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Colin Hinson
In the village of Blunham, Bedfordshire.

AM7175

UHF POWER AMPLIFIER

OPERATOR MAINTENANCE TRAINING MANUAL

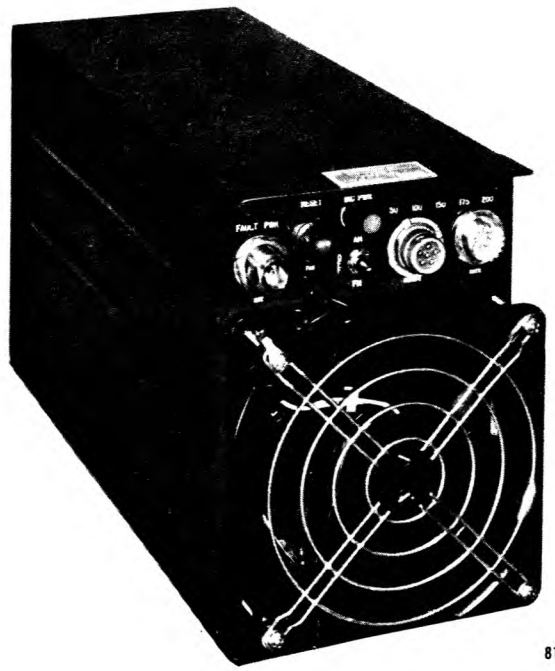
MOTOROLA INC.

Government Electronics Group

AM-7175
UHF POWER AMPLIFIER

OPERATION AND OPERATOR MAINTENANCE TRAINING MANUAL

JANUARY 1989



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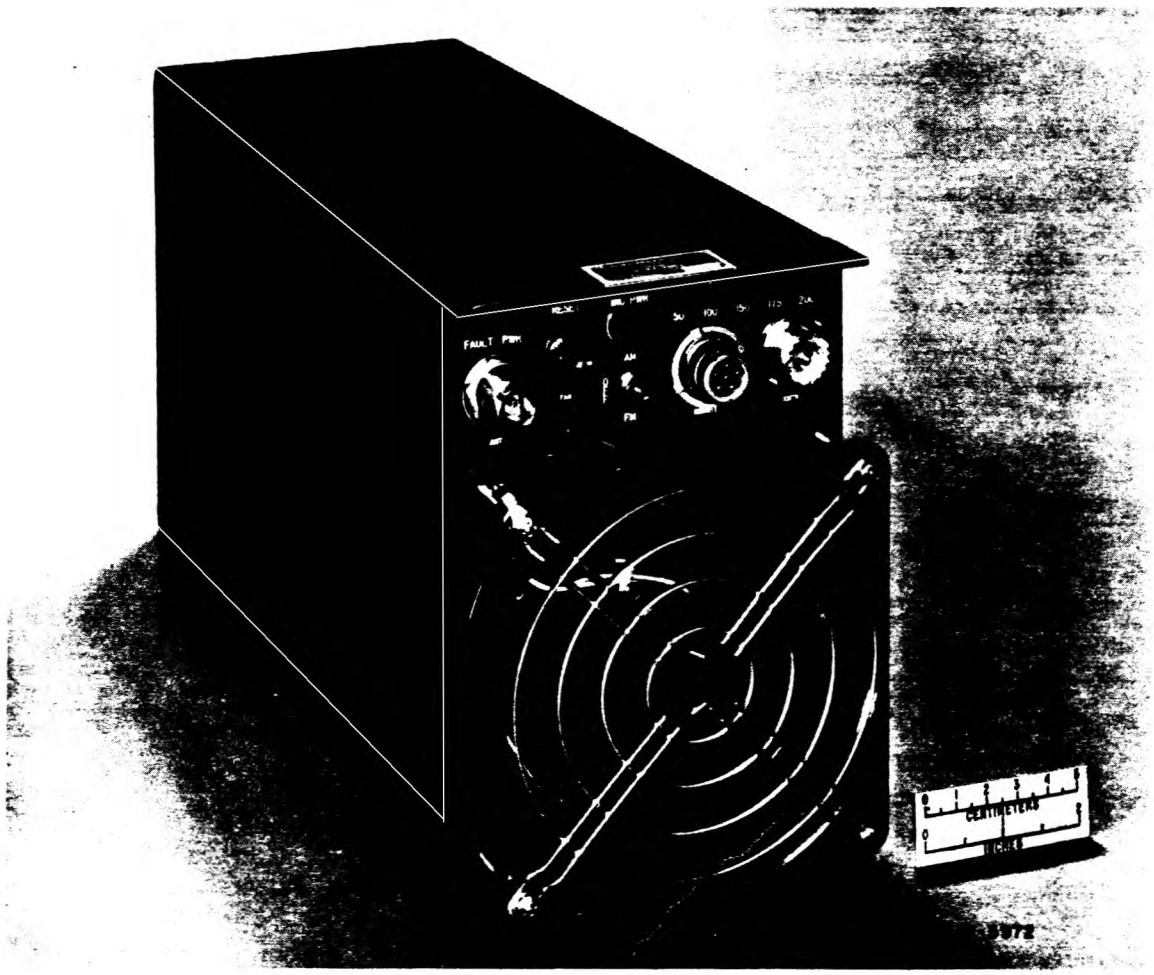
SECTION 1

DESCRIPTION

1-1 SYSTEM DESCRIPTION

1-2 The AM-7175/URC is an RF power amplifier system, hereafter called the Power Amplifier, providing automatic operation in a UHF transmit/ receive system. The Power Amplifier is shown in Figure 1-1.



1-3 The Power Amplifier contains RF amplifier stages which typically require a 1.5 watt input for an output of 200 watts.

1-4 In addition to the RF amplifiers, the Power Amplifier contains circuitry to control T/R switching, power output and several detection and control circuits to allow operation under adverse conditions while protecting against circuit failures.

1-5 The Power Amplifier operates over a frequency range of 225 MHz to 400 MHz. The unit is broadbanded and never needs tuning (by operators or service personnel).

1-6 The Power Amplifier functions in either "carrier operated" mode or under "key line" control. The carrier detect circuit has enough delay to hold the unit in transmit with an AM signal during normal negative amplitude excursions.

1-7 The Power Amplifier contains two output power leveling loops which, after the input power is above minimum level, adjust the overall gain of the RF amplifier chain to maintain a constant output level. The AM power leveling loop maintains the average carrier level at one-fourth the level of the FM loop and has a time constant long enough to reduce AM stripping to less than 1dB at 300 Hz.

1-8 The FM ALC is a fast response loop which protects the amplifier in case of excess amplitude modulation or sudden mismatch.

1-9 By using the key line, the Power Amplifier can be used as a linear amplifier with about 23dB of power gain.

1-10 The power indicating LED's display the power output at intervals of 50, 100, 150, 175 and 200 watts and vary intensity directly with the power levels between these points. Their fast response gives a visual indication of amplitude modulation of the signal.

1-11 The fault indication lamp is red (all the other lamps are green) and indicates two types of fault conditions.

1-12 A flashing fault lamp indicates a minor fault. These faults are usually operator controllable and, when removed, allow normal operation on the next receive-to-transmit transition. These faults are:

(a) High or Low input supply voltage. Input voltage must be greater than 22 volts and less than 32 volts.

(b) High input RF power. Input power must be less than 25 watts.

(c) High internal unit temperature.

1-13 A steady fault lamp indicates a major fault requiring technical service to the installation or internal circuitry.

1-14 Circuits are included to detect the failure of one of the two RF amplifiers and reduce power to allow continued operation with the remaining RF amplifier.

1-15 In the faulted or off state, the Power Amplifier automatically goes into a bypass mode to permit normal operation of the rest of the system.

1-16 A remote control connector is located on the front panel. The functions available from this connector are power ON/OFF, AM/FM control, power output adjustment, key line control and power output indication.

1-17 The operating parameters of the Power Amplifier are listed in Table 1-1. The environmental characteristics are listed in Table 1-2 and the input/output connections are listed in Table 1-3.

TABLE 1-1 OPERATING PARAMETERS

Function	Characteristics
Prime Power Input	28 VDC nominal, 28 amps 22 VDC minimum, 32 VDC maximum
Frequency Range	225-400 MHz
RF Input Power	1.5 to 15 watts with FM, FSK, PSK or AM
RF Output Power	200 watts, ± 1dB with FM, FSK or PSK 50 watts carrier, 200 watts peak with 100% AM
RF Output Power Range	Front Panel or Remote adjustable from 50 watts carrier to 200 watts
Load VSWR	Maximum of 2.5:1 for full power output

TABLE 1-2 ENVIRONMENTAL CHARACTERISTICS

Function	Characteristics
Size	
Height	7.00 inches
Width	4.95 inches
Depth	14.12 inches
Weight	23 lbs.
Operating Temperatures	-20 °C to +55°C (including sun loading)
Cooling	Air cooled with integral blower
Water	Splash proof and rain proof

TABLE 1-3 INPUT/OUTPUT CONNECTIONS AND LEVELS

Connector	Pin	Function	Levels
J1		RF Input	1.5 to 25 Watts
J2		RF Output	50 to 200 Watts
J3		Remote	
	A	Ground	
	B	Power On/Off Control	On = 0 to 0.5V @ -10Ma Off = 100K ohm to ground
	C	AM/FM Control	AM = 0 to 0.3V at 1 Ma FM = 5K ohm to ground
	D	Power Output Control	Maximum power with open circuit
	E	Output Power	10μA into 20K for 200 Watts
	F	Key	Open Circuit for Automatic operation <0.8 VDC for transmit >2.2 VDC for receive
P1	A & B	+28 VDC input	
	C & D	-28 VDC input	

SECTION 2

OPERATION

2-1 GENERAL

2-2 This section describes the operation of the Power Amplifier, including input signal requirements for automatic operation and use of the key line or remote control for manual operation.

