523-0762477-00711A

Rockwell International

Collins instruction book

548S-3/3A/5/5A/6 Power Amplifier-Coupler and 641D-1 Variable Capacitor

This instruction book includes:

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967M-5 Preregulator Test Set	523-0772089

Collins Telecommunications Products Division
Defense Electronics Operations
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Caution

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SERVICE BULLETINS/SERVICE INFORMATION LETTERS

All service bulletins (SB) and service information letters (SIL) incorporated in this instruction book are listed below. Applicable service bulletins and/or service information letters released after printing but prior to shipment of the instruction book are inserted in the front of the instruction book.

Note

Service bulletins are numbered in sequence for the life of the equipment. Service information letters are numbered in sequence starting at 1 for each calendar year.

SB/SIL	DESCRIPTION	ISSUE DATE
SB 1	Provide continuous +26-V dc (keep-alive) to mount	8/15/73 Revised 11/15/73
SB 2	Circuit change to provide +5-V dc pullup voltage	11/15/73
SB 4	Enable 548S-3 operation with 437R-2 Tuned HF Monopole Antenna in 2- to 16-MHz frequency range	12/1/73
SB 5	Improve tuning range to eliminate tuning faults caused by certain failures	2/1/77 Revised 8/1/77
SB 6	Eliminate fault indication in some systems when power to the 548S-( ) is removed and the 514A-4 Radio Set Control is in the off position	10/15/77
SB 7	Improve power supply cold temperature starting capability	11/15/78
SB 8	Solve airpressure leaks by substituting "O" rings for sealing washers	12/1/78
SB 9	Eliminate intermittent fault indications in some installations.	
SB 10	Eliminate tuning hole in some installations.	7/1/82

548S-3/3A/5/5A/6 Power Amplifier-Coupler and 641D-1 Variable Capacitor

Rockwell International

description

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Paragraph *Page*

NOTICE: This section replaces fifth edition dated 1 May 1979.

List of Effective Pages

*Zero in this column indicates an original page.

Record of Changes

CHG NO	CHANGE DATE	CHG NO	CHANGE DATE	CHG NO	CHANGE DATE	CHG NO	CHANGE DATE
1st Ed	1 Aug 70	5th Ed	1 May 79				
2nd Ed	1 Sep 71	6th Ed	1 Aug 82				
1	1 Jan 72						
3rd Ed	15 Dec 75						
4th Ed	1 Aug 77						

1. PURPOSE OF EQUIPMENT

The 548S-3/3A/5/5A/6 Power Amplifier-Coupler (figure 1) unit is a 100-watt pep and average transmitter that operates in the hf band (2 to 30 MHz). These units are part of the 718U-3/5/7 Lightweight HF Airborne Transceiver family.

Warning

This device contains a radio frequency transmitter which, when operated into an antenna, may produce electromagnetic fields in close proximity to the antenna that are in excess of the Occupational Safety and Health Administration (OSHA) recommended maximum limits.

The 548S-3/3A contains a solid-state power amplifier and a general purpose antenna coupler which, when used with optional tuning accessories (load coils or capacitors), is capable of tuning virtually any type of hf antenna. 548S-3 part number 787-6781-005 has the added capability of front panel time totalizing meter.

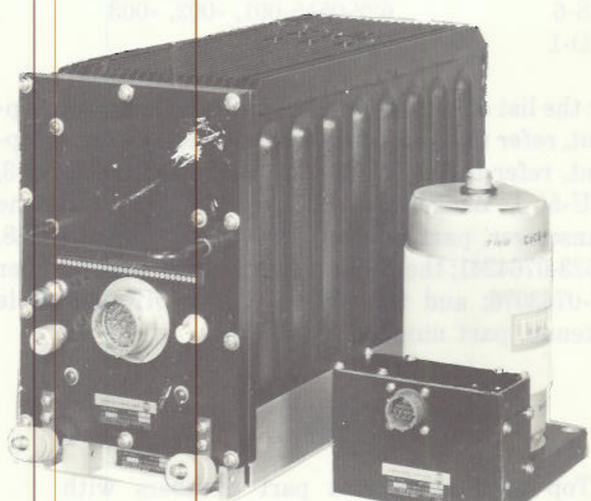
The 548S-5/5A is a pressurized version of the 548S-3/3A for extended high-altitude operation.

The 641D-1 Variable Capacitor is a 548S-3/3A/5/5A tuning accessory used for tuning shunt or notch type antennas.

The 548S-6 is a version of the 548S-5 (contains an internal 641D type capacitor) for special shunt antenna applications.

548S-3/3A

NOTE:
THE 548S-5/5A AND 548S-6 ARE IDENTICAL IN APPEARANCE EXCEPT THE 548S-6 IS 5.13 INCHES LONGER AND HAS A PRESSURE GAGE INSTALLED IN THE RIGHT SIDE OF THE CASE.



548S-5/5A/6 641D-1

TP4-7354-017

548S-3/3A/5/5A/6 Power Amplifier-Coupler and 641D-1 Variable Capacitor
Figure 1

The 548S-3A and 548S-5A are approved for FCC part 83 operation for mobile maritime service when used in the 718U-5M system.

Note

Type 548S Power Amplifier Coupler refers to all versions covered in this instruction book. Types 548S-3 and 548S-5 refer also to the 548S-3A and 548S-5A versions unless otherwise noted.

A series of mounts (990C-2/2A/5/6/8/9/12/14/16) used with the 548S units are covered in the 718U-( ) transceiver and mountings instruction books. Some of these mounts contain tuning accessories required to tune certain types of antennas.

2. EQUIPMENT SUPPLIED

The following individual equipments are supplied under the respective Rockwell-Collins part numbers.

EQUIPMENT	PART NUMBER
548S-3	787-6781-001, -002, -003, -004, -005, -006
548S-3A	622-2551-001, -002
548S-5	622-0192-001, -002, -003, -004, -006
548S-5A	622-2552-001, -002
548S-6	622-0515-001, -002, -003
641D-1	622-0193-001

For the list of subassemblies employed in each equipment, refer to table 1. For the required system equipment, refer to the instruction books for the 718U-3, 718U-5( ), or 718U-7 Lightweight HF Airborne Transceiver, part number 523-0762682, 523-0762588, or 523-0764241; the 718U-( ) mountings, part number 523-0763076; and the 437R-2 Tuned HF Monopole Antenna, part number 523-0765140.

Note

Top level equipment part numbers with higher status endings (-00X) can replace those with lower status endings; however the converse may not be true.

3. EQUIPMENT SPECIFICATIONS

3.1 Electrical Specifications

Frequency range ....2 to 29.999 MHz.

Power output ....100 watts pep/average (±1-1/2 dB) into 50 Ω (including antenna coupler) at 26.5 to 31.5-V dc input. Reduced output may occur at 22.0 to 26.5 - V dc input.

Power output into antenna can be approximated by the following (at any given frequency):

$$\text{Pwr to antenna} = \frac{200}{200 + \dfrac{\text{antenna series reactance}}{\text{antenna series resistance}}} \times 100$$

The coupler section provides accurate tuning of the antenna to present a load within a 1.3:1 vswr to the power amplifier section.

Input impedance ....50 Ω resistive within 1.3:1 vswr.

Rf input power ....Not more than 100 mW.

Dc input power ....Not more than 5.0 W at +28.0 V in receive and not more than 450 W steady state at +28.0 V in transmit (350 W nominal).

Power supply polarity ....The dc power supply shall have the negative side grounded.

Duty cycle ....Function of temperature/altitude. Refer to figures 2 and 3.

SSB voice or secure voice ....Refer to 25-W curve.

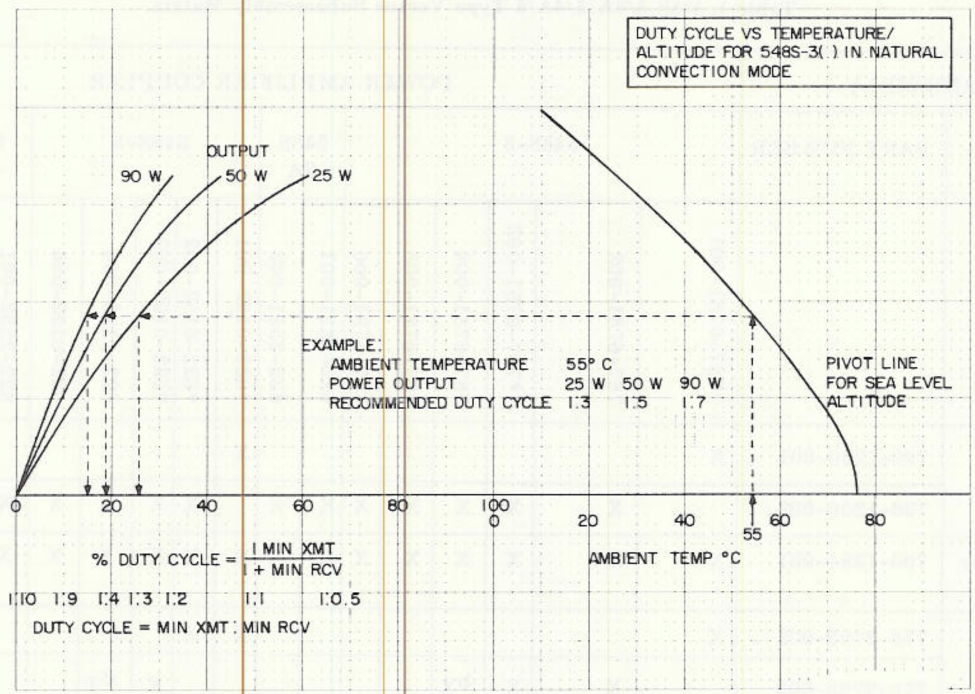
AM, modulated, or CW, keyed ....Refer to 50-W curve.

