

Agilent 87511A/B S-PARAMETER TEST SET
Operation and Service Manual

SERIAL NUMBERS

This manual applies directly to instruments with serial number prefix 3026J (87511A) and 3042J (87511B). For additional important information about serial numbers, read “INSTRUMENT COVERED BY MANUAL” in Chapter 1.



Agilent Part No. 87511-90010
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Manual Printing History

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Safety Summary

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific *WARNINGS* given elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument.

The Agilent Technologies assumes no liability for the customer's failure to comply with these requirements.

DO NOT Operate In An Explosive Atmosphere

Do not operate the instrument in the presence of flammable gasses or fumes. Operation of any electrical instrument in such an environment constitutes a safety hazard.

Keep Away From Live Circuits

Operating personnel must not remove the instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with the power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT Service Or Adjust Alone

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT Substitute Parts Or Modify Instrument

Because of the danger of introducing additional hazards, do not substitute parts or perform unauthorized modifications to the instrument. Return the instrument to a Agilent Technologies Sales and Service Office for service and repair to ensure the safety features are maintained.

Dangerous Procedure Warnings



Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

Warning



Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting this instrument.

Typeface Conventions

| | |
|-----------------|--|
| Bold | Boldface type is used when a term is defined. For example: icons are symbols. |
| <i>Italics</i> | Italic type is used for emphasis and for titles of manuals and other publications. Italic type is also used for keyboard entries when a name or a variable must be typed in place of the words in italics. For example: <i>copy filename</i> means to type the word <i>copy</i> , to type a space, and then to type the name of a file such as <i>file1</i> . |
| Computer | Computer font is used for on-screen prompts and messages. |
| HARDKEYS | Labeled keys on the instrument front panel are enclosed in  . |
| SOFTKEYS | Softkeys located to the right of the CRT are enclosed in  . |

Certification

Agilent Technologies certifies that this product met its published specifications at the time of shipment from the factory. Agilent Technologies further certifies that its calibration measurements are traceable to the United States National Institute for Standards and Technology, to the extent allowed by the Institution's calibration facility, or to the calibration facilities of other International Standards Organization members.

Warranty

This Agilent Technologies instrument product is warranted against defects in material and workmanship for a period of one year from the date of shipment, except that in the case of certain components listed in Chapter 1 of this manual, the warranty shall be for the specified period. During the warranty period, Agilent Technologies will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by Agilent Technologies. Buyer shall prepay shipping charges to Agilent Technologies and Agilent Technologies shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to Agilent Technologies from another country.

Agilent Technologies warrants that its software and firmware designated by Agilent Technologies for use with an instrument will execute its programming instruction when property installed on that instrument. Agilent Technologies does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

Limitation Of Warranty

The foregoing warranty shall not apply to defects resulting from improper or adequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environment specifications for the product, or improper site preparation or maintenance.

No other warranty is expressed or implied. Agilent Technologies specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

Exclusive Remedies

The remedies provided herein are buyer's sole and exclusive remedies. Agilent Technologies shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or any other legal theory.

Assistance

Product maintenance agreements and other customer assistance agreements are available for Agilent Technologies products.

For any assistance, contact your nearest Agilent Technologies Sales and Service Office. Address are provided at the back of this manual.

Safety Symbols

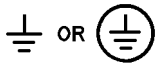
General definitions of safety symbols used on equipment or in manuals.



Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.



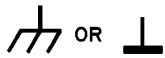
Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



Protective conductor terminal. For protection against electrical shock in case of a fault. Used with wiring terminals to indicate the terminal which must be connected to ground before operating equipment.



Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (Operation) manual, and before operating the equipment.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.



Alternating current (power line).



Direct current (power line).



Alternating or direct current (power line).

Warning



Warning denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

Caution



Caution sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

Note



Note denotes important information. It calls attention to a procedure, practice, condition or the like, which is essential to highlight.

General Information

INTRODUCTION

The purpose of this manual is to enable you to use your 87511A (including Option 001) or 87511B S-parameter test set efficiently and confidently. This manual contains both general and specific information. When information applies to both the 87511A (the 50 Ω test set, including Option 001) and the 87511B (the 75 Ω test set) the name 87511A/B is used. To use the 87511A/B to perform a specific function (without reading the entire manual), follow the directions in “USING THE 87511A/B”.

This chapter

- (1) outlines how to begin using the 87511A/B as quickly as possible,
- (2) describes what instrument are covered by this manual,
- (3) describes the test set itself,
- (4) mentions operating precautions, safety considerations and warranty restrictions,
- (5) lists the additional equipment required, and
- (6) defines and lists the required instrument specifications.

USING THE 87511A/B

The 87511A/B has been designed to operate specifically with the 8751A network analyzer.

- To install the instrument, turn to Chapter 2.
- To operate the 87511A/B, see the Chapter 3.
- To verify that the instrument meets its published specifications, turn to Chapter 4.
- to order replaceable parts of the 87511A/B, to turn to Chapter 6.
- To troubleshoot the 87511A/B, turn to Chapter 7.

INSTRUMENTS COVERED BY MANUAL

You will find a two-part serial number on the rear panel of the test set. The first four digits and the letter are the serial number prefix. The last five digits are the sequential suffix which is unique to each test set. The contents of this manual apply directly to test sets with the same serial number prefix as the one(s) on the title page under the heading SERIAL NUMBERS.

If the serial prefix of your test set is not listed on the title page, your instrument differs from those documented in this manual. The differences are documented in the yellow manual changes supplement supplied with the manual.

To keep this manual as current and accurate as possible, Agilent Technologies recommends that you periodically request the latest manual changes supplement, as it may contain replacement information as well as change information. The supplement for this manual is keyed to the manual's print date and part number (on the title page) and is available on request from Agilent Technologies.

This manual is also available on microfiche form (the part number appears on the title page). With the manual (in 4 × 6 inch microfilm transparency format) you will also receive the latest manual changes supplement.

DESCRIPTION AND OPERATING CHARACTERISTICS OF THE INSTRUMENT

The 87511A/B S-parameter test set has been designed to operate with the 8751A network analyzer. The 87511A/B provides a convenient means of measuring the reflection and transmission coefficients (scattering parameters) of one-port or two-port devices operating within the frequency range of 100 kHz to 500 MHz.

Table 1-2 lists the operating specifications and characteristics of the 87511A/B. The test set is shown on the cover of this manual and shown in Figure 3-1.

OPTIONS

Option 001, 50 Ω Type-N Test Port (87511A only)

Option 907, Front Handle Kit (Agilent Part Number 5062-3988)

Option 908, Rack Mount Kit (Agilent Part Number 5062-3974)

This option is a rack mount kit containing a pair of flanges and the necessary hardware to mount the instrument, with handles detached, in an equipment rack with 482.6 mm (19 inches) horizontal spacing.

Option 909, Rack Mount Flange and Handle Kit (Agilent Part Number 5062-3975)

This option is a rack mount kit containing a pair of flanges and the necessary hardware to mount the instrument with handles attached in an equipment rack with 482.6 mm (19 inches) horizontal spacing.)

Option 910, Extra Operation Manual

This option is an extra *OPERATION AND SERVICE MANUAL*. (Agilent Part Number 87511-90000)



Figure 1-1. 87511A/B S-Parameter Test Set with Accessories Supplied

ACCESSORIES

Accessories Supplied

Figure 1-1 shows the 87511A/B with the accessories supplied:

- Interconnect Cable
- RF Connecting Cables

Accessories Available

Calibration and Accessory Kits

The calibration kits listed in Table 1-1 contain the components required to characterize the systematic errors of various measurement systems. The calibration kits also contain precision adapters.

The accessory kits listed contain the components generally required to measure devices with the types of connectors indicated. Additional information is included in the 8751A manual.

Table 1-1. Accessories Available

| Connector Type | Calibration Kit | Accessory Kit |
|----------------|-----------------|---------------------|
| 7 mm | 85031B | |
| Type-N 50Ω | 85032B | 11853A ¹ |
| Type-N 75Ω | 85036B | |
| BNC 50Ω | | 11854A ¹ |

¹ use with 85032B type-N 50Ω calibration kit

Cable Sets

Use the 11857D 7 mm test port return cable set to extend the test ports of the 87511A. Use the 11851B 50Ω type-N cable to extend the test port of the 87511A with Option 001. Use the 11857B 75Ω type-N test port return cable set to extend the test port of the 87511B.

OPERATING AND SAFETY PRECAUTIONS

Operating

You need observe only normal precautions in handling and operating the 87511A/B. Do not exceed its operating level input of +23 dBm or any DC voltage.

Caution



Electrostatic discharge (ESD) can damage the highly sensitive microcircuits in the 87511A/B test sets. ESD damage is most likely to occur as the test sets are connected or disconnected. Protect them by wearing a grounding strap that provides a path to ground of high resistance. Alternatively, ground yourself by touching the outer shell of any grounded instrument chassis before touching the test port connectors.

Never touch the center contacts of the connectors.

