Agilent Technologies

777D Dual Directional Coupler

Operating Note

Manual part number: 00777-90004
Printed in USA
March 2001
Supersedes: May 2000

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In This Manual…

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Review this product and related documentation to familiarize yourself with safety markings and instructions before you operate the instrument. This product has been designed and tested in accordance with international standards.

WARNING

The WARNING notice denotes a hazard. It calls attention to a procedure, practice, or the like, that, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

CAUTION

The **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

Instrument Markings

	When you see this symbol on your instrument, you should refer to the instrument's instruction manual for important information.
	This symbol indicates hazardous voltages.
	The laser radiation symbol is marked on products that have a laser output.
	This symbol indicates that the instrument requires alternating current (ac) input.
	The CE mark is a registered trademark of the European Community. If it is accompanied by a year, it indicates the year the design was proven.
	The CSA mark is a registered trademark of the Canadian Standards Association.
1SM1-A	This text indicates that the instrument is an Industrial Scientific and Medical Group 1 Class A product (CISPER 11, Clause 4).
	This symbol indicates that the power line switch is ON.
	This symbol indicates that the power line switch is OFF or in STANDBY position.

Safety Earth Ground

This is a Safety Class I product (provided with a protective earthing terminal). An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the product must be made inoperative and secured against any unintended operation.

Before Applying Power

Verify that the product is configured to match the available main power source as described in the input power configuration instructions in this manual. If this product is to be powered by autotransformer, make sure the common terminal is connected to the neutral (grounded) side of the ac power supply.

Overview

Description

The Agilent 777D is a dual directional coupler. It is designed for use in 50-ohm coaxial systems. In this coupler, coupling attenuation (ratio of output power from secondary arm to main line input) is specified as mean coupling. The mean coupling of each auxiliary arm is stamped on its nameplate opposite the appropriate auxiliary arm. The variation in coupling is within ±0.4 dB of the mean, and the mean coupling is within ±0.5 dB of –20 dB. In addition, the variation in ratio of the two auxiliary arm coupling factors is within 0.5 dB. Complete specifications are given in Table 1 on page 3.

Uses of the coupler include reflectometer measurements, simultaneous forward and reverse power monitoring, and closed loop leveling applications.

Mounting

Each coupler is supported by four plastic feet (part number 0361-0207). The feet are inserts in 8-32 tapped holes (1/4-in deep) and may be removed to mount the coupler. Lateral dimensions between mounting holes are given in Figure 1 on page 1.

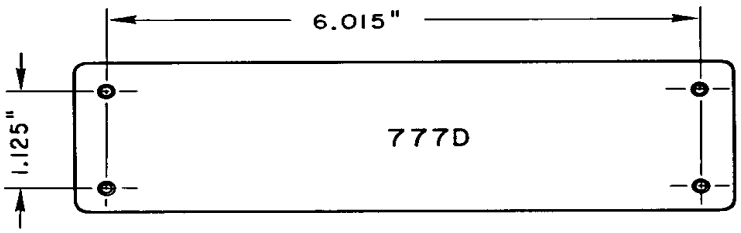

Figure 1 Lateral Dimensions of Tapped Mounting Holes

Connectors

Type N connectors installed on 777D directional couplers with serial numbers 3088 and above are stainless steel for long wear and are compatible with connectors whose dimensions conform to MIL-C-39012 or MIL-C-71B (see Figure 2).

