Agilent Technologies

776D Dual Directional Coupler

Operating and Service Manual

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In This Manual…

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Service and Support

Any adjustment, maintenance, or repair of this product must be performed by qualified personnel. Contact your customer engineer through your local Agilent Technologies Service Center. You can find a list of local service representatives on the Web at the address below.

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Country	Phone Number	Fax Number
Singapore	1-800-375-8100	(65) 836-0252
Malaysia	1-800-828-848	1-800-801664
Philippines	(632) 8426802 1-800-16510170 (PLDT Subscriber Only)	(632) 8426809 1-800-16510288 (PLDT Subscriber Only)
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People's Republic of China	800-810-0189 (preferred) 10800-650-0021	10800-650-0121
India	1-600-11-2929	000-800-650-1101

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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

This operating note contains operating information for the Agilent 776D dual directional coupler. Since the 776D must be returned to Agilent Technologies for repair, no service information is given. Instrument specifications are listed in Table 1. These specifications are the performance standards, or limits against which the instrument may be tested. Figure 1 defines the terms used in Table 1 and throughout this manual.

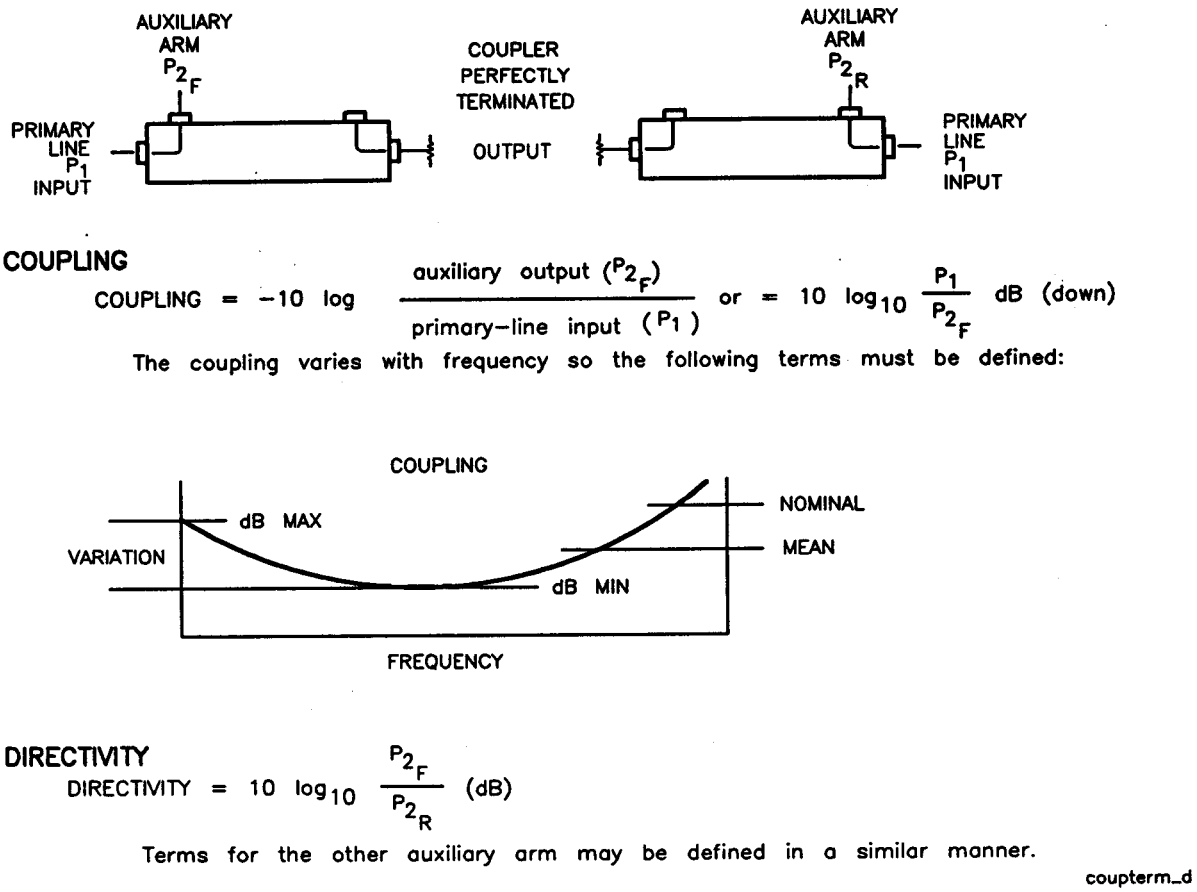

Figure 1 Coupler Terminology

Description

The 776D is a dual directional coupler designed for use in 50-ohm coaxial systems. In this coupler, nominal coupling is 20 dB. The coupling variation with frequency of each auxiliary arm is marked on the nameplate opposite the appropriate auxiliary arm.

Network Analyzer Reflectometer

A network analyzer with either phase magnitude display, phase gain display or polar display, with a sweep generator with appropriate RF unit plug-in, may be used with the 776D as a reflectometer test setup. The network analyzer reflectometer may be used either for fixed frequency or swept frequency measurements.

Fixed Frequency Reflectometer

A SWR meter with a sweep oscillator, with appropriate plug-in RF unit, or other signal source may be used with the 776D as a fixed frequency reflectometer.

Swept Frequency Reflectometer

A frequency response test set or network analyzer system together with a sweep oscillator with appropriate plug-ins may be used as a swept frequency reflectometer.

A SWR meter with a sweep oscillator and a 140 or 180 oscilloscope with appropriate plug-ins may be used as a swept frequency reflectometer.

Specifications

