9T97A250 450-MHz Power Amplifier
User Manual
9110.00118

REVB

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1 GENERAL

This manual is intended for use by experienced technicians familiar with RF communication systems. It contains all the necessary information required to align, install, interface, and operate the 9T97A250 UHF Power Amplifier.
Any questions regarding the equipment or this manual should be directed to Customer Service.

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2. Reserved

3 DESCRIPTION

The 9T97A250 UHF power amplifier is designed for FM operation in the 406 to 470 MHz band. The RF power output is continuously adjustable from 50 watts to 250 watts when driven by a 4-watt source. The RF input and output connectors are the type N panel mount (UG-58 AN) and are mounted on the rear of the power amplifier. Input dc power is fed to the power amplifier through a two-terminal barrier strip on the rear of the power amplifier. A 15-pin D-connector (for monitoring the power amplifier's operating condition using its associated test set) is mounted near the barrier strip. Forced air circulation is through the front panel, using an internally controlled dc fan. The power amplifier is self-protected against overheating and mismatched load conditions (including open and short circuit conditions).

DANGER !

RF power transistors and RF termination resistors contain beryllium oxide. Beryllium oxide fumes ARE TOXIC! No treatment should be attempted without proper precautions. Disposal via public waste is strictly forbidden!

3.1 Front Panel Display and Alarms

Power Output Bar-Graph Indicates relative output power in ten levels (red).
RF Input LED Indicates RF input power is applied (green).
High VSWR LED Indicates an alarm due to high reflection at the output (red).
High Temperature LED Indicates an alarm due to over heating (red).
Power On LED Indicates that the dc supply is applied to the power amplifier (green).

3.2 Features

The 9T97A250 power amplifier has the features listed below.

- Adjustable power output.
- Continuous operation.
- Mounts on a 19-inch standard EIA rack panel.
- Self-resetting protection circuitry.
- Modular construction.
- Status and power output display.
- Easy access to amplifiers and protection circuitry for adjustment.
- Independent fusing of each final module and the driver with open fuse indicator on the rear panel.

3.3 Physical Description

The 9T97A250 UHF power amplifier is rack panel mountable (19-inch). Front and rear covers are removable to gain access to all controls without removing the 9T97A250 from the rack.
The front panel display consists of a red LED bar-graph display showing output power. Two red and two green status LEDs are also located on the front panel.
The rear panel consists of an RF input connector, an RF output connector, a DB-15 connector, and a two-terminal barrier strip for dc power connections.

4 P. A. CIRCUIT AND LOGIC CIRCUIT DESCRIPTIONS

4.1 Power Amplifier Circuit Description

4.1.1 General

The RF input, which is sampled by the alarm logic, is amplified by the RF power driver. The driver's net RF power output is varied by adjusting the dc voltage supply. The driver's power output is split into four parts which become the input power to each final. Each final amplifies this input power and the output from the finals are combined and filtered. The alarm logic samples both the output forward power and reflected power.

4.1.2 Driver

The driver module has two functions. Its primary function is to provide a variable power input to the final power amplifier module, so that the net output power of the final amplifier can be adjusted. The second function is to provide a sampling point for the alarm logic at the input power point to the power amplifier.
The driver uses a MOS-FET transistor (Q1) with two dies in one package, operated in push-pull configuration. R2 and R3 provide zero bias at the gates of Q1 for class C operation. T1 and T2 are 1:1 balun transformers. Capacitor C4 at the input of the driver is adjusted to fine tune the input match to 50 ohms, thereby minimizing input standing wave reflection. Capacitor C16 couples a small amount of input power through diodes D1 and D2. This dc voltage, which is proportional to the RF input, is fed to the alarm logic. The rectified RF at the anode of D1 is smoothed by capacitor C17 and loaded by resistor R1. The main part of the RF input goes through T1, C2, C3, Z1 and Z2 and capacitors C1, C4 and C5 match the transistor's input impedance across the frequency band. Power (3-5 Vdc) is fed via a "fast-on" tab to the drains of transistor Q1.
Matching of the transistor's output impedance across the frequency band is provided by Z3, Z4, C6. C7 and C10. Capacitors C5 and C9 are for dc blocking.

