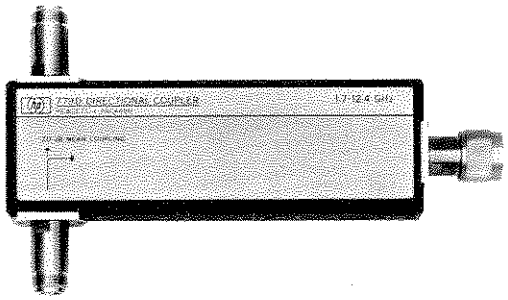
OPERATING NOTE

DIRECTIONAL COUPLER

779D

Serials Prefixed 901-



JAN. 1970

HEWLETT hp 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 ±0.5 dB
Coupling Variation: ±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.

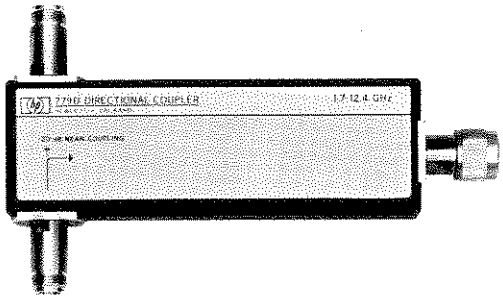
11. Mechanical Check.

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.

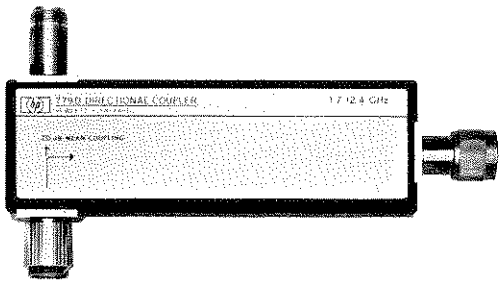
14. The electrical performance should be verified as soon as possible after receipt. Refer to the Performance Test for further instructions.

*Amphenol, RF Division, Danbury, Connecticut.



OPTION 010

INPUT, TYPE N FEMALE
OUTPUT, TYPE N MALE
AUXILIARY, TYPE N FEMALE



APC-7* CONNECTORS

PRECISION 7-MM APC-7*
CONNECTOR ON ANY (OR ALL)
PORT(S) ON SPECIAL ORDER.

Figure 1. Connector Options

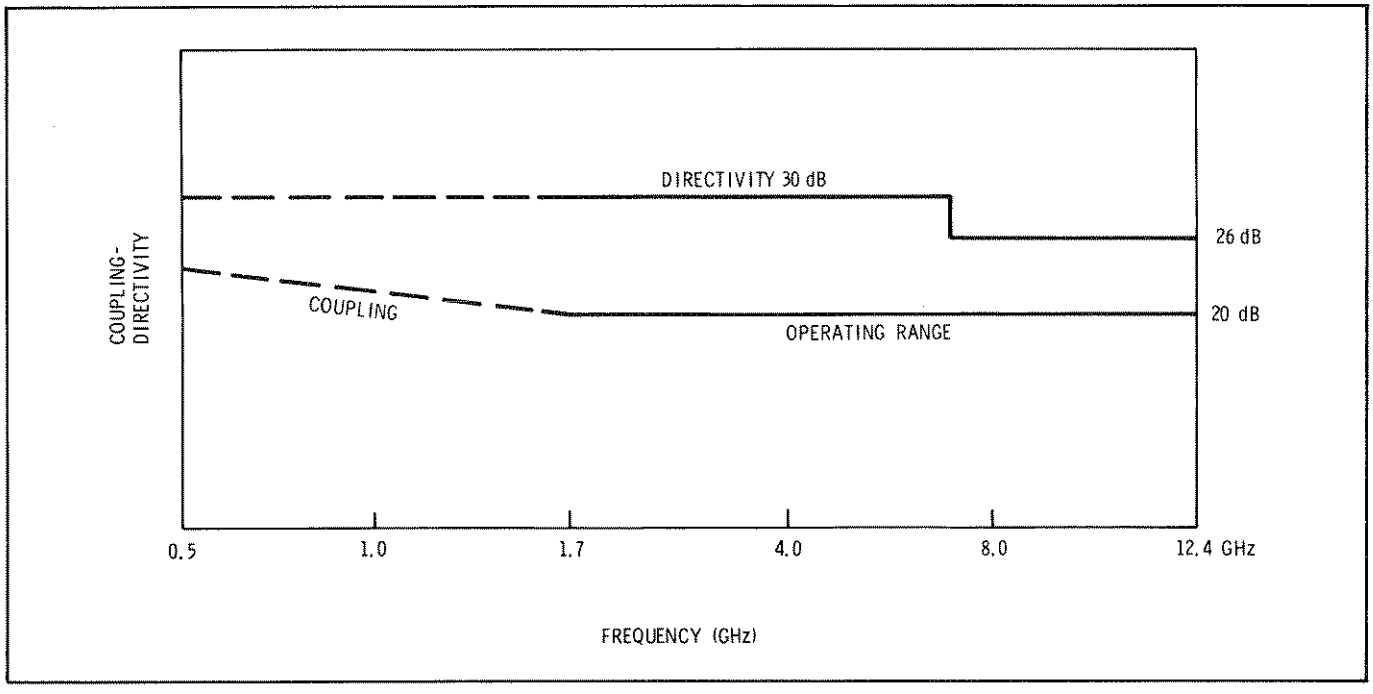


Figure 2. Coupling and Directivity Characteristics of the 779D Directional Coupler

