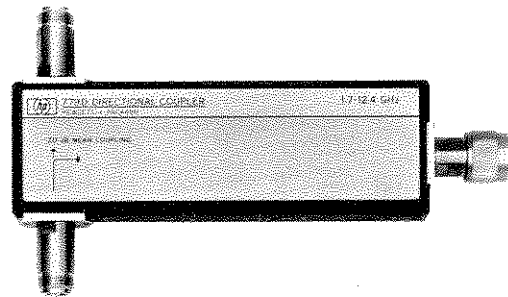


O P E R A T I N G N O T E

DIRECTIONAL COUPLER

779D

Serials Prefixed 901-



JAN. 1970

HEWLETT  PACKARD

1. DESCRIPTION.

2. The Hewlett-Packard Model 779D Directional Couplers are three-port passive devices for use in 7-mm, 50-ohm systems. A coupler is essentially a device for sampling power flowing in one direction in a transmission line. Since no coupler is perfect, some power flowing in the opposite direction is also sampled. The rejection of power flowing in the unwanted direction is called directivity and is the most important specification of a directional coupler. This coupler has 26 or 30 dB directivity, depending upon the frequency. Another specification is the forward coupling (usually called just coupling) which is the fractional amount of power transfer in the wanted direction. This coupler has a nominal 20 dB of coupling. These terms are defined in Figure 3, Coupler Terminology. Figure 3 also has a drawing of a typical coupling curve. This is a typical curve and not a specification. Table 1 contains the specifications.

Table 1. Specifications

Frequency Range: 1.7 to 12.4 GHz

Mean Coupling: 20 dB $\pm$ 0.5 dB

Coupling Variation: $\pm$ 0.75 dB

Directivity:

>30 dB from 1.7 to 4 GHz

>26 dB from 4 to 12.4 GHz

SWR and (Reflection Coefficient):

Primary line <1.2 (0.091)

Auxiliary line <1.2 (0.091)

Insertion Loss: <0.6 dB

Maximum Power Input:

Primary line 50 watts

Auxiliary line 0.5 watt

Connectors:

Input, Type-N male

Output, Type-N female

Auxiliary, Type-N female

Precision 7-mm APC-7* connector on any (or all) port(s) on special order

3. These couplers may be used in the measurement of reflection coefficient or SWR over a very wide frequency range. Because of the wide frequency range these couplers may also be useful as attenuators.

4. Port Terminology.

5. The two directly-connected ports are known as the primary-line ports. Note that these couplers are polarized, i.e., the input should be at the indicated port. The third, coupled, port is known as the auxiliary port. These couplers may be ordered with any combination of Type-N (male or female) connectors or APC-7* connectors on any or all ports.

6. INSTRUMENT IDENTIFICATION.

7. The Model 779D is identified by its serial number found on the back plate (opposite the nameplate). All correspondence with Hewlett-Packard Sales/Service offices in regard to this coupler should reference Model 779D and this serial number.

8. OPERATING NOTE CHANGES.

9. This note provides complete information for any Model 779D with the serial prefix indicated on the title page. If your serial prefix is different than shown on the front cover, a yellow change sheet should be supplied to adapt this note to your serial prefix coupler. If this sheet is missing contact your nearest Hewlett-Packard office.

10. INITIAL INSPECTION.

11. Mechanical Check.

12. If damage to the shipping carton is evident, ask that the carrier's agent be present when the instrument is unpacked. Inspect the parts for mechanical damage, such as scratches or dents. Also check the cushioning material for signs of severe stress (compacting).

13. Electrical Check.

14. The electrical performance should be verified as soon as possible after receipt. Refer to the Performance Test for further instructions.

*Amphenol, RF Division, Danbury, Connecticut.

