# MAINTENANCE MANUAL
## SERVICE SECTION
## FOR
## UHF MCS COMBINATIONS



TABLE OF CONTENTS



## DESCRIPTION

The Service Section contains the information necessary for aligning and troubleshooting the MCS two-way FM mobile radio. In addition, information is provided for disassembling the radio and replacing chip components.

## INITIAL ADJUSTMENT

After the radio has been installed as described in the Installation Manual, the following adjustments should be made by a certified electronics technician.

TRANSMITTER ADJUSTMENT

The transmitter has been adjusted at the factory and should require no readjustment. However, the antenna length should be adjusted for optimum VSWR, and the frequency and modulation measured and recorded for future reference. For the complete transmitter alignment, refer to the Alignment Procedure (see Table of Contents).

RECEIVER ADJUSTMENT

No initial adjustments to the receiver are required. Refer to the Table of Contents for the complete receiver alignment.

RE-INSTALLATION

The MCS series mobile radios are designed to operate in 12 volt negative ground vehicles only. If the mobile radio is moved to a different vehicle, always check the battery polarity of the new vehicle system.

## PREVENTIVE MAINTENANCE

To ensure high operating efficiency and to prevent mechanical and electrical failures from interrupting system operations, routine checks should be made of all mechanical and electrical parts at regular intervals. Preventive maintenance should include the following checks:

CONNECTIONS

Ground connections to the voltage source should be periodically checked for tightness. Loose or poor connections to the power source will cause excessive voltage drops and faulty operation. When ground connections are not made directly to the battery, the connection from the battery to vehicle chassis must be checked for low impedance. A high impedance may cause excessive voltage drops and alternator noise problems.

ELECTRICAL SYSTEM

Check the voltage regulator and alternator or generator periodically to keep the electrical system within safe and economical operation limits. Over-voltage is indicated when the battery loses water rapidly. Usage of 1 or 2 ounces of water per cell per week is acceptable for batteries in continuous operation. A weak battery will often cause excessive noise or faulty operation.

MECHANICAL INSPECTION

Since mobile units are subject to constant shock and vibration, check for loose plugs, nuts, screws and other parts to make sure that nothing is working loose.

ANTENNA

The antenna, antenna base and all contacts should be kept clean and free from corrosion. If the antenna or its base should become coated or poorly grounded, loss of radiation and a weak signal will result.

ALIGNMENT

The transmitter and receiver meter readings should be check periodically, and the alignment "touched up" when necessary. Refer to the Alignment Procedure in this service manual.

FREQUENCY CHECK

Check transmitter frequency and deviation. Normally, these checks are made when the unit is first put into operation, after the first six months, and once a year thereafter.

## DISASSEMBLY PROCEDURE

TO REMOVE THE BOTTOM COVER

1. Remove the M3.5-0.6 x 8 TORX screw (#15 drive) that secures the locking latch in place (refer to Figure 1).

2. Rotate the latch and remove the radio bottom cover.

TO REMOVE THE TOP COVER

After removing the bottom cover, rotate the latch, pry a side loose, and remove the top cover (refer to Figure 2).

TO REMOVE THE RF BOARD

1. Remove the top and bottom covers from the radio (refer to the procedure above).

2. Pry off the friction fit covers covering the RF Board.

3. Gently pry interconnect plug P702 from the Logic and RF Boards using a small standard screwdriver.

4. Remove the two M3.5-0.6 x 8 TORX screws (#15 drive) securing Q101 and U102 to the frame (on top side of board).

5. Remove the two M3.5-0.6 x 20 TORX screws (#15 drive) securing PA module U101 to the frame.

6. Remove the five M3.5-0.6 x 8 TORX screws (#15 drive) from the bottom side of the board.

7. Disconnect wires attached to J704 and J705.

8. Remove the six spring clips protruding through the RF Board from the bottom side.

9. Gently push the RF Board out of the radio casting.

TO REMOVE THE AUDIO BOARD

1. Pull out the black clip protruding through the Audio Board which holds the Logic Board 5 volt regulator against the casting.

2. Remove the four M3.5-0.6 x 8 TORX screws (#15 drive) securing the Audio Board to the radio. Pry out the board by inserting a screwdriver in the hole that was occupied by the clip.

TO REMOVE THE LOGIC BOARD

1. Remove the top cover, bottom cover, and the Audio Board from the radio. Refer to the disassembly for each in this section.

2. Remove interconnect plug P702 from the RF and Logic Boards on the bottom of the radio.

3. Remove the four M3.5-0.6 x 8 TORX screws (#15 drive) securing the Logic Board to the radio frame.

4. Carefully work the Logic Board out of the radio.

## COMPONENT REPLACEMENT

The procedure for removing chip components is given below. Replacement procedures for other unique components are found in the appropriate board LBI where the component is used (the 10 watt PA module replacement is in the RF Board LBI).

CHIP COMPONENT REPLACEMENT

Replacement of chip capacitors should always be done with a temperature controlled soldering iron, using a controlled temperature of 700°F (371°C). However, do NOT touch black metal film of the resistors or the ceramic body of capacitors with the soldering iron.

**NOTE**

The metalized end terminations of the parts may be touched with the soldering iron without causing damage.

To Remove Chip Components:

1. Using two soldering irons heat each end of the chip at the same time until solder flows, and then remove and discard the chip.