Table 1 Specifications

Characteristics	Value
Primary line insertion loss	Approximately 0.35 dB maximum
Minimum directivity [1]	40 dB
Nominal coupling attenuation (each secondary arm)	20 dB
Accuracy of coupling (each secondary arm)	Mean coupling 20 dB + 0.5 dB
Maximum coupling variation (each secondary coupling value)	± 1 dB of specified mean coupling value
Auxiliary arm tracking [2]	Equal to or less than 0.3 dB
Maximum primary line VSWR [1]	1.15
Maximum auxiliary arm VSWR	1.20
Primary line power handling capacity	50 watts average or 10 kW peak
Primary line connector [3]	Agilent compatible Type N connectors, one male and one female
Auxiliary arm 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	6-5/16 in x 2-5/16 in x 1-3/4 in (161 mm x 59 mm x 45 mm)
Net weight	2 lb (0.9 kg)

1. Measured with Agilent sliding load.
2. Maximum change in coupling curve of one secondary arm relative to the other.
3. Agilent Type N connectors mate with standard Type N connectors (see text)

Installation

Initial Inspection

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. Procedures for checking electrical performance are given in ""Performance Tests" on page 7". If the contents are incomplete, if there is mechanical damage or defect, or if the instrument does not pass the electrical performance test, notify the nearest Agilent Technologies office. If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as the Agilent Technologies office. Keep the shipping materials for the carrier's inspection. The Agilent office will arrange for repair or replacement without waiting for claim settlement.

Mating Connectors

Type N mating connectors used with the 776D should have dimensions compatible with US Military Standard MIL-C-39012.

N-female Pin Depth:	+0.207 inches to +0.201 inches (effective 0 to–0.006 inches)
N-male Pin Depth:	–0.207 inches to –0.213 inches (effective 0 to –0.006 inches)

Operating Environment

Operate the 776D in the range from 0 °C to +55 °C and protect it from excessive humidity.

CAUTION

Do not heat cycle this coupler during use or storage. Keep coupler near room temperature (25 °C).

Installation Instructions

Support Weight

When installing the 776D, be sure the auxilliary equipment supports its own weight. The coupler, particularly the connectors are not designed to support weight.

CAUTION

Do not drop the coupler. While the coupler probably with not break, it can be jarred out of adjustment and the connectors can be damaged.

On the bottom of each coupler is supported by four plastic feet (part number 0361-0207). The feet are inserts in 8-32 tapped holes (0.50 in deep) and may be removed to mount the coupler. Dimensions between mounting holes are shown in Figure 2.