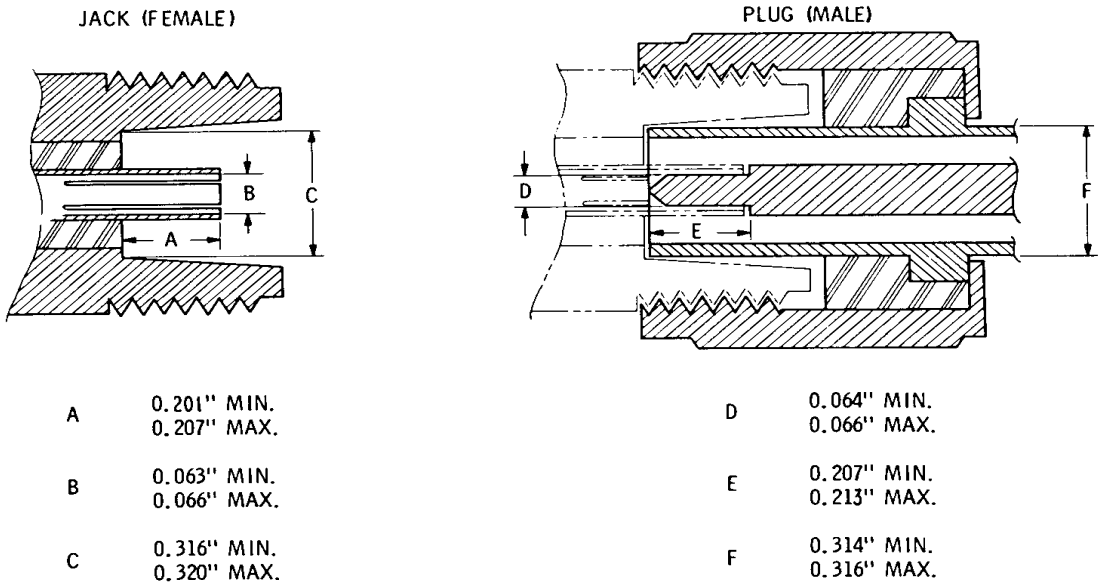

Figure 2 Type N Connector Dimensions

CAUTION

Do *not* mate with Type N male connectors with a pin diameter greater than 0.066 inches, as a discontinuity producing excess SWR will be formed and large diameter male pins may damage the female connector.

Agilent 777D directional couplers with serial numbers 3087 and below were equipped with Type N male connectors with center pin diameter greater than 0.070 inches. Many of these couplers have been modified with new connectors. However, check the dimensions of all male pins before mating Type N connectors.

Specifications

Table 1 Specifications

Characteristic	Value
Frequency Range	1.9 to 4.0 GHz
Primary Line Insertion Loss	≤0.75 dB
Minimum Directivity [1]	30 dB
Nominal Coupling Attenuation (each secondary arm)	20 dB
Accuracy of Coupling (each secondary arm)	± 0.5 dB
Maximum Coupling Variation (each secondary coupling value)	± 0.4 dB
Auxiliary Arm Tracking [2]	Equal to or less than 0.5 dB
Maximum Primary Line SWR[1]	1.2
Maximum Secondary Line SWR	1.3
Maximum Power Handling Capacity	50 W cw or 10 kW peak
Primary Line Connectors [3]	Agilent compatible Type N connectors, one male and one female
Secondary Line Connectors[3]	Agilent compatible Type N connectors, female
Accessories Available	Agilent 11511A Type N Female Shorting Jack Agilent 11512A Type N Male Shorting Plug
Dimension	8-7/8 in. x 2-1/2 in. x 1-1/8 in (225 mm x 64 mm x 29 mm)
Net Weight	1.5 lb (700 g)

1. Measured with a sliding load.
2. 0.5 dB maximum change in coupling curve of one secondary arm relative to the other.
3. Connectors mate with all connectors whose dimensions conform to MIL-C-71B or MIL-C-39012

Inspection and Shipping

Initial Inspection

Inspect the coupler for shipping damage as soon as it is unpacked. Check for broken connectors; inspect surfaces for dents and scratches. Check electrical performance using procedures in **Performance Tests** on page 6. If the coupler is damaged in any way, or fails to operate properly, notify the carrier and your nearest Agilent Technologies Sales and Service Office. In the event of mechanical damage, the packing material and carton should be held for carrier's inspection. For assistance of any kind, including instruments under warranty, contact the nearest Agilent Technologies Sales Office.

Repackaging for Shipment

The same type containers and materials used in factory packaging can be obtained through any Agilent Technologies office.

If the 777D is being returned to Agilent Technologies for servicing, attach a tag indicating the type of service required, return address, model number and full serial number. Also, mark the container *FRAGILE* to assure careful handling.

In any correspondence refer to the instrument by model number and full serial number.

Using Other Packaging

The following general instructions should be used when repackaging with commercially available materials:

1. Wrap the 777D in heavy paper or plastic. (If shipping to an Agilent Technologies service office or center, attach a tag indicating the type of service required, the return address, model number and full serial number.)
2. Use a strong shipping container. A double-wall carton made of 350 pound test material is adequate.
3. Use enough shock absorbing material (three to four inch layer) around all sides of the instrument to provide firm cushion and prevent movement inside the container.
4. Seal the shipping container securely, and mark it *FRAGILE* to assure careful handling.
5. In any correspondence refers to the instrument by model number and full serial number.

