S-PARAMETER TEST SET
8745A

SERIALS PREFIXED: 906-

This manual applies directly to HP Model 8745A S-Parameter Test Set Units having serial numbers prefixed 906-

SERIALS PREFIXED: 823-

See Appendix I

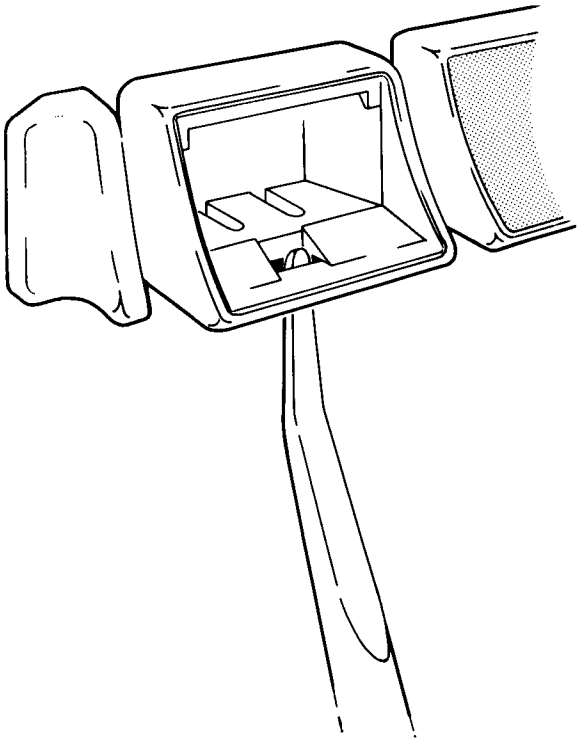
OTHER PREFIXES:

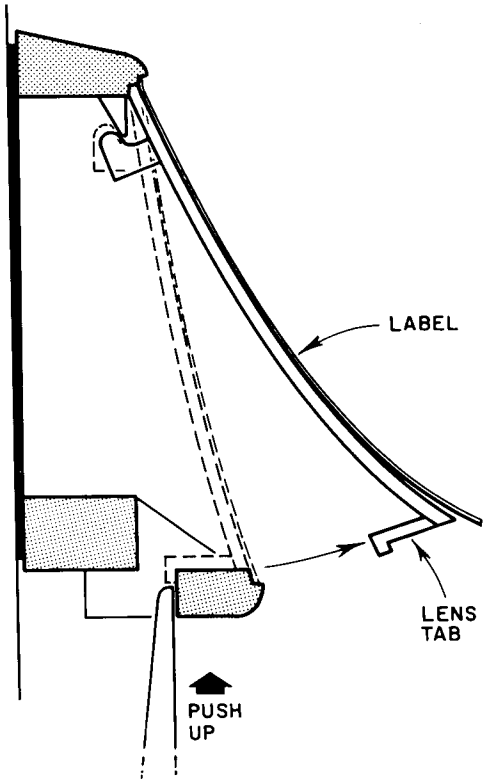
See Instruments Covered by Manual, Section I

08745-90009 **Printed: FEB 1969**

HEWLETT hp PACKARD

PUSHBUTTON LAMP REPLACEMENT





SIDE VIEW

1. DO NOT REMOVE PUSHBUTTON. Remove pushbutton lens and label by inserting a soldering aid or other small, blunt tool in the slot in the bottom of the pushbutton. Press tool forward against lens tab to release lens and label. If pushbutton comes out see NOTE in Step 3.

2. Remove defective lamp. A needle-nose pliers or tweezers can be used as an extracting tool. Install new lamp (HP part number 2140-0300).

3. Press lens and label into place in pushbutton opening.

NOTE:

If the pushbutton has been removed:

a. Reinstall pushbutton, lens and label removed.

b. Insert the metal contactor in slot of pushbutton as shown.

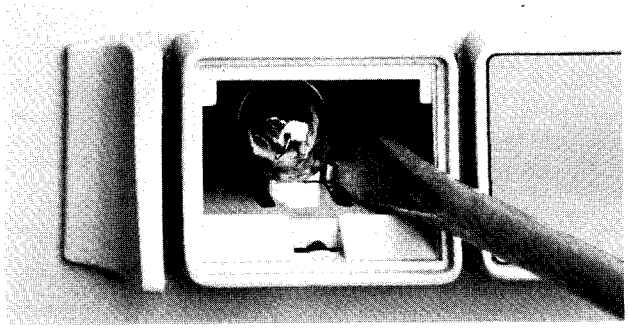
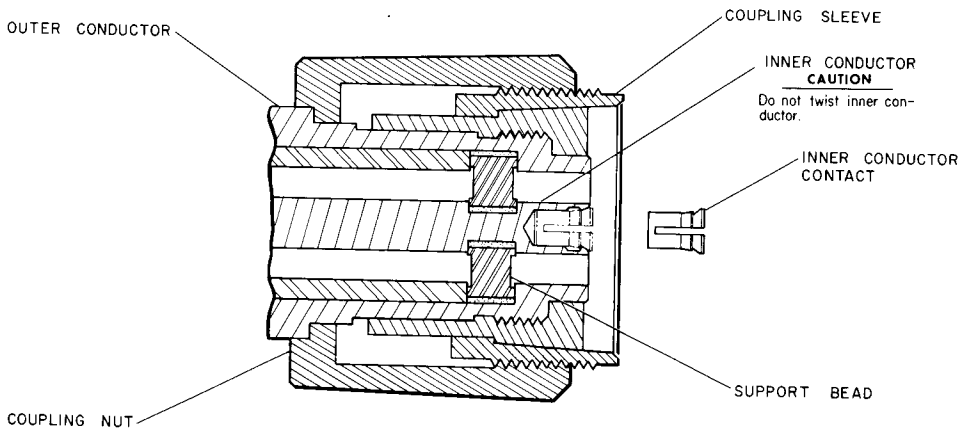


Figure 3-23. Pushbutton Lamp Replacement

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

APC-7 CONNECTORS



USE

To Connect:

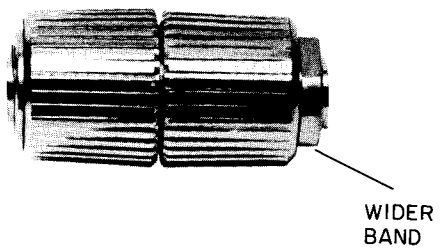
1. On one connector, retract the coupling sleeve by turning the coupling nut counterclockwise until the sleeve and nut disengage.

2. On the other connector, fully extend the coupling sleeve by turning the coupling nut clockwise. To engage coupling sleeve and coupling nut when the sleeve is fully retracted, press back lightly on the nut while turning it clockwise.

3. Push the connectors firmly together, and thread the coupling nut of the connector with retracted sleeve over the extended sleeve. Leave the other coupling nut in the original position: closing the gap between coupling nuts tends to loosen the electrical connection.

To Disconnect:

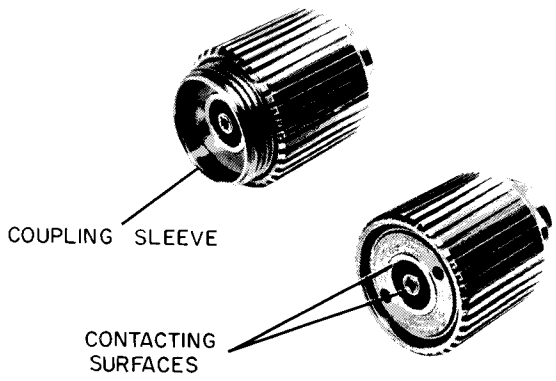
1. Loosen the coupling nut of the connector showing the wider gold band.



2. IMPORTANT: Part the connectors carefully to prevent striking the inner conductor contact.

CARE

1. Keep contacting surfaces smooth and clean. Irregularities and foreign particles can degrade electrical performance.



2. Protect the contacting surfaces when the connector is not in use by leaving the coupling sleeve extended.

3. Use lintless material and/or firm-bristled brush such as toothbrush for cleaning. If a cleaning fluid is needed use isopropyl alcohol. IMPORTANT: Do not use aromatic or chlorinated hydrocarbons, esters, ethers, terpenes, higher alcohols, ketones, or ether-alcohols such as benzene, toluene, turpentine, dioxane, gasoline, cellosolve acetate, or carbon tetrachloride. Keep exposure of the connector parts to both the cleaning fluid and its vapors as brief as possible.

Figure 3-22. APC-7 Connectors

LIST OF TABLES

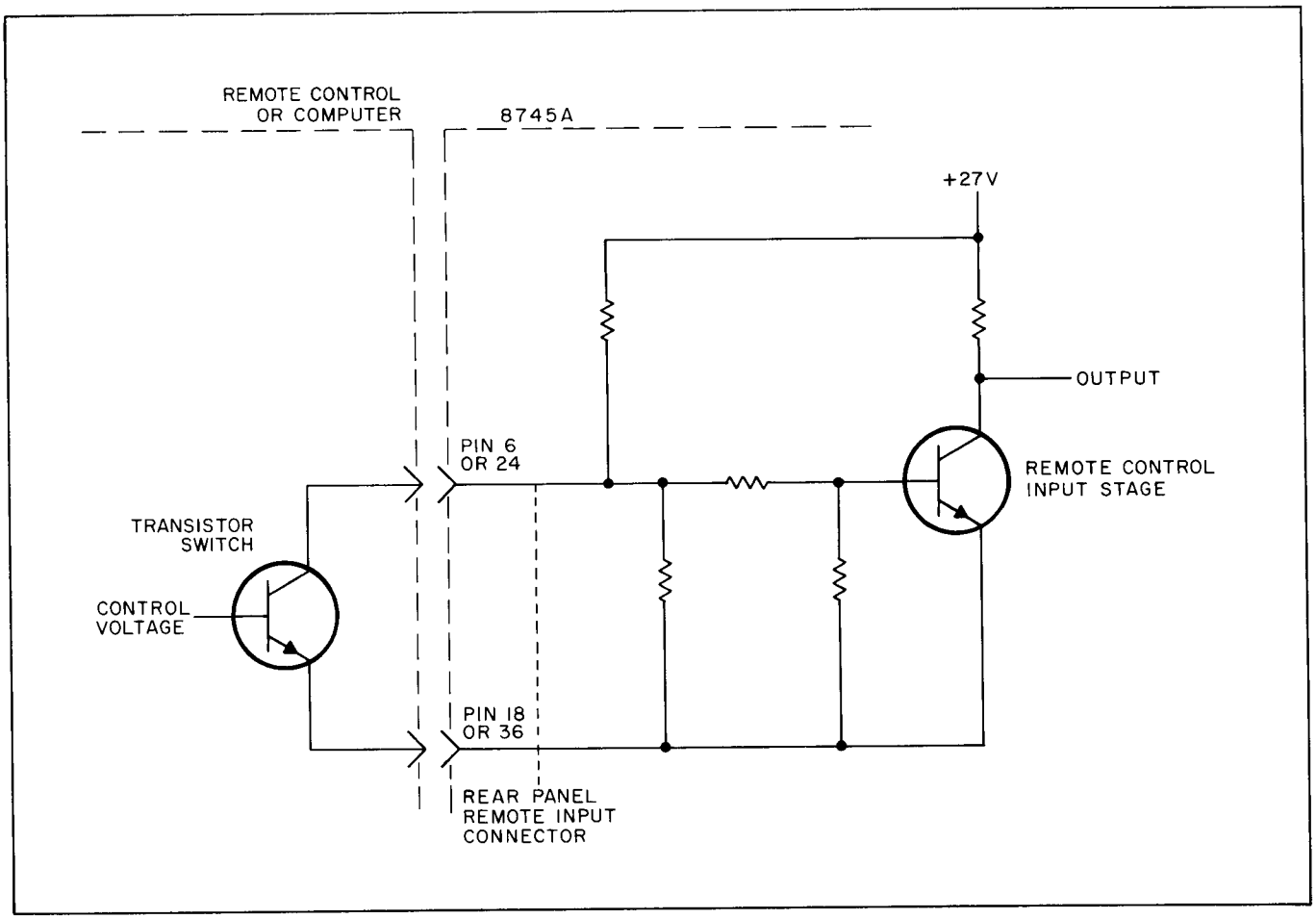


Figure 3-21. Typical Remote Contact Closure Circuit

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

d. Do not attempt to repair contacts.

e. Do not re-use contacts.