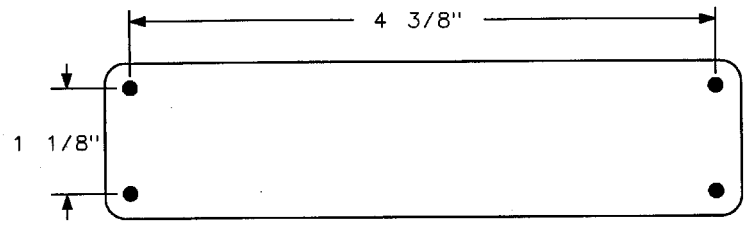

Figure 2 Dimensions of Trapped Mounting Holes

Signal Flow

Signal flow is indicated in Figure 3. Coupling is indicated by arrows. The 776D is bi-directional (signal may go through the coupler in either direction).

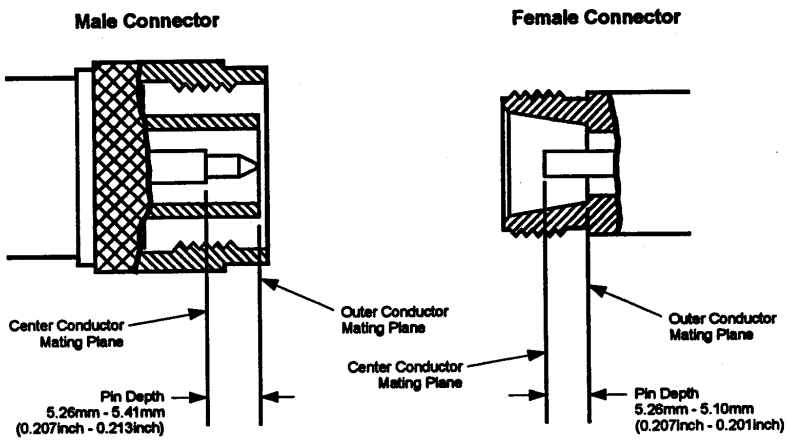

Figure 3 Type N Connector Dimensions

Storage and Shipment

Environment

The 776D may be stored in surroundings between –40 °C and +75 °C. However, heat cycling should be avoided by storing at an even room temperature (25 °C) if at all possible. The greater the heat cycling, the greater chance of dimensional change of the printed circuit board resulting in out-of-specification operation.

Original Packaging

Containers and materials identical to those used in factory packaging are available through Agilent Technologies offices. If the instrument is being returned to Agilent office 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.

Other Packaging

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

1. Wrap the instrument in heavy paper or plastic. (If shipping to a Agilent Technologies office or service center, attach a tag indicating the type of service required, return address, model number, and full serial number.)
2. Use a strong shipping container. A single wall carton made of 200-pound test material is adequate.
3. Use enough shock-absorbing material (3 to 4-inch layer) around all sides of the instrument to provide firm cushion and prevent movement inside the container.
4. Seal the shipping container securely.
5. Mark the shipping container *FRAGILE* to assure careful handling.

Performance Tests

The performance tests check the instrument's electrical performance using the specifications of Table 1 on page -3 as the performance standards.

Coupling Test

Specification

- Mean Coupling, 20 dB ± 0.5 dB
- Maximum Coupling Variation, ± 1 dB of mean coupling.

