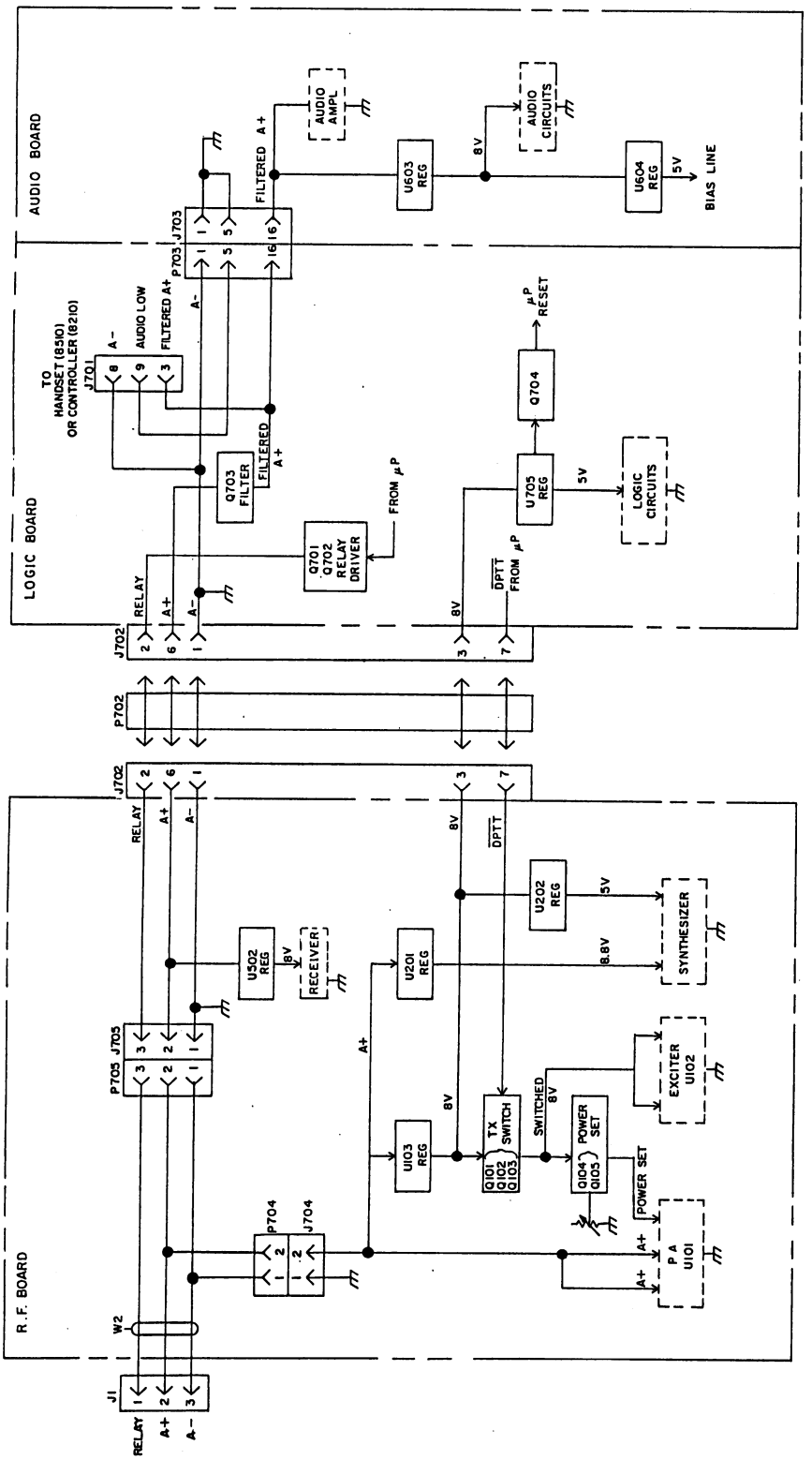


Figure 2 - Power Distribution Block Diagram

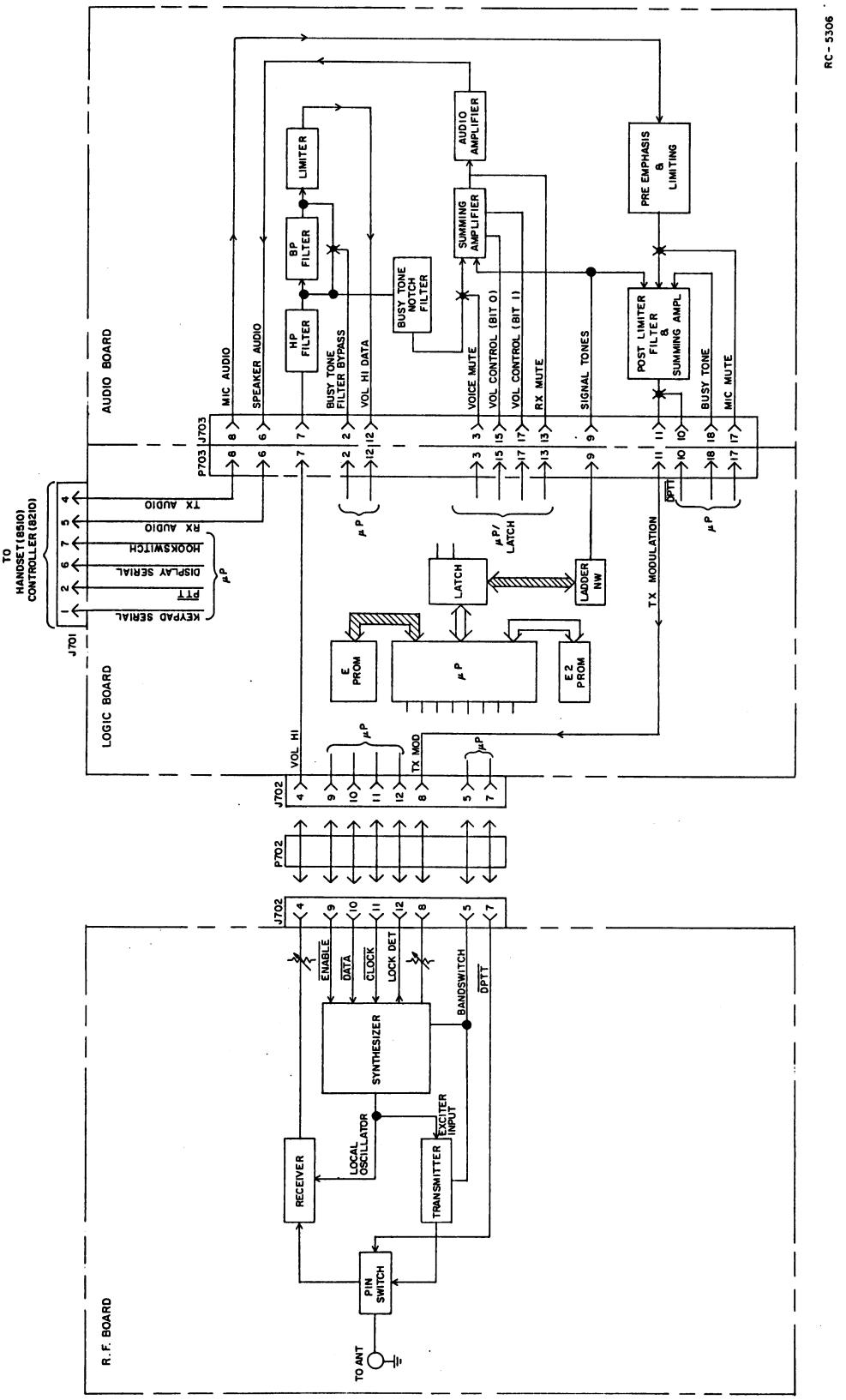


Figure 3 - Signal Flow Block Diagram

common gate mode. This configuration offers a typical input impedance of 75 ohms. The output circuitry is tuned and loaded to provide the proper source termination for the four pole crystal filter which follows.

The output of the crystal filter is matched by second IF amplifier transistor Q502. This port is also tuned and loaded to provide the proper filter termination. Transistor Q502 is a dual gate FET operating at a bias current of about 10 milliamps. The output of Q502 is tuned for maximum gain at 45 MHz and is loaded by the 2nd mixer in the U501 chip. This Q502 stage has a relatively high input and output impedance and needs high isolation within the active device. The dual gate FET provides the isolation required.