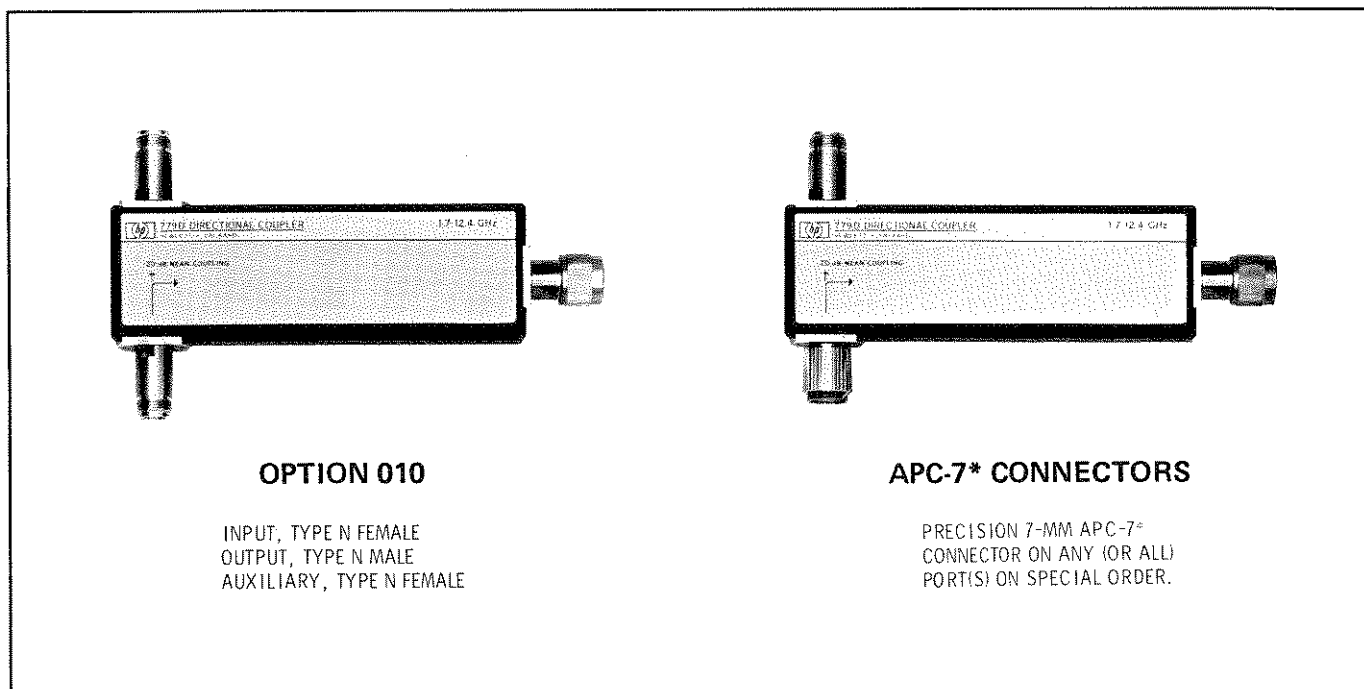


Figure 1. Connector Options

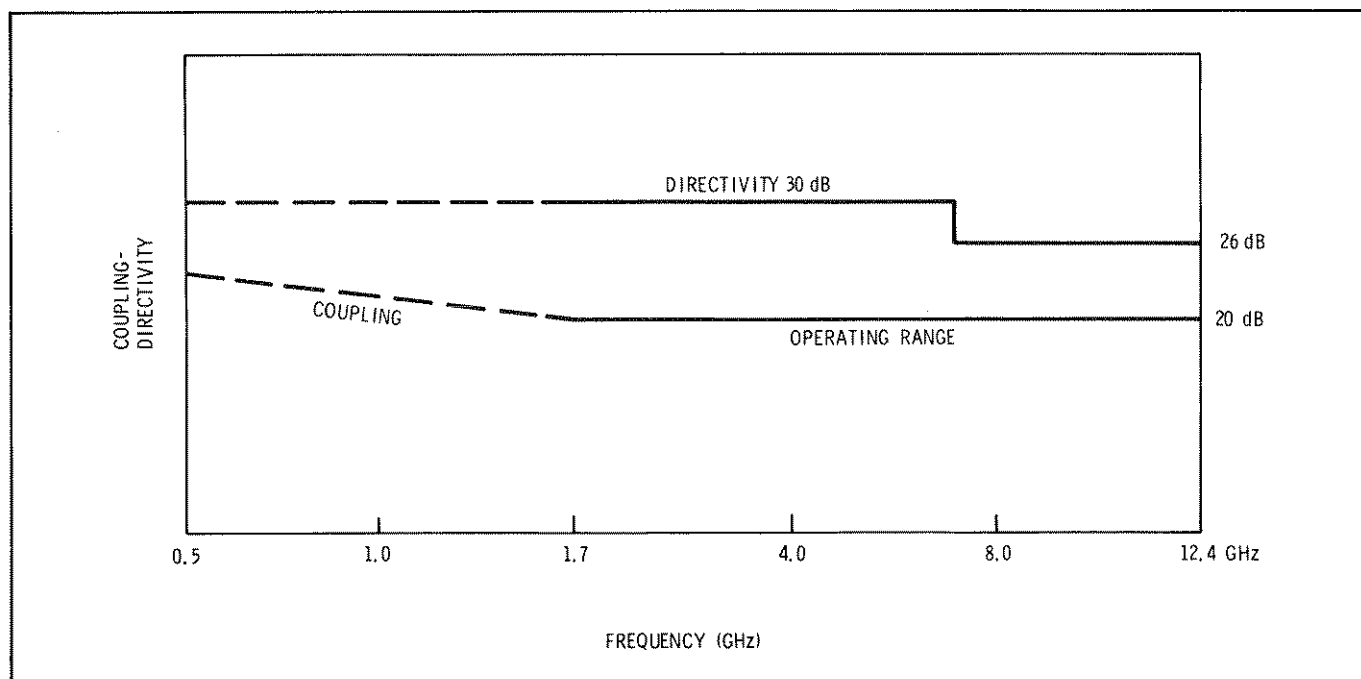


Figure 2. Coupling and Directivity Characteristics of the 779D Directional Coupler

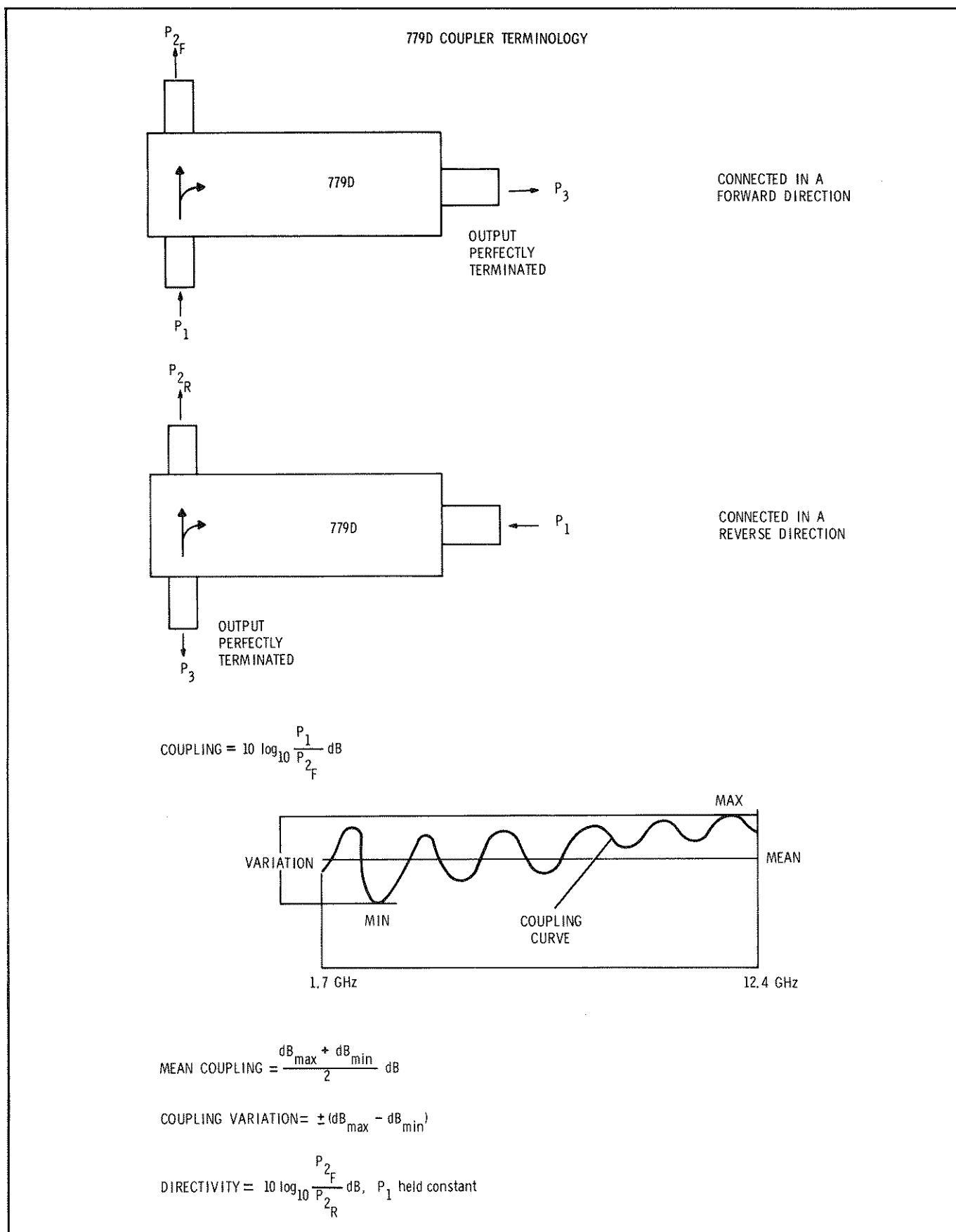


Figure 3. 779D Coupler Terminology

15. Claims for Damage.

16. If there is mechanical damage or the coupler fails to meet electrical specifications upon receipt, notify the carrier and your nearest Hewlett-Packard office immediately (a list of offices is at the end of this operating note). Retain the shipping carton and the padding material for the carrier's inspection.

17. REPACKAGING FOR SHIPMENT.**18. Using Factory-Type Packaging.**

19. The same type containers and material used in factory packaging can be obtained through the Hewlett-Packard offices listed at the end of this operating note.

20. If the coupler is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required and the return address. Also mark the container FRAGILE to assure careful handling.

21. Using Other Packaging.

22. The following general instructions should be used for repackaging with commercially available materials.

a. Wrap the coupler in heavy paper or plastic (if shipping to a Hewlett-Packard office or service center attach a tag indicating the type of service required, and your return address).

b. Use a strong shipping container. A double-wall carton made of 350-lb. test material is adequate.

c. Use enough shock-absorbing material (3- to 4-inch layer) around all sides of the coupler to provide firm cushioning and prevent movement inside the container.

d. Seal the shipping container securely.

e. Mark the shipping container FRAGILE to assure careful handling.

23. OPERATION.**24. Signal Flow**

25. Figure 4 shows the signal-flow path in the 779D when connected in the forward direction (779D shown with label facing reader, as with all diagrams in this operating note).

CAUTION

Do NOT exceed a maximum of 50 watts in the primary line. Do NOT exceed 0.5 watt in the auxiliary line.

26. Precautions.

27. Type-N Connectors. Type-N connectors used on the Model 779D are stainless steel for long wear and are compatible with connectors whose dimensions conform to MIL-C-39012 or MIL-C-71 (see Figure 5).

CAUTION

Do NOT mate with Type-N male connectors with a pin diameter of greater than 0.0655", as a discontinuity producing excess SWR will be formed even if the connector is not damaged.