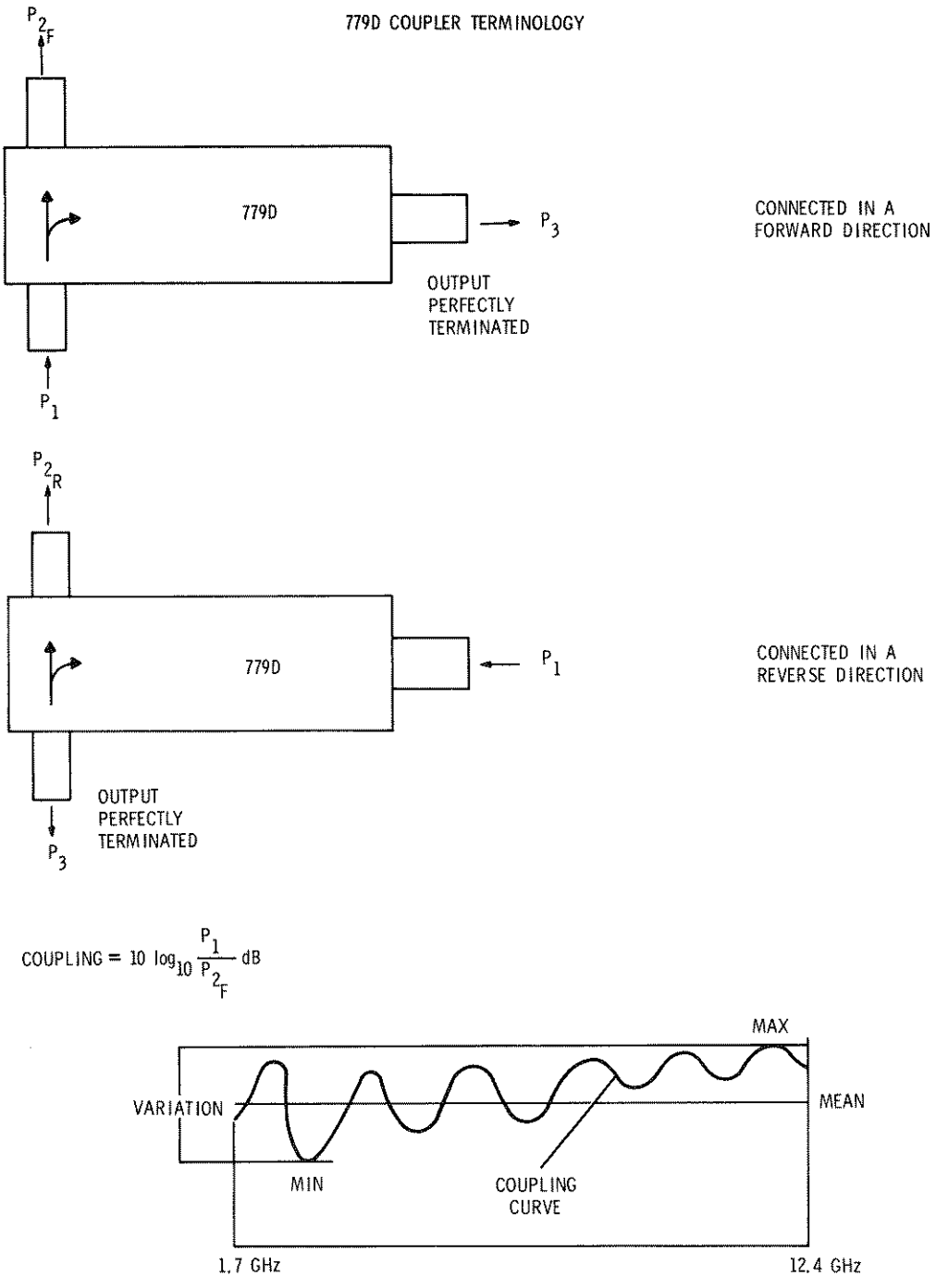


Figure 3. 779D Coupler Terminology

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.

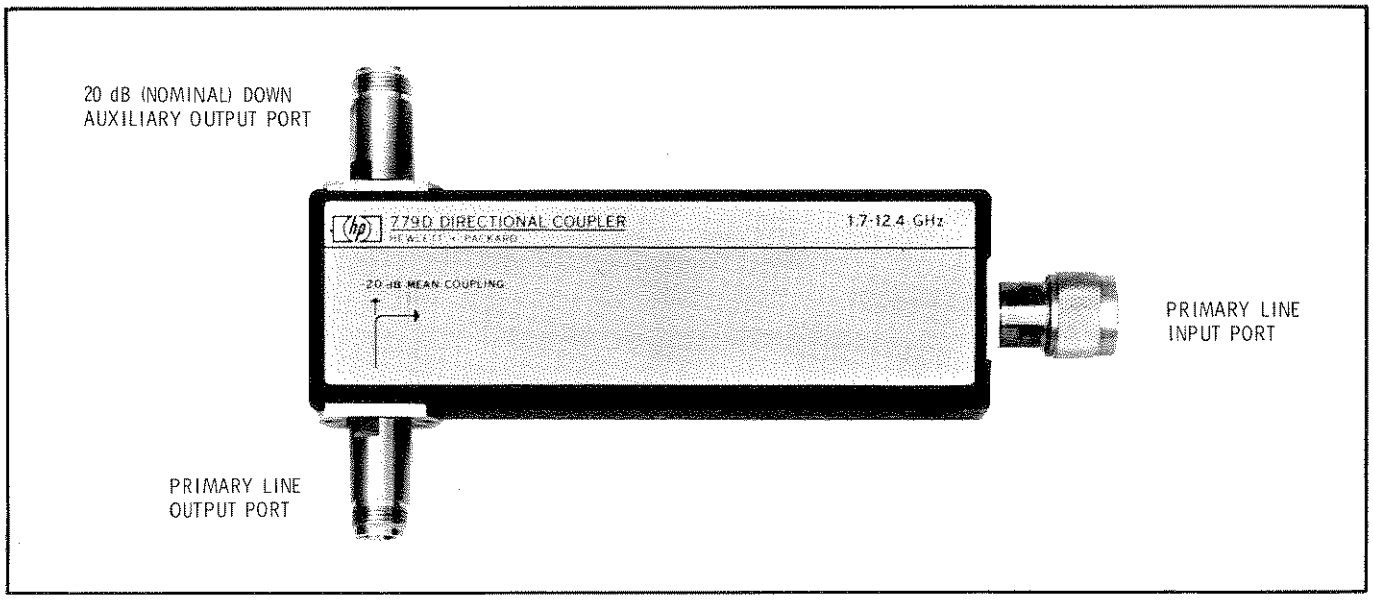


Figure 4. Signal Flow Path for Coupler Connected in the Forward Direction

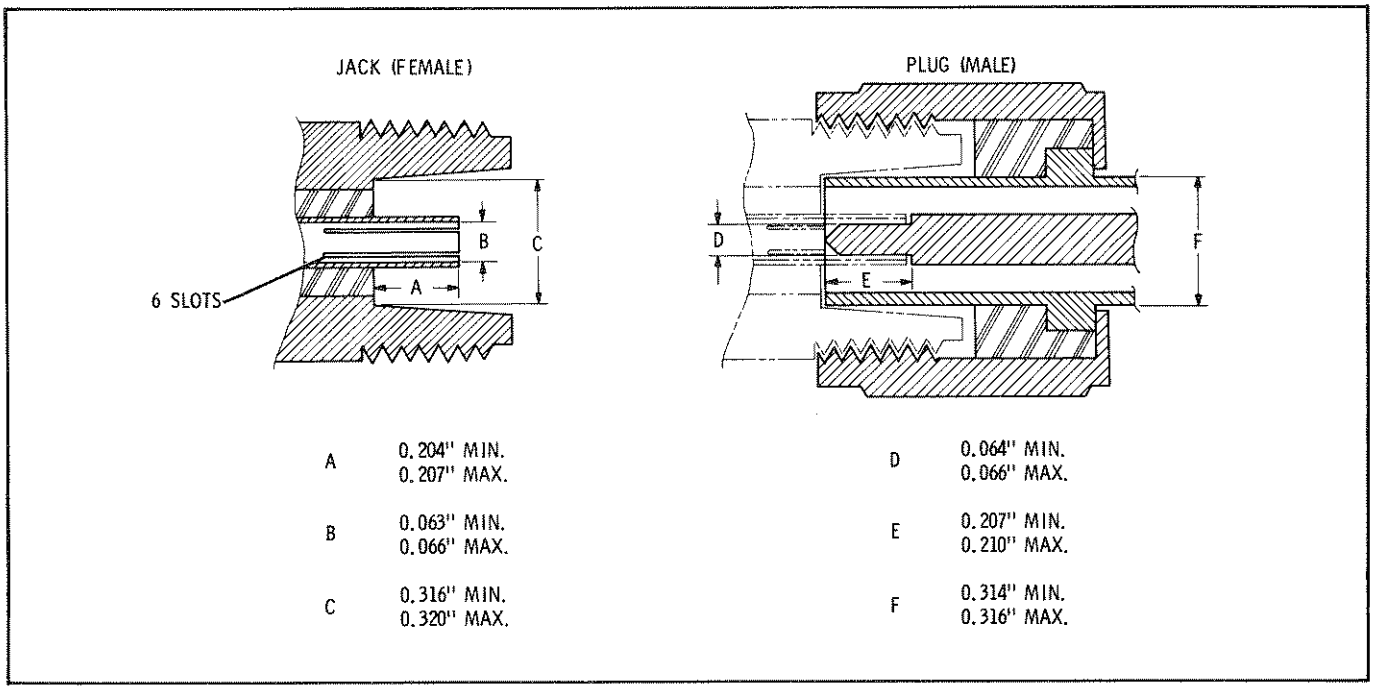


Figure 5. Type-N Connector Dimensions

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.