Use a work station equipped with an anti-static surface.

Service

The voltages in this test set do not warrant more than normal caution for operator safety. Nevertheless, service should be performed by qualified personnel.

RECOMMENDED TEST EQUIPMENT

Table 4-1 lists equipment and accessories required for testing, and repairing the 87511A/B. The table notes which items are required to verify the performance of the test set and which are required to troubleshoot it. Other equipment may be substituted if its specifications meet or exceed the specifications listed in the critical specifications column.

SPECIFICATIONS

Definitions

The specifications listed in Table 1-2 range from those guaranteed by Agilent Technologies to those typical of most 87511A/B instruments but are not guaranteed. Codes in the far right column of Table 1-2 reference a specification definition listed below. These definitions are intended to clarify the extent to which Agilent Technologies supports the specified performance of the 87511A/B.

- S This performance parameter is field verifiable using performance tests documented in the Chapter 4.
- T Typical but non-warranted performance characteristics intended to provide information useful in applying the instrument. Typical characteristics are representative of most instruments, though not necessarily tested in each unit and not field tested.

These specifications describe the analyzer's performance over the temperature range of 23 ± 5 °C.

Table 1-2. Specifications

| Parameter | 87511A | 87511B | Code |
|--|---|--|------|
| Frequency Range | 100 kHz to 500 MHz | 100 kHz to 500 MHz | S |
| Directivity ¹ : Port 1,2 | ≥ 30 dB, 100 kHz to 300 kHz ≥ 40 dB, 300 kHz to 200 MHz ≥ 35 dB, 200 MHz to 500 MHz $(\geq 37$ dB, 300 kHz to 200 MHz) ² | ≥ 30 dB, 100 kHz to 300 kHz ≥ 33 dB, 300 kHz to 500 MHz | |
| Port Match ¹ : R, A, B RF IN | ≥ 20 dB ≥ 20 dB | ≥ 20 dB ≥ 20 dB | T |
| Switch Repeatability | ± 0.03 dB | ± 0.03 dB | |
| Source Match ¹ | ≥ 15 dB, 100 kHz to 300 kHz ≥ 20 dB, 300 kHz to 500 MHz | ≥ 15 dB, 100 kHz to 300 kHz ≥ 20 dB, 300 kHz to 500 MHz | T |
| Frequency Response ¹ : Transmission Tracking Magnitude ³ Phase ⁴ | ± 1 dB $\pm 10^\circ$, 100 kHz to 300 kHz $\pm 5^\circ$, 300 kHz to 500 MHz | ± 1 dB $\pm 15^\circ$, 100 kHz to 300 kHz $\pm 5^\circ$, 300 kHz to 500 MHz | |
| Reflection Tracking Magnitude ³ Phase ⁴ | ± 1 dB $\pm 15^\circ$, 100 kHz to 300 kHz $\pm 5^\circ$, 300 kHz to 1 MHz $\pm 5^\circ$, 1 MHz to 500 MHz | ± 1 dB $\pm 20^\circ$, 100 kHz to 300 kHz $\pm 10^\circ$, 300 kHz to 1 MHz $\pm 5^\circ$, 1 MHz to 500 MHz | |
| Insertion Loss: RF IN to Port 1,2 RF IN to R, A, B | 13 dB 19 dB | 19 dB 31 dB | |
| Isolation between Port 1 and 2 | 110 dB | 100 dB | T |

1 can be greatly improved with 8751A accuracy enhancement techniques

2 Option 001 only

3 Deviation from mean value

4 Deviation from linear phase

Table 1-3. Specifications (continued)

| Parameter | 87511A | 87511B | Code |
|-----------------------|---|---|---------|
| Impedance: | | | Nominal |
| Port 1, 2 | 50Ω | 75Ω | |
| RF IN, R, A, B | 50Ω | 50Ω | |
| Connectors: | | | |
| Port 1, 2 | 7 mm (50 Ω) 50Ω type-N(f) ¹ | 75Ω Type-N(f) | |
| RF IN R, A, B | 50Ω type-N(f) | 50Ω type-N(f) | |
| Maximum Input Level | +20 dBm | +20 dBm | |
| Damage Level | +23 dBm | +23 dBm | |
| Operating Conditions: | | | |
| Temperature | 0°C to 55°C | 0°C to 55°C | |
| Relative Humidity | 95% at 40°C | 95% at 40°C | |
| Dimensions | 432 mm × 90 mm × 495 mm (17 × 3.5 × 19.5 inches) | 432 mm × 90 mm × 495 mm (17 × 3.5 × 19.5 inches) | |
| Weight | 5.7 kg | 5.7 kg | |
| Power | +22 Vdc from 8751A via interface cable (22 V, 20 mA typ.) | +22 Vdc from 8751A via interface cable (22 V, 20 mA typ.) | |

¹ Option 001 only

Installation

INTRODUCTION

This chapter explains how to install the 87511A/B test set. The topics covered include initial inspection, environment considerations, positioning and connecting the test set for use, and packaging the instrument.

INITIAL INSPECTION

Inspect the shipping container (including cushioning material) for damage. If it is damaged, keep it until you have checked the contents for completeness. The contents are listed in Table 2-1.

In addition, check the test set mechanically and electrically. If the test set and shipping container are undamaged, performing the Directivity performance test in Chapter 4 should suffice for incoming inspection. If the test set does not pass the performance test, refer to the troubleshooting procedures in Chapter 7.

If the shipping container is damaged, perform all electrical performance tests in Chapter 4. If the test set fails the electrical tests, or is damaged, defective, or incomplete, keep the shipping materials and notify both the carrier and the nearest Agilent Technologies office. The Agilent Technologies office will arrange for repair or replacement of the test set without waiting for settlement of the claim.

Table 2-1. Contents of the 87511A/B

| Component | Agilent Part Number | |
|-----------------------------------|---------------------|-------------|
| | 87511A | 87511B |
| Interconnect Cable | 08503-60051 | 08503-60051 |
| RF Connecting Cables ¹ | 8120-4782 | 8120-4782 |
| Operation and Service Manual | 87511-90000 | 87511-90000 |

¹ Consists of four cables

ENVIRONMENTAL CONSIDERATIONS

Operating and Storage

The 87511A/B should be operated in temperatures between 0°C and +55°C with relative humidity between 5% and 95% at 40°C (non-condensing). It may be operated at altitudes up to 4,500 meters (15,000) feet.

The 87511A/B may be stored in temperatures from -40°C to +70°C, with relative humidity up to 90% at +65°C (non-condensing) and at altitudes up to 15,240 meters (50,000 feet).

PREPARATION FOR USE

Positioning the Test Set

Typically the 87511A/B is placed under the 8751A network analyzer whether it is rack-mounted or used on a bench.

To install the 87511A/B for use on a bench, place it under or next to the 8751A. Use an anti-static work surface to lessen the chance of ESD damage.

Connecting the Test Set

Mating Connectors

Ports 1 and 2 of the 87511A are precision 7 mm connectors and mate with precision 7 mm connectors. Ports 1 and 2 of the 87511A Option 001 are precision 50Ω type-N female connector and mate with precision 50Ω male connectors. Ports 1 and 2 of the 87511B are precision 75Ω type-N female connector and mate with precision 75Ω male connectors.

Caution

Do not mate type-N 50Ω connectors to type-N 75Ω connectors or damage may result.



The RF IN, R, A and B ports of the 87511A/B are precision 50Ω type-N female connectors which mate with the corresponding precision type-N male connectors whose dimensions conform to US specification MIL-C-39012.

The NETWORK ANALYZER INTERCONNECT connector is a series D 25-contact female connector and mates with the corresponding male connector.

Power and Control Connections

Power for the 87511A/B is supplied by the 8751A network analyzer through the interconnect cable. The interconnect cable also transmits control signals between the test set and the network analyzer. Connect the interconnect cable from the NETWORK ANALYZER INTERCONNECT connector on the rear panel of the 87511A/B to the TEST SET INTERCONNECT connector on the rear panel of the 8751A.

Signal Path Connections

Place the test set under the network analyzer and connect its RF IN port to the network analyzer's RF OUT port, R to R, A to A, B to B. Use the four cables supplied with the test set.

To connect the signal path ports with the test set not positioned under the network analyzer, use the longer cables of the 11851B RF cable set. Connect the RF IN port to the RF OUT port with the longer cable. Connect port R to R, A to A, B to B with the three phase matched cables.

PACKAGING

If shipping to a Hewlett Packard service center is required, each test set should be repackaged using the original factory packaging materials.