AM, unmodulated, or CW, keydown ....Refer to 100-W curve.

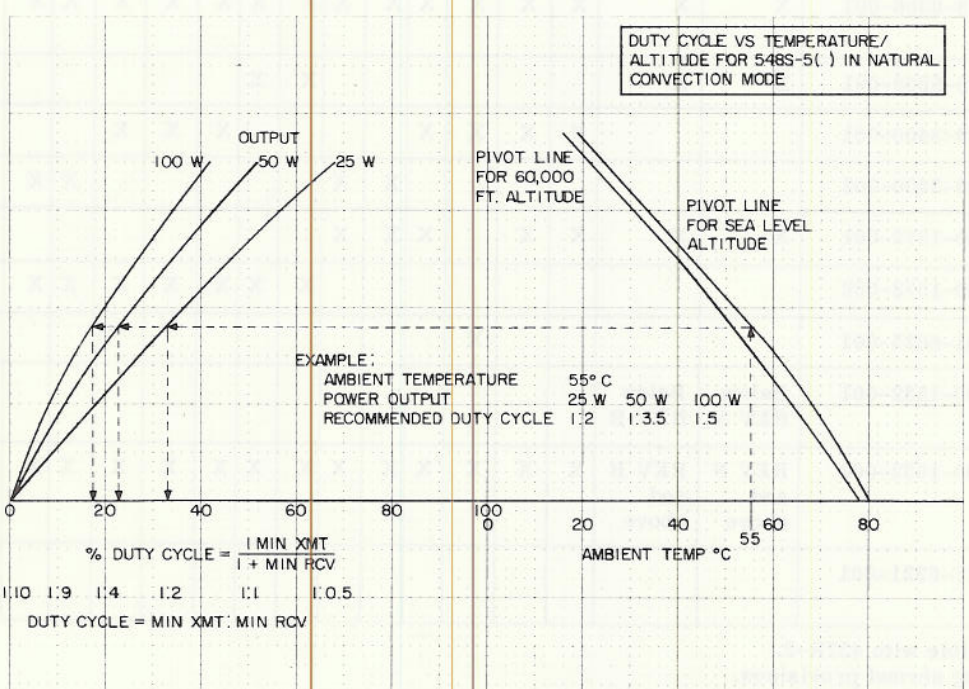
Table 1. 548S-3/3A/5/5A/6 Type Versus Subassembly Matrix.

SUBASSEMBLY		POWER AMPLIFIER COUPLER																	
TITLE	PART NUMBER	548S-3						548S -3A		548S-5					548S -5A		548S-6		
		*787-6781-001	787-6781-002	**787-6781-003	787-6781-004	787-6781-005	787-6781-006	622-2551-001	622-2551-002	*622-0192-001	*622-0192-002	a622-0192-003	622-0192-004	622-0192-006	622-2552-001	622-2552-002	622-0515-001	622-0515-002	622-0515-003
Rf tuner A1	790-1200-001	X								X							X		
	790-1200-002		X	X	X	X	X	X	X		X	X	X	X	X	X		X	X
Discriminator A2	790-1284-001	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Logic board A3	778-2793-002	X								X	X						X		
	778-2793-003		X	X	bX							X	dX						
	778-2793-004				cX			X					eX		X			X	
	646-5343-001					X	X		X					X		X			X
Dual servo amplifier A4	778-2743-001	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Power supply A6	778-0306-001	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Power amplifier A7	795-5308-001	X	X							X	X						X		
	629-3400-001			X	X	X	X					X	X	X				X	X
	629-3400-002							X	X						X	X			
Chassis A9	790-1572-001	X	X	X	X		X	X	X										
	790-1572-002									X	X	X	X	X	X	X	X	X	X
	641-6625-001					X													
Preregulator A10	790-1532-001	Below REV N	Below REV B																
	790-1532-002	REV N and above	REV B and above	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Loading capacitor A11	617-6921-001																X	X	X

*Status not compatible with 437R-2.
**Cover has cooling shroud provisions.
aCase has coax adapter.
bApplicable to serial numbers 101 thru 1205, 1210 thru 1493, 1495, 1498, 1499, and 1500.
cApplicable to serial numbers 1206 thru 1209, 1494, 1496, 1497, 1501, and subsequent.
dApplicable to serial numbers 101 thru 274, 278 thru 283, and 285 thru 288.
eApplicable to serial numbers 275 thru 277, 284, 289, 290, and subsequent.



Duty Cycle Vs Temperature/Altitude for 548S-3/3A
Figure 2



Duty Cycle Vs Temperature/Altitude for 548S-5/5A
Figure 3

Note

The power amplifier section contains thermal protection to automatically cut back to low power (approximately 15 watts into 50 ohms) any time duty cycle is exceeded.

Harmonic attenuation .... 548S-3/5/6 only: -50-dB minimum below the fundamental; 548S-3A/5A only: meets part 83 requirements.

Intermodulation distortion .... 548S-3/5/6 only: at rated pep output, -31-dB minimum; 548S-3A/5A only: meets part 83 requirements.

Tune time .... 3 s nominal (up to 6 s at lower frequencies with 641D-1 or 437R-2).

Tuning capability

Detailed tuning range is explained in paragraph 4.

The 548S-3/5 will tune the following typical antennas ....

a. 50 Ω (resonant dipole or wires).

b. Whips, 10.7 m (35 ft) or longer.

c. Open-end aircraft wires 10.7 m (35 ft) or longer.

d. Grounded aircraft wires, 9.15 m (30 ft) or longer.

e. 437R-2 monopole (see table 1 for compatible statuses).

f. 637K tactical antennas.

g. Shunt-fed engine, nacelle antenna.

With tuning accessories ....

h. Whips, 7.6 to 10.7 m (25 to 35 ft), use 990C-2.

i. Open aircraft lines, 6.1 to 10.7 m (20 to 35-ft), use 990C-2.

j. Grounded aircraft wires, 4.7 to 9.15 m (15 to 30 ft), use 990C-9A.

k. Shunt- or notch-type aircraft antennas, use 641D-1.

The 548S-6 will tune a typical shunt-type antenna.

3.2 Environmental Specifications

Temperature .... Operating: -54 to +55 °C (-65 to +131 °F).

Storage: -65 to +85 °C (-85 to +185 °F).

Altitude .... 548S-3, 10 668 m (35 000 ft); 548S-5/6 and 641D-1, 16 764 m (55 000 ft).

Humidity .... 48-hour temperature cycle: 50 °C (122 °F), 95% humidity, to 38 °C (100.4 °F), 85% humidity.

Vibration .... 548S-3/5 using 990C-( ) Mount with shock isolators meets categories G and S of RTCA DO-138; 548S-3/5 using 990C-( ) without isolators meets category N; 548S-3/5 without mount meets categories J and N.

Shock .... 6 g operational, 15 g crash safety.

Explosion .... 548S-5 meets explosion test requirements of DO-138, category E.

3.3 TSO Specification

The 548S-3/5 meets or exceeds FAA TSO-C31c and - C32c, using environmental conditions and test procedures specified in RTCA DO-138, as follows:

Temperature/ altitude	548S-3, categories B and D; 548S-5, category A.
Humidity	Meets category A.
Vibration	See environmental specifications above.
Shock	Per DO-138: 6 g operational, 15 g crash safety.
Explosion	548S-5 only: category E.

4. TUNING RANGE

Warning

Do not touch antenna or antenna feedline when radio is transmitting; painful rf burns may result from high rf voltages.

Caution

The antenna feedline must be spaced away from metal (or sharp objects) to avoid high-voltage flashover or arcing. A 25.4-mm (1.0-inch) (or larger) spacing is required for altitudes below 9.144 km (30,000 ft) (above 30,000 feet a 38.1-mm (1.5-inch) spacing is required).

Note

The importance of reading this section and Engineering Report on HF Antenna System, part number 523-0764982, before an installation cannot be overemphasized. The operational performance of the 718U-5 radio is completely dependent upon the antenna system and the radio/antenna interface. How much power is radiated by the antenna is strictly dependent upon the antenna type, how well the antenna is installed, and how well the radio is interfaced with it. The radio will tune and deliver power to the resulting antenna impedance if the impedance is within the coupler tuning limits given in figures 4 and 5 of the description section of this instruction book. To assist customers and installers, information given in this instruction book, and engineering report 523-0764982, on important installations will ensure overall good radio/antenna system performance.

The 548S-3/5 tuning range curves are given in figure 4 for 2, 4, 8, 16, and 30 MHz. The 548S-3/5 will tune antenna impedances within the limits shown in figure 4. Impedances that fall near or outside the limits shown (including all antennas with a resistance of less than 1 ohm) should be submitted to Rockwell-Collins engineering personnel for analysis to determine tuning capability.