IF IC U501 is a MC3361 chip. Pins 1 and 2 connect to an internally biased oscillator transistor. The external circuitry of this oscillator transistor includes crystal Y501 and forms an oscillator circuit operating at 45.455 MHz. The frequency of this third mode oscillator is adjusted by inductor L508. The oscillator drives the internal balanced mixer. The 45 MHz IF signal is translated to 455 KHz and appears at Pin 3 of U501. This IF signal is filtered by 6 pole ceramic filter Z503 and drives the internal 455 KHz amplifier and limiter. The limited 455 KHz in turn drives an internal quadrature detector. The phase shift network needed by the quadrature detector is provided by inductor L509. The audio output port is Pin 9 on U501. Inductor L509 is adjusted for maximum audio output level. The audio signal at Pin 9 is filtered by resistor R514 and capacitor C519 to reduce IF feedthrough. Buffer amplifier Q503, drives audio potentiometer R515. This allows a VOL HI signal whose amplitude may be set for proper system operation using R515.

Receiver Audio: (Refer to the Schematic Diagram in LBI-31654)

At this point the receive audio is routed to the Audio Board as described previously. The VOL HI signal, which arrived at J703-7, is filtered by audio amplifier U601-A and associated circuitry, forming an active high pass filter with a cut off frequency of approximately 200 Hz. At this point the audio divides into two paths. One path is through U601-B and the other is through U601-C.

The tone path is through U601-B, which consists of a band pass filter centered at approximately 3 KHz. A FET switch Q601, couples around the band pass filter. When the radio is in the channel acquisition mode, the control line to Q601 is high and Q601 is on. This allows the signalling tones to be coupled directly to comparator U605. The output of the comparator is a limited signal at the tone frequency. This signal is routed to the processor located on the Logic Board where the tone decoding is done in software. **NOTE**: The load pull up for the comparator is the processor port itself. After all tone signalling has been completed, the control line to Q601 pulls low and Q601 cuts off. The audio path is now the U601-B path. This filter separates the busy tone now present from the voice signal also present. This prevents voice blocking of the busy tone. The busy tone is then limited by U605-A and passed to the processor for detection.

The second path, the voice path, is fed through a busy tone notch filter consisting of U601-C, U601-D and associated circuitry. This filter removes the busy tone, 3051 Hz or the alternate busy tone, 2918 Hz, from the voice path. This filter also provides much of the receiver de-emphasis. The output of U601-D is fed through Q602, a FET muting switch. This switch is closed in the receive mode, with the control line in the high state. This path is muted when in the transmit mode or when only tone alerting is desired through the radio speaker. The output of the voice muting switch is fed to Summing Amplifier U301-A. This amplifier has another input labeled **TONES** on the Audio Board schematic. This line orginates on the Logic Board where the audio tones are generated using the processor and latch chip with a ladder network to form a 5-bit DAC. The tone sequences are used to alert and signal the listener of many events (see Operating Instructions for TMX-8210 and TMX-8510 radios). The summing amplifier is also used to produce a four level volume control when used with the TMX-8510 Handset. This is accomplished by Volume Bit 0 and Volume Bit 1 lines from the processor to Q603 and Q604. The Volume UP/DOWN button on the handset allows communication to these lines through the serial link between handset processor and the radio processor. The output of the summing amplifier is fed to a second muting switch, Q605. This switch provides additional audio muting when in the transmit mode. The RX MUTE line pulls low to accomplish this muting. Audio amplifier U602 is a 1 watt amplifier with a fixed gain of approximately 40 dB. This amplifier drives the speaker in the Audioset™ handheld controller used with the TMX-8210 radio. The handset attenuates this level before driving the earpiece in the TMX-8510 radio.

TRANSMIT OPERATION (Refer to the Schematic Diagram in LBI-31655)

RF:

The Signal Flow Diagram shows the synthesizer driving the exciter input. This drive level is approximately +10 dBm. The exciter is a sealed module which operates from a switched 8 volt supply. The exciter module bandwidth is sufficiently wide that both the 806 MHz to 825 MHz and the 851 MHz to 856 MHz bands are allowed. The output level is typically 150 milliwatts. Both input and output ports operate at 50 ohm impedance levels.

The power amplifier is again a single module that is mounted to the rear heat sink. This module requires a drive of greater than 100 milliwatts and provides a typical power output of 10 watts. As mentioned, output power is set by power adjustment control R108 to set the first stage supply voltage. This voltage may be adjusted from about 1.5 volts to 6.5 volts. Thermistor R111 senses the heat sink temperature and throttles the power level down above 70 degrees centigrade. The bandwidth of the power module is such that an approximately constant output is derived over the 806 to 825 MHz band. In the Direct Mode, 851 to 856 MHz band, the output level is boosted by applying full voltage to the power driver stage of the power amplifier module. This is accomplished by a command from the processor when the direct mode is selected by the TMX-8510 handset. This logical low on J702-5 allows the output of Q205 to be high. This feeds approximately 8 volts to the base of transistor Q104, which in turn causes the output of transistor Q105 to be about 7 volts causing maximum power output. The power set potentiometer is inoperative in this condition.

The output of the power amplifier is fed to transmit low pass filter A101 to reduce the harmonic content. This output is fed to transmit PIN diode D101. When in the transmit mode, the $\overline{\text{DPTT}}$ line is pulled low by the processor. This causes the switched 8 volts to be applied to the PA output line through inductor L102. This voltage is fed through the low pass filter to the anode of D101. The DC path is completed through D101 by inductor L101 and parallel resistors R101 and R114. The bias current is set at about 50 milliamps. This allows the output power to be coupled through the transmit PIN diode. About 1 dB of loss is incurred due to the low pass filter, PIN diode and the output cable.

Transmit Audio:

Transmit audio is derived from either the TMX-8210 Audioset™ handheld controller or the TMX-8510 handset and is fed to input connector J701-8. The level of this audio signal is nominally 25 millivolts at 1 KHz which is inteneded to produce 3 KHz of deviation. NOTE: The input impedance at this port is 180 ohms.

IC U301-D and associated circuitry performs several functions. This circuit provides the 6 dB per octave pre-empahsis desired for the transmit audio. Capacitor C301 and C304 and resistors R301-A thru D are frequency determing components. Limiting is also performed by this circuit. The limited output is determined by voltage divider R301-H, R301-G, R301-F and feedback diodes D301 and D302. This limited level is about 4 volts peak to peak.

The output is fed through one pole of RC filtering to FET swiitch Q301. This muting FET is controlled by the MIC MUTE line from the microprocessor. Here a logical high turns the gate on and a logical low turns the gate off. This gate allows muting of the voice channel in the receive mode and when only tones are to be transmitted.

The voice signal is fed to Summing Amplifier U301-C. This amplifier forms a two pole low pass filter making a post limiter filter with a total of 18 dB/ octave of filtering to the voice path. Two other inputs exist at the summing amplifier; a signalling tone port and a busy tone port. The busy tone is generated by the processor as a 5 volt squarewave. The signalling tones are generated by a five bit DAC. This signal level is also 5 volts peak to peak. Two of the three post limiter filter poles provide filtering for these tone signals. Resistors R306 and R308 fix the amplitude of these tones relative to the voice path. Since these tone amplitudes are fixed, their ratios to the limited voice signal amplitude will remain fixed.

The post limiter filter output is fed to second muting switch Q302. This switch allows additional muting when in the receive mode and is controlled directly by the $\overline{\text{DPTT}}$ line from the processor. In the transmit mode this line is low. This turns Q302 off and allows the gate of Q302 to float high, thus enabling Q302.

The output of the muting switch is then fed to the synthesizer modulation port (refer to the Signal Flow Diagram).

The combined voice/busy tone audio will be adjusted in level to produce the desired deviation. The ratio are as follows:

Limited Voice Deviation of 3.5 KHz

Busy Tone Deviation of 1 KHz

Signalling Tones Deviation of 3 KHz

NOTE

Signalling tones are transmitted with no voice present. Their levels are set for optimum system performance. The voice and busy tone are transmitted simultaneously. The summation of these signals can produce a maximum deviation of 4.5 KHz.

SYNTHESIZER OPERATION

The synthesizer circuit uses a phase-locked 800 MHz VCO (U206) operating on a frequency of 806 MHz to 825 MHz, in the normal mode of operation. In the Direct Mode (talk-around) the VCO operates at a frequency of 851 MHz to 870 MHz. The synthesizer output signal is generated directly by the sealed VCO. The frequency is amplified by buffer amplifier transistor Q204 to a level of +13 dBm, then split at R216 and R217 for the receive injection frequency and exciter input signals.

Using the 800 MHz divide-by 128/129 dual modulus prescaler (U203) the VCO is phased locked to a 12.5 KHz reference signal. This reference signal is derived by division within the PLL (U205) from the frequency of temperature compensated crystal controlled oscillator TCXO (U204). Oscillator module U204 operates at 12.8 MHz. The 800 MHz VCO output is divided by the dual modulus prescaler to become the Mod C input to the PLL (U205). Within U205, the 800 MHz signal is further divided to 12.5 KHz and compared to the reference frequency (12.8 MHz) which permits 12.5 KHz channel spacing.

