Chapter 4
Circuit Descriptions

The RF from the exciter/driver assembly connects from the RF Output "N" Jack J25, through a RG-55 cable, to the PA RF Input SMA Jack J200, located on the rear of the PA chassis assembly. The RF Input is cabled through UT-141 to port J111 on the main chassis. Jack J1 on the PA module assembly connects to the J111 port when the module assembly is slid into place.

The RF output from the 2 way UHF combiner connects to the PA RF Output Jack J2, located on the rear of the PA Module. Jack J2 on the PA module connects to the J115 port, on the main chassis assembly, when the module assembly is slid into place.

4.1 (A4) Power Amplifier Module Assembly (1302868; Appendix B)

The Power Amplifier Module Assembly contains (A1) a UHF Phase/Gain Board (1303213), (A2) a 150W Driver Pallet, Dual Output (1303293), (A3 & A4) UHF RF Module Pallet Assemblies (1300116), (A5) a 2 Way UHF Combiner Assembly (1303208), (A6) an Amplifier Control Board (1301962) and (A7) a Temperature Sensor IC.

4.1.1 (A1) UHF Phase/Gain Board (1303213; Appendix B)

The RF input from J1 on the PA assembly connects to J1 on the Phase/Gain Board. The UHF phase/gain board provides the circuits that adjust the gain and the phase of the RF signal for the PA amplifier assembly in which it is mounted. The input signal connects to the gain circuit through the capacitor C13. The gain circuit consists of U1, R16, CR4, R22, R17, CR5, R23, R27 and the gain pot, R25. U1 is a 90°, 2-way splitter. The signal at pin 1 of U1 is split and applied to pins 3 and 4. The signal reflects off CR4 and CR5 and is passed to pin 2. The gain between pins 1 and 2 changes with the voltage applied across CR4 and CR5. This voltage is controlled by the gain-adjust pot R25. The more positive the voltage, the more the diodes CR4 and CR5 conduct therefore the less gain through the circuit. The gain controlled output is coupled through C14 and the pi-type divider circuit consisting of R8, R5 and R9 that drops the level before it applied to the phase-shifter circuit.

The level controlled signal connects to the phase-shifter circuit that consists of U2, C20, C21, CR2, and CR3. U2 is a 90°, 2-way splitter. The signal at pin 1 of U2 is split and applied to pins 3 and 4. The signal reflects off CR2 and CR3 and is passed to pin 2. The phase shift between pins 1 and 2 changes with the voltage applied across CR2 and CR3. This voltage is controlled by the phase-adjust pot R24 through R26, R18 and R19. +12 VDC from an external switching power supply is applied to J3 on the board and is used as the reference that is applied to the phase-control pot. The gain and phase controlled output connects to J2 on the board.

4.1.2 (A2) 150 Watt Driver Pallet Assembly, Dual Output (1303293; Appendix B)

The output of the Phase/Gain Board is connected to the input J1 of (A2) the 150 Watt UHF amplifier assembly. The assembly contains a 150 Watt CW UHF Driver Board, Dual Output (1303169).

4.1.3 150 Watt Driver, Dual Output (1303169; Appendix B)

The board operates class AB and is a highly linear broadband amplifier for the frequency range of 470 to 860 MHz. It can deliver an output power of 150 watts (CW) with approximately 14 dB of gain.

The amplification circuit consists of LDMOS transistors Q1 and Q2 connected in parallel and operating class AB. The paralleling network is achieved with the aid of 3 dB couplers U3 and U4. The quiescent current settings are achieved by means of potentiometers R6 and R10. C39 and C38 are adjusted for best response. The settings are factory implemented and should not be altered.

PIN diode VR1 is a variable-damping circuit that is used to adjust the amplification of the module. The adjustment is performed with the Gain potentiometers R10 and R6. A readjustment of the amplification may be required, after repair work, to ensure that the PAs in multiple PA translators deliver the same output power.

4.1.4 (A3 & A4) UHF Module Assembly, RF Module Pallet, Philips (1300116;Appendix B)

The UHF Module Assembly, 250-watt module (Figure 4-1) is a broadband amplifier for the frequency range 470 to 860 MHz. The amplifier is capable of delivering an output power of 70 W_{rms}. The amplification is approximately 13 dB.

The amplification circuit consists of the parallel connected push-pull amplifier blocks V1 and V2 operating in class AB. In order to match the transistor impedance to the characteristic impedance of the input and output sides, matching networks are placed ahead and behind the amplifier blocks. Transformers Z3 to Z6 serve to balance the input and output signals. The paralleling circuit is achieved with the aid of 3-dB couplers Z1 and Z2.

The working point setting is factory implemented by means of potentiometers R9, R11, and R12 and should not be altered.