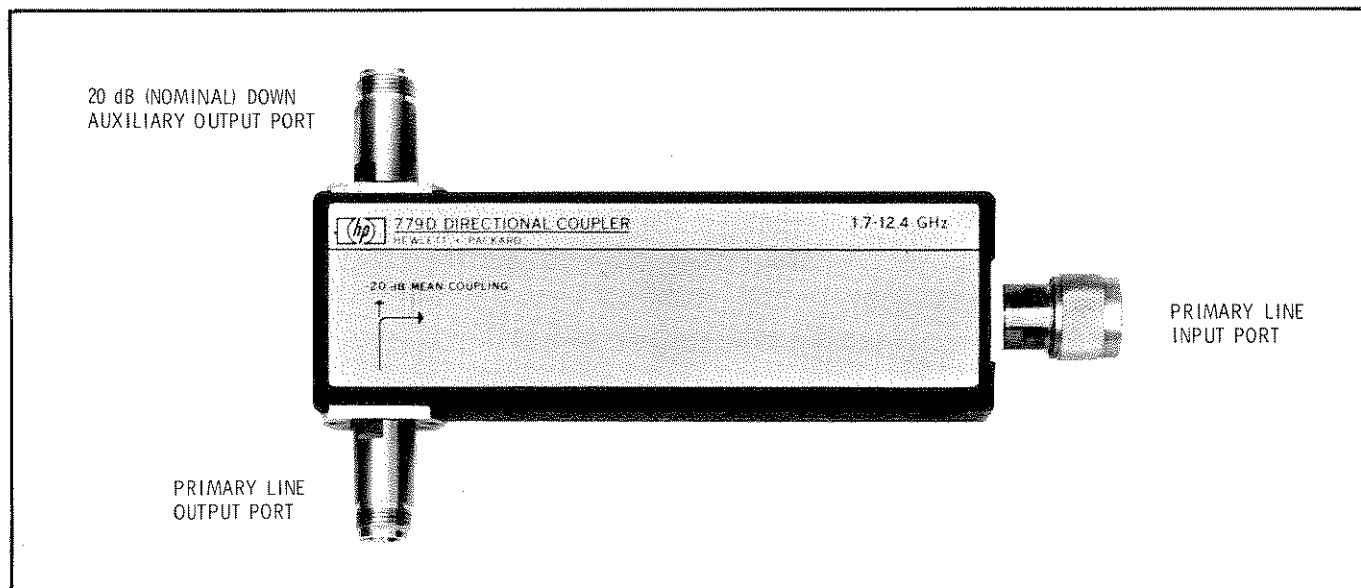


Figure 4. Signal Flow Path for Coupler Connected in the Forward Direction

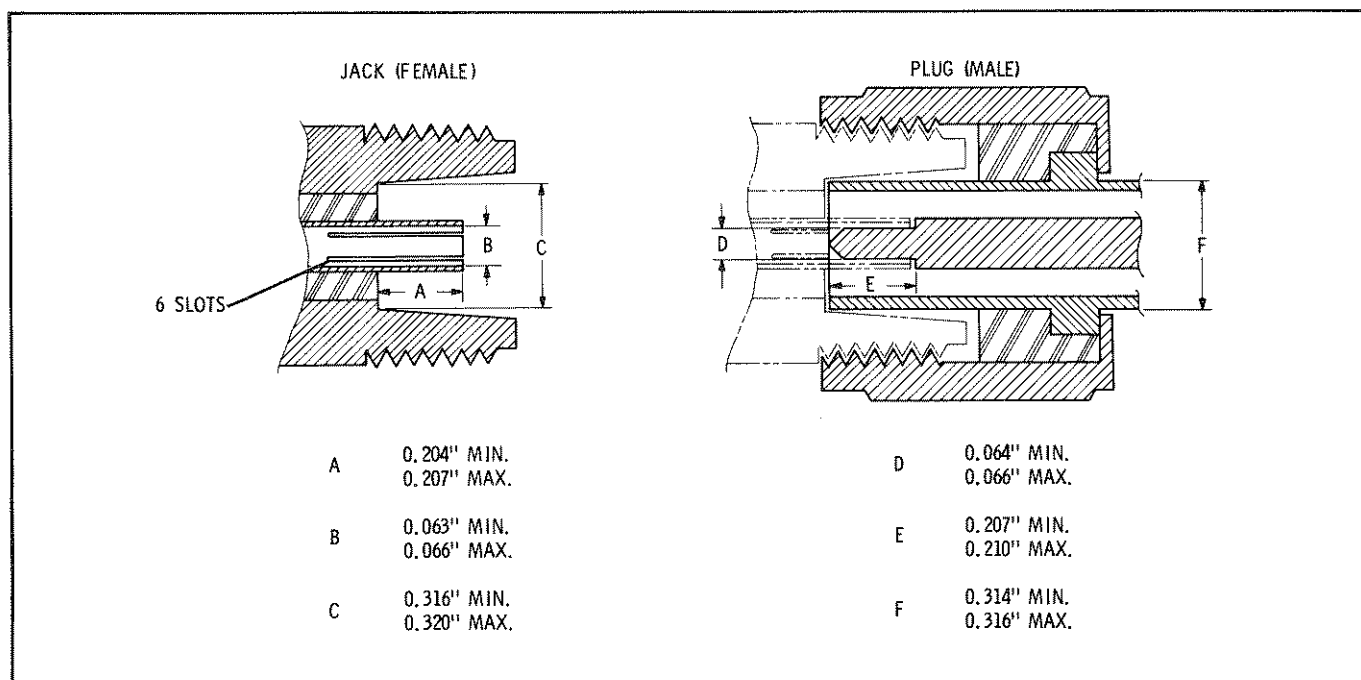


Figure 5. Type-N Connector Dimensions

28. APC-7 Connectors. Protect the face of the connectors from damage. Any scoring or burring of the mating surfaces causes discontinuity; the resulting increase in SWR degrades performance (see Service Note concerning APC-7 connectors obtainable free from any Hewlett-Packard sales/service office).

Do not exceed the load limits given in Figure 6 for this type of connector.

29. Do Not Drop. Do NOT drop the coupler. While the coupler probably will not break, it can be jarred out of adjustment and the connectors can be damaged.

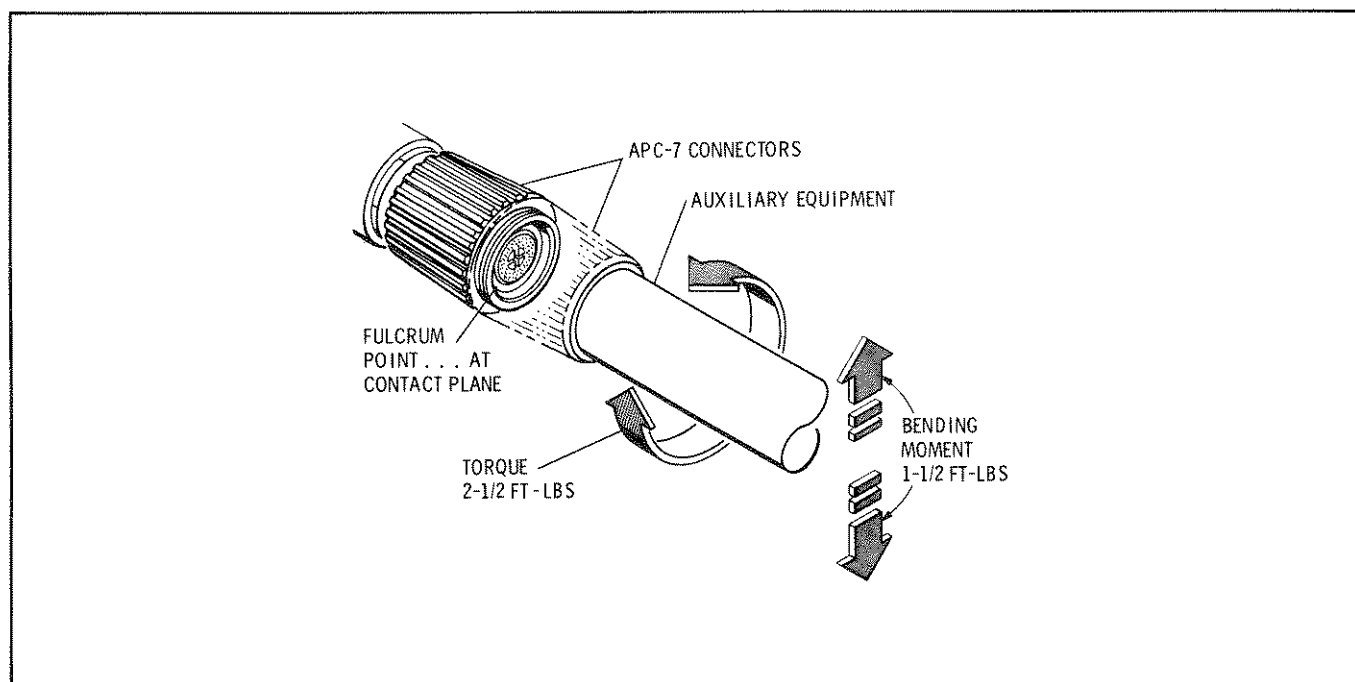


Figure 6. APC-7 Connector Load Limits

30. USES.

31. Reflectometer. Two 779D Directional Couplers connected together can be used with a sweep oscillator for making broadband reflectometer measurements. In the reflectometer, one coupler samples power going to the unknown while the other samples power reflected from the unknown. When the couplers are used with two Hewlett-Packard Model 423A Crystal Detectors, swept-frequency measurements of reflection coefficient versus frequency can be made easily. The detected output of the reverse coupler is displayed by an output indicator calibrated in reflection coefficient. For more information on reflectometer techniques, request a copy of Application Note 65, "Swept-Frequency Measurements", obtainable free from any Hewlett-Packard office listed at the end of this operating note.