CAUTION

Inward pressure or twisting force applied to the inner conductor can render the Model 8745A inoperative.

3-39. Because of the above considerations, contact removal should not be attempted with ordinary hand tools. Only the Hewlett-Packard self-positioning, hypodermic-action, contact extractor tool (Part Number 5060-0236)* should be used. This tool exerts no appreciable inward pressure and no twisting force on the inner conductor. Instructions for removing contacts are supplied with the tool.

3-40. No tool is required for installing a replacement contact. Insert the contact gently by hand, applying only enough inward pressure to snap it into place. Then check for proper installation by inspecting the contact for even spacing of its four segments. Also, test for normal spring action by applying light inward pressure against the end of the contact with a pencil eraser. As the pressure is released the contact's spring action should cause it to move outward. If not, the contact is defective and should be replaced.

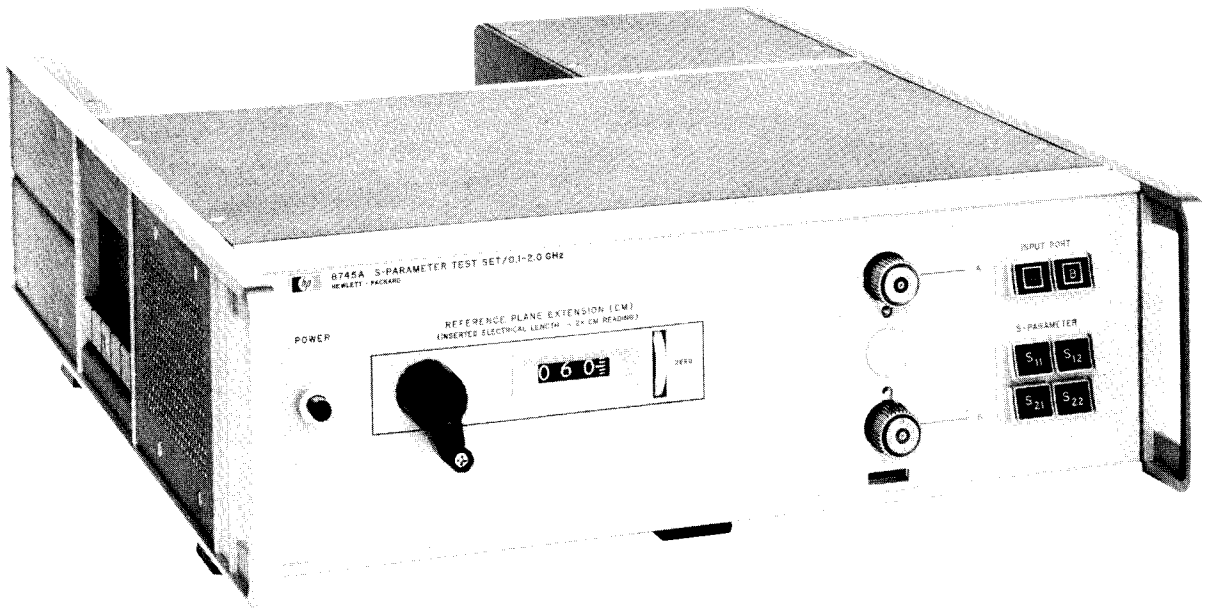
3-41. COUPLING MECHANISMS.

3-42. The coupling mechanism includes the coupling nut and the two-piece coupling sleeve assembly shown in Figure 3-22. Both of these parts can be replaced using procedures in Paragraph 4-33.

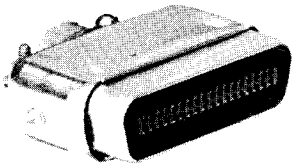
3-43. POWER SWITCH LAMP REPLACEMENT.

3-44. The lamp that indicates line power is applied to the Model 8745A is housed in the POWER switch pushbutton. To replace the lamp, unscrew the retaining ring near the front panel, pull out the pushbutton, and remove the lamp. Replacement lamp is HP Part Number 2140-0052, LAMP: GLOW.

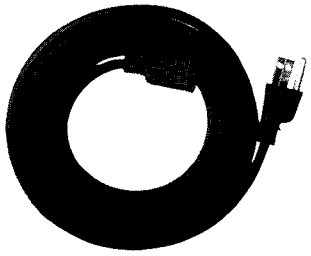
* Part of APC-7 Connector Tool Kit HP 11591A.



8745A

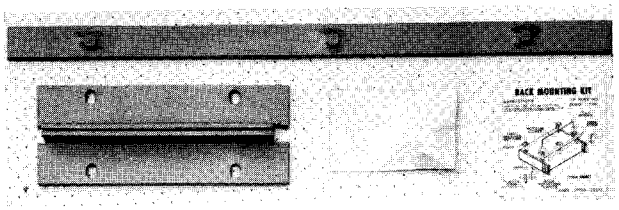


36-PIN CONNECTOR



POWER CABLE

SUB-DECK EXTENSION



RACK MOUNTING KIT

Figure 1-1. Model 8745A S-Parameter Test Set and Accessories.

3-32. A typical contact closure circuit is shown in Figure 3-21. The 8745A supplies approximately +12 Vdc when the contact is open and 12 mA of current flows when the contact is closed. Noise on the remote control lines should not exceed 3 volts peak-to-peak in the open circuit condition and 1.8 volts peak-to-peak in the closed circuit condition.

3-33. CARE OF APC-7 CONNECTORS.

3-34. RF connections to and from the device under test and to the phase-amplitude ratio indicator are made with APC-7 style, 50-ohm, 7-mm sexless connectors. These connectors should be handled with particular care for two reasons:

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

b. The inner conductors of the front-panel connectors are attached to directional coupler striplines, and any rotational force on the inner conductor may result in damage to the directional coupler.

3-35. Important recommendations about the handling and care of the APC-7 connectors are given in Figure 3-22. The part of an input connector that is most likely to be damaged is the inner conductor contact. Since it protrudes slightly beyond the plane of electrical contact, any wiping action of one connector across the other can damage the contact enough to cause a discontinuity. The risk of this kind of damage can be minimized, as stated in Figure 3-22, by always having the coupling sleeves on the input port connectors fully extended.

3-36. CONTACT REPLACEMENT.

3-37. Replacement inner conductor contacts are available from Hewlett-Packard (Part Number 1250-0907), and from Amphenol RF Division, Danbury, Connecticut (Part Number 131-129).

3-38. The important precautions that apply to the replacement of inner conductor contacts are these:

a. Do not disassemble the connector.

b. Do not apply more than slight inward pressure to the inner conductor.

Table 3-3. Signal Requirements for Remote S-Parameter Selection

Parameter to be measured	Input connected to PORT A			Input connected to PORT B		
	Pin 18 or 36 to:		Lamps Lit	Pin 18 or 36 to:		Lamps Lit
	Pin 24	Pin 6		Pin 24	Pin 6	
S_{11}	Open	Open	A, S_{11}	Shorted	Shorted	A, S_{22}
S_{12}	Open	Shorted	A, S_{12}	Shorted	Open	A, S_{21}
S_{21}	Shorted	Open	A, S_{21}	Open	Shorted	A, S_{12}
S_{22}	Shorted	Shorted	A, S_{22}	Open	Open	A, S_{11}

Before selecting parameters, setup for remote control by shorting pin 17 to either pin 18 or 36.
NOTE: There are two requirements for selecting each parameter.

SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Model 8745A S-Parameter Test Set contains the necessary microwave circuits for measuring s parameters from 0.1 to 2.0 GHz. It is designed to be used with a compatible phase-amplitude ratio indicator, such as the Model 8410A Network Analyzer or Model 8405A Vector Voltmeter. The measuring circuits for each s parameter are automatically set up with a front-panel pushbutton or with remote contact closures.

1-3. The s parameters of almost any device such as a microwave component or a transistor can be measured using one of the accessory fixtures. For transistor measurement, terminals are provided to apply dc bias. An accessory quick-connect adapter allows fixtures to be connected and disconnected from the 8745A with quick, simple lever action.

1-4. A built-in, calibrated line stretcher simplifies initial phase calibration and allows the plane of measurement to be extended beyond the 8745A terminals.

1-5. ACCESSORIES FURNISHED.

1-6. A rack-mounting kit, a male 36-pin connector (HP Part Number 1251-0084), a detachable power cable, and a platform to extend the sub-deck are furnished with the Model 8745A (see Figure 1-1).

1-7. RACK MOUNTING KIT.

1-8. The rack mounting kit contains all the hardware needed to adapt the Model 8745A cabinet for installation in equipment racks with standard 19-inch spacing. Instructions for conversion to rack mounting are included with the kit.

1-9. THIRTY-SIX PIN MALE CONNECTOR.

1-10. The 36-pin male connector mates with the rear-panel REMOTE INPUT connector, and permits all necessary remote programming and bias connections to be made to the 8745A. (See Table 3-1 for wiring information.)

1-11. SUB-DECK EXTENSION.

1-12. The sub-deck extension extends the sub-deck which supports the 8411A Harmonic Frequency Converter of the 8410A Network Analyzer. The sub-deck extension prevents strain on the connectors when attenuators are used between the 8411A and 8745A.

1-13. ACCESSORIES AVAILABLE.

1-14. TRANSISTOR FIXTURES.

