1. **Theory Of Operation**

1.1 **60 WATT LOW BAND POWER AMPLIFIER**

The power amplifier consists of 4 stages. The first stage, Q2110, is a Class A amplifier. Base bias is set by the 9.6V voltage being divided by R2110 and R2111.

The second stage, Q2120, power output is regulated by the power control circuitry located on the logic board.

Third and Fourth stages of amplification, Q2130 and Q2140 respectively, are powered by UNSW B+ and the output power is amplified to the 60 watt level.

The antenna switch uses pin diodes, CR2150 and CR2151, along with a current limiting resistor R2150 and components C2153, C2151, L2150, and L2151 to switch the transmitted signal to the antenna port.

The harmonic filter is a seven pole chebyshev filter. The insertion loss of the filter is designed to be less than 1 dB in the passband.

1.2 **25 WATT VHF POWER AMPLIFIER**

The 25 watt VHF amplifier consists of three basic circuits:

- Power amplifier
- Antenna switch
- Harmonic filter

The power amplifier consists of three stages. The first stage, Q2310, has its base biased up to 1.2 volts via 9.6V and limits the collector current to the device. The collector is driven by the controlled B+ voltage. This voltage determines the gain of the first stage.

The second stage, Q2320, is operated in Class C mode with UNSW B+ supplied to the collector. The first two stages amplify the signal supplied by the VCO to approximately 3 watts.

The third stage, Q2330, is a Class C amplifier and amplifies the 3 watts from the second stage to 30 watts.

The antenna switch consists of two pin diodes, CR2350 and CR2351, a pi network, C2335, C2336, L2334, C2337, C2338, and current limiting resistors. 9.6 volts is supplied to the antenna switch circuit to turn on the pin diodes in transmit. L2351 and C2351 form a 1/4 wave matching circuit at VHF.

When 9.6 volts is applied to pin diodes CR2350 and CR2351, a low impedance path is provided to the antenna through J1. A high impedance path is presented to the transmitted signal to prevent RF from reaching the receiver front end via P4.

The harmonic filter is a seven pole chebyshev lowpass filter. The 3 dB knee of the filter is designed to be approximately 205 MHz and the insertion loss of the filter is designed to be less than 1 dB in the passband.

1.3 **45 WATT VHF POWER AMPLIFIER**

The power amplifier consists of four stages. The first stage, Q2410, has a forward bias of 1.2 volts from the 9.6V line and is designed to run Class AB under a constant load to avoid load pulling of the VCO. Good return loss is also assured with the first stage acting as a buffer.

The additional stages, Q2420, Q2430, and Q2440, are operated as Class C RF amplifiers. RF input drive to the PA from the VCO is at +13.0 dBm minimum. The first two stages amplify this signal to 36.5 dBm or 4.5 watts.

The third stage, Q2430, amplifies the power to 11 watts, and the fourth stage amplifier, Q2440, supplies 65 watts to the antenna port J1.

Antenna switch and harmonic filter are the same as the 25 watt VHF PA.

1.4 **25 WATT UHF POWER AMPLIFIER**

The amplifier has 4 stages. The first stage, Q2610, is operated Class A and biased via R2610, R2611, and R2612. 9.6V voltage is applied to the collector and the biasing resistors. Nominal gain of the stage is 11.8 dB or 300 milliwatts.
The second stage, Q2620, has a nominal gain of 8.2 dB and power output of 2 watts. Output of this stage is regulated by the power control circuit located on the logic board.

The third stage, Q2630, has its collector tied directly to UNSW B+. This stage is operated Class C and has a nominal gain of 8.1 dB or power output of 13 watts.

The fourth stage, Q2640, is the final stage of amplification and has a power output of 25 watts. The stage is operated Class C and the collector is tied to UNSW B+.

The antenna switch consists of pin diodes CR2650 and CR2651, current limiting resistors, and C2652, C2650, L2651, L2652, and C2651. 9.6T voltage is applied to the antenna switch to provide the path for transmitted signal to the antenna port.