32. Power Leveling. With its broad frequency coverage, the 779D can be used in leveling applications formerly requiring three or more couplers. When the 779D is used with sweep oscillators, the power output is sampled at the auxiliary port and detected with a crystal detector. The rectified detector voltage, when applied to the sweep oscillator ALC input, maintains a constant RF power

level out of the main line of the directional coupler, within the flatness of the coupling curve of the directional coupler.

33. PERFORMANCE TEST.

34. Use the following procedure for initial electrical check, performance testing, or whenever the coupler performance is suspected. Table 2 lists the recommended test equipment. Other equipment may be substituted provided its specifications equal or exceed the critical specifications. Table 3 provides a place to record the results of the test. The coupler should be tested on a swept-frequency basis to assure that there are no out-of-specification narrow-frequency bands. If the results of the swept-frequency testing are doubtful, or if the equipment for swept-frequency testing is not available, the fixed-frequency test may be used. The performance tests should be performed in the order given. Note that in many of these tests a 10-dB attenuator is used in series with the flexible arm. This attenuator reduces mismatch ambiguity by isolation. With the attenuator the mismatch is reduced to approximately the mismatch of the attenuator which is lower than the mismatch of the other components.

Table 2. Recommended Test Equipment

The following test equipment is recommended for testing the 779D. Other test equipment may be substituted provided its specifications equal or exceed the specifications listed under "Critical Specifications."		
Instrument	Critical Specifications	HP Model Number
Sweep Oscillator	Frequency: band of interest Power output: >10 mW	8690A/B mainframe with 8699B (110 MHz to 4 GHz) 8690A/B mainframe with 8691A/B (1 to 2 GHz) 8690A/B mainframe with 8692A/B (2 to 4 GHz) 8690A/B mainframe with 8693A/B (4 to 8 GHz) 8690A/B mainframe with 8694A/B (8 to 12.4 GHz)
Directional Coupler	Frequency range: 1.7 - 12.4 GHz Directivity: >30 dB 1.7 - 4 GHz >26 dB 4 - 12.4 GHz	779D

Table 2. Recommended Test Equipment (cont'd)

Instrument	Critical Specifications	HP Model Number
Network Analyzer	No other network analyzer will do	8410A/8411A/8413A
Sliding Load	Slides $\lambda/2$ at test frequency SWR: <1.05	905A (1.8 to 18 GHz)
Oscilloscope with Swept-frequency Indicator	Vertical Sensitivity: 50 mV/cm linear 0.5 dB/cm log. Provision for storing trace Bandwidth: variable to 30 kHz Sweep and Blanking: compatible with sweep oscillator	141A with 1416A
Reflection/Transmission Test Unit	No other transmission/reflection test unit will do.	8743A
Flexible Arm	Frequency range: 1.7 — 12.4 GHz SWR: < 1.25	11605A
10-dB Attenuator	Frequency: 1.7 — 12.4 GHz Attenuation: 10 dB (accuracy not important since used for isolation) SWR: < 1.25	8491A/B (Type-N connector) Opt. 010 8492A (APC-7* connector) Opt. 010
X-Y Recorder	Sensitivity: 50 mV/inch Impedance: 200K ohms/V	7035B
Coaxial Termination (2)	Impedance: 50 ohms SWR: <1.1	909A Option 12 (Type-N male) 909A Option 13 (Type-N female) 909A Standard APC-7
Slotted-Line Sweep Adapter**	Frequency: 1.8 — 12.4 GHz Matched crystal detectors	448A (includes 447B)
Slotted Section **	Frequency: 1.8 — 12.4 GHz Compatible with carriage	816A

Table 2. Recommended Test Equipment (cont'd)

Instrument	Critical Specifications	HP Model Number
Carriage**	Holds slotted section	809C
BNC Tee	BNC: 2 female thru, 1 male	1250-0781 (UG-274A/U)
Oscilloscope	Vertical Sensitivity: $> 10 \text{ mV/cm}$ Bandwidth: 5 MHz	140A/1405A/1422A or 180A/1801A/1821A
Short	Connector: coaxial 7-mm	11511A (Type-N female) 11512A (Type-N male) 11565A (APC-7)
*Amphenol RF Division, Danbury, Connecticut.		
** Hewlett-Packard Model 817A Swept Slotted Line System may be used instead of these items.		

Table 3. Performance Test Record

Hewlett-Packard Model 779D		Tested by _____
Directional Coupler		Date _____
DIRECTIVITY:		
1.7 to 4 GHz	_____ dB ($> 30 \text{ dB}$)	
4 to 12.4 GHz	_____ dB ($> 26 \text{ dB}$)	
COUPLING:		
Mean coupling	_____ dB ($20 \pm 0.5 \text{ dB}$)	
Coupling variation	_____ dB ($\pm 0.75 \text{ dB}$)	
INSERTION LOSS :		_____ dB ($< 0.6 \text{ dB}$)
SWR (REFLECTION COEFFICIENT):		
Primary line	_____	[$< 1.2 (0.091)$]
Auxiliary line	_____	[$< 1.2 (0.091)$]

PERFORMANCE TEST

35. DIRECTIVITY.

SPECIFICATION:

1.7 to 4 GHz, >30 dB

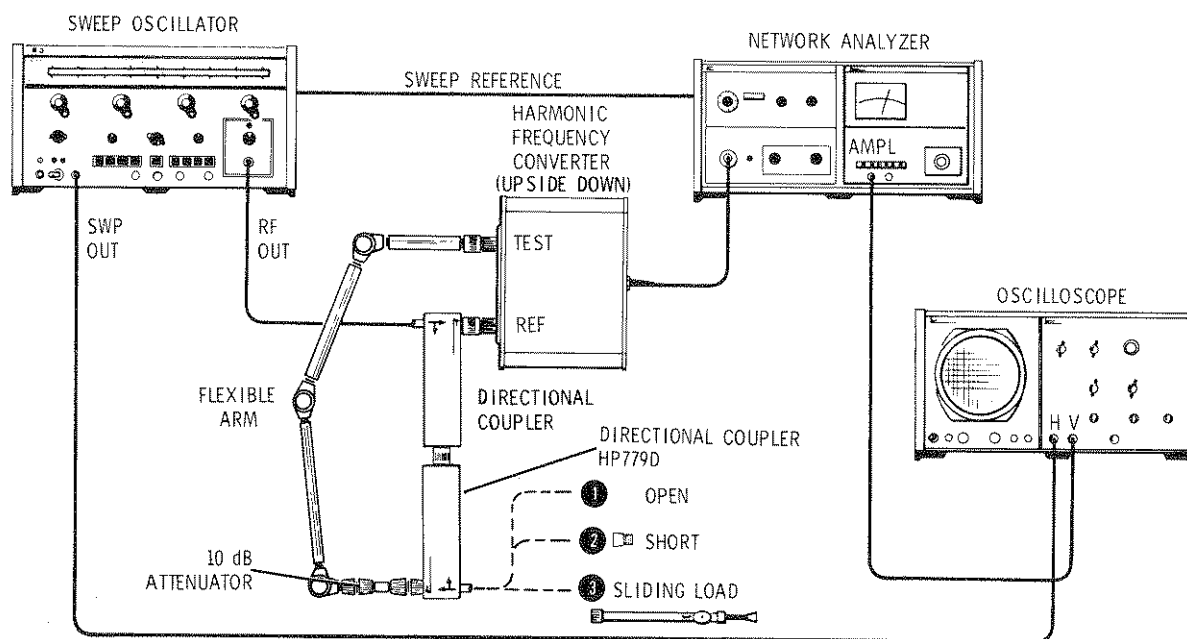
4 to 12.4 GHz, >26 dB

DESCRIPTION:

Directivity of a coupler is the ratio of power at the auxiliary port with coupler in forward direction to power at the auxiliary port with coupler in reverse direction (coupler terminated each time and same power). The 779D should be swept-frequency tested to be sure that there are no narrow-band out-of-specification points that would be missed with fixed-frequency testing. A fixed-frequency test follows the swept-frequency test. The fixed-frequency test should be used at frequencies where ambiguous results are obtained with swept-frequency testing.