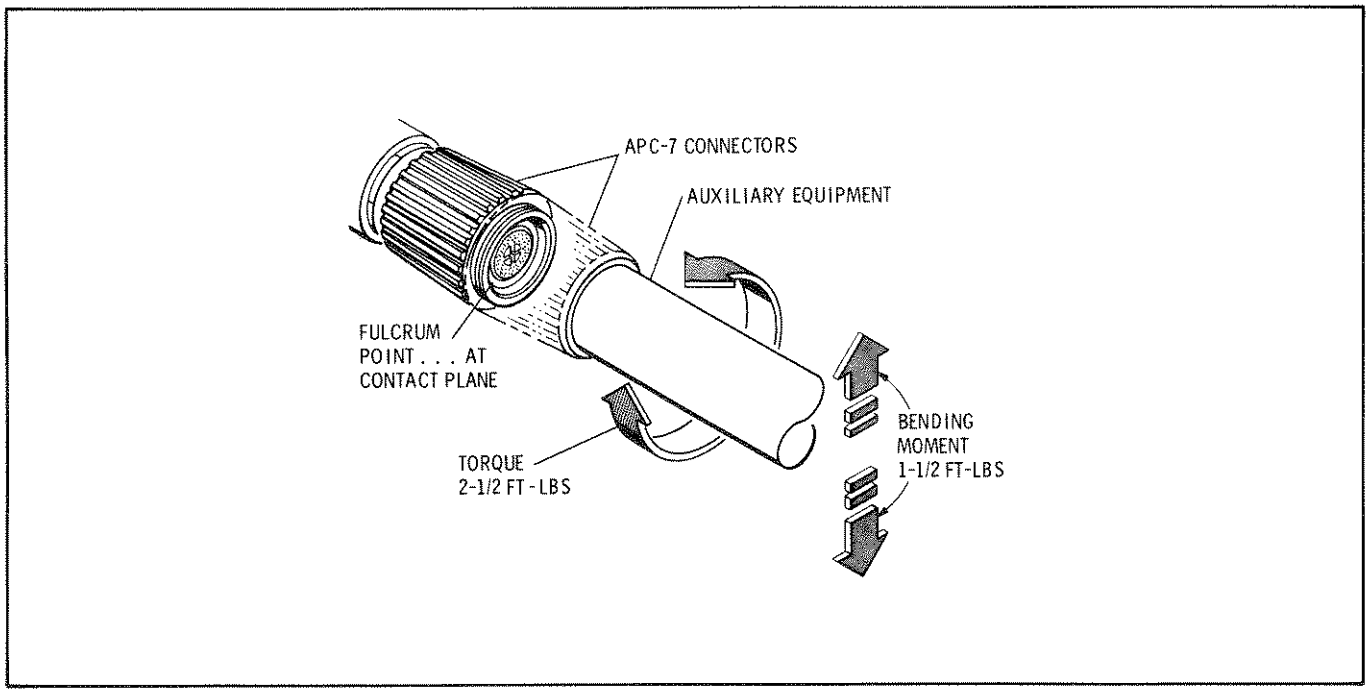


Figure 6. APC-7 Connector Load Limits

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 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

Directional Coupler

Tested by _____

Date _____

DIRECTIVITY:

1.7 to 4 GHz _____dB (> 30 dB)

4 to 12.4 GHz _____dB (> 26 dB)

COUPLING:

Mean coupling _____dB (20 ± 0.5 dB)

Coupling variation _____dB (± 0.75 dB)

INSERTION LOSS : _____dB (< 0.6 dB)

SWR (REFLECTION COEFFICIENT):

Primary line _____ [< 1.2 (0.091)]

Auxiliary line _____[< 1.2 (0.091)]

35. DIRECTIVITY.

SPECIFICATION:

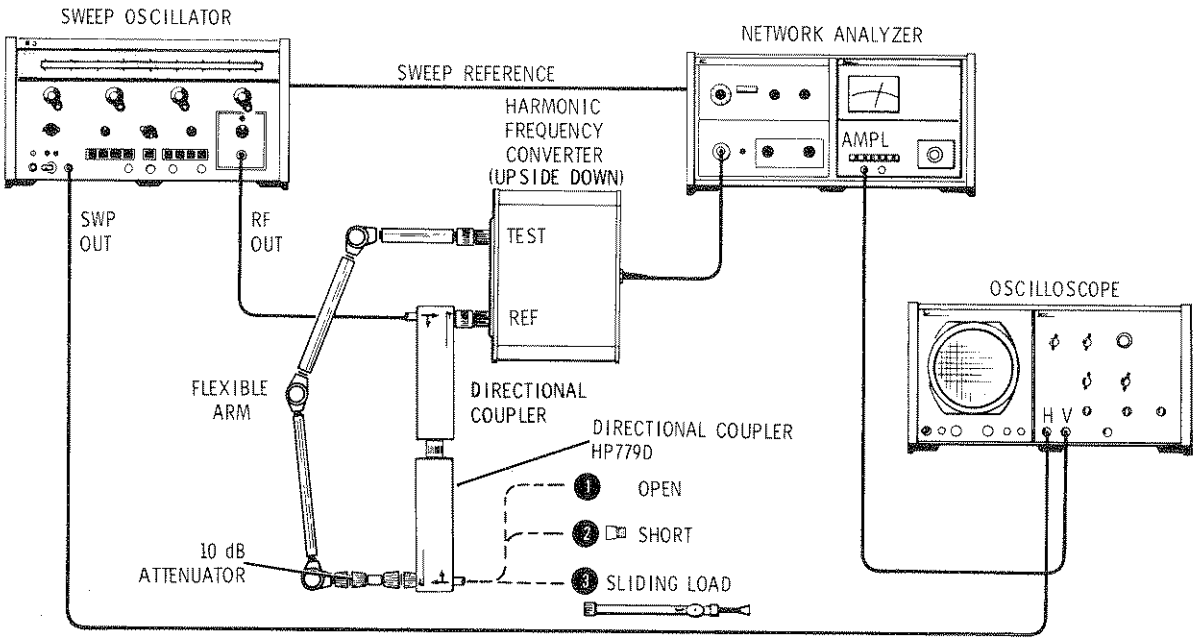
1.7 to 4 GHz, >30 dB
4 to 12.4 GHz, >26 dB

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

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.

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 ($e_{load} < e_{unknown}$) need be consulted since, with a good load (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.