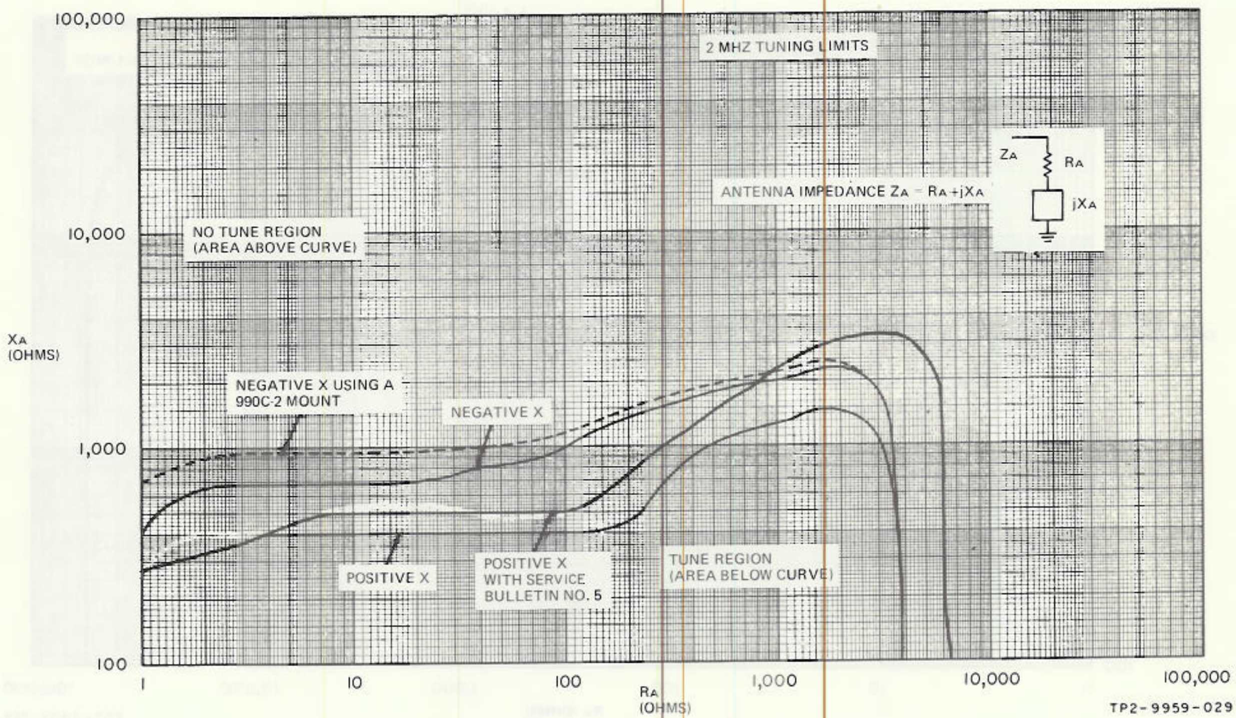
Note

If there are any questions on tuning capability, contact the nearest Rockwell-Collins representative.

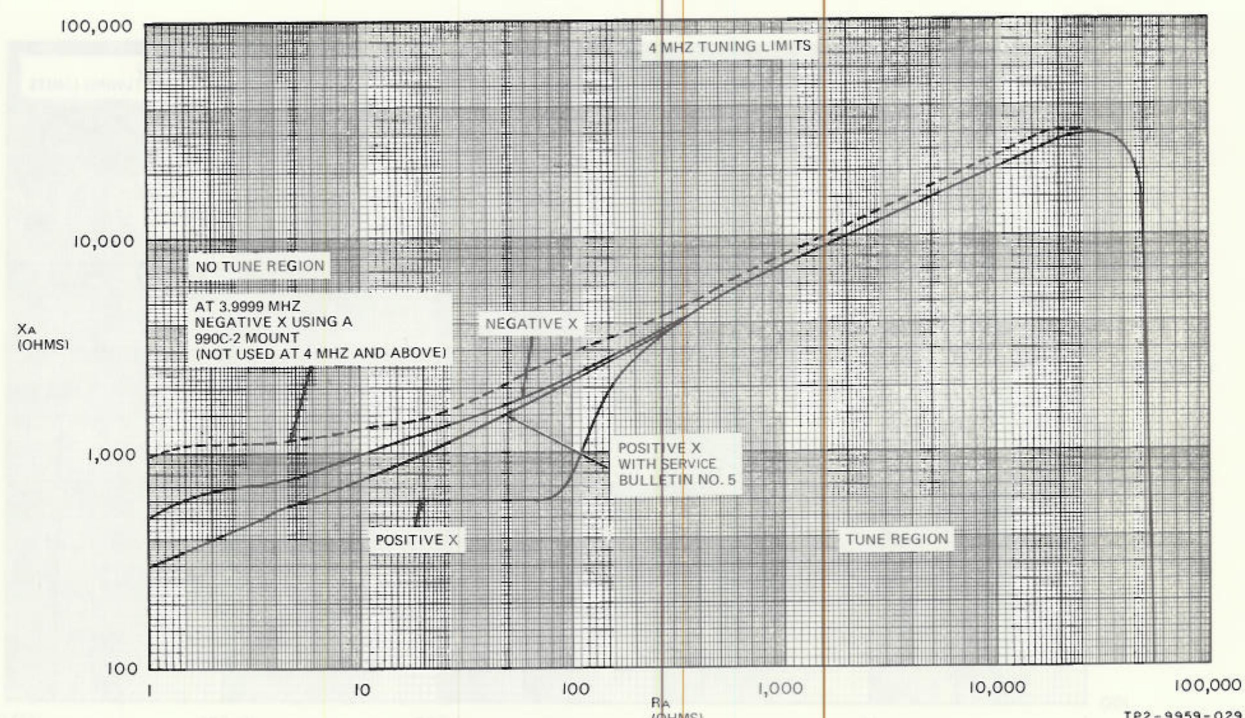
A complete family of tuning curves could be plotted for all frequencies using interpolation.

At frequencies other than 2, 4, 8, 16, and 30 MHz, use linear interpolation between tuning limit curves. For example, to determine the 3-MHz tuning limit curve, draw a new curve for 3 MHz that is in the middle (50 percent) between the 2- and 4-MHz curves. A curve for 5 MHz would be drawn at 25 percent between the 4- and 8-MHz curves (closer to the 4-MHz curve).

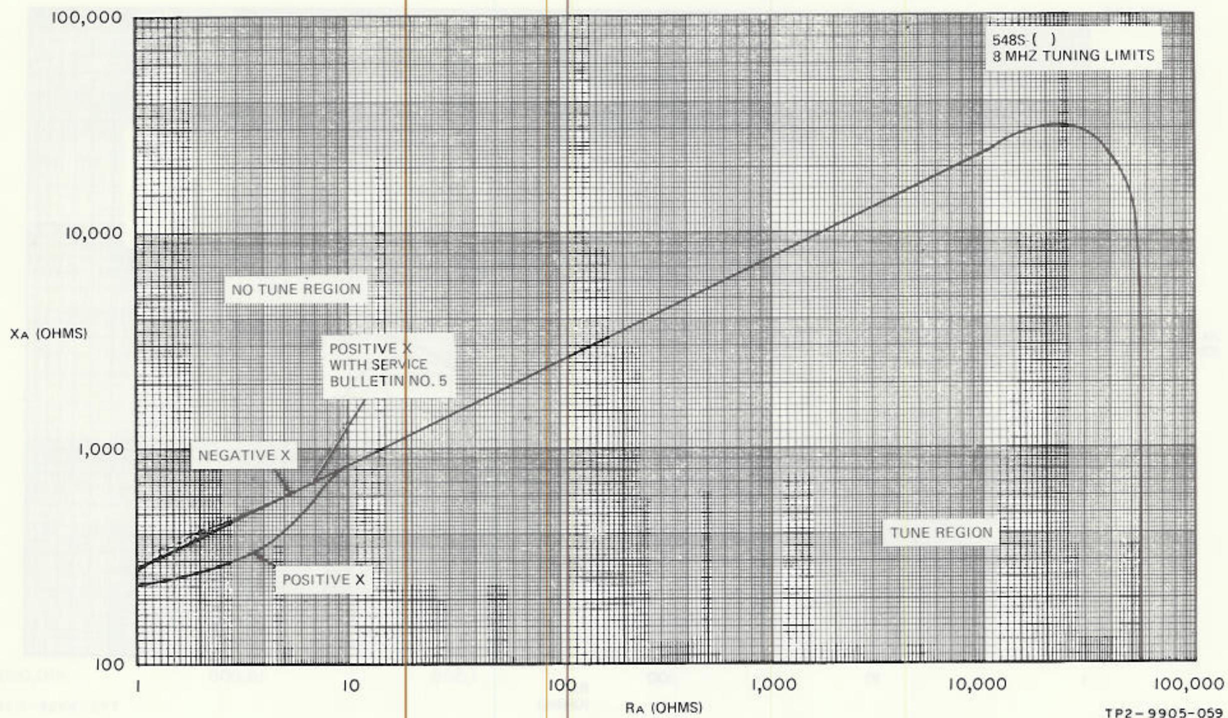
Note that the dashed curves at 2 and 4 MHz show the increased tuning area using the 990C-2 external load coil (548S-3/3A only). Tuning curves for the 548S-6 or the 548S-3/5 using the 641D-1 remote capacitor are given in figure 5 for 2 to 16 MHz. The 548S-3/5/6 will tune antenna impedances within limits shown in figure 5. Loading capacitor assembly A11 in the 548S-6 or the 641D-1 (548S-3/5) is not used above 16 MHz, for impedances with an R component >50 Ω, or for capacitive impedances. The other tuning curves (figure 4) apply there.