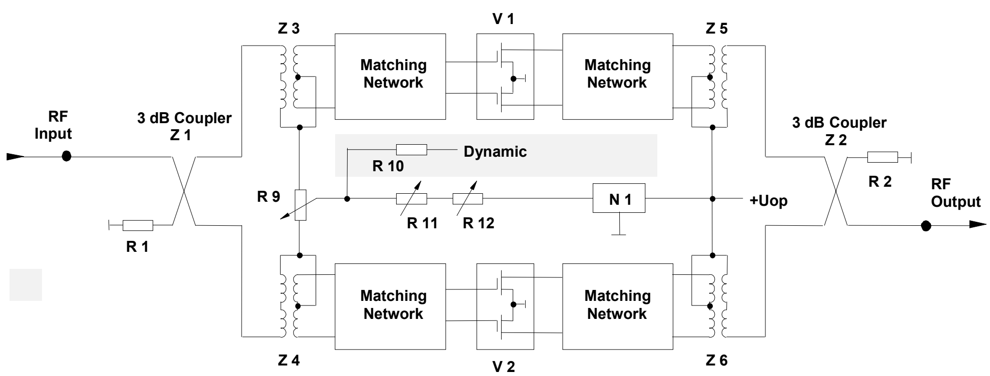

Figure 4-1. UHF Amplifier Module, 250 Watts

4.1.5 (A5) 2 Way UHF Combiner Assembly (1303208; Appendix B)

The 2 Way UHF combiner board assembly combines the two outputs of the UHF Module Assemblies and also provides forward and reflected power samples of the output to (A6) the amplifier control board where it connects to the input of the overdrive-protection circuit.

The RF inputs to the 2 way UHF combiner assembly, from the UHF amplifier modules, are soldered to the external connection points J3 and J4. The RF is combined by the stripline tracks and R5 a 100 ohm matching resistor across the two inputs, to the RF Output solder connection point at J5. A hybrid-coupler circuit picks off a power sample that is connected to SMA type connector jack J1 as the forward power sample. Another power sample is taken from the coupler circuit that is connected to SMA type connector jack J2 as the reflected power sample. Two 50Ω terminations, created from two 100 ohm resistors in parallel, used as dissipation loads, connect from the forward and reflected ports to ground.

4.1.6 (A5) Amplifier Control Board (1301962; Appendix B)

The amplifier control board provides LED fault and enable indications on the front panel of the module and also performs the following functions: overdrive cutback, when the drive level reaches the amount needed to attain 110% output power; and overtemperature, VSWR, and overdrive faults. The board also provides connections to the LCD Display for monitoring the % Reflected Power, % Output Power, and the power supply voltage.

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U4, located upper center of page, is an in circuit microcontroller. The controller is operated at the frequency of 3.6864 MHz using crystal Y1. Programming of this device is performed through the serial programming port J2. U4 selects the desired analog channel of U1 through the settings of PA0-PA3. The outputs of Port A must be set and not changed during an analog input read of channels PA5-PA7. PA4 of U4 is a processor operating LED that monitors the +/-12 VDC. PA5 is used to monitor the +12VDC supply to the board. PA6 is the selected channel of analog switch U1. PA7 is connected to a via, V10, for future access.

U6 is a serial to RS-485 driver IC. U7 is a watchdog IC used to hold the microprocessor in reset, if the supply voltage is less than 4.21 VDC. U7 momentarily resets the microcontroller if Pin 6 (!ST) is not clocked every second. A manual reset switch is provided but should not be needed.

Upper left corner U3 is used to determine where the amplifier control board is located. The eight inputs come from the main amp connector and are used to set the SCADA address of the controller. Pull-up resistors set a default condition of logic high.

U5 below U3 is used for getting digital input information of the board. Page two has several monitoring circuits that provide information on the amplifier's status. Many of these circuits automatically shut down the amplifier if a specific fault occurs.

U8 below U5 is used to control four board mounted status LEDs. A FET is turned On to shunt current away from the LED to turn it Off. U9 below U8 is used to enable different features within the software. Actual use is to be determined.

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In the lower right corner are voltage regulator circuits. U22 should allow for 0.14 amps of power using its 92 C/W rating if Ta = 60°C max and Tj = 125°C max 0.26 amps can be obtained from U22 if the mounting pad is 0.5 square inches. The controller will not need this much current.

U23 and U24 are low drop out +5 VDC, voltage regulators with a tolerance greater than or equal to 1%. 100mA of current is available from each device but again the controller will not need this much current.