The harmonic filter is a 7 pole chebyshev lowpass filter. Insertion loss through the filter will be less than 1 dB.

1.5 UHF 40 WATT POWER AMPLIFIER

The amplifier is identical to the 25 watt UHF amplifier except for the third and fourth stages of amplification.

The first stage, Q2710, is operated Class A and the bias voltage is established by R2710, R2711, and R2712. Gain of the stage is 11.8 dB and power output is 300 milliwatts.

The second stage, Q2720, has its collector voltage regulated by the power control circuit on the logic board. Power output is 2 watts.

The last two stages, Q2730 and Q2740, are operated Class C and have nominal gains of 8.1 dB and 5.9 dB respectively. Power output of the final stage is 40 watts.

The antenna switch consists of pin diodes CR2750 and CR2751, current limiting resistors, and C2750, C2751, C2752, L2750, L2751 and L2752. The pin diodes, CR2750 and CR2751, have each been fitted into a small metal spring clip. The purpose of this is to prevent the diodes from exceeding their maximum temperature ratings under extreme conditions of heat and high VSWR.

The harmonic filter is the same as the 25 watt UHF power amplifier. Capacitors C2760, C2761, C2762, C2763, and C2764, have been changed from chip capacitors to clamped mica to handle the 40 watt power level.

1.6 800 MHZ 15 WATT AND 35 WATT POWER AMPLIFIERS

The 800 MHz power amplifier has four stages of amplification. The first stage of amplification, Q3110 (15 watt amplifier) or Q3210 (35 watt amplifier), is controlled by the 9.6T voltage supplied to the collector of each device.

The second, third, and fourth stages of RF amplification are done by using an RF module, U3120 (15 watt) or U3220 (35 watts), to boost the RF level to the necessary output power.

Controlled B+, from the power control circuit located on the logic board, is used to control the second stage of amplification located within the module.

Unswitched B+ is supplied to the third and fourth stages of amplification within the module.

The antenna switch theory of operation is the same as VHF and UHF.

The harmonic filter uses strip line inductors instead of airwound coils, but is the same type of filter arrangement as the VHF or UHF models.

1.7 POWER CONTROL CIRCUITRY

The transmit power control circuitry is common to all MaxTrac models currently being produced. The following is an explanation of the different sections of power control.

1.7.1 Control Lines

(1) Unswitched B+. This line is connected directly to the car battery. The line has a reverse polarity protection by the diode. Some line filtering is provided by the accompanying capacitors. The voltage is supplied to the third and fourth stages of RF amplification.

(2) 9.6T. This line goes to 9.6V when in the transmit mode. During transmit, 9.6T line will provide the base bias for the first stage amplifier and will supply 9.6V to the antenna switch. During the receive mode, this line is OV and the first stage amplifier and the antenna switch are turned off.

(3) Controlled B+. This line controls the power out of the PA by regulating the collector voltage to the second stage amplifier.

(4) Current Sense HI/LO. Uses current sensing as an indication of the RF power output. These two lines provide negative feedback to the transmitter power control, located on the logic board, so that power regulation is achieved.

1.7.2 Over-Current Protection

When the radio is keyed up and the RF signal is sent through the PA Deck, the Final PA will start drawing current. A small metering resistor is used to measure the Final's collector current. CURRENT SENSE HI (P7–3) is tied directly to the top of the metering resistor, which is tied to the + battery lead. CURRENT SENSE LO (P7–4) is tied to the bottom of the metering resistor, and under normal conditions should be no more than a few hundred millivolts below B+. These lines are tied to the +/− inputs of the op Amp U451B, which is located on the logic board. The output of U451B will be a positive voltage (6–8V DC) directly proportional to the amount of current drawn by the Final PA stage.