Divider circuits in U205 are programmed by three inputs from the Logic Board (A1), which are buffered and inverted by transistors Q201, Q202 and Q203. The S ENABLE pulse (10 milliseconds) activates switch U207 to allow more rapid channel acquisition during channel changes. A LOCK DET signal, from the PLL goes to the microprocessor for processing to prevent transmission when the VCO is not on frequency and to provide an error message to the user.

When the radio is used in the Direct Mode (talk-around), the VCO is band switched to the 851 to 870 MHz frequency range and phase locked to the reference oscillator. Transistor Q205 inverts and buffers the BAND SWITCH signal from the microprocessor and also drives the FULL POWER SW circuit for full power during talk-around operation.

Audio modulation, from Audio Board (A2) is applied to the VCO module through modulation adjust potentiometer R226.

DISASSEMBLY PROCEDURE

To Remove Radio From Mounting Plate: (Refer to Figure 4)

1. Unplug the power cable.
2. Disconnect the RF cable.
3. Remove the shipping screw that secures the locking latch with No. 15 TORX® driver STO606. If a security screw is used in place of the standard shipping screw, use No. 15 TORX® tamper-proof driver STO618.

   TORX® Trademark of CAMCAR Division TEXTRON, Inc.
4. Rotate locking knob clockwise.
5. Pull the radio from the plate.

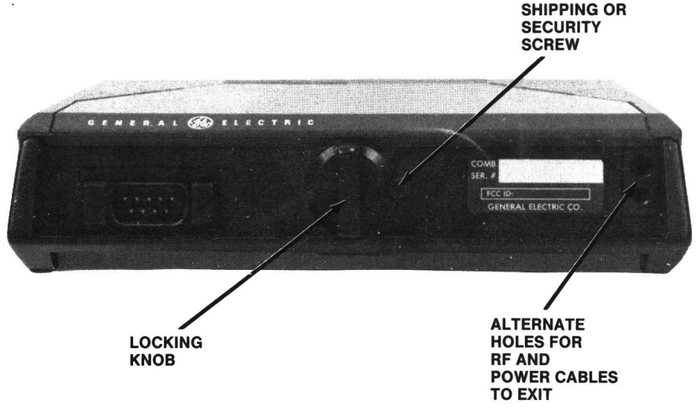
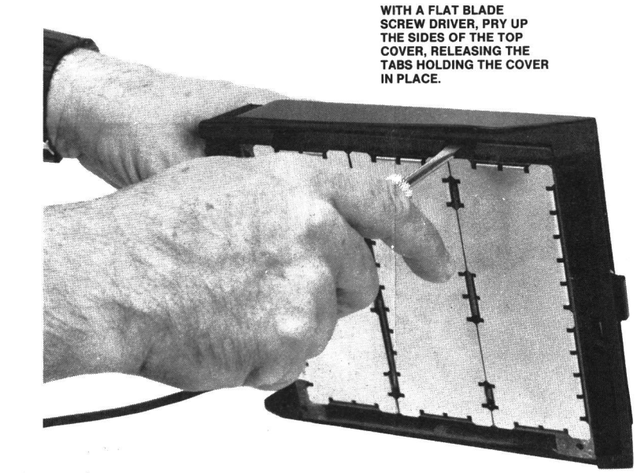


Figure 4 - Removal of Radio from Mounting Plate

To Remove the Top Cover: (Refer to Figure 5)

1. Rotate locking knob counterclockwise.
2. Pry a side loose.
3. Remove the top cover.



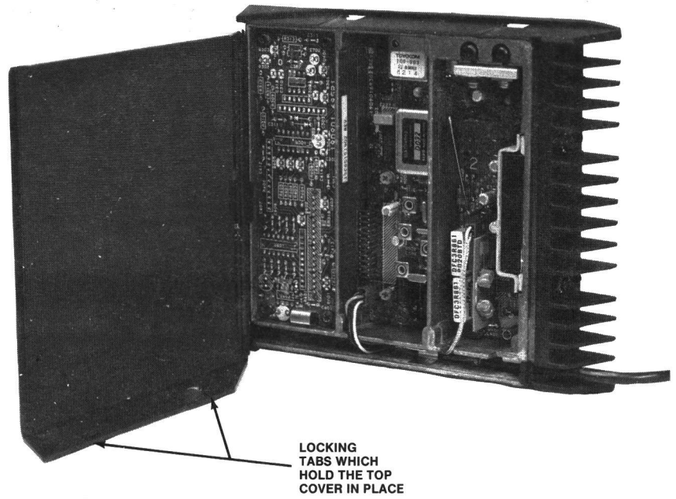


Figure 5 - Removal of the Top Cover

Removal of the Bottom Cover: (Refer to Figure 6)

Pry the shields loose and remove.

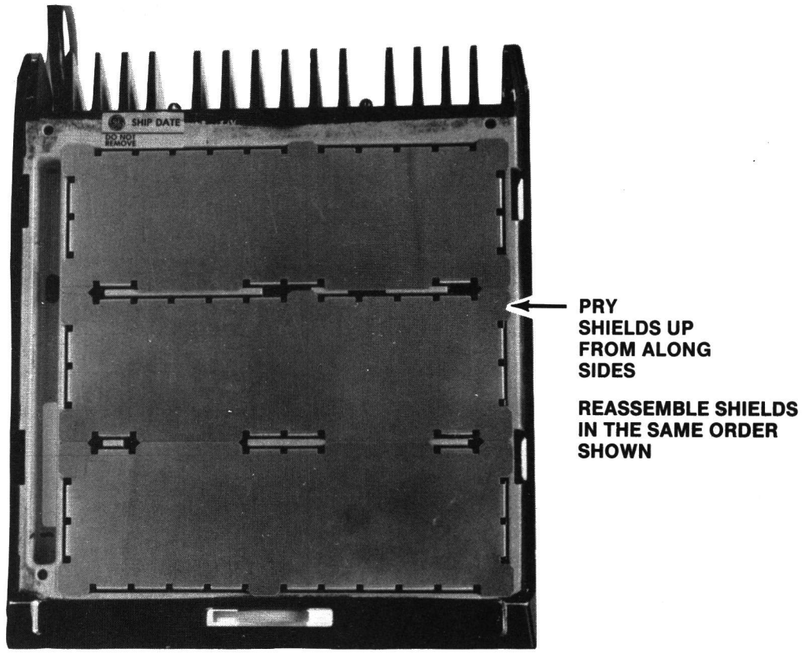


Figure 6 - Removal of the Bottom Shields

RADIO ALIGNMENT

To align a complete radio, it must be assembled with power cables, RF cables and botton shields. All retaining and ground clips must be in place (refer to Test Preparation description).

When power is turned on, the radio unit performs a "power on" test which consists of the following:

- Verifies that the synthesizer will lock in the proper amount of time at various frequencies across the band.
- Verifies that the personality PROM is programmed.
- Verifies that illegal tones are not in the personality PROM.
- Performs a "checksum" test of the EEPROM memory.

A successful test will result in a "PASSed" indication being sent to the handset (TMX-8210 - "PASSed" is displayed permanently - TMX-8510 - "PASSed" is displayed for about 1 second).

Enter the test mode by depressing the CL (CANCEL/MON) key while simultaneously depressing the STO key.

TRANSMIT ALIGNMENT

Frequency Set:

Key the transmit circuit and measure the transmit frequency. It should be within ±250 Hz of the programmed carrier frequency (channel 730). The temperature should be 25 ±5°C. If not within the required temperature limits, adjust U204 for F_c ±100 Hz (refer to Figure 7).

Modulation:

Select Channel 1530 and apply a 1 KHz, 300 millivolt rms signal to the microphone input. Turn on the microphone and transmit busy tone. Adjust modulation potentiometer R226 for 4.5 +0.1/-0.2 KHz deviation.

NOTE

The input impedance of the modulation port is 180 ohms.

Power Set:

Set Power Adjust Control R108 for 10 watts ±.2 watt output on Channel 1530.

RECEIVE ALIGNMENT

Frequency Set:

Monitor TP-501, located on the RF Board (455 KHz IF) with a frequency counter. Inject a strong on channel signal at antenna jack J401 and adjust L508 for a counter reading of 455 KHz ±100 Hz (assumes that the TX frequency has been set).

Tune IF For A Peak:

Monitor TP-501 with an AC voltmeter. Inject an on channel signal at J401 and adjust L504, L506 and L507 for a peak indication on the voltmeter. Adjust the level of the signal generator to keep the signal supplied to the voltmeter out of limiting.

Adjust Quadrature Detector:

Monitor the audio output with an AC voltmeter. Inject a strong on channel signal at J401 modulated with 1 KHz at 3 KHz deviation. Adjust L509 for a peak on the voltmeter. Make sure the audio is not clipping when making this adjustment.

Receive Audio Gain Adjust:

Select Channel 730 and apply a -50 dBm signal modulated by 1 KHz at 3 KHz deviation to the RF input. Select the highest volume setting. With an 8 ohm load attached to the audio output terminals, adjust R515 for 2.8 ±.1 volt rms across the 8 ohm load.