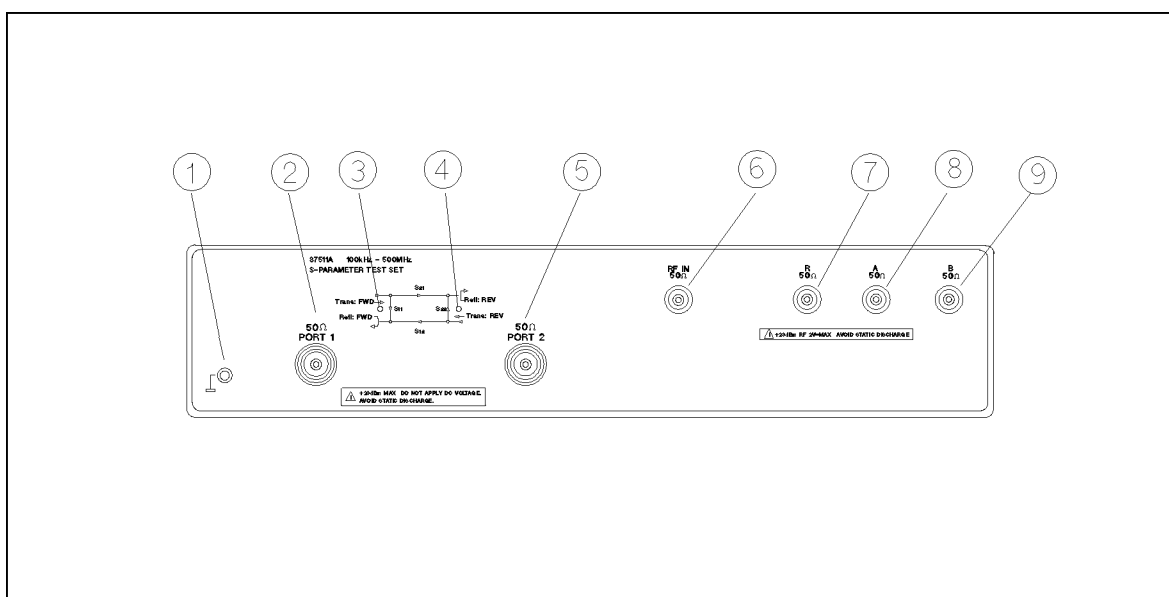
Alternatively, comparable packaging materials may be used. Wrap the test set in heavy paper or anti-static plastic. Use sufficient shock absorbing material on all sides of the 87511A/B to provide a thick, firm cushion and prevent movement. Seal the shipping container securely and mark it *FRAGILE*.

In any correspondence with Agilent Technologies, refer to the 87511A/B by its full model and serial number.

Operation

INTRODUCTION

This chapter illustrates the features of the front and rear panels of the 87511A/B (Figure 3-1 and Figure 3-2). Figure 3-3 shows a typical test set measurement setup. Figure 3-4 depicts the RF signal path through the test set for each of the four S-parameter measurements.



AB003001

Figure 3-1. Front Panel Features

1. *Guard Terminal*. This terminal is tied to the instrument's chassis and can be used for measurements that require guarding.
2. *PORT 1*. The device under test is connected here or to port 2 or to both

Caution

Do not input more than +23 dBm or any DC Voltage to PORT 1 and PORT 2.



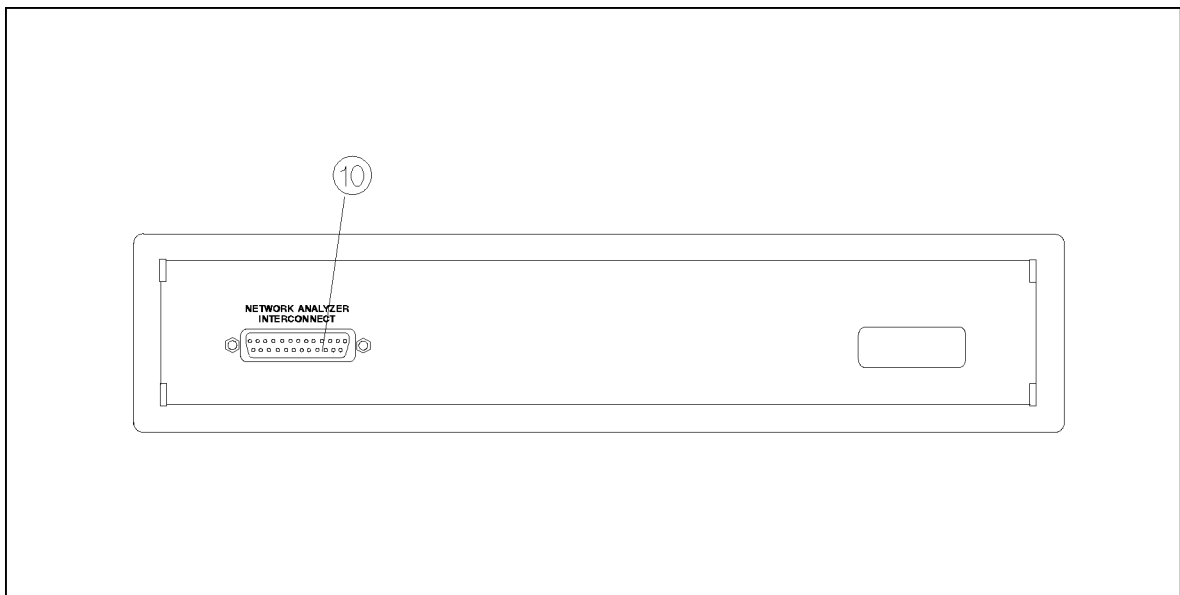
Note

The connector for the PORT 1 terminal is designed with a MOVABLE TEST PORT; and this is not a defect.



3. *S₁₁ S₂₁ Indicator LED*. This indicator lights when the test set is in the S₁₁ or S₂₁ measurement mode and power is incident from port 1.

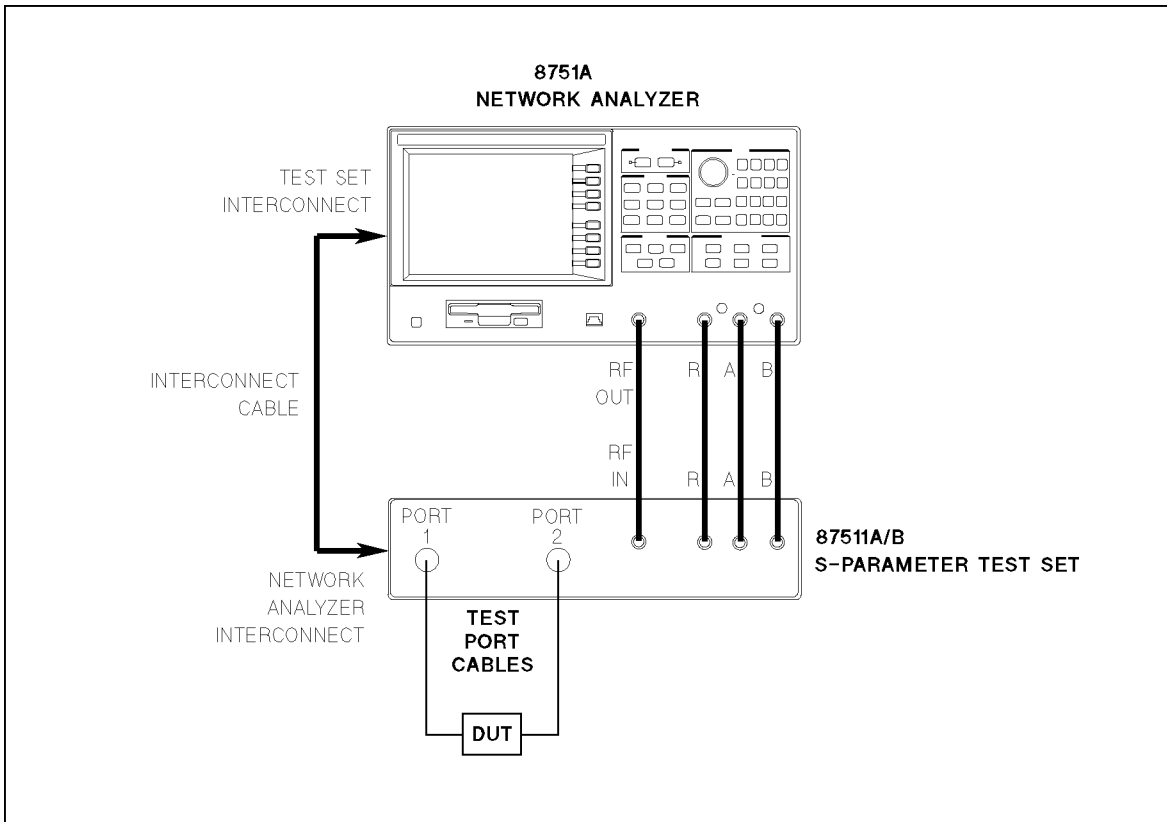
4. *S₂₂ S₁₂ Indicator LED*. This indicator lights when the test set is in the S₂₂ or S₁₂ measurements mode and power is incident from port 2.
5. *PORT 2*. The device under test is connected here or to port 1 or to both
6. *RF IN*. This RF input connector receives the RF signal from the 8751A RF OUT connector.
7. *R*. This RF connector provides the reference signal to port R of the 8751A.
8. *A*. This RF connector provides an RF input signal to port A of the 8751A from the device under test.
9. *B*. This RF connector provides an RF input signal to port B of the 8751A from the device under test.



