Errata

Title & Document Type: **789C Directional Detector Operating and Note**

Manual Part Number: **00789-90001**

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HP References in this Manual

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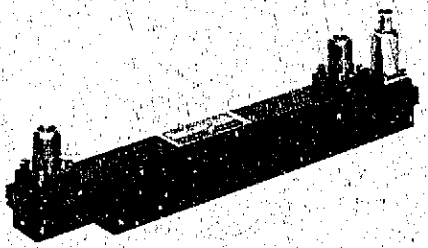
OPERATING NOTE

DIRECTIONAL DETECTOR

789C



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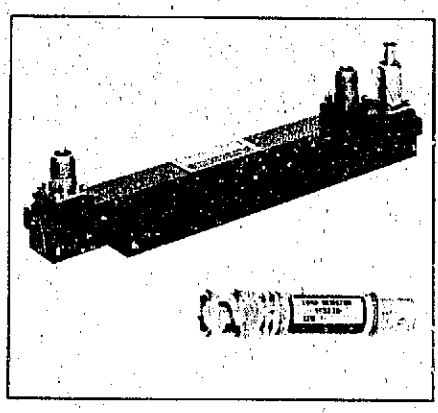


Figure 1. Model 789C and Option 002 Load Resistor

INTRODUCTION

The Model 789C Directional Detector, a directional coupler with built-in crystal detector, is designed for use in 50-ohm coaxial systems in the 8.0 to 12.4 GHz range. Uses include closed-loop leveling, observation of I/F envelope variation, and relative power monitoring. Output polarity of the detected signal is normally negative, but positive output polarity is available as Option 003. Figure 1 is a picture of the Model 789C with the Option 002 Load Resistor, and Table 1 lists complete instrument specifications.

The 789C and the optional square-law load (HP Model 11523A, Option 002, see Figure 1 and Table 1) are separately housed. This arrangement permits choice of 789C operation for optimum square-law response for detected outputs of up to 50 mV (with the load attached) or maximum output sensitivity (without the load). If a load has been matched to the 789C, then the 789C has been labeled with a serial number. This serial number is the serial number on the load label. If you have more than one load (HP Model 11523A), always check that the serial number of the load and 789C are identical.

PRECAUTIONS

Static Electrical Damage

The maximum pulse rating for the detector element (diode) used in the 789C is 0.1 erg of energy. A four-foot length of coaxial RG 58/U cable, the equivalent of a 100-pF capacitor, when charged to 14 volts is the equivalent of 0.1 erg of energy. Be certain that connecting cables are always connected to associated equipment and discharged before connecting to the detector output.

Handling Damage

DO NOT HANDLE DETECTOR ELEMENT NEEDLESSLY. Static electricity which builds up on the body, especially on a cold, dry day, must never be allowed to discharge through the detector element. Avoid exposed leads to or from the detector output, since these are often touched accidentally.

Table 1. Specifications

Frequency Range: 8 to 12.4 GHz

Frequency Response: ± 0.5 dB

Sensitivity with Respect to Power Out:
Low Level: greater than 20 μV/μW CW
High Level: 7 mW produces at least 100 mV output.

Directivity: 17 dB

Maximum Main Line SWR: 1.4:1

Equivalent Source Match:[1] 0.111 (1.25:1 SWR)

Maximum Main Line Input: 1 watt

Insertion Loss:[2] 1.2 dB maximum

Detector Output Impedance: 15 Ω max shunted by 10 pF

Detector Element: Supplied

Noise: Less than 200 μV peak-to-peak with CW power applied to produce 100 mV output.

Detector Output Polarity: Negative

Detector Output Connector: BNC female

RF Connectors: Type N, two female

Size: 11-5/8 x 1 x 3 inches (295 x 25 x 76 mm)

Net Weight: 1 lb., 11 oz (766 g)

Options: 002: Load Resistor (HP Model 11523A) furnished for optimum square-law response at 24°C (75°F): Square-law variation ± 0.5 dB for up to 50 mV peak output (working into external load 75K). Sensitivity typically > 5 μV/μW CW.

Option 003:
Positive polarity detector output.