4.1.3 Splitter

The splitter consists of three splitters to provide a four-way divider. Each splitter is a ninety degree hybrid and a 50-ohm load. A ninety degree hybrid is a length of wire line in this case. The length is determined by the frequency band of the power amplifier. The wireline is a form of semi-rigid 50-ohm coax that has two center conductors insulated from each other.
Within the useable bandwidth, each hybrid splits the RF power into approximately two equal parts that differ in phase by about ninety degrees. As the split and phase differ, some power is dissipated in the load resistors terminating the fourth port of the hybrids. When power is reflected from any other port, the bulk of this reflected power (nominally half) is dissipated in the load. The remaining power is split equally between the other two ports. The process of splitting and combining is very phase sensitive. Incorrect phasing will result in power wastage, increased heat through power dissipation, reduced MTBFs. and reduced output power. As a result, all cables between the splitter and the finals, and the combiner must be exactly the same length. The necessary phase adjustments for manufacturing tolerances are provided by the tuning capacitors in the finals.

4.1.4 Final

All final modules are identical, only one module is described. The final module amplifies the output of the splitter to about 65 watts and feeds this to the combiner.
The final is a common emitter class C amplifier. The transistor's (Q1) input impedance is matched to 50 ohms across the frequency bandwidth using micro striplines Z2, and Z3, with capacitors C2, C3, C17, C5, and C6. Power (28 Vdc) is fed via a faston tab to the collector of transistor Q1 through a dc-coupling network. Matching of the transistor's (Q1) output is provided by Z4, Z3, C8, C9, C10, and C18. In addition, C12 fine tunes the output.

4.1.5 Combiner

Like the splitter, the combiner consists of three ninety-degree combiners providing a four-way combiner. Each combiner is a ninety degree hybrids and a 50-ohm load. A ninety degree hybrid is a length of wireline in this case. The length is determined by the frequency band of the power amplifier. The wireline is a form of semi-rigid 50-ohm coax that has two center conductors insulated from each other.
Within the useable bandwidth, each hybrid combines the approximately equal RF feeds (each feed differs in phase by about ninety degrees), into one. As the phase differs, some power is dissipated in the load resistor terminating the fourth port of the hybrid. The resistive load's most important function in the combiner is to dissipate the bulk of any reflected power (nominally half). The remainder of the reflected power is split equally between the other two ports (typically).

4.1.6 Low Pass Filter and Directional Coupler

The low pass filter attenuates the harmonics generated by the power amplifier. The directional coupler samples, and detects output power and reflected power. These signals are then passed to the alarm logic. The output of the combiner is fed through the low pass filter (C1, C2, C3, C4, L1, L2, and L3) and the directional coupler to the power amplifier's output connector. The directional coupler consists of three micro striplines Z1, Z2, and Z3 with loads and detector circuits at both coupled ports. The directional coupler provides about -33 dB of coupling at the center frequency. Schottkey diodes (D1 and D2) are used for detection of forward and reflected RF power.

4.1.7 DC Distribution Board

The distribution board supplies 28 Vdc to each final module and 3 to 25 Vdc to the driver module. Each final and the driver is fused through 10 A fuses F2 to FS, current monitoring resistors R1 to R4 and EMI filters for short circuit protection and shielding purposes. For added protection, the current to each final may be monitored. Capacitors and the low pass EM! filters are used on each of these lines to prevent low and high frequency noise from penetrating or leaving the shielded amplifier housing. Fuse Fl is for short circuit protection on the logic board and driver module.
The adjustable dc supply to the driver module and the direct current signals representing the RF input, RF output, and reflected RF are also filtered on this board. The power amplifier's dc input terminals TB2 and test set connector JI are mounted on this board. Connections to the logic board are also made through P2.

4.2 Logic Circuit Description

4.2.1 General

The logic board is a control board mounted behind the front panel of the 97 series RF power amplifiers. It gives visual indication of the RF power amplifier's operating condition, and indication of the variable power supply to the driver of the RF power amplifier. The logic board also contains the RF detection circuit, power meter, temperature controller, 2 minute timer, fan driver, and optional fixed bias supply. The logic board has three connectors; a 1 x 2-pin connector for the dc fan power, a 6-pin connector for the regulator, and a 2 x 8-pin connector for the power control signals.

4.2.2 Power Supplies

4.2.2.1 Introduction

The three power supplies internal to the PA are: the adjustable driver supply with the ability to switch between high and low power, the 8 Vdc regulator, and the fixed bias power supply.