AS003002

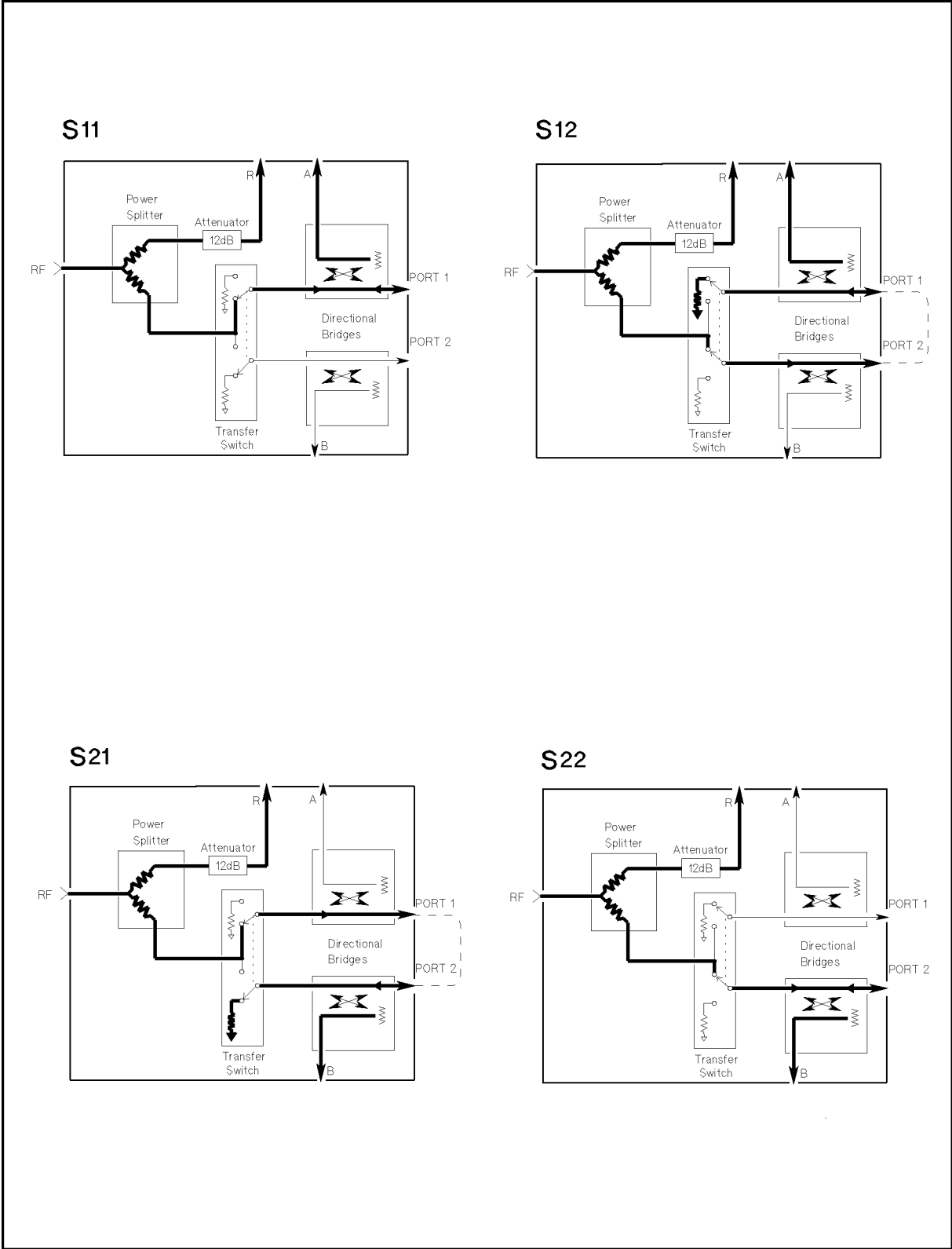
Figure 3-2. Rear Panel Features

10. *NETWORK ANALYZER INTERCONNECT* This connector supplies the test set with power from the network analyzer and also serves as a bidirectional control path.



A8003003

Figure 3-3. Typical Measurement Setup



A8003004

Figure 3-4. RF Signal Path

3-4 Operation

Performance Tests

INTRODUCTION

This chapter provides the test procedures used to verify that the 87511A/B's specifications listed in this manual are met. All tests can be performed without access to the interior of the instrument. The performance tests can also be used to perform incoming inspection, and to verify that the 87511A/B meets performance specifications after troubleshooting or adjustment. If the performance tests indicate that the 87511A/B is NOT operating within the specified limits, check your test setup, and then proceed to Adjustments or Troubleshooting in the 87511A/B service manual, if necessary.

Note Perform all performance tests in an ambient temperature of $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$.



PERFORMANCE TEST RECORD

Record the performance test results in the Test Record at the end of this chapter (Photocopy the Test Record and use the photocopy). The Test Record lists all test specifications and their acceptable limits. Test results recorded during incoming inspection can be used for comparison purposes during periodic maintenance, troubleshooting, and after repair or adjustment.

Note The test limits indicated for each test do not take into account the measurement error of the test equipment used. Be sure to take the test equipment's measurement error into account when determining whether or not the 87511A/B meets specifications.



CALIBRATION CYCLE

The 87511A/B requires periodic performance verification. The frequency of performance verification depends on the operating and environmental conditions under which the 87511A/B is used. Verify the 87511A/B's performance at least once a year, using the performance tests described in this chapter.

EQUIPMENT REQUIRED

The equipment required for performance testing is listed in Table 4-1. Substitutions can be made for the equipment in this list if the specifications meet or exceed the specifications listed in the requirement column.

Table 4-1. Recommended Test Equipment

| Instrument | Critical Specifications | Recommended Model |
|------------------|--|-------------------|
| Network Analyzer | no substitute | 8751A |
| Cable | RF Cable Set (50 Ω type-N, three 24 inch phase-matched, one 35 inch) | 11851B |
| | Interconnect Cable | PN 87511-61609 |
| | RF connecting Cable, 4 ea. | PN 8120-4387 |
| | GPIB Cable | 10833A |
| Calibration Kit | no substitute | 85031B |
| | | 85032B |
| | | 85036B |
| Adapter | 7 mm-N(f), 50 Ω , 2 ea. | PN 85054-60001 |
| | Minimum Loss Pad | 11852B |
| Load | type-N, 50 Ω (return loss \geq 49) | 909F Opt.012 |
| Controller | HP Technical Computer with BASIC rev 5.0 or above | HP 9000 Model 310 |
| Disk Drive | CS80 | 9122A |
| DVM | DC: up to 22 V ¹ | 3458A |

1 Only Used For Troubleshooting

DIRECTIVITY TEST

Directivity is a measure of the ability of a directive device (in this case the 87511A/B) to discriminate between incident and reflected signals. In this procedure directivity is tested by using the internal bridge to measure the reflection coefficient of a standard termination. Since the return loss of the termination is much greater than the directivity of the test set, the measurement made in this procedure is essentially the directivity of the 87511A/B test set. Use the highest quality termination available as that factor determines the accuracy of the procedure.

Specification

Directivity

| Frequency Range | 87511A | 87511A Opt. 001 | 87511B |
|-------------------------------------|--------------|--------------------|--------------|
| 100 kHz \leq Freq. \leq 300 kHz | \geq 30 dB | \geq 30 dB | \geq 30 dB |
| 300 kHz $<$ Freq. \leq 200 MHz | \geq 40 dB | \geq 37 dB | \geq 33 dB |
| 200 MHz $<$ Freq. \leq 500 MHz | \geq 35 dB | \geq 35 dB | \geq 33 dB |

Test Equipment

| Test Equipment | 87511A | 87511A Opt.001 | 87511B |
|-------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| Network Analyzer | 8751A | 8751A | 8751A |
| Interconnect cable | PN 87511-61609 ¹ | PN 87511-61609 ¹ | PN 87511-61609 ¹ |
| RF Cable | PN 8120-4387 ² , 4 ea. | PN 8120-4387 ² , 4 ea. | PN 8120-4387 ² , 4 ea. |
| Calibration Kit | 85031B | 85032B | 85036B |
| 50 Ω Termination | | 909F Opt.012 | |

1 This cable is supplied with test set.

2 This cable is supplied with test set.

Procedure

Note



By convention, when the connector sex is indicated in parentheses for a calibration standard, it refers to the sex of the test port connector (not the actual standard). For example, short (f) indicates that the test port connector, note the short circuit connector, is female.

