

**MAINTENANCE MANUAL
RF BOARD
19D902243G4 (403-440 MHz)
19D902243G5 (440-470 MHz)
19D902243G6 (470-512 MHz)
FOR MVS**

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DESCRIPTION

The RF Board for the MVS radio consists of the following circuits:

- A frequency synthesizer for generating the transmit carrier frequency and the receive circuit first mixer injection frequency.
- The transmit exciter, PA and power control stages.
- The receive circuit front end, IF, and FM detector.
- Voltage regulators.

The 403-512 MHz range of UHF frequencies is covered by three groups of RF Boards:

- 19D902243 G4: 403-440 MHz
- 19D902243 G5: 440-470 MHz
- 19D902243 G6: 470-512 MHz

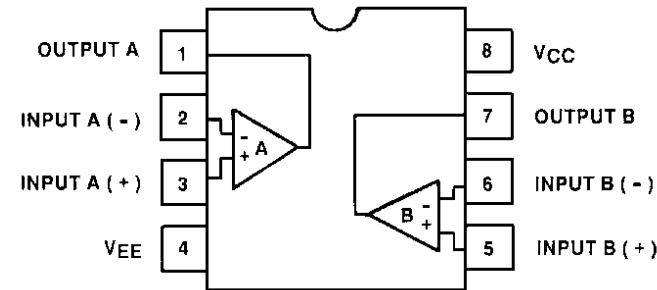
The RF Board is mounted in the bottom of the frame assembly. Refer to Combination Manual for a mechanical layout of the radio. Figure 1 provides a block diagram of the receive and transmit circuits. Figure 2 provides a block diagram of the synthesizer.

Transmit circuit adjustments for frequency, power and deviation are accessible from the topside of the board, as are IF alignment, second oscillator and audio level adjustments for the receive circuit. Chip components on the bottom of the board provide optimum RF performance, while being accessible for easy servicing by removing the "friction fit" bottom shields.

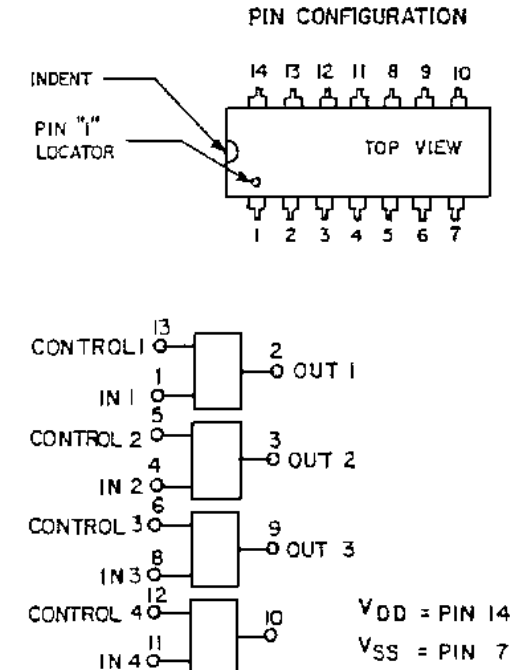
Selected use of sealed modules permits small board size as well as RF and mechanical protection for sensitive circuitry. Modules are not repairable and must be replaced if they are determined to be damaged.

IC DATA

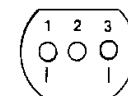
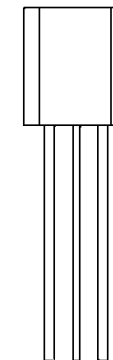
**OPERATIONAL AMPLIFIER
19A701789P2**



**QUAD BILATERAL SWITCH
(U202)
19A700029P44**



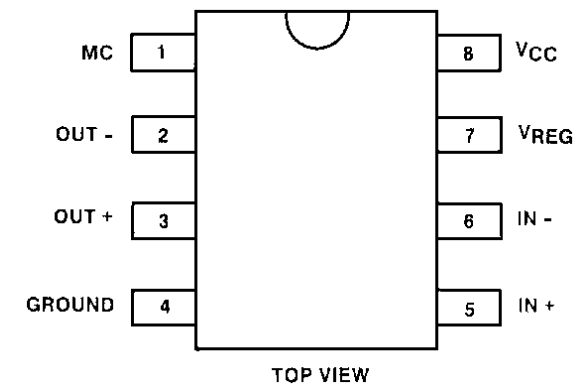
**VOLTAGE REGULATOR
19A704971P1**



**BOTTOM VIEW
PIN IDENTIFICATION**

- PIN 1. ADJUST
- PIN 2. OUTPUT
- PIN 3. INPUT

**DIVIDER
(U205)
19A704287P2**



Ericsson Inc.
Private Radio Systems
Mountain View Road
Lynchburg, Virginia 24502
1-800-592-7711 (Outside USA, 804-592-7711)

CIRCUIT ANALYSIS

SYNTHESIZER CIRCUIT

The synthesizer generates all transmit and receive RF frequencies. The circuit uses a phase-locked VCO module U201 feeding a doubler circuit. While transmitting, the VCO operates at 1/2 the actual transmitter frequency (201.5-256.0 MHz to produce 403-512 MHz). While receiving, the VCO operates at 1/2 of the difference between the receiver frequency and the 45 MHz IF (179.0-233.5 MHz for 403-512 MHz).

Q201 doubles the VCO output frequency with input and output filters broadly fixed tuned to allow the VCO second harmonic to pass while rejecting all other frequencies. The doubled signal is amplified by Q201 to a level of +10 dBm. This signal feeds the receiver mixer and is attenuated to +3 dBm by R202 to feed the transmitter exciter module.

The synthesizer frequency is controlled by the microprocessor on the Logic Board (A1). Frequency stability is maintained by a temperature compensated crystal controlled oscillator (TCXO) module. The oscillator has a stability of ± 5 PPM (0.0005%) over the temperature range of -30°C to +60°C and determines the overall frequency stability of the radio. An optional high stability ± 2.5 PPM oscillator module is available.

The VCO output is also buffered by Q204 to feed the divide by 128/129 dual modulus prescaler U205. The prescaler feeds the FIN input of the PLL U206. Within U206, the prescaled signal is further divided down to 6.25 kHz to be compared with a reference signal. This reference signal is derived from the 12.8 MHz TCXO module U204. U206 divides the 12.8 MHz TCXO down to the 6.25 kHz reference frequency.

Divider circuits in U206 are programmed by three inputs from the Logic Board (A 1), which are buffered and inverted by transistors Q208, Q209, and Q210. The S ENABLE pulse (5 milliseconds) activates switch U202 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. During receive, an unlocked synthesizer is indicated by E0 (Error 0) in the LCD and by a quickly pulsed alert tone. The microprocessor will continually try to reload the frequency information into the PLL until the synthesizer locks. During transmit, only a slower pulsed alert tone will be heard.

Once unlocked in transmit, the synthesizer will not be reloaded. The transmitter PTT must be unkeyed and then rekeyed to attempt to reload.