1-15. The Models 11600A and 11602A Transistor Fixtures provide a convenient and accurate way to hold transistors and many other devices when making s-parameter measurements from dc to 2.0 GHz. The 11600A accepts transistors with TO-18 and TO-72 base patterns, and has four snap-on dials, two for bipolar transistors and two for FET's. The 11602A accepts transistors with TO-5 and TO-12 base patterns. It has two snap-on dials for different types of bipolar transistors and provides for FET's without a dial. When a transistor fixture is used with the 8745A, transistor bias connections are made through the S-Parameter Test Set. The RF input and output connectors on the transistor fixtures mate with APC-7* style 50-ohm precision 7mm sexless connectors.

1-16. CALIBRATION SET.

1-17. The 11601A and 11603A Calibration Sets are used with transistor fixtures to obtain greater accuracy. The kit consists of a short circuit termination, a 50-ohm through section, and a 50-ohm termination. The Model 11601A is used with the Model 11600A Transistor Fixture and the Model 11603A is used with the Model 11602A Transistor Fixture.

1-18. UNIVERSAL EXTENSION.

1-19. The Model 11604A Universal Extension is composed of four rotary joints and two rotary air lines. It allows the 8745A input port spacing to be adapted to almost any microwave component, providing the accuracy of rigid air line with the flexibility of cable. The two connectors which attach the universal extension to the 8745A mate with APC-7* style connectors and the two connectors that attach to the device under test are APC-7* style 50-ohm precision 7mm sexless connectors. A coaxial link is included with the Universal Extension. The coaxial link replaces the 8745A rear-panel coaxial link to compensate for the Universal Extension's electrical length.**

1-20. QUICK CONNECT ADAPTER.

1-21. The Model 11599A Quick Connect Adapter connects and disconnects Model 11600-series transistor fixtures and the Model 11604A Universal Extension with the simple motion of a lever. In addition to saving

---

* Amphenol RF Division, Danbury, Connecticut.

** For test units equipped with rear-panel coaxial link.

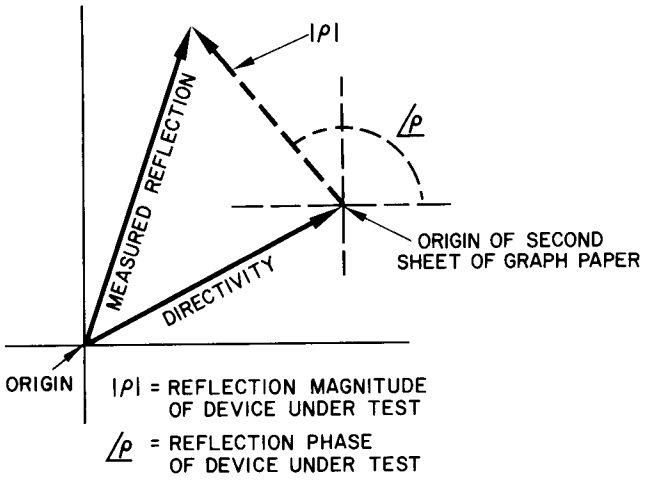


Figure 3-19. Typical Polar Plot Showing Graph Method of Cancelling Directivity

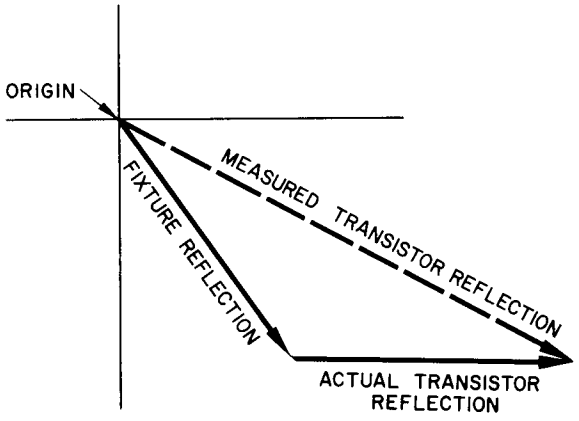


Figure 3-20. Typical Polar Plot Showing Measured Transistor Reflection as the Sum of Fixture and Transistor Reflections

S_{11} and S_{22}. Make sure the input port of the 8745A is the one that will be used for the transistor measurement. Since the magnitude of the 50-ohm termination's reflection is very small, the measured reflection coefficient can be considered the fixture reflection plus the directivity vector.

3-25. When using the Network Analyzer with a polar display, the vector subtraction can be performed directly with the horizontal and vertical position controls on the display. Adjust these controls until the dot representing the measured reflection is at the center of the display. Fixture reflection is now eliminated at this frequency and for this 8410A gain setting. When using the Network Analyzer with a 8413A display unit, or the 8405A, the vector subtraction can be performed (using reflection coefficient, not dB), as in paragraph 3-22c, by inserting fixture plus directivity for directivity.

3-26. REMOTE S-PARAMETER SELECTION.

3-27. A thirty-six pin connector on the rear panel of the 8745A provides contacts for remote s parameter selection and biasing. Eleven of the thirty-six pins are used in the 8745A. The pins and their uses are given in Table 3-1. The pins used for remote selection are:

Pin	Function
17	Remote Select
6	Remote S Parameter Select.
24	Remote S Parameter Select.
18 and 36	Remote Control Common

3-28. When remote select pin 17 is open or not connected to a remote control common (pins 18 or 36), the 8745A is in the manual mode. In this mode of operation the front panel push-buttons are all enabled and s parameter select pins 6 and 24 are disabled. Parameters can be selected from the front panel only, and either port A or port B can be selected as the input port to the device under test.

3-29. When remote select pin 17 is connected to a remote control common (pins 18 or 36), the 8745A is in the remote mode. In this mode of operation the front-panel pushbuttons are disabled and remote s parameter select inputs pins 6 and 24 are enabled, allowing s parameter selection through only the remote input lines.

3-30. When the 8745A is set to the remote mode, port A is always defined as the input port to the device under test. Since the four s parameters are defined as: S_{11} = input reflection coefficient, S_{21} = forward transmission coefficient, S_{12} = reverse transmission coefficient and S_{22} = output reflection coefficient, the input port of the device under test must be clearly defined. When a transistor fixture is being used with a 8745A, the snap-on dial may indicate that port B is to be selected; however, in remote operation port B cannot be selected. Nevertheless, results equivalent to selecting port B can be obtained. As indicated in Figures 3-3 and 3-4, selecting port A and S_{11} is equivalent to selecting port B and S_{22}; therefore, to measure S_{11} remotely when port B is connected to the input port of the device under test, remotely select S_{22}.

3-31. The contact closures required for remote selection of s parameters are listed in Table 3-3. Shorting pin 17 to either of the remote control returns, pin 18 or pin 36, selects remote programming. To select S_{11}, for example, pins 6 and 24 must be open with respect to both of the remote control returns.

Table 1-1. Specifications

Frequency Range:

100 MHz to 2 GHz. Can be used below 100 MHz since coupler directivity remains above 36 dB.

Impedance:

50 ohms nominal.

Directivity:

Below 1 GHz, > 36 dB; 1-2 GHz, > 32 dB.

Coupling:

Above 120 Mhz, 20 dB nominal; below 120 MHz, rolls off at 6 dB/octave.

Insertion Loss:

From RF input to test ports, 4 dB nominal.

From test ports to 8405A or 8410A outputs, 20 dB nominal.

Load Match[1]:

Reflection coefficient (VSWR)

<0.10 (<1.22), 100-200 MHz.

<0.063 (<1.13), 200-2000 MHz.

Source Match[2]:

Reflection coefficient (VSWR)

<0.057 (<1.12), 0.11-2.0 GHz.

Maximum RF Power:

2 Watts.

Connectors:

RF Input: Type N female.

Test Ports: APC-7[3] precision connectors.

Outputs to 8405A or 8410A: Mates with APC-7[3] precision connectors.

Option 01, Type N female (for use with 8505A Vector Voltmeter).

Reference Plane Extension:

Maximum length 30 cm, 0.01 cm precision. Extends reference plane 0 to 15 cm.

Microwave Coax Switches:

Typical switching time, 40 msec.

Estimated switch lifetime > 1 million cycles.

Remote Programming:

Remote s parameter selection by closing 2 contacts of 36-pin rear panel connector to ground pin. Contact is at 12 volts and short to ground will draw 12 mA.

Transistor Biasing:

Bias and bias sensing connections are made to the biasing networks built into the 8745A via the 36-pin rear panel connector.

Maximum Bias:

100V dc (50V dc on instruments with serial number prefixed 823-); 1.0 amp.

Power:

115 or 230V ±10%, 50 to 1000 Hz, 40 watts.

Weight:

35 lb. (15, 9 kg).

Dimensions:

5-1/2 x 16-3/4 x 25-3/4 inches (139 x 423 x 650mm).

[1] Load Match: Reflection coefficient of the port used to terminate the device under test.

[2] Source Match: Effective Reflection coefficient of the port used to supply incident signal to the device under test. A function of directivity and main line VSWR of coupler monitoring incident signal, and not a function of signal source VSWR.

[3] Amphenol RF Division, Danbury Connecticut.

as a HP Model H01-909A, to the 8745A incident power port (INPUT PORT A or B) at the reference plane. Since the magnitude of the Model H01-909A reflection is very small, the measured reflection coefficient can be considered the directivity vector. Adjust the 8414A horizontal and vertical controls to place the dot in the center of the CRT. Directivity is now cancelled for this frequency and this test channel gain on the Network Analyzer.

3-22. With either the 8413A or 8405A, the vector subtraction must be done manually:

a. For single frequencies above 1GHz, setup the 8745A to measure the desired reflection coefficient (S_{11} or S_{22}). Calibrate the display unit and attach a sliding load (HP Model 907A) to the 8745A incident power port (INPUT PORT A or B). Slide the load to find the maximum magnitude* of reflection coefficient, $|\rho 1|$. Record $|\rho 1|$ and its phase angle. Slide the load to find the minimum magnitude** of reflection coefficient, $|\rho 2|$. Record $|\rho 2|$ and its phase angle. If the directivity vector is larger than the load reflection, the measured phase angle of $|\rho 1|$ and $|\rho 2|$ will be the same, as shown in Figure 3-17, and the magnitude of the directivity vector can be determined from:

$$\frac{|\rho 1| + |\rho 2|}{2}$$

If the directivity vector is smaller than the load reflection, the phase angle of $|\rho 2|$ will be 180° from the phase angle of $|\rho 1|$ as shown in Figure 3-18, and the magnitude of the directivity vector can be determined from:

$$\frac{|\rho 1| - |\rho 2|}{2}$$

Record the magnitude and phase of the directivity vector. The phase is the phase angle of $|\rho 1|$. The directivity vector must be vectorially subtracted from any reflection measurement at this frequency (see step c).