1. Connect the equipment as shown in Figure 4-1.

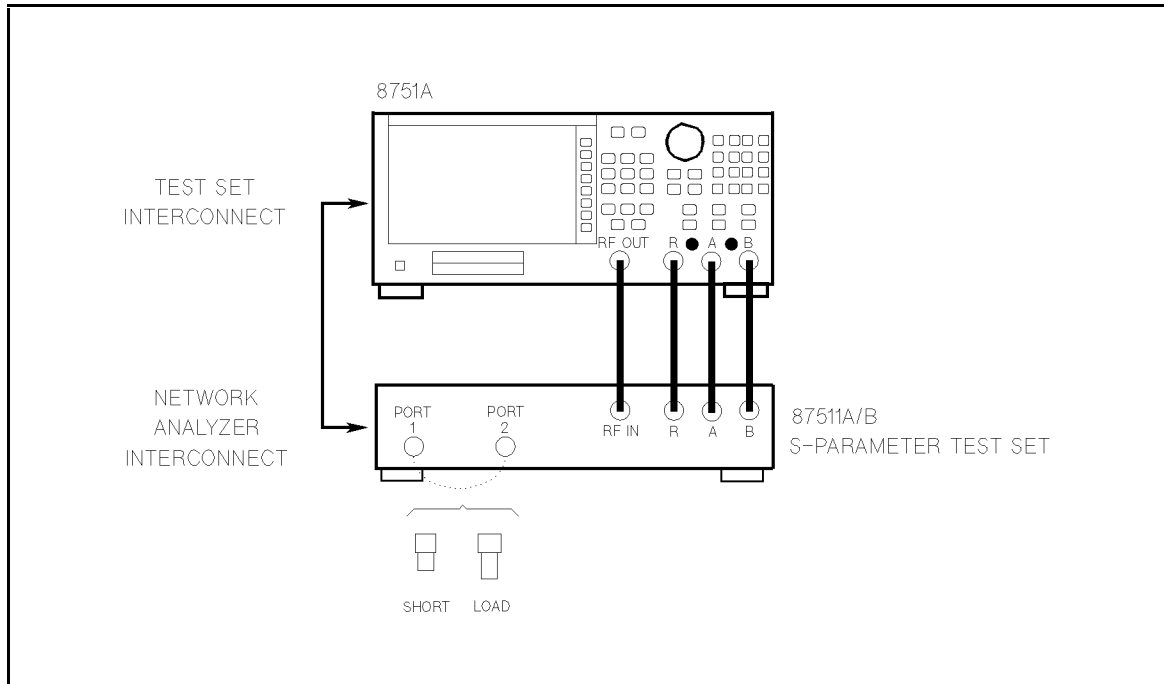


Figure 4-1. Directivity Test Setup

2. Set the 8751A as follows:

Control Settings

PRESET

Source Power = 0 dBm (87511A)

Source Power = 10 dBm (87511B)

Sweep Type: LOG FREQ

IF BW = 200 Hz

Key Strokes

PRESET

MENU, **0**, **x1**

MENU, **1**, **0**, **x1**

MENU, **SWEEP TYPE MENU**, **LOG FREQ**

AVG, **IF BW**, **2**, **0**, **0**, **x1**

3. To set the system impedance,

87511A: Press **CAL**, **CAL KIT**, **7 mm**.

8751A Opt.001: Press **CAL**, **CAL KIT**, **N 50 Ω**.

87511B: Press **CAL**, **CAL KIT**, **N 75 Ω**.

4. Press **CAL**, **CALIBRATE MENU**, **RESPONSE** to enter the response calibration menu.
5. When prompted, connect the SHORT supplied with the calibration kit to the test set's TEST PORT 1.
6. Press **SHORT** (**SHORT[F]** for 87511A opt. 001 and 87511B) to measure the calibration standard on the 8751A.
7. Press **DONE: RESPONSE** after the short has been measured. The status indicator "Cor" should appear at the left side of the display.
8. Remove the SHORT, and connect the following Termination to 87511A/B TEST PORT 1.

4-4 Performance Tests

87511A: 7 mm 50 Ω Termination supplied with the 85031B
 87511A Opt.001: Type-N 50 Ω Termination (909F opt.012)
 87511B: Type-N 75 Ω Termination supplied with the 85036B

9. Perform the following key strokes to generate a single sweep.
 [MENU], TRIGGER MENU, SINGLE
10. Perform the following key strokes to set the marker search range from 100 kHz to 300 kHz.
 [MKR], ACTIVE MARKER, MARKER 2, [3], [0], [0], [k/m], [MKR], Δ MODE MENU, Δ REF MARKER, Δ REF-1, [MKR FCTN], SEARCH RANGE, SEARCH RNG STORE, PART SEARCH on OFF
11. Perform the following key strokes to move the marker to the maximum point. Record the maximum reading value on the Performance Test Record.
 [MKR FCTN], MKR SEARCH, MAX, [MKR], Δ MODE MENU, Δ MODE OFF
12. Press Δ REF MARKER, Δ REF-1.
13. Perform the following key strokes to set the marker search range from 300 kHz to 200 MHz.
 [MKR], ACTIVE MARKER, MARKER 1, [2], [0], [0], [k/m], [MKR], ACTIVE MARKER, MARKER 2, [1], [9], [9], [0], [7], [M/u], [MKR FCTN], SEARCH RANGE, SEARCH RNG STORE
14. Perform the following key strokes to move the marker to the maximum point. Record the maximum reading value on the Performance Test Record.
 [MKR FCTN], MKR SEARCH, MAX, [MKR], Δ MODE MENU, Δ MODE OFF
15. Press Δ REF MARKER, Δ REF-1.
16. Perform the following key strokes to set the marker search range from 200 MHz to 500 MHz.
 [MKR], ACTIVE MARKER, MARKER 1, [1], [9], [9], [0], [7], [M/u], [MKR], ACTIVE MARKER, MARKER 2, [3], [0], [0], [M/u], [MKR FCTN], SEARCH RANGE, SEARCH RNG STORE
17. Perform the following key strokes to move the marker to the maximum point. Record the maximum reading value on the Performance Test Record.
 [MKR FCTN], MKR SEARCH, MAX, [MKR], Δ MODE MENU, Δ MODE OFF
18. Press [MEAS], REFL:REV S22(B/R).
19. Press [CAL], CALIBRATE MENU, RESPONSE, to enter the calibration menu.
20. When prompted, connect the SHORT supplied with the calibration kit to 87511A/B TEST PORT 2.
21. Press SHORT (SHORT[F] for 87511A Opt. 001 and 87511B) to measure the calibration standard on the 8751A.

22. Press **DONE: RESPONSE** after the short has been measured. The status indicator “Cor” should appear at the left side of the display.
23. Remove the SHORT, and connect the following Termination to 87511A/B TEST PORT 2.

87511A: 7 mm 50 Ω Termination supplied with the 85031B
 87511A Opt.001: Type-N 50 Ω Termination (909F opt.012)
 87511B: Type-N 75 Ω Termination supplied with the 85036B

24. Perform the following key strokes to generate a single sweep.

MENU, **TRIGGER MENU**, **SINGLE**

25. Perform the following key strokes to set the marker search range from 100 kHz to 300 kHz.

MKR, **ACTIVE MARKER**, **MARKER 1**, **1**, **0**, **0**, **k/m**, **ACTIVE MARKER**, **MARKER 2**, **3**, **0**, **0**, **k/m**, **MKR**, **Δ MODE MENU**, **Δ REF MARKER**, **ΔREF-1**, **MKR FCTN**, **SEARCH RANGE**, **SEARCH RNG STORE**.

26. Perform the following key strokes to move the marker to the maximum point. Record the maximum reading value on the Performance Test Record.

MKR FCTN, **MKR SEARCH**, **MAX**, **MKR**, **Δ MODE MENU**, **Δ MODE OFF**

27. Press **Δ REF MARKER**, **ΔREF-1**.

28. Perform the following key strokes to set the marker search range from 300 kHz to 200 MHz.

MKR, **ACTIVE MARKER**, **MARKER 1**, **2**, **0**, **0**, **k/m**, **MKR**, **ACTIVE MARKER**, **MARKER 2**, **1**, **9**, **9**, **0**, **7**, **M/u**, **MKR FCTN**, **SEARCH RANGE**, **SEARCH RNG STORE**

29. Perform the following key strokes to move the marker to the maximum point. Record the maximum reading value on the Performance Test Record.

MKR FCTN, **MKR SEARCH**, **MAX**, **MKR**, **Δ MODE MENU**, **Δ MODE OFF**

30. Press **Δ REF MARKER**, **ΔREF-1**.

31. Perform the following key strokes to set the marker search range from 200 MHz to 500 MHz.

MKR, **ACTIVE MARKER**, **MARKER 1**, **1**, **9**, **9**, **0**, **7**, **M/u**, **MKR**, **ACTIVE MARKER**, **MARKER 2**, **3**, **0**, **0**, **M/u**, **MKR FCTN**, **SEARCH RANGE**, **SEARCH RNG STORE**

32. Perform the following key strokes to move the marker to the maximum point. Record the maximum reading value on the Performance Test Record.