[1] Source match is the apparent reflection coefficient at the 789C output when in a closed-loop leveling system.

[2] Including loss due to coupling.

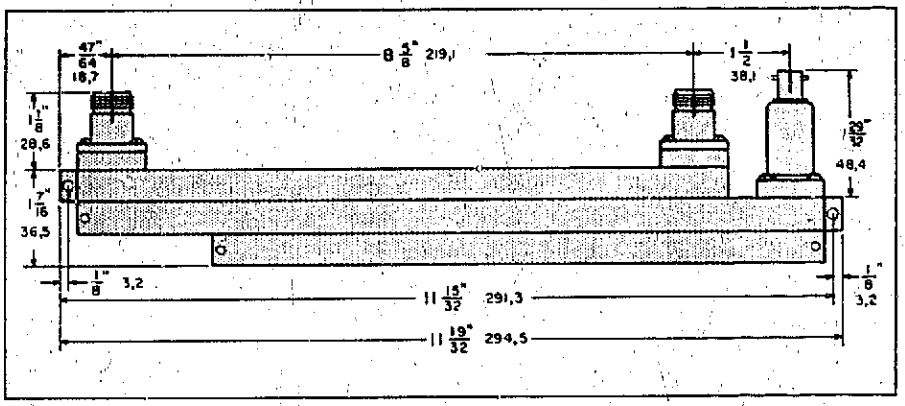


Figure 2. Model 789C General Dimensions

DO NOT DROP. Severe shock due to dropping is hard on the detector element and can break the internal coupler loads or dent the directional detector body causing a degradation in operating characteristics.

GENERAL OPERATION

The directional detector is useful as the sampling and detection device in closed-loop leveling setups as described in Closed-Loop Leveling, page 4. It can also be used as a calibrated power monitor, by determining the correlation between detected output and main line RF output levels, or for relative RF envelope observation with an oscilloscope. If the 789C is to be permanently mounted for any applications, refer to Figure 2 which illustrates the location of the two 6-32 tapped mounting holes and the general side dimensions of the 789C. Before installing the 789C in any setup, the following information should be considered:

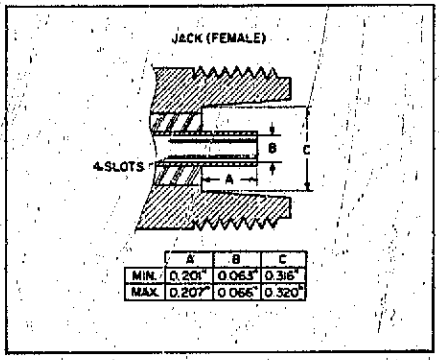
a. The type N connectors used on the Model 789C are stainless steel for long wear and are compatible with connectors whose dimensions conform to MIL-C-39012 or MIL-C-71 (see Figure 3).

CAUTION

Do NOT mate the female connector with male connectors with center pins larger than 0.066 inches OD. Damage may result.

b. The detector element used in the 789C is sensitive to either amplitude-modulated or continuous-wave (CW) RF power. If RF power is amplitude-modulated at a 1000 Hz ±5% rate, the sensitive HP Model 415B or 415E (SWR Meter) can be used as the indicator. For CW detection, a dc milliammeter or millivoltmeter (with an input impedance of at least 100K ohms) such as the HP Model 425A Microvolt-Ammeter can be used as the indicator.

c. For detector-to-oscilloscope connections, to observe waveshapes of rise times less than 5 μsec the coaxial cable connecting the detected output and the oscilloscope should be as short as possible and shunted with a resistor. Ideally, this resistor should be 50 ohms to terminate the coaxial cable in its characteristic impedance. However, with 50 ohms, the video pulse may have too small an amplitude to drive some oscilloscopes. Typically, the value is between 50 and 2000 ohms. The larger the resistance, the slower the observable rise time.