2-3 CONTROLS AND INDICATORS

2-4 All operating controls are located at the front of the unit above the cooling fan. Control and indicator functions are described in Table 2-1. Locations are shown in Figure 2-1.

2-5 OPERATIONAL CHECKOUT

2-6 General . The unit can be used in the automatic mode once a suitable power source has been connected to it as described in Section 3 and the proper RF signal source is available. A system interconnect diagram is shown in Figure 2-2.

2-7 The following instructions describe how to operate the Power Amplifier to amplify signals from the transceiver to the antenna while allowing normal receiver operation. When the Power Amplifier is switched off, it is a straight-through connection allowing normal operation of the transmit/receive system.

TABLE 2-1 CONTROLS AND INDICATORS

Control/Indicator	Type	Function
Circuit Breaker	Toggle	35 Amp Breaker
AM/OFF/FM	3 position switch	ON/OFF & Mode
Power Control	Single Turn Control	Adjusts Output Power
Fault Light	Red LED	No light-no faults. Flashing light-see Para. ~~7-12~~. Steady light-see Para. ~~7-13~~. PAGE 6-3 PAGE 6 4
Power Light	Green LED	Light indicates DC power applied.
50, 100, 150, 175, 200 Lights	Green LED's	Lights indicate output power level.

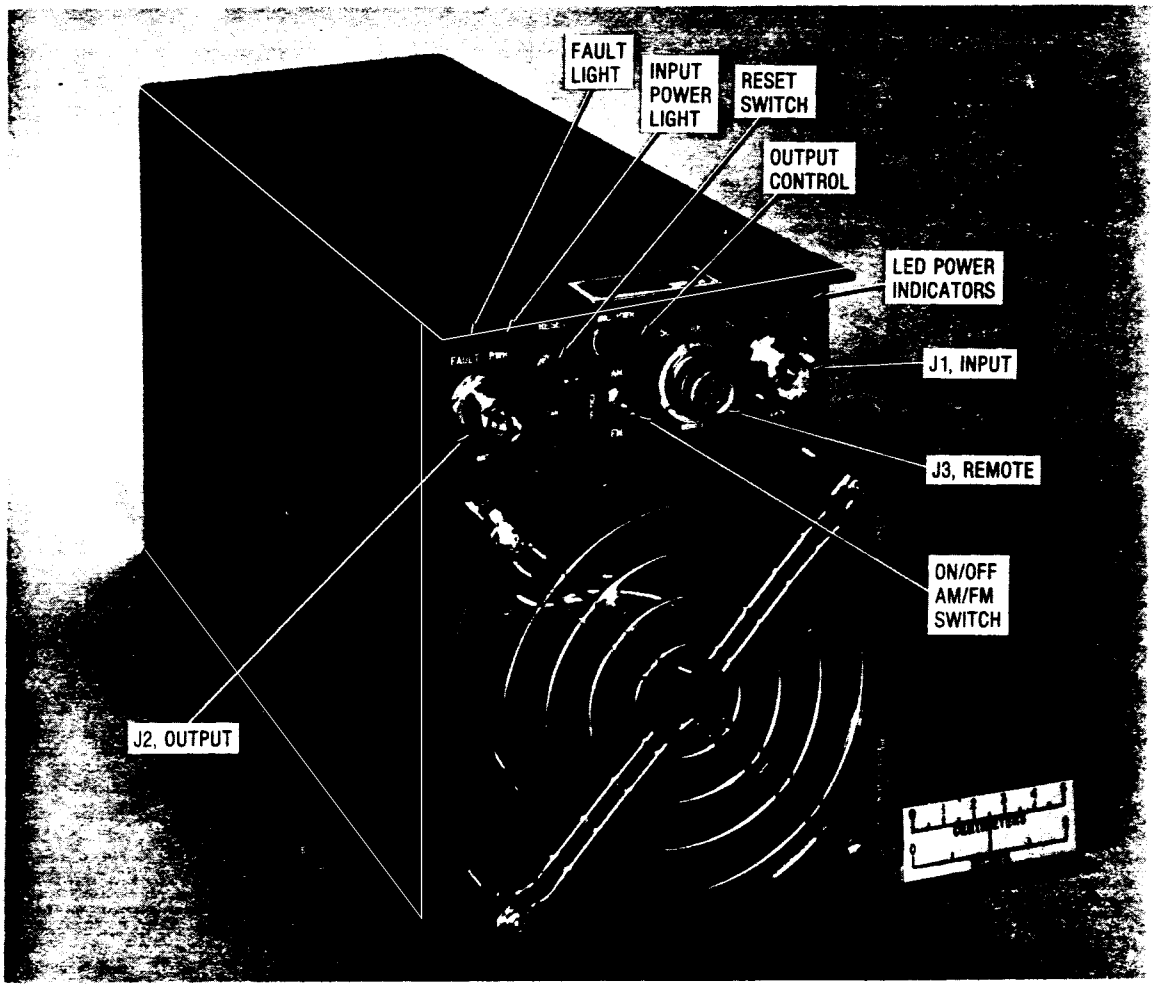
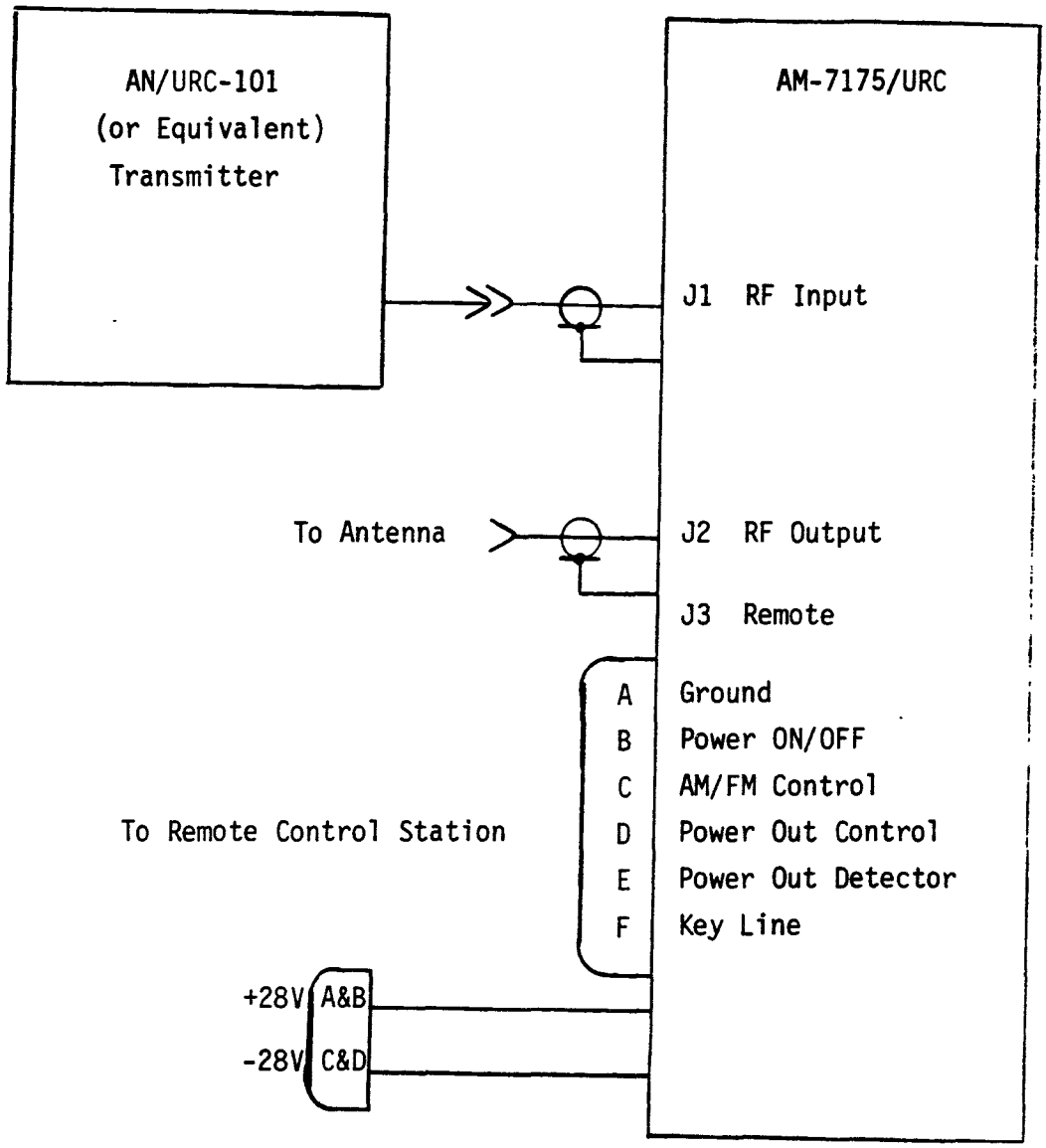


Figure 2-1. CONTROL AND INDICATOR LOCATIONS



SYSTEM INTERCONNECT DIAGRAM

Figure 2-2

2-8 TURN ON PROCEDURE

2-9 Refer to Table 2-1 for the functional description of the controls and indicators and Figure 2-1 for their locations to perform the following steps.