TRANSMIT VERIFICATION

Transmit Frequency:

Check transmit frequency on Channel 730. The frequency should be F_c ±250 Hz.

Transmit Power:

Check transmit power on Channel 1530. Power should be greater than 9 watts.

Modulation Limiting:

Check transmit deviation with a 300 millivolt, 1 KHz signal applied to the microphone input and busy tone turned on. Check on Channel 1530. Deviation should be 4.5 ±0.2 Hz.

Busy Tone Deviation:

Measure busy tone deviation on Channel 730. Deviation should be 1 KHz +.2/-.3 KHz.

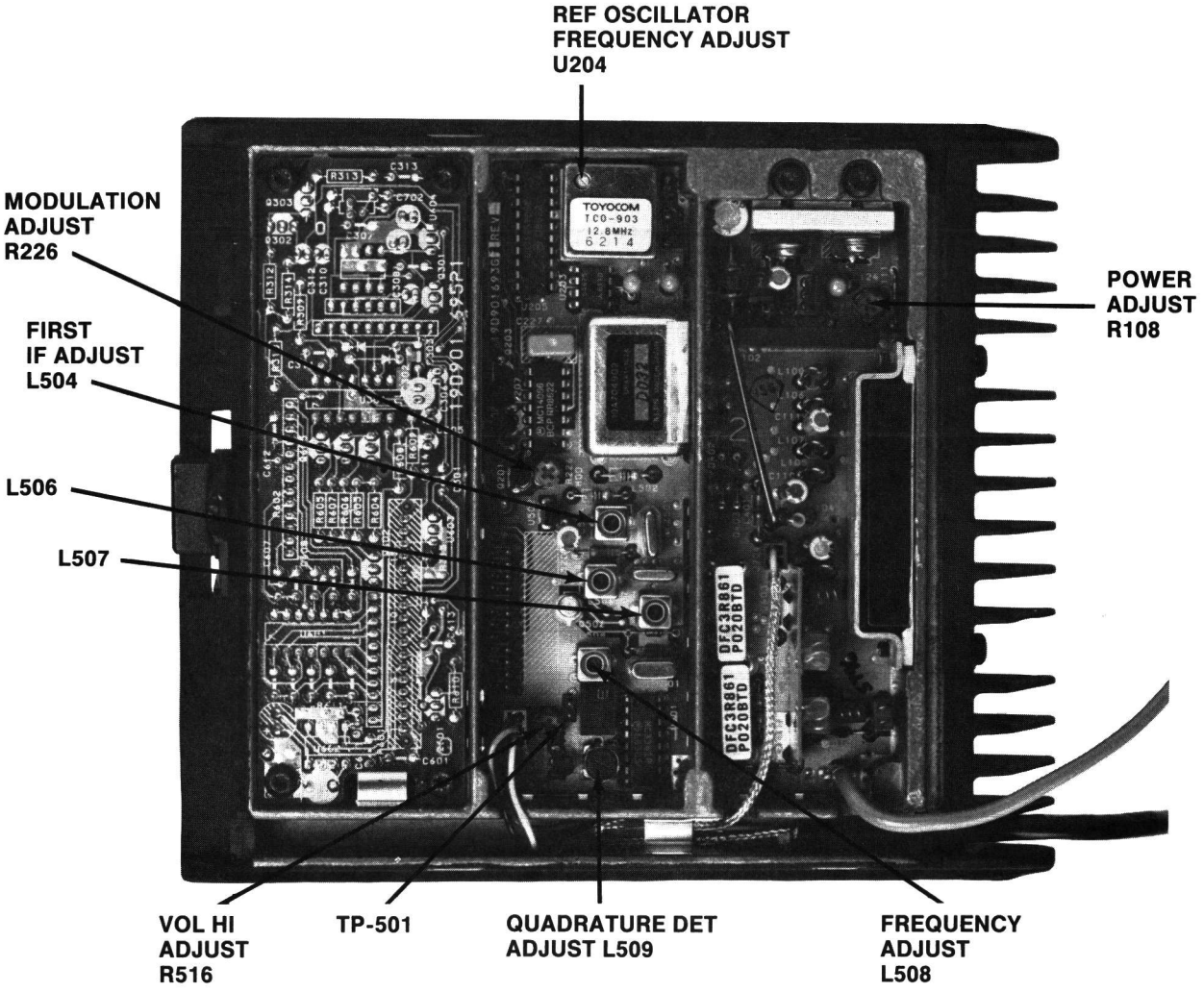


Figure 7 - Alignment Controls and Test Points

RECEIVER VERIFICATIONS

12 dB SINAD:

Apply a signal modulated with 1 KHz at 3 KHz deviation to the RF input. Set the level to -116 dBm. Check Channels 10, 730 and 1530 for greater than 12 dB SINAD.

Audio Output:

Apply a signal modulated with 1 KHz at 3 KHz deviation to the RF input. Set the level to -50 dBm. With the receive circuit output terminated with 8 ohms, the audio level should be 2.8 $\pm$0.3 Volts rms. Measure audio distortion. Distortion should be less than 10%.

TROUBLESHOOTING PROCEDURE

ISOLATION OF A PROBLEM TO THE DEFECTIVE BOARD

1. Apply power using the test set up shown in Figure 4.
2. Look for error messages on the handset display (See error message identification listed on page 25 of this publication).
3. The correct operational sequences are:

   TMX-8510 - "PASSed" will be displayed for one second. The display will then revert to the area and group selected when the radio was last operated.

   TMX 8210 - "PASSed" wil be displayed continuously.
4. If the handset is blank on power up, check for filtered A+ to the handset. If absent, consult the Power Distribution Block Diagram and troubleshoot.
5. Put the handset into the Test Mode. If the radio will not go into the Test Mode, check the Personality PROM Programming, with Suitcase Programmer TQ2310, for the selection of Test Mode operation.
6. With the radio in the Test Mode condition, use the Test Mode Commands, previously covered and the following Symptoms and Checks to troubleshoot the radio.

SYMPTOMS AND CHECKS

SYMPTOMS	CHECKS
• No TX Power	Check the DPTT command to the RF Board. If present, then the problem is most likely on the RF Board. If the DPTT is not present, the problem is most likely on the Logic Board.
• Low TX Power	This is probably a defective circuit on the RF Board. Check the Synthesizer Load Commands from the Logic Board. If the commands are not present, a problem on the Logic Board is likely.
• No TX Modulation	Check the audio input to the RF Board. If present, the problem is most likely on the RF Board. If not present, determine what is missing: tone, voice or both. Missing Tone - Look for the Tone input to the Audio Board (two inputs: one for Busy Tone and one for all other tones). If the Tones are not present the problem is most likely on the Logic Board. If the tones are present, look for the proper unmute commands to the Audio Board from the Logic Board. If the commands are not present the problem is most likely on the Logic Board. If the commands are present the problem is most likely on the Audio Board. Voice Signal Missing - Again, check the mute commands from the Logic Board. Check for the voice input to the Audio Board. If all signals are correct, the problem is most likely on the Audio Board.
• Distorted TX Audio	Check for the presence of the VCO ground clip. Check for good grounding of all boards to the casting. Check for the presence of board shields on the bottom of the radio. Check the audio input to the RF Board. If distorted, a problem on the Audio Board is likely. Check the mute commands. If incorrect, a difficulty on the Logic Board is indicated. If only the tones are distorted, a Logic Board problem is likely (faulty tone generation).
• TX Off Frequency	This is most likely a problem on the RF Board. Check the synthesizer load command. If the load command is improper a Logic Board problem is likely.

SYMPTOMS AND CHECKS (CONTINUED)

SYMPTOMS	CHECKS
• Low, Distorted Or No RX Audio	Check the receiver VOL HI output. If audio is improper the problem is most likely on the RF Board. If synthesizer load commands are not correct, it is possible the problem is on the Logic Board. If the audio is correct at VOL HI, check the Audio Board for proper unmute commands from the Logic Board. Improper commands indicate a Logic Board problem. Proper commands indicate an Audio Board problem.
• No RX Alert Tones (Radio OK Otherwise)	Check the Tone Outputs from the Logic Board. Operate the volume control on the handset. If tones are not present, a problem on the Logic Board is indicated. If the tones are present, the problem is most likely on the Audio Board, unless the mute commands from the Logic Board are improper.
• Poor RX Sensitivity	The problem is most likely on the RF Board. Check the synthesizer load commands.
• Radio Processes Calls Incorrectly	Check personality PROM programming. Check for proper TX and RX operation. Refer to TX & RX Verification (see Table of Contents). If TX/RX verify OK, determine if the problem is in the transmit circuit or the receive circuit. RX Decode Check: Use S11 and S13 test mode commands for the decode check. Modulate the generator with the correct tone sequence and busy tone. If the test fails, check the limited data output from the Audio Board (VOL HI DATA OUTPUT). If the data is present, the problem is most likely on the Logic Board. If the data is not present the problem is most likely on the Audio Board. TX Encode Check: Use S08 for the Encode test. If the test fails, the problem may be on either the Logic Board or on the Audio Board. Look for proper tones to the Audio Board and proper unmute commands from the Logic Board. If all inputs are correct the problem is most likely on the Audio Board. If the inputs are not correct the problem is most likely on the Logic Board. TX/RX Encode/Decode OK: Check for the proper synthesizer switching time. Use S10 for the test. If the switching time is incorrect the problem is most likely on the RF Board.
• Improper Direct Mode	Use the S21 test command and check the BANDSWITCH line. If the command is correct the problem is most likely on the RF Board. If the command is incorrect the problem is most likely on the Logic Board.