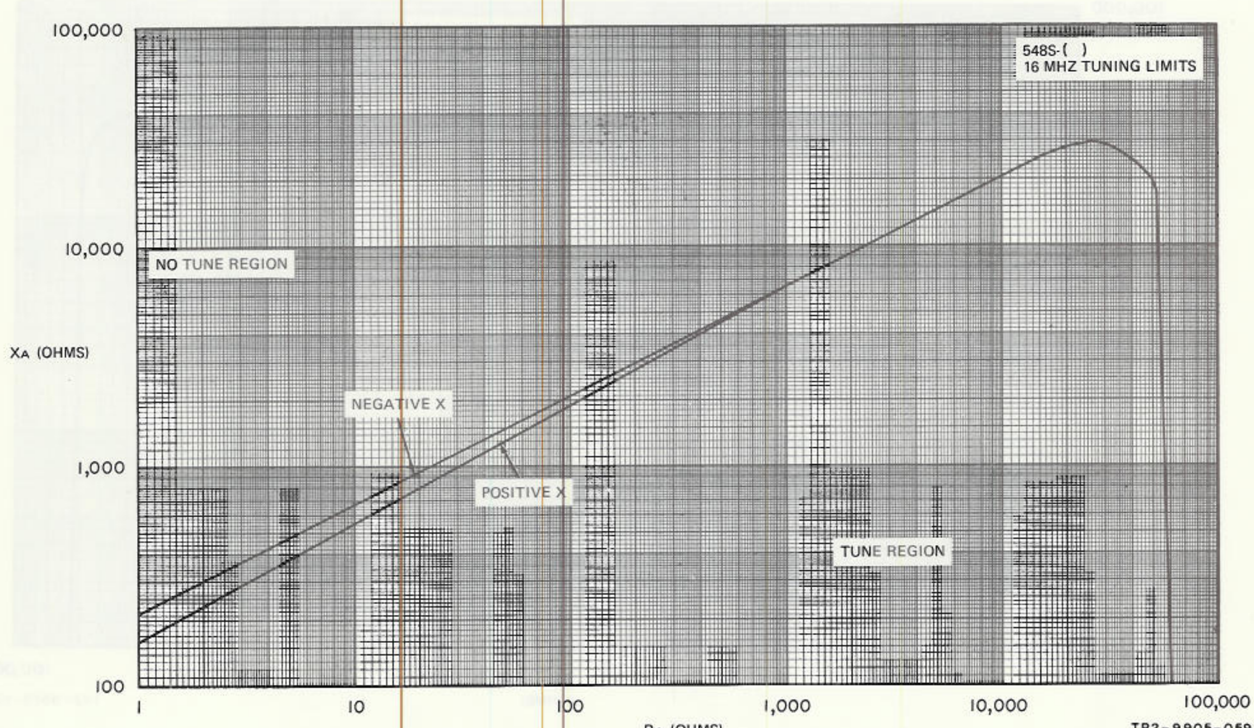
Tuning Curves
Figure 4 (Sheet 1 of 5)



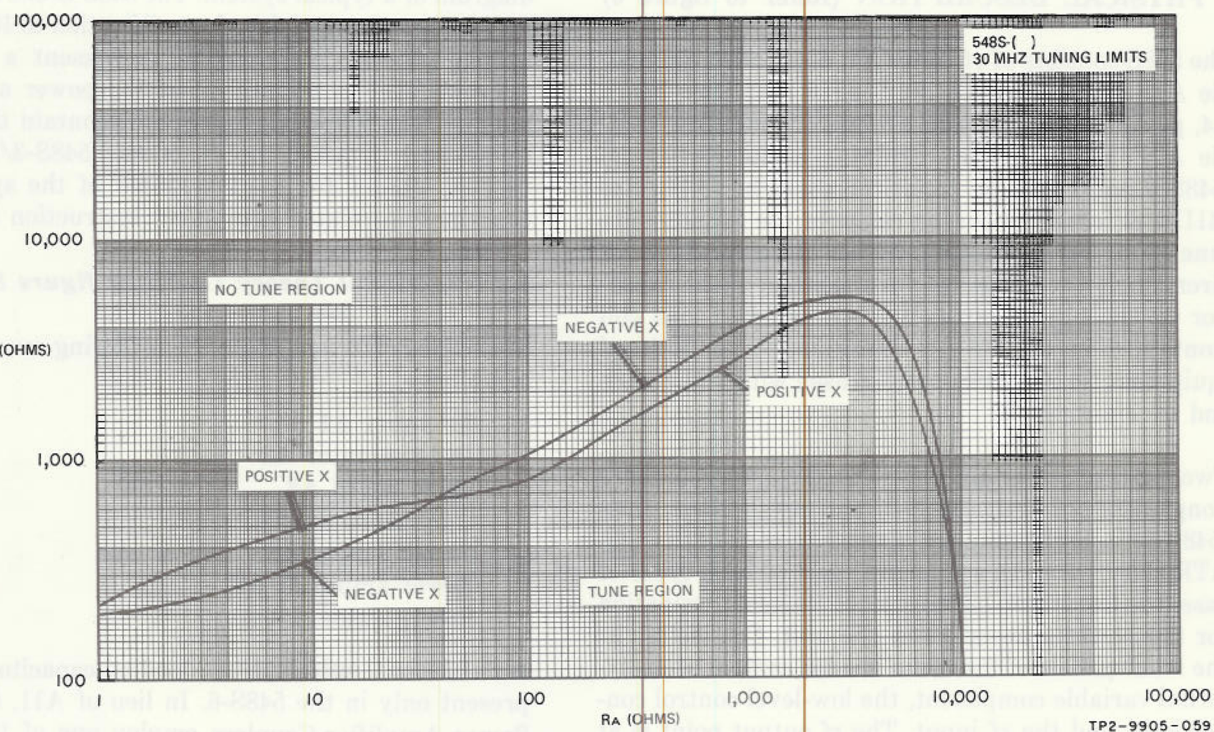
Tuning Curves
Figure 4 (Sheet 2)



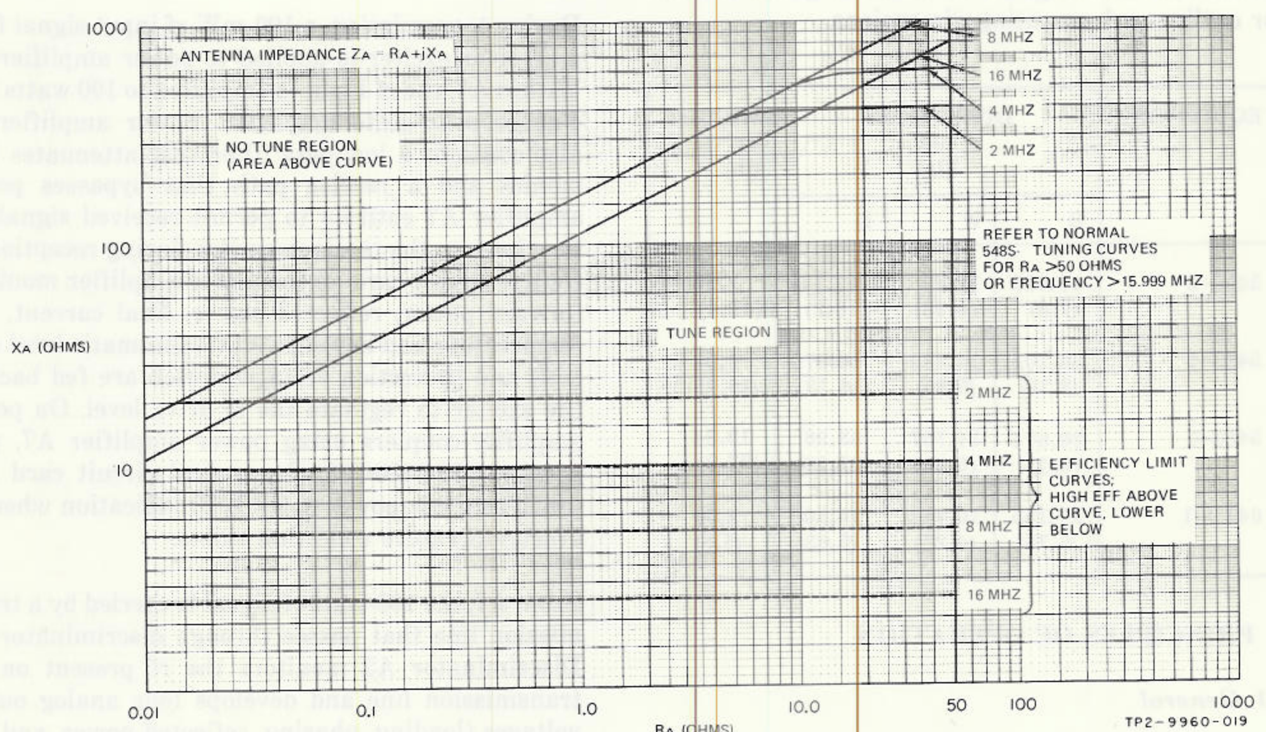
Tuning Curves
Figure 4 (Sheet 3)



Tuning Curves
Figure 4 (Sheet 4)



Tuning Curves
Figure 4 (Sheet 5)



Tuning Curves for the 548S-6 or the 548S-3/3A/5/5A Using 641D-1 Variable Capacitor
Figure 5

5. PHYSICAL DESCRIPTION (Refer to figure 6)

The 548S consists of rf tuner A1, discriminator module A2, logic board A3, dual servo amplifier board A4, power supply module A6, power amplifier module A7, chassis A9, preregulator module A10, and (548S-6 only) loading capacitor assembly A11. The 641D-1 extends the tuning range of the 548S-3/-5 to tune shunt-fed antenna (antennas an integral part of aircraft). Refer to figure 5 for the effect of the capacitor on the tuning capability. An external load coil (contained in the 990C-2 Shockmount) is optional equipment for the 548S-3 and is used with short whip and wire antennas.

Two types of power amplifier-coupler are available: a nonpressurized unit (548S-3) and pressurized units (548S-5/6). Both units are similar to the Collins 1/2-ATR short case. As an integral part of both types of case, the finned top surface provides heat dissipation for the power transistors of the unit. Connectors at the front panels of the units are for control of an external variable component, the low-level control connections, and the rf input. The rf output point is at the rear. An elapsed time meter is located on the front panel of the 548S-3, part number 787-6781-005.

Refer to the following tabulation for equipment dimensions and weights and to the diagrams section for outline and mounting dimensions.

EQUIPMENT	DIMENSIONS cm (in)			WEIGHT kg (lb)
	H	W	D	
548S-3	19.812 (7.8)	12.65 (4.98)	41.148 (16.2)	7.620 (16.8)
548S-5	20.701 (8.15)	14.859 (5.85)	40.970 (16.13)	8.96 (19.25)
548S-6	20.574 (8.1)	14.757 (5.81)	53.98 (21.26)	12.34 (27.2)
641D-1	17.155 (6.75)	10.744 (4.23)	14.300 (5.63)	2.50 (5.5)

6. PRINCIPLES OF OPERATION

6.1 General

The 548S-3/5/6 Power Amplifier Coupler is part of the 718U-3, 718U-5, or 718U-7 Lightweight HF Airborne Transceiver. Refer to figure 7 for a block diagram of a typical system. The 548S-3/5/6 contains the circuits required for rf amplification to 100 watts and for tuning the antenna to present a 50-ohm resistive load to the output of the power amplifier module. The following paragraphs contain the functional and detailed theory of the 548S-3/5/6 and 641D-1. Theory for the remainder of the system is contained in related equipment instruction books.