	A	B	C
MIN.	0.201"	0.063"	0.316"
MAX.	0.207"	0.066"	0.320"

Figure 3. HP Type N Connector Dimensions

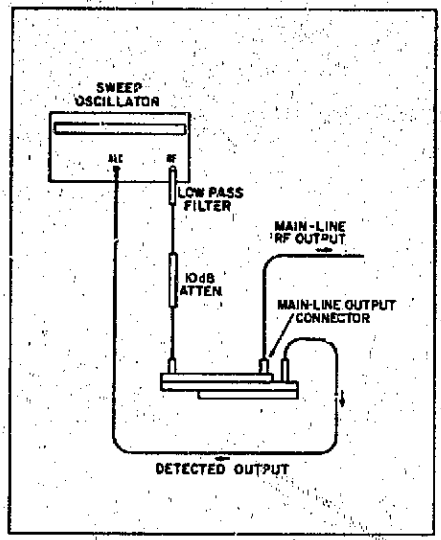


Figure 4. Typical Closed-Loop Leveling Setup

d. A low-pass filter should be used in all applications where harmonic frequencies may be present.

SENSITIVITY

For low-level main-line RF outputs up to at least 0.1 mW, the ratio of detected output voltage to main line RF power output (in microvolts per microwatt) is at least 20 to 1. For high-level main-line RF outputs between 1 mW and 7 mW, the sensitivity ratio (in millivolts per milliwatt), is at least 14 to 1. For main-line RF outputs between 0.1 mW and 1.0 mW, the sensitivity ratio relationship changes gradually from a 20 to 1 to a 14 to 1 relationship. For main-line RF outputs of greater than 7 milliwatts, the detected output to main line RF output ratio begins to decrease and, depending upon the individual internal detector element, reaches a peak point where increased RF power will not produce a detected output signal much in excess of about 300 to 500 millivolts.

SQUARE-LAW LOADING

The square-law load (HP Model 11523A) is selected for optimum response (minimum deviation from square law) at 24 degrees C (75 degrees F). Typically, detected output varies ± 0.3 dB from exact square law for values of output voltage between 5 mV and 50 mV. At higher temperatures output-voltage vs. input-power deviation is more negative and at lower temperatures the opposite is true. The change with temperature is approximately 0.04 dB/°C. For example, a detected output which varies ±0.3 dB from exact square-law at 24 degrees C would vary about ±0.1 to -0.5 dB at 29 degrees C (84 degrees F).

CLOSED-LOOP LEVELING

Technique. The Directional Detector has a direct application in systems employing closed-loop leveling of the RF source. Any variation in the RF output level causes a proportional variation in the detected output level and is used for maintaining a constant RF output level. These detected output variations, when applied to a sensitive dc amplifier such as the leveler amplifier built into the HP Model 8690-series Sweep Oscillator, are amplified to produce control voltages used to maintain a leveled RF output (refer to Figure 4).

Leveling Capability. The leveling capability of the leveler amplifier/directional detector combination is limited mainly by the frequency response of the detector, the coupling variation of the sampling device, and the frequency response of the leveler amplifier. For the 789C, the frequency response of the detector and the coupling variation are combined in one specification: frequency response. The frequency response of the leveler amplifier depends upon the unit being used. When the HP Model 8690 Sweep Oscillator is used, the typical frequency response error characteristic of the leveler amplifier is ±0.2 dB.

Source Match. The source match specification of the directional detector is the reflection or mismatch error that the main-line output connector of the directional detector presents to a system WHEN IT IS USED IN A CLOSED-LOOP LEVELING SETUP. This source match, or source reflection-coefficient, specification eliminates the need to consider directivity imperfections when calculating system mismatch errors for power and attenuation measurements. For detailed information about mismatch error analysis, refer to Application Note 56, a copy of which can be obtained from your local Hewlett-Packard field office.

CALIBRATED POWER MONITOR

The Directional Detector can also be used as a power monitor. By determining the correlation between the detected output and the main-line RF output levels the detected output indicator monitor can be calibrated and the directional detector used to sample indicated RF power levels at any point in a system. A power meter can be used to measure main-line RF output levels for calibration of detected output indicator monitor which may be an Oscilloscope, DC Voltmeter, or SWR Meter.