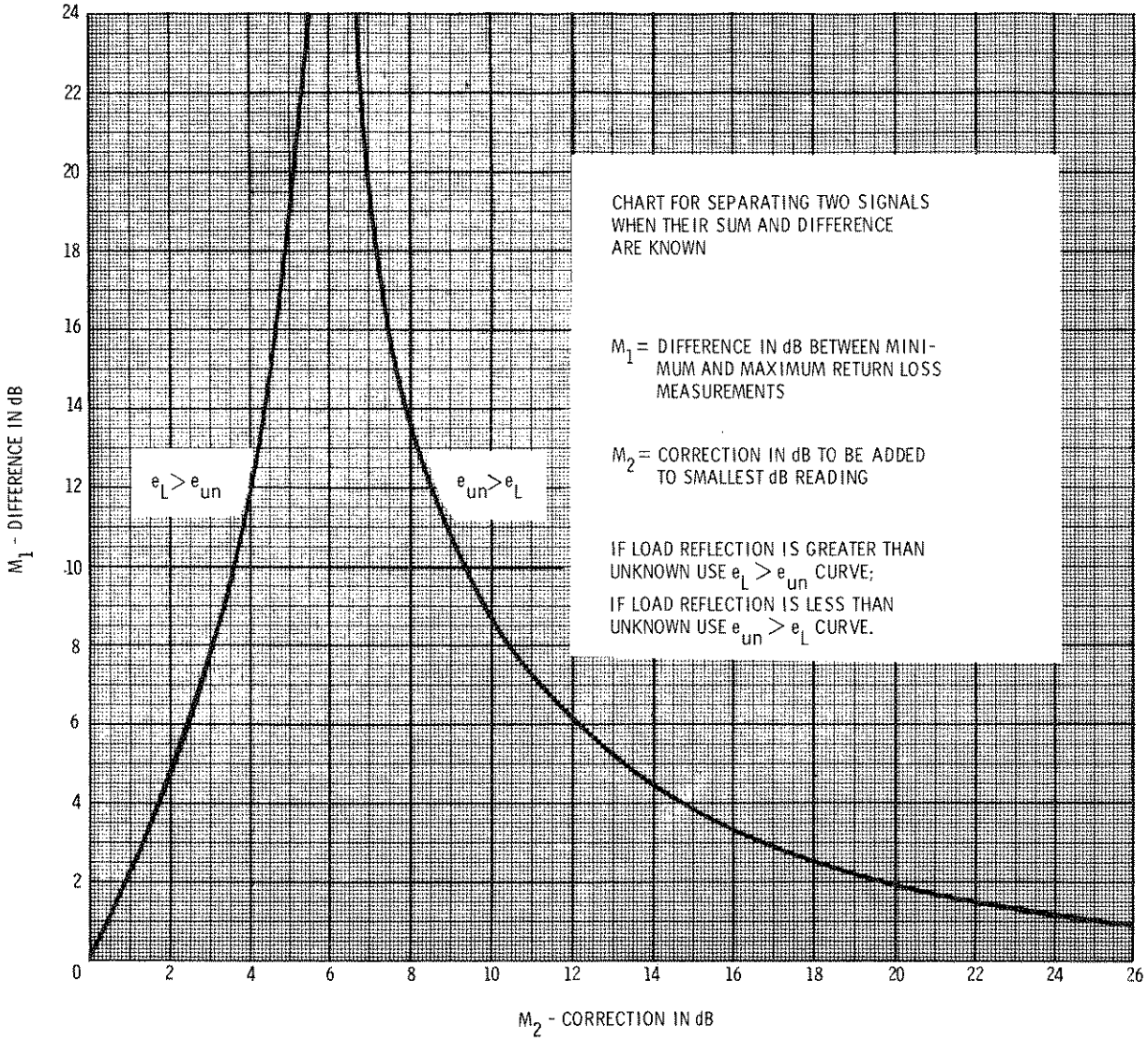


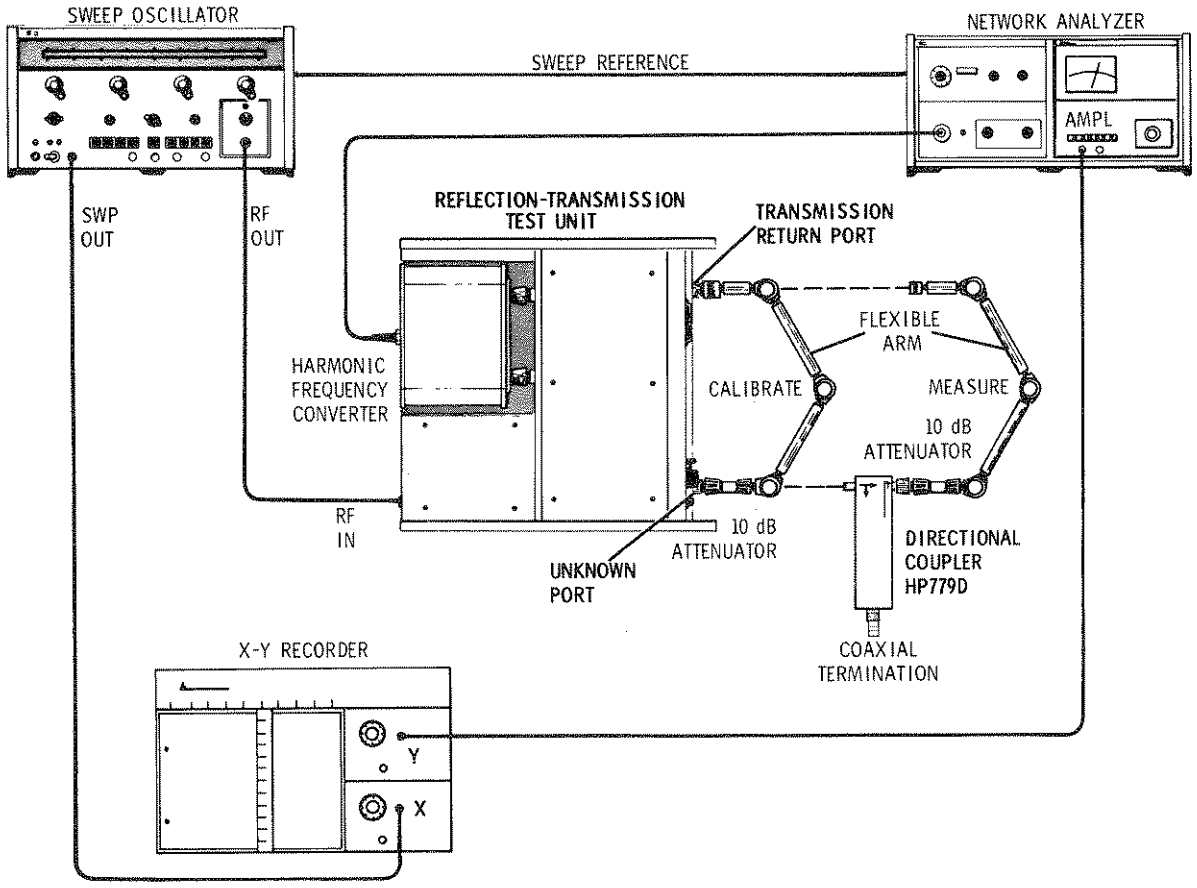
Figure 8. Signal Separation Chart

36. COUPLING.

SPECIFICATION:
Mean coupling, 20 dB ±0.5 dB
Coupling variation, ±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

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.

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

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

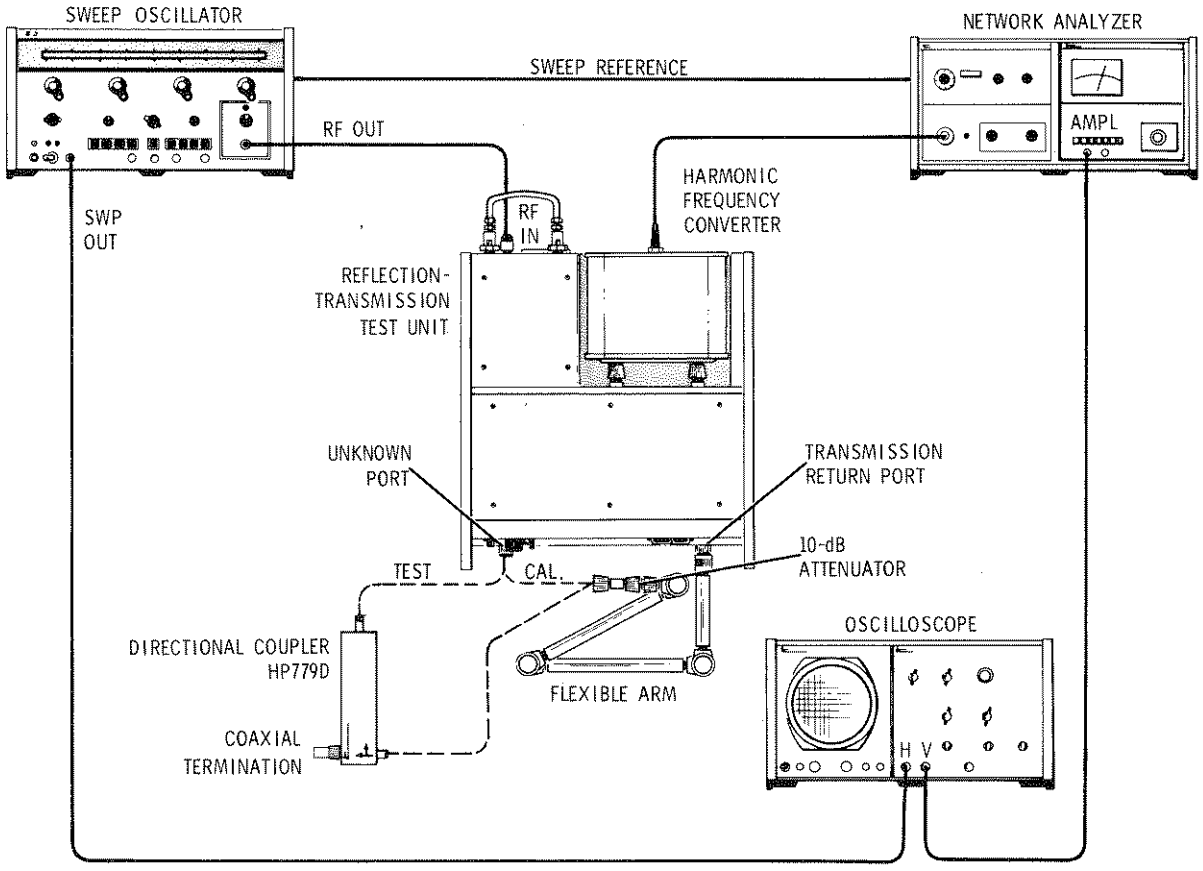
37. INSERTION LOSS.