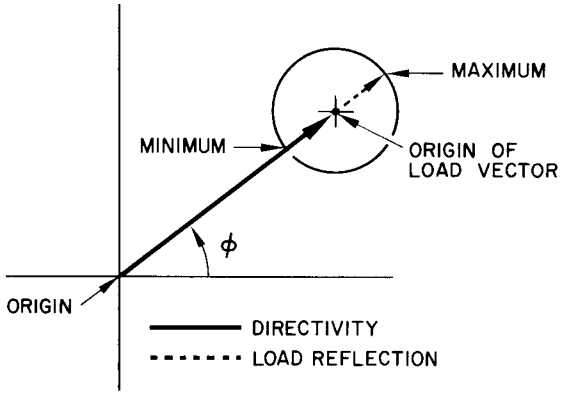


Figure 3-17. Typical Polar Plot Showing Method of Separating Load Vector from Directivity Vector when Directivity Vector is Larger than Load Vector

* Maximum magnitude: directivity vector plus reflection from sliding load adding in phase.

**Minimum magnitude: reflection from sliding load 180° from directivity vector.

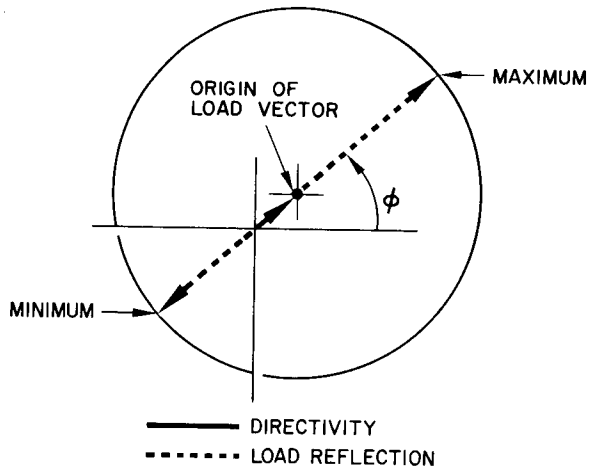


Figure 3-18. Typical Polar Plot Showing Method of Separating Load Vector from Directivity Vector when Directivity Vector is Smaller than Load Vector

b. For single frequencies below 1GHz, setup the 8745A to measure the desired reflection coefficient (S_{11} or S_{22}). Calibrate the display unit and connect a low reflection termination ($|\rho| = 0.005$ max.), such as a HP Model H01-909A, to the 8745A incident power port (INPUT PORT A or B). Since the magnitude of the Model H01-909A reflection is very small, the measured reflection coefficient can be considered the directivity vector. Record the phase and magnitude of the directivity vector. This vector must be subtracted from any reflection measurement at this frequency (see step c below).

c. The vector subtraction can be accomplished conveniently be performing the subtraction graphically (using reflection coefficient, not db) as shown in Figure 3-19. Plot the directivity vector and the measured reflection vector on polar graph paper. Place a second sheet of polar graph paper over the first with the origin of the second graph at the tip of the directivity vector, and with the vertical and horizontal axes parallel to the vertical and horizontal axes of the first graph. Draw a vector from the origin (tip of the directivity vector) to the tip of the measured vector. This vector is the reflection coefficient of the device under test.

3-23. CALIBRATING OUT THE REFLECTION OF THE TRANSISTOR FIXTURE.

3-24. The reflection of the transistor fixture is significant when the reflection of the device under test is very small. The error can be calibrated out at single frequencies. Figure 3-20 shows how the fixture reflection can add vectorially to the transistor reflection. Measure the fixture reflection at a single frequency by plugging the 50-ohm termination from the fixture calibration kit into the fixture and measure

time, this lever-action coupling eliminates wear on connector coupling mechanisms. Two permanently-attached, hand-tightened screws fasten the adapter in place over the input port connectors of the test set. A plug-in slide that supports and aligns the transistor fixtures and a wrench for adjusting coupling action are supplied with the adapter.

1-22. ACCESSORY KIT TO CONNECT MODEL 8405A TO MODEL 8745A.

1-23. The Model 11507A Accessory Kit includes one Model 11549A Power Splitter (used to make initial calibration of 8405A), two 11536A 50-ohm Tees, and two 908A Terminations. In addition to the 11570A Accessory Kit, two Model 11524A APC-7* to female type N adapters are required to make connections to the 8745A.

1-24. COMPLEMENTARY EQUIPMENT.

1-25. MODEL 8410A NETWORK ANALYZER.

1-26. The 8410A Network Analyzer measures relative amplitude and phase of two RF input signals. The instrument is capable of single- or swept-frequency measurements in the range of 0.11 to 12.4 GHz. Two plug-in display units are available. The 8413A plug-in unit displays relative amplitude and phase data on a meter. Phase and amplitude output signals allow display of swept signals on an oscilloscope or X-Y recorder. The 8414A plug-in unit displays relative amplitude and phase data in polar coordinates on a 5-inch CRT for either swept or CW measurements.

1-27. MODEL 8405A VECTOR VOLTMETER.

1-28. The 8405A Vector Voltmeter measures magnitude and phase at single frequencies in the range of 1.0 MHz to 1.0 GHz. Signal magnitude and phase are displayed on separate meters.

1-29. MODEL 8717A TRANSISTOR POWER SUPPLY.

1-30. The 8717A Transistor Power Supply is designed especially for use with the 8745A S-Parameter Test Set and the 11600A and 11602A Transistor Fixtures. This programmable supply provides bias levels for the semiconductor devices tested in the fixtures. Feedback circuits within the supply provide very stable bias conditions. Overload protection for the device under test is selectable. Maximum current is 500mA and maximum voltage is 30Vdc.

1-31. MODEL 8690B SWEEP OSCILLATOR MAINFRAME WITH 8699B PLUG-IN.

1-32. The entire range of the 8745A is covered in one sweep range of the 8699B plug-in. The 8699B has a low range from 0.1 to 2.0 GHz and a high range from 2 to 4 GHz.

1-33. MODEL 3200B VHF OSCILLATOR.

1-34. The 3200B VHF Oscillator with the 13515A Frequency Doubler Probe is a CW RF signal source covering the 10 MHz to 1.0 GHz range and is an ideal source to use with the 8405A Vector Voltmeter and the 8745A.

1-35. INSTRUMENTS COVERED BY MANUAL.

1-36. This manual applies directly to instruments having serial numbers prefixed 906- (first three numbers of serial number). If the serial prefix of your instrument is other than 906-, there are differences between the instrument described in this manual and your instrument. These differences are described in the appendix at the rear of this manual for serial numbers prefixed 823-. For other prefixes the differences are described in a Manual Changes sheet supplied with this manual. If the manual changes sheet is missing, the information can be supplied by your nearest Hewlett-Packard Sales and Service Office (see lists at the rear of this manual). The manual changes sheet may also include an "ERRATA" section which describes manual correction information which applies to the manual for all instruments INCLUDING instruments prefixed 906-.

---

* Amphenol RF Division, Danbury, Connecticut.

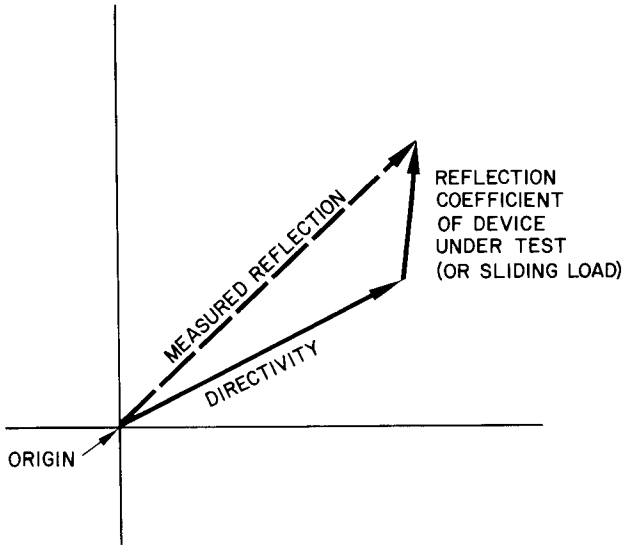


Figure 3-14. Typical Polar Plot Showing Measured Reflection as the Sum of Directivity and Load Vectors

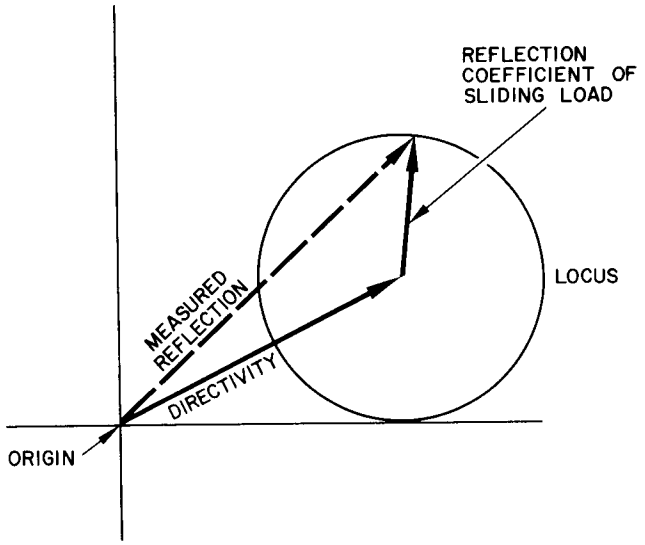


Figure 3-15. Typical Polar Plot Showing Locus of Measured Reflection when Sliding Load is Moved

3-18. INCREASED ACCURACY BY MINIMIZING DIRECTIVITY ERRORS.

3-19. Greatest accuracy for single-frequency, high-resolution reflection measurements can be obtained by connecting the device under test directly to the front-panel ports of the 8745A. If it is necessary to make connections through an 11604A, air line, or coaxial cable, any movement of the 11604A swivel joints or flexing of coaxial cable will alter the phase relations of the reflections in the test setup; therefore, any component inserted between the 8745A and the device under test should remain in the same position for both calibration and measurements.

3-20. Directivity errors are not significant unless small reflection coefficients are being measured. This error can be cancelled at single frequencies when necessary. The measured reflection is the vector sum of the directivity vector plus the reflection coefficient of the device under test (Figure 3-14). The error can be calibrated out by using a sliding load. Figure 3-15 depicts the sliding load in one position at a given frequency. As the sliding load is moved, the magnitude of its reflection coefficient remains constant but the phase of the coefficient changes. As the load is moved its reflection coefficient indication rotates in a circle of constant magnitude about the directivity vector. The center of this circle is the tip of the directivity vector. When the location of the center of the circle is known, the error can be vectorially subtracted from the measured reflection to obtain the reflection coefficient of the device under test.