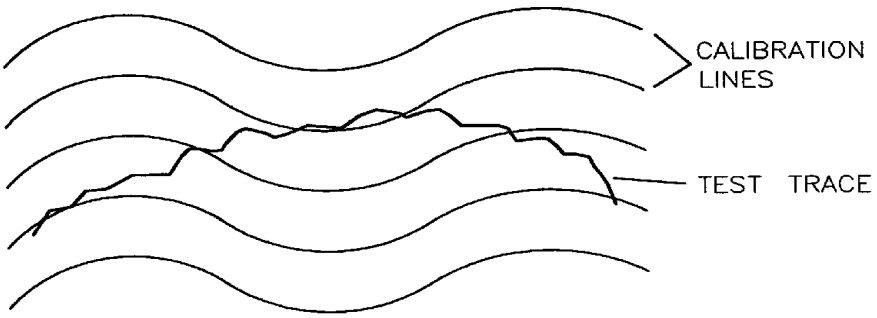

Figure 4 Coupling Test Setup

Procedure

1. Set up the equipment as shown in Figure 5.
2. Set the SWR meter to maximum bandwidth, 50 dB range.
3. With 1000 Hz square-wave modulation, tune SWR meter FREQ control for a maximum indication. Set the SWR meter GAIN control for an indication of 0 dB on the meter.
4. Observe the waveform while sweeping the oscillator manually from 940 to 1900 MHz. If the waveform is not square:
   a. Adjust the loop gain of the oscillator. If still not square,
   b. Add a 10 dB attenuator to the 20 dB attenuator, and repeat step 4.
5. Adjust the gain of the SWR meter to 0 dB on the 50 dB-NORMAL range on the SWR meter and run a calibration line on the X-Y recorder.
6. Set level to 0.5 dB and run a calibration line.
7. Set level to 1.0 dB and run a calibration line.

8. Set level to 1.5 dB and run a calibration line.
9. Set level to 2.0 dB and run a calibration line.
10. Adjust the gain of the SWR meter for an indication of 1 dB. Remove the 20 dB attenuator and insert the 776D under test, as shown in Figure 4. Run a test trace. See Figure 5. The test trace should have a variation of less than ± 1 dB and the mean coupling should be between 19.5 and 20.5 dB.
11. Reverse the 776D under test end-for-end and repeat the test for coupling on the other arm.