MKR FCTN, **MKR SEARCH**, **MAX**, **MKR**, **Δ MODE MENU**, **Δ MODE OFF**

SWITCH REPEATABILITY TEST

The test checks the repeatability of the switch by toggling it ten times and comparing the initial trace to the resultant trace after toggling.

Specification

Switch Repeatability: ± 0.03 dB

Test Equipment

| Test Equipment | 87511A | 8751A Opt.001 | 87511B |
|---------------------------------|-------------------------------------|-----------------------------------|-----------------------------------|
| Network Analyzer | 8751A | 8751A | 8751A |
| RF Cable Set | 11851B | 11851B | 11851B |
| Adapters | PN 85054-60001 ¹ , 2 ea. | | 11852B, 2 ea. ² |
| Interconnect Cable ³ | PN 87511-61609 ³ | PN 87511-61609 ³ | PN 87511-61609 ³ |
| RF Cable | PN 8120-4387 ³ , 2 ea. | PN 8120-4387 ³ , 2 ea. | PN 8120-4387 ³ , 2 ea. |

1 A part of the 85032B calibration kit

2 Minimum Loss Pad

3 This cable is supplied with test set

Procedure

1. Connect the equipment as shown in Figure 4-2.

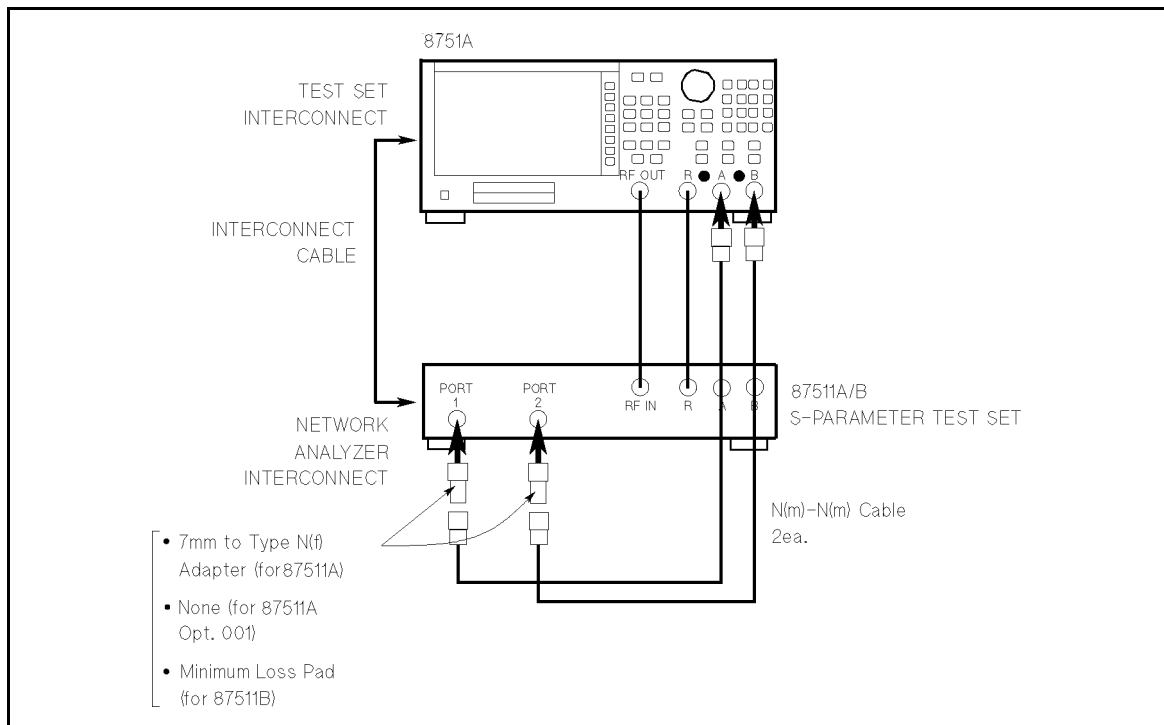


Figure 4-2. Switch Repeatability Test Setup

2. Set up the 8751A as follows:

Control Settings

Key Strokes

PRESET

PRESET

Source Power = 0 dBm (87511A)

MENU, **POWER**, **0**, **x1**

Source Power = 10 dBm (87511B)

MENU, **POWER**, **1**, **0**, **x1**

IF Bandwidth = 200 Hz

AVG, **IF BW**, **2**, **0**, **0**, **x1**

Scale Ref. = 0.01

SCALE REF, **0**, **1**, **x1**

3. Press **MENU**, **TRIGGER MENU**, **SINGLE** to generate a single sweep with the network analyzer.
4. At the end of the sweep, press **DISPLAY**, **DEFINE TRACE**, **DATA->MEMORY**, **DATA/MEM** to store the sweep in memory.
5. Press **MENU**, **TRIGGER MENU**, **CONTINUOUS** to put the 8751A in continuous sweep in memory.
6. Press **MEAS** and then toggle the 87511A/B switch by alternately pressing **Ref1:REV S22(B/R)** and **Ref1:FWD S11 (A/R)** ten times on the 8751A. You should be able to hear the switch cycle and see two LEDs light alternately each time you press the keys. Finish with the instrument in the “Ref: FWD S11” mode.
7. Press **MENU**, **TRIGGER MENU**, **SINGLE** to generate one more sweep.
8. Note the amount the trace deviates from the reference line and enter that value in the Performance Test Record (S11).
9. Press **MEAS**, **Ref1:REV S22(B/R)**, **MENU**, **TRIGGER MENU**, **SINGLE** to generate a single sweep in the S22 measurement mode.
10. At the end of the sweep, press **DISPLAY**, **DEFINE TRACE**, **DATA->MEMORY**, **DATA/MEM** to store the sweep measurement data into memory.
11. Press **MENU**, **TRIGGER MENU**, **CONTINUOUS** to put the 8751A in continuous sweep in memory.
12. Press **MEAS** and then toggle the 87511A/B switch by alternately pressing **Ref1:FWD S11 (A/R)** and **Ref1:REV S22 (B/R)** on the 8751A ten times. You should be able to hear the switch cycle and see two LEDs light alternately each time you press the keys. Finish with the instrument in the “Ref: REV S22(B/R)” mode.
13. Press **MENU**, **TRIGGER MENU**, **SINGLE** to generate one more sweep.
14. Note the amount the trace deviates from the reference line and enter that value in the Performance Test Record (S22).

EFFECTIVE SOURCE MATCH TEST

This test checks the source match of the 87511A/B. This procedure determines the effective source match of port 1 and port 2 by examining the calibration coefficient arrays. These arrays are generated during measurement calibration. The array data are the difference between the measured known calibration standards and ideal modeled data. Thus the calibration coefficient arrays are a direct indication of performance because they represent the systematic errors of the test set.

Specification

| Frequency Range | 87511A | 87511A Opt.001 | 87511B |
|-------------------------------------|--------------|-------------------|--------------|
| 100 kHz \leq Freq. \leq 300 kHz | \geq 15 dB | \geq 15 dB | \geq 15 dB |
| 300 kHz $<$ Freq. \leq 500 MHz | \geq 20 dB | \geq 20 dB | \geq 20 dB |

Test Equipment

| Test Equipment | 87511A | 87511A Opt.001 | 87511B |
|----------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| Network Analyzer | 8751A | 8751A | 8751A |
| RF cable | PN 8120-4387 ¹ , 4 ea. | PN 8120-4387 ¹ , 4 ea. | PN 8120-4387 ¹ , 4 ea. |
| Interconnect cable | PN 87511-61609 ¹ | PN 87511-61609 ¹ | PN 87511-61609 ¹ |
| Calibration Kit | 85031B | 85032B | 85036B |
| 50 Ω Termination | | 909F Opt.012 | |
| Controller | HP 9000 Model 310 | HP 9000 Model 310 | HP 9000 Model 310 |
| Disk Drive | 9122A | 9122A | 9122A |
| GPIB Cable | 10833A, 2 ea. | 10833A, 2 ea. | 10833A, 2 ea. |
| BASIC 5.1 Operating System | 98616A | 98616A | 98616A |

¹ This cable is supplied with test set.