3-21. On the 8414A polar display, the vector subtraction can be performed directly with the horizontal and vertical position controls. Increase the 8410A test

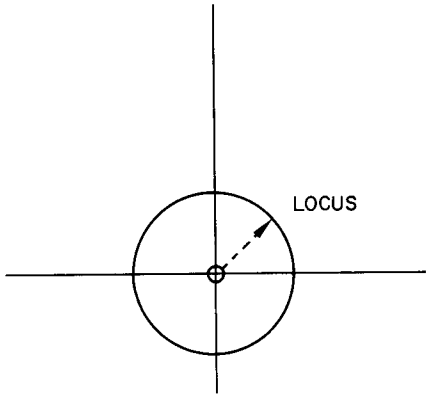


Figure 3-16. Polar Display Showing Locus of Sliding Load Vector with Directivity Cancelled

channel gain so full scale reflection on the polar display is suitable for the component you wish to measure and perform the following:

a. For single frequencies above 1GHz, setup the 8745A to measure the desired reflection coefficient (S_{11} or S_{22}). Calibrate the display unit and attach the sliding load (HP Model 907A) to the 8745A incident power port (INPUT PORT A or B). Slide the load and adjust the horizontal and vertical controls until the circle rotates about the center of the CRT, as shown in Figure 3-16. Directivity is now cancelled for this frequency and this test channel gain on the Network Analyzer.

b. For single frequencies below 1 GHz, setup the 8745A to measure the desired reflection coefficient (S_{11} or S_{22}). Calibrate the display unit and connect a low reflection termination ($|\rho|$ = 0.005 max.), such

MICROWAVE HARDWARE MEASUREMENTS WITH 8410A

CALIBRATION DESCRIPTION. Calibration consists of obtaining a reference indication using a termination of known magnitude and phase angle. Magnitude and phase reference indications for calibration are given in Table 3-2. A through section is obtained by connecting the two 11604A Universal Extension arms together. For normal calibration, only one s parameter with only one of the known terminations is needed. Calibration for greater accuracy is discussed in Paragraph 3-18.

CALIBRATION PROCEDURE. To calibrate the system containing a Universal Extension and 8410A Network Analyzer readout, perform the following:

1. Connect equipment as shown in test setup opposite.
2. Set the signal source to sweep the band of interest.
3. Set the 8745A to look at a reflection coefficient of an open or a short and adjust the 8745A REFERENCE PLANE EXTENSION to cancel out the linear phase error (equal reference and test channel electrical lengths). For the 8414A, adjust for the smallest cluster. For an 8413A with an oscilloscope connected to its PHASE output, adjust for a horizontal line.
4. Connect the termination to be used (Table 3-2).
5. If an 8414A is used as the readout, adjust the Network Analyzer controls as follows:
   a. Adjust the PHASE VERNIER for the reference phase indication of the termination selected (e.g., through section press S_{21} or S_{12}, adjust for 0°).
   b. Adjust the TEST CHANNEL GAIN and AMPL VERNIER controls for a magnitude of one.
6. If an 8413A is used as the readout, set the signal source to CW and adjust the 8410A controls as follows:
   a. Adjust the PHASE VERNIER control for the reference phase indication of the termination selected (e.g., through section press S_{21} or S_{12}, adjust for 0°).
   b. Adjust the TEST CHANNEL GAIN and AMPL VERNIER controls for a zero dB indication. For S_{11} and S_{22} the 8413A indicates return loss (0 dB return loss equals a reflection coefficient of 1). For S_{21} and S_{12} the 8413A indicates gain or loss in dB.

MEASUREMENT. To measure the s parameters of the microwave device under test, perform the following:

1. Insert the device to be tested between the arms of the Universal Extension and select INPUT PORT A or B as desired.
2. Select the S PARAMETER to be measured.
3. If an 8414A plug-in is used in the 8410A Network Analyzer, read the magnitude and phase from the CRT.
4. If an 8413A is used in the 8410A the amplitude display is relative magnitude in dB of the incident and reflected (S_{11},S_{22}) or incident and transmitted (S_{21}, S_{12}) signals. These can be converted to reflection $|\rho|$ or transmission $|\tau|$ coefficients with the following equations:

$$|\rho| = \log^{-1} (0.05 \text{ return loss in dB})$$

or

$$|\tau| = \log^{-1} (0.05 \text{ return loss in dB})$$

Figure 3-13. Microwave Hardware Measurement with 8410A Network Analyzer Readout (Sheet 2 of 2)

SECTION II
INSTALLATION.

2-1. INCOMING INSPECTION.

2-2. Inspect instrument for shipping damage as soon as it is unpacked. Check that all accessories listed in Paragraph 1-5 have been included. Check for broken knobs and connectors; inspect cabinet and panel surfaces for dents and scratches. If the instrument is damaged in any way or fails to operate properly, notify the carrier and your nearest Hewlett-Packard Sales and Service Office. For assistance of any kind, including instruments under warranty, contact the nearest Hewlett-Packard Sales and Service Office.

2-3. REPACKAGING FOR SHIPMENT.

2-4. USING ORIGINAL PACKAGING.

2-5. The same containers and materials used in factory packaging can be obtained through the Hewlett-Packard offices listed at the rear of this manual. For units equipped with a rear-panel coaxial link, remove the coaxial link, wrap it separately, and include it in the shipping container.

2-6. If the Model 8745A is being returned to Hewlett-Packard 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.

2-7. In any correspondence, refer to the instrument by model number and full serial number.

2-8. USING OTHER PACKAGING.

2-9. The following general instructions should be used when repackaging with commercially-available materials:

a. Wrap the instrument in heavy paper or plastic. For units equipped with a rear-panel coaxial link, remove the coaxial link, wrap it separately, and include it in the shipping container. If shipping to a Hewlett-Packard service office or center, attach a tag indicating the type of service required, the return address, model number, and full serial number.

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

c. Use enough shock-absorbing material (3 to 4 inch layer) around all sides of the instrument to provide cushion and prevent movement inside the container. Protect the control panel with cardboard.

d. Seal the shipping container securely, and mark it FRAGILE to assure careful handling.

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

2-10. PREPARATION FOR USE.

2-11. REAR-PANEL COAXIAL LINK.

2-12. For units equipped with a rear-panel coaxial link, connect the coaxial link to the rear panel as shown in Figure 3-2. If a Model 11604A Universal Extension is to be used with the 8745A, connect the rear-panel coaxial link received with the Universal Extension.

2-13. POWER REQUIREMENTS.

2-14. The Model 8745A requires a power source of 115 or 230 volts ac ±10%, 50 to 1000 Hz, single phase that can supply approximately 40 watts.

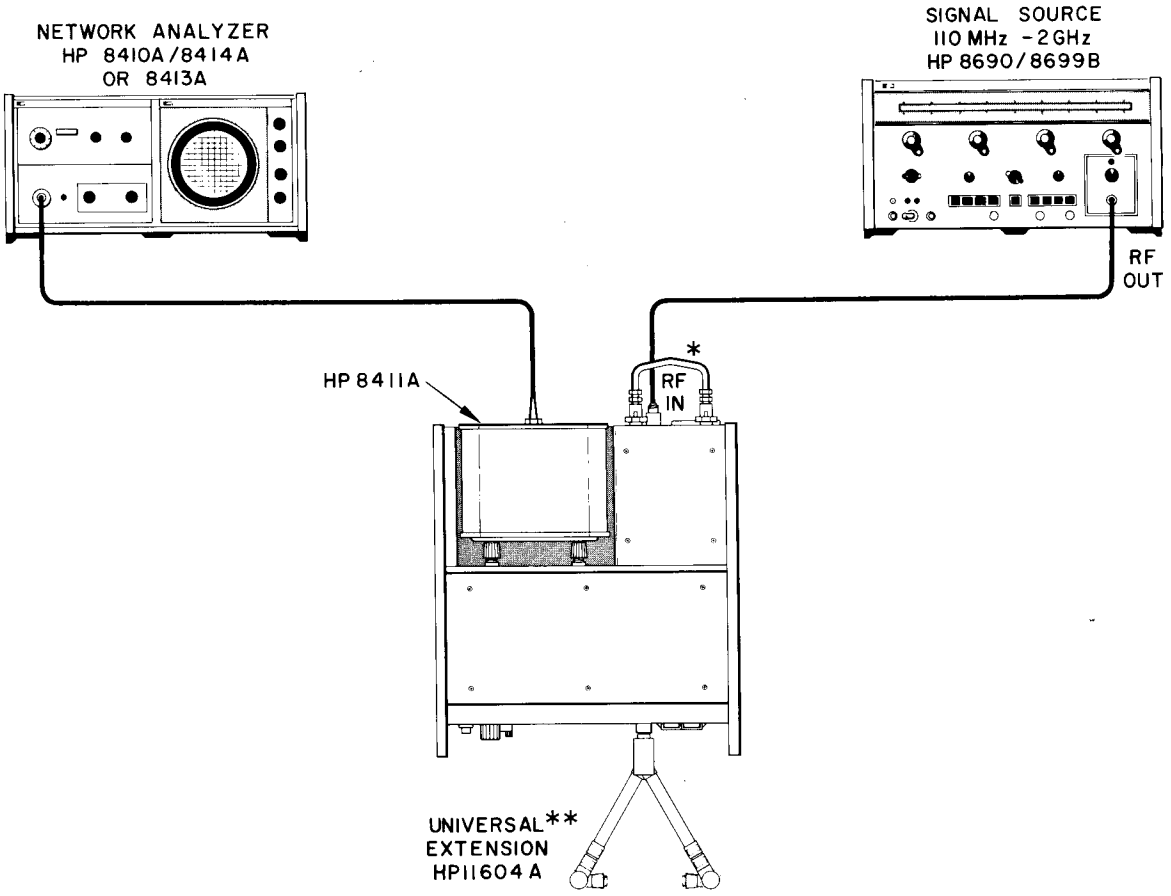
2-15. 115/230 VOLT OPERATION.

2-16. A two-position slide switch on the rear panel of the Model 8745A permits operation from either a 115- or 230- volt power source. The number showing on the switch slider indicates the voltage for which the instrument is connected. The correct line fuse rating for each line voltage is marked on the plate adjacent to the fuse.

2-17. To prepare the Model 8745A for operation, position the 115-230 volt switch so that the number showing on the slider corresponds to the available line voltage, and install a line fuse of correct rating. "Slo-blo" fuses should be used.

CAUTION

To avoid damage to the instrument, set the 115-230 switch to the line voltage to be used before connecting the power cable.



* Rear-panel coaxial link (HP Part Number 11604-20021). See Paragraph 3-12a.

**When making reflection measurements without the Universal Extension use a 20cm air line. See Paragraph 3-12a.

Figure 3-13. Microwave Hardware Measurement with 8410A Network Analyzer Readout (Sheet 1 of 2)

2-18. POWER CABLE.

2-19. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that instrument panels and cabinets be grounded. Accordingly, the Model 8745A is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds panel and cabinet. The offset pin of the three-prong connector is the grounding pin.

2-20. To preserve the protection feature when operating the Model 8745A from a two-contact outlet, use a three-prong to two-prong adapter (HP Stock Number 1251-0048), and connect the green wire on the adapter to ground.

2-21. BENCH OPERATION.

2-22. The Model 8745A cabinet has plastic feet and a foldaway tilt stand for convenience in bench operation. The stand inclines the instrument enough to make the panel features easier to see. The plastic feet provide clearance for air circulation and make the Model 8745A self-aligning when stacked on other Hewlett-Packard full rack-width modular instruments.