2. Remove excess solder with a vacuum solder extractor.

3. Carefully remove the epoxy adhesive and excess flux to prevent damage to the printed board.

To Replace Chip Components:

1. Using as little solder as possible, "tin" one end of the component and one of the pads on the printed wiring board.

2. Place the "tinned" end of the component on the "tinned" pad on the board and simultaneously touch the component and the pad with a well "tinned" soldering iron while pressing the component down on the board.

3. Place the "tinned" soldering iron on the other end of the component and the pad simultaneously. Apply solder to the top of the end of the component until the solder starts to flow. Use as little solder as possible while getting a good joint.

4. After the component has cooled, remove all flux from the component and printed wiring board with alcohol.

**CAUTION**

The CMOS Integrated Circuit devices used in this equipment can be destroyed by static discharges. Before handling one of these devices, the serviceman should discharge himself by touching the case of a bench 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 iron should also have a 3-prong power cord connected to an outlet with a known good earth ground. A battery-operated soldering iron may be used in place of the regular soldering iron.

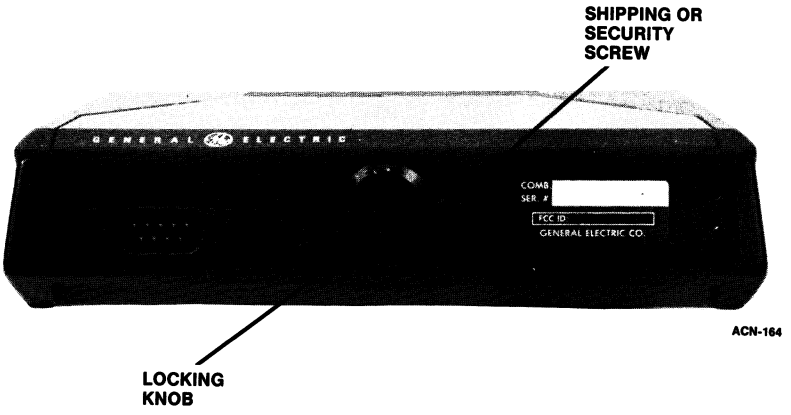



FIGURE 1 - REMOVAL OF THE BOTTOM COVER

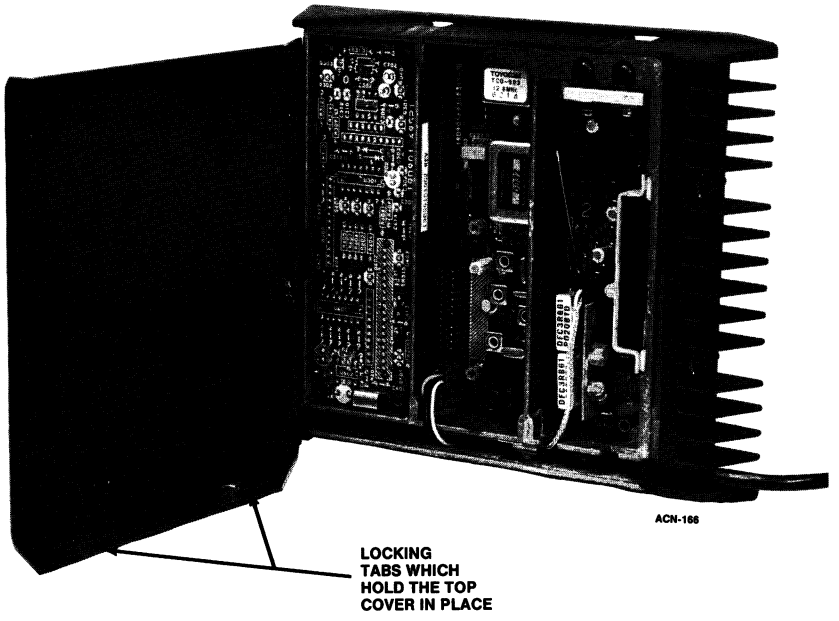



FIGURE 2 - REMOVAL OF THE TOP COVER

## TROUBLESHOOTING PROCEDURE

This section should help isolate a problem to a particular board or circuit. Troubleshooting charts and block diagrams for power distribution and signal flow are given. Refer to the appropriate LBI on the suspect board for additional troubleshooting and circuit information.

The MCS radio is divided into 4 functionalized boards or assemblies. The outline below gives a quick list of the major functions for each board. Refer to the appropriate LBI on each for more details.

1. RF Board

   Contains:

   - Synthesizer - generates all transmit and receive frequencies.
   - Receiver - provides detected audio to the Audio Board.
   - Transmitter - includes exciter and 10 watt PA Module.
   - Power control circuitry for the transmitter.
   - Pin diode TX/RX switch.
   - Lowpass filter for the transmitter.

2. Audio Board

   Contains:

   - RX squelch - provides the CAS signal to the Logic Board.
   - RX Audio - provides filtered and gated audio to the System Board.
   - Tone processing - provides receiver tone data to the Logic Board.
   - TX Audio - processes the mic and tone audio to feed the RF Board synthesizer.

3. Logic Board

   - Routes signals between the RF and Audio Boards and the Control Head.
   - Contains the EEPROM for the radio personality.
   - Contains the main radio microprocessor.
   - Accepts PTT From the microphone.
   - Provides DPTT to turn on the transmitter.
   - Provides synthesizer channel data to the RF Board.
   - Decodes tone data from the Audio Board.
   - Generates the Channel Guard tones and data.
   - Controls all audio switches on the Audio Board.
   - Accepts the CAS squelch output from the Audio Board.