Swept-Frequency Test:

This test will be performed using a network analyzer and a reflectometer setup. The procedure is similar to using any reflectometer; calibration by returning all of the output signal and then using a sliding load to determine the true directivity (see Application Note 65, obtainable free from any Hewlett-Packard sales/service office, for further information).



EQUIPMENT

SWEEP OSCILLATOR	HP Model 8690A/B with 8691-4A/B plug-ins
DIRECTIONAL COUPLER	HP Model 779D
HARMONIC FREQUENCY CONVERTER	HP Model 8411A
NETWORK ANALYZER	HP Model 8410A with 8413A plug-in
OSCILLOSCOPE	HP Model 140A
FLEXIBLE ARM	HP Model 11605A
10-dB ATTENUATOR	HP Model 8492A
SHORT	HP Model 11511A (Type-N female)
	11512A (Type-N male)
	11565A (Type APC-7)
SLIDING LOAD	HP Model 905A

Figure 7. Directivity Test Setup

PERFORMANCE TEST (cont'd)

PROCEDURE:

- a. Connect the equipment as shown in Figure 7.
- b. Set the oscilloscope sensitivity to 50 mV/cm.
- c. Adjust the network analyzer to get an amplitude trace on the oscilloscope.
- d. Open ① and short ② the 779D under test. Take the average of the traces as the calibration trace. Mark the trace on the CRT with a grease pencil. If a short is not available use just the open circuit trace.
- e. Connect a sliding load ③ to the 779D under test.
- f. Increase the network analyzer test channel gain by 30 dB (1.7 to 4 GHz) or 26 dB (4 to 12.4 GHz).
- g. Run a slow trace while rapidly phasing the sliding load over at least $\lambda/2$. The *average* of the traces should be below the grease pencil line at all frequencies. If not, proceed with the following.

PERFORMANCE TEST (cont'd)

Single-Frequency Test:**DESCRIPTION:**

The following single-frequency test will enable you to find the true value of directivity. A sliding load is used and both the maximum indication (where the voltage reflected from the load adds to the directivity signal) and the minimum indication (where the voltage reflected from the load subtracts from the directivity signal) are determined. Entering these values in Figure 8, Signal Separation Chart, will enable you to determine the true directivity. With a good load this should be close to the average reading. The corrected directivity reading should be less than the directivity specification at the frequency tested.

- h. Manually set the sweep oscillator to the frequency of interest.
- i. Remove the sliding load and set the open ① and short ② readings on the 8413A meter equally spaced around zero using the most sensitive scale.
- j. Replace the sliding load and increase the gain as in step f above.
- k. Observe amplitude meter readings while phasing sliding load.
- m. To find the true value of directivity subtract the two readings (for example, 34 dB – 31 dB = 3 dB). Enter the following signal separation chart on the vertical scale at 3 dB, read over to the curve and drop down to the value of $M_2 = 1.25$ dB. Add this correction to the *lowest* numerical reading (31 + 1.25 dB = 32.25 dB) as the true reading. This reading should be greater than the directivity specification at that frequency.

NOTE

Only the left-hand curve ($e_{\text{load}} < e_{\text{unknown}}$) need be consulted since, with a good load ($\text{SWR} < 1.06$), the unknown voltage being measured will be greater than the voltage reflected from the load.

- n. Repeat the above measurement at all frequencies of interest.

PERFORMANCE TEST (cont'd)

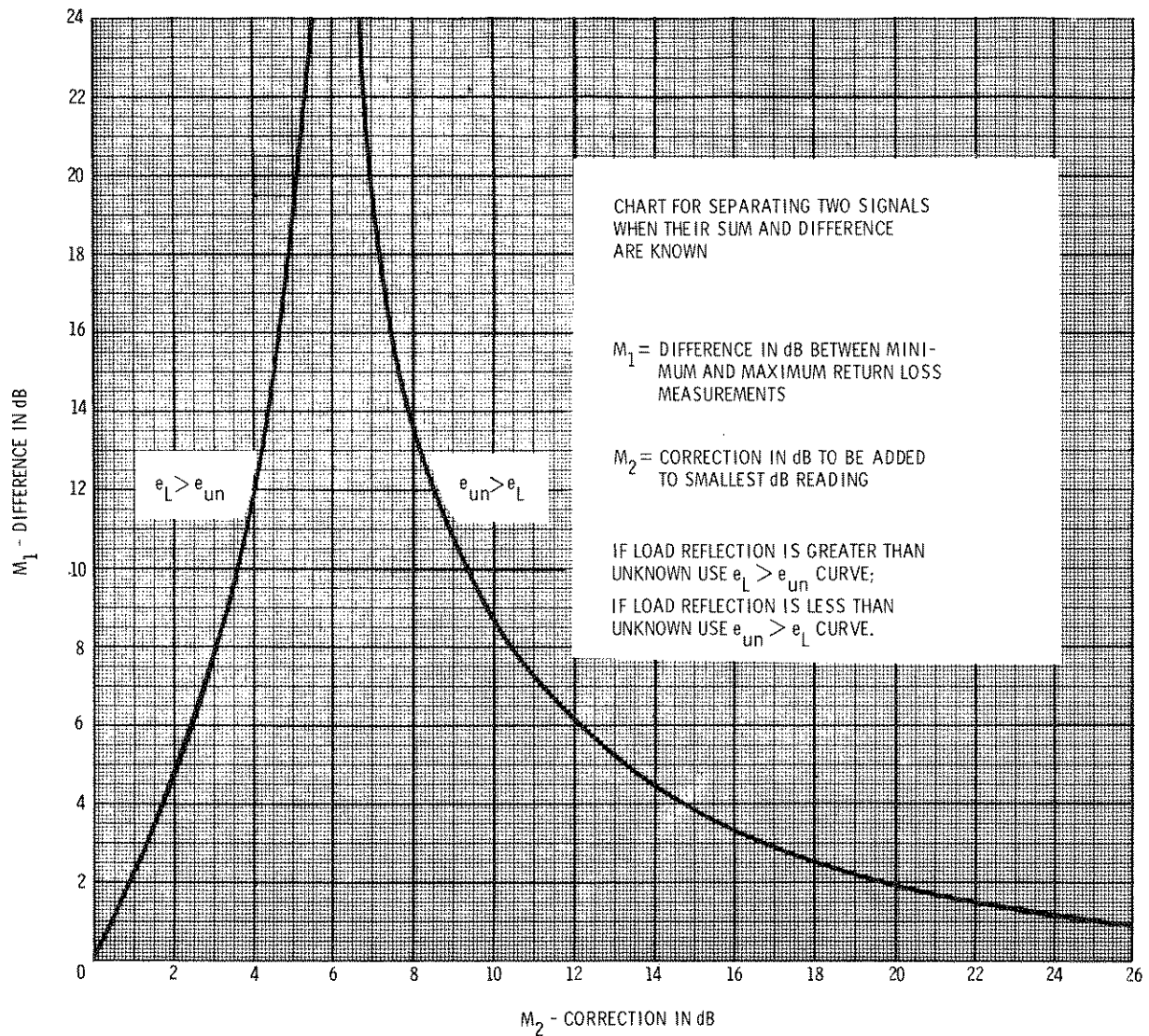


Figure 8. Signal Separation Chart

PERFORMANCE TEST (cont'd)

