CHAPTER 7

POWER AMPLIFIER

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INTRODUCTION

1. The Power Amplifier (PA) comprises the following circuits:

(a) PTT Switch
(b) RF Amplifier
(c) Bias Regulator
(d) Driver
(e) Power Amplifier
(f) Automatic Level Control (ALC)
(g) Fault Detector / Low Power Initiate

These circuits are all mounted on the Power Amplifier PCB.

2. The Power Amplifier PCB is screwed to the back of a large aluminium heatsink. Transistors TR3, 5, 6, 7 and 8 are mounted directly onto the heat sink. The PCB is protected by a top cover which is secured to the heat sink by spacers. The complete assembly is installed on the left hand side (viewed from front) of the transceiver.

CIRCUIT DESCRIPTION

3. Refer to Figure 2 for a circuit diagram of the Power Amplifier.

4. The operation of the circuits that comprise the Power Amplifier are described in the following paragraphs.

PTT SWITCH

5. The p.t.t. switch (TR4) is normally held cut-off by the +24V d.c. applied to the base via R14. When the p.t.t. pressel is operated, the PTT LINE is connected to 0V. Consequently T4 is switched on and current is able to flow from +24V to the r.f. amplifier and bias regulator stages.

RF AMPLIFIER

6. The 300mV p.p. r.f. signal connected to the PCB at pins 1 and 2 is amplified in TR1 and TR2 and coupled by transformer T1 to the driver stage. Gain control in the r.f. amplifier is provided by pin-diode D1, which is connected in TR1 emitter circuit. The characteristics of this diode are such that its impedance to r.f. is determined by the d.c. current flowing through it. The impedance can vary between 10Ω with maximum current, to open-circuit with no current.

BIAS REGULATOR

7. The d.c. potentials developed at D2 and D3 anodes, due to the current flowing in TR3, are applied as bias voltages to the base circuit of the driver (TR6) and power amplifier (TR7, TR8) transistors respectively. The bias levels are determined by the total current flowing in TR3. This is set at R22. Transistor TR5, which is mounted on the Power Amplifier heatsink, tracks temperature changes within the assembly and adjusts the drive to TR4 to provide temperature compensation and bias regulation.

DRIVER

8. The driver output, developed in transformer T2, is coupled to the Power Amplifier circuit.

POWER AMPLIFIER

9. The power transistors TR7 and TR8 are connected into a class AB push-pull amplifier configuration with T2. The amplifier gives a flat response over the frequency range. The stage quiescent current, 250mA, is set at R22. The output transformer, T3, is a transmission line type and consists of a hybrid coupler, an impedance transformer and a balanced to unbalanced transformer. The 200V p.p. output is taken directly from T3 via the monitor transformer T4.

AUTOMATIC LEVEL CONTROL (ALC)

10. The automatic level control circuit provides the d.c. current control for pin-diode D1. In the quiescent condition TR10 base is held low, transistors TR10 and TR9 are cut-off and maximum current flows in D1. The diode r.f. impedance is therefore minimum and the gain of the r.f. amplifier is maximum.

FAULT DETECTOR / LOW POWER INITIATE

11. The presence of a fault or the initiation of a low power condition (TUNE or AM mode selected) is detected by the operation of four operational amplifiers that sense current differences in the input circuits. The fault conditions detected are described below.

(a) Over power

An over power condition is detected in IC1c.
In the absence of a 0V LOW POWER INITIATE signal transistors TR13 and TR12 are held cut-off by V3 via R52. The current reference level into IC1c.13 is therefore set at R57 (Adj. High Pwr). The FWD PWR signal, generated on the Harmonic Filter p.c.b. and connected to the PA through PL12/4, causes current to flow into IC1c.8.
When the current into IC1c.8 exceeds the reference current (adjusted for maximum power) IC1c.9 and, consequently, IC1a.3 goes towards zero by an amount depending on the input level.
As IC1a reference current input into IC1a.2, taken from R31/R32 junction, now exceeds the -ve input current, IC1a.4 output rises to +12V.
This + 12V, connected to the ALC circuit through D7 and R26, which reduces the current flowing through D1.
The diode r.f. impedance is therefore increased and the gain of the r.f. amplifier reduced.

(b) Low Power

The transceiver is set to the low power condition when the TUNE or AM mode is selected.
A LOW POWER INITIATE signal (0V), applied to the PA p.c.b. pin 13, causes transistors TR13 and TR12 to conduct.
IC1c.13 is then connected to +12V. The current flowing into IC1c.13 is limited by R56.
The current flowing into IC1c.8 is derived from two sources.
(i) From V3 via TR12, R47 and R48.
(ii) From the FWD PWR input.
The current in TR12 is set at R47 (Adj. Low Power) for maximum low power level.
When the sum of the two currents exceeds the current into IC1c.13, IC1c.9 goes towards 0V and the circuit operates as previously described.