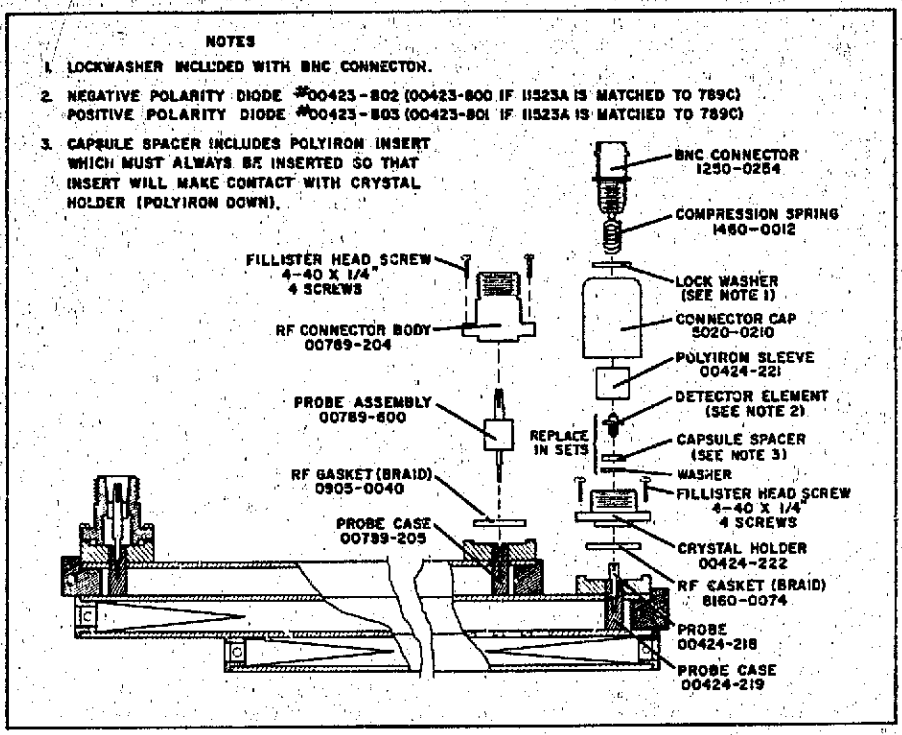


Figure 5. 789C Connector Assembly

MAINTENANCE

Succeeding paragraphs give instructions for repair of the 789C and the HP Model 11523A (Option 002) Load Resistor. Figures 5 and 6 illustrate the replaceable parts assembly for the directional detector. Figures 7 and 8 illustrate the replaceable parts assembly for the load resistor. Stock numbers required when ordering replacement parts are given in the respective assembly illustrations. To order a replacement part, address order or inquiry to your Hewlett-Packard field office.

Detector Element Replacement

CAUTION

The detector element (see Figure 5) can be damaged electrically by dropping or incorrect handling procedure. Read the following handling precautions before doing anything which involves detector element handling.

Handling Precautions

a. Before installing detector element in mount, touch exposed metal on mount with hand to discharge any static charge. Then insert detector element.

b. When handing crystal to another person, touch hands first to ensure there is no difference in static electrical potential between you.

c. Do not use an ohmmeter to measure forward- and back-resistance. The open-circuit voltages and short-circuit currents from the ohmmeter can damage detector element (diode).

Procedure

a. Note Figure 5 and remove connector cap from holder. To remove connector cap, use a pair of gas pliers and protect cap with heavy paper or tape.