2-23. RACK MOUNTING.

2-24. All necessary hardware and instructions are contained in the supplied rack-mounting kit (HP Stock Number 5060-0775). The ambient operating temperature should not exceed 55°C (140°F).

MICROWAVE HARDWARE MEASUREMENTS WITH 8405A

CALIBRATION DESCRIPTION. Calibration consists of obtaining a reference indication using a termination of known magnitude and phase angle. Magnitude and phase reference indications for calibration are given in Table 3-2. A through section is obtained by connecting the two 11604A Universal Extension arms together. For normal calibration, only one s parameter with only one of the known terminations is needed. Calibration for greater accuracy is discussed in Paragraph 3-18.

CALIBRATION PROCEDURE. To calibrate the system containing a Universal Extension and 8405A Vector Voltmeter readout, perform the following:

1. Connect equipment as shown in test setup opposite. If measurements are to be made at more than one frequency, make zero adjustment of the vector voltmeter before connecting the probe tee's to the 8745A as follows:
   a. Connect the signal source to the input port of the Model 11549A Power Splitter.
   b. Connect the probe tee's to the two output ports of the power splitter. Terminate probe tee's with 908A 50-ohm loads.
   c. Adjust the 8405A PHASE METER OFFSET to zero, and adjust PHASE ZERO for zero phase-meter reading.
   d. Disconnect the RF cable and probe tee's from the power splitter. Connect the RF cable to the 8745A RF INPUT. Connect the probe tee's to the 8745A, Channel A to the REFERENCE output and Channel B to the TEST output.
2. Set the 8405A to phase lock to the applied signal.
3. Connect the calibrator to be used (Table 3-2), and select the appropriate s parameter.
4. Adjust the signal source RF output to obtain a convenient Channel B voltage reference on the 8405A.
5. Note Channel A magnitude.
6. Adjust the 8745A REFERENCE PLANE EXTENSION for the reference indication of the calibrator selected (e.g., open circuit, press S_{11} or S_{22}, adjust for 0^{o}). See Table 3-2.

The system is now calibrated for the frequency of the signal source. If measurements are to be made at more than one frequency, check for equal reference and test channel electrical lengths by changing the frequency of the signal source. If the electrical lengths are equal, the phase will not change with a change in frequency. To equalize the electrical lengths, adjust the 8405A PHASE ZERO to the appropriate phase reference indication at the lowest frequency, then adjust the 8745A REFERENCE PLANE EXTENSION for the same phase reference indication at the highest frequency of interest. Repeat these adjustments for minimum change in phase.

MEASUREMENT. To measure the s parameters of the microwave device under test, perform the following:

1. Insert the device to be tested between the arms of the Universal Extension and select INPUT PORT A or B as desired.
2. Select the S PARAMETER to be measured.
3. Adjust the signal source RF output to return the 8405A Channel A signal to the magnitude noted in step 5 of the calibration procedure.
4. Compute the s parameter magnitude from

$$\text{Magnitude} = \frac{\text{measured channel B voltage}}{\text{reference channel B voltage}}$$

5. Read the phase directly on the 8405A phase meter.

Figure 3-12. Microwave Hardware Measurements with 8405A Vector Voltmeter Readout (Sheet 2 of 2)

SECTION III
OPERATION

3-1. INTRODUCTION.

3-2. The combination of the Model 8745A S-Parameter Test Set with its accessory fixtures and adapters, a signal source, and a compatible phase-amplitude ratio indicator, such as the Model 8410A Network Analyzer or Model 8405A Vector Voltmeter, make up a system to measure the parameters of almost any device. These measurements can be made at single frequencies or at swept frequencies from 0.1 to 2.0 GHz. When used with the HP Model 8405A Vector Voltmeter, measurements are limited to single frequencies and an upper frequency limit of 1.0 GHz. The Model 8745A can be used at frequencies below 100 MHz; however, the coupling attenuation of the internal directional couplers increases by approximately 6 dB per frequency octave. Consequently, when making measurements below 100 MHz the level of power delivered from the signal source should be monitored closely. Be sure power limits are not exceeded while trying to obtain sufficient indication on the readout instrument.

3-3. DESCRIPTION OF PANEL FEATURES.

3-4. Front and rear panel controls, connectors and indicators are described in Figures 3-1 and 3-2. In these figures the numbers on the panel illustrations match the description numbers.

3-5. OPERATING PRECAUTIONS.

3-6. MAXIMUM RF POWER.

3-7. Do not apply more than 2 watts of RF power to the Model 8745A RF INPUT. Power in excess of 2 watts may damage the internal 3 dB pad. Also care must be taken to ensure that the power returned to the Model 8745A from an active device under test does not exceed 2 watts or the 50-ohm terminations may be damaged.

3-8. MAXIMUM DC ON RF LINES.

3-9. DC voltage on the inner conductor of the transmission lines in the Model 8745A must not exceed ±100 volts or the breakdown voltage of the internal bias blocking capacitor will be exceeded; therefore, the combination of dc voltage to bias a device under test and the dc voltage on the center conductor from the RF source must not exceed 100 volts (50 volts for instruments with serial prefixed 823- and below). The maximum dc current on the RF lines must not exceed 1.0 amp.

3-10. S-PARAMETER MEASUREMENT.

3-11. GENERAL MEASUREMENT DESCRIPTION.

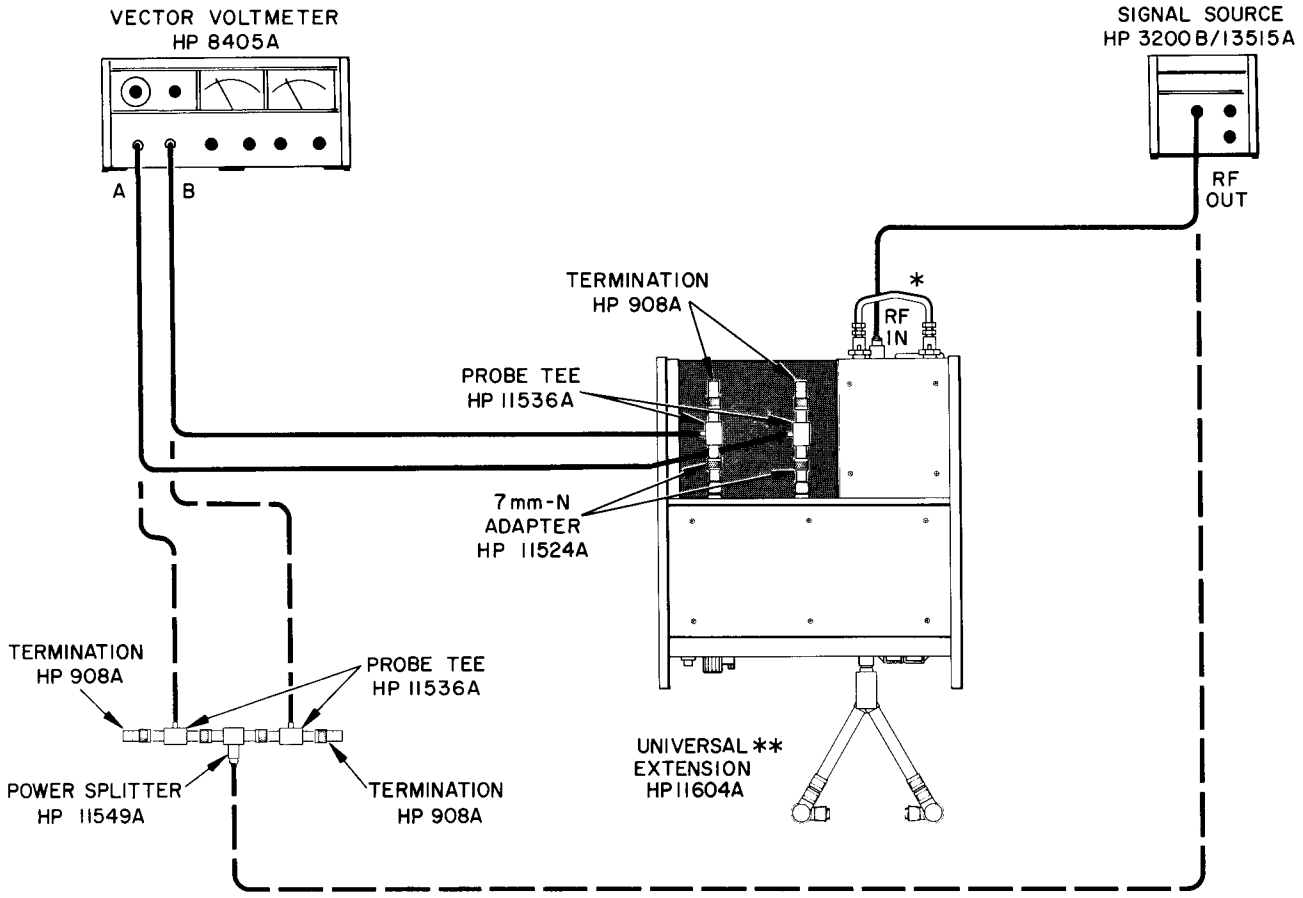
3-12. The S-Parameter Test Set may be used to make s-parameter measurements with several combinations of complementary equipment. A simplified block diagram of the test setup is shown in Figure 3-5. Readout is on a phase-amplitude ratio indicator such as the HP 8405A or the HP 8410A with 8413A or 8414A plug-in. Microwave components may be connected to the S-Parameter Test Set by accessories such as the 11600A or 11602A Transistor Fixture or the 11604A Universal Extension. Detailed procedures, using various combinations of equipment, are given in Figures 3-10 through 3-13. The following general outline explains the steps necessary when making measurements with any combination of equipment.

a. If swept-frequency measurements are to be made, the reference and test channel line length between the device under test and the indicator unit must be equal. This is adjusted by the 8745A REFERENCE PLANE EXTENSION and, if necessary, additional line length can be inserted in the reference channel ahead of the 8411A. For units equipped with a removable rear-panel coaxial link, the link may be removed and additional reference channel electrical length may be installed to extend the reference plane any desired distance beyond the front-panel connectors. To best utilize the REFERENCE PLANE EXTENSION range, the following combinations are recommended: When making measurements with a transistor fixture use the short coaxial link (HP part number 08745-20064). When making microwave hardware measurements with the Universal Extension use the long coaxial link supplied with the Universal Extension (HP part number 11604-20021). When making microwave hardware measurements without a Universal Extension use either coaxial link and use a 20 cm air line instead of the Universal Extension. Correct adjustment of the reference and test channel electrical lengths is obtained when no linear phase shift occurs over a wide band of frequencies.

b. Calibrate the system for s parameter measurement by terminating the input fixture with an open, a short, or a through section. Additional accuracy may be obtained by compensating for directivity error as described in Paragraph 3-18.

c. If a transistor fixture is used, the device under test must be properly biased by using either the HP 8717A Bias Supply or a standard dual dc power supply. Refer to Paragraph 3-13 for bias supply connections.

d. Measure the parameters of the device under test. This is accomplished by selecting input port A or B then selecting the s parameter of interest. Figures 3-3 and 3-4 show the internal connections within the S-Parameter Test Set for the different switch combinations.