(a) Verify that the Power Amplifier is connected as described in Section 3 and that the RF source has the proper modulation, frequency and power level.

(b) With no RF power being delivered to the Power Amplifier, switch on the circuit breaker/switch.

(c) Set the AM/OFF/FM switch to the corresponding mode of the RF source.

(d) Verify that the green PWR LED is lit, indicating that 28 VDC power is being supplied to the Power Amplifier.

(e) The fault LED should be off. If the fault light is on (steady or flashing) refer to the Fault Indication Operator Notes at the end of Section 6.

(f) Turn the power control CW to the stop.

(g) Applying RF to J1, XMTR input, should cause the RF power indicator lamp(s) to indicate the output power level.

(h) If an automatically-leveled output is desired from the Power Amplifier, adjust the power control to obtain the desired carrier power level in AM or FM. For SSB, DSB, CW or Pulse, where a leveled output is not meaningful, the control should be turned completely CW. The ALC circuits in the Power Amplifier should not be used to "clip" or "limit" the output in these modes.

2-10 KEY LINE CONTROLLED OPERATION

2-11 Key line operation is necessary for transmission in SSB, DSB, CW or Pulse modes to prevent loss of output signal during switching from receive to transmit and to avoid excessive toggling of the R/T relays.

2-12 Faster R/T turnaround is also possible using the key line circuit. The activation and deactivation time constants needed for carrier control of the Power Amplifier are overridden by the key line signal.

2-13 REMOTE CONTROLLED OPERATION

2-14 Remote controlled operation is allowed with a suitable remote control unit. To prepare the system for remote operation, set the following on the Power Amplifier.

(1) Circuit breaker/switch = ON (in/up)
(2) AM/OFF/FM = OFF (Center Position)
(3) Power Control = CW (maximun power)

Attaching the remote control to J3, the front panel remote connector, allows full remote control of the Power Amplifier.

2-15 To return the Power Amplifier to local control, remove the front panel remote plug.

SECTION 3

INSTALLATION

3-1 GENERAL

3-2 This section describes the installation of the Power Amplifier in a typical system.

3-3 The Power Amplifier is designed for both fixed and mobile installation.

3-4 The unit should be held securely in place in any mobile installation since an unsecured unit may damage itself, surrounding equipment and personnel. Mounting holes are provided at the front and back of the Power Amplifier.

3-5 Dimensions of the unit and location and size of the mounting holes are shown in Figure 3-1.

3-6 A shock tray with an attached power filter/distribution box is available for use in vehicular and aircraft installations. This tray will mount a Power Amplifier and PET radio to provide a complete communications system.

3-7 The Power Amplifier is normally supplied with an MW 10M (M) A for power connection. This plug is connected as follows:

- o A and B are positive (red and green)
- o C and D are negative and case ground (black and white)

3-8 The Power Amplifier contains both shunt and series diodes to protect the unit from application of reverse polarity voltages. The series diode blocks reverse current except for a small amount of leakage (2-3 ma), which is returned to ground via the shunt diode. This diode pair protects the unit from normal reverse polarity power; however, reverse voltages in excess of 45 volts will damage the unit.

In power on standby mode, current to the Power Amplifier should be less than 100 MA and the power lamp should light. If there is any doubt about the connection, a 28V source limited to less than 1 amp should be used to check the unit in the power on standby mode.

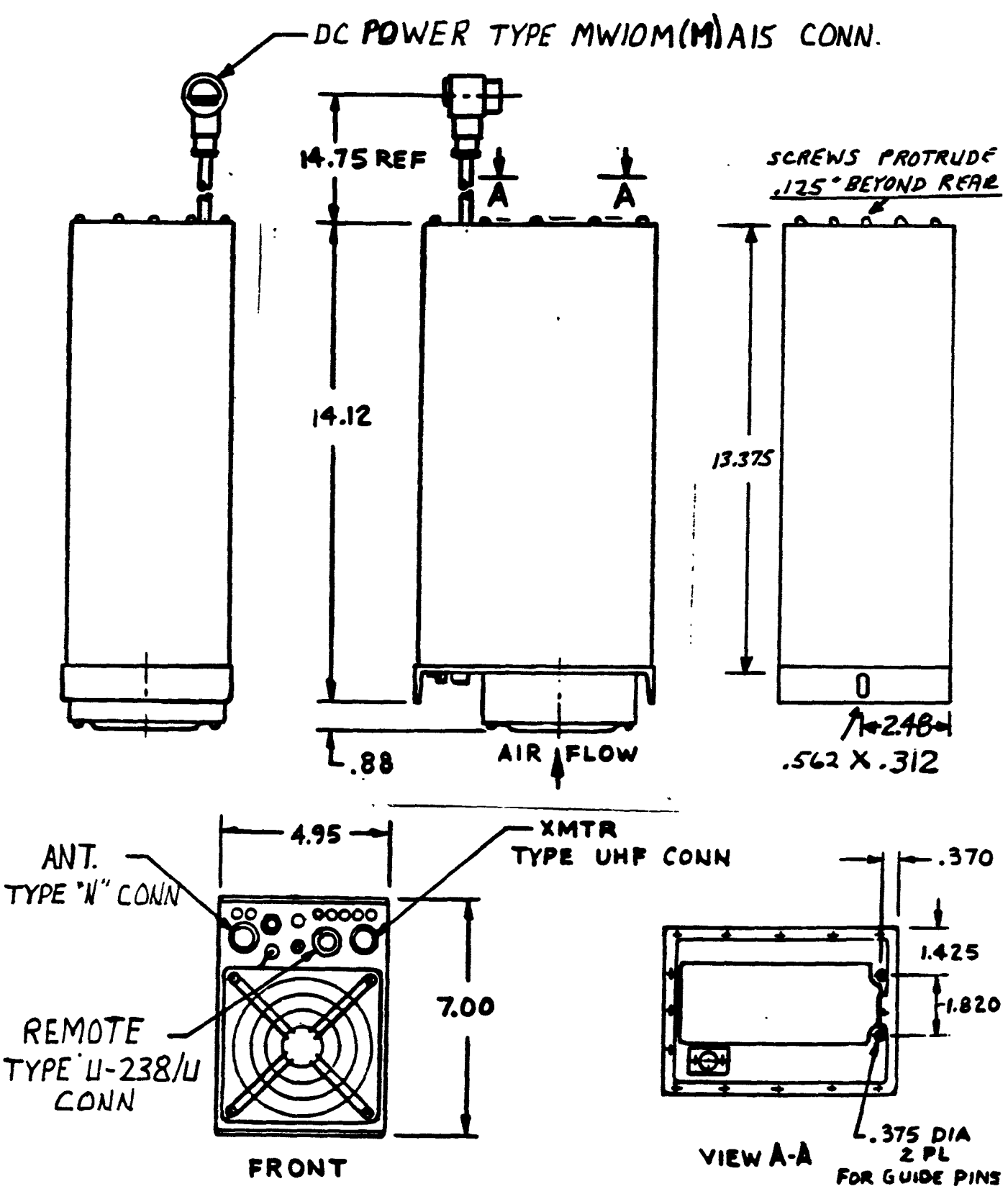


FIGURE 3-1
POWER AMPLIFIER
OUTLINE DRAWING

3-9 Due to the high current (up to 30 amps) drawn by the unit at maximum output, attention must be given to the lines bringing power to the unit:

(a) A two conductor cable should use wire no smaller than 14 gauge.
(b) A four conductor cable should use wire no smaller than 16 gauge.
(c) Length should be kept to a minimum and good electrical connections must be made to the power source.
(d) The combination of cable length and conductor gauge should be chosen so that a drop of less than 2 volts occurs from the power supply to the unit under the conditions of maximum power output.

CAUTION

DUE TO THE HIGH RF POWER PRODUCED BY THE POWER AMPLIFIER, THE OPERATING PERSONNEL SHOULD STAY CLEAR OF THE ANTENNA RADIATION PATTERN. RF BURNS COULD RESULT IF THIS CAUTION IS NOT EXERCISED.