4.2.2.2 Adjustable Driver Supply

An adjustable voltage (produced by regulator U5) buffered by a transistor external to the logic board produces a stable, high power variable power supply even under a dynamic load.
The output is adjusted by resistors R52 and R53, and can be switched to high power (default), low power (high at P10-10 to switch Q6, or a high at P10-6 when JR27 is installed), or power off (high at P10-6 to switch Q3 when JR26 is installed). When Q3 is turned ON, the adjustment pin of U5 is shorted to ground. This will cause the output of U5 to drop to a minimum voltage (about 0.9 Vdc at P10-2, 3). Filtering capacitors C33, C30, C52, C51, C54, C53, C55, C56, and C57 are used at the input and output of U5 and the external transistor, in order to reduce the ripple voltage which may be caused by the ac line voltage, dc fan, or possibly the RF signal. Resistors R55 and R57 provide minimum load current for U5 and the external transistor while D22 and D24 protect U5 from potential reverse bias conditions.

4.2.2.3 Eight Volt Supply

The 8 Vdc regulation and power to the logic circuit is handled by U6 which is protected by diode D23.

4.2.2.4 Fix Bias Supply

At P10-4, a 0.64 and 0.05 Vdc bias power supply is produced by QA1B, QA1D, QA1E, and Q5. This bias voltage is used to bias some of the power amplifier's driver transistors.

4.2.3 RF Power Detection

The rectified RF signals (RF in, forward RF output, and reflected RF output) provided by the power amplifier's directional coupler and input detector are processed to indicate the power amplifier's status.
The RF levels are buffered and compared by U3 and U7. See Section 6.2.2, Low and High Power Adjust, for setting the comparator's reference voltage level. The forward RF output signal is fed to US.
The linear bar graph gives an approximation of the power amplifier's output RF power. The indication range of bar graph LED's Dl1 to D20 is from 10% to 100% of the power amplifier's RF output. Resistor R48 is used to adjust the bar graph. One of ten jumpers (JR 12 to JR2I) is used to set the relative low forward RF output; a logic high at U2' s pin 5 indicates a relative low RF level detected. The second jumper (from JR2 to JRI 1) is selected for turning on the fan whenever output power is detected above a threshold level (about 20%).

4.2.4 Status Indication and Alarm

The power on LED D7, and RF IN LED D8, are green. LED D8 indicates the input status of the power amplifier. LED D8 is turned on whenever 50% of rated exciter power is detected. The level of triggering D8 is adjusted by R50.

The high reflection output LED D9, and overheat LED D10, are red. When these LED's are illuminated, this indicates a problem in the power amplifier. LED D9 is latched by Q1 where the reflected level is detected above a certain level (30% of rated power amplifier power) for approximately 10 ms. LED D9 is disabled only by resetting the latch (U1 and the NOR RS flip flop). It is reset on the application or removal of PTT (or by a transition from low to high or high to low power) if the alarm condition has been corrected.

The temperature sensor, mounted on the heatsink, will switch on Q2 and LED D10 when it detects the ambient temperature of the heat sink is above the rated temperature level (set by R14 and R28 or R51). There is about 10oC hysteresis built into the temperature sensor circuitry to ensure the power amplifier is cooled down before the next transmission. The overheat signal sent by the temperature sensor is latched by U1, and sends an alarm signal to the system through P10-11. The overheat alarm will only be reset when the heat sink is cool enough for the power amplifier's next transmission.

The alarm signal is fed to driver regulator switch Q3, and it will disable the power amplifier (JR26 installed) or switch the power amplifier to low power (JR27 installed) as long as the alarm condition is present. On the other hand, it is desirable to disable the alarm signal, and enable the power amplifier when a new antenna system is set up at a site. This can be achieved by removing JR26 or JR27 (which ever is installed).

Note

Remember to replace JR26 or JR27 (whichever was installed) after theantenna system is set up. The power amplifier may be shutdown remotely if desired, by supplying 5 Vdc to pin 14 on connector DB15.

4.2.5 Timer and Fan Driver

The oscillator and programmable timer (U10), has its oscillation frequency determined by R46, R47, and C48 (fosc = 1/(2.3 R47 C48) when R46 = 2*R47). This driver operates as a one shot 2 minute timer, and its counter is reset when it is powered up or pin 6 of U10 is set. The counter will count up to 2 minutes of logic low at pin 6 of U10, then reset the Q output to a logic low.