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

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:

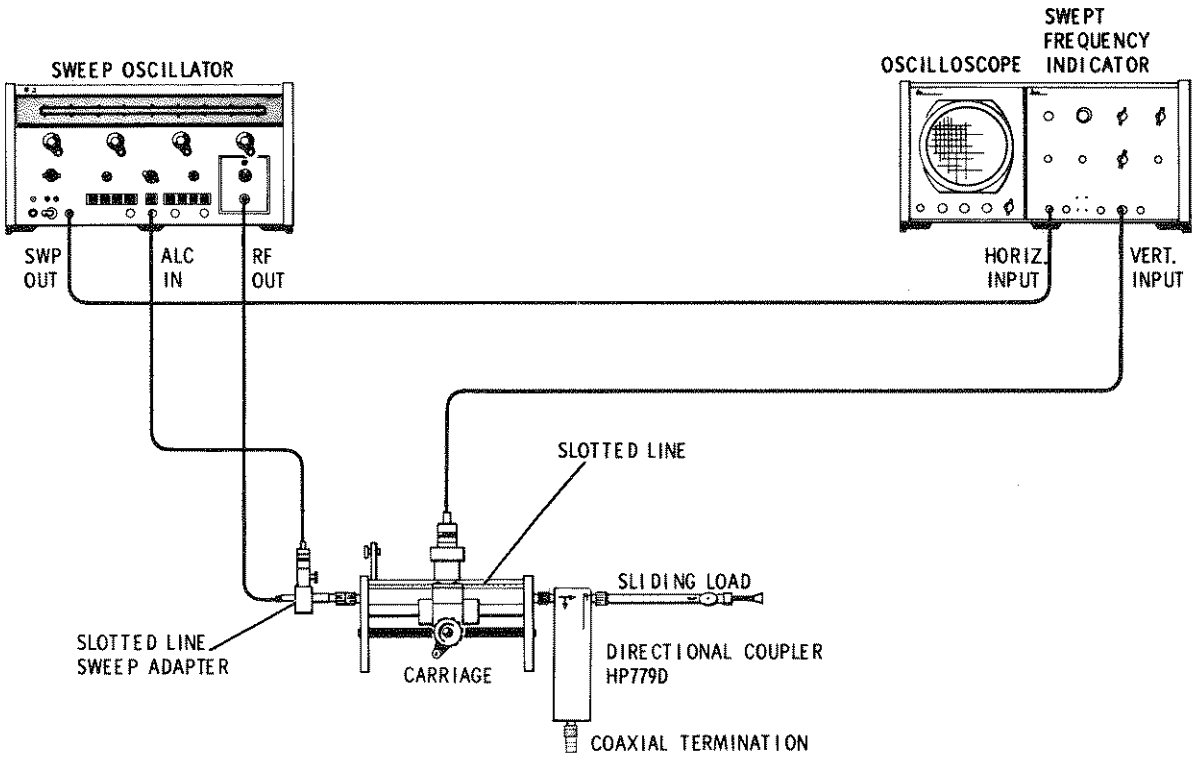
h. Open the flexible arm between the unknown port and the 10-dB attenuator (or between adapters, if used) and insert the primary line of the 779D as shown for "TEST." Be sure to support the weight of the 779D independently.

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.

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

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:

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

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.

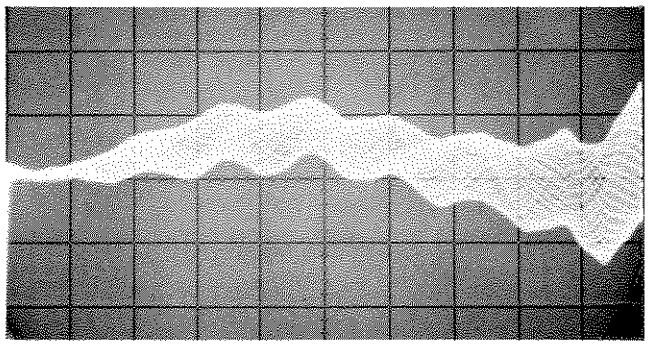


Figure 12. Typical Oscilloscope Display

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.

---

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

HEWLETT · PACKARD

ELECTRONIC INSTRUMENTATION SALES AND SERVICE

UNITED STATES, CENTRAL AND SOUTH AMERICA, CANADA

UNITED STATES

ALABAMA
P.O. Box 4207
2003 Byrd Spring Road S.W.
Huntsville 35802
Tel: (205) 881-4591
TWX: 810-726-2204

ARIZONA
3009 North Scottsdale Road
Scottsdale 85251
Tel: (602) 945-7601
TWX: 910-950-1282

5737 East Broadway
Tucson 85716
Tel: (602) 298-2313
TWX: 910-952-1162

CALIFORNIA
1430 East Orangethorpe Ave.
Fullerton 92631
Tel: (714) 870-1000

3939 Lankershim Boulevard
North Hollywood 91604
Tel: (213) 877-1282
TWX: 910-499-2170

1101 Embarcadero Road
Palo Alto 94303
Tel: (415) 327-6500
TWX: 910-373-1280

2591 Carlsbad Avenue
Sacramento 95821
Tel: (916) 482-1463
TWX: 910-367-2092

1055 Shafter Street
San Diego 92106
Tel: (714) 223-8103
TWX: 910-335-2000

COLORADO
7965 East Prentice
Englewood 80110
Tel: (303) 771-3455
TWX: 910-935-0705

CONNECTICUT
508 Tolland Street
East Hartford 06108
Tel: (203) 289-9394
TWX: 710-425-3416

111 East Avenue
Norwalk 06851
Tel: (203) 853-1251
TWX: 710-468-3750

DELAWARE
3941 Kennett Pike
Wilmington 19807
Tel: (302) 655-6161
TWX: 510-666-2214

FLORIDA
P.O. Box 545
Suite 105
9999 N.E. 2nd Avenue
Miami Shores 33153
Tel: (305) 754-4565
TWX: 810-848-7262

P.O. Box 20007
Herndon Station 32814
621 Commonwealth Avenue
Orlando
Tel: (305) 841-3970
TWX: 810-850-0113

P.O. Box 8128
Madeira Beach 33708
410 150th Avenue
St. Petersburg
Tel: (813) 391-0211
TWX: 810-863-0366

GEORGIA
P.O. Box 28234
450 Interstate North
Atlanta 30328
Tel: (404) 436-6181
TWX: 810-766-4890

ILLINOIS
5500 Howard Street
Skokie 60076
Tel: (312) 677-0400
TWX: 910-223-3613

INDIANA
3839 Meadows Drive
Indianapolis 46205
Tel: (317) 546-4891
TWX: 810-341-3263

LOUISIANA
P.O. Box 856
1942 Williams Boulevard
Kenner 70062
Tel: (504) 721-6201
TWX: 810-955-5524

MARYLAND
6707 Whitestone Road
Baltimore 21207
Tel: (301) 944-5400
TWX: 710-862-0850

P.O. Box 1648
2 Choke Cherry Road
Rockville 20850
Tel: (301) 948-6370
TWX: 710-828-9684

MASSACHUSETTS
32 Hartwell Ave.
Lexington 02173
Tel: (617) 861-8960
TWX: 710-326-6904