RF BOARD TROUBLESHOOTING

Transmit Circuit:

Most transmit problems can be isolated by checking the power gains shown in Figure 8, along with the following DC voltage measurements.

DC Measurements: (Test Mode)

1. First ensure that DPTT is low through the use of S01 in the test mode.

2. Check for approximately 8 volts at P5 and P9 of U102 (Exciter). If not present Troubleshoot transistors Q101, Q102 and Q103.

3. Check for approximately 7 volts across resistors R101 and R104. If not present, check PIN diode D101 and the conduction path from R101 to Q103.

4. Check for an adjustable voltage of 4 to 7.5 volts on Pin 2 of U101 (PA). If not present, check transistors Q104 and Q105 plus associated circuitry.

5. Check for 13.6 volts on Pin 4 and Pin 3 of U101, and ensure a good mechanical and electrical ground from the PA to the bracket and casting.

RF Measurements:

Measure RF signal levels according to Figure 8 and isolate the faulty components which are suspected to have low gain (or high loss). **NOTE:** Power levels are relative and do not represent exact power levels due to the loading effect of the 50 ohm cable. This also accounts for the anomaly at the PA filter interface which makes the filter appear to have gain.

An alternate method for checking gains involves replacing each part of the chain with an external source. For instance, capacitor C217 could be removed and the R229 - C217 interface driven at +13 dBm from a generator. If this scheme is pursued, drive the exciter on Pin 1 at 0 dBm and the PA at Pin 1 with +20 dBm (100 mw).

Typical power levels are measured with a 50 ohm coax cable, terminated with a power meter.

Test points may be probed with the open end of the 50 ohm coax cable.

DC connections to points indicated are allowed.

Keep the 50 ohm coax cable as short as possible.

Data is typical for a radio suppling 10 watts.

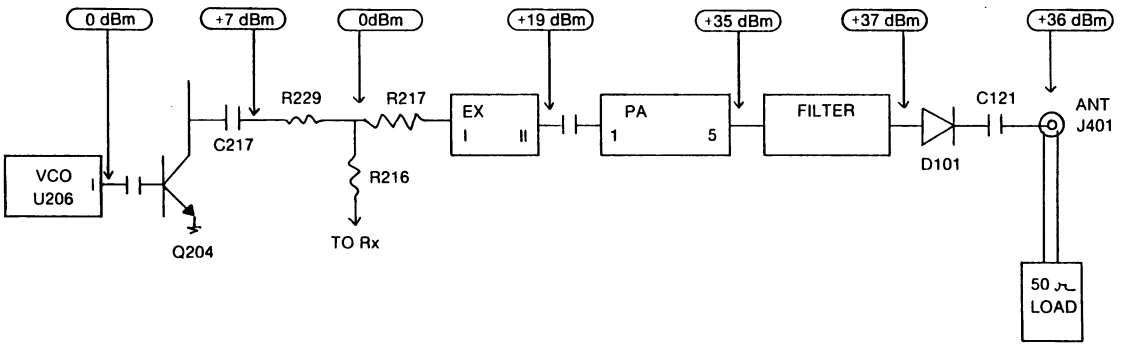


Figure 8 - Typical Power Levels

Receive Circuit:

To isolate a receive circuit problem refer to the following Receive Circuit Symptoms and Checks.

RECEIVE CIRCUIT SYMPTOMS AND CHECKS

SYMPTOMS	CHECKS
• No Audio	1. U502 regulator 2. The level and frequency of the first mixer injection frequency 3. The level and frequency of the second mixer injection frequency 4. Quadrature detector circuit 5. Quadrature detector coil tuning
• Poor SINAD	1. Consult Figure 9 - Gain Distribution Diagram and troubleshoot 2. Input cable 3. PIN Diode switch voltage
• Distorted Audio	1. Both mixer injection frequencies 2. Quadrature detector coil tuning 3. Crystal filter source and load tuning 4. Z503: 455 KHz ceramic filter

Synthesizer:

Synthesizer troubleshooting consists of first checking for the proper DC levels, then determining if the proper waveforms are present and checking individual modules.

DC Analysis:

An 8.8 Volts of DC is supplied by regulator U201 to U205 and U207. It serves as the pullup reference voltage for transistors Q201, Q202, Q203 and Q205. Resistor R221 decouples the 8.8 Volts for use in VCO module U206. The 25 milliamp current drain of this module results in approximately 8.6 Volts DC on Pin 2. Transistor Q204 also draws approximately 25 milliamps, resulting in a collector voltage of 5 Volts DC at the junction of resistor R218 and capacitor C218. Lack of VCO RF output will modify this voltage.

Regulator U202 uses the 8 volts from transmitter regulator U103 to generator 5 volts for U203 and U204.

Waveforms:

Waveforms associated with the synthesizer were measured with a 10 megohm, 30 pF probe. Use DC coupling (see Figure 10-15).

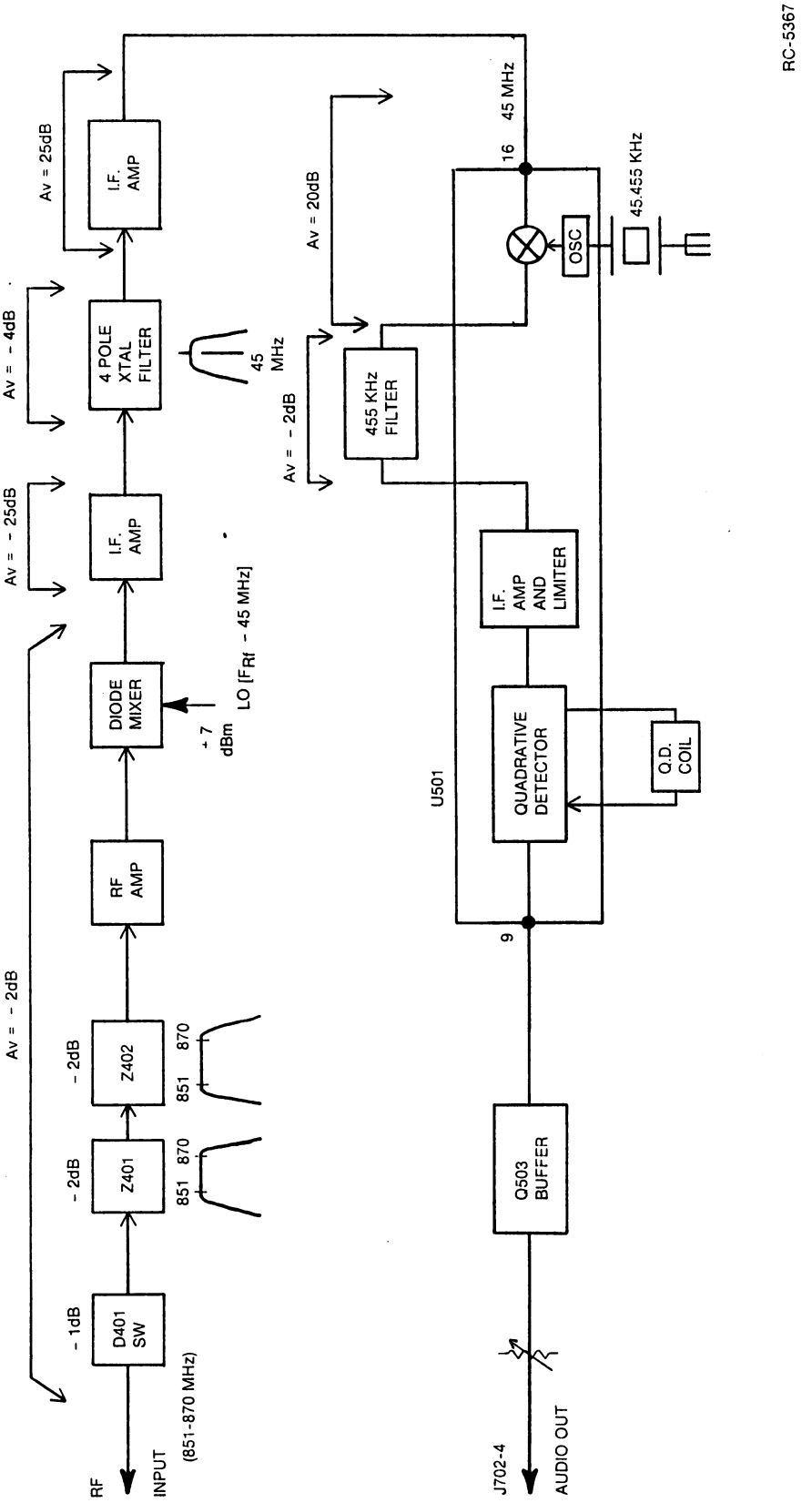


Figure 9 - Gain Distribution Diagram

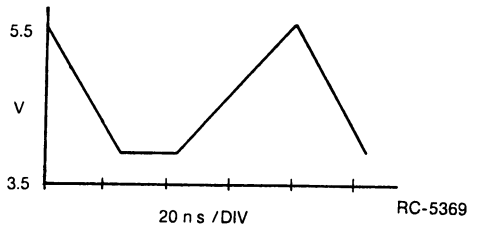


Figure 10 - Reference Oscillator (Input to U205, Pin 2)