Audio modulation from Audio Board A3 is applied to the VCO module through DEVIATION ADJUST potentiometer R226. VCO TUNE potentiometer R218 adjusts the operating frequency range of the VCO by varying a negative bias from D202 and D203.

TRANSMITTER CIRCUIT

The transmitter consists of a fixed-tuned exciter module, a 10 Watt PA module, a pin diode switch, a low pass filter, a directional coupler, a power control circuit, and a transmit voltage switch.

Exciter Module

Figure 1 shows the synthesizer driving the receiver mixer at +10 dBm and is attenuated by R202 to +3 dBm for driving the exciter input. The exciter module A102 operates from a switched 8 volt supply. A different exciter module is required for each of the three band splits. No tuning is required. Both input and output ports operate at 50 ohms impedance. The exciter module provides typically 20 dB of gain and 200 mW of output power to drive the power amplifier module.

Power Amplifier Module

The PA module U101 requires a drive of 200 mW from the exciter module to deliver up to 10 Watts power output. The module is mounted to the rear heatsink. The PA module output drives the 25 Watt PA Board through J103. The power control circuit controls the PA module output power.

Pin Diode Switch, Low Pass Filter, and Directional Coupler

The output from the 25 Watt PA Board feeds transmit pin diode switch D104 through J102. In transmit, switched 8 volts is applied through L102, turning on pin diodes D104 and D401. The DC path is completed through R401 and R402 with the bias current set at about 40 mA. D 104 couples the PA Board power from J102 to low pass filter A101. D401 provides a RF path to ground to protect the receiver input.

The low pass filter reduces the harmonic output from the transmitter. The low pass filter feeds the directional coupler, W101 and W102. The directional coupler provides a sample of

transmitter power for the power control circuit. The coupler output feeds the antenna jack J101.

Power Control Circuit

The power control circuit samples the output power to the antenna to maintain a constant power level across the band. Also, a thermistor senses the heatsink temperature to throttle the power level down above 70°C. The circuit controls the supply voltage to one of the amplifier stages in the PA module U101.

The directional coupler (W101 and W102) provides a sample of transmitter power to diode D101. D101, R106, and C104 produce a positive DC voltage proportional to the transmitter output power level. This DC level feeds the (-) input of amplifier U103-B. Power set pot R111 and thermistor R118 determine the DC level to the (+) input of U103-B. U103 -B amplifies the difference between the (-) and (+) inputs, forcing the output power level to equal the power set level by varying the drive to Q102 and Q101. Q101 supplies the control voltage to the PA module U101. For example, if the output power level begins to drop below the power set level, the output of U103-B increases positively, causing Q102 to conduct less. The base of Q101 rises, increasing the control voltage to the PA module, which increases the output power level back to the desired set level.

Q104, C123, and R105 improve the transient stability of the power control loop when the transmitter is keyed.

Transmit Switch

During transmit, the Logic Board (A1) microprocessor pulls the DPTT line low causing the output of U103-A to go low. Q103 turns on to supply SW 8V to the exciter module, the power control circuit and the pin diode switch. During receive, the output of U103-A supplies 12 volts to the receiver RF pre-amp Q401.

RECEIVER CIRCUIT

The dual conversion receiver circuit consists of a front end section, a 45 MHz first IF, and a 455 kHz second IF with an FM detector. All audio processing and squelch functions are accomplished on the Audio Board (A3).

Front End Section

RF is coupled from antenna jack J101 through the directional coupler and the low pass filter to pin diode D401. In transmit, SW 8V is applied through L102, turning on pin diodes D104 and D401, with the DC path completed through R401 and R402. D401 provides a RF path to ground for the receiver input while in transmit. In receive, D401 is off allowing RF to pass by D401 unattenuated.

Receiver front end filtering is provided by RF filters Z401 and Z402. Both filters are fixed tuned 3-pole helical filters with 20 MHz bandwidths. These filters do not require tuning unless a different 20 MHz segment of the band split is required. RF amplifier transistor Q401 is a common emitter circuit with 15 dB gain. Inductor L402 and capacitors C405 and C406 provide a broadband match from Z401 to the transistor input. Diode D402 protects the amplifier from high input signal levels. Inductors L403 and L404 plus the associated capacitors provide a broadband impedance match from the amplifier output to RF filter Z402.

Test point TP401 is a 50-ohm point for measuring front end gain or to align the receiver to another 20 MHz segment of the band split. The front end gain from antenna jack J101 to TP401 is typically 10 dB.

The mixer, Z403, is a doubly balanced diode mixer. This mixer is driven by a local oscillator signal of +10 dBm or greater to provide good inter-modulation performance, spurious performance, and local oscillator isolation. The mixer conversion loss is typically about 6 dB.

45 MHz IF

The first 45 MHz IF amplifier transistor Q501 is a junction FET operated in the common gate mode. This configuration offers a typical input impedance of 75 ohms. The output circuitry is tuned by L504 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 by L506 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 by L507 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 provides high isolation within the active device.