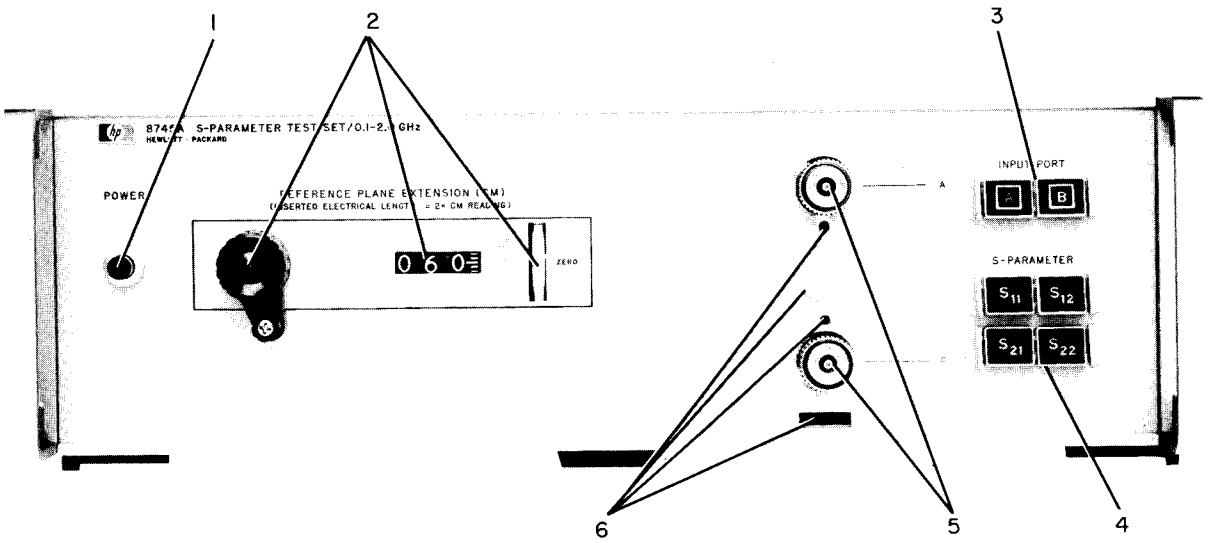


* Rear panel coaxial link (HP Part Number 11604-20021). See Paragraph 3-12a.

**When making reflection measurements without the Universal Extension use a 20cm air line. See Paragraph 3-12a.

Figure 3-12. Microwave Hardware Measurements with 8405A Vector Voltmeter Readout (Sheet 1 of 2)

FRONT PANEL FEATURES



1. POWER. Combination line power switch and power on indicator. Pushbutton glows when instrument is on. Pushbutton retainer unscrews for lamp replacement.

2. REFERENCE PLANE EXTENSION (CM). Crank controls internal line stretcher to vary electrical distance from RF INPUT to REFERENCE output. Used to equalize test and reference channel signal path lengths for phase calibration. Also permits extending the reference plane up to 35 cm beyond the front panel connectors. Minimum Reference Plane Extension is about 20 cm (crank at counterclockwise stop). ZERO thumbwheel is for setting reference indication on counter without changing line length.

3. INPUT PORT selectors. Select port A or port B for the RF input port to the device under test. Pushbutton glows, indicating the input port selected. During remote operation port A is always selected as the input port.

4. S-PARAMETER selectors. Select the s parameter to be measured. Pushbutton glows, indicating the s parameter being measured.

5. Input ports A and B. These ports make RF input and output connections to the device under test. Bias circuit from rear-panel REMOTE INPUT connector is completed through center conductor. APC-7* 50-ohm precision 7 mm sexless connectors.

6. Mounting holes for HP 11599A Quick Connect Adapter.

---

* Amphenol RF Division, Danbury, Connecticut.

Figure 3-1. Front Panel Features

SEMICONDUCTOR MEASUREMENT WITH 8410A

CALIBRATION DESCRIPTION. Calibration consists of obtaining a reference indication using a termination of known magnitude and phase angle. Magnitude and phase reference indications for calibration are given in Table 3-2. An open circuit is obtained by not plugging anything into the transistor fixture. Model 11601A and 11603A Calibration Sets contain a short, 50-ohm termination and a through section. If a calibration set is used, see Figure 3-8 for proper positioning of fixture snap-on dial and calibrator. For normal calibration, only one s parameter with only one of the known terminations is needed. Calibration for greater accuracy is discussed in Paragraph 3-18.

CALIBRATION PROCEDURE. To calibrate the system containing a transistor fixture and 8410A Network Analyzer readout, perform the following:

1. Connect equipment as shown in setup opposite.
2. Set the signal source to sweep the band of interest.
3. Set the 8745A to look at the reflection coefficient of an open or a short and adjust the 8745A REFERENCE PLANE EXTENSION to cancel out the linear phase error (equal reference and test channel electrical lengths). For the 8414A, adjust for the smallest cluster. If an 8413A with an oscilloscope connected to its PHASE output is used, adjust for a horizontal line.

NOTE

For small signal measurements, adjust the signal source RF output for minimum signal level required to maintain a phase locked condition in the Network Analyzer.

4. Connect the calibrator to be used. (See Figure 3-8.)
5. If an 8414A is used as the readout, adjust the 8410A controls as follows:
   a. Adjust the PHASE VERNIER for the reference phase indication of the calibrator selected (e.g., open circuit, press S_{11} or S_{22}, adjust for 0 degrees). See Table 3-2.
   b. Adjust the TEST CHANNEL GAIN and AMPL VERNIER controls for a magnitude of one.
6. If an 8413A is used as the readout, set the signal source to CW and adjust the 8410A controls as follows:
   a. Adjust the PHASE VERNIER control for the reference phase indication of the termination selected (e.g., open circuit, press S_{11} or S_{22}, adjust for 0°). See Table 3-2.
   b. Adjust the TEST CHANNEL GAIN and AMPL VERNIER controls for a 0 dB indication. For S_{11} or S_{22}, the 8413A indicates return loss (0 dB return loss equals a reflection coefficient of 1). For S_{21} and S_{12}, the 8413A indicates gain or loss in dB.

SEMICONDUCTOR BIASING. The semiconductor under test must be biased for a given collector-emitter or drain-source voltage and a given collector or drain current. The two voltages required may be furnished either by the HP Model 8717A Transistor Bias Supply, or by a dual dc power supply. Instructions for connecting the bias supply to the 8745A and adjusting it to bias the unit under test are presented in Paragraph 3-13.

MEASUREMENT. To measure the s parameters of the semiconductor under test, perform the following:

1. Select INPUT PORT A or B as indicated on the transistor fixture.
2. Select the S PARAMETER to be measured.
3. If an 8414A plug-in is used in the 8410A Network Analyzer, read the magnitude and phase from the CRT.
4. If an 8413A is used in the 8410A the amplitude display is relative magnitude in dB of the incident and reflected (S_{11}, S_{22}) or incident and transmitted (S_{21}, S_{12}) signals. These can be converted to reflection $|\rho|$ or transmission $|\tau|$ coefficients with the following equations:

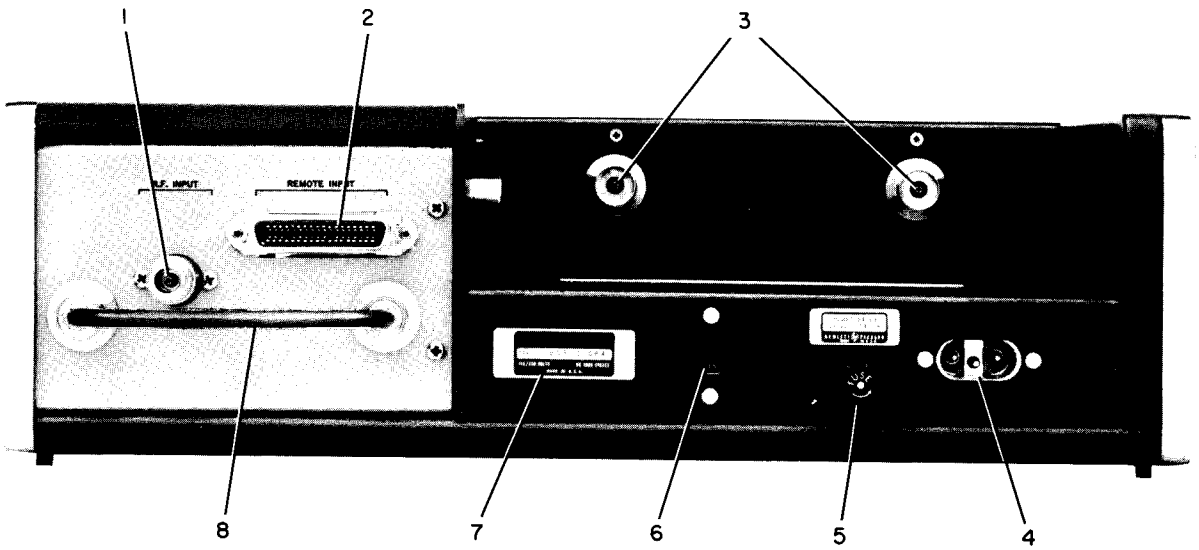
$$|\rho| = \log^{-1} (0.05 \text{ return loss in dB})$$

or

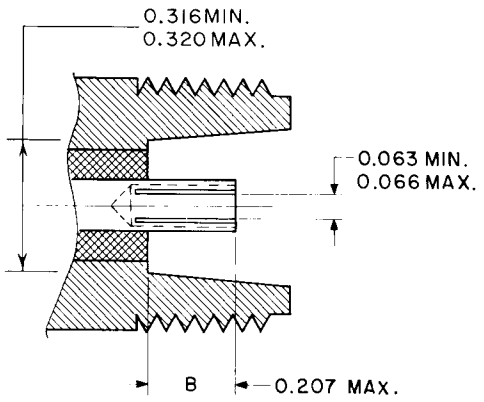
$$|\tau| = \log^{-1} (0.05 \text{ return loss in dB})$$

Figure 3-11. Semiconductor Measurement with 8410A Network Analyzer Readout (Sheet 2 of 2)

REAR PANEL FEATURES



1. RF INPUT. Input for RF signal that is applied to the device under test. Frequency range is 0.1 to 2.0 GHz. Maximum RF power level is 2 watts. For maximum dc level see Paragraph 3-8. Connector is 50-ohm type N and mates compatibly with type N connectors whose dimensions conform to MIL-C-39012 and MIL-C-71. (See dimension drawing below.)



2. REMOTE INPUT. Accepts contact closure type remote programming to select the s parameter to be measured. Nominal voltage from the 8745A when the contact is open is 12 Vdc. Maximum current from the 8745A when the contact is short circuited is 12 mA. Also accepts dc bias for device under test. Maximum bias voltage 50 Vdc. Maximum bias current 1.0 amp.