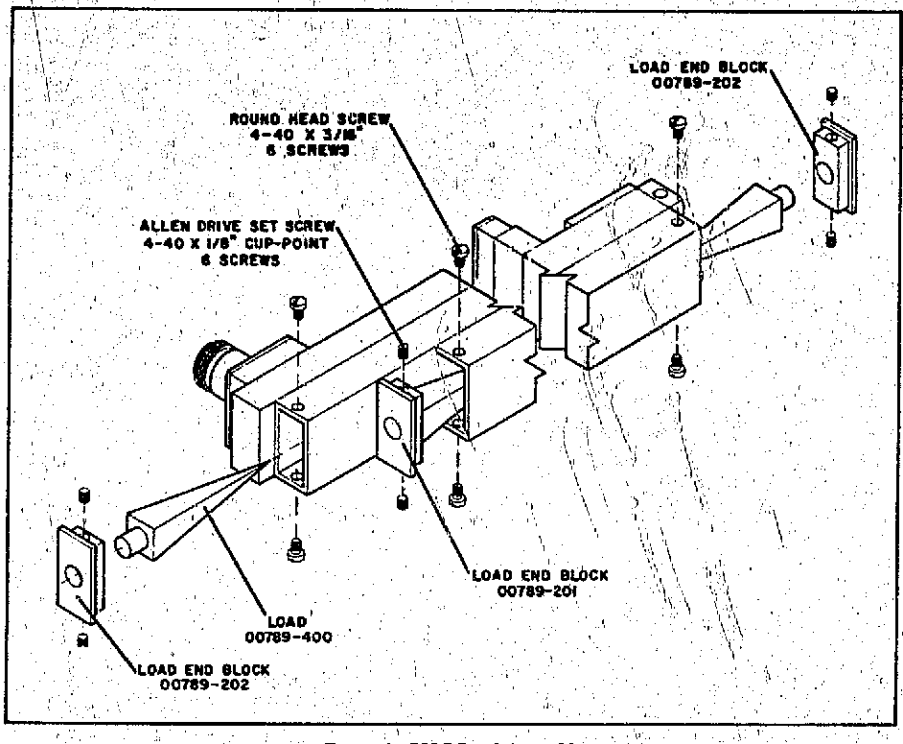


Figure 6. 789C Load Assembly

b. Remove old detector element.

c. Install replacement detector element; black resistive end goes into crystal mount (detector element should be a snug fit).

Note: The replaceable detector element assembly may include a resistor. The resistor is for use in the Model 11523A Load Resistor and must be installed to retain proper square-law operation if the directional detector is equipped with this optional load.

Replacing 789C BNC

Tools Required:

a. Needle-point soldering iron.
b. Gas Pliers.
c. Male BNC mating connector.
d. Tweezers.

Procedure

a. Refer to Figure 5. Remove BNC connector and lockwasher.

b. Unsolder spring soldered to center conductor lead.

c. Slip spring over center conductor lead of new BNC and solder.

d. Let spring cool, and then replace lockwasher and connector in connector cap.

Replacement of Type N Connectors

a. Remove four retaining screws and RF Connector Body only. Do not remove probe assembly or rotate probe position (see Figure 5).

b. Place new RF Connector Body and the RF gasket in place and tighten four retaining screws. Do not allow RF gasket to slip underneath RF connector body causing RF leakage.

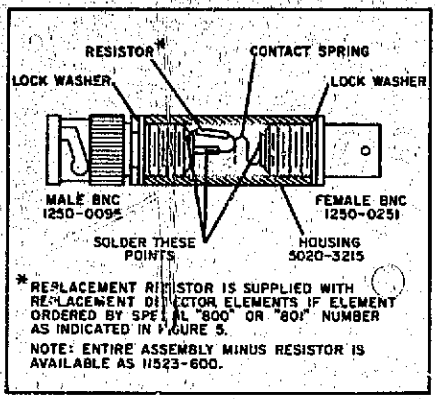


Figure 7. Option 002 Load, Cutaway View

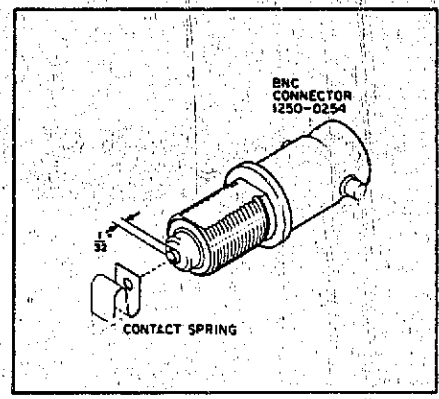


Figure 8. Option 002 BNC Assembly

RF Probe Assembly Replacement

a. Refer to Figure 5. Remove four retaining screws and the RF Connector body.

b. Remove the Probe Assembly.

c. Insert new probe assembly in probe case. The probe assembly is a snug fit.

d. Place RF connector body and RF gasket in place and tighten four retaining screws. Do NOT allow RF gasket to slip underneath RF connector body causing RF leakage.