SECTION 4

PERFORMANCE TESTING

4-1 INTRODUCTION

4-2 This section describes field performance evaluation of the Power Amplifier. This testing should be performed once a year or when degraded operating performance of the unit is suspected. Although this is not a complete test of all internal circuits, it is a good overall check of the unit, requiring no disassembly.

4-3 TEST EQUIPMENT REQUIRED

The test equipment listed in Table 4-1 is required to test the Power Amplifier.

TABLE 4-1 TEST EQUIPMENT LIST

Description	Capability (minimum requirements)
Power Supply	20 to 34 VDC at 30 amps
Power Attenuator	30dB at 300 Watts
Voltmeter	0 to 50 VDC
Wattmeter	1 mw to 3 watts, 0.5dB resolution
RF Power Source	variable to 5 watts 225 to 400 MHz

4-4 The following tests require accurate measurement of both the output power and input voltage. The attenuator and coaxial cables used in this test must be calibrated so that the exact losses are known at all specified frequencies; neglecting the losses can cause power measurement errors in excess of 1.5 dB. The excessive power output caused by such errors will result in drastically reduced life expectancy or imminent failure of the Power Amplifier. The results of the calibration measurements should be used to determine the actual output power of the Power Amplifier. Input voltage measurement should be made as close to the unit as possible to eliminate the voltage drop caused by the resistance of the DC power cable.

4-5 With the Power Amplifier connected for operation into the attenuator, the following conditions shall apply for the FM test:

a. V_{in} = 28 VDC
b. AM/OFF/FM = FM
c. Power Control = maximum (CW).
d. Pin = 5W
e. Key line = open

4-6 The output power at 225, 325 and 400 MHz shall be between 165 watts and 225 watts.

4-7 Supply current shall be less than 30 amps.

4-8 Turning the power control to minimum (CCW) shall reduce the output power by 6 dB $\pm$ 1 dB.

4-9 The following conditions shall apply for the AM test:

a. V_{in} = 28 VDC
b. AM/OFF/FM = AM
c. Power Control = maximum (CW)
d. Pin = 1.5W
e. Key line = open

4-10 The output power shall be 50W $\pm$ 13W.

4-11 Supply current shall be less than 20 amps.

4-12 Turning the power control to minimum (CCW) shall reduce the output power by 6 dB $\pm$ 1dB.

4-13 Reduce the input RF to minimum, then slowly increase it until the Power Amp keys on. This should occur at 1W of input RF.

4-14 Increase input RF to 1.5 watts and apply 2.2V to the key line. This should force the unit into bypass.

4-15 Set the following conditions:

a. V_{in} = 28 VDC
b. AM/OFF/FM = FM
c. Power Control = maximum (CW)
d. Pin = 5W at 325 MHz
e. Key line = grounded (0V)

4-16 All RF power LED's shall be lit. Slowly decreasing the input RF shall cause the LED's to smoothly extinguish in a high to low progression. The unit shall not go into bypass with the input RF at minimum.

4-17 Increase the input RF to 5W and raise the voltage to 32 volts. The unit should continue to function and P_{out} should not change by more than 10W.

4-18 Decrease the input voltage to 20 volts. The unit should continue to operate but P_{out} shall decrease by at least 50W.

4-19 If the fan has not run at any time during these tests, return the input voltage to 28 volts and maintain full power output for 3 minutes or until the fan operates. If air temperatures are much below 25°, it may take longer than 3 minutes for the fan to operate. If the fan fails to operate, perform the following test:

a. Unplug the fan at the power amplifier front panel.
b. Connect a source of +28VDC capable of at least 0.5 amps to the disconnected lead (negative return goes to the Power Amplifier chassis).
c. If the fan fails to operate, the fan is defective and should be replaced.
d. If the fan operates, the Power Amplifier is defective and requires disassembly and repair.

4-20 With the Power Amplifier switched off, the output power (produced by the 5W generator) should be noted. A barrel connector should be substituted for the Power Amplifier and the output power noted. There should be less than 1.7dB difference in these readings.

4-21 A final test of the AM operation of the unit should be made using a transceiver such as the AN/URC-101 in low power AM and monitoring the output on a receiver. The audio should be understandable with the Power Amplifier off or on (make sure that the signal is sufficiently attenuated so that overload of the receiver does not occur when the Power Amplifier is switched on). Operating the Transmitter/Amplifier into the attenuator with no direct connection to the receiver in the same room should provide an adequate signal level for this check.

4-22 If the unit fails any of these tests, refer to the Operator Trouble-shooting Table 6-1.

4-23 If the problem cannot be determined, the Power Amplifier requires higher level maintenance.

SECTION 5

5-1 FUNCTIONAL DESCRIPTION

This chapter provides a functional description of the Power Amplifier. A description of the major systems is presented, referring to the Simplified Block Diagram, Figure 5-1.

A detailed description of the Functional Block Diagram, Figure 5-2, is then presented.

5-2 OVERALL FUNCTIONAL DESCRIPTION

The overall function of the Power Amplifier can be seen in the Simplified Block Diagram, Figure 5-1.

The input RF signal is applied to the XMTR input jack. The input signal should be 1 to 25 watts at a frequency of 225 to 400 MHz.

In automatic T/R mode, when the above requirements are met, or when the key line input is forced to a logic low level, the T/R relay energizes and the RF signal is applied to the voltage controlled attenuator (VCA) on the A1 assembly. The VCA is the control element in a feedback loop which determines the output power level. The attenuation of the VCA is varied by the automatic level control (ALC) on the A2 assembly.

The output of the VCA is supplied to a two-stage amplifier, then to an RF splitter which divides this signal into two equal amplitude signals differing in phase by 90°.

These two signals are amplified separately in RFA1 and RFA2, then added by the RF Combiner which brings the two signals back into phase.

The combined output signal is applied to a low pass filter (FL1) to remove unwanted harmonics, then to a power sensor (A5) which detects the amount of forward and reverse power passing through it. These signals are used by the ALC to monitor and control the output power level.

The RF is routed through the relay board (A4) to the antenna output connector.

5-3 FUNCTIONAL BLOCK DIAGRAM DESCRIPTION

The following description pertains to the Functional Block Diagram, Figure 5-2.