6.2 Functional Theory (Refer to figure 8)

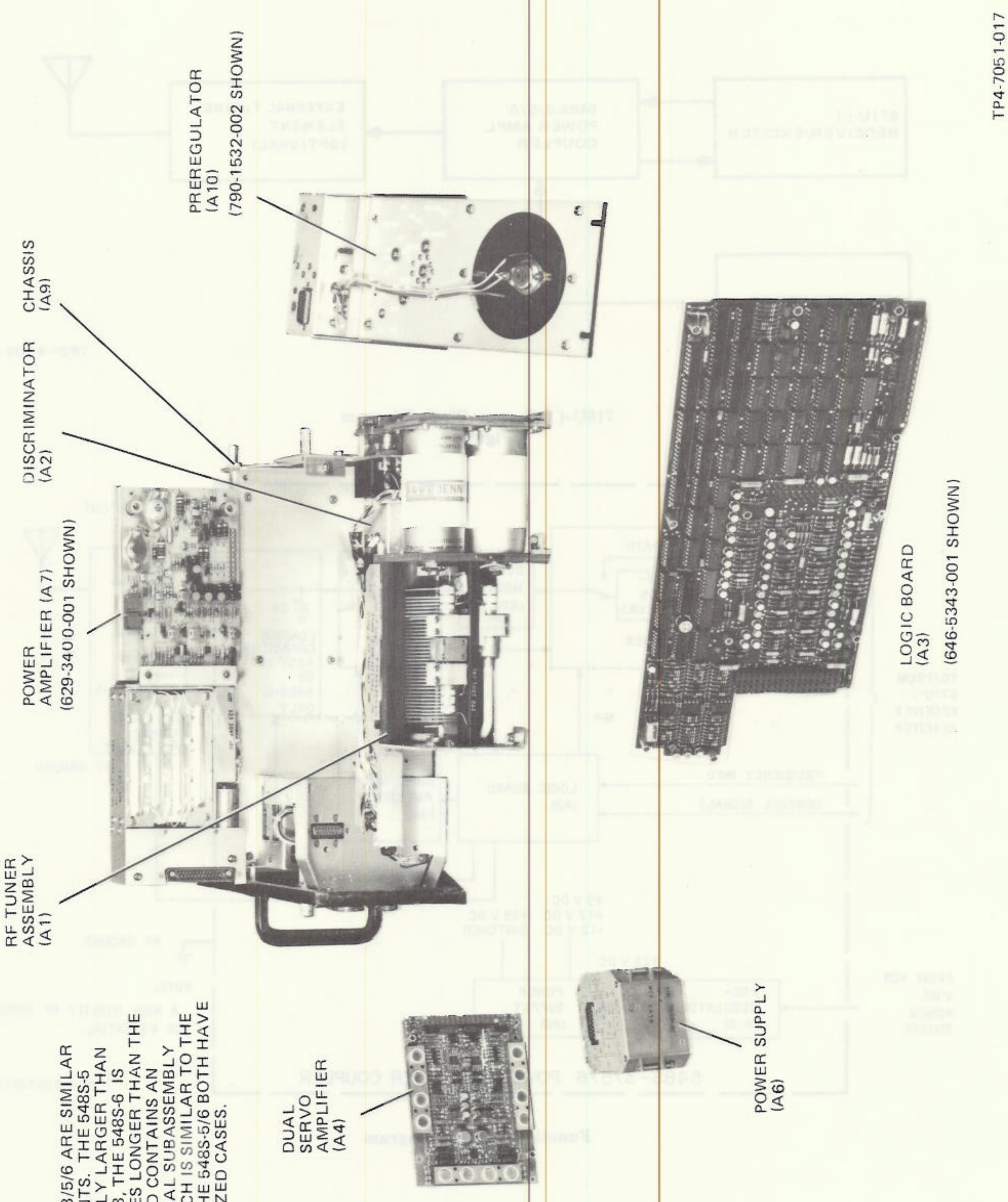
The 548S-3/5/6 comprises the following seven subassemblies:

RF tuner A1
Discriminator A2
Logic board A3
Dual servo amplifier A4
Power supply A6
Power amplifier A7
Preregulator A10

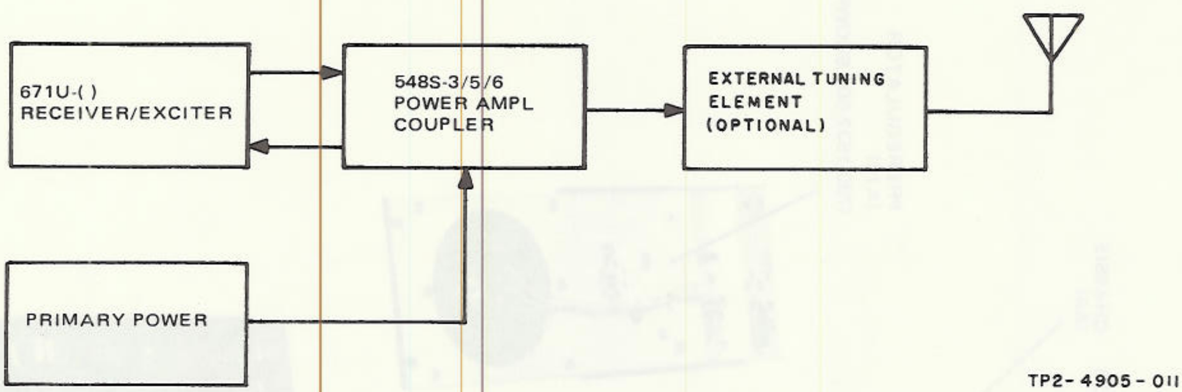
An additional subassembly, loading capacitor A11, is present only in the 548S-6. In lieu of A11, 548S-3/5 Power Amplifier-Couplers employ one of three optional tuning accessories: a loading coil in the 990C-2 Mount, a capacitor in the 990C-9 Mount, or the 641D-1 Variable Capacitor described in this instruction book.

During transmission, a 100-mW rf input signal from a receiver-exciter is applied to power amplifier A7. Within A7, the rf input is amplified to 100 watts by a 4-stage solid-state amplifier. Power amplifier A7 also contains a low-pass filter that attenuates harmonics and a receive path that bypasses power amplifier A7 entirely to permit received signals to flow back to the receiver-exciter during reception. A control circuit card on the power amplifier monitors forward power, reflected power, final current, and temperature and develops ALC (automatic level control) and protection voltages which are fed back to the exciter to regulate the rf drive level. On power amplifier-couplers using power amplifier A7, part number 629-3400-002, the control circuit card also provides a low-power ($\overline{\text{LO PWR}}$) indication when an overtemperature condition exists.

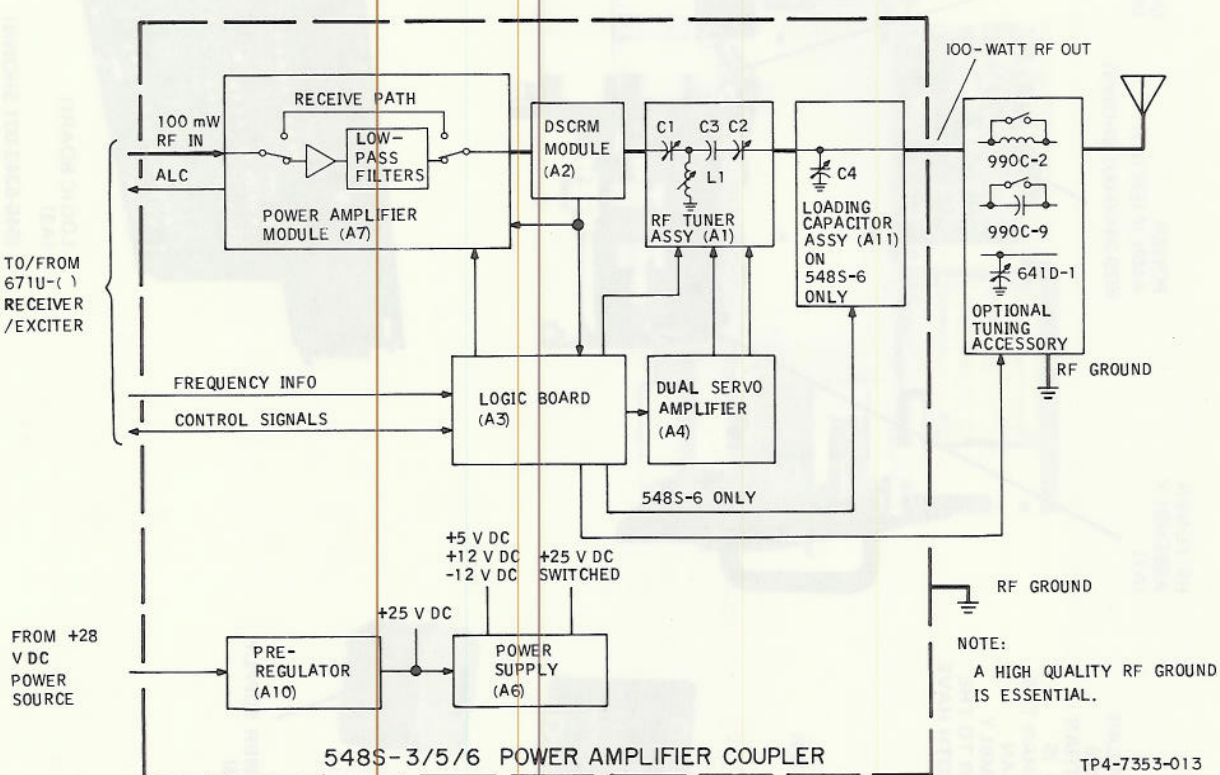
From A7, the 100-watt rf signal is carried by a transmission line that passes through discriminator A2. Discriminator A2 monitors the rf present on the transmission line and develops four analog output voltages (loading, phasing, reflected power, and forward power). The discriminator signals are passed on to the logic board and converted to binary information.