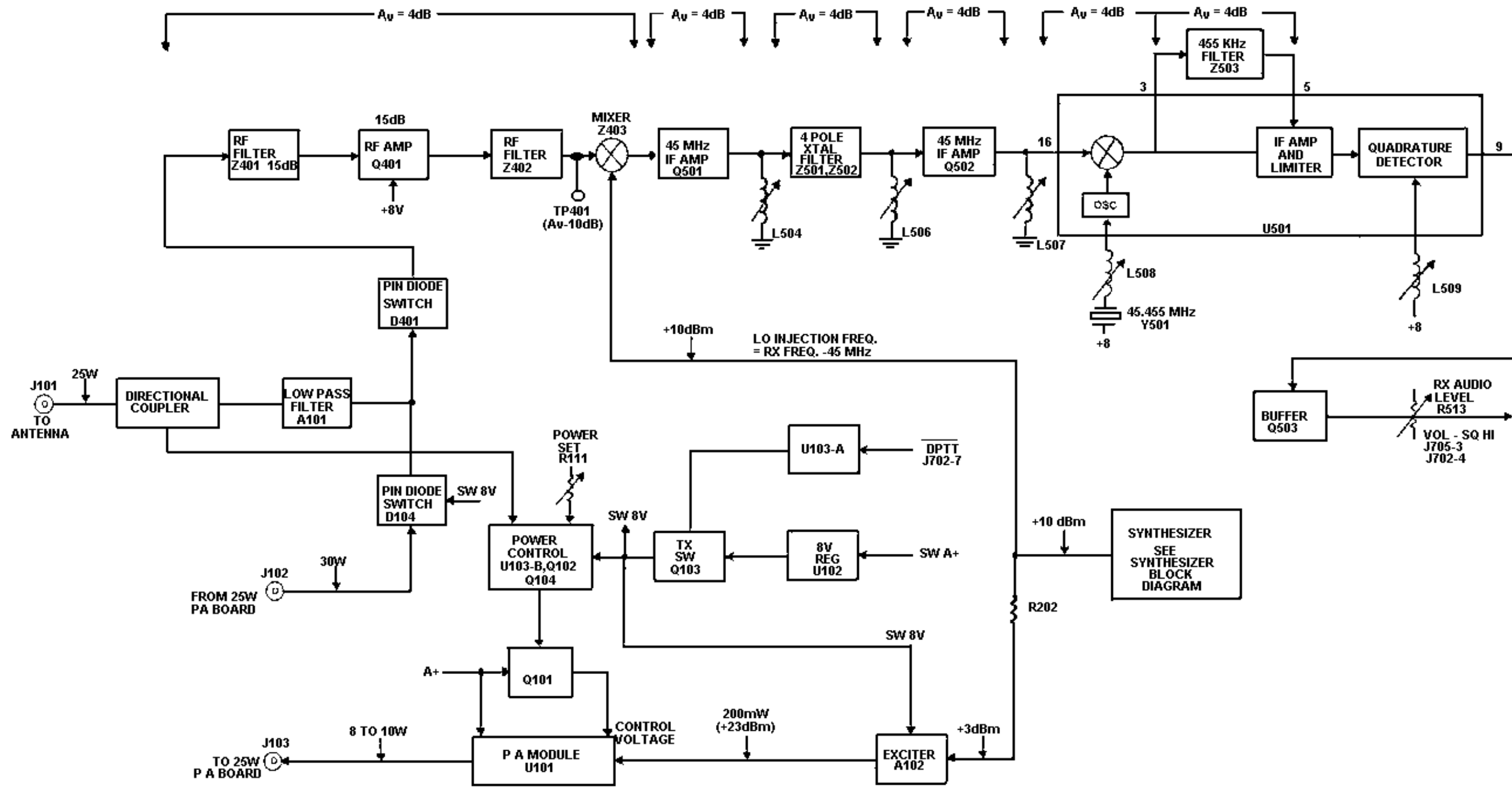
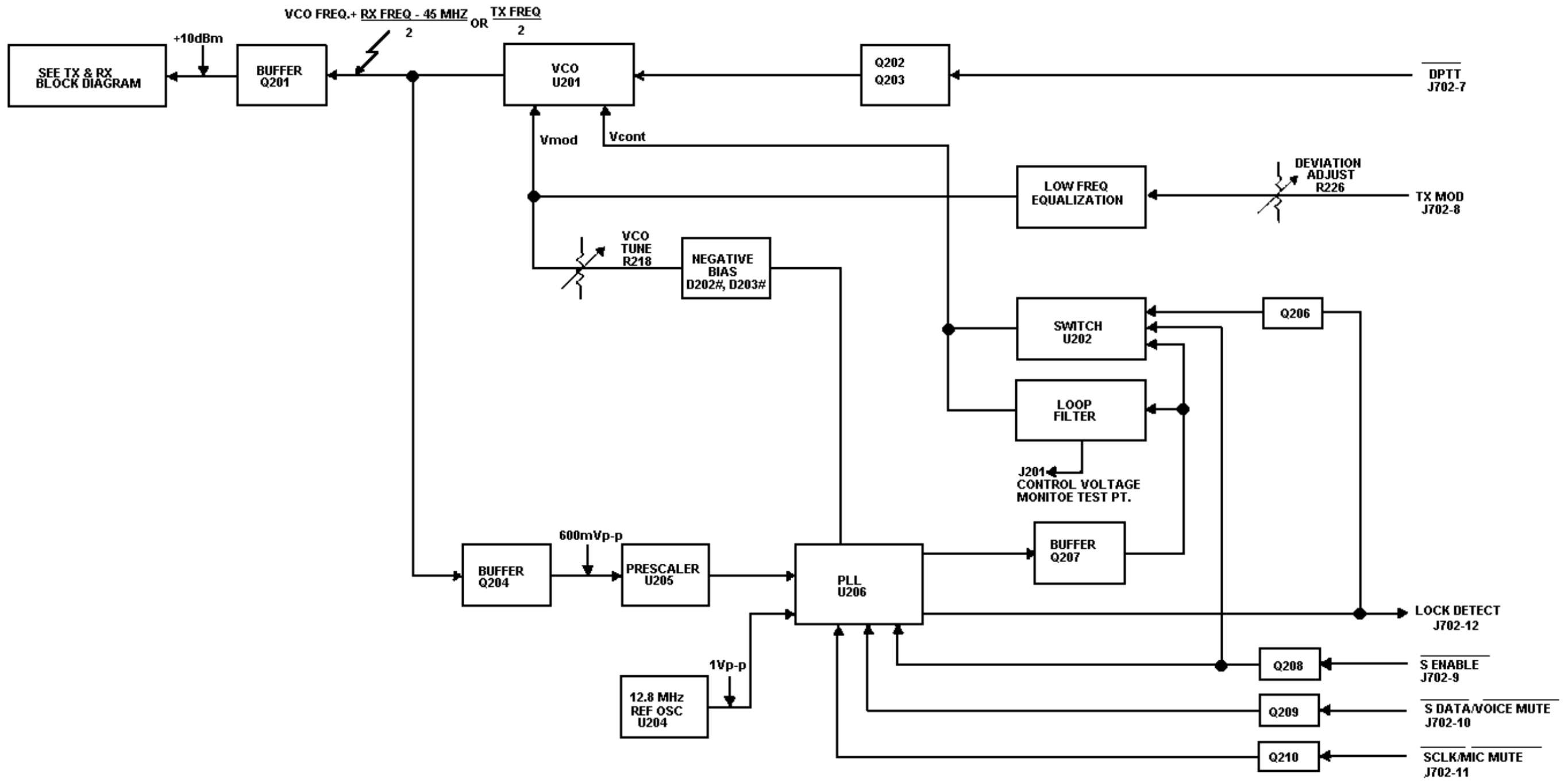


Figure 1 - TX And RX Block Diagram



R
F
B
O
A
R
D

Figure 2 - Frequency Synthesizer Block Diagram

Converter/IF/Detector IC

IF IC U501 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 R512 and capacitor C519 to reduce IF feedthrough. Buffer amplifier Q503, drives audio potentiometer R513. This allows a VOL/SQ HI signal whose amplitude may be set for proper system operation using R513.

Power Distribution

Unswitched 13.8 Volts (A+) is supplied to the RF Board through connector J704 and feeds the power control transistor Q101, the PA module U101, and 20V transient suppressor D105. D105 protects the radio from noise spikes and other overvoltage transients appearing on the input power cable.

Switched 13.6 Volts (SW A+) is supplied to the RF Board through J702 and J705 and feeds regulators U102, U207, and U502. U102 supplies 8 Volts to the transmitter switch, the synthesizer 5 Volt regulator U203, and the Logic Board (AI) through J702. U207 supplies 8.3 Volts to the synthesizer. U502 supplies 8 Volts to the receiver.