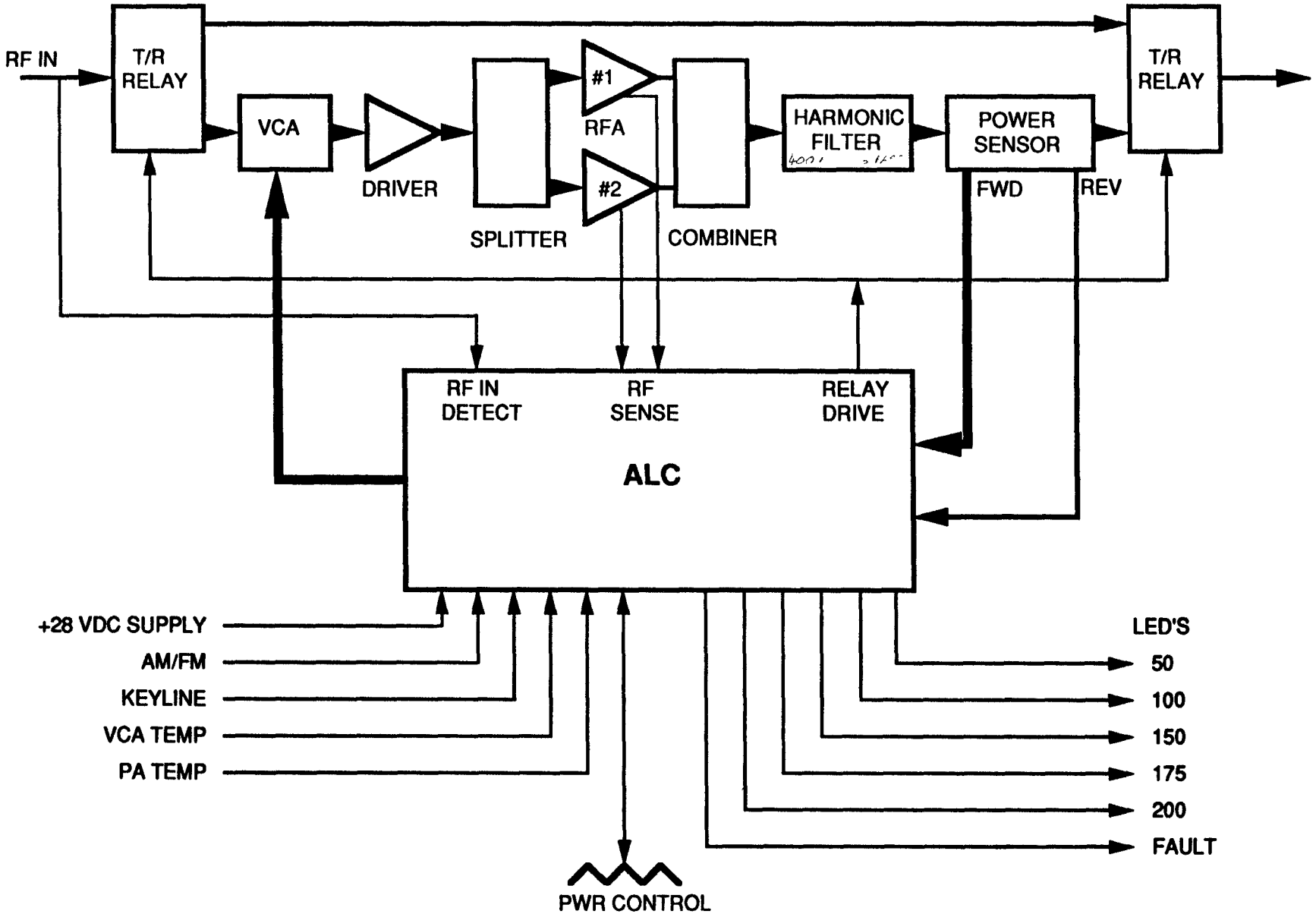


Figure 5-1. AM-7175 SIMPLIFIED BLOCK DIAGRAM

5-4 Circuit Breaker

The front panel mounted circuit breaker is a thermal trip-free type. The power to all circuits in the Power Amplifier is routed through this device. The breaker is rated at 35 amps and is designed so that even if the toggle is stopped from reaching the "off" position, excessive current drawn by the unit will cause the breaker to open and minimize internal or external damage. The breaker will automatically reset after a short time.

5-5 Transient Filter

This low pass filter consists of a custom 10 microhenry series inductor shunted by a 10 uf film type capacitor. This filter is needed to reduce the spikes on the DC input line to a level which will not damage internal circuits. A secondary winding on the inductor core is connected to a power resistor to de-Q this input circuit; Without this de-Qing, ripple in a vehicular system could be increased to a damaging level by circuit resonance. The input capacitor was selected to withstand the large circulating currents which could occur if there is a fault in the vehicular generator.

5-6 Power On Lamp Circuit

This circuit consists of an LED and resistor connected to the switched 28V input to the ALC and control circuits of the Power Amplifier.

5-7 Hi/Lo Voltage Sense

This circuit senses the input voltage to the Power Amplifier and provides a logic control signal to the fault logic circuits. This signal is active for an input of greater than 32 volts and less than 20 volts and prevents (or discontinues) amplifier operation for these out-of-range voltages. This is indicated by a flashing fault lamp.

5-8 Voltage Limiters

The 3 series pass Voltage Limiters protect the sensitive RF power devices as well as other sensitive components from damage due to excessive input voltage. The transistors in these circuits can maintain the output level to 30 volts for inputs of 100 volts indefinitely and 120 volts for short intervals.

For voltages of 20 to 30 volts, the limiters act as saturated switches with a drop of less than 1 volt. For voltages of 30 to 32 volts, the limiters act as series pass voltage regulators, maintaining the output at 30 volts. For an input voltage greater than 32 volts, the limiters are switched off and the output is nearly zero volts.

5-9 15V @ 100mA Regulator

This circuit is a single series pass emitter follower voltage regulator. This regulator provides 13 to 15 volts output whenever the power is switched on. It powers the operational amplifiers, the 5V 50mA voltage regulator and 2.5V reference. As this circuit is not protected by a series limiter, it has been designed to withstand more than 100 volts input. Tight line and load regulation is not required or attempted by this simple regulator.

5-10 5V @ 50mA Regulator

Power to this circuit is provided by the 15V regulator. This is a series pass regulator using a 2N2222 transistor as the pass element, with an operational amplifier in the output control feedback loop. The 2.5 volt reference is used by the amplifier circuit with an accurate gain of 2 to provide the 5V output.

5-11 2.5V Reference

This circuit is powered by the 15V regulator and consists of an MC1403 2.5V reference I.C. This circuit provides a precision voltage for use throughout the unit.

5-12 5V @ 1.5 A Bias

Power to this circuit is provided by voltage limiter No. 3. The circuit operation is the same as the low current 5V logic supply, except a heat sunk power device is used for the series pass element to handle the higher output current requirement.

5-13 Temperature Controlled Fan Switch

This is a solid state switch circuit using a thermistor mounted in the main RF amp heat sink to determine when a temperature has been reached requiring fan cooling. The circuit turns on the fan motor at a temperature of about $60^{\circ}C$, and shuts off the motor at about $55^{\circ}C$ (about 5° of hysteresis).

5-14 RF Level Detect

This circuit uses a filtered average output level from the forward power sense circuit to determine the RF power provided to the output port. This level is compared to fixed DC levels and signals are provided to the LED drivers which indicate the output power. The drive is a linearly increasing voltage which takes effect when the previous power level lamp has reached its peak intensity (when output power is equal to the level indicated by that lamp) and reaches a maximum when its indicated power level has been reached. The lowest power lamp begins to receive drive when the output power is one-half the level indicated. With this system, proportional power level increases or decreases can be seen.

5-15 Lamp Drivers

The lamp drivers are 2N2222 transistors. Maximum current drive to the LED's is limited by a combination of the highest drive level delivered from the power level detect circuit and an emitter resistor.

5-16 Heat Sink Temperature to Power Output Control Circuit

The circuit uses a thermistor mounted close to the RF amplifiers. The output power level of the Power Amplifier is unaffected until a heat sink temperature of approximately 85°C is reached. At this temperature the circuit causes the output of the amplifier to be reduced. The output linearly decreases to a low level for a heat sink temperature of 100°C. This circuit decreases the output power to prevent a further significant increase in heat sink temperature, allowing continued operation at reduced power.

5-17 Input Voltage to Power Output Control Circuit

This circuit prevents improper operation of the Power Amplifier with reduced input voltage. The output available from a Power Amplifier depends on the output load and supply voltage. The Power Amplifier produces the required output power at a nominal input voltage. Below some voltage, maintaining this level results in excessive distortion; this circuit reduces the maximum output power to prevent this. This power reduction is inversely proportional to the square of the supply voltage reduction. The output power is proportional to the square of the power reference voltage; therefore, power is reduced by subtracting the output of this circuit from the Power Reference Level circuit output. This circuit provides a constant level output down to 27 volts and reduces to a minimum for an input voltage of 21 volts.

5-18 Power Reference Level Circuit

This circuit combines the inputs from the Heat Sink Temperature to Power Output Control Circuit, Input Voltage to Power Output Control Circuit, Reduce Power Circuit and Front Panel Power Control to produce a power reference level used by the ALC loops to control the output power level. With the exception of the Reduce Power Circuit, then input "requesting" the lowest output power will dominate the other two inputs. This allows the protection circuits or front panel control to set the maximum output power in response to the circuit requesting the greatest power reduction, ignoring the other two inputs which would have allowed a higher output power. The Reduce Power Circuit cuts power to one-fourth of that set by the dominant input. This circuit is activated if one of the RF Amplifiers fails, making the power output of the remaining RF Amplifier approximately the same as before the failure.

5-19 RFA #1 and RFA #2 Output Sense

This circuitry consists of an RF detector on each RFA board and a signal processing circuit. The signal processing consists of a fast-attack/slow-release circuit to prevent negative AM peaks from triggering an RFA failure indication. The time constants were selected so that, under the normal symmetrical modulation, the most negative excursion of the output of this circuit would be the same or greater than that of the unmodulated carrier at frequencies down to 10 Hz.

5-20 RFA Fail Sense

This circuit uses logic to determine if one of the RF amplifiers has failed, providing an output to the Reduce Power Latch.

5-21 Reduce Power Latch

This circuit locks the unit in a low power mode (50W) once a failure in an RF Amp has been detected. To return to normal full power in the automatic operation mode, remove the RF input and reapply it; in key line mode, open the key line before cycling the RF.

5-22 Reduce Power Circuit

This circuit causes the power reference voltage to be cut in half (reducing output power to one fourth). This reduction is in addition to any proportional reduction which has occurred due to low voltage or high temperature. This allows the remaining RF amplifier to continue operation at the same level prior to failure of the other RF amplifier. Power lost to the Combiner isolation load is half the total power from the remaining RF amp, so that one-fourth the previous power is sent to the output.

5-23 T/R Relays

Two DPDT relays are used to transfer the signal path from bypass (input connector to output connector), the Amplifier On mode (input to PA in, output to PA out). Timing to these relays and the VCA drive circuits is set so the relays will never switch more than 25 watts "hot".

5-24 Voltage Controlled Attenuator (VCA)

This is a PIN diode DC controlled RF attenuator that varies from less than 1dB attenuation at Vin = 0 to better than 25dB at Vin = 1.2V. This unit can dissipate up to 25 watts safely (the maximum input RF power allowed).

5-25 Drivers

The driver section consists of two stages of broadband (225-400 MHz) gain which amplify the input from about 1 watt to 50 watts to drive the RF amplifiers.