RF Load Replacement

a. Refer to Figure 6. Remove two round-head retaining screws and the load assembly.

b. Remove load from load end block by removing two retaining set screws.

c. Remove any loose or broken portions of the old load from inside the directional detector by shaking gently.

CAUTION

Do not use forced air to remove any dust, dirt, or loose portions of load from directional detector. Air under pressure can break internal loads.

d. Installation of new load is reverse of removal.

Replacement of 11523A Male BNC

a. Refer to Figure 7. Unscrew male BNC and lock-washer from housing by using a 3/8-inch open-end wrench and holding housing either in a vise or with gas pliers.

Note: If gas pliers are used housing should be protected with tape or heavy paper.

b. Unsolder resistor.

c. Solder resistor to new BNC.

d. Let resistor cool, then check resistance from male BNC pin through resistor; resistance measured should be ±10% that indicated by the coding.

e. Replace lockwasher and male BNC.

Replacing 11523A Female BNC

a. Unscrew BNC with a BNC wrench or male BNC used as a wrench.

b. Unsolder contact spring.

c. Prepare replacement BNC connector:

(1) Cut center conductor lead to approximately 1/32 inch (refer to Figure 8).

(2) With flat file, smooth end of load; wipe off burr with tweezers or similar metal instrument.

d. Slip contact spring over center conductor lead, and solder.

Note: Use solder sparingly or it will creep back on spring. Solder on spring destroys its usefulness and is difficult to remove.

e. Let contact spring cool and then screw BNC into housing.

PERFORMANCE CHECK

Test equipment recommended for checking performance of directional detector is listed in Table 2. Equipment whose characteristics are equal to or better than the critical specifications listed may be substituted for the equipment listed.

Mechanical Inspection. Mechanical inspection should include periodic mechanical dimension checks on the female type N connectors (refer to Figure 3 for important dimensions). Also, any accumulated dust and dirt should be removed from connectors.

Electrical Inspection. Electrical inspection should include directivity, frequency response, sensitivity, and main-line SWR. (The source match, or source SWR, as specified is dependent upon these three characteristics and satisfactory performance checks indicate satisfactory source match.)

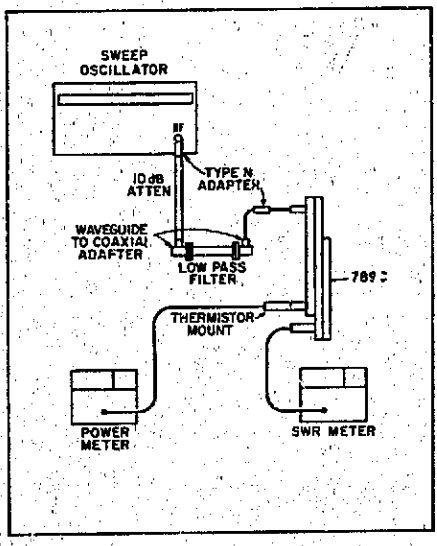


Figure 9. Frequency Response Check

Frequency Response and Sensitivity Check

Frequency Response: ± 0.5 dB

Sensitivity: 100 mV detected output for 7 mW RF output.

a. FREQUENCY RESPONSE: Set up equipment as shown in Figure 9.

NOTE

The RF Source and the SWR Meter should not be connected to common grounds; common ground might cause erratic meter readings. Connect RF Source to power-line ground and isolate the SWR Meter.

b. Set Sweep Oscillator for single frequency, square-wave modulated RF output at 8.0 GHz.

c. Set any convenient reference on the Power Meter and a reference of 1 on the SWR Meter DB—EXPAND scale.

d. Increase RF output frequency to 9.0 GHz and adjust RF output level to obtain reference setting of step c on Power Meter.

Frequency Response: ± 0.5 dB (or 1.0 dB max variation)
POWER Meter Ref setting (step c)
SWR Meter Reading (at 9.0 GHz)

e. Repeat step d at every 1 GHz across the frequency range and optionally at any other points of interest.