(c) Over temperature

Thermal switch S1, mounted on the heatsink, closes when the temperature exceeds 100°C to connect 0V to the LOW POWER INITIATE circuit via D16. The circuit operation is then as previously described.

(d) **Antenna System faults**

An antenna system fault (mismatch of feeder open/short circuit) is indicated by a + ve potential on the REFL PWR input circuit, the greater the mismatch the higher the voltage level. This signal is applied to the inverting input (IC1d.11) of linear amplifier IC1d. Consequently IC1d.9 output (normally at + 12V) is taken towards 0V. This is applied to IC1a.3 via R34 and TR11 via R42.

The –ve going signal at IC1a.3 inverting input results in a + ve going output (IC1a.4) which is applied to the ALC circuit as previously described.

TR11 is switched on to apply + 12V to the HIGH VSWR circuit via R60.

(e) **Harmonic filter System Faults**

The PA output is sampled at the junction of the capacitive voltage divider comprising C46 and C47. The output of monitor divider T4 (developed across R53 and having a 180° phase shift relative to the r.f. output) is applied via D13 to C46/C47 junction where it is summed with the r.f. output sample. The resultant is connected by R49 to IC1b.1.

Under normal conditions the FWD PWR input signal, developed at the front end of the Harmonic Filter, controls IC1b.6, which provides a 0V ALC circuit input signal, resulting in maximum gain. Should a fault occur in the Harmonic Filter or in the coaxial feeder connecting the PA to the Harmonic Filter, such that an excessive amount of power is dissipated in the circuit, IC1b.6 goes negative with respect to IC1b.1. This results in a positive signal being applied to the ALC circuit and a reduction in PA gain.

SERVICING AND TEST INSTRUCTIONS

TEST EQUIPMENT

12. The following items of test equipment are required to perform the procedures detailed:

DC POWER SUPPLY	:	0–30V 15A with current limiting 2A to 15A, e.g. HP6269B
THERMAL POWER METER	:	0–100W and 50Ω load, e.g. Marconi Type TF2503
RF SIGNAL GENERATOR	:	e.g. Marconi TF 144H/4
MULTIMETER	:	20 000Ω/V, e.g. AVO 8
MILLIAMMETER	:	0–500mA
PTT SWITCH	:	Toggle, single pole
TOROIDS	:	3 in No.

PRELIMINARY OPERATIONS

13. (1) Connect the Power Amplifier into the test circuit configuration illustrated overleaf.
Switch the RF Signal Generator outputs OFF, or reduce to minimum.

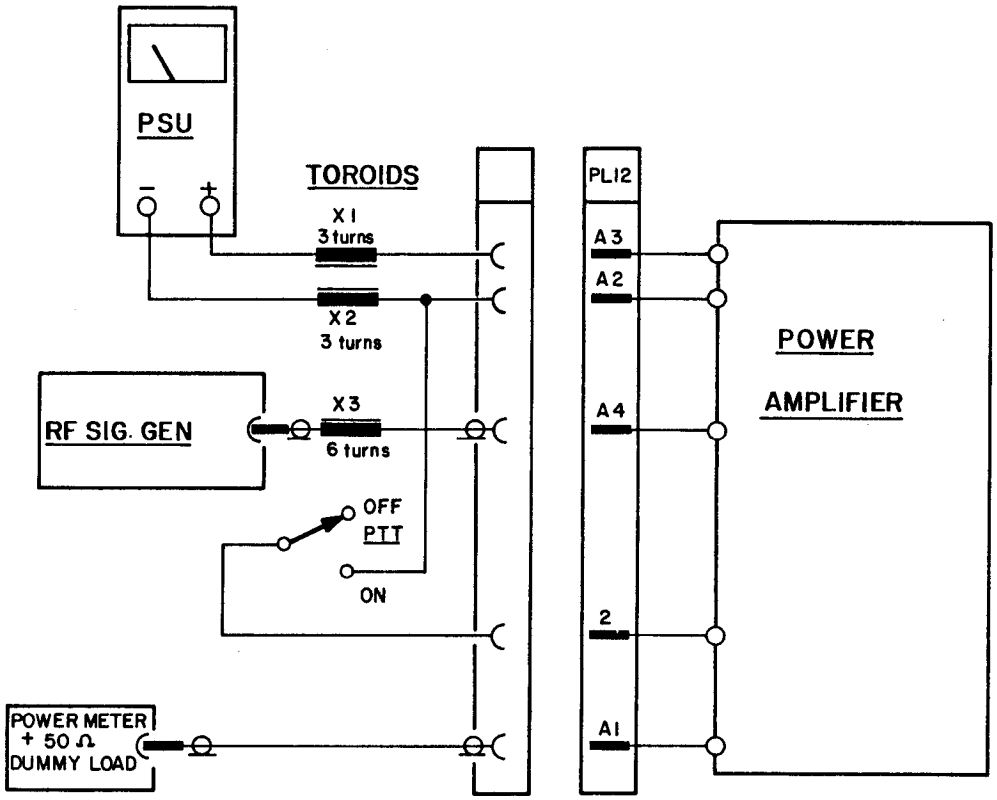
(2) Disconnect choke L4 from PCB pin 18.