Reflectometer Application

Description

Figure 3 illustrates a typical setup for making reflectometer measurements. The forward output, of the coupler is used for leveling the sweep oscillator. The output of the reverse arm that is proportional to the reflections from the device under test is displayed on an SWR meter. The device under test is connected to the main line output of the coupler.

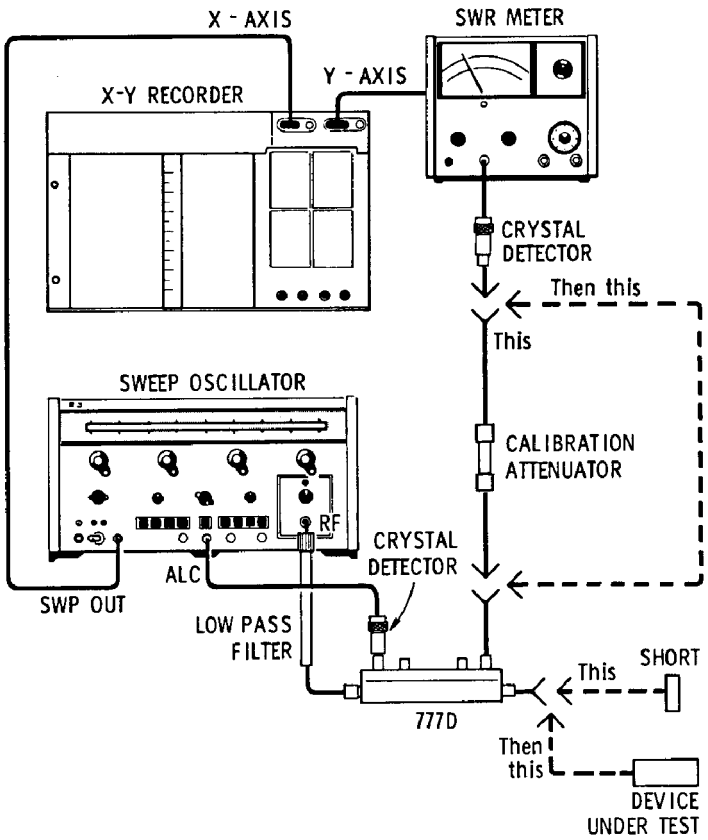

Figure 3 Typical Reflectometer Setup

Equipment Considerations

The Agilent 423B crystal detectors are suitable for use as the detectors. A SWR meter and oscilloscope are suitable for use as the calibrated display instruments. If a permanent record of the measurements is required, choose a recorder that is suitable for use with the SWR meter.

Performance Tests

The procedures in the follow tests functions check the 777D performance for incoming inspection and periodic evaluation. The specifications in Table 1 on page 3 are the performance standards.

Test Equipment Required

The test instruments and accessories required to make the performance tests are listed in Table 2. Test instruments can be used provided their performance equals or exceeds the Critical Specifications listed.

Table 2 Recommended Test Equipment

Instrument	Critical Specifications
Sweep Oscillator	Frequency: 1.9 to 4.0 GHz Residual FM: <3 kHz rms leveled output capability Power output: ≥25 mW into 50 ohms Amplitude Modulation: square-wave, 950 to 1050 Hz
10 dB Attenuator (2)	Frequency Range: 1.9 to 4.0 GHz Attenuation: 10 dB ±0.5 dB SWR: ≤1.15 Connectors: APC-7*
Coaxial Short	Type N male and Type N female
Short	APC-7*
Sliding Load	Frequency Range: 1.9 to 4.0 GHz
X-Y Recorder	Range: Variable from 10 mV to 100 mV Input Impedance: ≥100K ohms Accuracy: ±3% of full scale
Network Analyzer & Harmonic Frequency Converter	
Polar Display Unit	
Phase Gain Indicator	
Reflection-Transmission Test Unit	Frequency Range: 1.9 to 4.0 GHz
Flexible Arm	Frequency Range: 1.9 to 4.0 GHz Impedance: 50 ohms Reflection Coefficient: ≤0.11 Connectors: APC-7*
Coaxial Termination (2)	Frequency Range: 1.9 to 4.0 GHz Impedance: 50 ohms Reflection Coefficient: ≤0.05 Connectors: Type N male

Table 2 Recommended Test Equipment

Instrument	Critical Specifications
Adapter (3)	APC-7* to Type N Frequency Range: 1.9 to 4.0 GHz Impedance: 50 ohms Reflection Coefficient: ≤0.03
Swivel Adapter (2)	Frequency Range: 1.9 to 4.0 GHz SWR: ≤1.2 Connectors: Must mate with APC-7

* Registered Trademark: Amphenol RF Division, Danbury, Connecticut

Directivity Test

Specification Minimum directivity: 30 dB.