4. Control Head

   Contains:

   - 5 watt audio PA.
   - Volume control.
   - Switches for channel, power and monitor.
   - Speaker

<u>Power-on Checks</u>

The MCS radio provides several self diagnostic checks when power is applied and informs the user of a possible problem within the radio. These tests provide the following alert tones when a problem is detected:

1. Continuous, quickly pulsed alert tone: Synthesizer is unlocked in receive. The Logic Board is continuously reloading the synthesizer with data trying to achieve lock. Switching to different channel frequencies may reveal some channels that will lock. The synthesizer load commands or the VCO adjustment may not be correct.

2. One beep every half second: Personality EEPROM not programmed with customer information.

3. Two beeps every half second: EPROM program memory checksum error. If the Logic Board microprocessor uses external memory, the EPROM may be corrupted or malfunctioning.

4. Three beeps every half second: Personality EEPROM may be corrupted with bad data.

SYMPTOMS AND CHECKS

| SYMPTOMS | CHECKS |
|---|---|
| • Low, Distorted or No RX Audio | Check the receiver VOL/SQ HI output. If audio is improper the problem is most likely on the RF Board. If synthesizer load commands are not correct, the problem maybe on the Logic Board.<br><br>If the audio is correct at VOL/SQ HI, check the Audio Board RX AUDIO output. If improper, 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.<br><br>If RX AUDIO is correct, the problem may be the 5W audio PA in the Control Head. |
| • No RX Alert Tones (Radio OK Otherwise) | Check the Signalling Tone output from the Logic Board. Operate the volume control. If tones are not present, a problem on the Logic Board is indicated.<br><br>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 o the RF Board. Check the receiver alignment. Refer to the RF Board LBI for additional service notes. |
| • 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. |
| • No TX Power and alert tone immediately heard when PTT keyed | Synthesizer on RF Board is unlocked or became momentarily unlocked. Possible power source problem or resistive A+ connections. (The voltage momentarily dropped below 10 volts when the transmitter was keyed which caused the synthesizer to unlock, turning off the transmitter, and sounding the alert tone.) |
| • Low TX Power | Check the TX frequency:<br><br>If the TX frequency is out of the band, check the synthesizer 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.<br><br>If the TX frequency is correct, refer to the RF Board LBI and troubleshoot the transmitter. |

| SYMTOMS | CHECKS |
|---|---|
| • No TX Modulation | Check the TX MOD input to the RF Board. If present, the problem is most likely on the RF Board. If not present, determine what is missing: Channel Guard Tones, voice, or both.<br><br>Missing Tone - Look at the Signalling Tone input to the Audio Board.<br><br>If the Tones are not present the problem is most likely on the Logic Board.<br><br>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.<br><br>If the commands are present the problem is most likely on the Audio Board.<br><br>Voice Signal Missing - Again, check the mute commands from the Logic Board. Check the MIC HI input to the Audio Board. If all signals are correct, the problem is most likely on the Audio Board. |
| • Distorted TX Audio | Check for good grounding of all boards to the casting.<br><br>Check for the presence of board shield on the bottom of the radio.<br><br>Check the TX MOD input to the RF Board. If distorted, a problem on the Audio Board is likely.<br><br>Check the mute commands. If incorrect, a difficulty on the Logic Board is indicated.<br><br>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. Refer to the frequency set instructions in the transmitter alignment section in this LBI. Check the synthesizer load command. If the load command is improper a Logic Board problem is likely. |

## POWER DISTRIBUTION

Refer to Figure 6 - Power Distribution Block Diagram for an understanding of the distribution of A+, SW A+, and the regulated voltages throughout the radio.

A+

A+ powers the 10 watt PA Module on the RF Board. D105 provides reverse polarity and over-voltage spike protection. A+ also feeds the power control transistor Q101 which supplies the power control voltage to the PA Module.

SW A+

Switched A+ originates from the power switch on the Control Head and supplies power to the 5 watt audio PA and the TX LED. SW A+ leaves the Control Head and enters the radio assembly through J1 of the radio power cable W2.

SW A+ enters the RF Board on J704 and J705. SW A+ supplies power to three 8 volt regulators and the transmitter power control. SW A+ leaves the RF Board on J702 to feed the SW A+ filter circuit Q703 on the Logic Board. Q703 reduces alternator whine interference. The Logic Board does not use SW A+ or SW A+ FILTERED. The Logic Board supplies SW A+ FILTERED to the Audio Board through P703 and the Control Head through J701.

REGULATED VOLTAGES

SW A+ is the source of power for all voltage regulators. Several 5 volt regulators receive power from an 8 volt regulator to allow less power dissipation in the 5 volt regulators.

RF Board

The receiver has an 8 volt regulator U502. The synthesizer has a separate 8.3 volt regulator (U207) and a 5 volt regulator U203. The transmitter uses another 8 volt regulator (U102). The output of U102 is switched to the exciter and the power control circuit. U102 also powers the Logic Board. U102 (TX 8 volt supply) and Q101 (power control output transistor) are mounted for heat sinking.

Logic Board

A single 5 volt regulator U705 is used to power the Logic Board. The input voltage is derived from the 8 volt TX regulator U102 on the RF Board. The power-on reset circuitry for the Logic Board microprocessor is part of regulator U705. This reset signal prevents scrambled operation due to low voltage transients during automobile starting.

Audio Board

An 8 volt regulator U606 provides power to all of the Audio Board circuitry except U603. SW A+ FILTERED from the Logic Board provides the input voltage to the regulator.