(3) Set the PSU current limit to 2A and voltage output control to minimum.

(4) Switch ON the PSU and increase output voltage to 27V d.c.
Note the current supplied.
This should be approximately 35mA.

(5) Using the multimeter measure the voltage at D4 cathode.
This should be 12,0V ±0,6V.

(6) Switch OFF the PSU.



TEST PROCEDURES

CAUTION

Do not switch the PSU ON or OFF with the PTT switch closed.

Power Amplifier (TR7, TR8) Iq Adjustment

14. (1) Set R22 fully counterclockwise

(2) Connect the 0–500mA meter between PCB pin 18 and L4.

(3) Switch ON the PSU.

(4) Set the PTT Switch to ON (closed).

(5) Adjust R22 for a meter reading of 250mA ± 5mA.

(6) Set the PTT switch to OFF.

(7) Switch OFF the PSU.

(8) Connect L4.

(9) Set the PSU current limit to 10—15A.

(10) Switch ON the PSU.

(11) Set the PTT switch to ON.
Note the current supplied (with no r.f. input signal)
This should be 1,15A ± 0,1A.

Power Output

15. (1) Set the r.f signal generator controls for a 4MHz CW output (no modulation).

(2) Adjust the signal level to obtain a power meter reading of 25W (100V peak-to-peak into 50Ω).

(3) Note the input r.f. signal level.
This should be 20mV ± 5mV.

(4) Note the d.c. current supplied
This should be 4,5A ± 0,25A.

(5) Increase the r.f. signal input level to obtain a power meter reading of 100W (200V peak-to-peak into 50Ω).

(6) Note the input r.f. signal level.
This should be 45mV ± 5mV.

(7) Note the d.c. current supplied.
This should be 8,5A ± 0,3A.

(8) Decrease the r.f. input signal level by 10dB and repeat Steps (5), (6) and (7) at 1,6MHx, 16MHz and 30MHz.
The r.f. input signal and d.c. currents for each frequency should be as detailed below.

1,6MHz	45mV ± 5mV	10A maximum
16MHz	45mV ± 5mV	10A maximum
30MHz	50mV ± 5mV	10A maximum.

Short Circuit Test at 4MHz.

16. (1) Decrease the r.f. input signal level by 10dB.

(2) Set the r.f. input signal to 4MHz.

(3) Adjust the r.f. input signal to obtain a power meter reading of 100W.

(4) Connect a jumper lead between the r.f. output terminal and the head of the screw securing the PCB to the heatsink.

(5) Note the d.c. current supplied.
This should be less than 6A.

(6) Remove the jumper lead.

Open Circuit Test at 4MHz.

17. (1) Check the power meter reading is 100W.
Adjust r.f. signal level if necessary.

(2) Disconnect the 50Ω load.

(3) Note the d.c. current supplied.
This should be less than 2A.

(4) Swtich OFF and remove all test equipment.

PARTS LIST

18. The component tolerances and ratings given in these parts list are optimum. However if such components are not immediately available alternatives with closer tolerances and/or higher wattage or voltage ratings may be used in manufacture or supplied as replacements.

19. When ordering replacements please quote the full description including the circuit reference and the Order No.

POWER AMPLIFIER ASSEMBLY

FIG. NO.	REF.	ORDER NO.	CODIFICATION	ITEM	DESCRIPTION	NO/UNIT
		1100-0853		ASSEMBLY	POWER AMPLIFIER	
				Sub-Assemblies		
		1300-0875			Power Amplifier p.c.b.	
		3300-1285			Conn. Plug C-A 9-way	
				Switch		
	S1	2900-2004			Thermal Trip, 100°C SP Make contact. (Thermo type Z19001-E100EA or equiv.)	
				Transistors		
	TR6	3600-0943			PT9788 NPN Flange Mount HFE MTC.	
	TR7	3600-0944			PT9780 See note below	
	TR8	3600-0944			PT9780 See note below	
					Note: TR7 and TR8 are a matched pair.	