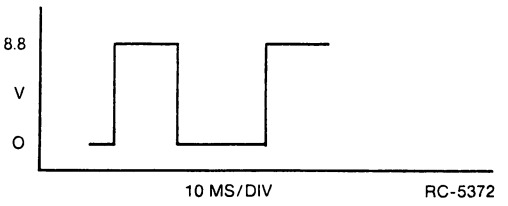


Figure 13 - S Enable (Input to U205, Pin 13. Select S10)

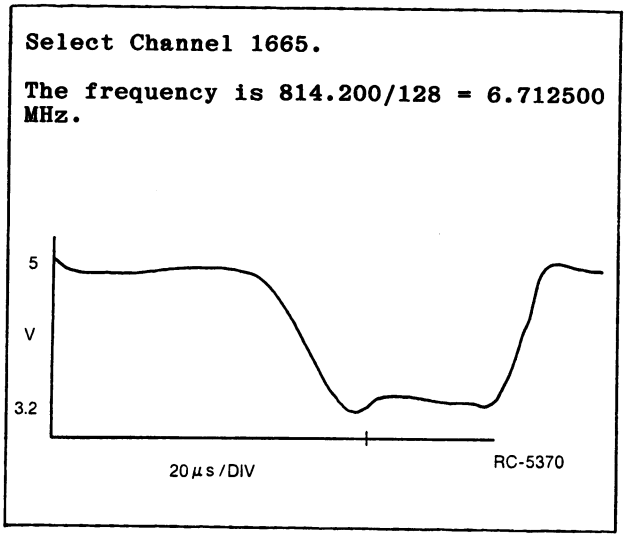


Figure 11 - F_{IN} (Input to U205, Pin 10)

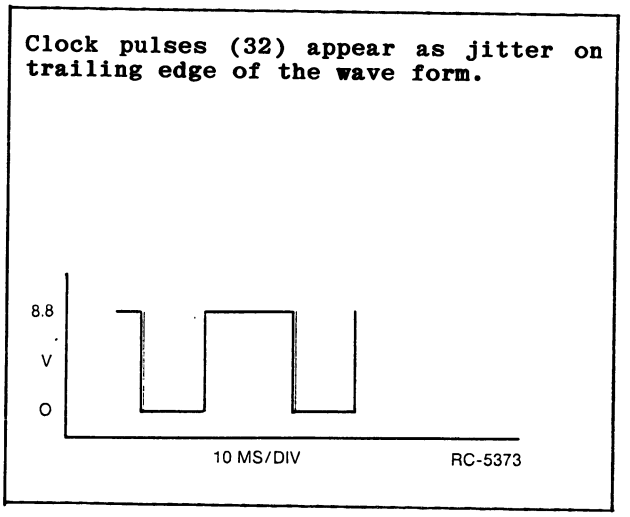


Figure 14 - S Clock (Input to U205, Pin 12. Select S10)

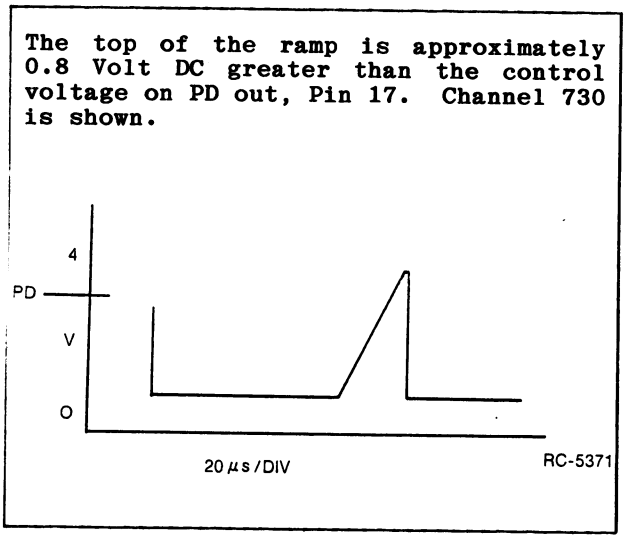


Figure 12 - Ramp (Generated in U205 and appears on Pin 5)

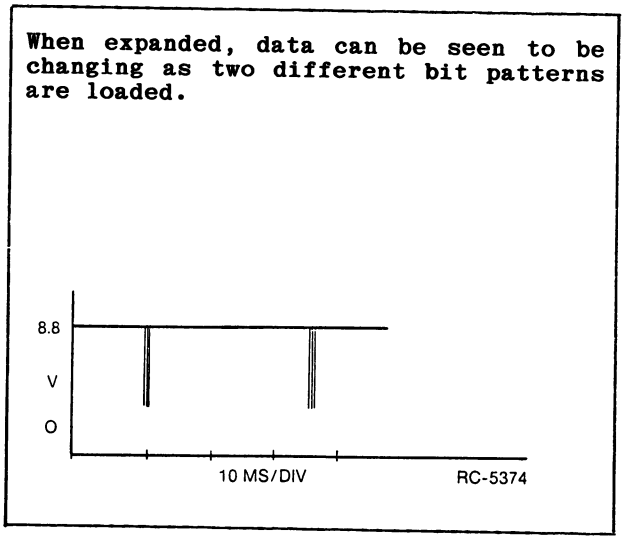


Figure 15 - S Data (Input to U205, Pin 11. Select S10)

Module Isolation:

Reference Oscillator U204: Look for a waveform similar to the reference (Figure 10) on Pin 2. If not present, remove capacitor C210. If waveform is still not present, the oscillator module is probably defective.

VCO U206: Connect a DC power supply to Pin 3. With 2.5 Volts DC on Pin 3, the output of U206 on Pin 1 should be approximatly 803 MHz. With 6.5 Volts DC on Pin 3, the output should be approximately 828 MHz. Select S21 and Pin 5 should go to 8.8 Volts. The frequency for 2.5 volts and 6.5 volts should be approximately 45 MHz higher.

Power output of the VCO can be measured by connecting a 50 ohm coax directly to the module, between Pin 1 and ground. The output should be approximately 0 dBm with C219 still connected.

Prescaler U203: Connect Pin 3 of the VCO to 4.5 Volts DC. Set BS on Pin 5 low. Monitor the frequencies of the VCO at the connection of capacitor C217 and W201. DC short Pin 7 of U203 to ground to cause divide by 129 to occur. The frequency output at Pin 5 should be the VCO frequency divided by 129. Tie Pin 7 to Pin 1 (5 Volts) to cause divide by 128 to occur. Check Pin 5 to confirm that this occurs. Improper division may indicate a defective Prescaler.

Bilateral Switch U207: The Bilateral switch is used to short around parts of the loop filter during channel scan. A shorted (to ground or adjacent gate) gate may be isolated by comparing voltages through the loop filter to those of a functioning radio. Defective gates might be suspected when the radio does not change frequency quickly enough.

Phase-Lock-Loop U205: There are no other specific checks which aid in evaluation of U205. Usually, it is suspected only if all other checks are OK. Before changing, inspect chip components for mechanical damage and check resistances through the loop filter.

Transistor Q204: After checking for proper DC operation, measure the gain from the VCO, Pin 1 to R229/C217. The gain should be approximately 10 dB.

AUDIO BOARD TROUBLESHOOTING

Refer to Figure 16 - RX Audio and Figure 17 - TX Audio - for proper signal level and gains at critical points.

Note the state of FET switches for muting. Remember, these switches are controlled by the Logic Board. If a mute line is high (+5V) it is OK to ground that pin and monitor the results. However, if a mute line is low, it may not be pulled high unless the Audio Board is disconnected from the Logic Board.