## AUDIO SIGNAL FLOW

Refer to Figure 7 - Audio Signal Flow Block Diagram for an understanding of the distribution of RX and TX audio signals throughout the radio. Audio levels at important points are also shown.

TRANSMITTER AUDIO

Microphone audio (MIC HI) is routed from the mic connector on the Control Head through the Logic Board to feed the Audio Board. After processing and summing the Channel Guard tones, the audio (TX MOD) is fed through the Logic Board to the RF Board. TX MOD is adjusted by Deviation Adjust R226 before feeding the modulation input to the synthesizer VCO.

RECEIVER AUDIO

Discriminator audio is buffered by Q503 on the RF Board and adjusted by R513. This audio (VOL/SQ HI) is routed to the Audio Board by way of the Logic Board. On the Audio Board, VOL/SQ HI feeds 3 paths. Two paths (not shown on the block diagram) are the squelch path and the tone path to process tones for decoding in the Logic Board microprocessor. The third path is the RX Audio path which is filtered and routed through the Logic Board to feed the Control Head. RX AUDIO feeds the volume control and the 5 watt Audio PA in the Control Head.

## LOGIC SIGNAL FLOW

Refer to Figure 8 - Logic Signal Flow Block Diagram for an understanding of the distribution of logic signals throughout the radio. Microprocessor U701 on the Logic Board provides synthesizer data to the RF Board and control signals to the FET switches on the Audio Board. U701 also accepts squelch and tone data from the Audio Board and PTT, monitor, and channel switch signals from the Control Head. All logic lines should have 4-5 volts for a logic high and less than 0.5 volts for a logic low.

## ALIGNMENT PROCEDURE

The following procedures are performed with a regulated 13 Vdc power source applied to the radio. For a complete alignment of the MCS radio, the tests should be performed in the order given below.



### TRANSMITTER ALIGNMENT

Figure 3 provides a test set up configuration. Figure 4 idtentifies the adjustment controls.

#### VCO SET

1. Select a frequency within 200 kHz of the upper band limit.(G1 - within 200 kHz of 440 MHz.) (G2 - within 200 kHz of 470 MHz.) (G3 - within 200 kHz of 512 MHz.).

2. While in receive adjust R218 on the RF Board for 6.0 Vdc ±0.2 volts as measured at J201 on the RF Board.

#### FREQUENCY SET

1. Select any channel and key the transmitter.

2. While holding the transmitter keyed, check the frequency output of the transmitter and adjust reference oscillator U204 to within ±50 Hz of the channel frequency. The operating temperature of the radio should be 25 degrees Celsius ±5 degrees.

#### TRANSMITTER POWER SET

Select any channel and adjust R111 in the power control circuit for 10 watts.

#### DEVIATION ADJUSTMENT

1. Select the channel representing the lowest operating frequency and the lowest Channel Guard frequency.

2. Apply a 1 kHz 300mVrms signal to the microphone input at J701-4.

3. Key the transmitter and adjust R226 on the RF Board for 4.5 kHz ±0.1 kHz. The modulation analyzer should have no highpass filter, and a 15 kHz lowpass filter selected.

**NOTE**

Make sure that deviation is set on a channel with Channel Guard present to prevent over deviation.