Description Refer to Figure 4 for test setup and Table 2 on page 6 for test equipment.

The 777D under test is connected as a reflectometer to the network analyzer. The system is calibrated with a coaxial short for a reflection coefficient of 1. The short is removed and the 777D is terminated with a sliding load. The network analyzer test channel gain is increased by 30 dB making the calibration of the polar display's outer graticule circle equal to the directivity specification.

NOTE

If the sliding load was a perfect termination, any energy from the coupler's reverse arm would be due only to the directivity signal; however, the energy from the coupler's reverse arm, and thus the indication on the Polar Display, is due to the directivity signal plus the reflection from the sliding load.

The Sweep Oscillator is set to sweep the frequency band of interest very slowly. The sliding load is phased causing its reflected vector to rotate about the tip of the directivity vector. The center of the circle caused by phasing the sliding load must be within the outer graticule circle.

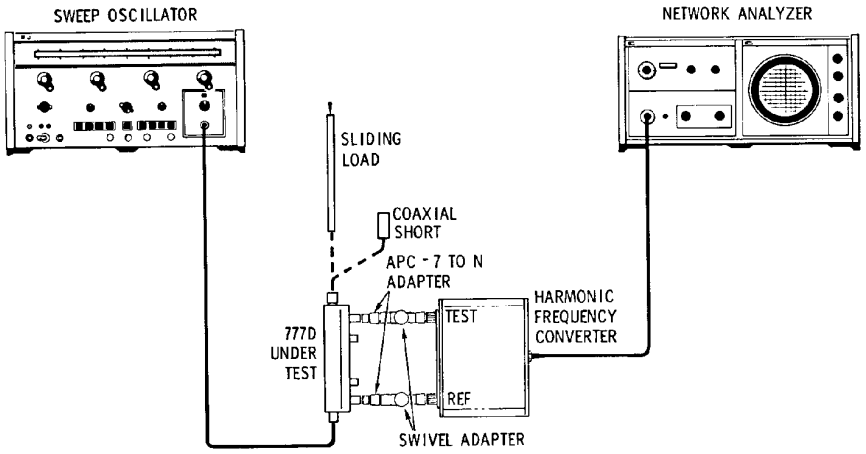

Figure 4 Directivity Test Setup

Equipment

The directivity test equipment includes the following:

- Sweep oscillator
- Network analyzer
- Harmonic frequency converter
- Sliding load
- Coaxial short
- APC-7 to Type N adapter (2)
- Swivel adapter (2)

Procedure

1. Connect equipment as shown in Figure 4 with the 777D terminated in a coaxial short.
2. Phase lock the network analyzer over the frequency band of interest.
3. Adjust the network analyzer test channel gain and amplitude vernier controls to locate the trace on the outer graticule circle.
4. Remove the coaxial short and terminate the 777D with the sliding load.
5. Increase the network analyzer test channel gain by 30 dB.
6. Set the sweep oscillator to very slowly sweep the frequency range of interest.
7. Phase the sliding load while observing the polar display. The center of the circle caused by phasing the sliding load must be within the outer graticule circle.
8. Repeat steps (1) through (9) at other frequencies to cover the 777D operating range. Reverse the 777D and test the other coupled arm.

Coupling Attenuation and Coupling Variation Test

Specification

Coupling attenuation: 20 dB ±0.5 dB
Maximum coupling variation: ±0.4 dB

Description

Refer to Figure 5 for test setup and Table 2 on page 6 for test equipment.

The equipment shown in Figure 5 is calibrated for a transmission measurement with the Flexible Arm, Attenuators, and APC-7 Adapters connected in a through path. The Network Analyzer test channel gain and amplitude vernier controls are adjusted for a zero dB meter indication at the lowest frequency of .the band to be swept. The X-Y Recorder Y axis sensitivity is adjusted so that 0.2 dB equals approximately one inch with zero dB at the center. Calibration lines are drawn in 0.2 dB increments to ±0.8 dB by adjusting the Network Analyzer amplitude vernier control. The 777D coupled arm is inserted in the test setup. The Network Analyzer test channel gain is increased 20 dB and the coupling response is drawn on the X-Y recorder. Coupling attenuation and coupling variation are determined from the X-Y Recorder graph.