SERVICE NOTES

TRANSMITTER CIRCUIT

Most transmitter circuit problems can be isolated by checking the TX power gains shown in Figure 1 - RX and TX Block Diagram. The 25 watt PA Board may be bypassed by placing a jumper cable between J103 and J102 on the RF Board. The PA module U101 is capable of producing 10 watts output.

Transmitter DC measurements

1. First ensure that DPTT is low when the mic PTT is keyed low.

2. Check for approximately 8 volts at L105 feeding the Exciter Module. If not present, troubleshoot the TX switch circuitry, Q103 and U103.
3. Check for approximately 7 volts across resistors R401 and R402. If not present, check the pin diodes D104 and D401 and the conduction path from R401 to the TX switch Q103.
4. Check for an adjustable voltage of 0 to 12 volts on pin 2 of the PA module U101. At maximum power, with Power Set adjustment R111 fully clockwise, pin 2 should be at 12 volts. If not present, check the power control circuitry: U103, Q101, Q102, and Q104.
5. Check for 13.6 volts on pins 3 and 4 of the PA module U101, and ensure a good mechanical and electrical ground from the PA module to the bracket and casting.

RECEIVER CIRCUIT

To isolate a receiver circuit problem refer to the Receiver Circuit Symptoms and Checks chart.

RECEIVER FRONT END TUNING

Each receiver front end has been preset to a fixed 20 MHz segment of each split. To adjust the front end for another 20 MHz segment of the split, a sweep tuning procedure will be required to maintain the necessary bandwidth.

1. Apply a sweep signal generator (or tracking generator) with markers set for the desired 20 MHz bandwidth at the antenna jack J101.
2. Measure the RF signal at TP401 with a high impedance RF probe. A 50-ohm RF probe may be used at TP401 if coupling capacitor C415 is removed (if damaged, C415 may be replaced by a short piece of hookup wire).
3. Connect the RF sweep detector/display (or spectrum analyzer) to the RF probe.
4. Tune the slugs of Z401 and Z402 for the required 20 MHz bandwidth. Ripple will be 1 dB to 2 dB typical. Reduce the RF input level, if necessary, to keep Q401 out of saturation and protection diode D402 off. The filter response will not change at lower RF input levels if the front end has been tuned up correctly.

SYNTHESIZER CIRCUIT

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

RECEIVER CIRCUIT SYMPTOMS AND CHECKS

SYMPTOMS	CHECKS
<ul style="list-style-type: none"> • No Audio 	<ol style="list-style-type: none"> 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
<ul style="list-style-type: none"> • Poor SINAD 	<ol style="list-style-type: none"> 1. Consult Figure 1 - RX and TX Block Diagram for RX stage gains and troubleshoot. NOTE: Use high impedance RF probe when measuring gain at TP401. A 50-ohm probe may be used if C415 is removed. DO NOT adjust Z401 or Z402 without sweep equipment or the 20 MHz sensitivity bandwidth will be sharply reduced. 2. Input cable 3. PIN Diode switch is shorted
<ul style="list-style-type: none"> • Distorted Audio 	<ol style="list-style-type: none"> 1. Both mixer injection frequencies 2. Quadrature detector coil tuning 3. Crystal filter source and load tuning 4. Z503-455 kHz ceramic filter

DC Analysis

8.3 Vdc is supplied by regulator U207 and serves as the biasing voltage for transistor circuits Q204, Q206, Q207, Q208, Q209, and Q210. Resistor R207 decouples the 8.3 volts for use in the VCO module U201. The 10 milliamp current drain of this module results in approximately 6.5 volts DC on Pin 4. Transistor Q201 also draws approximately 25 milliamps, resulting in a collector voltage of 3.7 volts DC at the junction of resistor R204 and capacitor C201. Lack of VCO RF output will modify this voltage.

Regulator U203 uses the 8 volts from transmitter regulator U102 to generate 5 volts for U204 and U205.

Waveforms

Waveforms associated with the synthesizer were measured with a 10 megohm, 30 pF probe. Use DC coupling (see Figures 3-8).

Module Isolation

Reference Oscillator U204:

Look for a waveform similar to the reference (Figure 3) on Pin 2. If waveform is not present, the oscillator module is probably defective.

VCO U201:

Connect a DC power supply to Pin 3. With 2.5 volts DC on pin 3, the output of U201 (pin 5) should be approximately 197 MHz. With 6.5 volts DC on pin 3, the output should be approximately 212 MHz. These values are correct for the 440-470 MHz split, with the ranges 179-197 MHz and 212-233 MHz being correct for the lower and upper split, respectively.

Power output of the VCO can be measured by connecting a coax directly to the module, between pin 5 and ground. The output should be approximately 0 dBm with C237 still connected in the circuit. In transmit, a negative bias should exist on pin 1. If not present, check Q202, Q203, and C206 before removing the VCO.

Prescaler U205:

Connect pin 3 of the VCO to 4.5 volts DC. With the radio in receive, monitor the frequencies of the VCO at the connection of capacitor C210 and resistor R211. DC short pin 1 of U205 to ground to cause divide by I29 to occur. The frequency output at pin 3 should be the VCO frequency divided by 129. Tie pin I to pin 7 (5 volts) to cause divide by 128 to occur. Check pin 3 to verify that this occurs. Improper division may indicate a defective prescaler.

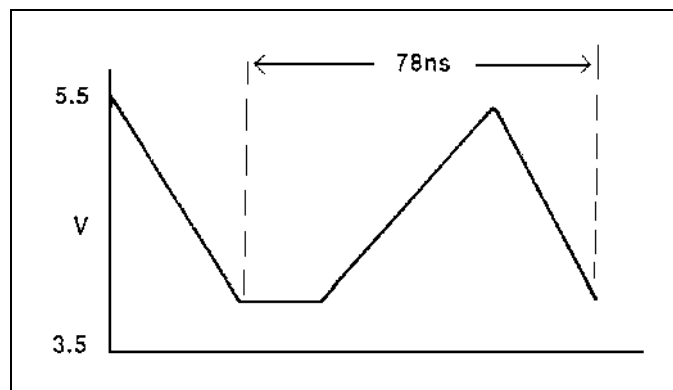
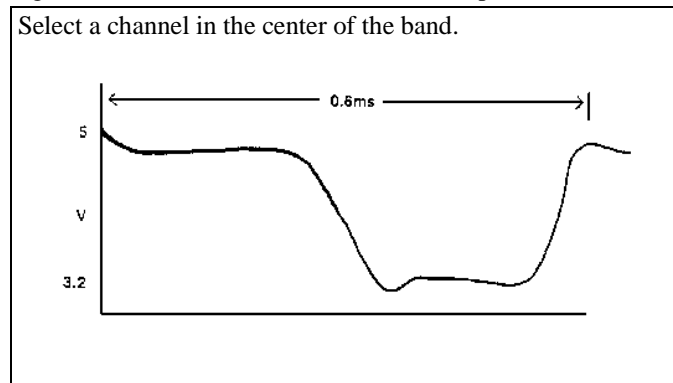


Figure 3 - REFERENCE OSCILLATOR (Input to U206, Pin 2)

Figure 4 - F_{IN} (input to U206, Pin 10)

The top of the ramp is approximately 0.8 Volt DC greater than the control voltage on PD out, Pin 17. A channel in the center of the band is shown.