### RECEIVER ALIGNMENT

#### FREQUENCY SET

1. Verify that the transmitter is on frequency as described in the transmitter alignment above.

2. Inject a strong on channel signal at the antenna J101.

3. Monitor J501 with a frequency counter and ad just L508 for a reading of 455 kHz ±100 Hz.

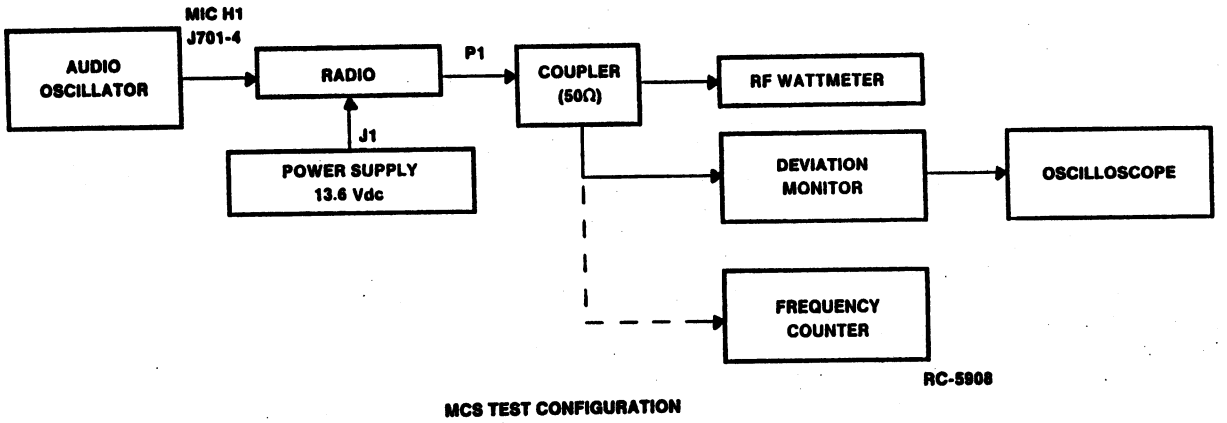
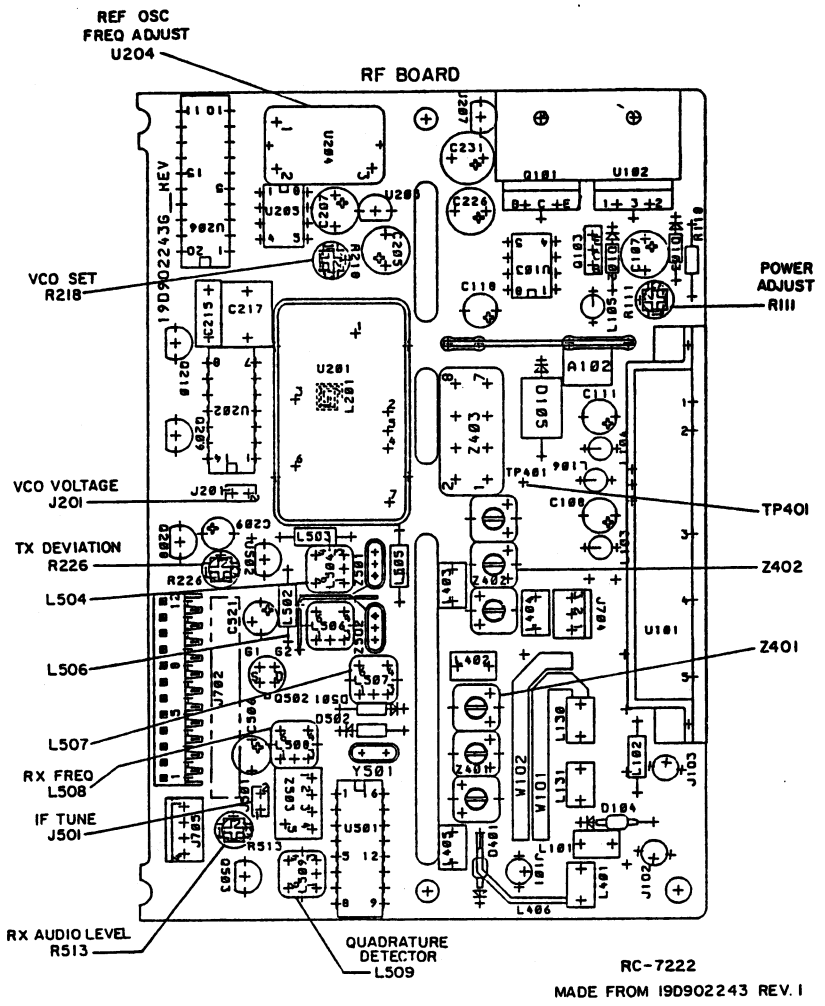



FIGURE 3 - TEST CONFIGURATION



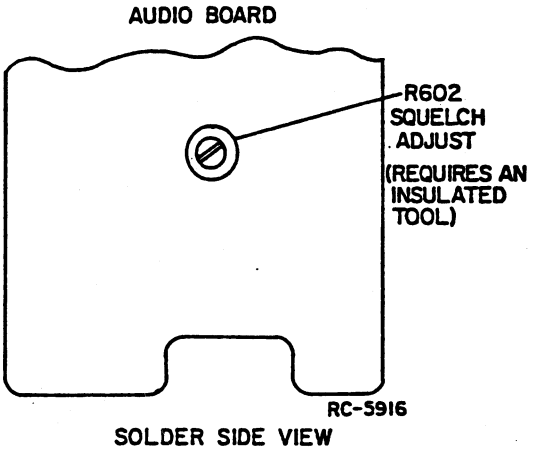




FIGURE 4 - ALIGNMENT CONTROLS AND TEST POINTS

## RF TUNING
## (CHANGE 20 MHZ SEGMENT OF BAND SPLIT)

See Figure 5 for test configuration. The receiver RF filters Z401 and Z402 are fixed tuned for the most commonly used 20 MHz segment of a split. The filters do not require tuning even if they are replaced. The purpose of the tuning adjustment for each filter is to move the pass-band to another 20 MHz segment of the split. If all the receiver channels are within the preset 20 MHz bandwidth, skip the rest of this section since no front end tuning is required.

**CAUTION**

A sweep tuning procedure is necessary to adjust the RF filters for another 20 MHz segment of the split. Do not adjust Z401 or Z402 without sweep equipment or the receiver sensitivity bandwidth will be sharply reduced.

1. Apply a sweep signal generator (or equivalent equipment) with markers set for the desired 20 MHz bandwidth to antenna jack J101 as shown in Figure 5. RF output level of the generator should not exceed -10 dBm. Reduce the output level if necessary to keep RF amplifier Q401 out of saturation and protection diode D402 off.
2. Measure the RF signal at TP401 with a high impedance RF probe. A 5--ohm RF probe may be used at TP401 if coupling capacitor C415 is removed. Connect the RF sweep detector and display (or equivalent equipment) to the RF probe.
3. Tune the slugs of Z401 and Z402 for the required 20 MHz bandwidth. Ripple will be 1 dB to 2 dB typical. Install coupling capacitor C415 if it had been removed for the alignment procedure.

## IF TUNING

1. Select a frequency in the center of the receiver's operating range.
2. Monitor J501 with an AC voltmeter and inject an on channel signal modulated by 1 kHz tone at 5 kHz deviation at the antenna jack.
3. Adjust L504, L506, and L507 for a peak on the voltmeter. Adjust the level of the signal generator to keep the signal at J501 out of limiting.
4. Repeak the coils.

## QUADRATURE DETECTOR ADJUSTMENT

1. Inject a strong on channel signal at the antenna jack modulated with 1 kHz tone at 1.5 kHz deviation.
2. Monitor VOL/SQ HI J705-3 with an AC voltmeter and adjust L509 for a peak on the meter.