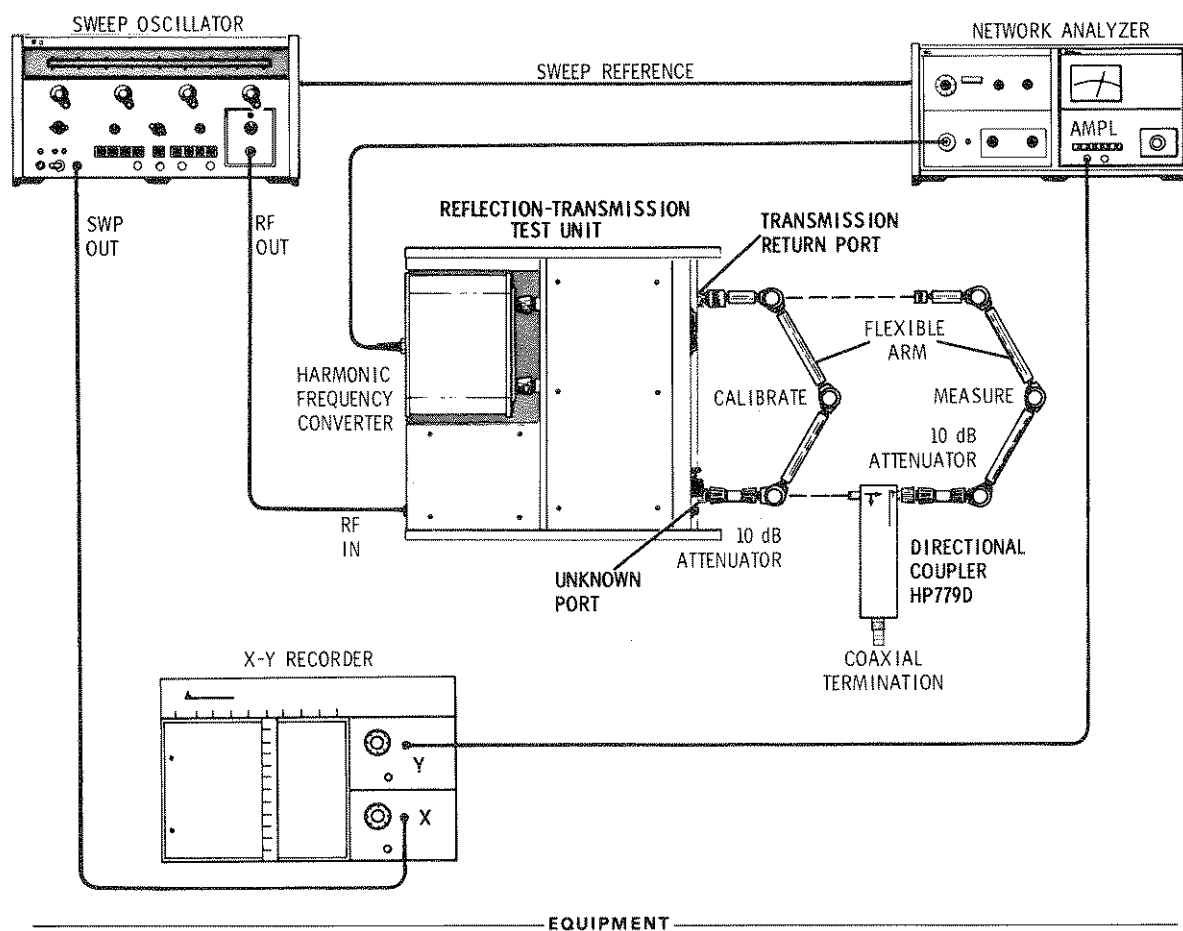
36. COUPLING.

SPECIFICATION:

Mean coupling, 20 dB $\pm$ 0.5 dBCoupling variation, $\pm$ 0.75 dB.

DESCRIPTION:

Coupling is measured by first calibrating a network analyzer for a transmission measurement without the coupler inserted. The coupler is then inserted and the amount of power coupled out the auxiliary port is measured. This value is the coupling of the directional coupler.



EQUIPMENT	
SWEEP OSCILLATOR	HP Model 8690A/B with 8691-4A/B plug-ins
REFLECTION-TRANSMISSION TEST UNIT	HP Model 8743A
NETWORK ANALYZER	HP Model 8410A with 8413A plug-in
X-Y RECORDER	HP Model 7035B
HARMONIC FREQUENCY CONVERTER	HP Model 8411A
FLEXIBLE ARM	HP Model 11605A
10-dB ATTENUATOR	HP Model 8492A
COAXIAL TERMINATION	HP Model 909A Option 12 (Type-N male) 909A Option 13 (Type-N female) 909A Standard (APC-7)

Figure 9. Coupling Test Setup

PERFORMANCE TEST (cont'd)

PROCEDURE:**Calibration:**

- a. Connect the equipment as shown in Figure 9, Coupling Test Setup.
- b. Connect the two ports of the 8743A together as shown for "CALIBRATE" with a 10-dB attenuator (see Performance Test introduction). If any adapters will be necessary later in the test to connect the 779D under test, the adapters should be inserted now so that their insertion loss will be calibrated out.
- c. Tune sweep oscillator manually throughout its entire frequency band without recording to be sure the X-Y recorder will remain on-scale throughout the entire frequency range. Do not reduce the sensitivity much below about 100 mV/inch since the output of the 8413A is 50 mV/dB and 0.5 dB must be resolved. The sensitivity may be increased if the trace will still stay on-scale.
- d. Record a reference line on the X-Y recorder across each frequency band and mark this trace 20 dB. Record the value of network analyzer test channel gain for future use.
- e. Record two traces that represent limits of acceptable coupling variations as follows:
 1. Increase the test channel gain 1 dB and run a line.
 2. Decrease the test channel gain 2 dB (1 dB less than the reference line) and run a line.

Measurement:

- f. Detach the flexible arm at the unknown port of the 8743A and insert the 779D under test, as shown for "MEASURE." Detach at the end of the 10-dB attenuator connected to the unknown port.
- g. Increase the test channel gain 20 dB from the setting in step d and record a trace.
- h. Sweep each band and record the trace until the entire frequency range from 1.7 to 12.4 GHz has been covered.
- i. Measuring from the 20-dB line recorded in step d and using the limit lines as ± 1 -dB calibrations, find the highest point and lowest point on the measurement traces.

$$\frac{\text{Highest} + \text{Lowest}}{2} = \text{Mean coupling}$$

$$\frac{\text{Highest} - \text{Lowest}}{2} = \text{Coupling variation}$$

PERFORMANCE TEST (cont'd)