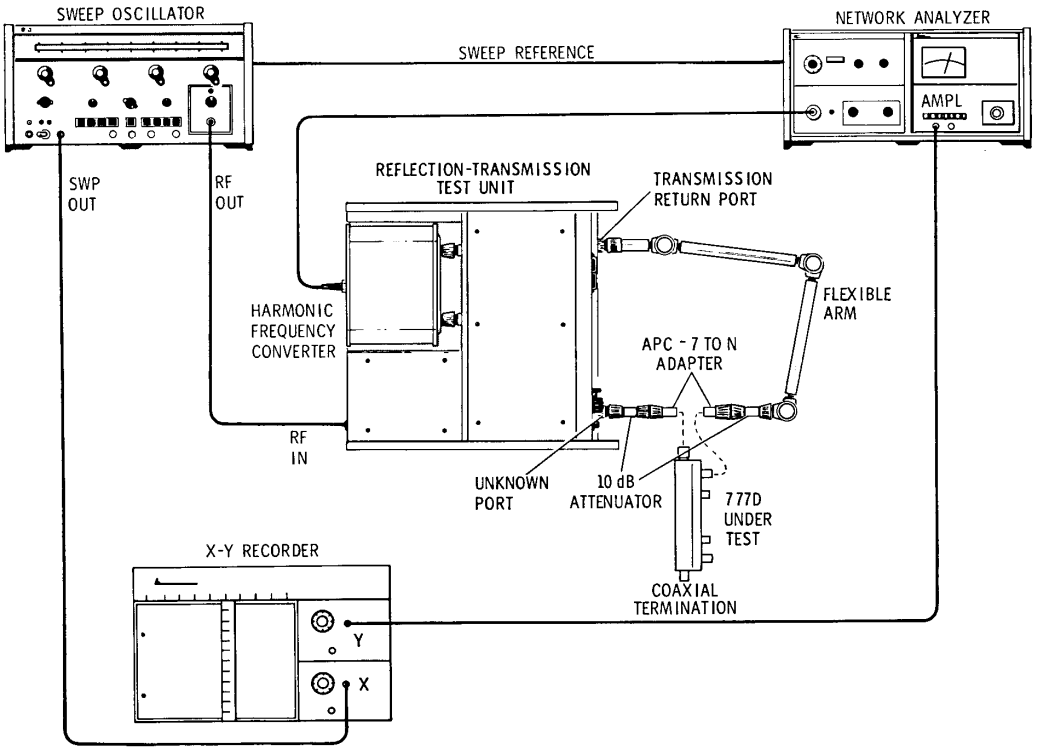

Figure 5 Coupling test and Primary Line Insertion Loss Test Setup

Equipment

- Sweep Oscillator
- Reflection-Transmission Test Unit
- Network Analyzer
- Harmonic Frequency Converter
- X-Y Recorder
- Flexible Arm
- 10 dB Attenuator (2)
- Coaxial Termination
- APC-7 to Type N Adapter (2)

Procedure

1. Connect equipment as shown in Figure 5 with the flexible arm, attenuators, and APC-7 to Type N adapters connected in a through-transmission path.
2. Phase lock the network analyzer over the frequency band of interest.
3. Adjust the network analyzer test channel gain and amplitude vernier controls for a zero dB 8413A meter indication at the lowest frequency of the band to be swept.
4. Adjust the X-Y recorder's Y axis sensitivity so that 0.2 dB (10 mV) equals approximately one inch with zero dB at the center.
5. Record calibration lines in 0.2 dB increments to ±0.8 dB by adjusting the network analyzer amplitude vernier control. Return the amplitude vernier control to the zero dB setting.
6. Insert the 777D coupled arm in the setup.
7. Increase the network analyzer test channel gain 20 dB. The zero dB calibration line now equals 20 dB.
8. Record the 777D coupling response. Determine the minimum and maximum points on this trace in dB.
9. Coupling attenuation (mean coupling) = Maximum + Minimum/2 and must be 20 dB ± 0.5 dB.
10. Coupling variation = Maximum – Minimum/2 and must be ≤0.4 dB.