Power Amplifier PCB

FIG. NO.	REF.	ORDER NO.	CODIFICATION	ITEM	DESCRIPTION				NO/UNIT
		1300-0875		PCB	POWER AMPLIFIER				
				Capacitors					
	C1	2600-1708			Ceramic	470pF	100V	2p.c.	
	C2	2600-3266			Ceramic	10nF	100V	10p.c.	
	C3	2400-1017			Electrolytic	10uF	40V	−20 + 50p.c.	
	C4	2500-6070			Tantalum	10uF	35V	20p.c.	
	C5	2500-6067			Tantalum	3,3uF	35V	20p.c.	
	C6	2600-3266			Ceramic	10nF	100V	10p.c.	
	C7	2600-3619			Ceramic	390pF	200V	10p.c.	
	C8	2600-3266			Ceramic	10nF	100V	10p.c.	
	C9	2600-3292			Ceramic	100nF	50V	10p.c.	
	C10	2600-3292			Ceramic	100nF	50V	10p.c.	
	C11	2700-2603			Polystyrene	390pF	160V	5p.c.	
	C12	2500-6070			Tantalum	10uF	35V	20p.c.	
	C13	2500-3601			Tantalum	47uF	20V	20p.c.	
	C14	2600-3708			Ceramic	220nF	50V	10p.c.	
	C15	2600-3708			Ceramic	220nF	50V	10p.c.	
	C16	2600-3292			Ceramic	100nF	50V	10p.c.	
	C17	2600-3266			Ceramic	10nF	100V	10p.c.	
	C18	2600-3292			Ceramic	100nF	50V	10p.c.	
	C19	2500-6070			Tantalum	10uF	35V	20p.c.	
	C20	2600-3266			Ceramic	10nF	100V	10p.c.	
	C21	2600-3266			Ceramic	10nF	100V	10p.c.	
	C22	2500-4602			Tantalum	220uF	10V	20p.c.	
	C23	2600-3292			Ceramic	100nF	50V	10p.c.	
	C24	2600-3404			Ceramic	470nF	50V		

Power Amplifier PCB (Cont.)

FIG. NO.	REF.	ORDER NO.	CODIFICATION	ITEM	DESCRIPTION				NO/UNIT
	C25	2600-3292			Ceramic	100nF	50V	10p.c.	
	C26	2600-3421			Ceramic	1uF	50V	20p.c.	
	C27	2600-3421			Ceramic	1uF	50V	20p.c.	
	C28	2600-3292			Ceramic	100nF	50V	10p.c.	
	C29	2500-2610			Tantalum	10uF	50V		
	C30	2700-1205			Polystyrene	56pF	63V	10p.c.	
	C31	2600-3421			Ceramic	1uF	50V	20p.c.	
	C32	2700-2216			Polystyrene	250pF	63V	5p.c.	
	C33	2600-3266			Ceramic	10nF	100V	2p.c.	
	C34	2600-3404			Ceramic	470nF	50V		
	C35	2600-3404			Ceramic	470nF	50V		
	C36	2500-6070			Tantalum	10uF	35V	20p.c.	
	C37	2500-3601			Tantalum	47uF	20V	20p.c.	
	C38	2500-6070			Tantalum	10uF	35V	20p.c.	
	C39	2500-6064			Tantalum	1uF	35V	20p.c.	
	C40	2600-3266			Ceramic	10nF	100V	2p.c.	
	C41	2600-3266			Ceramic	10nF	100V	2p.c.	
	C42	2600-3266			Ceramic	10nF	100V	2p.c.	
	C43	2600-3374			Ceramic	1nF	200V	10p.c.	
	C44	2600-3374			Ceramic	1nF	200V	10p.c.	
	C45	2600-3266			Ceramic	10nF	100V	2p.c.	
	C46	2600-4383			Mica	20pF	500V	2p.c.	
	C47	2700-2216			Polystyrene	250pF	63V	5p.c.	
	C48	2600-3266			Ceramic	10nF	100V	2p.c.	
	C49	2600-3266			Ceramic	10nF	100V	2p.c.	
	C50	2600-3266			Ceramic	10nF	100V	2p.c.	
	C51	2500-3601			Tantalum	47uF	20V	20p.c.	
	C52	2600-3266			Ceramic	10nF	100V	2p.c.	
	C53	2600-3266			Ceramic	10nF	100V	2p.c.	
	C54	2600-3266			Ceramic	10nF	100V	2p.c.	

Power Amplifier PCB (Cont.)