The current detect voltage is then sent to the emitter follower Q454, whose output will be summed with samples of the +9.6v and SWB+ lines. This summed voltage is applied to the inverting input of the comparator U451A. If there is an
increase in +9.6v, SWB+, or PA Current, the voltage at U451A–2 will increase causing a decrease in voltage at U451A's output (pin 1).

The decreased voltage out of U451A is seen on the base of Q453 and will cause it to decrease conduction. Q453 is supplying a base current path for the Control Voltage Amps, Q451 and Q452. When Q451 and Q452 conduct less they will pass less of the battery voltage from their emitters to their collectors. This will decrease the voltage on the CONTROLLED B+ line.

1.7.3 DAC Reference Voltage

The non-inverting input to the Comparator U451A, is the sum of a reference voltage coming from the DAC IC U801 and a sample of the +9.6V DC supply. This input voltage to U451A will typically be 4–6V DC. When the radio is keyed, the microprocessor loads data into U801 using the SR DATA, SR CLK, and DAC LE lines. U801 converts this digital information into analog voltages at its outputs Q1–Q6. By summing two or more of these outputs, a more precise output voltage can be obtained. Q1 and Q2 are summed together using the resistive network of R808–11. +9.6V DC is divided by R462 and R463. All of these inputs sum together to charge the capacitor C461. The charged voltage of C461 is then applied to the positive input of the comparator, U451A.

1.7.4 Over-Temperature Protection

In order to protect against an over-temperature condition, the radio's microprocessor calculates the temperature of its PA Deck. It keeps track of Temp Sense from the RF Board, the amount of time the transmitter is keyed, and the amount of time the transmitter is unkeyed. If the calculated temperature should increase past a safe value stored in the memory of the radio, the microprocessor will cut back on the reference voltage via U801.

1.7.5 Control Voltage Shutback

The CONTROLLED B+ is fed into an Analog to Digital Converter (ADC) port on the microprocessor on U802 pin 45. The ADC’s output is written into RAM approximately every 17 ms. This value is then compared against the maximum control voltage variable in the code plug. If the radio's control voltage exceeds the maximum control voltage variable, the the power out DAC voltage is decremented by one. Since the DAC is decremented by one, it will take a maximum of 270 ms to shut back the Control Voltage from maximum to minimum.

2. Troubleshooting

Transmit problems can be found in one of three areas:

- Modulation path
- RF path
- Power Control circuitry.

The J7–P7 connection between the logic board and PA deck can be helpful in determining where to start the troubleshooting. The “LOW TRANSMITTER POWER” chart will also help to isolate the problem to a certain area.

Take voltage readings on the J7 pins and compare your readings with those shown in Table 1. Power control loops that exist between the PA deck and the logic board will have to be “broken” before you can isolate to the problem.

| J7–1  | 9.6T | 0V DC | +9.6V DC |
| J7–2  | CTL B+ | 2V DC | 3–12.5V DC |
| J7–3  | CURRENT SENSE + | BATTERY | BATTERY |
| J7–4  | CURRENT SENSE - | BATTERY | (J7–3)–X00 MV DC |
| J7–5  | UNSW B+ | BATTERY | BATTERY |

On the logic board, begin to isolate transmit problems at P7–2. The controlled B+ voltage to the PA can be substituted here by carefully prying up on the plastic finger holding the P7–2 pin. After removing this wire and pin from P7–2, supply a good DC voltage from either an external power supply or by using a jumper wire from P7–2 to J6–1. This will supply 9.6 V DC to the PA Deck. If the radio keys up with good power output, then the PA deck is good and the problem is in the power control circuitry located on the logic board.

Refer to the troubleshooting chart “LOW TRANSMITTER POWER OUT” for power control circuit problems. This chart will guide you through the logic board power control circuitry.

No or low power out of the radio with a good external DC voltage indicates a problem either in the PA deck or VCO. Check the power level out of the RF board. This level should be a minimum of +13 dBm or 20 milliwatts. If a proper reading is not obtained, refer to the RF board section and the troubleshooting chart on Synthesizer/VCO.