Note: If HP Model 478A Thermistor Mount is used, the HP Model X486A Thermistor Mount with an X281A waveguide-to-coaxial adapter must be substituted above 10 GHz.

Frequency Response: ±0.5 dB (1.0 dB max variation)

SWR Meter Readings:

____(10 GHz) ____(11 GHz) ____( )
____(12 GHz) ____(12.4 GHz) ____( )
____( ) ____( ) ____( )

f. SENSITIVITY: Remove 10-dB Attenuator from setup (of Figure 9) and connect low-pass filter directly to adapter at Sweep Oscillator output after decreasing RF output so as not to damage Thermistor Mount.

g. Replace SWR Meter with a DC Voltmeter, such as HP Model 410C, and connect a BNC-to-Binding Adapter to detector output for voltmeter lead connections.

CAUTION

An RF power level exceeding 10 mW can damage Thermistor Mount. Be careful not to exceed 10 mW to mount.

h. Release SQ WAVE button and, noting Power Meter does not exceed 10 mW, increase unmodulated RF power output level for a 10 mV reading on the Voltmeter.

SENSITIVITY: 100 mV detected output for 7 mW or less main-line output.

SWR Check

MAXIMUM MAIN LINE SWR: 1.4:1

a. Set up equipment as shown in Figure 10.

Note: A spurious reading or beating may be observed if the Sweep Oscillator and SWR Meter have a common ground.

b. Set Sweep Oscillator for a single frequency, square-wave-modulated RF output.

Table 2. Recommended Test Equipment

Instrument Type	Critical Specifications	Check	Model
Low-Pass Filter	Cutoff Frequency: 12.4 GHz Rejection: 40 dB Type N Coaxial Connectors	All	HP X382A (Filter) and 2 HP X281A (Adapters)
Sweep Oscillator	Frequency: 8–12.4 GHz Power Output: 3 mW minimum Leveled Output Capability: ± 0.3 dB Residual FM: ≤ 30 kHz peak	All	HP 8694A or HP 8694B
SWR Meter	Frequency: 100 Hz ±5% Calibration: Square Law Accuracy: ±0.2 dB Sensitivity: 0.1 μV	All	HP 415B or HP 415E
Waveguide Directional Coupler & Crystal Detector	Frequency Range: 8–12.4 GHz Frequency Response: ± 0.3 dB Sensitivity: 4 μV/μW CW Coupling: 10 dB nominal	Directivity	HP X752C (Coupler) and HP X424A (Detector)
Sliding Load	Frequency Range: 8–12.4 GHz Residual SWR: < 1.05	Directivity, SWR	HP 905A HP 907A
Power Meter and Thermistor Mount	Frequency Range: 8–12.4 GHz Power Range: −10 to +10 dBm Accuracy: ±0.3%	Sensitivity, Frequency Response	HP 431B (Meter) and HP 478A (Mount, up to 10 GHz) and HP X486A (Mount, up to 12.4 GHz)
DC Voltmeter	Range: 20 to 100 mV Accuracy: ± 2% of full scale Input Impedance: 10 megohm	Sensitivity	HP 410C
Fixed Attenuator	Frequency Range: 8–12.4 GHz Attenuation: 10 dB	Frequency Response, Directivity	HP 8491A, Opt. 010
Probe Carriage and Slotted Section and Probe Detector	Frequency Range: 8–12.4 GHz Residual SWR: < 1.06 up to 10 GHz < 1.1 10.0 to 12.0 GHz Connectors: Standard Type N	SWR	HP 809C (Carriage) HP 816B (Slotted Section) HP 447B (Untuned Probe)
Variable Attenuator	Frequency Range: 4–12.4 GHz Attenuation: 17 dB Accuracy: ± 1%.	Directivity	HP X382A