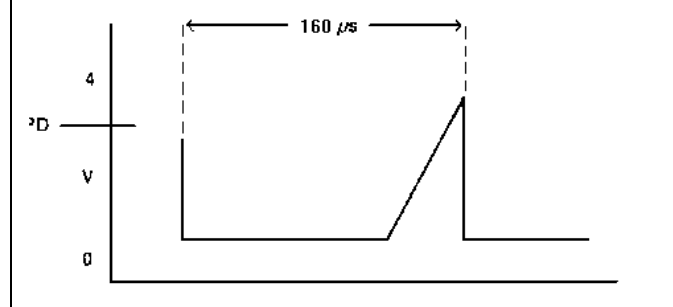


Figure 5 - RAMP (Generated in U206 and appears on Pin 15)

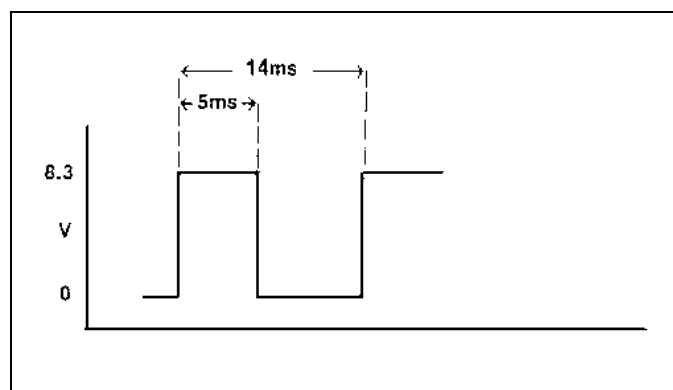


Figure 6 - S ENABLE (Input to U206, Pin 13) (Radio in

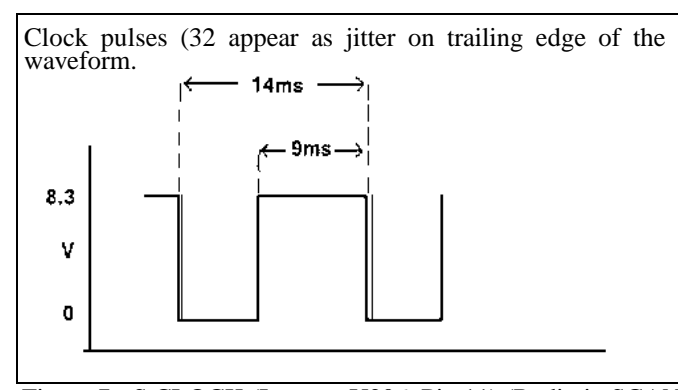


Figure 7 - S CLOCK (Input to U206, Pin 11) (Radio in SCAN on a single channel)

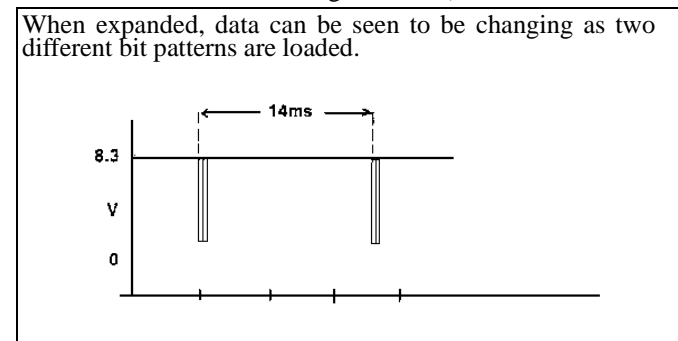


Figure 8 - S DATA (Input to U206, Pin 12) (Radio in SCAN on a single channel)

Bilateral Switch U202:

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 U206:

There are no other specific checks which aid in evaluation of U206. 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 Q201:

After checking for proper DC operation, measure the frequency and gain from the VCO, pin 5 to R202/C203. The gain should be approximately 10 dB at 2 times the VCO frequency.