Module and Board Identification
Figure 6



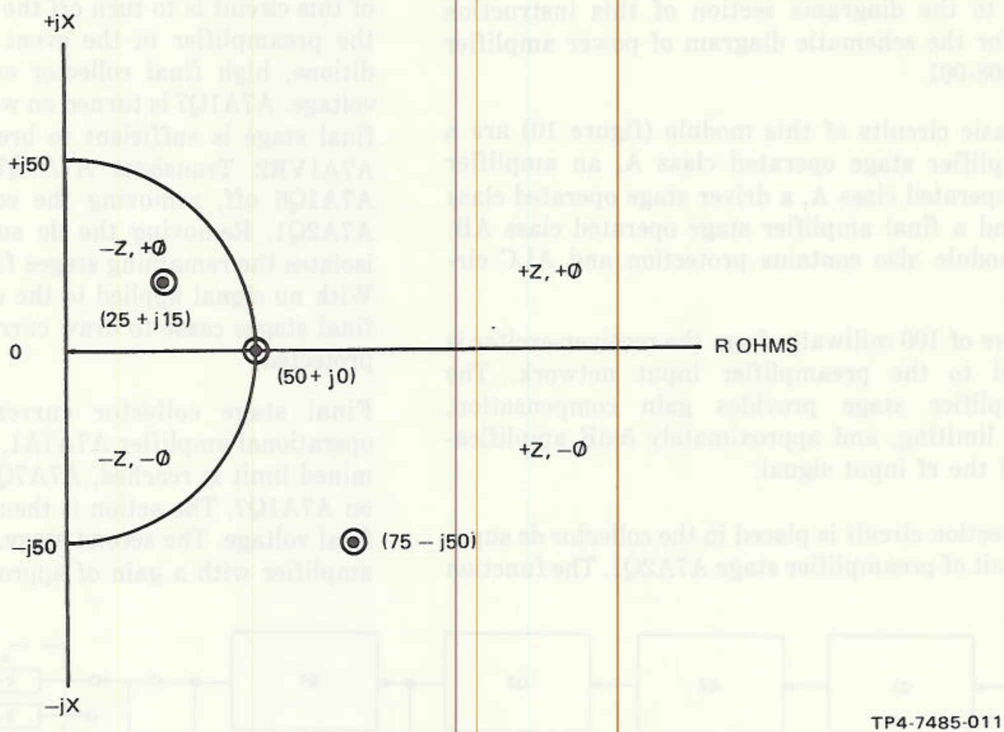
718U-( ) System Block Diagram
Figure 7



Functional Block Diagram
Figure 8

If the impedance seen by the discriminator is greater than 50 ohms, a positive loading signal (+Z) is developed. Conversely, if the impedance is less than 50 ohms, a negative loading signal (-Z) is developed. A positive phasing signal ($+\phi$) is developed if the impedance is inductive and a negative phasing signal ($-\phi$) is developed if the impedance is capacitive. A reflected power signal is developed if the vswr is excessive and a forward power signal is developed proportional to the rf output power level.

As shown in figure 9, an antenna impedance of 25 + j15 ohms would give a negative loading signal (-Z) and a positive phasing signal ($+\phi$), while an impedance of 75 - j50 would give +Z and $-\phi$ discriminator outputs. When the antenna is tuned (50 +



RX Impedance Plane as Seen by Discriminator
Figure 9

j0), the loading, phasing, and reflected power signals are near zero, and only the forward power signal is present.

Impedance matching between the 548S-3/5/6 and the antenna is accomplished by rf tuner A1, in conjunction with capacitor assembly A11 for the 548S-6 only, or, if used, one of the optional tuning accessories for the 548S-3/5. The rf tuner is controlled by both logic board A3 and dual servo amplifier A4, whereas capacitor assembly A11 and any of the three optional tuning accessories are controlled only by logic board A3.

The basic rf portion of the rf tuner is a T-network consisting of variable input series capacitor, C1, variable shunt inductor L1, variable output series capacitor C2, and fixed capacitor C3. During tuning, the dual servo amplifier is engaged and the discriminator signals servo position C1 and L1 into the tune point. C1 is servo positioned by the phasing voltage from the discriminator; L1 is servo positioned by the loading voltage from the discriminator; C2 and C3 are varied and switched, respectively, by both phasing and loading voltages from the discriminator.

The logic board, using information from the discriminator and other inputs (end limit switches, etc), steps through the tuning sequence, controlling the relays and motors of the coupler. The forward and reflected power signals from the discriminator are used by the logic board to determine the start and completion of the tuning sequence; they are also used by the power amplifier control card to develop ALC and protection voltages.

Power for the 548S-3/5/6 is received from power supply A6 and preregulator A10. A10 regulates the dc input down to +25 V dc, which is applied directly to portions of the 548S-3/5/6 and also applied to power supply A6. The latter produces fixed supplies of +5, +12, and -12 V dc, and +25 V dc switched.

A high-quality rf ground, common to both the 548S-3/5/6 and any optional tuning accessories used, is essential to the proper operation of the equipment.

6.3 Detailed Theory

6.3.1 Power Amplifier A7, Part Number 795-5308-001

Note

Power amplifier A7, part number 629-3400-001 or 629-3400-002, can replace part number 795-5308-001, but part number 795-5308-001 cannot replace part number 629-3400-001 or 629-3400-002. It is also recommended, for improved performance, that preregulator A10, part number 790-1532-001, be replaced with part number 790-1532-002 when the change to A7 is made.

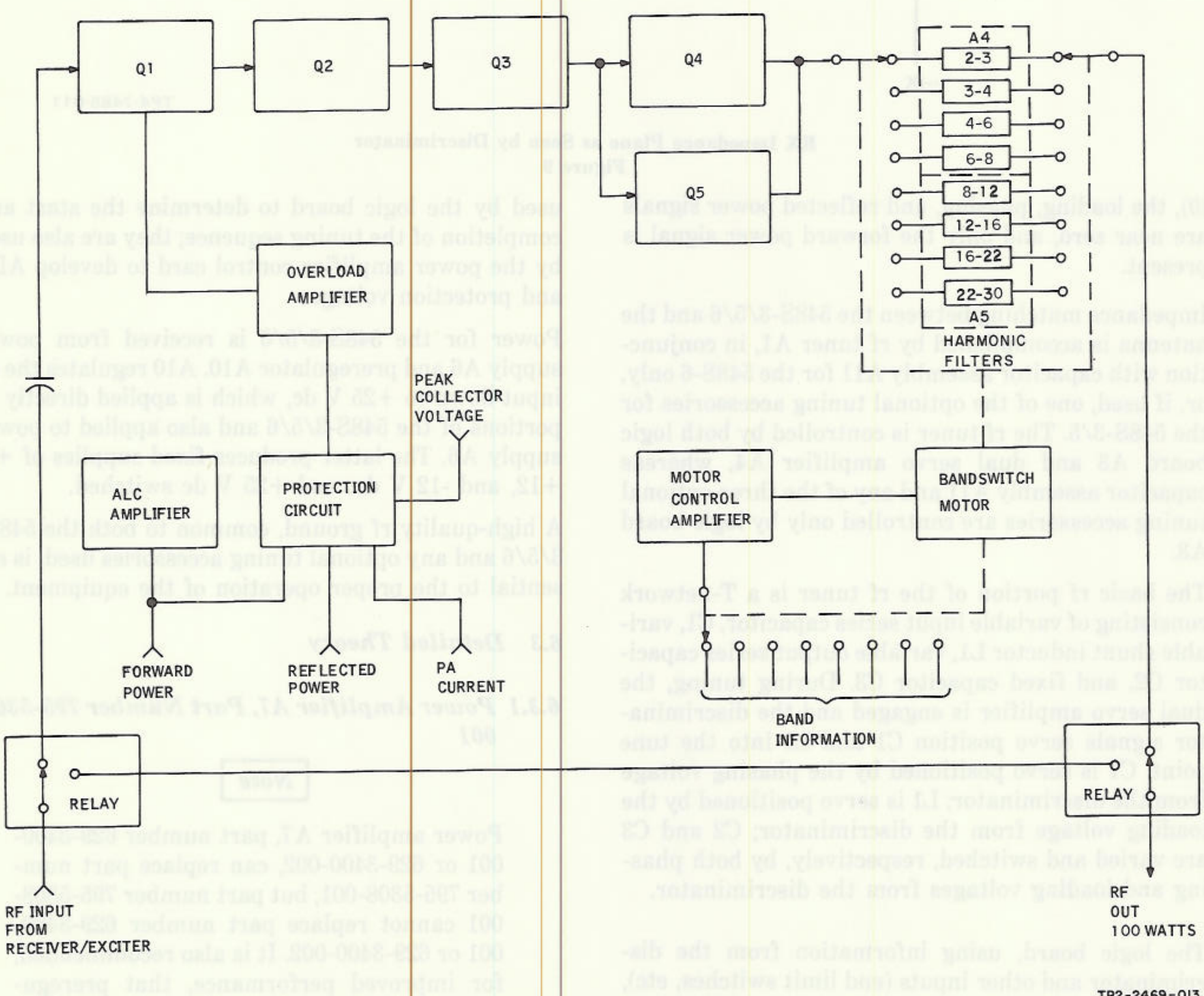
Refer to the diagrams section of this instruction book for the schematic diagram of power amplifier 795-5308-001.