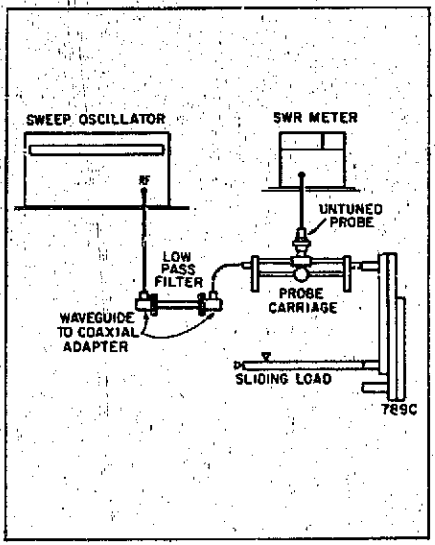


Figure 10. SWR Check

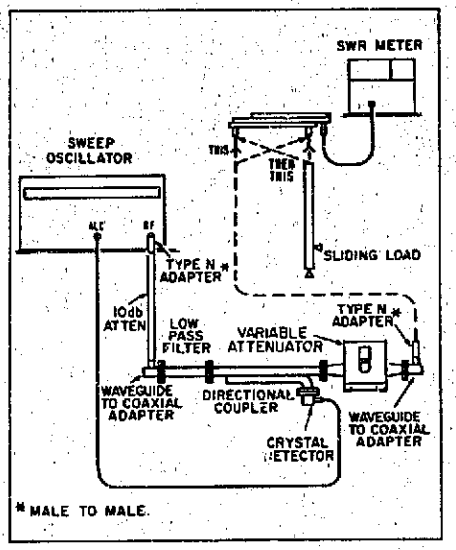


Figure 11. Directivity Check

c. Set any convenient preliminary reference on the SWR Meter 40-dB NORMAL scale.

d. Slide Untuned Probe along Probe Carriage to an up-scale SWR-scale indication as near the center of the Slotted Section as possible.

e. Phase the Sliding Load to obtain an up-scale SWR-scale peak.

f. Repeat steps d and e to be sure of settings and set a 1.0 peak on the SWR scale.

g. Position Probe Carriage for a down-scale SWR null.

SWR measured must be equal to or less than 1.4:1.

Directivity Check

MINIMUM DIRECTIVITY: at least 17 dB

a. Set up equipment as shown in Figure 11.

Note: A spurious reading or beating may be observed if the Sweep Oscillator and SWR Meter have a common ground.

b. Set Sweep Oscillator for leveled, square-wave-modulated RF output, and 100-second sweep rate.

c. Set Variable Attenuator to 17 dB.

d. Set 3 dB reference on SWR Meter, using Sweep Oscillator output or SWR Meter gain controls.

e. Reverse 789C in setup so that Sliding Load is connected to output connector.

f. Decrease SWR Meter range by 20 dB.

g. Reduce Variable Attenuator to 0 dB.

h. Continuously phase Sliding Load and note null SWR Meter indications in relation to 3 dB reference (17 dB down).

i. If the directivity is less than 17 dB down at any frequency, the 789C may or may not be within specifications. (The voltage vector due to the load may be adding in phase to the voltage directivity vector from the 789C.) To determine the true directivity at the frequency in question, proceed as follows:

(1) Set Sweep Oscillator on CW at the frequency in question.

(2) Phase the sliding load and observe the maximum and minimum SWR readings.

(3) Average the readings obtained in (2). The average reading should be 17 dB or greater. If not and the 789C shows no obvious signs of damage, consider the possibility of 789C internal load damage. This load must come to a very sharp point (<0.040" wide) for proper operation.

APPENDIX

TYPE N CONNECTORS

On some older instruments of this type "precision" (non-compatible) connectors were used. To determine if your instrument has these connectors look for the following:

MALE CONNECTORS — Slots in the outer conductor.

FEMALE CONNECTORS — Silver (not gold) plated center pin

LABEL — None reading "MATES WITH MIL-C-39012 CONNECTORS"

If all of the above are fulfilled you have "precision" connectors. These connectors make better connections with standard and "compatible" connectors but will not mate with each other.

CAUTION

Do NOT attempt to mate a male "precision" connector with a female "precision" connector as the center conductor will be damaged due to the forced fit. Use an adapter made of standard Type N connectors with "precision" male connectors.

If you have "precision" connectors on your instrument, the dimensions are slightly different as shown in the drawing below.