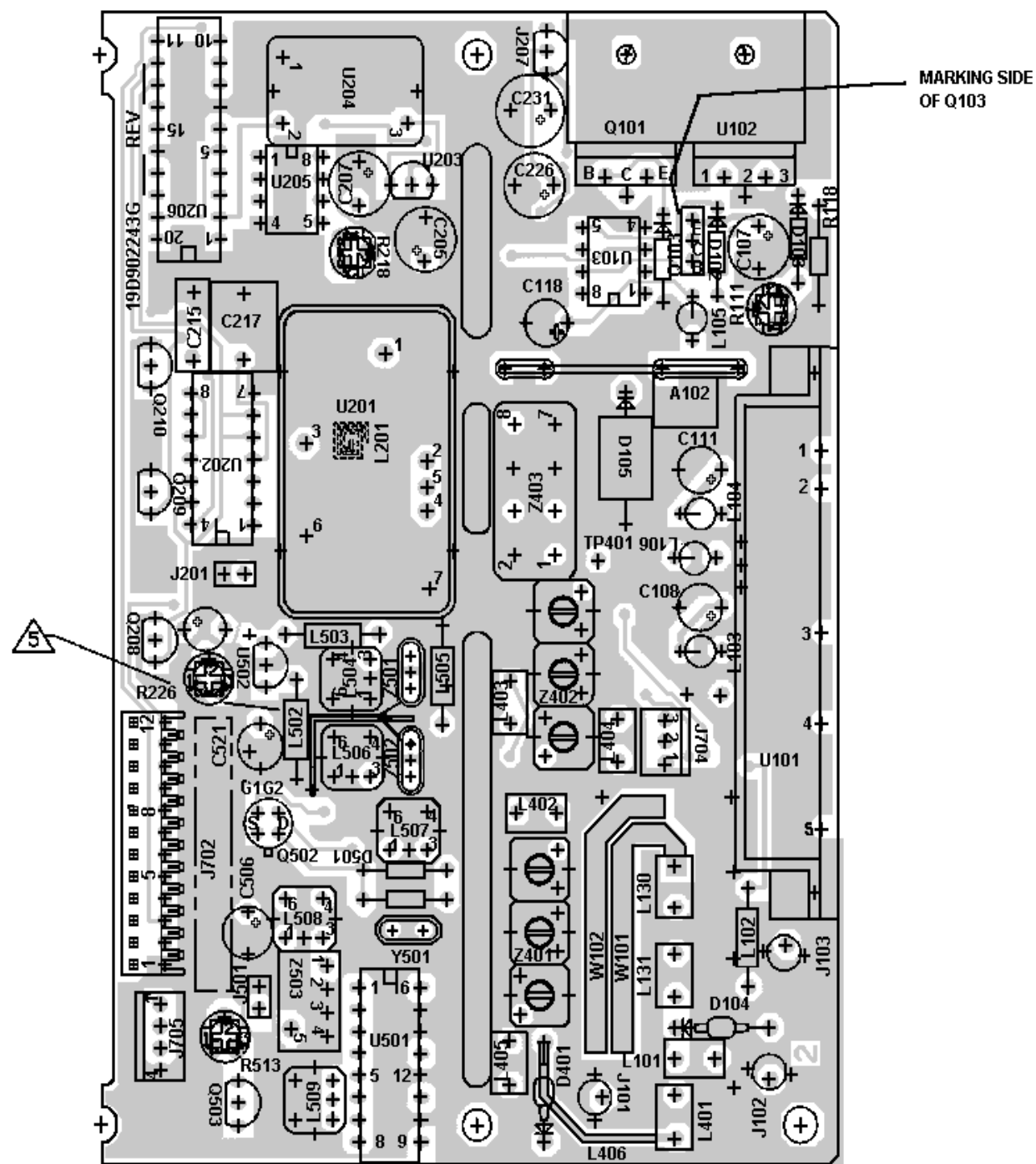
PA MODULE REPLACEMENT

To Remove PA Module U101

1. Unsolder the five leads from U101, using either solder removal braid, or a mechanical de-soldering tool. These leads are fragile and can be bent very easily. Do NOT unsolder the shield that wraps around the module.
2. Remove the RF Board from the radio chassis assembly. Refer to the disassembly procedure provided in the Service Section. Carefully slide the module out of the shield, and away from the board.

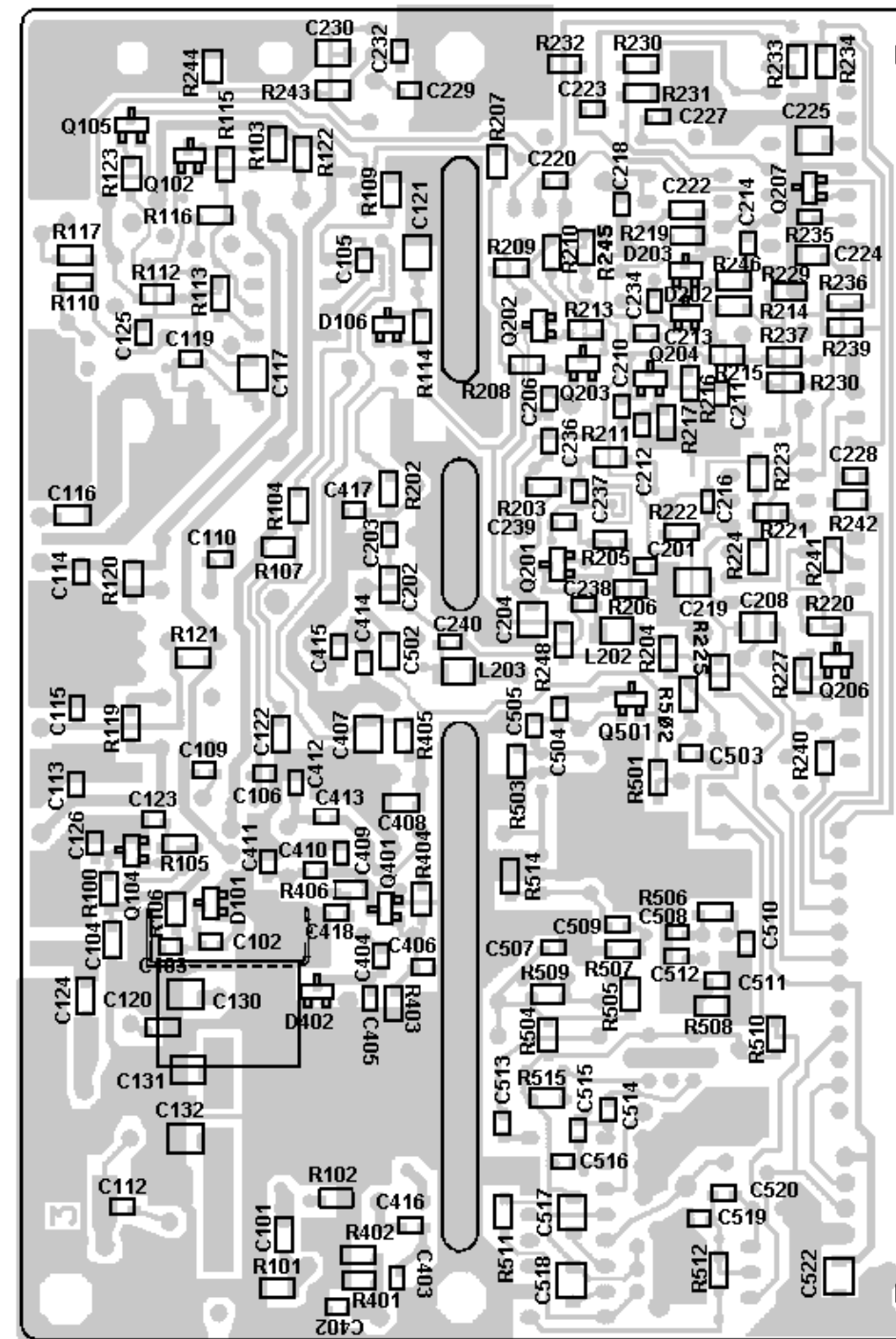
To install PA Module U101

1. Apply some silicone grease to the metal side of the replacement module.
2. Carefully insert the five leads from the module into the five corresponding PWB holes, and slide the module into the shield. Do NOT solder the leads yet.
3. Slide the RF Board assembly back into the radio frame. Reinstall all hardware, harnesses, cables, etc. Replace all screws.
4. Install the two PA bracket screws before soldering the four module leads. Trim excess wire.



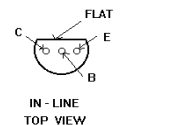
MARKING SIDE OF Q103

COMPONENT SIDE
(19D902443, Sh. 1, Rev. 5)
(19D902244, Component Side, Rev. 2)



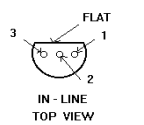
SOLDER SIDE
(19D902243, Sh. 1, Rev. 5)
(19D902244, Solder Side, Rev. 2)

LEAD IDENTIFICATION FOR Q208, Q209, Q210 & Q503



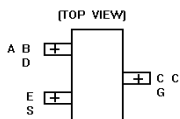
NOTE: CASE SHAPE IS DETERMINING FACTOR FOR LEAD IDENTIFICATION.