MICHIGAN
24315 Northwestern Highway
Southfield 48075
Tel: (313) 353-9100
TWX: 810-232-1532

MINNESOTA
2459 University Avenue
St. Paul 55114
Tel: (612) 645-9461
TWX: 910-563-3734

MISSOURI
11131 Colorado Ave.
Kansas City 64137
Tel: (816) 763-8000
TWX: 910-771-2087

2812 South Brentwood Blvd.
St. Louis 63144
Tel. (314) 962-5000
TWX: 910-760-1670

NEW JERSEY
W. 120 Century Road
Paramus 07652
Tel: (201) 265-5000
TWX: 710-990-4951

1060 N. Kings Highway
Cherry Hill 08034
Tel: (609) 667-4000
TWX: 710-892-4945

NEW MEXICO
P.O. Box 8366
Station C
6501 Lomas Boulevard N.E.
Albuquerque 87108
Tel: (505) 255-5586
TWX: 910-989-1665

156 Wyatt Drive
Las Cruces 88001
Tel: (505) 526-2485
TWX: 910-983-0550

NEW YORK
1702 Central Avenue
Albany 12205
Tel: (518) 869-8462
TWX: 710-441-8270

1219 Campville Road
Endicott 13760
Tel: (607) 754-0050
TWX: 510-252-0890

82 Washington Street
Poughkeepsie 12601
Tel: (914) 454-7330
TWX: 510-248-0012

39 Saginaw Drive
Rochester 14623
Tel: (716) 473-9500
TWX: 510-253-5981

1025 Northern Boulevard
Roslyn, Long Island 11576
Tel: (516) 869-8400
TWX: 510-223-0811

5858 East Molloy Road
Syracuse 13211
Tel: (315) 454-2486
TWX: 710-541-0482

NORTH CAROLINA
P.O. Box 5188
1923 North Main Street
High Point 27262
Tel: (919) 885-8101
TWX: 510-926-1516

OHIO
25575 Center Ridge Road
Cleveland 44145
Tel: (216) 835-0300
TWX: 810-427-9129

3460 South Dixie Drive
Dayton 45439
Tel: (513) 298-0351
TWX: 810-459-1925

OKLAHOMA
2919 United Founders Boulevard
Oklahoma City 73112
Tel: (405) 848-2801
TWX: 910-830-6862

OREGON
Westhills Mall, Suite 158
4475 S.W. Scholls Ferry Road
Portland 97225
Tel: (503) 292-9171
TWX: 910-464-6103

PENNSYLVANIA
2500 Moss Side Boulevard
Monroeville 15146
Tel. (412) 271-0724
TWX: 710-797-3650

1021 8th Avenue
King of Prussia Industrial Park
King of Prussia 19406
Tel: (215) 265-7000
TWX: 510-660-2670

RHODE ISLAND
873 Waterman Ave.
East Providence 02914
Tel: (401) 434-5535
TWX: 710-381-7573

TEXAS
P.O. Box 1270
201 E. Arapaho Rd.
Richardson 75080
Tel: (214) 231-6101
TWX: 910-867-4723

6300 Westpark Drive
Houston 77027
Tel: (713) 781-6000
TWX: 910-881-2645

231 Billy Mitchell Road
San Antonio 78226
Tel: (512) 434-4171
TWX: 910-871-1170

UTAH
2890 South Main Street
Salt Lake City 84115
Tel: (801) 487-0715
TWX: 910-925-5681

VERMONT (Feb. 70)
P.O. Box 2287
Kennedy Drive
South Burlington 05401
Tel: (802) 658-4455
TWX: 710-658-4712

VIRGINIA
P.O. Box 6514
2111 Spencer Road
Richmond 23230
Tel: (703) 282-5451
TWX: 710-956-0157

WASHINGTON
433-108th N.E.
Bellevue 98004
Tel: (206) 454-3971
TWX: 910-443-2303

*WEST VIRGINIA
Charleston
Tel: (304) 768-1232

FOR U.S. AREAS NOT LISTED:
Contact the regional office nearest you: Atlanta, Georgia . . . North Hollywood, California . . . Paramus, New Jersey . . . Skokie, Illinois. Their complete addresses are listed above.

*Service Only

CENTRAL AND SOUTH AMERICA

ARGENTINA
Hewlett-Packard Argentina S.A.C.e.I.
Lavalle 1171 - 3
Buenos Aires
Tel: 35-0436, 35-0627, 35-0431
Telex: 012-1009
Cable: HEWPACKARG

BRAZIL
Hewlett-Packard Do Brasil I.e.C. Ltda.
Rua Coronel Oscar Porto, 691
Sao Paulo - 8, SP
Tel: 71-1503
Cable: HEWPACK Sao Paulo

Hewlett-Packard Do Brasil I.e.C. Ltda.
Avenida Franklin Roosevelt 84-grupo 203
Rio de Janeiro, ZC-39, GB
Tel: 232-9733
Cable: HEWPACK Rio de Janeiro

CHILE
Héctor Calcagni y Cia. Ltda.
Bustos, 1932-3er Piso
Casilla 13942
Santiago
Tel: 4-2396
Cable: Calcagni Santiago

COLOMBIA
Instrumentación Henrik A. Langebaek & Kier Ltda.
Carrera 7 No. 48-59
Apartado Aereo 6287
Bogota, 1 D.E.
Tel. 45-78-06, 45-55-45
Cable: AARIS Bogota
Telex: 044-400

COSTA RICA
Lic. Alfredo Gallegos Gurdian
Apartado 3243
San José
Tel: 21-86-13
Cable: GALGUR San José

ECUADOR
Laboratorios de Radio-Ingenieria
Calle Guayaquil 1245
Post Office Box 3199
Quito
Tel: 12496
Cable: HORVATH Quito

EL SALVADOR
Electrónica
Apartado Postal 1589
27 Avenida Norte 1133
San Salvador
Tel: 25-74-50
Cable: ELECTRONICA San Salvador

GUATEMALA
Olander Associates Latin America
Apartado Postal 1226
Ruta 4, 6-53, Zona 4
Guatemala City
Tel: 63958
Cable: OLALA Guatemala City

JAMAICA
General Engineering Services, Ltd.
27 Dunrobin Ave
Kingston
Tel: 42657
Cable: GENSERV

MEXICO
Hewlett-Packard Mexicana, S.A. de C.V.
Moras 439
Col. del Valle
Mexico 12, D.F.
Tel: 5-75-46-49

NICARAGUA
Roberto Terán G.
Apartado Postal 689
Edificio Terán
Managua
Tel: 3451, 3452
Cable: ROTERAN Managua

PANAMA
Electrónica Balboa, S.A.
P.O. Box 4929
Ave. Manuel Espinosa No. 13-50
Bldg. Alina
Panama City
Tel: 30833
Cable: ELECTRON Panama City

PERU
Fernando Ezeta B.
Avenida Petit Thouars 4719
Miraflores
Casilla 3061
Lima
Tel: 45-2335
Cable: FEPERU Lima

PUERTO RICO
San Juan Electronics, Inc.
P.O. Box 5167
Ponce de Leon 154
Pda. 3-Pta. de Tierra
San Juan 00906
Tel: (809) 725-3342
Cable: SATRONICS San Juan
Telex: SATRON 3450 332

URUGUAY
Pablo Ferrando S.A.
Comercial e Industrial
Avenida Italia 2877
Casilla de Correo 370
Montevideo
Tel: 40-3102
Cable: RADIUM Montevideo

VENEZUELA
Hewlett-Packard De Venezuela C.A.
Apartado 50933
Caracas
Tel: 71.88.05, 71.88.69, 71.99.30
Cable: HEWPACK Caracas

FOR AREAS NOT LISTED, CONTACT:
Hewlett-Packard INTERCONTINENTAL
3200 Hillview Ave.
Palo Alto, California 94304
Tel: (415) 326-7000
TWX: 910-373-1267
Cable: HEWPACK Palo Alto
Telex: 034-8461