Procedure

1. Connect the equipment as shown in Figure 4-3.

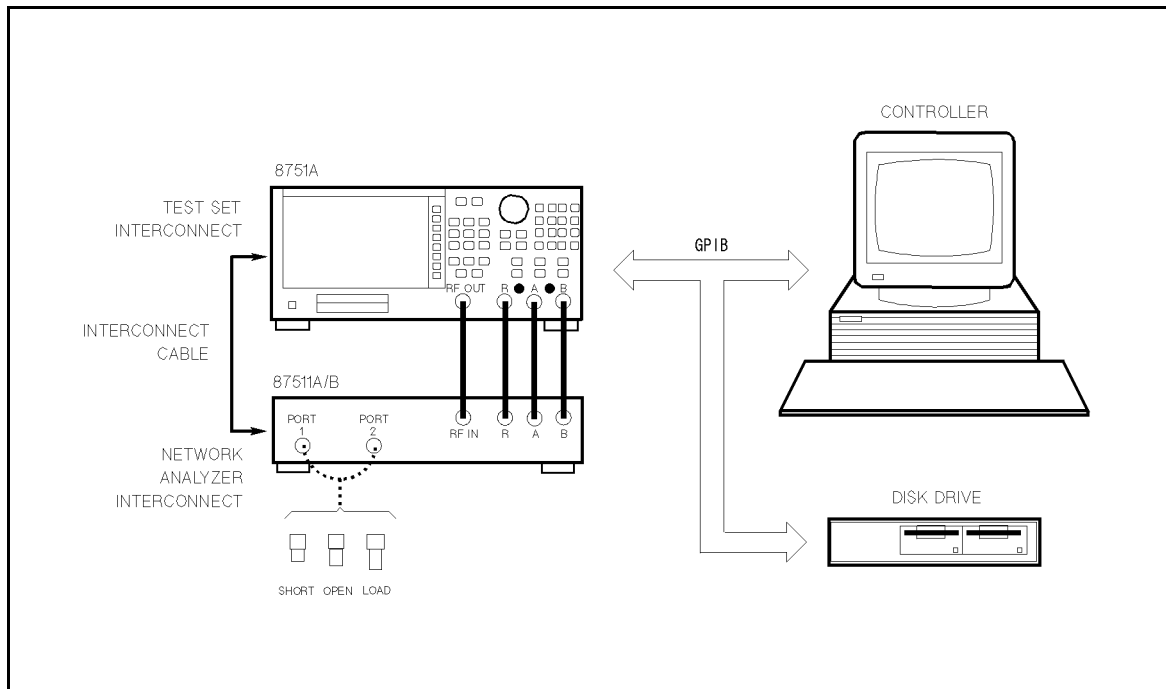


Figure 4-3. Effective Source Match Test Setup

2. Set the 8751A as follows:

Control Settings

PRESET

Sweep Type: LOG FREQ

Source Power = 0 dBm (87511A)

Source Power = 10 dBm (87511B)

IF Bandwidth = 200 Hz

Key Strokes

PRESET

MENU, **SWEEP TYPE MENU**, **LOG FREQ**

MENU, **POWER**, **0**, **x1**

MENU, **POWER**, **1**, **0**, **x1**

AVG, **IF BW**, **2**, **0**, **0**, **x1**

3. To set the system impedance,

87511A: Press **CAL**, **CAL KIT**, **7 mm**.

87511A Opt.001: Press **CAL**, **CAL KIT**, **N 50 Ω**.

87511B: Press **CAL**, **CAL KIT**, **N 75Ω**.

4. Press the **CAL**, **CALIBRATE MENU**, **S11 1-PORT** to enter the 1-port calibration menu, and then perform the 1-port calibration as follows.

1-PORT Calibration

- a. Connect an OPEN to the TEST PORT 1 of the 87511A/B, and press the following softkeys.

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87511A: Press **OPEN** .
 87511A Opt. 001: Press **OPENS** , **OPEN[F]** , **DONE: OPENS** .
 87511B: Press **OPENS** , **OPEN[F]** , **DONE: OPENS** .

- b. Remove the OPEN from the TEST PORT 1, and connect the SHORT to the TEST PORT 1, and press the following softkeys.

87511A: Press **SHORT** .
 87511A Opt. 001: Press **SHORTS** , **SHORT[F]** , **DONE: SHORTS** .
 87511B: Press **SHORTS** , **SHORT[F]** , **DONE: SHORTS** .

- c. Remove the SHORT from the TEST PORT 1, and connect the following Termination to the TEST PORT 1, and press **LOAD** .

87511A: 7mm - 50 Ω Termination supplied with the 85031B
 87511A Opt.001: Type-N 50 Ω Termination (909F opt.012)
 87511B: Type-N 75 Ω Termination supplied with the 85036B

- d. Press **DONE 1-PORT CAL** to conclude the calibration routine. The display should show "Cor" in the status indicator area.

5. Load BASIC and input the following program (do NOT *RUN* the program yet, however).

```

10 OPTION BASE 1
20 COMPLEX A(201)
30 DIM B(26),C(175)
40 REMOTE 717
50 OUTPUT 717;"FORM4"
60 OUTPUT 717;"OUTPCALCO2?"
70 ENTER 717;A(*)
80 OUTPUT 717;"INPUFORM";A(*)
90 FOR I=1 TO 26
100 B(I)=20*LOG(ABS(A(I)))
110 NEXT I
120 FOR I=27 to 201
130 C(I-26)=20*LOG(ABS(A(I)))
140 NEXT I
150 D=MAX(B(*))
160 E=MAX(C(*))
170 PRINT "Effective Source Match"
180 PRINT "100 kHz to 300 kHz:",D;"dB"
190 PRINT "300 kHz to 500 MHz:",E;"dB"
200 END

```

6. Press **LOCAL** , **SET ADDRESS** , **1** , **7** , **X1** to set the 8751A's GPIB address to 17.

7. RUN the program.

8. The effective source match is displayed on the computer. Record the Performance Test Program.
9. Press **LOCAL**.
10. Press **CAL**, **CALIBRATE MENU**, **S22 1-PORT** to enter 1-port calibration menu, and then perform the 1-port calibration as follows.

1-PORT Calibration

- a. Connect an OPEN to the TEST PORT 2 of the 87511A/B, and press the following softkeys.

87511A: Press **OPEN** .
 87511A Opt. 001: Press **OPENS** , **OPEN[F]** , **DONE: OPENS** .
 87511B: Press **OPENS** , **OPEN[F]** , **DONE: OPENS** .

- b. Remove the OPEN from the TEST PORT 2, and connect the SHORT to the TEST PORT 2, and press the following softkeys.

87511A: Press **SHORT** .
 87511A Opt. 001: Press **SHORTS** , **SHORT[F]** , **DONE: SHORTS** .
 87511B: Press **SHORTS** , **SHORT[F]** , **DONE: SHORTS** .

- c. Remove the SHORT from the TEST PORT 1, and connect the following Termination to the TEST PORT 1, and press **LOAD**.

87511A: 7mm - 50 Ω Termination supplied with the 85031B
 87511A Opt.001: Type-N 50 Ω Termination (909F opt.012)
 87511B: Type-N 75 Ω Termination supplied with the 85036B

- d. Press **DONE 1-PORT CAL** to conclude the calibration routine. The display should show "Cor" in the status indicator area.
11. RUN the program.
12. The effective source match is displayed on the computer. Record the Performance Test Program.

Performance Test Record

Agilent 87511A S-PARAMETER TEST SET

Date: _____
 Temperature: _____
 Humidity: _____
 Serial No.: _____
 Tested by: _____

| Parameter | Specification | Test Result | Measurement Uncertainty |
|---------------------------------|---------------|-------------|-------------------------|
| Directivity | | | |
| Port 1 | | | |
| 100 kHz \leq f < 300 kHz | \geq 30 dB | _____ | \pm 0.7 dB |
| 300 kHz \leq f \leq 200 MHz | \geq 40 dB | _____ | \pm 1.9 dB |
| 200 MHz < f \leq 500 MHz | \geq 35 dB | _____ | \pm 1.1 dB |
| Port 2 | | | |
| 100 kHz \leq f < 300 kHz | \geq 30 dB | _____ | \pm 0.7 dB |
| 300 kHz \leq f \leq 200 MHz | \geq 40 dB | _____ | \pm 1.9 dB |
| 200 MHz < f \leq 500 MHz | \geq 35 dB | _____ | \pm 1.1 dB |
| Switch Repeatability | | | |
| S11 | \pm 0.03 dB | _____ | negligible |
| S22 | \pm 0.03 dB | _____ | negligible |
| Effective Source Match | | | |
| Port 1 | | | |
| 100 kHz \leq f \leq 300 kHz | \geq 15 dB | _____ | \pm 0.5 dB |
| 300 kHz \leq f \leq 500 MHz | \geq 20 dB | _____ | \pm 0.8 dB |
| Port 2 | | | |
| 100 kHz \leq f \leq 300 kHz | \geq 15 dB | _____ | \pm 0.5 dB |
| 300 kHz \leq f \leq 500 MHz | \geq 20 dB | _____ | \pm 0.8 dB |