## RX AUDIO LEVEL SET

1. Inject a strong on channel signal modulated by 1 kHz tone at 3 kHz deviation at the RF input.
2. Monitor RX AUDIO J701-5 (or J703-6 on the Audio Board) with an AC voltmeter and adjust R513 for a reading of 1.0 ±0.1 Vrms.

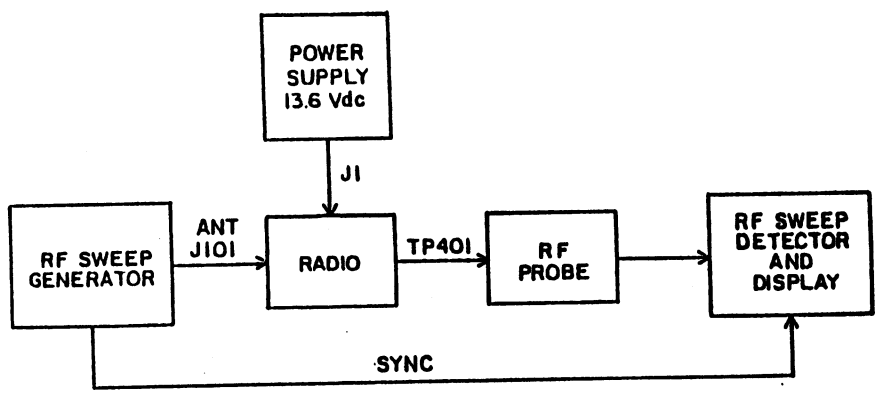



FIGURE 5 - RECEIVER RF TUNING TEST CONFIGURATION

SQUELCH ADJUST

1. Select any channel and apply a signal modulated with a 1 kHz tone at 3 kHz deviation to the antenna input jack J101.

2. Using an insulated tool, turn R602 to the maximum counterclockwise position.

3. While monitoring RX AUDIO J701-5, adjust the signal generator for 8 dB SINAD.

4. Adjust R602 fully clockwise then adjust counterclockwise until squelch just opens.

## TRANSMITTER-RECEIVER VERIFICATION

### TRANSMITTER VERIFICATION

TRANSMIT FREQUENCY

Key the transmitter and measure the transmit frequency. The measured frequency should be the programmed frequency ±100 Hz.

TRANSMITTER POWER/CURRENT

Select a channel at the upper band limit and the lower band limit and key the transmitter while measuring power and current. Power should be 10 watts ±0.5 dB. Current should be less than 4 amperes.

MODULATION LIMITING

1. Apply a 1 kHz 300 mVrms signal to the microphone input at J701-4 to the channel to be tested.

2. Key the transmitter and verify that the deviation is <4.5 kHz. Test all channels.

**NOTE**

For this test and the following test, the modulation analyzer should have no highpass filter and a 15 kHz lowpass filter selected.

TRANSMITTER DISTORTION

1. Inject an audio tone of 1 kHz at MIC HI J701-4. The tone should have enough amplitude to produce 2 ±0.2 kHz deviation when the transmitter is keyed.

2. Deemphasize the transmitted signal, and measure distortion. Distortion should be less than 3%.

3. Transmit on a channel with the lowest Channel Guard tone frequency and measure distortion. Distortion should be less than 3%.

TRANSMITTER HUM AND NOISE

Measure residual hum and noise with a modulation analyzer referenced to a 1 kHz tone at 3 kHz deviation. Setting should include 750uS deemphasis, 300 Hz highpass filter, and 3000 Hz lowpass filtering. Measure at the upper end of the band. H/N should be greater than 48 dB.

### RECEIVER VERIFICATION

SINAD

Apply the proper RF signal modulated with 1 kHz tone at 3 kHz deviation to the antenna jack J101. Set the signal level to -116 dBm. Check for greater than 12 dB SINAD at the upper and lower band limit.

CHANNEL GUARD DECODING

Select a channel with the highest operating Channel Guard tone. Apply an on carrier signal of -116 dBm modulated with the above tone at 500 Hz deviation. Verify that the squelch opens.