CANADA

ALBERTA
Hewlett-Packard (Canada) Ltd.
11745 Jasper Ave.
Edmonton
Tel: (403) 482-5561
TWX: 610-831-2431

BRITISH COLUMBIA
Hewlett-Packard (Canada) Ltd.
1037 West Broadway
Vancouver 12
Tel: (604) 731-5301
TWX: 610-922-5059

MANITOBA
Hewlett-Packard (Canada) Ltd.
511 Bradford Ct.
St. James
Tel: (204) 786-7581
TWX: 610-671-3531

NOVA SCOTIA
Hewlett-Packard (Canada) Ltd.
2745 Dutch Village Rd.
Suite 203
Halifax
Tel: (902) 455-0511
TWX: 610-271-4482

ONTARIO
Hewlett-Packard (Canada) Ltd.
880 Lady Ellen Place
Ottawa 3
Tel: (613) 722-4223
TWX: 610-562-1952

Hewlett-Packard (Canada) Ltd.
50 Galaxy Blvd.
Rexdale
Tel: (416) 677-9611
TWX: 610-492-4246

QUEBEC
Hewlett-Packard (Canada) Ltd.
275 Hymus Boulevard
Pointe Claire
Tel: (514) 697-4232
TWX: 610-422-3022
Telex: 01-20607

FOR CANADIAN AREAS NOT LISTED:
Contact Hewlett-Packard (Canada) Ltd. in Pointe Claire, at the complete address listed above.

HEWLETT · PACKARD

ELECTRONIC INSTRUMENTATION SALES AND SERVICE

EUROPE, AFRICA, ASIA, AUSTRALIA

EUROPE

AUSTRIA
Unilabor GmbH
Wissenschaftliche Instrumente
Rummelhardtgasse 6/3
P.O. Box 33
Vienna A-1095
Tel: 42 61 81
Cable: LABORINSTRUMENT
Vienna
Telex: 75 762

BELGIUM
Hewlett-Packard Benelux S.A.
348 Boulevard du Souverain
Brussels 16
Tel: 72 22 40
Cable: PALOBEN Brussels
Telex: 23 494

DENMARK
Hewlett-Packard A/S
Langebjerg 6
2850 **Naerum**
Tel: (01) 80 40 40
Cable: HEWPACK AS
Telex: 66 40

FINLAND
Hewlett-Packard Oy
Gyldenintie 3
Helsinki 20
Tel: 67 35 38
Cable: HEWPACKOY-Helsinki
Telex: 12-1563

FRANCE
Hewlett-Packard France
Quartier de Courtaboeuf
Boite Postale No. 6
91 Orsay
Tel: 920 88 01
Cable: HEWPACK Orsay
Telex: 60048

Hewlett-Packard France
4 Quai des Etroits
69 **Lyon** 5ème
Tel: 42 63 45
Cable: HEWPACK Lyon
Telex: 31617

GERMANY
Hewlett-Packard Vertriebs-GmbH
Lietzenburgerstrasse 30
1 **Berlin W** 30
Tel: 24 60 65/66
Telex: 18 34 05

Hewlett-Packard Vertriebs-GmbH
Herrenbergerstrasse 110
703 **Böblingen**, Württemberg
Tel: 07031-6671
Cable: HEPAG Böblingen

Telex: 72 65 739
Hewlett-Packard Vertriebs-GmbH
Achenbachstrasse 15
4 **Düsseldorf** 1
Tel: 68 52 58/59
Telex: 85 86 533

Hewlett-Packard Vertriebs-GmbH
Berliner Strasse 117
6 **Nieder-Eschbach/Frankfurt 56**
Tel: (0611) 50 10 64
Cable: HEWPACKSA Frankfurt
Telex: 41 32 49

Hewlett-Packard Vertriebs-GmbH
Beim Strohhause 26
2 **Hamburg** 1
Tel: 24 05 51/52
Cable: HEWPACKSA Hamburg
Telex: 21 53 32

Hewlett-Packard Vertriebs-GmbH
Reginfriedstrasse 13
8 **München** 9
Tel: 0811 69 59 71/75
Cable: HEWPACKSA München
Telex: 52 49 85

GREECE
Kostas Karayannis
18, Ermou Street
Athens 126
Tel: 230303 232947
Cable: RAKAR Athens
Telex: 21 59 62 RKAR GR

IRELAND
Hewlett-Packard Ltd.
224 Bath Road
Slough, Bucks, England
Tel: Slough 753-33341
Cable: HEWPIE Slough
Telex: 84413

ITALY
Hewlett-Packard Italiana S.p.A.
Via Amerigo Vespucci 2
20124 **Milano**
Tel: 6251 (10 lines)
Cable: HEWPACKIT Milan
Telex: 32046

Hewlett-Packard Italiana S.p.A.
Palazzo Italia
Piazza Marconi 25
00144 **Rome** - Eur
Tel: 591 2544
Cable: HEWPACKIT Rome
Telex: 61514

NETHERLANDS
Hewlett-Packard Benelux, N.V.
Weerdestein 117
Amsterdam, Z 11
Tel: 42 77 77
Cable: PALOBEN Amsterdam
Telex: 13 216

NORWAY
Hewlett-Packard Norge A S
Box 149
Nesveien 13
Hasum
Tel: 53 83 60
Cable: HEWPACK Oslo
Telex: 6621

PORTUGAL
Telectra
Rua Rodrigo da Fonseca 103
P.O. Box 2531
Lisbon 1
Tel: 68 60 72
Cable: TELECTRA Lisbon
Telex: 1598

SPAIN
Ataio Ingenieros
Ganduxer 76
Barcelona 6
Tel: 211-44-66

Ataio Ingenieros
Enrique Larreta 12
Madrid, 16
Tel: 235 43 44
Cable: TELEATAIO Madrid
Telex: 2 72 49

SWEDEN
Hewlett-Packard (Sverige) AB
Hagakersgatan 9C
S 431 04 **Mölndal** 4
Tel: 031 - 27 68 00

Hewlett-Packard (Sverige) AB
Svetsarvägen 7
S171 20 **Solna** 1
Tel: (08) 98 12 50
Cable: MEASUREMENTS
Stockholm
Telex: 10721

SWITZERLAND
Hewlett Packard (Schweiz) AG
Zurcherstrasse 20
8952 Schlieren
Zurich
Tel: (051) 98 18 21 24
Cable: HEWPACKAG Zurich
Telex: 53933

Hewlett Packard (Schweiz) A.G.
Rue du Bois-du-Lan 7
1217 Meyrin-**Geneva**
Tel: (022) 41 54 00
Cable: HEWPACKSA Geneva
Telex: 2 24 86

TURKEY
Telekom Engineering Bureau
P.O. Box 376 - Galata
Istanbul
Tel: 49 40 40
Cable: TELEMATION Istanbul

UNITED KINGDOM
Hewlett-Packard Ltd.
224 Bath Road
Slough, Bucks
Tel: Slough 33341
Cable: HEWPIE Slough
Telex: 84413

YUGOSLAVIA
Belram S.A.
83 avenue des Mimosas
Brussels 15, Belgium
Tel: 34 33 32, 34 26 19
Cable: BELRAMEL Brussels
Telex: 21790

FOR AREAS NOT LISTED, CONTACT:
Hewlett-Packard S.A.
Rue du Bois-du-Lan 7
1217 Meyrin-**Geneva**
Tel: (022) 41 54 00
Cable: HEWPACKSA Geneva
Telex: 2 24 86

AFRICA, ASIA, AUSTRALIA

ANGOLA
Telectra Empresa Técnica
de Equipamentos Eléctricos
SAR
Rua de Barbosa Rodrigues
42-1°
Box 6487
Luanda
Cable: TELECTRA Luanda

AUSTRALIA
Hewlett-Packard Australia
Pty. Ltd.
22-26 Weir Street
Glen Iris, 3146
Victoria
Tel: 20 1371 (4 lines)
Cable: HEWPARD Melbourne
Telex: 31024