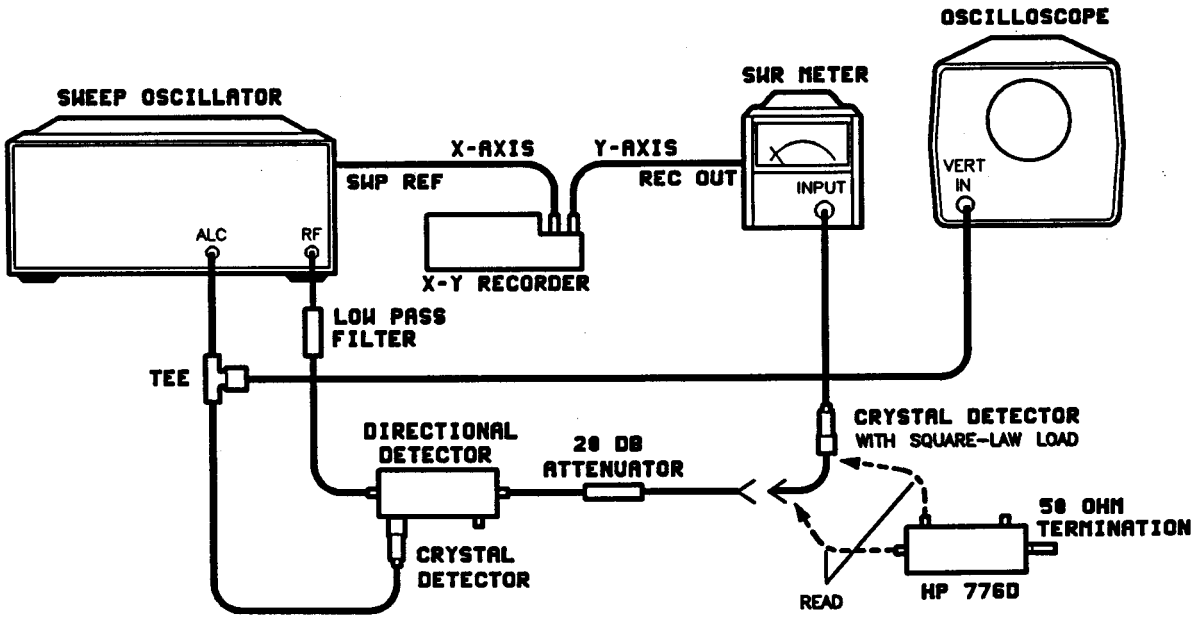

Figure 5 Coupling Test Trace

Directivity Test

Specification: Minimum directivity 40 dB

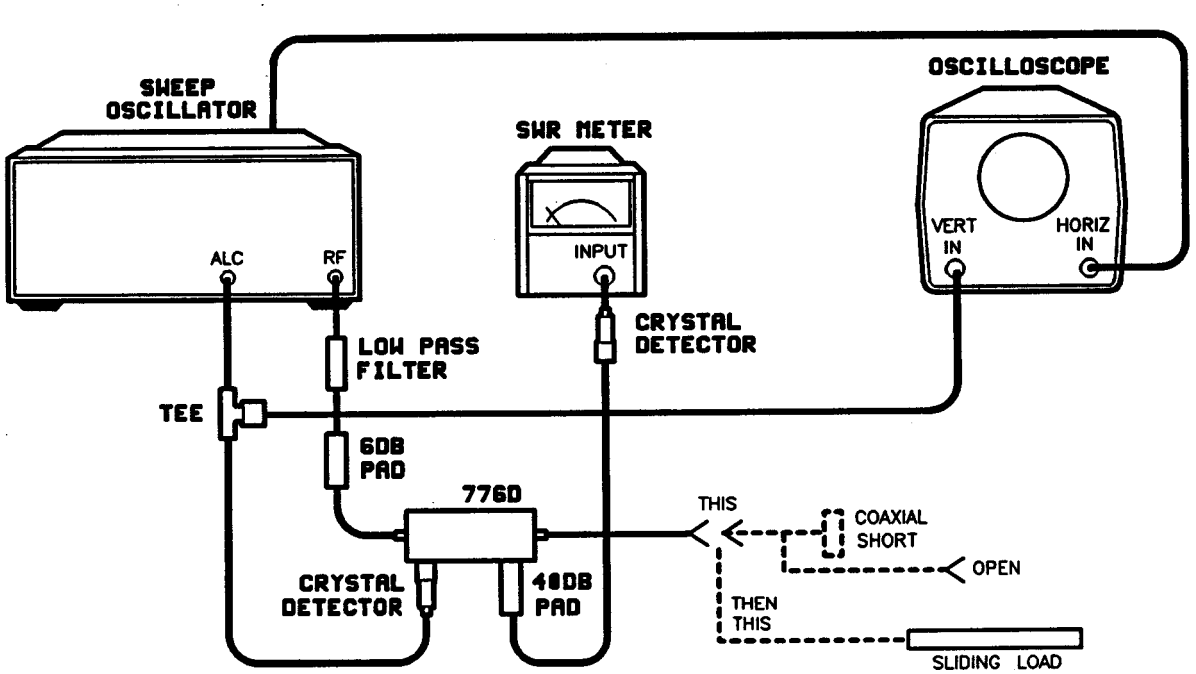

Figure 6 Directivity Test Setup

Procedure

1. Connect the equipment as shown in Figure 6, with the Agilent 776D under test un-terminated.
2. Set the SWR meter to maximum BANDWIDTH, and full gain on the 50 dB range.
3. Modulate the sweep oscillator with 1000 Hz square-wave modulation and tune the SWR meter FREQ control for a peak indication.
4. Adjust the RF output for a 5 mV signal on the oscilloscope.
5. Manually sweep the oscillator from 940 to 1900 MHz while observing the waveform. If the waveform does not remain square, adjust the ALC loop gain of the oscillator.