The basic circuits of this module (figure 10) are a preamplifier stage operated class A, an amplifier stage operated class A, a driver stage operated class AB, and a final amplifier stage operated class AB. The module also contains protection and ALC circuits.

Rf drive of 100 miliwatts from the receiver-exciter is applied to the preamplifier input network. The preamplifier stage provides gain compensation, signal limiting, and approximately 5-dB amplification of the rf input signal.

A protection circuit is placed in the collector dc supply circuit of preamplifier stage A7A2Q1. The function of this circuit is to turn off the dc collector supply to the preamplifier in the event of unsafe vswr conditions, high final collector current, or high final voltage. A7A1Q7 is turned on when the voltage in the final stage is sufficient to break down zener diode A7A1VR2. Transistor A7A1Q7 conducts and turns A7A1Q6 off, removing the collector dc supply to A7A2Q1. Removing the dc supply from the stage isolates the remaining stages from the signal source. With no signal applied to the driver, the driver and final stages cease to draw current and are therefore protected.

Final stage collector current is monitored by operational amplifier A7A7A1, and when a predetermined limit is reached, A7A7Q1 conducts and turns on A7A1Q7. The action is then the same as for high final voltage. The second stage, A7A2Q2, is a class A amplifier with a gain of approximately 8 dB.



Power Amplifier A7 (795-5308-001), Block Diagram
Figure 10

The driver stage, A7A2Q3, is operated class AB. Base bias of the stage is maintained slightly above the verge of conduction with bias regulator A7A7Q2 and A7A7Q3. Diode A7A1CR5 is thermally connected to the case of A7A7Q3 and serves as a thermometer, sensing the case temperature and adjusting the bias voltage to prevent thermal runaway at high temperatures.

The final stage consists of A7A2Q4 and A7A2Q5 and associated circuits. The transistors are operated in parallel class AB, and each transistor has its own collector and base matching networks. Bias regulation is supplied by final bias regulator circuit A7A7Q4 and A7A7Q5.

Final collector current is limited by A7A1R1 during antenna tuning. When a logic 1 is applied to the tune in progress line, A7A3Q1 and A7A3Q2 conduct and energize A7A3K2. With A7A3K2 energized, A7A1R1 is switched into the final collector circuit. Energized contacts of A7A3K2 also switch A7A1R36 in parallel with the output of the final amplifier to provide a stable load during the tune cycle.

ALC amplifier A7A7A4 monitors forward power delivered to the coupler. This voltage is amplified and processed to send a high-gain negative-going signal back to the receiver-exciter when forward power reaches 100 watts pep. ALC amplifier A7A7A4 also monitors the output of thermostat A7A1S4. If the heat-sink temperature reaches +90 °C, the output of A7A7A4 goes negative. This negative output limits the drive from the 671U-( ) to the level required to obtain approximately 10 watts out of the power amplifier.

The ALC line is connected to the internal protection circuits. If the protection circuits limit the collector voltage on A7A2Q1, resistive dividers R8 and R9 provide a negative voltage to the ALC line through forward biased diode CR2.

One-half octave bandpass filters are used to attenuate rf harmonics in the power amplifier output. Eight separate filters are used (four in A7A5 and four in A7A6) to cover the 2- to 30-MHz frequency range. Filter one covers 2 to 3 MHz, filter two covers 3 to 4 MHz, filter three covers 4 to 6 MHz, filter four covers 6 to 8 MHz, filter five covers 8 to 12 MHz, filter six covers 12 to 16 MHz, filter seven covers 16 to 22 MHz, and filter eight covers 22 to 30 MHz.

Switches A7A1S1, A7A1S2, and A7A1S3 are mechanically ganged together and driven by motor A7A1B1 through Geneva mechanism and gear reduction. The Geneva mechanism is used to prevent motor overrun from changing switch positions. The proper bandpass filter is connected in the output circuit by driving and stopping motor A7A1B1 according to band information. A logic 0 on the band line drives motor A7A1B1 and a logic 1 stops A7A1B1.

Bcd band information from the receiver-exciter is applied to logic board A3. Logic board A3 converts this information and applies it to the band lines. The selected band will be a logic 1 and the remaining seven bands will be logic 0.

For explanation purposes, assume the following conditions; band line three is the selected band and is a logic 1. The remainder of the band lines are logic 0, and A7A1S1, A7A1S2, and A7A1S3 are in position 1.

The logic 0 at position 1 of A7A1S1 is applied to the base bias circuit and cuts off A7A7Q8. With A7A7Q8 cut off, A7A7Q7 conducts and energizes A7A7K1. Ground is now applied to motor A7A1B1 through the energized contacts of A7A7K1 and the motor steps the switches to position 2. Position 2 also has a logic 0 applied and the same stepping action occurs. When motor A7A1B1 steps the switches to position 3, the logic 1 on this position is applied to A7A7Q8 base and turns on A7A7Q8. With A7A7Q8 conducting, A7A7Q7 is cut off and A7A7K1 is deenergized. With A7A7K1 deenergized, the ground is removed from motor A7A1B1 and it stops. At this time a band-switch complete signal is sent to the logic board from resistive dividers A7A7R60 and A7A7R61.

When the system is keyed, the ground supplied to the tr relay line energizes A7A1K1 and A7A3K1. The energized contacts of A7A1K1 and A7A3K1 connect the receiver-exciter to the input of the power amplifier and also connect the output of the selected bandpass filter to the antenna. During receive mode, the deenergized contacts of A7A1K1 and A7A3K1 bypass the power amplifier.

6.3.2 Power Amplifier A7, Part Number 629-3400-001, -002

Note

Power amplifier A7, part number 629-3400-001 or 629-3400-002, can replace part number 795-5308-001, but part number 795-5308-001 cannot replace part number 629-3400-001 or 629-3400-002. It is also recommended, for improved performance, that preregulator A10, part number 790-1532-001, be replaced with part number 790-1532-002 when the change to A7 is made.

Refer to the diagrams section of this instruction book for the schematic diagram of power amplifier 629-3400-001, -002. The 629-3400-002 module differs from the 629-3400-001 since it has improved intermodulation distortion characteristics required to satisfy FCC Part 83 requirements. This is achieved through the use of special output transistors (A7A4Q104A and Q104B).

The power amplifier comprises the following subassemblies:

Low-band filter A7A1
High-band filter A7A2
Control circuit card (plug-in) A7A3
Rf power amplifier (plug-in) A7A4
Relay cover assembly A7A5
Chassis A7A6

Rf power amplifier A7A4 contains a preamplifier, a driver, and a power output amplifier. Rf excitation enters through P1-34 and is given initial amplification, gain compensation, and signal limitation by the 2-stage preamplifier, Q101 and Q102. These two stages operate class A. From Q102 the signal passes to driver Q103, which also operates class A. From the driver, the signal passes through T3 and is split between Q104A and Q104B, which operate as a class AB push-pull amplifier. Output transformers T7 and T8 combine the signal to give 100 watts output. Before reaching the antenna, the 100-watt rf output passes through one of two half-octave filters, low-band filter A7A1 (up through 8 MHz) or high-band filter A7A2 (above 8 MHz). These filters provide -45-dB harmonic suppression.

Operation and/or protection of the rf power amplifier is achieved by the band-switch circuit, the automatic level control (ALC) circuit, the tune-in-progress (TIP) circuit, the rf attenuator circuit, the power amplifier final stage bias circuit, and the power amplifier driver bias circuit. Each of these circuits is discussed below.

The band-switch circuit connects the power amplifier output to a suitable section of the harmonic suppression filter. The rf output is passed through one of eight half-octave filters in A7A1 or A7A2. The appropriate filter is connected between the power amplifier output at A7A4E7 and the two transmit-receive (tr) relays, A7A6K101 which channels the rf input, and A7A6K102 which connects the rf output to the antenna coupler. Eight separate filters are used (four in A7A1 and four in A7A2) to cover the 2- to 30-MHz frequency range. Filter one covers 2 to 3 MHz, filter two covers 3 to 4 MHz, filter three covers 4 to 6 MHz, filter four covers 6 to 8 MHz, filter five covers 8 to 12 MHz, filter six covers 12 to 16 MHz, filter seven covers 16 to 22 MHz, and filter eight covers 22 to 30 MHz.

Switches A7A6S101, A7A1S102, and A7A1S103 are mechanically ganged together and driven by motor A7A6B101 through a Geneva mechanism and gear reduction. The Geneva mechanism is used to prevent motor overrun from changing switch positions. The proper bandpass filter is connected in the output circuit by driving and stopping band-switch motor A7A6B101 according to band information. A logic 0 on the band line drives motor A7A6B101 and a logic 1 stops the motor.

Bcd band information from the receiver-exciter is applied to logic board A3, which converts this information and applies it to the band lines. The selected band is a logic 1 and the remaining seven bands are logic 0. For explanation purposes, assume the following: band-line three is selected and is a logic 1; the remainder of the band lines are logic 0; and A7A6S101, A7A1S102, and A7A1S103 are in position 1. Also,note that the band-switch motor, A7A6B101, is connected across A7A3P1-22(+) and A7A3P-18(-).

Under the conditions assumed, the logic 0 at position 1 of A7A6S101 is applied to the band-switch motor control circuit through A7A3P1-17 and reaches the base of A7A3Q6. With A7A3Q6 cut off, A7A3Q7 is turned on, which turns on A7A3Q9. When turned on, A7A3Q9 starts the band-switching motor, A7A6B101, by grounding the negative connection of the motor through A7A3P1-18. The motor operates until A7A6S101 reaches position 3, at which time the logic 1 at position 3 is applied to A7A3Q6, turning it on, turning off A7A3Q7 and A7A3Q9, and stopping the motor by removing its ground connection.