FIG. NO.	REF.	ORDER NO.	CODIFICATION	ITEM	DESCRIPTION	NO/UNIT
	C55	2600-3266			Ceramic 10nF 100V 2p.c.	
	C56	2600-6783			Mica 820pF 500V 2,5p.c.	
	C57	2600-6888			Mica 1000pF 500V 2p.c.	
				Diodes		
	D1	3600-1219			IN5767/HP 5082-3080	
	D2	3600-0398			IN4004	
	D3	3600-0398			IN4004	
	D4	3600-1207			12,0V Zener 1W 5p.c. 1N4742A	
	D5	3600-0404			IN4153	
	D6	3600-0404			IN4153	
	D7	3600-0404			IN4153	
	D8	3600-0404			IN4153	
	D9	3600-0404			IN4153	
	D10	3600-0404			IN4153	
	D11	3600-7292			BAT 85 S Ch. Barr. Diode	
	D12	3600-7292			BAT 85 S Ch. Barr. Diode	
	D13	3600-7292			BAT 85 S Ch. Barr. Diode	
	D14	3600-0404			IN4153	
	D15	3600-0326			13,0V Zener 0,4W 5p.c. BZX 79C13	
	D16	3600-0404			IN4153	
	D17	3600-0404			IN4153	
				Inductors		
	L1	3100-0343			Choke 100uH	
	L2	3100-0278			Choke 2,2uH	
	L3	3100-0278			Choke 2,2uH	
	L4	3100-0706			Choke 0,4uH	

Power Amplifier PCB (Cont.)

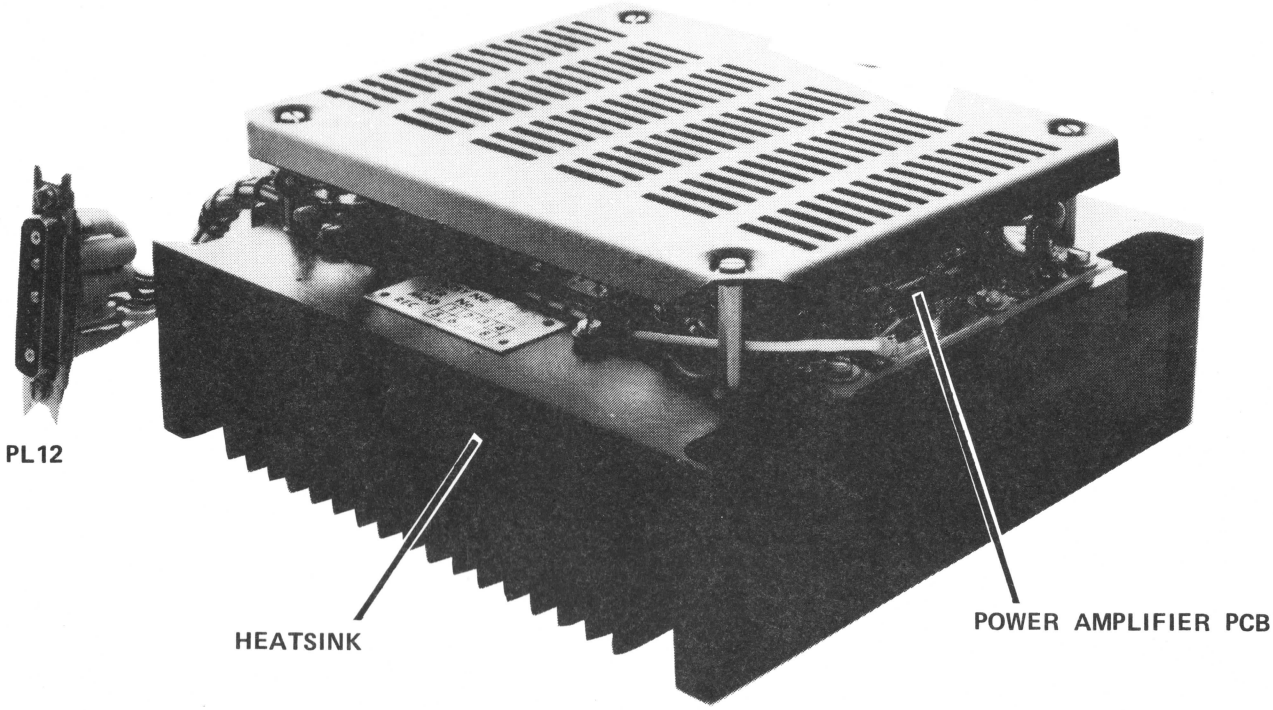
FIG. NO.	REF.	ORDER NO.	CODIFICATION	ITEM	DESCRIPTION	NO/UNIT
				Integrated Circuits		
	IC1	3600-6117			Quad Op. Amp. LM2900N	
				Resistors		
	R1	2000-0322			Carbon 56 ohms 5p.c. 0,25W	
	R2	2000-0343			Carbon 3k3 5p.c. 0,25W	
	R3	2000-0322			Carbon 56 ohms 5p.c. 0,25W	
	R4	2000-0339			Carbon 1k5 5p.c. 0,25W	
	R5	2000-0349			Carbon 10k 5p.c. 0,25W	
	R6	2000-0325			Carbon 100 ohms 5p.c. 0,25W	
	R7	2000-0339			Carbon 1k5 5p.c. 0,25W	
	R8	2000-0329			Carbon 220 ohms 5p.c. 0,25W	
	R9	2000-0317			Carbon 22 ohms 5p.c. 0,25W	
	R10	2000-0441			Carbon 2k2 5p.c. 0,5W	
	R11	2000-0429			Carbon 220 ohms 5p.c. 0,5W	
	R12	2000-0353			Carbon 22k 5p.c. 0,25W	
	R13	2000-0537			Carbon 1k 5p.c. 1W	
	R14	2000-0351			Carbon 15k 5p.c. 0,25W	
	R15	2000-0405			Carbon 2,2 ohms 5p.c. 0,5W	
	R16	2000-0345			Carbon 4k7 5p.c. 0,25W	
	R17	2000-0322			Carbon 56 ohms 5p.c. 0,25W	
	R18	2000-0531			Carbon 330 ohms 5p.c. 1W	
	R19	2000-0313			Carbon 10 ohms 5p.c. 0,25W	
	R20	2000-0313			Carbon 10 ohms 5p.c. 0,25W	
	R21	2000-0531			Carbon 330 ohms 5p.c. 1W	
	R22	2200-0130			Variable 100 ohms	
	R23	2000-0349			Carbon 10k 5p.c. 0,25W	
	R24	2000-0337			Carbon 1k 5p.c. 0,25W	