A good RF level at J5 verifies a PA deck problem. Visually observe the power amplifier for signs of component failure such as burned resistors or inductors.

Check the 9.6T voltage when the transmitter is keyed. If 9.6 volts is not measured, troubleshoot the PA deck first stage amplifier and the antenna switch for component failure. Also verify that the problem does not exist on the logic board.

Verify that UNSW B+ is measured on the collectors of the PA finals.

With a RF Detector Probe, such as the RTL4075A, measure the output of each stage. Check for a DC voltage that is equal to the RMS value of the signal under test. Refer to the schematic for parts location.

The PA’s final amplifiers operate in Class C—the amplifiers draw no current when no input signal is present. Observe the current drain of the PA deck while in transmit to determine if the driver transistors or PA finals are drawing current. Also verify that the current sense resistors are the
correct resistance. Refer to the "LOW TRANSMIT POWER" chart for correct resistance readings.

**IMPORTANT**
For the PA to operate as designed, proper soldering of the power module leads is critical in all bands, but even more so in the 800 MHz models.

In the VHF PA, the amplifier's (Q2320) body must be soldered to the mounting plate. A defective solder joint will cause symptoms of no power, or low power out.

Verify that the pin diode circuitry is working properly. Check the pin diodes with an ohmmeter if you suspect a bad diode. An ohm–check through the harmonic filter may also help locate a bad component.
1. Radio Disassembly and Assembly

1.1 TO REMOVE CONTROL HEAD AND CHASSIS COVERS

(1) Remove control head mounting screws (Figure 1). Pull control head off and away from the radio.

(2) Remove the two chassis cover screws from each side (Figure 1). Remove top and bottom covers from chassis.

1.2 TO REMOVE RF CHASSIS SHIELD

Remove RF chassis shield by prying each of the four corners at the indentations provided (Figure 2). Be careful not to over bend any one corner.

1.3 TO REMOVE THE POWER AMPLIFIER HEATSINK (EXCEPT LOW BAND AND 35 WATT 800 MHZ)

(1) Disconnect the transmit and receive coaxial cables from the RF Board (Figure 3).

(2) Disconnect the 5-pin connector from the logic board (Figure 4).

(3) Remove the heatsink mounting screws (Figure 4). Pull heatsink off of chassis while carefully feeding the transmit and receive coax cables through their respective holes in the chassis.

1.4 TO REMOVE THE POWER AMPLIFIER HEATSINK (LOW BAND AND 35 WATT 800 MHZ ONLY) (REFER TO Figure 5)

(1) Disconnect the transmit and receive coaxial cables from the RF board.
(2) Disconnect the 5-pin connector P2180 from its mating connector J2180 on the Feedthru Capacitor board.

(3) Remove six screws securing the heat sink cover to the heat sink. Remove heatsink cover.
1.6 TO REMOVE THE LOGIC CIRCUIT BOARD

(1) After the RF board has been removed, turn the radio over and pry off the logic shield (Figure 7), again being careful not to bend any one corner or side.

(2) Remove all logic board mounting screws (Figure 7).

(3) No remove the two regulator heat sink mounting screws from the side of the chassis (Figure 7). The logic board can now be lifted out of the chassis.

1.7 TO REMOVE THE POWER AMPLIFIER CIRCUIT BOARD (EXCEPT LOW BAND AND 35 WATT 800 MHZ)

(1) Remove the power amplifier shield by carefully prying each corner and side until you can slide the shield off easily (Figure 8). Remove the shield completely by guiding the coaxial cables out.

(2) Unsolder the A+ power connector feedthru leads and the antenna connector lead (Figure 9).
(3) UHF ONLY – Remove the stud mount transistor mounting nut from the back of the heat sink (Figure 11).

(4) Remove two power device mounting screws and all P.A. board mounting screws (Figure 9 and Figure 10), and then take out the P.A. board.