There are four possible inputs that reset the 2 minute timer; power on, high RF input level, high RF output level, and overheat sensor.

Note

The fan may be jumpered on by installing JR25.

4.2.6 Overheat Sensor and Reference Temperature Level

If the ambient temperature detected by the temperature sensor is higher than the reference temperature (set by R14, and R28, or R51), the temperature sensor turns on switch Q2. Switch Q2 then turns on overheat LED D10, and sets the alarm. The temperature sensor has hysteresis determined by R29 and R32.

5 INSTALLATION

5.1 Overview

The transmitter location should be chosen to protect the equipment from dust and extreme environmental conditions. The transmitter can either be installed in any standard EIA 19-inch rack or ordered with one of two optional 19-inch rack cabinets. An optional cabinet can be ordered for indoor transmitter locations. Before installing the cabinet, open the transmitter's cabinet door and examine all equipment closely to ensure that all packing was removed and that all required printed circuit boards, other plug-in units, bolt-on equipment and electrical connections are secure. Replace any panels removed, and close the cabinet door after your inspection.

Cabinet Installation

DANGER

The optional cabinet, with one transmitter, has an approximate mass (weight) of 76 kg (167 lbs.). Ensure that the proper equipment and the required number of persons are available when lifting or moving your cabinet-installed transmitter to prevent injury to personnel or equipment.

Indoor Cabinets

This upright style cabinet has provisions in the base for bolting it down to a concrete floor. All cabinets have an ac power outlet strip with six grounded outlets and a 4.5 meter (15 foot) CSA (UL) approved, three-wire line cord installed in the cabinet's base. Remove the knockouts that best fit your installation needs when routing the ac power cord, antenna cable, and other wiring.

Caution

DOC and FCC Rules and Regulations require that the transmitter be installed so that all controls are protected from adjustment by unauthorized personnel. Cabinet doors must be kept locked unless the transmitter area is secure.

Transmitter Rack Mounting

When the Power Amplifier is ordered without a cabinet, it is supplied with rack mounting hardware and can be installed in any standard EIA 19-inch rack. However, certain guidelines should be followed when installing the transmitter. The Power Amplifier location should provide enough unobstructed space (at least 30cm [12 inches]) immediately to the rear of the large finned heat sink and fan located on the rear of the PA chassis. This space is necessary for proper cooling of the amplifier power elements.

When the Power Amplifier is installed in a cabinet, airflow through the cabinet should not be restricted, and the cabinet should have ample louver openings for airflow at both top and bottom.

5.3 Operating and Servicing Hazards

Voltages

Operating voltages ranging from a few volts to 120 or 240 volts ac are present in this equipment. Care has been taken in the design of the equipment to insure personnel safety. Terminals where ac line voltages are present are enclosed by covers that require tools for removal. Do not remove these covers or service the equipment with ac power applied to the equipment.

Human Exposure to Radio Frequency Energy

In August 1996 the Federal Communications Commission (FCC) of the United States with its action in Report and Order FCC 96-326 adopted an updated safety standard for human exposure to radio frequency (RF) electromagnetic energy emitted by FCC regulated transmitters. Those guidelines are consistent with the safety standard previously set by both U.S. and international standards bodies. The design of this product complies with the FCC guidelines and these international standards.

This equipment is intended for use only in a permanent professionally installed licensed site. Licensing of that site may require that an Environmental Assessment be performed based upon human access, antenna type, antenna mounting height, ERP, operating frequency, duty factor, and any co-located transmitters that contribute to the overall Radio Frequency energy exposure level.

Compliance is ultimately the responsibility of the site licensee and a determination of compliance can only be made by evaluating the complex factors of the specific site.

5.4 Checks and Adjustments

Your transmitter was completely checked out and performing within operating specifications when it left the factory. Since signal levels, control voltages, and possible ac line voltage may vary from those used in factory testing, the following system checks and adjustments should be made when the equipment is initially placed into service.

5.5 Equipment Needed

The following tools and equipment will be required to install the 9T97A250 RF power amplifier.

- ISC Technologies UHF 4-watt amplifier and DSP exciter.
- Power supply: 28 Vdc 24 A minimum.
- Directional wattmeter, 50 ohms, 5-watts full scale, 5% accuracy.
- Directional wattrneter, 50 ohms, 250-watts full scale, 5% accuracy.
- 50-ohm termination 250 W.
- DC voltmeter: 30 Vdc minimum.
- DC ammeter: 25 A full scale, 2.5% accuracy.
- Rack mount hardware.
- Cables with appropriate connectors.
- One jumper: 0.1 spacing, (270-0501).