Power Amplifier PCB (Cont.)

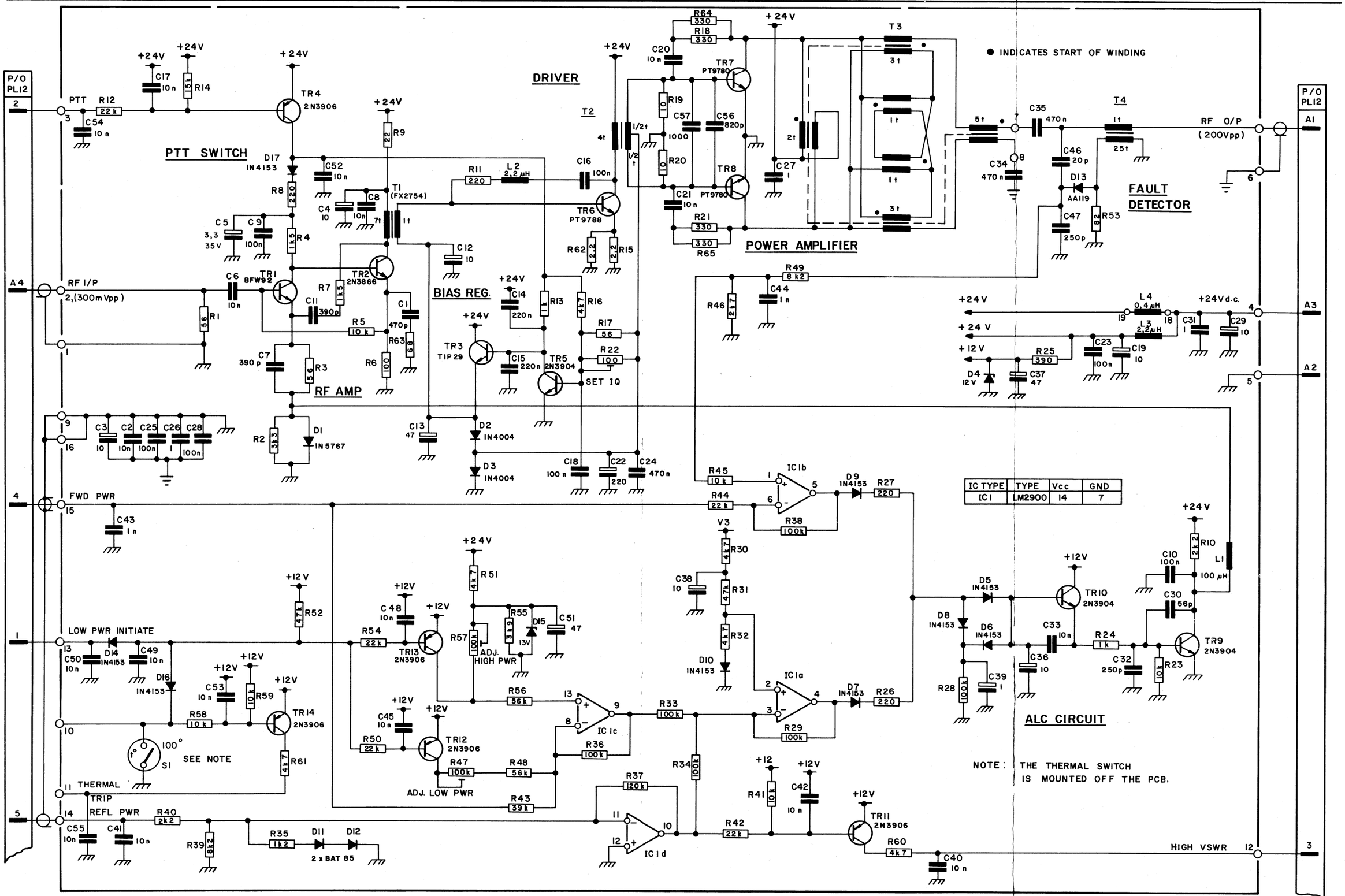
FIG. NO.	REF.	ORDER NO.	CODIFICATION	ITEM	DESCRIPTION	NO/UNIT
	R25	2000-0532			Carbon 390 ohms 5p.c. 1W	
	R26	2000-0329			Carbon 220 ohms 5p.c. 0,25W	
	R27	2000-0329			Carbon 220 ohms 5p.c. 0,25W	
	R28	2000-0361			Carbon 100k 5p.c. 0,25W	
	R29	2000-0361			Carbon 100k 5p.c. 0,25W	
	R30	2000-0345			Carbon 4k7 5p.c. 0,25W	
	R31	2000-0357			Carbon 47k 5p.c. 0,25W	
	R32	2000-0345			Carbon 4k7 5p.c. 0,25W	
	R33	2000-0361			Carbon 100k 5p.c. 0,25W	
	R34	2000-0361			Carbon 100k 5p.c. 0,25W	
	R35	2000-0338			Carbon 1k2 5p.c. 0,25W	
	R36	2000-0361			Carbon 100k 5p.c. 0,25W	
	R37	2000-0362			Carbon 120k 5p.c. 0,25W	
	R38	2000-0361			Carbon 100k 5p.c. 0,25W	
	R39	2000-0348			Carbon 8k2 5p.c. 0,25W	
	R40	2000-0341			Carbon 2k2 5p.c. 0,25W	
	R41	2000-0349			Carbon 10k 5p.c. 0,25W	
	R42	2000-0353			Carbon 22k 5p.c. 0,25W	
	R43	2000-0356			Carbon 39k 5p.c. 0,25W	
	R44	2000-0353			Carbon 22k 5p.c. 0,25W	
	R45	2000-0349			Carbon 10k 5p.c. 0,25W	
	R46	2000-0342			Carbon 2k7 5p.c. 0,25W	
	R47	2200-0159			Variable 100k	
	R48	2000-0358			Carbon 56k 5p.c. 0,25W	
	R49	2000-0348			Carbon 8k2 5p.c. 0,25W	
	R50	2000-0353			Carbon 22k 5p.c. 0,25W	
	R51	2000-0345			Carbon 4k7 5p.c. 0,25W	