Hewlett-Packard Australia
Pty. Ltd.
61 Alexander Street
Crows Nest 2065
New South Wales
Tel: 43 7866
Cable: HEWPARD Sydney
Telex: 21561

Hewlett-Packard Australia
Pty. Ltd.
97 Churchill Road
Prospect 5082
South Australia
Tel: 65 2366
Cable: HEWPARD Adelaide

Hewlett Packard Australia
Pty. Ltd.
2nd Floor, Suite 13
Casablanca Buildings
196 Adelaide Terrace
Perth, W.A. 6000
Tel: 21-3330

CEYLON
United Electricals Ltd.
P.O. Box 681
Yahala Building
Staples Street
Colombo 2
Tel: 5496
Cable: HOTPOINT Colombo

CYPRUS
Kypronics
19-19B Hommer Avenue
P.O. Box 752
Nicosia
Tel: 6282-75628
Cable: HE-I-NAMI

ETHIOPIA
African Salespower & Agency
Private Ltd., Co.
P. O. Box 718
58/59 Cunningham St.
Addis Ababa
Tel: 12285
Cable: ASACO Addisababa

HONG KONG
Schmidt & Co. (Hong Kong) Ltd.
P.O. Box 297
1511, Prince's Building
10, Chater Road
Hong Kong
Tel: 240168, 232736
Cable: SCHMIDTCO Hong Kong

INDIA
The Scientific Instrument
Co., Ltd.
6, Tej Bahadur Sapru Road
Allahabad 1
Tel: 2451
Cable: SICO Allanbad

The Scientific Instrument
Co., Ltd.
12 5 Dickenson Road
Bangalore -1
Cable: SICO Bangalore

The Scientific Instrument
Co., Ltd.
240, Dr. Dadabhai Naoroji Road
Bombay 1
Tel: 26-2642
Cable: SICO Bombay

The Scientific Instrument
Co., Ltd.
11, Esplanade East
Calcutta 1
Tel: 23-4129
Cable: SICO Calcutta

The Scientific Instrument
Co., Ltd.
30, Mount Road
Madras 2
Tel: 86339
Cable: SICO Madras

The Scientific Instrument
Co., Ltd.
17, Kamaleyayan Society
P.O. Navajiwan
Ahmedabad 14
Cable: SICO, Ahmedabad

The Scientific Instrument Co. Ltd.
5-8-525 Mahatma Gandhi Road
Hyderabad-1 (A-P) India
Cable: SICO Hyderabad

The Scientific Instrument Co., Ltd.
B-7, Ajmeri Gate Extn.
New Delhi 1
Tel: 27-1053
Cable: SICO New Delhi

INDONESIA
Bah Bolon Trading Coy. N.V.
Djalah Merdeka 29
Bandung
Tel: 4915 51560
Cable: ILMU
Telex: 809

IRAN
Telecom. Ltd.
P. O. Box 1812
240 Kh. Saba Shomali
Teheran
Tel: 43850, 48311
Cable: BASCOM Teheran

ISRAEL
Electronics & Engineering
Div. of Motorola Israel Ltd.
17 Aminadav Street
Tel-Aviv
Tel: 36941 (3 lines)
Cable: BASTEL Tel-Aviv
Telex: Bastel Tv 033-569

JAPAN
Yokogawa-Hewlett-Packard Ltd.
Nisei Ibaragi Bldg.
2-2-8 Kasuga
Ibaragi-Shi
Osaka
Tel: 23-1641

Yokogawa-Hewlett-Packard Ltd.
Ito Building
No. 59, Kotori-cho
Nakamura-ku, Nagoya City
Tel: 551-0215

Yokogawa-Hewlett-Packard Ltd
Ohashi Building
59 Yoyogi 1-chrome
Shibuya-ku, Tokyo
Tel: 370-2281-7
Telex: 232-2024YHP
Cable YHPMARKET TOK 23-724

KENYA
R. J. Tilbury Ltd.
P. O. Box 2754
Suite 517/518
Hotel Ambassadeur
Nairobi
Tel: 25670, 68206, 58196
Cable: ARJAYTEE Nairobi

KOREA
American Trading Co., Korea, Ltd
P.O. Box 1103
Dae Kyung Bldg.
107 Sejong Ro
Chongro Ku
Seoul
Tel: 75-5841 (4 lines)
Cable: AMTRACO Seoul

LEBANON
Constantin E. Macridis
Clemenceau Street
P.O. Box 7213
Beirut
Tel: 220846
Cable: ELECTRONUCLEAR Beirut

MALAYSIA
MECOMB Malaysia Ltd.
2 Lorong 13/6A
Section 13
Petaling Jaya, **Selangor**
Cable: MECOMB Kuala Lumpur

MOZAMBIQUE
A. N. Goncalves, LDA.
4.1 Apt. 14 Av. D. Luis
P.O. Box 107
Lourenco Marques
Cable: NEGON

NEW ZEALAND
Hewlett-Packard (N.Z.) Ltd.
32-34 Kent Terrace
P.O. Box 9443
Wellington, N.Z.
Tel: 59-559
Cable: HEWPACK Wellington

PAKISTAN (EAST)
Mushko & Company, Ltd.
Zirat Chambers
31, Jinnah Avenue
Dacca
Tel: 280058
Cable: NEWDEAL Dacca

PAKISTAN (WEST)
Mushko & Company, Ltd.
Oosman Chambers
Victoria Road
Karachi 3
Tel: 511027, 512927
Cable: COOPERATOR Karachi

PHILIPPINES
Electromex Inc.
2129 Pasong Tamo
Makati, Rizal
P.O Box 4326
Manila
Tel: 88-91-71 or 88-83-76
Cable: ELEMEX Manila

SINGAPORE
Mechanical and Combustion
Engineering Company Ltd.
9, Jalan Kilang
Singapore, 3
Tel: 642361-3
Cable: MECOMB Singapore

SOUTH AFRICA
Hewlett-Packard South Africa
(Pty.), Ltd.
Hill House
43 Somerset Rd.
Cape Town
Tel: 3-6019
Cable: HEWPACK Cape Town
Telex: 7038CT

Hewlett Packard South Africa
(Pty.), Ltd.
P.O. Box 31716
30 De Beer Street
Braamfontein, **Johannesburg**
Tel: 724-4172 724-4195
Telex: 0226 JH
Cable: HEWPACK Johannesburg

TAIWAN REP. OF CHINA
Hwa Sheng Electronic Co., Ltd.
P. O. Box 1558
Room 404
Chia Hsin Building
No. 95 Chung Shan
North Road, Sec. 2
Taipei
Tel: 555211 Ext. 532-539
545936, 546076, 548661
Cable: VICTRONIX Taipei

TANZANIA
R. J. Tilbury Ltd.
P.O. Box 2754
Suite 517/518
Hotel Ambassadeur
Nairobi
Tel: 25670, 26803, 68206, 58196
Cable: ARJAYTEE Nairobi

THAILAND
The International
Engineering Co., Ltd.
P. O. Box 39
614 Sukhumvit Road
Bangkok
Tel: 910722 (7 lines)
Telex: INTENCO BK 226
Cable: GYSOM BANGKOK

UGANDA
R. J. Tilbury Ltd.
P.O. Box 2754
Suite 517/518
Hotel Ambassadeur
Nairobi
Tel: 25670, 26803, 68206, 58196
Cable: ARJAYTEE Nairobi

VIETNAM
Peninsular Trading Inc.
P.O. Box H-3
216 Hien-Vuong
Saigon
Tel: 20.805
Cable: PENINSULA Saigon

ZAMBIA
R. J. Tilbury (Zambia) Ltd.
P.O. Box 2792
Lusaka
Zambia, Central Africa

FOR AREAS NOT LISTED, CONTACT:
Hewlett-Packard
INTERCONTINENTAL
3200 Hillview Ave.
Palo Alto, California 94304
Tel: (415) 326-7000
TWX: 910-373-1267
Cable: HEWPACK Palo Alto
Telex: 034-8461

00779-90003

PRINTED IN U.S.A.