To avoid applying excitation to the power amplifier during band-switching, the band-switch circuit disables the rf input transmit-receive relay, A7A6K101, whenever band-switch motor A7A6B101 is operating. This is accomplished by the connection between A7XA3P1-18 and A7A6K101-X1 which, when the band-switch motor is operating, applies a ground to the positive side of relay A7A6K101.

To enable keying once band switching is complete, transistor A7A3Q8 is turned on by A7A3Q6 turning on, and A7A3Q8 applies a positive voltage to the positive side of relay A7A6K101 through the connection between A7A3P1-18 and A7A6K101-X1 mentioned above. As transistor A7A3Q8 turns on when the band switching ends, it also brakes the band-switch motor by shorting across the motor terminals at A7A3P1-22 and A7A3P1-18.

The ALC circuit maintains the rf input excitation at a level which will produce full amplifier power output (approximately 100 watts). ALC control of rf excitation is accomplished by feeding back a negative-going control voltage to the exciter. ALC voltage is developed within two circuits. One circuit includes A7A3U2A, which develops ALC voltage by comparing a forward power analog from the discriminator module with a preset reference level. The forward power analog is applied to the power amplifier through A7A6P101-1 and the preset reference level is established by adjusting A7A3R25. As forward power rises above the acceptable limit, the ALC voltage reduces excitation, and vice versa.

The second ALC voltage source is the circuit which includes A7A3U1B. In this circuit, A7A3U1B develops a voltage by comparing a forward power analog with a weighted summation of a reflected power analog and an analog of power output stage current levels. The current analog voltage is developed across A7A6R112 and is amplified by A7A3U1A before reaching A7A3U1B. The reflected power analog is developed by the discriminator module and is applied to the power amplifier through A7A6P101-2. The forward power analog to which the weighted summation is compared is an amplified portion of the forward power signal from the discriminator module; A7A3U3A amplifies this signal. Potentiometer A7A3R21 permits nulling of the operational amplifier offsets.

Operation of the second ALC voltage source is such that, when either the reflected power or the current in the power amplifier output stage, or both, reach undesirable levels, A7A3U1B produces a negative ALC voltage which tends to reduce the excitation level. The relative levels of the two sources of ALC voltage are such that the effects of overcurrent and/or excessive reflected power are predominant; ie, overcurrent and/or excessive reflected power will reduce exciter output, even in the face of insufficient forward power.

During antenna tuning, the tune-in-progress (TIP) circuit performs four functions. In the presence of a TIP logic 1 at A7A3P1-11 (received from logic board A3), the following occurs:

a. A7A3Q1 is turned on, establishing a shunt to ground through A7A3R4. This shunt partially overrides the effect of the reflected power and current sense components on the ALC voltage produced by A7A3U1B. Such an arrangement prevents the ALC voltage from disrupting the tuning process.
b. Transistors A7A3Q3 and A7A3Q4 are turned on, activating TIP relay A7A5K103. Two results follow: The network comprising A7A6R113, A7A6R114, and A7A6R120 is placed in series with the power output stage collector, to limit power output during tuning. Resistor A7A6R111 is connected in parallel with the antenna to provide a stable load during antenna tuning.
c. A7A3Q10 is turned on, shunting A7A3R25 and thereby fixing the forward power reference level to a lower value during antenna tuning.

The rf attenuator circuit provides additional protection against overexcitation, in the event the exciter fails to respond to the ALC voltage sufficiently to hold down the excitation to a level that ensures safe operation of the amplifier. The additional protection is obtained by attenuating the rf input to the first preamplifier stage, A7A4Q101. Through A7A4P1-19, a positive rf attenuation voltage is applied. When this voltage becomes positive enough to forward bias A7A4CR2 and A7A4CR3, those two diodes begin to conduct, and they ground the rf input signal through capacitor A7A4C2. The use of two diodes in series prevents conduction at the voltage level produced by a normal rf input signal.

The source of the rf attenuation voltage is the circuit that includes A7A3U2B and A7A3Q5. A7A3U2B compares a fixed reference voltage to the ALC voltage developed by A7A3U1B or A7A3U2A. ALC voltage from those two sources reaches A7A3U2B through diodes A7A3CR5 and A7A3CR6, respectively. The latter two diodes are so configured that the most negative of the two ALC voltage sources determines the level of the voltage output from A7A3U2B. When the ALC voltage goes below the threshold set at the positive input to A7A3U2B, the output of A7A3U2B, which is normally negative, starts to travel toward +12 V dc. This travel permits emitter follower A7A3Q5 to turn on to a level of approximately +19 V dc, maximum, and the +19 V dc so derived is the rf attenuation voltage which reaches the first preamplifier stage through A7A3P1-9. Diodes A7A3CR9, A7A3CR10, and A7A3R50 provide current limitation through A7A3Q5.

It should be noted that the operation of the rf attenuation function requires the presence of the -12-V dc source (at A7A3R46). As described below, the power amplifier stage bias circuit includes a protective circuit which shuts down amplifier operation in the event of -12-V dc failure.

The bias of the final power amplifier stage is established by A7A6U101, which turns on transistor A7A6Q105 to apply a bias voltage derived from the +25-V dc source entering the circuit at A7XA3P1-10. The bias level is adjusted by A7A6R102 and is applied to the final power amplifier stage through A7XA4P1-4. Diode A7A6CR102 is a temperature-compensation diode which adjusts the power amplifier bias to prevent thermal runaway at high temperatures.

Since the operation of A7A6U101 requires a -12-V dc source, transistor A7A6Q105 is turned off in the absence of the -12-V dc source, shutting down the power amplifier final stage by lack of bias. This arrangement ensures that the final stage is not operated when the -12-V dc operating voltage is not available to the rf attenuator circuit described above.

The driver bias is derived from a voltage divider between +20 V dc and ground, consisting of A7A6R104, A7A6R103, and A7A6CR103. In this circuit, A7A6R103 provides the means for bias level adjustment. Diode A7A6CR103 is a temperature compensation diode which adjusts the driver bias to prevent thermal runaway at high temperatures.

Further protection with respect to temperature is provided by thermal switch A7A6S104, which opens when the temperature reaches 205 °F (96.1 °C). The opening of A7A6S104 turns on A7A6Q107, thereby shunting A7A6R103 with A7A6R122. Potentiometer A7A6R122 has been adjusted to change the driver bias to a level which permits continued operation of the power amplifier in the presence of abnormal heat. Simultaneously, the opening of A7A6S104 reduces the power output level to approximately 20 watts. Power reduction occurs because the thermal switch turns on A7A3Q2, shunting A7A3R25 and thereby changing the ALC threshold so as to reduce the amplifier operation to approximately 20 watts. The voltage used to turn on A7A6Q107 is derived from the +12-V dc supply and is applied to the circuit through A7XA3P1-21. Also, when the thermal switch opens, a LO PWR output indication is generated by A7A3Q11 and applied out through A7P1-9.

6.3.3 RF Tuner A1

Refer to the diagrams section of this instruction book for the schematic diagram of the rf tuner/variable capacitor 641D-1/loading capacitor assembly A11.

Note

Rf tuner, part number 790-1200-002, can replace part number 790-1200-001 in all applications.

The three variable tuning elements, C1, L1, and C2 in the rf tuner, are driven by servo motors B1 and B3 and dc motor B2, respectively. Relays K1, K2, and K3 are gear train locks to prevent movement of the elements after completion of a tune cycle. Switches S3 through S9 give minimum-maximum position of the elements so that certain logic decisions can be made during a tune cycle. Switches S1 and S2 are an integral part of capacitors C1 and C2 and automatically short the capacitors at their maximum setting. Relay K4 is used to connect L1 in parallel with the rf transmission line.

Variable capacitor C4 in loading capacitor assembly A11 (548S-6 only) is driven by dc motor B1. The remote tuning elements, loading coil L2 (p/o 990C-2), 548S-3 only, or capacitor C4 (641D-1) are optional units and are used in special applications.

The tuning sequence is performed in six separate steps: home, standby, tune A, tune B, tune C, and operate. Refer to figure 11 for the flow diagram of the entire tuning sequence. The numbers in the upper left-hand corner of the symbols of figure 11 correspond to the numbers across the top of figure 12 and represent that time period of the tuning cycle. By following the function lines of figure 12 to the right, the logic state for each function/time period may be determined.

When a tuning sequence is initiated, the variable elements are driven to their home positions. Capacitors C1 and C2 are driven to maximum capacity and shorted. Capacitor C3 is shorted, remote coil L2 (if used) is driven to minimum inductance and shorted, and L1 is driven to minimum inductance, shorted, and switched off the transmission line. After all elements are home, the coupler is advanced to standby position. In this position the receiver-exciter input has a direct connection from the antenna through the untuned coupler. In standby position, main coupler power is turned off and only keep-alive power is applied to the necessary circuits.

A ground on the transceiver key line initiates power turn on and the coupler tuning sequence. Tune A is a phasing and loading operation using C2/C4 (or one of the remote tuning elements, L2 or C4, if used) and is accomplished by the method shown in figure 11. At the start of tune A, it is determined whether capacitor C4 is being used and on the line. If C4 is on line, the loading magnitude is checked. If the loading magnitude is negative (less than 50 ohms), C4 is run toward maximum capacitance until either the loading magnitude is positive or until C4 reaches maximum. If C4 reaches maximum before the loading magnitude is positive, C2 is run toward minimum until the loading magnitude goes positive or until C2 reaches minimum. In either case the system steps to tune B. If the loading magnitude went positive before C4 reaches maximum, the phasing angle of the antenna is checked.

If the phasing angle is negative, the coupler steps to tune B. If the phasing angle is positive, capacitor C2 is checked. If C2 is at minimum, the coupler system steps to tune B. If not, it is run toward minimum and the loading magnitude is again checked. The procedure described in the preceding paragraph is then repeated.