Agilent 87511A Option 001 S-PARAMETER TEST SET

Date: _____
 Temperature: _____
 Humidity: _____
 Serial No.: _____
 Tested by: _____

| Parameter | Specification | Test Result | Measurement Uncertainty |
|-------------------------------|---------------|-------------|-------------------------|
| Directivity | | | |
| Port 1 | | | |
| 100 kHz ≤ Freq. < 300 kHz | ≥ 30 dB | _____ | ± 0.9 dB |
| 300 kHz ≤ Freq. ≤ 200 MHz | ≥ 37 dB | _____ | ± 1.9 dB |
| 200 MHz < Freq. ≤ 500 MHz | ≥ 35 dB | _____ | ± 1.6 dB |
| Port 2 | | | |
| 100 kHz ≤ Freq. < 300 kHz | ≥ 30 dB | _____ | ± 0.9 dB |
| 300 kHz ≤ Freq. ≤ 200 MHz | ≥ 37 dB | _____ | ± 1.9 dB |
| 200 MHz < Freq. ≤ 500 MHz | ≥ 35 dB | _____ | ± 1.6 dB |
| Switch Repeatability | | | |
| S11 | ±0.03 dB | _____ | negligible |
| S22 | ±0.03 dB | _____ | negligible |
| Effective Source Match | | | |
| Port 1 | | | |
| 100 kHz ≤ Freq. ≤ 300 kHz | ≥ 15 dB | _____ | ± 0.8 dB |
| 300 kHz ≤ Freq. ≤ 500 MHz | ≥ 20 dB | _____ | ± 1.4 dB |
| Port 2 | | | |
| 100 kHz ≤ Freq. ≤ 300 kHz | ≥ 15 dB | _____ | ± 0.8 dB |
| 300 kHz ≤ Freq. ≤ 500 MHz | ≥ 20 dB | _____ | ± 1.4 dB |

Agilent 87511B S-PARAMETER TEST SET

Date: _____
 Temperature: _____
 Humidity: _____
 Serial No.: _____
 Tested by: _____

| Parameter | Specification | Test Result | Measurement Uncertainty |
|-------------------------------|---------------|-------------|-------------------------|
| Directivity | | | |
| Port 1 | | | |
| 100 kHz ≤ Freq. < 300 kHz | ≥ 30 dB | _____ | ± 1.4 dB |
| 300 kHz ≤ Freq. ≤ 200 MHz | ≥ 33 dB | _____ | ± 1.9 dB |
| 200 MHz < Freq. ≤ 500 MHz | ≥ 33 dB | _____ | ± 1.9 dB |
| Port 2 | | | |
| 100 kHz ≤ Freq. < 300 kHz | ≥ 30 dB | _____ | ± 1.4 dB |
| 300 kHz ≤ Freq. ≤ 200 MHz | ≥ 33 dB | _____ | ± 1.9 dB |
| 200 MHz < Freq. ≤ 500 MHz | ≥ 33 dB | _____ | ± 1.9 dB |
| Switch Repeatability | | | |
| S11 | ±0.03 dB | _____ | negligible |
| S22 | ±0.03 dB | _____ | negligible |
| Effective Source Match | | | |
| Port 1 | | | |
| 100 kHz ≤ Freq. ≤ 300 kHz | ≥ 15 dB | _____ | ± 0.8 dB |
| 300 kHz ≤ Freq. ≤ 500 MHz | ≥ 20 dB | _____ | ± 1.4 dB |
| Port 2 | | | |
| 100 kHz ≤ Freq. ≤ 300 kHz | ≥ 15 dB | _____ | ± 0.8 dB |
| 300 kHz ≤ Freq. ≤ 500 MHz | ≥ 20 dB | _____ | ± 1.4 dB |

Adjustments

The 87511A and 87511B S-parameter test sets have no adjustable components.

Service

INTRODUCTION

This chapter provides instructions for troubleshooting and repairing the 87511A and 87511B S-parameter test sets. It includes simplified block diagrams.

TROUBLESHOOTING

The intent of this chapter is to enable technicians to isolate problems to the assembly level, identify the defective assembly, and to order the replacement part. The block diagram, as shown in Figure 7-1, may be used to aid in troubleshooting. Recommended test equipment is listed in Table 4-1.

Troubleshooting Procedures

1. Check for proper voltages on the A1 logic assembly on the test sets.
 - a. A1TP3: +22 V
 - b. A1TP5: +5 V

The test set receives +22 Vdc from the 8751A via the interconnect cable. Thus If this check FAILED, check the interconnect cable's connection and function.

2. Check that the PORT 1 LED is lit on the test sets's front panel after turning on the 8751A with the test sets.

If the LED is NOT lit, replace the A1 logic board.

3. Perform the directivity performance tests in the Chapter 4. Performance Tests. If PORT 1's directivity test failed, replace the PORT 1's directional bridge. If PORT 2's directivity test failed, replace PORT 2's directional bridge.

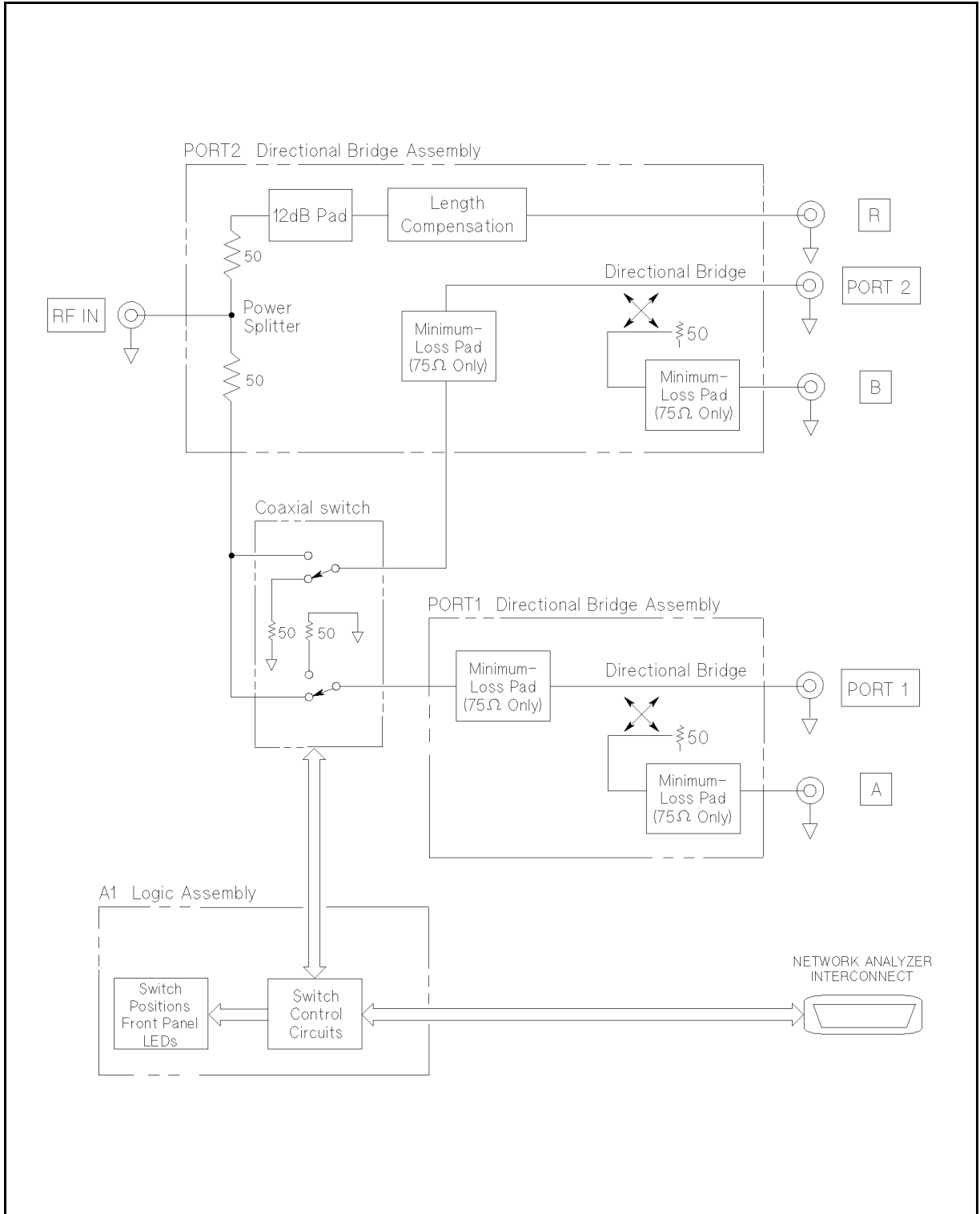


Figure 7-1. Simplified Block Diagram

Manual Changes

INTRODUCTION

This appendix usually contains information required to adapt this manual to earlier versions or configurations of the 87511A/B than the current printing date of this manual. The information is this manual directly to 87511A/B S-parameter test set whose serial number prefix is listed on the title page of this manual.

MANUAL CHANGES

To adapt this manual to your 87511A/B, refer to Table A-1, and make all of the manual changes listed opposite your instrument's serial number.

Instruments manufactured after the printing of this manual may be different than those documented in this manual. Later instrument versions will be documented in a manual change supplement that will accompany the manual shipped with that instrument. If your manual or in Table A-1, it may be documented in a yellow *MANUAL CHANGES* supplements.

For additional information on serial number coverage, refer to "Serial Number" in Chapter 1.

Table A-1. Manual Changes by Serial Number

| Serial Prefix or Number | Make Manual Changes |
|-------------------------|--|
| | There are no earlier configurations than the printing date of this manual. |