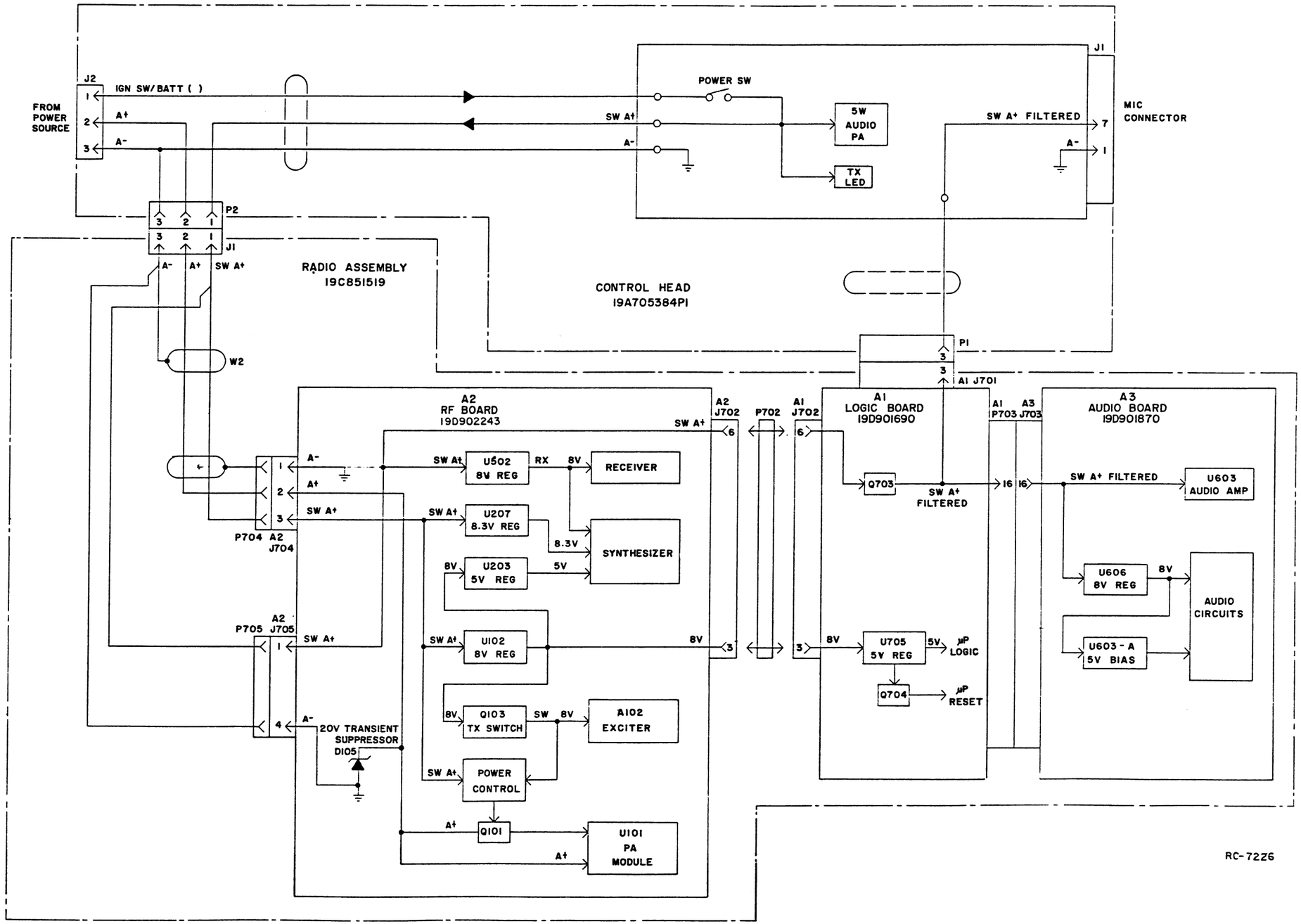
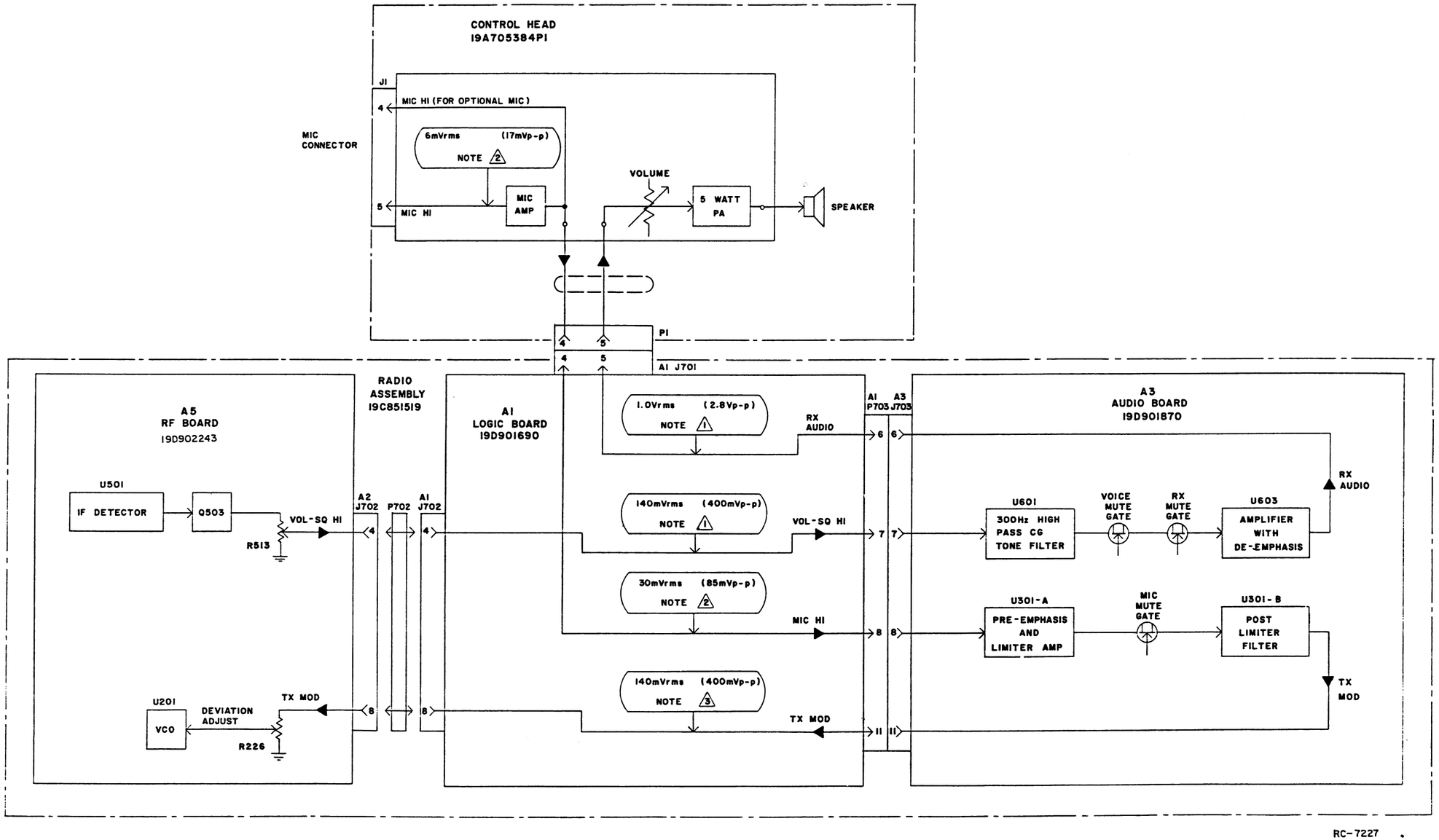