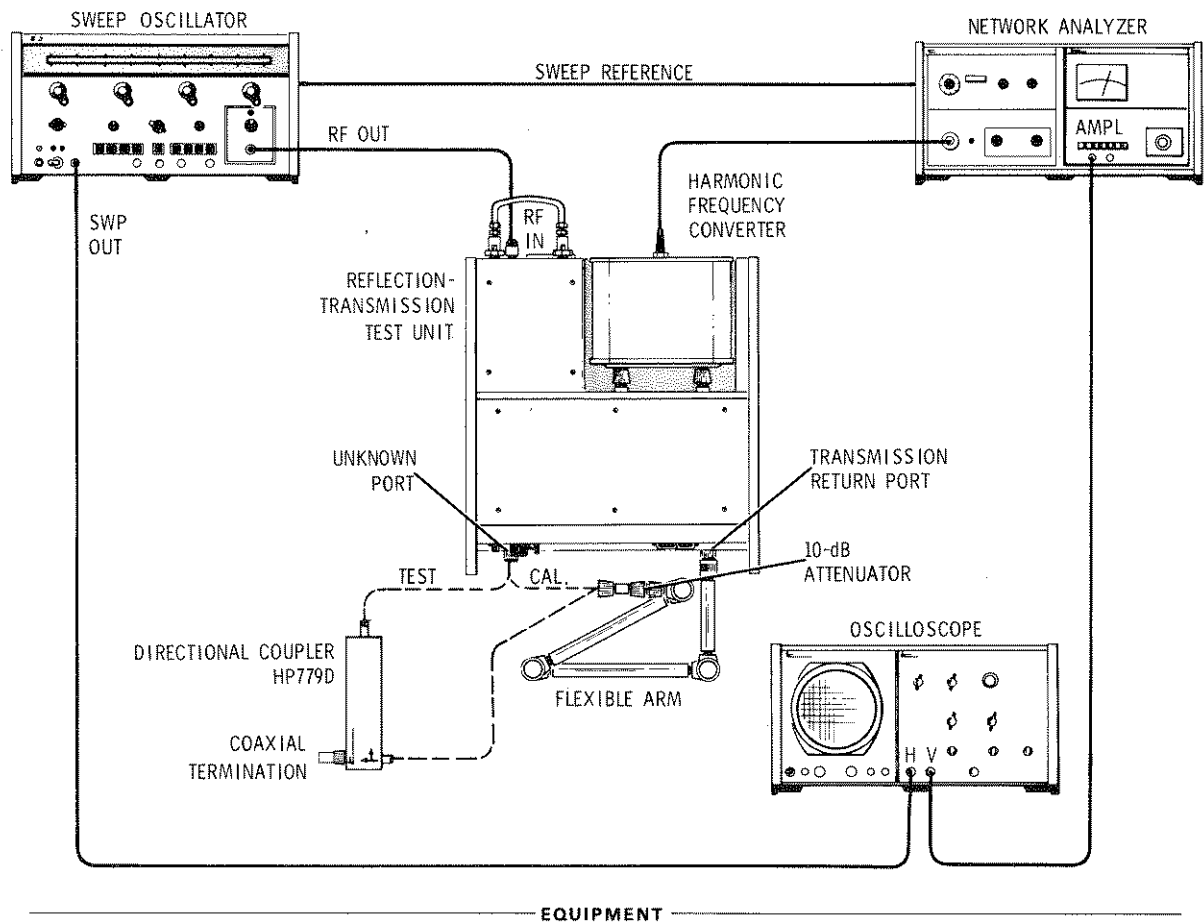
37. INSERTION LOSS.

SPECIFICATION:

<0.6 dB

DESCRIPTION:

The insertion loss specification includes the loss in the coaxial line plus the coupling loss. A network analyzer is used to measure transmission loss without and with the coupler inserted. The difference is the insertion loss.



EQUIPMENT	
SWEEP OSCILLATOR	HP Model 8690A/B with 8691-4A/B plug-ins
REFLECTION-TRANSMISSION TEST UNIT.....	HP Model 8743A
HARMONIC FREQUENCY CONVERTER.....	HP Model 8411A
NETWORK ANALYZER.....	HP Model 8410A with 8413A plug-in
OSCILLOSCOPE.....	HP Model 140A
FLEXIBLE ARM.....	HP Model 11605A
10-dB ATTENUATOR.....	HP Model 8492A
COAXIAL TERMINATION	HP Model 909A Option 12 (Type-N male)
	909A Option 13 (Type-N female)
	909A Standard (APC-7)

Figure 10. Insertion Loss Test Setup

PERFORMANCE TEST (cont'd)

PROCEDURE:**Calibration:**

- a. Connect the equipment as shown in Figure 10.
- b. Connect a 10-dB attenuator, such as the Hewlett-Packard 8492A Option 10, to the Hewlett-Packard 11605A Flexible Arm (see paragraph 33), and connect the attenuator to the 8743A unknown port. Include any adapters necessary to later connect the 779D under test. This will cancel out the loss of the adapters.
- c. Set the sweep oscillator to sweep the desired band. Adjust 8410A for a stable display over the entire band being swept.
- d. Dc couple and dc-balance the oscilloscope vertical amplifier. Adjust the oscilloscope to display the amplitude output from the 8413A. Set the display for 10 mV/cm sensitivity.
- e. Set the trace approximately two centimeters from the top of the screen. Draw the trace on the screen of the oscilloscope with a grease pencil.
- f. Decrease the 8410A test channel gain by 1 dB. The trace on the oscilloscope should drop exactly 5 centimeters. This checks the calibration of the oscilloscope. If the trace does not drop exactly 5 cm with 10 mV/cm sensitivity, set the oscilloscope vertical gain vernier for exactly 5 cm vertical deflection.
- g. Go back to the original setting on the 8410A. Drop the trace down 3 cm = 0.6 dB. Do this by noting the value where the trace crosses the center vertical graticule line. Then, with the 8410A amplitude vernier control move the trace down exactly 3 cm. Draw this trace with a grease pencil. Reset the trace to top grease pencil line with the 8410A amplitude vernier control.

Measurement:**DESCRIPTION:**

Since we have two insertion-loss limit lines drawn we can now insert the primary line of the 779D and see if it falls within these limit lines. If it does, the 779D is within insertion-loss specifications. Proceed as follows:

- h. Open the flexible arm between the unknown port and the 10-dB attenuator (or between adapters, if used) and insert the primary line of the 779D as shown for "TEST." Be sure to support the weight of the 779D independently.
- i. The trace on the oscilloscope should be between the two grease pencil lines on the CRT for the 779D to be within specifications. If not, check the connectors and especially the connector faces.

PERFORMANCE TEST (cont'd)

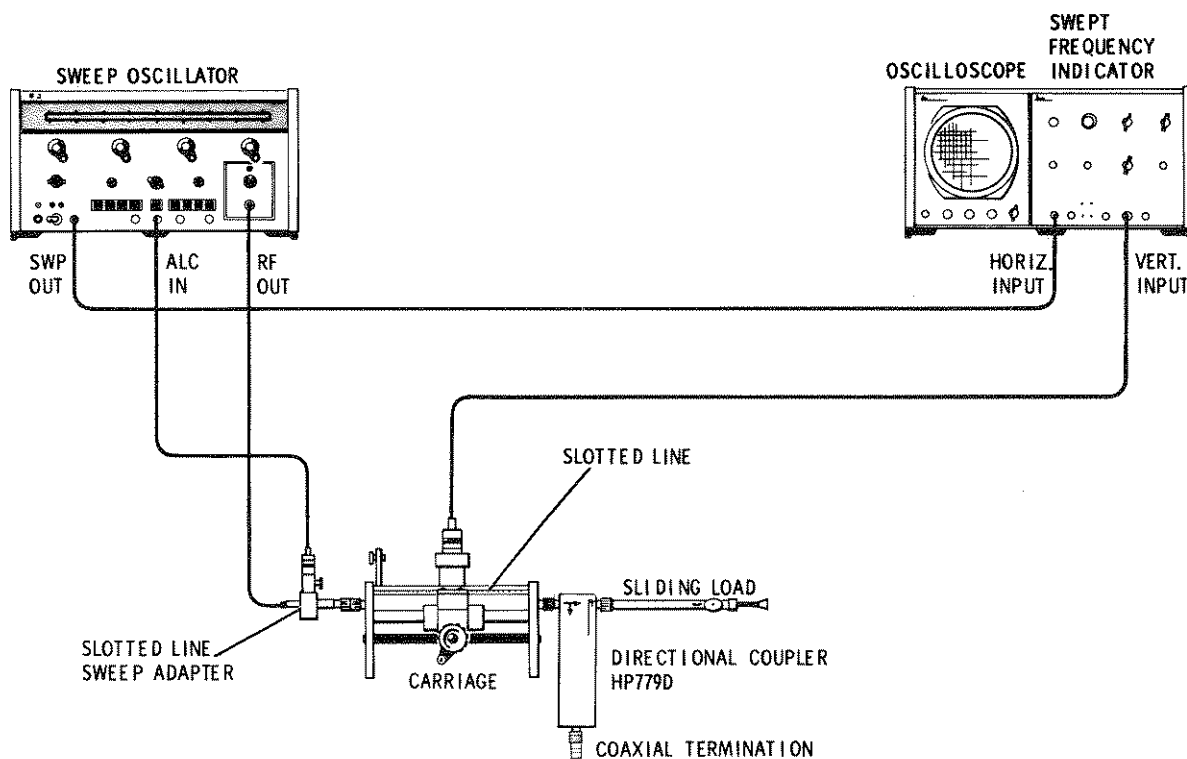
38. SWR AND (REFLECTION COEFFICIENT):

SPECIFICATION:

Primary line <1.2 (0.091)Auxiliary line <1.2 (0.091).