LEAD IDENTIFICATION FOR U203, U207 & U502



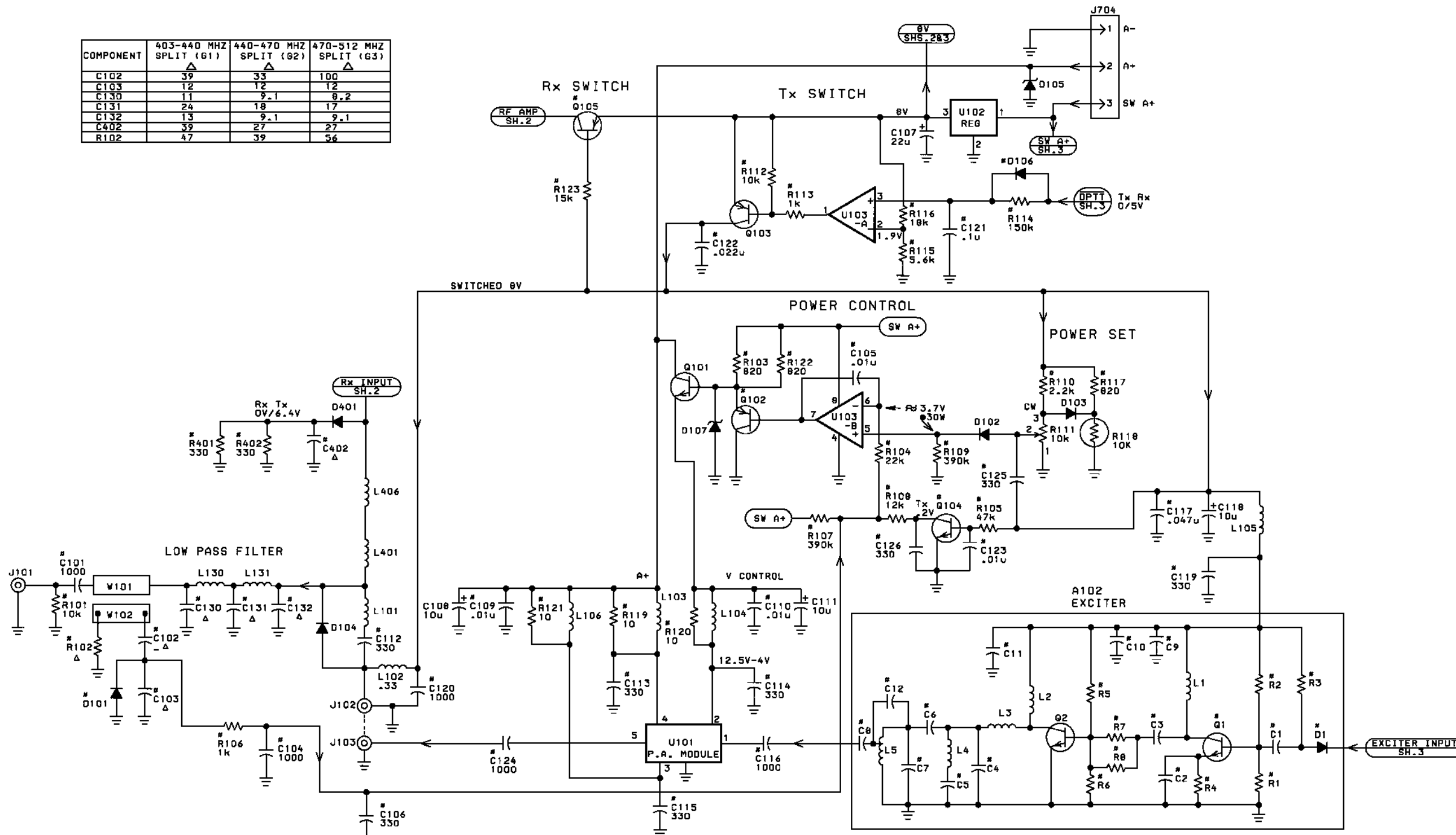
NOTE: CASE SHAPE IS DETERMINING FACTOR FOR LEAD IDENTIFICATION.

LEAD IDENTIFICATION FOR (SOT) TRANSISTORS AND DIODES



- 4 THE FOLLOWING ITEMS ARE MOS DEVICES REQUIRING SPECIAL CARE PER 19A7-1294, U202, U205, U206, & Q502.
- 5 Z501 AND Z502 ARE A MATCHED PAIR OF CRYSTAL FILTERS WHICH MUST BE ORIENTATED WITH "B" RESONATOR AS SHOWN. "B" RESONATOR IS IDENTIFIED BY DOT ON CAN.

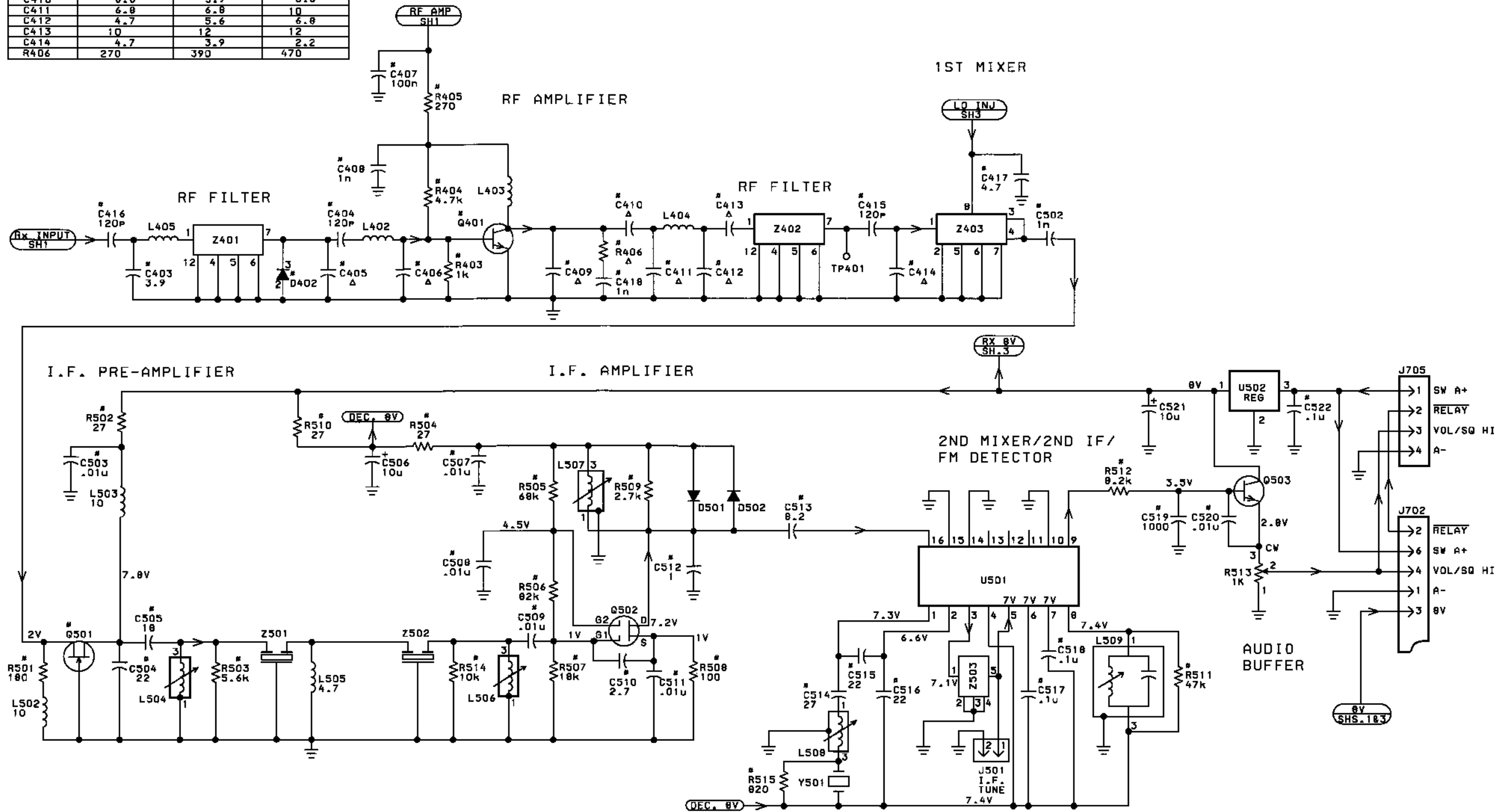
COMPONENT	403-440 MHZ SPLIT (G1)	440-470 MHZ SPLIT (G2)	470-512 MHZ SPLIT (G3)
C102	39	33	100
C103	12	12	12
C130	11	9.1	8.2
C131	24	18	17
C132	13	9.1	9.1
C402	39	27	27
R102	47	39	36