6. With the SWR Meter set to the 50 dB-NORMAL range, adjust the GAIN control to obtain a full-scale (0 dB) indication.
7. Terminate the 776D under test with the coaxial short. Note the SWR Meter indication. Adjust SWR meter GAIN control to indicate half-way between this indication and the indication in step 6. This will balance out any source match errors. The setup is now calibrated.
8. Connect the sliding load in place of the coaxial short.
9. Remove the 40 dB pad from the crystal detector and reconnect the 776D under test.
10. Manually slowly sweep the oscillator from 940 MHz to 1900 MHz while rapidly phasing the sliding load. Note the minimum number of dB down that the signal indicates on the SWR meter. Be sure to add any SWR meter range changing and the 40 dB removed by the pad to the indicated value. If the indication is more than 40 dB down at all frequencies, the 776D is within specifications and no further directivity testing need be done. If not, note the frequencies where the 776D appears out of specification. (The 776D may not be out of specification. The directivity signal and the signal reflected from the load may be adding in-phase.) To find the true directivity, proceed with the following tests.
11. Set the sweep oscillator for CW operation at the frequency where the directivity appears to be out of specification. Phase the sliding load and note the dB attenuation values of the maximum and minimum meter indications. Record these indications. Subtract the smaller value from the larger. The remainder is M_1. For example, if the indications were –0.5 and 4.4 dB with a pad of 40 dB, the two indications are 39.5 and 44.4 dB down. The difference between the two indications is 4.9 dB (which is M_1).
12. Refer to the Signal Separation Chart in Figure 7. Determine values for M_2, which are the two correction values to be used. Add the minimum dB indication of step 11 to each correction value (M_2). For example, if the difference in dB ($M_{1)}$ is 4.9 dB, then entering the graph in Figure 7 at 4.9 dB on the vertical scale, read the two correction values of 2.1 and 13.3 dB on the horizontal scale. Add these values to the smaller of the two dB indications. In our example, the corrected results would be 41.6 dB and 52.8 dB. In this case, since both results are better than the specifications no further tests need be made. However, if one of the corrected results is out of specifications, proceed to the following tests
13. Two results were determined in step 12. One of these results is the coupler directivity and one is the load reflection, but it is not known which is which. To identify the directivity value from the load reflection value, loosen the sliding load center conductor lock and pull out the center conductor a small distance. Tighten the center conductor lock.

14. Repeat steps 11 and 12. The corrected result for sliding load reflection should remain practically the same as the original corrected result (with a few tenths of a dB). The true 776D directivity is the other original corrected result, which changed when the sliding load was loosened. It is not intuitively obvious that loosening the sliding load conductor affects the directivity value instead of the sliding load value. The reflection from the added discontinuity due to the loosened conductor adds to the measured directivity signal while the reflection from the moving portion of the sliding load has not been changed by loosening the connector.
15. Reverse the 776D under test end-for-end and repeat steps 1 through 14. This completes the CW directivity test.
16. If a swept frequency directivity test is desired, an X-Y recorder may also be used. Connect the Y input of the recorder to the REC OUT connector on the rear of the SWR meter. Insert a tee connector in the recorder X input line and connect the itweep oscillator SWEEP OUT signal to the recorder. Sweep from 940 MHz to 1900 MHz while phasing the sliding load. For any measurements where a tracking error of 0.3 dB would be significant, reset the open/short reference at the frequency in question and re-run the measurement.

Signal Separation Chart

The chart shown in Figure 7 is used for separating two signals when their sums and differences are known.

M_1 = difference in dB between the minimum and maximum return loss measurements

M_2 = correction in dB to be added to smallest dB reading

If Load Reflection is greater than unknown, use the $e_L > e_{un}$ curve.

If Load Reflection is less than unknown, use the $e_L < e_{un}$ curve.