5-26 RF Splitter

The device splits the output of the Driver amp to drive the RFA's. This circuit is identical to the RF Combiner and consists of a quadrature coupler and its isolation load. This load absorbs any inbalance between the two outputs.

5-27 RFA #1 and RFA #2

The RF amplifiers are two identical units that amplify an input of 25 watts to about 125 watts. A pair of power transistors is used for each RF amp; a split-amplify-recombine approach similar to that used with the two RF amps achieves more power output than obtained from a single device. The amplifiers are broadbanded and cover the 225-400 MHz frequency range without tuning by operator or service personnel.

5-28 RF Combiner

This device combines the output of each of the RF amplifiers. It allows one of the RFA's to fail without completely disrupting the output from the remaining RFA. An isolation load in this circuit absorbs RF power caused by any imbalance in the output of the RFA's. If one RFA fails, half of the power from the remaining RFA is consumed by this load. To maintain the power out of the remaining RF amplifier at a safe level, system output power is reduced to one-fourth.

5-29 Harmonic Filter

This is a low pass filter with a cutoff frequency just over 400 MHz. All harmonics from 225-400 MHz are out of band for this filter.

5-30 Power Sensor

The combined RF amplifier output passes through the power sensor which detects the forward and reverse power levels. The ALC uses these signals to control the output power.

5-31 Fwd/Rev Combiner

This circuit combines the forward and reverse detector signals to create a buffered signal which gives smooth loop control. The forward signal dominates the loop until a mismatch of 2.5:1 is detected; the reverse signal then becomes large enough to take over loop control. With an open or shorted output, the Power Amplifier output is cut back to about 22 watts by the circuit.

5-32 AM Loop Amp and LP Filter

This circuit develops high open loop gain to ensure good control of the output power level. It has a low open loop frequency response to prevent modulation stripping in the loop. It also ensures good stability of the loop and prevents a peaked frequency response.

5-33 FM Loop Amp

This amplifier is similar to the AM loop amplifier and filter but does not prevent AM stripping since AM is undesirable here. The circuit time constants were set to allow the fastest attack time possible for good loop stability. This loop dominates when a sudden mismatch occurs (such as a shorted or broken antenna), rapidly reducing the Power Amplifier output to prevent damage to the RF power transistors.

5-34 Quarter Power Attenuator

This circuit reduces the power reference voltage delivered to the AM loop to one-half that for the FM loop, so that the AM loop maintains a carrier output power of one-fourth that of the FM loop.

5-35 VCA Amp and Driver Control Circuit

This circuit combines the outputs of all loop control signals and amplifies the dominant control signal to a power level sufficient to drive the VCA. These signals are combined so the VCA is controlled by the control signal requiring the lowest output power. This allows both the AM and FM loops to function in the AM mode. Since the reference level delivered to the AM loop corresponds to one-fourth the output power of the FM loop, the AM loop controls the output level. In case of a sudden mismatch or overmodulation, the FM loop, with its fast attack time, acts to protect the output devices. This also allows the use of a clamp circuit to force the VCA to maximum attenuation during T/R relay switching.

5-36 VCA Clamp and Delay

This circuit reduces the amount of RF power output during the transition time of the T/R relays. The relays are prevented from "hot" switching high power which would substantially reduce their lifetimes. At the start of a transition to transmit, a pulse is generated, causing the VCA to go to its maximum attenuation. This 15 msec pulse is long enough to allow the relay to operate and settle before the RF power climbs to its proper level. When a transition to receive or amplifier bypass begins, the VCA is forced to maximum attenuation and held while the relay switches and power is removed from the drivers and RF amps.

5-37 AM Loop Defeat

This circuit is controlled by the front panel AM/OFF/FM switch. The switching from AM to FM is done by grounding the AM loop drive to the attenuator. The FM loop then takes control of the output power leveling.

5-38 RF In Sense

This circuit responds to an input from the XMT jack. The signal from this detector is sent to the High RF Detect and T/R Detect circuits.

5-39 T/R Detect

This circuit allows automatic RF-controlled T/R switching or external key line control. With no connection to the key line, this circuit allows automatic RF control of the T/R function with an input of at least 1 watt from the transmitter. When the key line is less than 0.5 volts, the T/R circuit forces the Power Amp (barring a lockout fault) into transmit unconditionally. If the key line is above 2.2 volts, the Power Ampilifer is forced into bypass, ignoring the presence of RF at the input. This allows rapid turnaround when desired, remote control of amplifier mode, TTL or CMOS logic control, and use of pulsed or CW operation.

5-40 Lockout Latch #1

This circuit prevents the unit from operating when it is activated by high input RF, a tripped heat sink thermostat or high/low input DC voltage. When actuated during a transmit cycle, this circuit will remain in lockout until the end of the transmission, even if the condition which caused the lockout clears. This prevents toggling of the Power Amplifier during transmission. Either transferring to receive or switching the unit off and on will clear the latch when the fault condition has been cleared. An output from this circuit is sent to the fault lamp circuit, causing the lamp to flash and indicating that a minor fault has been detected. This prevents operation of the Power Amplifier.

5-41 Lockout Latch #2

This latch is activated by a major fault in the Power Amplifier, requiring repair of the unit. This latch can be set by ALC loop failures or gross failure of the RF amplifiers/VCA. After the latch trips and forces the amplifier into bypass, the fault light remains on steadily until a transmit-to-receive sequence occurs.

5-42 Error Check Delay

This circuit delays the operation of latch #2 for about 100 msec during a receive-to-transmit sequence. This allows the ALC and the RF detectors to stabilize before checking for an error.

5-43 Amp On/Off

This circuit checks the latches and, if these are clear, provides a turn-on signal to voltage limiters, relay drive and error check delay circuits.

5-44 High RF Detect

This circuit detects an input power exceeding 25 watts and sets lockout latch #1. It prevents damage to the VCA and Pre-driver in the case of excessive input power.

5-45 Thermostat Trip Sense

This circuit wire or's the heat sink thermostats together; the tripping of either one will activate lockout latch #1. This circuit is a backup for the power controlling thermistor circuit and operates if this circuit fails to prevent excessively high heat sink temperatures.

5-46 Power On Reset

This circuit resets the latches whenever power is applied to the Power Amplifier, thereby starting it in a no fault condition.

5-47 Loop Error Detect

This is one of four circuits used to prevent damage to the RF amplifiers if the ALC fails. The circuit senses when the detected output power voltage is greater than the loop reference voltage. This occurs if the FM loop fails to maintain the output power leveling.

5-48 Excessive RF Power Detect

This circuit detects an output power in excess of 250 watts. This indicates a major fault and activates lockout latch #2.

5-49 Overdriven VCA Detect

This circuit is activated whenever VCA drive voltage exceeds 1.45 volts, indicating the end of the usable range of the VCA. This occurs only when the VCA is unable to reduce the output level to that required for proper amplifier operation.

5-50 No RF Out For RF In Detect

This circuit detects output of less than 9 watts for 1 watt or more of input. This indicates a major fault in the RF amplifiers and activates lockout latch #2.

5-51 Fault Lamp Driver

This circuit provides the necessary drive to the fault lamp to either pulse the lamp or maintain a continuous output as called upon by the lockout circuits.