5.6 Procedure

1. Install the exciter shelf, power supply, and power amplifier into the rack, but do not interconnect.

2. Connect the voltmeter to the power supply. Check that polarity is correct. Check that the leads are not shorted out.

3. Switch ON the power supply and check that the voltage is 28 Vdc within 0.1 Vdc. Adjust the power supply if necessary.

4. Switch OFF power supply.

5. Disconnect voltmeter leads after the power supply has discharged.

6. Connect the power supply to the barrier strip on the rear of the power amplifier. Check that polarity is correct.

7. Remove placard and turn ON power supply. Check that the green power light on the front panel of the power amplifier is illuminated, and the fan is operating.

8. If the LED is not on, turn OFF the power supply and check fuses and polarity of the cables. If the LED still does not illuminate, or the fan does not start. contact ISC Technologies Customer Service before continuing.

9. Switch OFF the power supply and connect the exciter output through the 5-watt F.S. directional wattmeter to the 5-watt R.F. load.

10. Switch ON the power supply, and key the exciter. Check that about 4.0 watts +/-0.2 watts is produced when the exciter is keyed. Switch OFF the exciter and disconnect the 5-watt R.F. load.

11. Connect the 50-ohm cable from the power amplifier's output through the 250-watt F.S. directional wattmeter to the 250-watt R.F. load.

12. Connect the exciter's output from the 5-watt F.S. directional wattmeter to the power amplifier's input.

13. Switch ON the power supply and key the exciter momentarily. Check that the power amplifier's power output is about 250 watts.

14. If this is not the case, follow the power amplifier alignment and logic circuit alignment procedures in Section 6 before continuing with this installation.

15. Key the exciter momentarily and note the reflected power between the exciter and the power amplifier. If this is greater than 0.2 watt, contact ISC Technologies Customer Service before continuing.

16. Switch OFF the power and disconnect the 5-watt F.S. directional wattmeter between the exciter and power amplifier. Connect the exciter directly to the power amplifier.

17. Switch ON the power supply and key the exciter. Check that the power amplifier's output power is acceptable.

18. Switch OFF the power supply and disconnect the 250-watt R.F. load. Remove the front panel of the power amplifier and connect the power amplifier's output to the antenna system through the 250-watt F.S. directional waif meter.

19. Switch ON the power supply and key the exciter momentarily. Note the reflected power from the antenna system.

20. If the power amplifier shuts down, remove JR26 or JR27 (whichever is installed) on the logic board and note the reflected power from the antenna system.

DANGER

If the reflected power is greater than 8% of the required output power, the power amplifier should not be used in this application subject to a void warranty. Contact ISC Technologies Customer Service.

21. If the reflected power is less than 8%, and the power amplifier shuts down with JR26/JR27 installed, switch OFF the power supply and contact ISC Technologies Customer Service.

22. Replace JR26 or JR27 if removed previously. (The power amplifier did not shut down, and reflected power is less than 8%).

23. Disconnect the 250-watt F.S. directional wattmeter, and replace the front cover. The power amplifier is ready for use.

6 ADJUSTMENTS

6.1 Power Amplifier Alignment and Tuning

6.1.1 Why You Need to Tune

The 9T97A250 RF power amplifier is factory adjusted at the desired frequency. If the frequency of operation has to be changed by more than 2 MHz away from the previous frequency, then the following adjustments should be made. This is to ensure the power amplifier's optimum performance and increase the life of the RF power transistors.

6.1.2 Equipment Needed

The following tools and equipment will be required to properly align the 9T97A250 RF power amplifier.

- Directional wattmeter, 50 ohms, 5-watts full scale, 5% accuracy.
- Directional watimeter, 50 ohms, 250-watts full scale, 5% accuracy.
- 50-ohm termination 250 W.
- Tuning tool, slot, insulated.
- DC ammeter: 25 A full scale, 2.5% accuracy.
- Cables with appropriate connectors.
- Test set: M-97.