All bias points (B) shown on the Audio Board Schematic Diagram (LBI-31654) are at 5 volts, which is generated by regulator U604. Without the presence of this voltage, none of the Operational Amplifier circuits will operate properly.

All Operational Amplifiers are operated from an 8 volt supply created by U603 regulator.

When measuring signals, remember that the negative Operational Amplifier input ports are "virtual" grounds. This means that no AC voltages will be present at these ports.

LOGIC BOARD TROUBLESHOOTING

If a faulty Logic Board is suspected it may be useful to confirm this by substitution of a known good board.

Troubleshooting may be accomplished by use of DC power analysis and the test mode.

DC Checks:

Power for the Logic Board is supplied by the 8 volts on J702, Pin 3. This comes from the transmitter regulator U103.

1. Check for +5 volts ±0.25 volts on U705, Pin 5.
2. Check Power-On Reset on U701, Pin 9 (see Figure 18). If not present, check regulator U705, Pin 2 and transistor Q704.

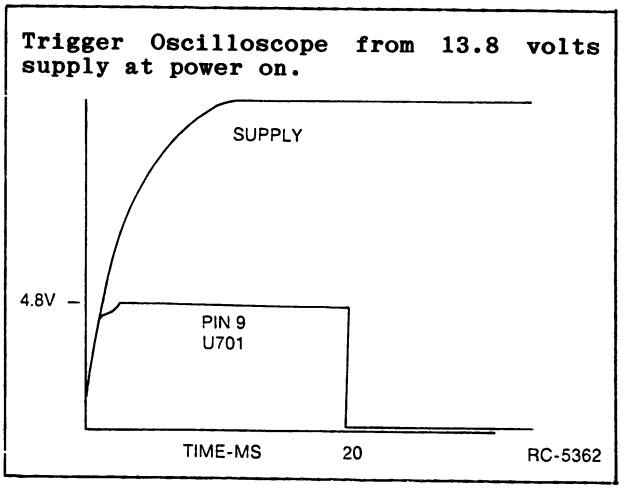
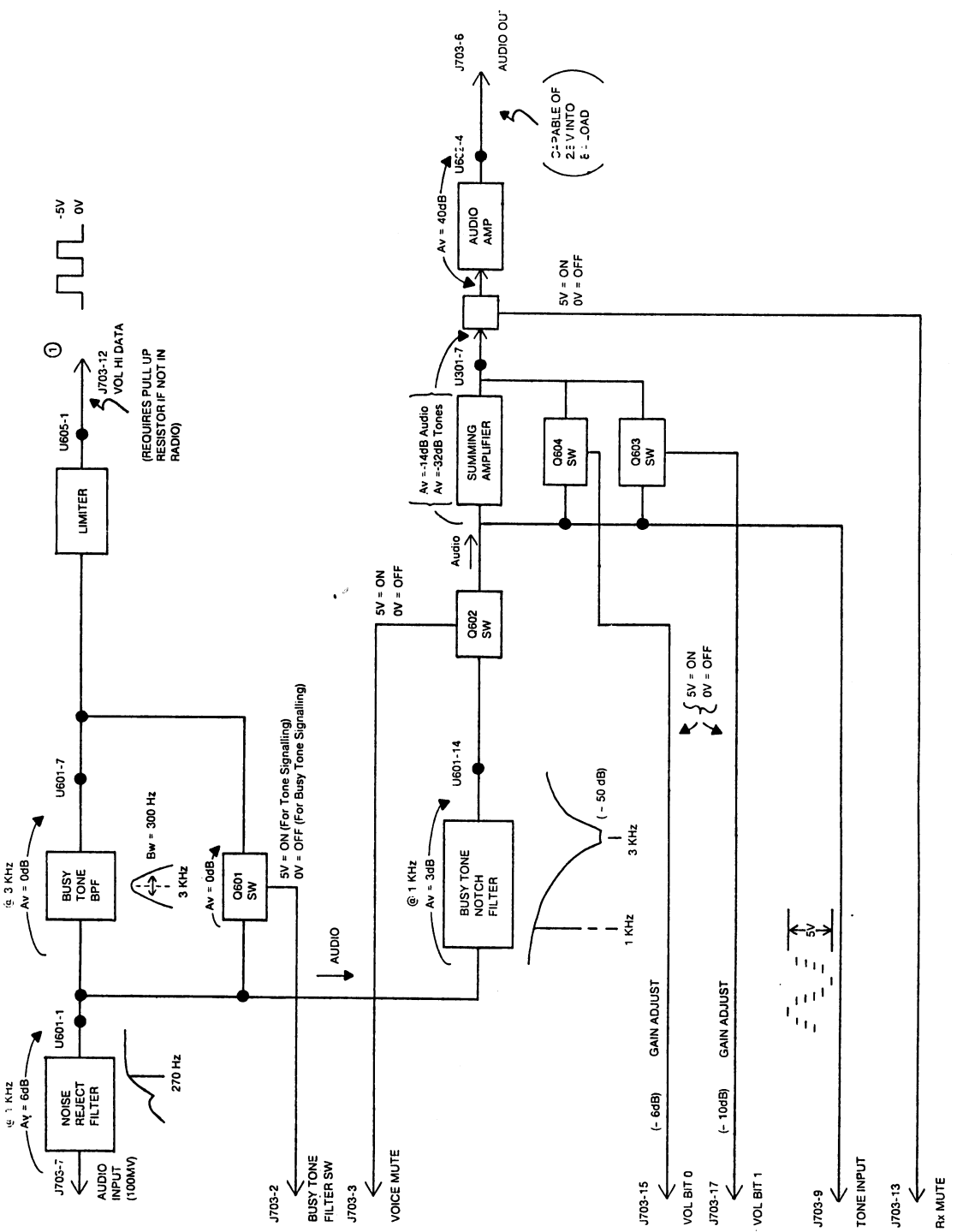


Figure 18 - Reset Waveform



RC-5365

Figure 16 - RX Audio

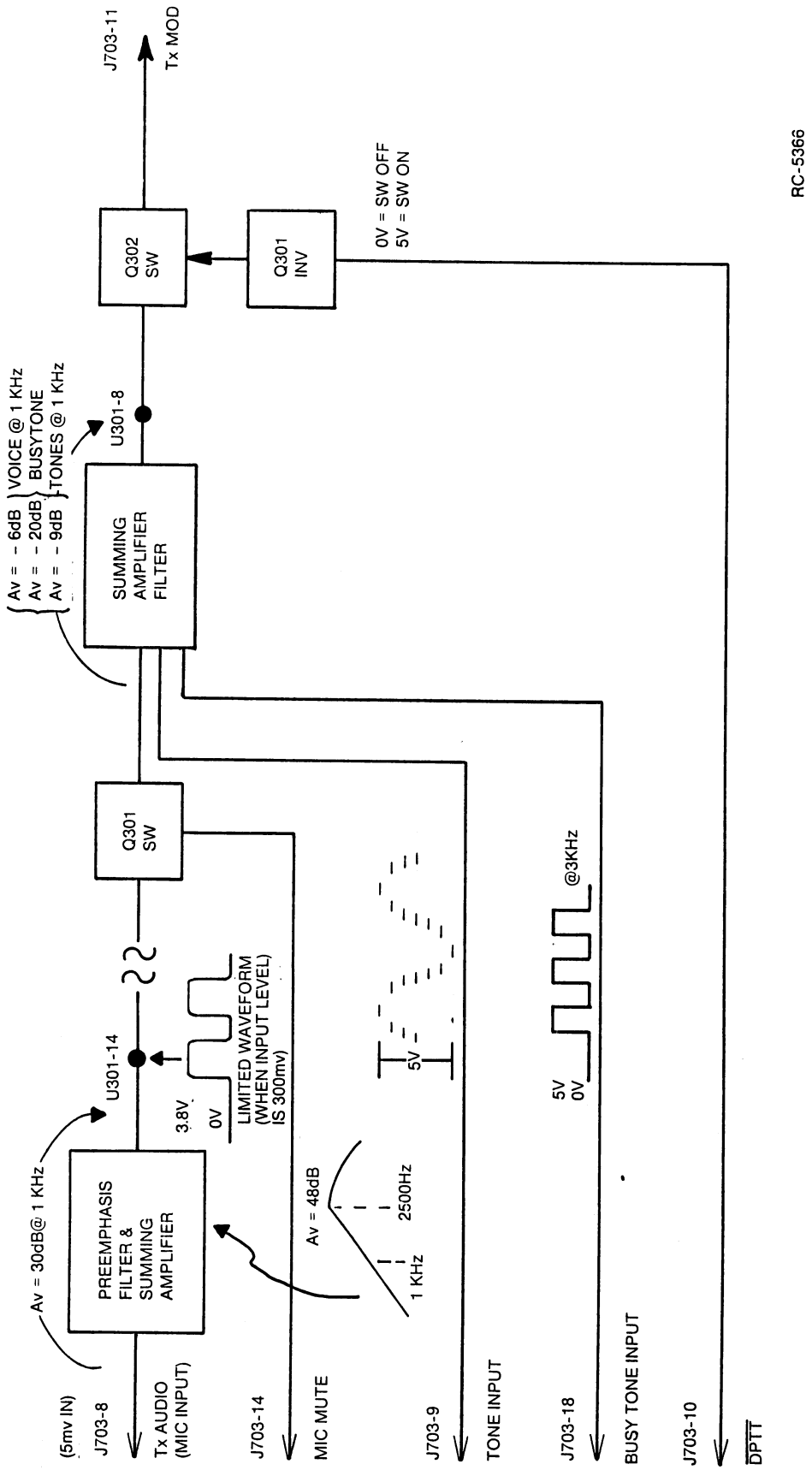


Figure 17 - TX Audio

3. Check for oscillator activity by examining the ALE clock on U701, Pin 30 (see Figure 19). If not present, examine the system clock on U701, Pin 18 (5 volts pp at 11.059 MHz). The presence of the system clock, but no ALE may indicate a bad U701. If the system clock is not present, suspect Y701 and related components.