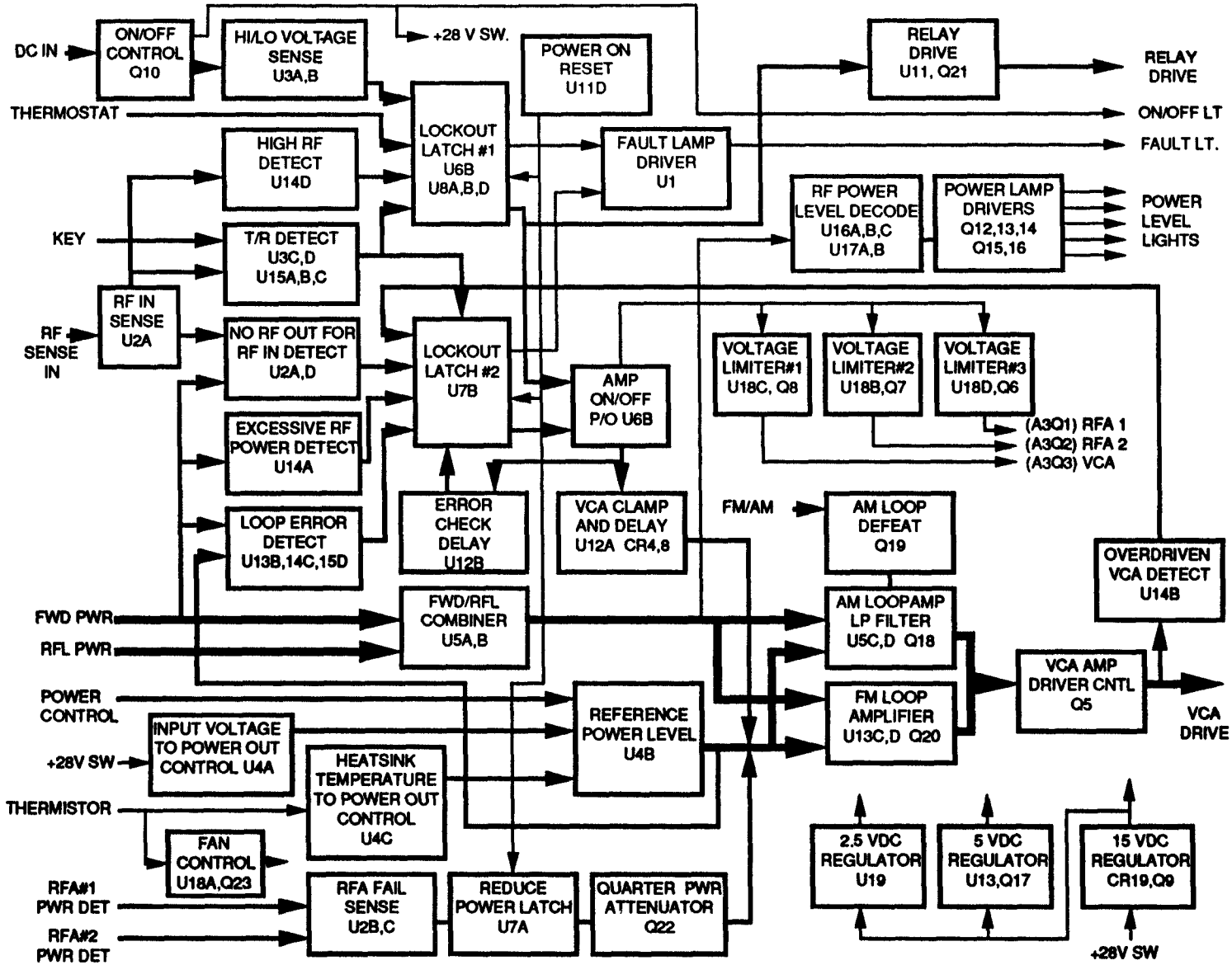


Figure 5-2. AM-7175 ALC BLOCK DIAGRAM

SECTION 6

6-1 SYSTEM TROUBLESHOOTING AND MAINTENANCE

6-2 This section explains the procedure an operator follows to determine if a problem is caused by system deficiencies or by improper use of the Power Amplifier, and outlines performance evaluations to be made at a properly equipped service depot.

6-3 OPERATOR TROUBLESHOOTING

6-4 LOW OUTPUT POWER CAUSES

6-5 Low output power can be caused by the following:

(a) Low input RF (3 watts are required to assure a 200 watt output)

(b) Wrong frequency of input RF (frequency of RF source should be between 225 and 400 MHz)

(c) High VSWR caused by open, shorted or wrong antenna.

(d) Low input voltage (input voltage should be greater than 26 VDC to assure a specified output)

(e) If one of the two RF amplifiers fails, the power reduces to one-fourth.

(f) High internal unit temperature. No significant power reduction should occur for any operation at ambient air temperature up to 55°C (131°F) as long as (1) the cooling fan is plugged in and functioning properly, (2) the heat sink fins are clear of dirt and debris, and (3) the air intake or outlet is not obstructed.

6-6 FLASHING FAULT LIGHT CAUSES

The following lead to a flashing fault light. These faults are often temporary or under control of the operator and will clear automatically once the ~~problem~~ operator is eliminated.

(a) High or low input voltage. Input voltage should be greater than 20 VDC and less than 32 VDC.

(b) High RF drive level. RF input should be less than 25 watts.

(c) High Power Amplifier Temperature. This is a safety circuit and is reset automatically as the internal temperature drops.

6-7 FLASHING FAULT RESETTING

If the cause of a flashing fault is eliminated, the fault lamp will stop flashing immediately, but if the fault occurred during a transmission (causing the amplifier to go into bypass), the Power Amplifier will remain in bypass until a transmit-to-receive transition has occurred. This prevents toggling of the Power Amplifier during a transmission.

6-8 STEADY FAULT LIGHT CAUSES

A steady fault light indicates a malfunction has occurred requiring servicing of the unit. The following can cause a steady fault:

(a) No RF out for RF in

(b) ALC loop error

(c) Excessive output power detected

(d) Overdriven VCA

6-9 A steady fault could be caused by conditions which are under control of the operator. These are enumerated in the Operator Troubleshooting Table 6-1.

If one of these conditions occurs during a transmission, the unit will automatically switch to bypass and the fault lamp will remain on through the rest of the transmission. A transition to receive will extinguish the lamp and reset the fault detection circuit.

TABLE 6-1 OPERATOR TROUBLESHOOTING

SYMPTOM	CAUSE	CURE
Will not operate	Low input power	Increase input power
	High output VSWR	Check/Correct Antenna
Single flash of fault light with no continued PA operation	Power Source voltage drooping	Provide larger cable conductors Start engine or power generator Replace defective power source
	Marginally high input power	Reduce input power
Flashing fault light	Low or high input voltage	Start engine or generator Adjust power source to 22-32V (28V nominal)
	High input RF power	Reduce input power to less than 25 watts
	Overheat thermostat tripped	Wait for unit to cool. Check fan plug, fan rotation or cooling duct.

TABLE 6-1 (Con't)

SYMPTOM	CAUSE	CURE
Steady fault light	Reversed Xmtr and Antenna connections	Change Xmtr and antenna connections.
	High power cable resistance	Increase gauge and/or reduce length of cable
	Out-of-band operation	Set input RF inband (225 to 400 MHz)
	Power ouput too low	Correct any of the following: High VSWR, high temperature, low voltage or low front panel power setting causing a power output of less than 15 watts; or increase power output level.
	Power output to power input ratio too low	Output power should be at least 6dB greater than input power. Reduce input power or increase output power

6-10 PERFORMANCE TESTING

6-11 Test equipment required for proper performance testing is presented in Table 6-2.

TABLE 6-2 TEST EQUIPMENT REQUIRED

DESCRIPTION	RECOMMENDED MODEL	SUPPLIER
POWER SUPPLY 19-33 volts @ 35 amps	SWA-28K	Power Mate
AMMETER - 35 amp		
RF GENERATOR - 225 to 400MHz; AM/CW; 0 to 50 watt	473	Ailtech
LOAD/ATTENUATOR 30dB; 300 watt	8329	BIRD
POWER METER - 0 to 30 watt	HP 436A	Hewlett-Packard
MODULATION ANALYZER AM; 225 to 400 MHz	82AD	Boonton
SPECTRUM ANALYZER 100 KHz to 1 GHz	141T; 8554B; 8552B	Hewlett-Packard
AUDIO OSCILLATOR 300 Hz and 1 KHz	HP200CD	Hewlett-Packard
DISTORTION ANALYZER	HP333A	Hewlett-Packard
DIGITAL MULTIMETER	HP3465A	Hewlett-Packard

6-12 PERFORMANCE EVALUATION

6-13 The Power Amplifier should be configured as in Figure 6-1.

CAUTION : It is important to use calibrated equipment and accurate measurement techniques when making power measurements. An error of ± 1dB can cause nearly a 100 watt variation in apparent output.