Primary Line Insertion Loss Test

Specification ≤0.75 dB.

Description Refer to Figure 5 on page 10 for test setup and Table 2 on page 6 for test equipment.

The equipment shown in Figure 5 is calibrated for a transmission measurement with the flexible arm, attenuators, and APC-7 to Type N adapters connected in a through path. The network analyzer test channel gain and amplitude vernier controls are adjusted for a zero dB 8413A meter indication at the lowest frequency of the band to be swept. The X-Y recorder Y axis sensitivity is adjusted so that 0.2 dB equals approximately one inch with zero dB in the upper portion of the graph. A zero dB calibration line is drawn and a calibration line at -0.75 dB is drawn by adjusting the Network Analyzer amplitude vernier control. The 777D primary line is inserted in the setup (secondary line connectors terminated). A test trace is drawn on the X-Y Recorder. The test trace must be within the two calibration traces.

Procedure

1. Connect equipment as shown in Figure 5 on page 10 with flexible arm, attenuators, and APC-7 to Type N adapters connected in a through transmission path.
2. Phase lock the network analyzer over the frequency band of interest.
3. Adjust the network analyzer test channel gain and amplitude vernier controls for a zero dB meter indication at the lowest frequency of the band to be swept.
4. Adjust the X-Y recorder Y axis sensitivity so that 0.2 dB (10 mV) equals approximately one inch with zero dB in the upper portion of the graph.
5. Record a zero dB calibration line. Adjust the network analyzer amplitude vernier control for a –0.75 dB meter indication and record the –0.75 dB calibration line. Return the network analyzer amplitude vernier control to the zero dB setting.
6. Insert the 777D primary line in the setup.
7. Record the insertion loss test trace. The test trace must be within the two calibration lines.

Primary and Secondary Line SWR

Specification

Maximum Primary Line SWR: ≤1.2
Maximum Secondary Line SWR: ≤1.3

NOTE

The SWR and directivity characteristics of the 777D are interdependent; therefore, a satisfactory directivity check should indicate satisfactory SWR.

Description

Refer to Figure 6 on page 14 for test setup and Table 2 on page 6 for test equipment.

SWR is measured using a network analyzer, polar display unit, and test set. The test setup is calibrated for a reflection coefficient of 1. Gain is inserted in the test channel to obtain the appropriate full scale calibration for the 777D connector being measured. A swept frequency measurement of the 777D connector is made, which includes the ambiguity due to directivity of the 8743A test set. If the sum of 777D connector SWR and test set directivity exceeds 1.22 for secondary line connectors or 1.12 for primary line connectors, single frequency measurements are made with test set directivity calibrated out. Main line connector SWR is measured at single frequencies with both test set directivity calibrated out and with the main line termination reflection calibrated out.

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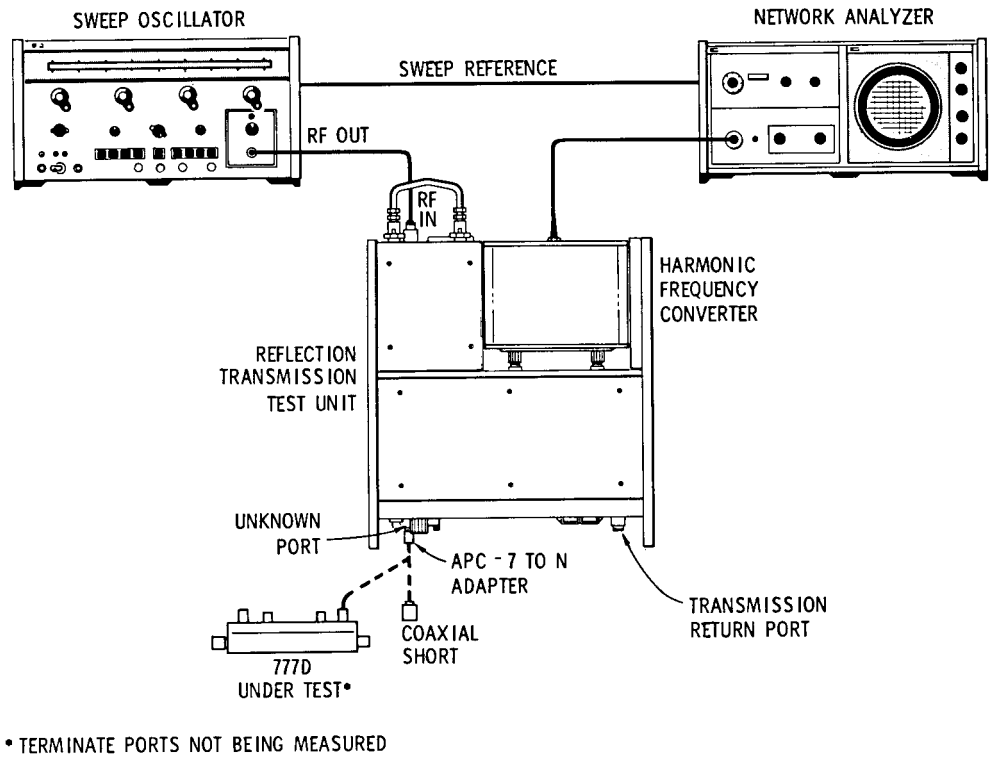