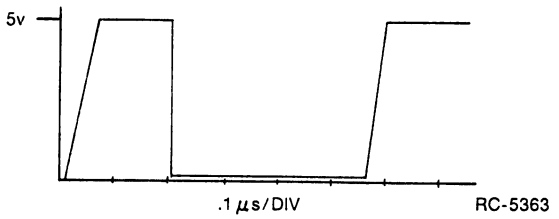


Figure 19 - ALE Clock

4. Check J703 for approximately 13 volts. This is a decoupled voltage obtained from the radio 13.8 volts on J702, Pin 6. This decoupled voltage powers the Handset, Audio Board and the PTT light if the Audioset™ is used.

Power-On Checks:

An improper "power-on" message may be due to a malfunction at U701, Pin 6, Pin 1 or Pin 3 or any other associated circuitry. Upon "power-on", before the test mode is entered, the following error messages may appear:

ERROR 1: No personality. The radio has not been programmed with customer information.

ERROR 2: ANI tones in tone table. ANI tones are not allowed in normal use.

ERROR 3: Synthesizer unlocked. If the radio is otherwise known to operate properly, this may be due to a bad microprocessor or interconnection to the RF Board.

ERROR 4: Program memory checksum error. If the microprocessor uses external memory, the EPROM has been corrupted or is malfunctioning.

Test Mode Checks: (Refer to test Mode Commands Section)

1. Port pin toggle: Checks for proper operation of microprocessor pins used for control functions. Use S19 to initiate and examine each microprocessor pin with an oscilloscope and/or counter.

2. DAC check: Select a tone with S08. Transmit this tone with S01. Examine P703, Pin 9 for a sinewave waveform. The sinewave is approximated by voltage steps. If incorrect, check for level movement on input Pins 14, 17, 4, 18 and 3 and the corresponding outputs on Pins 15, 16, 5, 19, and Pin 2 of Latch U702. Pin 11 is the strobe which latches the data. Also, if outputs are incorrect, check resistors R703 and R704.

   Check the rest of the latch by operating the volume control and function S21 for the BANDSWITCH function.

3. External relay: Attach a 10K ohm pullup resistor from J702, Pin 2 to 13.8 volts and activate the relay circuit with S18. The output on J702, Pin 2 should toggle at a 1 KHz rate.

4. Check Busy Tone: Transmit Busy Tone (S06). Examine P703, Pin 18 for a 3051 Hz squarewave.

5. Check PTT: Select S16 and check that the PTT button causes the radio to transmit. If a Low occurs on Pin 1 of the microprocessor and no transmit occurs, the port, at Pin 1, may be defective.

6. Check Hook Switch: With the radio programmed for hook switch initiation of call, operate the hook switch with a handset holder. If the correct operation does not occur, the port on the microprocessor, Pin 2 may be defective.

7. Personality PROM check:

WARNING

THE USER INFORMATION WILL BE DESTROYED BY THIS TEST.

Select S17. A "PROM OK" message will appear if the EEPROM is working correctly.

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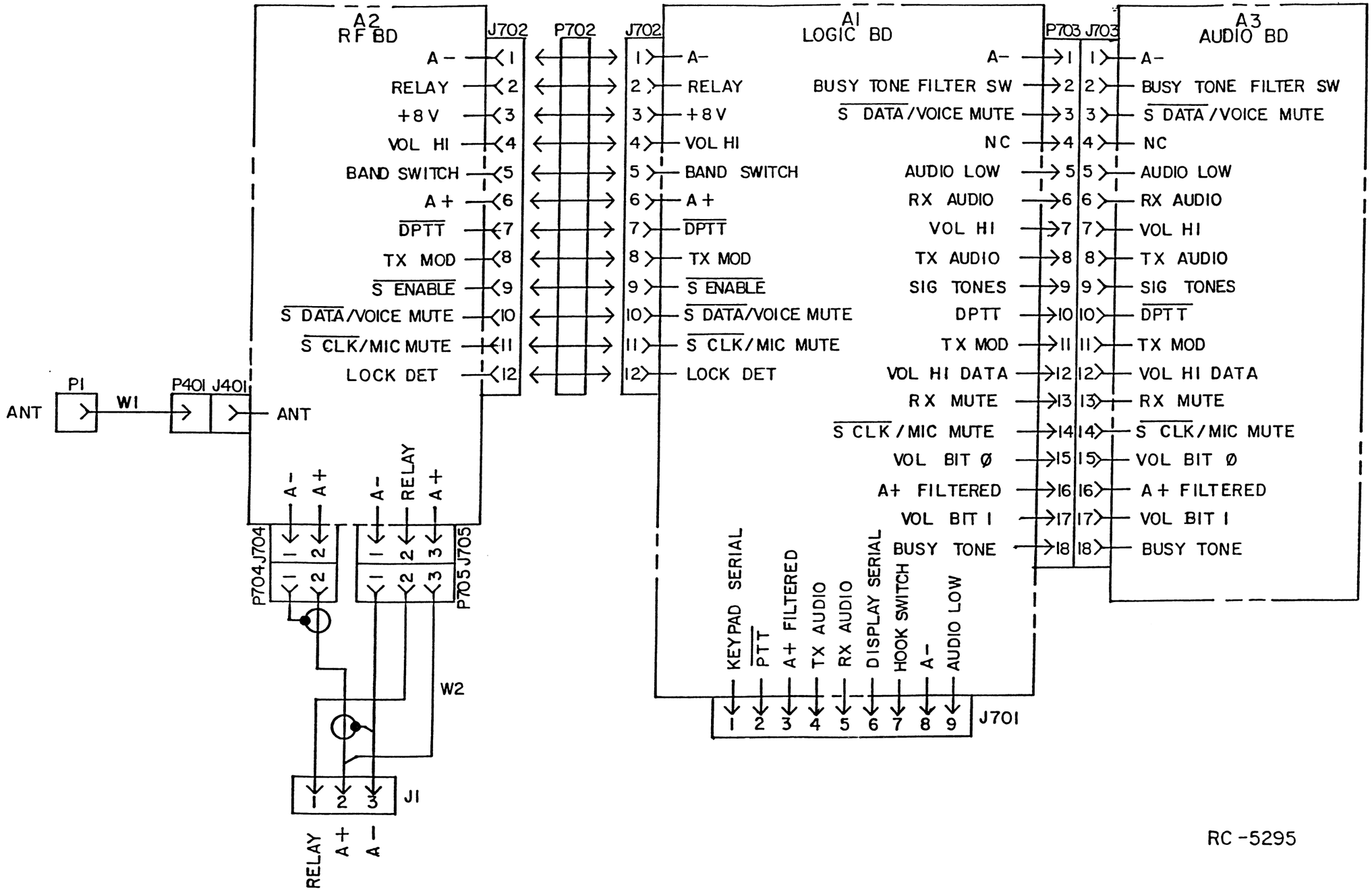
A2
RF BD
J702
P702
J702
A1
LOGIC BD
P703
J703
A3
AUDIO BD
A-
RELAY
+8 V
VOL HI
BAND SWITCH
A+
DPTT
TX MOD
S ENABLE
S DATA/VOICE MUTE
S CLK/MIC MUTE
LOCK DET
BUSY TONE FILTER SW
NC
AUDIO LOW
RX AUDIO
TX AUDIO
SIG TONES
VOL HI DATA
RX MUTE
VOL BIT Ø
A+ FILTERED
VOL BIT I
BUSY TONE
P1
W1
P401
J401
ANT
P704
J704
P705
J705
W2
J1
KEYPAD SERIAL
PTT
DISPLAY SERIAL
HOOK SWITCH
J701

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