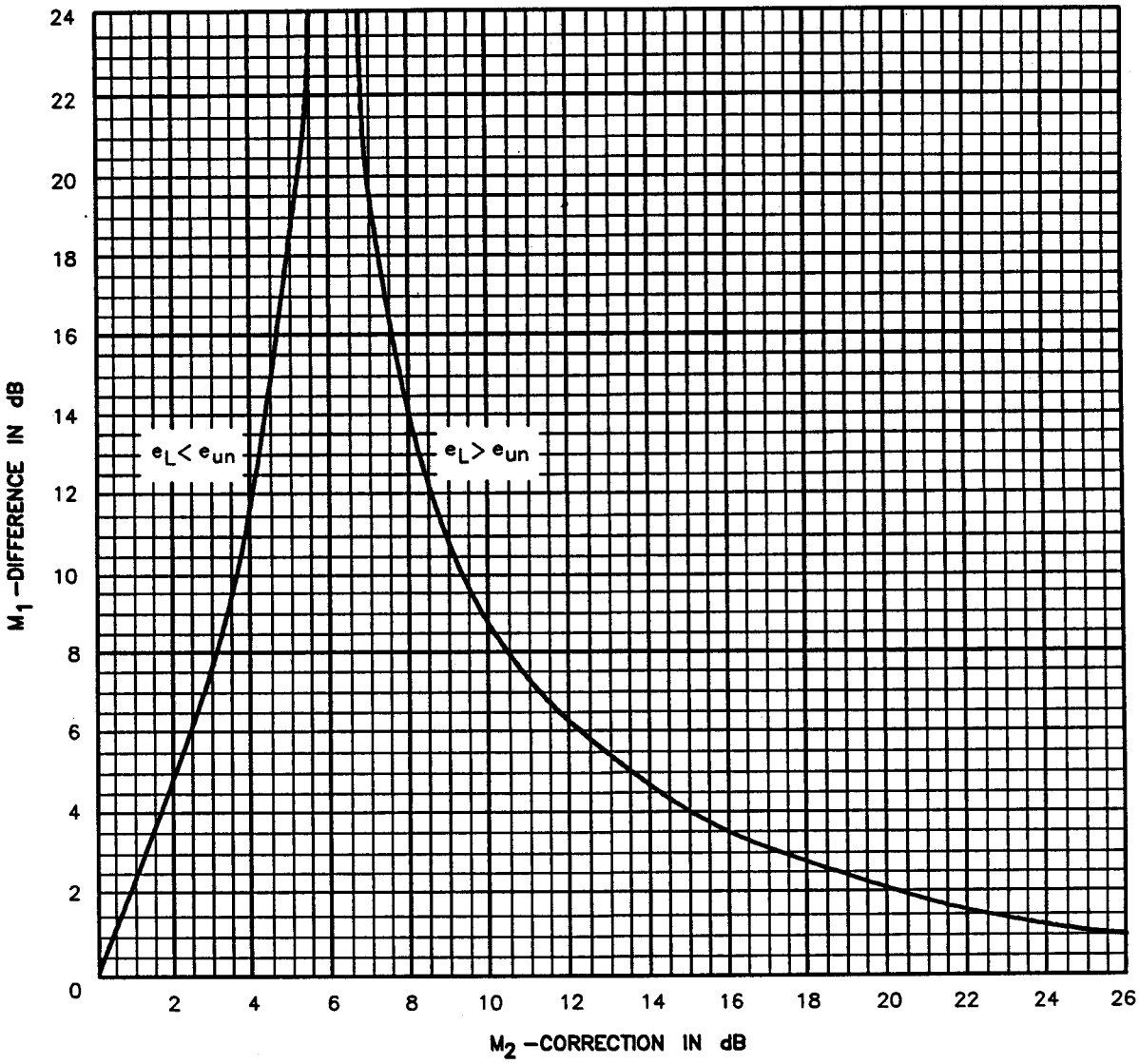

Figure 7 Signal Separation Chart

VSWR Test

Specification

- Maximum Primary Line SWR, 1.15
- Maximum Auxiliary Arm SWR, 1.20

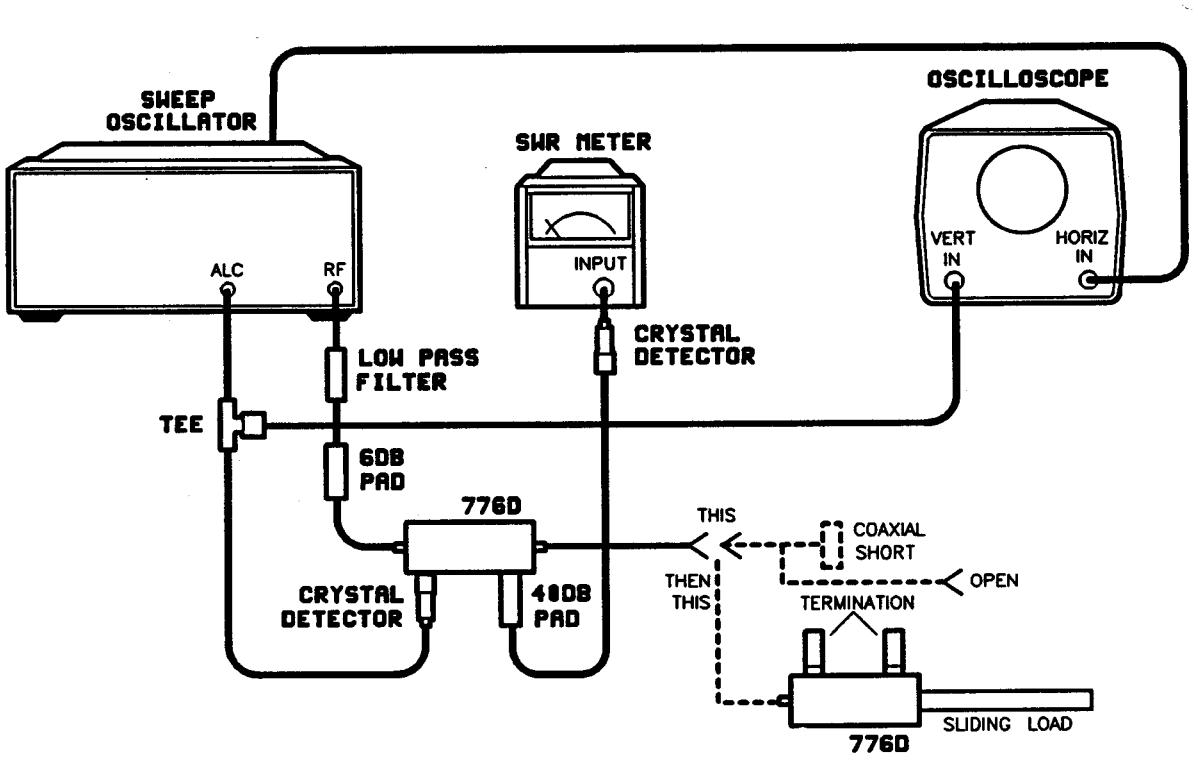

Figure 8 VSWR Test Setup

Procedure

1. Connect the equipment as shown in Figure 8, with the 776D under test unterminated.
2. Set SWR meter to maximum BANDWIDTH and full gain on the 40 dB range.
3. Modulate the sweep oscillator with 1000 Hz square-wave modulation and tune the SWR meter FREQ control for a maximum indication.
4. Set the oscillator RF output for an indication of 0 dB.
5. Manually sweep the oscillator from 940 to 1900 MHz while observing the waveform. If waveform is not square, a. Adjust the ALC loop gain of the oscillator. If it cannot be adjusted to be square, b. Replace the 10 dB leveling pad with a 20 dB pad and repeat step 5.

6. Set the CW frequency to approximately midband (1420 MHz). With the SWR meter set to the 40 dB range, adjust the GAIN control to full scale 0 dB indication.
7. Terminate the measurement 776D with a coaxial short. Note the indication. Set the SWR meter GAIN control to indicate half way between this indication and the indication in step 6. This procedure will balance out any source match errors. The setup is now calibrated.
8. Connect the port of the 776D under test as a load on the measurement 776D. Terminate the 776D under test with a sliding load.
9. Remove the 20 dB pad from the crystal detector and reconnect the measurement 776D.
10. Manually sweep the oscillator slowly from 940 MHz to 1900 MHz while rapidly phasing the sliding load. Read the number of dB down the signal indicates on the SWR meter. Be sure to add the SWR meter range changing and the dB removed by the pad to the indicated value.
11. Whenever the value in step 10 approaches 24.5 dB (VSWR of 1.15 measured with a directional coupler directivity of 40 dB, (computed with a Reflectometer Calculator, obtainable from Agilent, p/n 5952-0948), set for CW operation on that frequency and vary the sliding load. Take the average of the readings as the true value.
12. Reverse the 776D under test end-for-end and repeat steps 1 through 11 on the opposite port of the mainline.
13. To measure the VSWR of the auxiliary arms, terminate both ports of the mainline with 50 ohm loads. Connect auxiliary port under test to the measurement 776D where the mainline port under test was originally connected. It is not necessary in this case to terminate the unused auxiliary port or use a sliding load. The indication should be less than 21.9 dB (SWR of 1.2 measured with a directional coupler directivity of 40 dB).