Figure 6 SWR Test Setup

Equipment

- Sweep oscillator
- Reflection-transmission test unit
- Network analyzer
- Harmonic frequency converter
- Coaxial short
- Coaxial termination
- APC-7 to Type N adapter (2)

Procedure

To calibrate the equipment

1. Connect equipment as shown in Figure 6 with appropriate adapter and coaxial short connected to the unknown port.
2. Phase lock the Network Analyzer over the desired frequency band.
3. Push and hold the beam CTR push-button and adjust the horizontal and vertical position controls to place the dot in the center of the graticule.
4. Obtain equal reference and test channel electrical lengths by adjusting the line stretcher to collapse the trace to a dot or smallest cluster.

5. Adjust the network analyzer phase vernier, test channel gain and amplitude vernier controls to place the dot or cluster for a reference indication of r = 1 <180 degrees.

6. For primary line connectors, increase the network analyzer test channel gain by 25 dB. The network analyzer is now calibrated for a full-scale reflection coefficient of 0.058 (SWR = 1.12). For secondary line connectors increase the network analyzer test channel gain by 20 dB. The network analyzer is now calibrated for a full-scale reflection coefficient of 0.1 (SWR = 1.22).

To perform a measurement

1. For swept frequency measurements, proceed as follows:

   a. Remove the coaxial short and connect 777D connector to the test set UNKNOWN port. The displayed trace (combination of 777D SWR and test set directivity) should be within the outer graticule circle. If the displayed trace is outside the outer graticule circle at any frequency, make single frequency measurements with test set directivity calibrated out as follows:

2. For single frequency measurements with test set directivity calibrated out, proceed as follows:

   a. Set the sweep oscillator to the desired single frequency.

   b. Remove the 777D under test and connect a sliding load to the appropriate adapter on the test set UNKNOWN port.

   c. Slide the load and adjust the network analyzer horizontal and vertical position controls until the circle rotates about the center of the CRT.

   d. Remove the sliding load and connect 777D connector to be measured to the test set UNKNOWN port.

   e. For the 777D secondary line connectors the display must be within the outer graticule circle. For primary line connectors, calibrate out termination reflection as follows:

3. For primary line connectors, perform step i and the following:

   a. Terminate the 777D primary line with the sliding load.

   b. Slide the load and with a grease pencil mark the center of the circle on the display. The reflection coefficient represented by this mark must be within the outer graticule circle.

Test Record

Table 3 is a performance test record. This table may be used during the test to record the test values obtained, and it provides a permanent record of the test values for use at a later time during periodic evaluation.

Table 3 Performance Test Record

Model 777D		Tested by _____
Dual-Directional Coupler		Date _____
Serial Number		
Directivity	≥30 DB Incident Port Reflected Port	. _____ _____
Coupling Attenuation	20 dB ±0.5 dB Incident Port Reflected Port	. _____ _____
Coupling Variation	≤ ± 0.4 dB Incident Port Reflected Port	. _____ _____
Primary Line SWR	≤1.2 Input Port Output Port	. _____ _____
Secondary Line SWR	≤1.3 Incident Port Reflected Port	. _____ _____
Primary Line Insertion Loss	≤ ±0.75 dB	_____

Although input power can be applied to either main line port, for this test record the ports are identified as follows when holding the 777D so that the name plate can be read:

Input Port	**= Main line port to the left**
Output Port	**= Main line port to the right**
Incident Port	**= Coupled port to the left**
Reflected Port	**= Coupled port to the right**