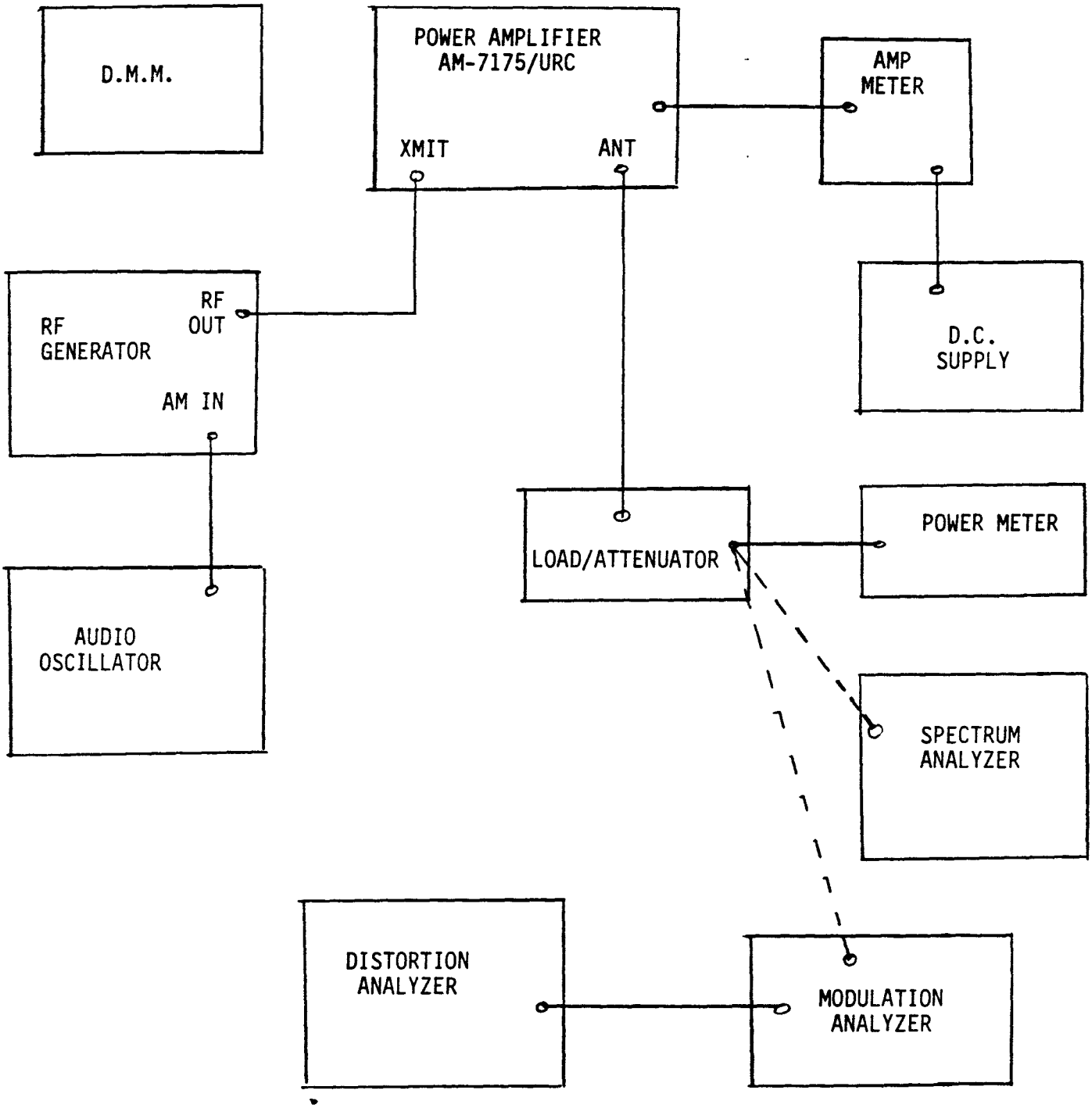


FIGURE 6-1. PERFORMANCE EVALUATION SET-UP

6-14 OUTPUT POWER AND EFFICIENCY MEASUREMENTS

The following steps should be taken when measuring the maximum power output and maximum input current to the amplifier.

a) Vin = 28V $\pm$ 0.2V; Remote Control disconnected, RF Generator set at minimum output.

b) Switch amplifier on to FM and adjust PWR control fully CW (maximum power)

c) Adjust RF Generator to 325 MHz and 5 watts.

d) P_{out} should be 165 watts to 225 watts.

e) I_{in} should be 30 amps maximum.

f) Manually sweep the signal generator from 225 to 400 MHz while observing output power and input current.

g) No surges or dips of greater than 1dB should occur over any 10 MHz range.

h) Current should never exceed 30 amps and power output should be in the range of 165 watts to 225 watts.

If the current or power exceeds its maximum allowable specification (225 watts, 30 amps), testing should be discontinued and trouble-shooting implemented immediately.

6-15 ALC Range Testing

Set the signal generator to 325 MHz and reduce the level to minimum.

a) Adjust the front panel power control to minimum (CCW).
b) Adjust the RF generator output level to 20 watts.
c) Output from the amplifier should be between 32 and 79 watts and no faulting should occur.
d) Reduce the input RF power to 5 watts and increase the front panel power control to maximum (CW).
e) Switch the unit to AM and slowly decrease the front panel power setting until the unit faults or minimum power is obtained.
f) Power should have reduced to less than 25 watts without a fault occurring.

6-16 Output Power vs. Input Voltage Tests

a) Switch the unit to FM, set RF input to 5 watts and the power supply voltage to 22 volts.
b) The output power should be between 75 watts and 150 watts.

6-17 Fan Operation

a) With 5 watts of RF into the unit in FM mode and 28 VDC input, the fan shall automatically operate in less than 5 minutes for an ambient temperature above 15°C (60°F).

b) No reduction of power or faulting of the unit should occur before the fan operates.

6-18 AM-Distortion Measurement

a) Switch the unit to off and apply an amplitude modulated RF signal with the following characteristics:

- o RF level = 1.5 watts (Carrier)
- o Modulation frequency = 1 KHz
- o Modulation = 80%

b) Using the Modulation Analyzer and Distortion Analyzer, measure the distortion level with the amplifier off (bypass).

c) Distortion should be less than 2.5% in order to make valid added distortion measurements (Note actual distortion level).

d) Switch amplifier on to AM with power control at maximum (CW) and measure distortion.

e) Distortion shall not have increased more than 10%.

6-19 AM Stripping Measurement

a) Adjust the RF input modulation frequency to 300 Hz.

b) With the amplifier off, adjust the modulation level to 30%.

c) Switch the amplifier on and measure the modulation level.

d) Modulation shall not have decreased to less than 20%.

6-20 Harmonics and Spurious Response Measurements

a) Set the RF generator as follows:

- o F = 225 MHz
- o Power = 5 watts (CW)

b) Observe the output of the RF generator (Power Amplifier off) on a spectrum analyzer covering 100 KHz to 1 GHz.

c) Harmonics must be at least 45dB down from the 225 MHz carrier level and spurious responses must be down at least 65dB.

d) With the Power Amplifier on FM and the power control at maximum (CW), harmonics and spurious responses should be down at least 45dB.

6-21 Remote Control Testing

a) Connect a remote control to the unit and set the following controls:

- o Power Amplifier
  AM/OFF/FM = OFF
  Power = Max (CW)

- o Remote Control
  AM/OFF/FM = OFF
  Power = Max (CW)
  Key Line = Open Circuit

b) The unit should be off.

c) Switch remote control to FM and apply 5 watts of RF at 325 MHz.

d) Power Amplifier output should be between 165 and 225 watts.

e) Decreasing power control to minimum should reduce output power to between 32 and 79 watts.

f) Increase power control to maximum; reduce RF input to 1.5 watts and switch remote control to AM.

g) Output power should be between 32 and 79 watts

h) Short the key line to ground; switch the Remote Control to FM and increase the RF input to 5 watts.

i) Slowly decrease the input RF level while observing the power indicator.

j) There should be a reduction of power observed on the remote control power indicator and on the external power meter as the drive level is decreased to zero.

k) The Power Amplifier should remain in transmit without switching to bypass.

l) Apply 2.2 volts to the key line input and increase the RF input power to 5 watts.

m) The Power Amplifier should have switch to bypass and remained in bypass as long as 2.2 volts is applied to the key line input.

MOTOROLA

200 WATT UHF AM/FM POWER AMPLIFIER AM-7175/URC

DESCRIPTION

The AM-7175/URC is an all solid state, highly-reliable unit providing up to 200 watts of power output in the 225-400 MHz band. This unit is compatible with a variety of modulation schemes including AM, FM, or CW. Use of broadband techniques allows compatibility with any UHF transmitter having a carrier output of 2-25 watts and an output impedance of 50 ohms.

Designed for use in the demanding land vehicle environment, this amplifier is extremely rugged and has a calculated 5000 hour mean time between failure (MTBF).

Variable AM/FM output power is achieved by a rotary knob on the front panel with proportional LED output indicators. Maximum AM output is 50 watts carrier, 200 watts peak. Maximum FM output power is 200 watts.

The amplifier contains a thermostatically-contolled fan for use in high temperature environments or where continuous operation is necessary.

Weighing 22 pounds, the 200 watt amplifier is sealed in a weather-resistant housing to permit continuous operation in virtually all weather conditions. Loss of one of the dual output power amplifiers is automatically detected and continuous operation at reduced power is allowed. If a major failure occurs, the unit will go into a bypass mode.

AM-7175/URC Power Amplifier with LST-5C and AN/CSZ-1A
Sunburst Processor (wide/narrow band voice/data encryptor)

FEATURES

- *AM, FM, or CW*
- *50-200 watt power output-FM (adjustable)*
- *12.5-50 watt carrier power output-AM (adjustable)*
- *Front panel AM/FM power output control*
- *Designed for continuous operation*
- *Capable of being remotely controlled*
- *All solid state circuits*
- *No tuning required*
- *Airborne/vehicular configurations*
- *Automatic or key line control with logic compatibility*
- *Double thermal protection*
- *Triple ALC loop failure detection*
- *Weather-resistant housing*
- *Module failure will cause automatic switch-over to bypass mode*

TECHNICAL CHARCTERISTICS

Frequency	*225-400 MHz*
Input	*2-25 Watts*
Output (50Ω)	*200 Watts Max. FM 50 Watts Max, AM (Carrier)*
Input impedance	*50Ω*
Harmonics	*45 dB below carrier*
Load VSWR	*2:1*
Amplifier Distortion	*AM 10% @ 70% Mod.*
Primary power	*22-32 VDC @ 30 amps*
Size	*13.5 x 7 x 5 inches*
Weight	*22 lbs*
Operating Temperature	*–20°C to + 55°C*
MTBF	*5000 hrs*

90219-4221 10/94 2.5M VMP DKFL

MOTOROLA
Government and Systems Technology Group

For more information, or to order call
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