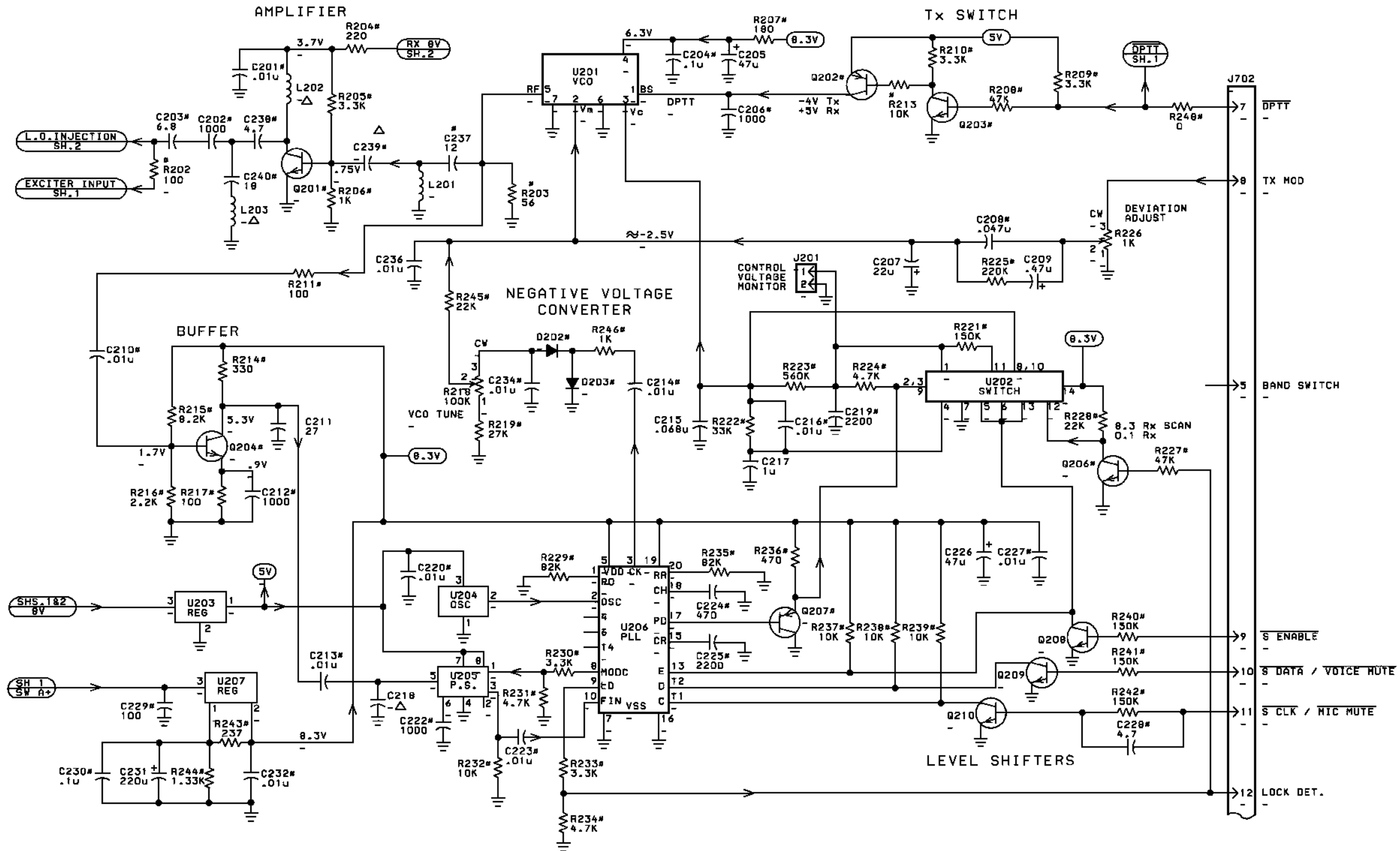


ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE SPECIFIED AND RESISTOR VALUES IN OHMS UNLESS FOLLOWED BY K-1000 OHMS OR M-1,000,000 OHMS. CAPACITOR VALUES IN PICO FARADS (EQUAL TO MICROMICROFARADS) UNLESS FOLLOWED BY u-MICROFARADS. INDUCTANCE VALUES IN MICROHENRYS UNLESS FOLLOWED BY MH-MILLIHENRYS, NH-NANOHENRYS OR H-HENRYS.

MODEL NO.	REV. LETTER
19D90224361	D
19D90224362	C
19D90224363	C
19D90224364	A
19D90224365	A
19D90224366	A

COMPONENT	403-440 MHZ SPLIT (G1)	440-470 MHZ SPLIT (G2)	470-512 MHZ SPLIT (G3)
C405	10	6.8	8.2
C406	10	5.6	12
C409	2.2	2.7	.7
C410	6.8	3.9	5.6
C411	6.8	6.8	10
C412	4.7	5.6	6.8
C413	10	12	12
C414	4.7	3.9	2.2
R406	270	390	470





RF BOARD

COMPONENT	403-440 MHZ SPLIT (G1)	440-470 MHZ SPLIT (G2)	470-512 MHZ SPLIT (G3)
L202	27NH	27NH	22NH
L203	27NH	27NH	22NH
C239	8.2	8.2	6.8
C218	27	22	22