	R52	2000-0357			Carbon 47k 5p.c. 0,25W	
	R53	2000-0324			Carbon 82 ohms 5p.c. 0,25W	
	R54	2000-0353			Carbon 22k 5p.c. 0,25W	

Power Amplifier PCB (Cont.)

FIG. NO.	REF.	ORDER NO.	CODIFICATION	ITEM	DESCRIPTION	NO/UNIT
	R55	2000-1923			Metal Film 3k9 2p.c. 0,25W	
	R56	2000-0358			Carbon 56k 5p.c. 0,25W	
	R57	2200-0159			Variable 100k	
	R58	2000-0349			Carbon 10k 5p.c. 0,25W	
	R59	2000-0349			Carbon 10k 5p.c. 0,25W	
	R60	2000-0345			Carbon 4k7 5p.c. 0,25W	
	R61	2000-0345			Carbon 4k7 5p.c. 0,25W	
	R62	2000-0405			Carbon 2,2 ohms 5p.c. 0,5W	
	R63	2000-0323			Carbon 68 ohms 5p.c. 0,25W	
	R64	2000-0531			Carbon 330 ohms 5p.c. 1W	
	R65	2000-0531			Carbon 330 ohms 5p.c. 1W	
				Transformers		
	T1	3100-0802			Transformer Assy	
	T2	3100-0801			Transformer Assy	
	T3	3100-0674			Transformer Assy	
	T4	3100-0611			Transformer, Current Sensing	
				Transistors		
	TR1	3600-0089			BFW92 NPN	
	TR2	3600-0183			2N3866 NPN	
	TR3	3600-0112			TIP 29 NPN	
	TR4	3600-0187			2N3906 PNP Si	
	TR5	3600-0185			2N3904 NPN Si	
	TR9	3600-0185			2N3904 NPN Si	
	TR10	3600-0185			2N3904 NPN Si	
	TR11	3600-0187			2N3906 PNP Si	
	TR12	3600-0187			2N3906 PNP Si	
	TR13	3600-0187			2N3906 PNP Si	
	TR14	3600-0187			2N3906 PNP Si	