DESCRIPTION:

SWR (Reflection Coefficient) is measured with a swept slotted-line system. This system enables the SWR to be measured on a swept-frequency basis so that there are no narrow-band out-of-specification frequencies which could be missed with spot single-frequency testing. SWR is measured using a storage oscilloscope and while moving the probe in the slotted-line section. This procedure moves the indication through all possible phases so that the maximum SWR may be measured.



EQUIPMENT

SWEEP OSCILLATOR	HP Model 8690A/B with 8691-4A/B plug-ins
SLOTTED-LINE SWEEP ADAPTER*	HP Model 448A
CARRIAGE*	HP Model 809C
BNC TEE	HP 1250-0781 (UG-274A/U)
SLIDING LOAD	HP Model 905A
OSCILLOSCOPE	HP Model 141A
SWEPT FREQUENCY INDICATOR	HP Model 1416A
SLOTTED LINE*	HP Model 816A
COAXIAL TERMINATION	HP Model 909A Option 12 (Type-N male) Option 13 (Type-N female) Standard (APC-7)

* These items can be obtained as the Hewlett-Packard Model 816A Swept Slotted Line System.

Figure 11. SWR Test Setup

PERFORMANCE TEST (cont'd)

PROCEDURE:**Power Leveling:**

- a. Connect the equipment as shown in Figure 11.
- b. Set sweep oscillator to sweep desired band.
- c. Level the output of the sweep oscillator as instructed in the operating instructions for the swept slotted-line system. Note that, due to the extremely wide frequency range of the swept-slotted line system, the RF output may vary widely even though the input is leveled. This occurs because the efficiency of both probes drops off at the lower frequencies. Since leveling is controlled by the dc voltage developed by the leveling probe, this voltage will depend upon the efficiency of the probe pickup. However, by matching the characteristics of both probes and using them as a matched pair the output variation can be held to approximately ± 3 dB per octave.

Measurement:

- a. Set sweep oscillator for single-frequency (CW) operation at the center of the band under test.
- b. Locate a maximum in the standing-wave pattern. A maximum is the widest portion of the display (see Figure 12 for a typical display).
- c. If the slotted-line probe penetration has not been set, loosen the carriage probe by turning the knurled lock in the carriage and move the probe until the output is 5 mV.
- d. Set the sweep oscillator to sweep the band of interest.
- e. To make sure that the maximum picked in step b is the maximum in the display, observe the oscilloscope in linear operation on the 1 mV/cm range, adjusting probe for 5-cm high display. Tighten the knurled lock. The position of the carriage probe is now correct for square-law operation.
- f. Set swept-frequency indicator to logarithmic mode and move the carriage over at least one-half wavelength while viewing on a storage oscilloscope (if storage oscilloscope is not available take a time exposure of the trace). Read maximum width of trace in dB.
- g. Compute the voltage ratio using the formula:

$$\text{SWR} = \log^{-1} (\text{dB}/20) \quad \text{or} \quad 1.2 \text{ SWR} = 1.58 \text{ dB}.$$

If bandwidth of swept-frequency indicator is too low or the sweep rate too high, some of the fine structure of the SWR pattern may be lost. Due to noise the widest bandwidth may not give the best pattern, but the optimum combination can easily be determined experimentally by keeping the slotted-line carriage stationary and adjusting the sweep rate and bandwidth for the most fine structure.

PERFORMANCE TEST (cont'd)

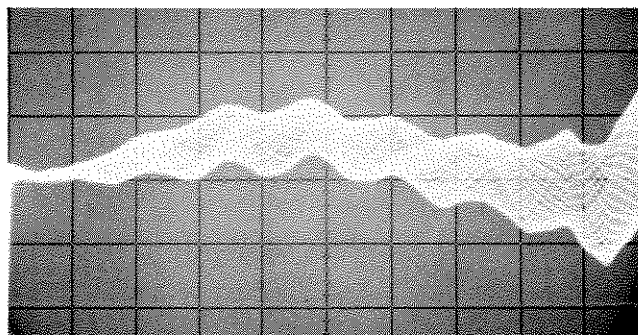


Figure 12. Typical Oscilloscope Display

h. If the results do not meet specification, the width of the trace may be at fault. To compensate for the width of the trace, proceed as follows.

i. Observe the trace with the carriage stationary. Read the trace-width. Subtract this reading from the reading obtained in step f.

j. If the results are still not within specifications, the reflection vector from the termination may be adding in-phase to the reflection vector being measured. These two signals can be resolved by using a sliding load as the termination as follows.

1. With the above setup, set the sweep oscillator to CW on a single frequency under question.
2. Obtain the maximum height vertical trace by moving both the slotted-line probe and the sliding load. Grease pencil the path followed by the spot.
3. With the slotted-line probe still at the maximum trace height position move the sliding load for the minimum height trace (by moving the bottom of the trace up).
4. Measure the SWR in the same manner as with the swept-frequency test.

k. Repeat the measurement on the other ports. Be sure to keep all ports not under test properly terminated.

For a discussion of swept-slotted line systems and other information concerning this method see Stephen F. Adam, "Swept-Frequency SWR Measurements in Coaxial Systems," *Hewlett-Packard Journal*, Vol. 18 No. 4, obtainable from your nearest Hewlett-Packard office.

39 REPAIR.

40. APC-7 Connectors.

41. Directional couplers with APC-7 connectors should be handled with particular care for two reasons:

a. Continuity through APC-7 connectors is obtained by end-to-end contact of the inner and outer conductors. Consequently, the electrical performance of the connector is largely dependent upon the condition of these exposed surfaces.

b. The inner conductor of the APC-7 connector is connected directly to the inner coaxial conductor of the directional coupler.

CAUTION

Any twisting force on this inner conductor may throw the directional coupler out of specifications.

42. The part of an APC-7 connector that is most likely to be damaged is the inner conductor contact. Since it protrudes slightly beyond the plane of electrical contact, any wiping action of one conductor across the other can damage the contact enough to cause a discontinuity. If damage is suspected, examine the contact with a magnifying glass and push lightly with the eraser on the end of a pencil. As the pressure is released the contact's spring action should cause it to move outward. If not, the contact is defective. Replace as follows:

43. Contact Replacement. Replacement inner conductor contacts are available from Hewlett-Packard (Part Number 1250-0907), and from Amphenol RF Division, Danbury, Connecticut, (Part Number 131-129). When ordering from Hewlett-Packard also request the Service Note concerning 7-mm connectors for further information.

44. The important precautions that apply to the replacement of inner conductor contacts are these:

- a. Do NOT disassemble the connector.
- b. Do not apply more than slight inward pressure to the inner conductor.

c. Do not apply ANY twisting force to the inner conductor.

d. Do not attempt to repair contacts.

e. Do not re-use contacts.

CAUTION

Inward pressure or twisting force applied to the inner conductor of the APC-7 connector can throw the 779D out of specifications.

45. Because of the above considerations, contact removal should not be attempted with ordinary hand tools. Only the Hewlett-Packard self-positioning, hypodermic-action contact extractor tool (part number 5060-0236)¹ should be used. This tool exerts no appreciable inward pressure and no twisting force on the inner conductor. Instructions for removing contacts are supplied with the tool.

46. No tool is required for installing a replacement contact. Insert the contact gently by hand, applying only enough inward pressure to snap it in place. Then check for proper installation by inspecting the contact with a magnifying glass for even spacing of its four segments. Also, test for normal spring-action by applying light inward pressure against the end of the contact with an eraser at the end of a pencil. As the pressure is released the contact's spring-action should cause it to move outward. If not, the contact is defective. Replace with another contact.

47. Type-N Connectors.

48. Replacement of Type-N connectors is not recommended, since just loosening the outer shell mounting screws may throw the coupler out of specifications. Return the coupler to Hewlett-Packard if a Type-N connector needs repair.

¹Part of APC-7 Connector Tool Kit 11591A.

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