In the upper left section are circuits with U12 and U13. U12 is used to generate a regulated voltage that is about 5 volts less than the +32 VDC supply, approximately +26.25 VDC. When the +32 VDC supply is enabled, the circuitry around U13B is used to provide gate voltage to Q10 that is 5 volts greater than the source pin of this FET. The gate of Q10 can be turned Off by any one of a few different circuits.

U10A is used to turn Off the gate of Q10 in the event of high current in amplifier #1. At 0.886 VDC the current to amplifier #1 should be greater than 5 Amps. U11B is used to turn off the Q10 FET, if high current is detected in amplifier #2. U11A is used to turn off the Q10 FET, if high current is detected in amplifier #3. With 2.257 VDC at Pin 5 of U11B or Pin 3 of U11A, the voltage output of current sense amplifier U17 or U18 at high current shut down should be greater than 15 Amps.

U14B is used to turn Off the gate of Q10 in the event of high power supply voltage, approximately +35.4 VDC. U14A is used to keep the FET disabled in the event of low power supply voltage, approximately +25.4 VDC.

Current monitoring sections of the board.

The ICs U16, U17 and U18 along with associated components set up the current monitoring sections of the board. R67, R68 and R69 are 0.01Ω/5W 1% through hole resistor is used for monitoring the current through several sections of the amplifier. The voltage developed across these resistors are amplified for current monitoring by U16, U17 or U18. The LT1787HVCS8 precision high side current sense IC amplifier accepts a maximum voltage of 60 VDC. The 43.2 kΩ resistor from pin 5 to ground sets the gain of the amplifier to about 17.28. This value is not set with much accuracy since the manufacturer internally matches the resistors of this part but their actual resistance value is not closely defined. A trimming resistor is suggested to give a temperature stability of −200 ppm/C, but instead the microcontroller will determine the exact gain of the circuit and use a correction factor for measurements. Circuit loading components are located in the lower portion of each current monitoring circuit. These components allow for short duration high current loading of the supply. By measuring the current through the sense resistor with and without the additional four 30.1 Ω 1% resistors. For very short duration pulses, a 1206 resistor can handle up to 60 watts. The processor requires 226 uSec per conversion. A supply voltage of +32 VDC will pass 1.06 amps + 1% through the load resistors.

A6 is a temperature sensor thermistor that is used to monitor the temperature of the module's heat sink. It connects to J6 pins 1 & 2 on the board wand is wired to the comparator IC U10B. If the temperature increases above 75°C the output will go Low that is used as a temperature fault output, which generates a Fault alert at U15A and disables Amplifier #1.

Aural, Visual/Average and Reflected power detector sections of the board.

Page 3

A Forward Power Sample enters the board at SMA Jack J3 and is split. One part connects to J4 on the board that is cabled to J1, the SMA Forward Power Sample Jack, located on the front panel of the assembly. The other part of the split forward power sample is detected by CR17 and the DC level amplified by U25A. The output of U25A at pin 1 is split with one part connected to the Aural Power sample, which is not used in this digital translator. The other split output connects to U265A that is part of the Forward Average Power circuit. The detected level is connected to L4 that is part of an intercarrier notch filter circuit that is tuned to eliminate the 4.5 MHz aural intercarrier, if present. The Average power sample is amplified by U26D and connected through the average calibration pot R166 to U26C. The output of U26C is connected to the comparator IC U26B that has Aural Null and Offset Null, if present in the system, connected to the other input. The output Average Forward power level connects to J9 pin 2 of the board.

A Reflected Power Sample enters the board at SMA Jack J5 and is detected by CR20 and the DC level amplified by U28B. The output of U28B at pin 7 is connected through the reflected calibration pot R163 to U28C. The output is split with one part connected to J9 pin 5, the Reflected Power Output level of the board. The other part of the split from U28C connects to the comparator IC U28D that has a reference level connected to the other input. If the reflected level increases above the reference level a low output is produced and connected to the Reflected Power Shutdown circuit at CR28. The low shuts off Q14 causing pin 3 to go high that is connected to the inverter U15C. The output of U15C goes low producing a Reflected Power Fault that is connected to an output of the board, the Fault Alert circuit and also shuts down Amplifier #1.

Gain of the power measurements is completed through software. Only the Aural Null and Offset Null need to be done through front panel pots.

4.2 Power Supply Assembly (1302863; Appendix B)

The Power Supply Assembly contains (A1) a +32V/2000W switching power supply (1301504) and (A2) a ±12V/40W switching power supply (1303242). The +32VDC connects through J1 (+32VDC) and J2 (RTN) to the rest of the amplifier assembly. The +/-12VDC outputs, the +32VDC control lines and the 220VAC connect to the assembly through Jack J3.

Both power supplies contain no customer adjustments.

This completes the description of the Power Amplifier Module Assembly and the Power Supply Assembly.