FIGURE 6 - POWER DISTRIBUTION BLOCK DIAGRAM




NOTES:

1. RECEIVING A 100uV ON-FREQUENCY SIGNAL MODULATED BY 1000 Hz AT 3kHz DEVIATION.
2. AUDIO GENERATOR APPLIED TO MIC HI OF CONTROL HEAD MIC CONNECTOR J1 AND ADJUSTED FOR 15mVrms AT 1000 Hz.

FIGURE 7 - AUDIO SIGNAL FLOW BLOCK DIAGRAM

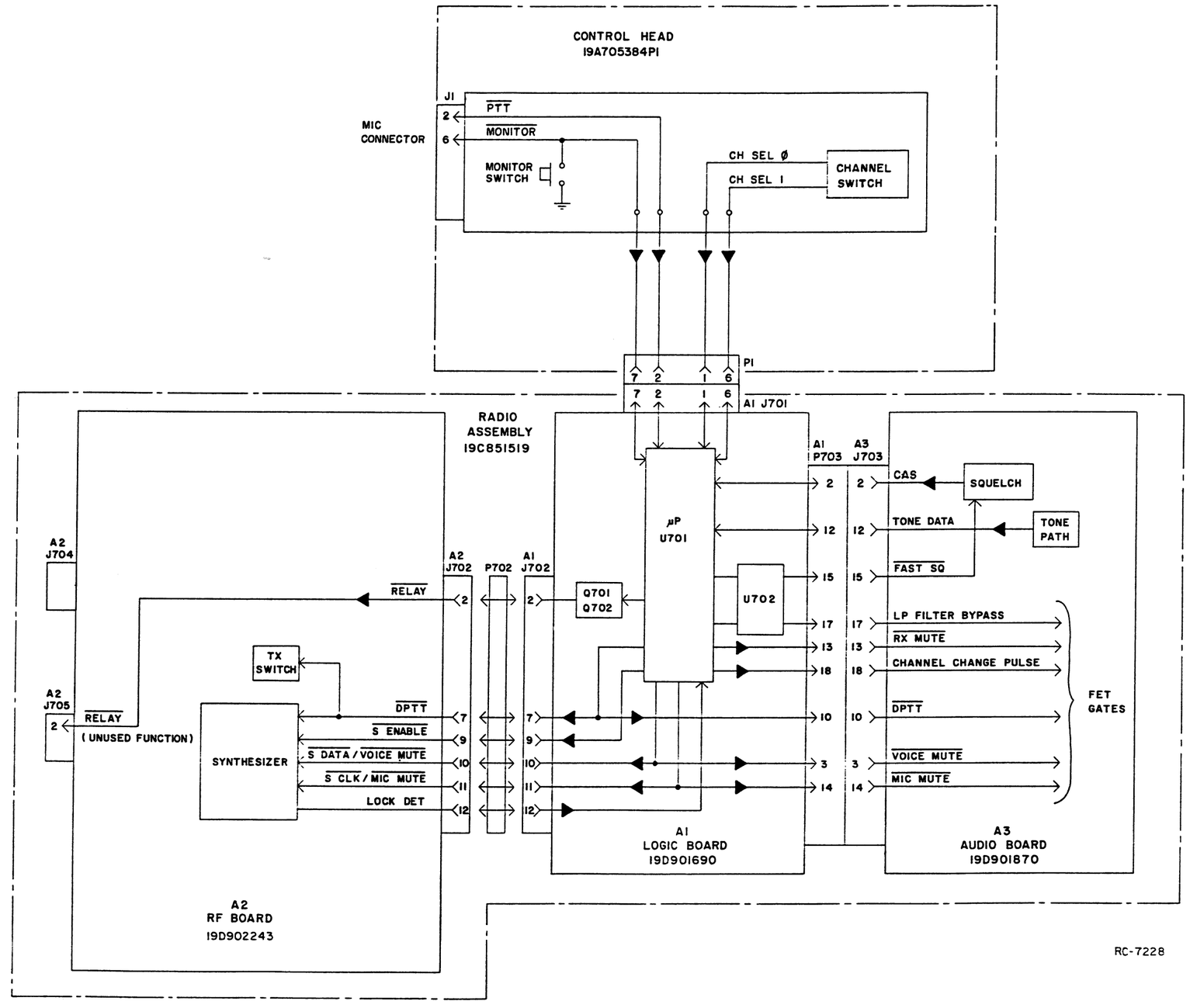



FIGURE 8 - LOGIC SIGNAL FLOW BLOCK DIAGRAM