6.1.3 Exciter Check

1. Set up the exciter and test equipment as shown in Figure 6-1.

2. Switch ON the power supply and key the exciter. Check that the output power is 4.0 watts +/- 0.2 watts.

3. If the power output is not within this range, switch OFF the power supply and replace the exciter.

6.1.4 Power Amplifier Adjustments

1. Switch ON the power supply and key the exciter.

2. Adjust C12 on the first final for maximum power.

3. Record the current reading of this final from the M-97 test set.

4. Increase the capacitance of C12 on the first final until the power drops by 2 watts from the maximum power peak.

5. Check that the current reading has decreased on the M-97 test set.

6. Repeat steps 2 to 6 for the second final.

7. Repeat steps 2 to 6 for the third final.

8. Repeat steps 2 to 6 for the fourth final.

9. Adjust C4 on the driver module for minimum reflected power from the power amplifier back to the exciter.

10. Adjust C2 or C3 (depending upon the band) on each final power amplifier module for maximum output power.

11. Adjust R52 (HIGH PWR ADJ) on the logic board for 250 watts of output power.

12. Repeat steps 3 to 11 until tuning does not effect the output power of the power amplifier.

13. Check that the total dc current draw for the power amplifier is less than 21 A on the dc ammeter, and the M-97 test set current reading for the final modules is less than 20.

14. Adjust R52 (HIGH PWR ADJ) for the desired output power level.

15. Switch OFF the power supply, disassemble the test equipment, and connect the exciter and power amplifier in its normal configuration.

6.2 Logic Alignment

6.2.1 Equipment

The following tools and equipment will be required to properly align the 9T97A250 RF power amplifier.

- Directional wattmeter, 50 ohms, 250 watts full scale, 5% accuracy.
- Directional wattmeter, 50 ohms, 5 watts full scale, 5% accuracy.
- 50-ohm termination 250 W.
- 10 Vdc minimum voltmeter.
- Two jumpers, 0.1 spacing (GL 270-0501).
- DC ammeter: 25 A full scale, 2.5% accuracy.
- 3 dB attenuator, 5 watt minimum.
- Test set: M-97.

6.2.2 Low and High Power Adjust

1. Remove JR26 or JR27 (which ever is installed) to inhibit power auto shutdown.

2. Switch the M-97 test set to low, power, or connect pin 12 to pin 15 of the DB15 connector, or install JR29.

3. Switch ON the power and key the exciter.

4. Adjust R53 (LOW PWR ADJ) on the logic board until the desired LOW power output is obtained.

5. If the LOW power setting is not required, turn R53 fully counter clockwise.

Note

Rotating R53 (LOW PWR ADJ) clockwise, increases output power.

6. Switch the M-97 test set to “HIGH” power, or disconnect pin 12 from pin 15 of the DB15 connector, or remove JR29 if installed. Turn R52 (HIGH PWR ADJ) on the logic board until the power amplifier’s forward output power is about 225 watts.

7. Turn R48 (BAR GRAPH ADJ) on the logic board so that 100% LED D11 of the bar graph,just lights up.

8. Turn R52 (HIGH PWR ADJ) on the logic board until the desired HIGH power output is obtained,

9. Switch OFF the power and install a 3 dB attenuator between the exciter and the power amplifier. Switch ON the power again and key the exciter.

10. Turn R50 (RF IN LEVEL SET) on the logic board until the RF IN LED D8, just lights up.

11. Install JR28 and verify that LED D8 still turns on. Turn R50 if necessary, until D8 (RF IN LED) just turns on, then remove JR28.

12. Switch OFF the power, and remove the 3 dB attenuator installed between the exciter and the power amplifier.

13. Install either JR26 or JR27 to enable the power auto shutdown to either NO POWER or LOW POWER respectively.

14. Switch ON the power, key the exciter, and connect a 10 Vdc voltmeter to test point TP4 (P 13-1) on the logic board. Turn R51 (TEMP ALARM SET) until the voltage reads 3.0 Vdc.

15. Unkey the exciter and remove the voltmeter.

Caution

The low RF alarm trip point is set by one of jumpers JR12 to JR21. This is set to 20% with jumper JR20 at the factory. You may increase this setting in 10% steps from 100% to 10% by installing a jumper at one of the JR positions. The 100% position is jumper JR12, and the 10%position is JR21.

WARNING

DO NOT install more than one alarm trip point jumper at any time, or else the display driver will be damaged.

16. Switch OFF the power.

17. Install JR26 or JR27 (which ever was installed previously).

18. Disassemble the test equipment, and connect the exciter and power amplifier in its normal configuration.