(5) Apply heat from the soldering iron to the (–) lead of the power connector while simultaneously lifting the board upward at an angle until antenna connector clears the hole in the heatsink.

1.9 TO RE-ASSEMBLE THE RADIO (EXCEPT LOW BAND AND 35 WATT 800 MHZ)

Reverse the disassembly procedure and tighten all screws to the torques specified in Table 1.

1.10 TO RE-ASSEMBLE THE RADIO (LOW BAND AND 35 WATT 800 MHZ ONLY) (REFER TO Figure 5)

(1) Set the circuit board into the heatsink.

(2) Reinstall lock washer and nut securing antenna connector J1 and tighten.

(3) Reinstall five transistor mounting screws and tighten.

(4) Reinstall eight circuit board mounting screws and tighten. Note that the hole marked “*” is secured by one of the heatsink cover mounting screws, so do not install board mounting screw in this hole.

(5) Reinstall Feedthru Capacitor Board to heatsink wall using two screws.

(6) Reassemble heatsink to radio chassis and secure with four heatsink mounting screws.

(7) Reconnect 5–pin connector P2180 to J2180 on Feedthru Capacitor Board, and reconnect two coaxial cables to RF board.

(8) Replace heatsink cover and secure with four cover mounting screws.

2. Programming

The MaxTrac radios can be programmed in the field to these parameters:

- Receive and Transmit frequencies
- Transmit Frequency Adjustment (warp)
- PL or DPL encode and decode Codes
- Transmit Power Output
- Transmit Deviation
- Time Out Timer
- Mode Slaved Scan List

Configuration information for programming these parameters is contained in the MaxTrac RADIO SERVICE SOFTWARE package (RVN4019C for 5.25 inch drives and RVN4020C for 3.5 inch drives).

A personal computer (P.C.) and the appropriate software Diskette will be required in addition to the items listed in Recommend Test Equipment.

We strongly suggest the servicer become familiar with the programming techniques applicable to the MaxTrac Radios.
<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>LOCATION</th>
<th>QTY</th>
<th>DRIVER SIZE</th>
<th>INPUT TORQUE</th>
<th>REPAIR TORQUE</th>
<th>ILLUSTR. REF.</th>
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<tr>
<td>03-10945A11</td>
<td>Plastite M3 x SLT. Torx Pan Head</td>
<td>Control Head Brds. and Int'l. Spx'y</td>
<td>9</td>
<td>T10</td>
<td>8 in. lbs.</td>
<td>7 in. lbs.</td>
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<td>03-80270L01</td>
<td>Machine M4 x .7 x 38 Torx. Cap Screw Blk.</td>
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<td>T15</td>
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<td>Taprite M2.5 x 8 Slt. Torx. Pan Head</td>
<td>Regulator H.S. Device Mounting</td>
<td>5</td>
<td>T8</td>
<td>6–8 in. lbs.</td>
<td>4–6 in. lbs.</td>
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<td>RF/Logic Brd. Mounting</td>
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<td>T10</td>
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<td>03-10943M10</td>
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<td>8–10 in. lbs.</td>
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<tr>
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<td>Regulator H.S. Device Mounting</td>
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<td>03-10943R55</td>
<td>Taprite M3 x 8 Torx. Flat Blk.</td>
<td>Chassis Covers</td>
<td>4</td>
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<td>External Speaker Mounting Trunnion</td>
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<td>Field Inst.'</td>
<td>Field Inst.'</td>
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<td>03-00140001</td>
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<td>18–20 in. lbs.</td>
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<td>—</td>
<td>—</td>
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<td>03-84244C03</td>
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<td>External Speaker Mounting Trunnion</td>
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<td>—</td>
<td>Field Inst.'</td>
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<td>Radio Mounting Trunnion</td>
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<td>T25</td>
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<td>T10</td>
<td>9–11 in. lbs.</td>
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