POWER AMPLIFIER



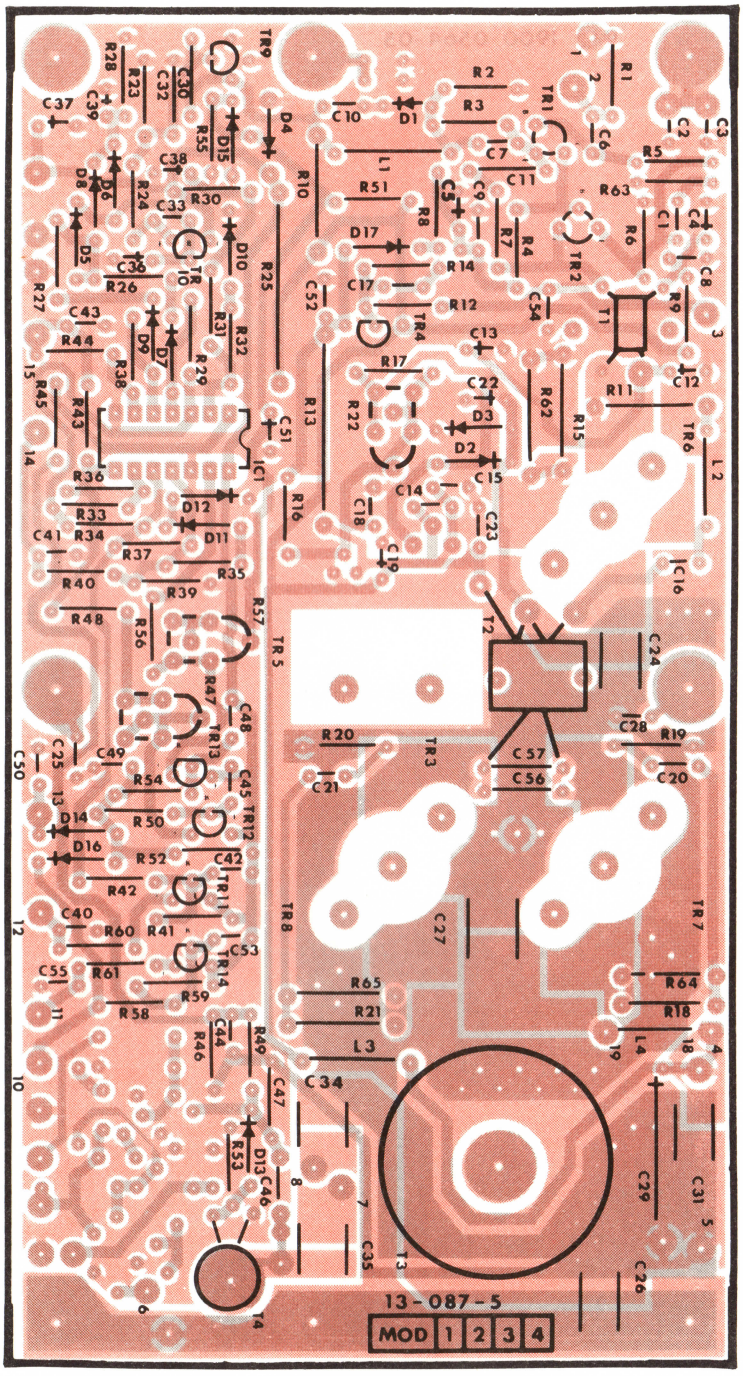
IC TYPE	TYPE	Vcc	GND
IC1	LM2900	14	7

NOTE: THE THERMAL SWITCH IS MOUNTED OFF THE PCB.

POWER AMPLIFIER PCB CIRCUIT DIAGRAM

GE003.1085

FIG. 2



PCB Component Side:

PCB Track Side:

POWER AMPLIFIER PCB

COMPONENT LOCATION