3. REFERENCE and TEST. Reference and Test channel outputs to phase-amplitude ratio indicator. APC-7* 50-ohm precision 7 mm hybrid connectors. The REFERENCE channel connector is mechanically floating to assure alignment with 8411A Harmonic Frequency Converter of 8410A Network Analyzer.

4. Power Cable Connector. NEMA type with offset pin connected to 8745A cabinet. Power requirements: 115 or 230 Vac ±10%, 50 to 1000 Hz, approximately 40 watts.

5. Power Line Fuse Holder. "Slo-blo" fuse ratings for 115 and 230 Vac on adjacent plate.

6. Line Voltage Selector. Permits operation from 115 or 230 Vac. Number showing on slider is the selected operating voltage. Correct line fuse rating is on plate adjacent to fuse holder.

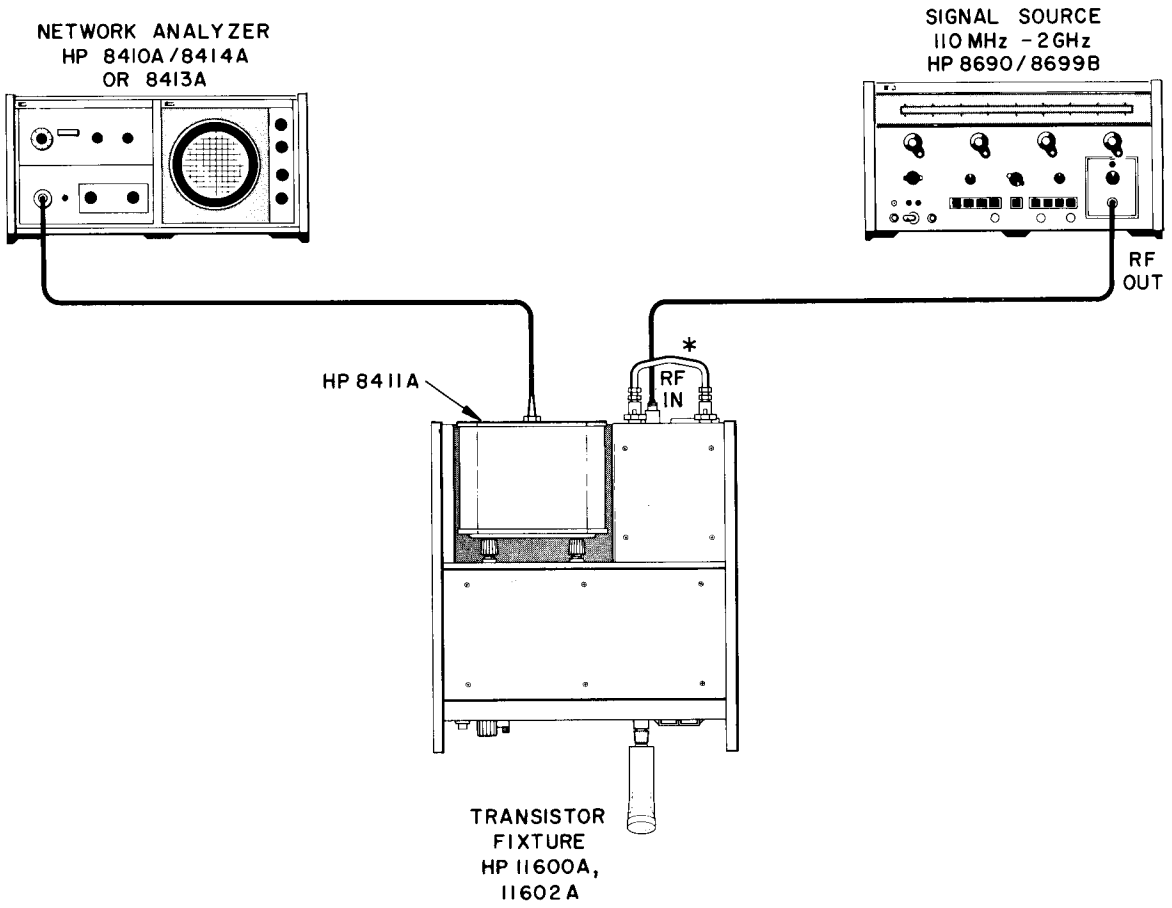
7. Serial Number Plate. Eight-digit serial number should be included in any correspondence concerning the 8745A.

8. Coaxial Link. Some units are equipped with a rear-panel coaxial link. This link may be removed and additional reference channel electrical length may be installed to extend the reference plane to any desired distance beyond the front-panel connectors.

---

* Amphenol RF Division, Danbury, Connecticut.
**REFERENCE and TEST channel output ports are type N female on Option 01.

Figure 3-2. Rear Panel Features



*Rear-panel coaxial link (HP Part Number 08745-20064). See Paragraph 3-12a.

Figure 3-11. Semiconductor Measurement with 8410A Network Analyzer Readout (Sheet 1 of 2)

PORT A SELECTED

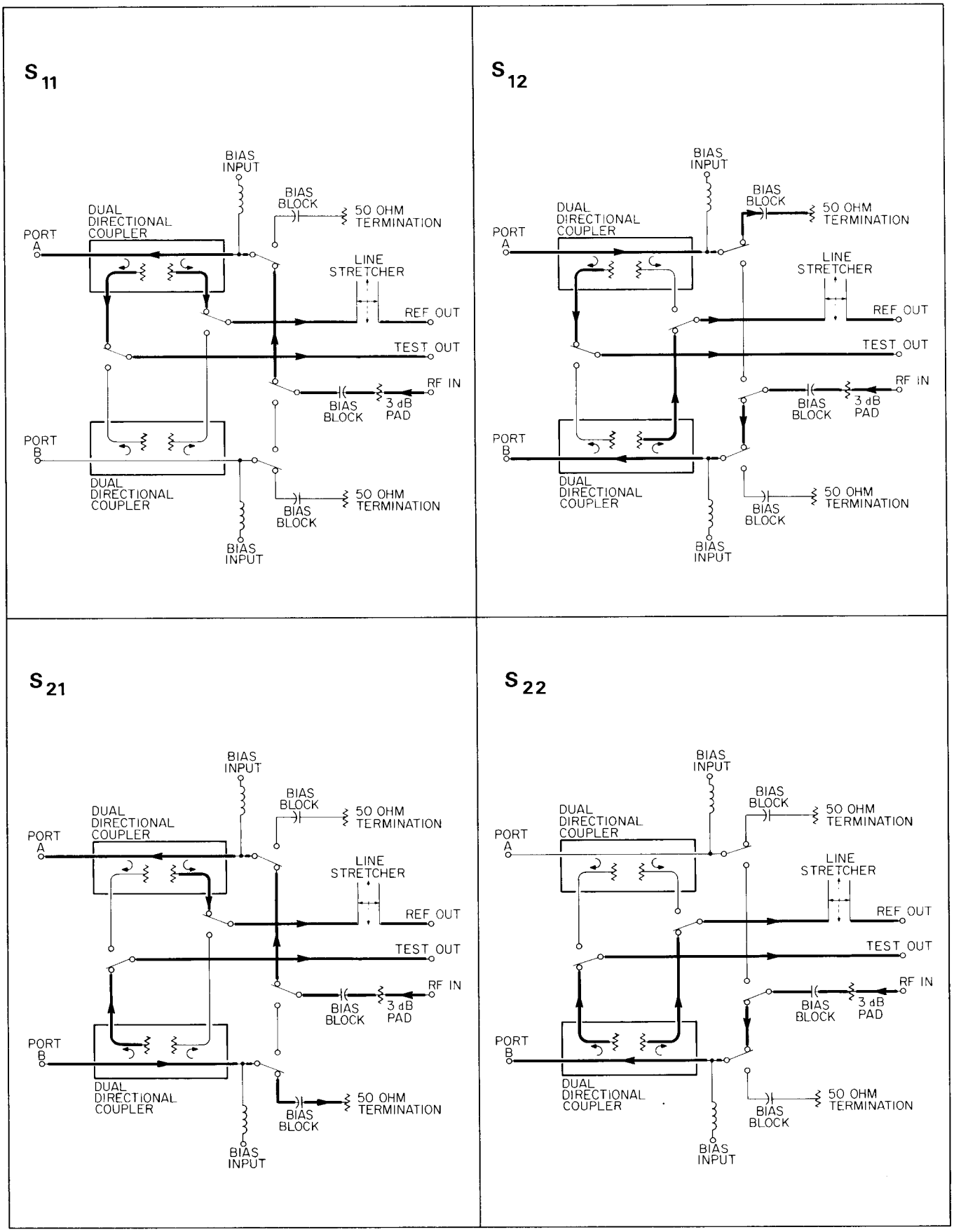


Figure 3-3. Internal Connections with INPUT PORT A and One S-Parameter Pushbutton Pressed

SEMICONDUCTOR MEASUREMENT WITH 8405A

CALIBRATION DESCRIPTION. Calibration consists of obtaining a reference indication using a termination of known magnitude and phase angle. Magnitude and phase reference indications for calibration are given in Table 3-2. An open circuit is obtained by not plugging anything into the transistor fixture. Model 11601A and 11603A Calibration Sets contain a short, 50-ohm termination, and a through section. If a calibration set is used, see Figure 3-8 for proper positioning of fixture snap-on dial and calibrator. For normal calibration, only one s parameter with only one of the known terminations is needed. Calibration for greater accuracy is discussed in Paragraph 3-18.

CALIBRATION PROCEDURE. To calibrate the system containing a transistor fixture and 8405A Vector Voltmeter readout, perform the following:

1. Connect equipment as shown in setup opposite. If measurements are to be made at more than one frequency, make zero adjustment of the Vector Voltmeter before connecting the probe tee's to the 8745A as follows:

   a. Connect the signal source to the input port of the Model 11549A Power Splitter.

   b. Connect the probe tee's to the two output ports of the power splitter. Terminate probe tee's with 908A 50-ohm loads.

   c. Adjust the 8405A PHASE METER OFFSET to zero, and adjust PHASE ZERO for zero phase-meter reading.

   d. Disconnect the RF cable and probe tee's from the power splitter. Connect the RF cable to the 8745A RF INPUT. Connect the probe tee's to the 8745A, Channel A to the REFERENCE output and Channel B to the TEST output.

2. Set the 8405A to phase lock to the applied signal.

3. Insert the calibrator to be used (Figure 3-8), and select the appropriate s parameter (See Table 3-2).

4. Adjust the signal source RF output to obtain a convenient Channel B voltage reference on the 8405A.

   NOTE

   For small signal measurements, adjust the signal source RF power for minimum signal level which will provide the desired dynamic range.

5. Note Channel A magnitude.

6. Adjust the 8745A REFERENCE PLANE EXTENSION for the reference indication of the calibrator selected (e.g., open circuit, press S_{11} or S_{22}, adjust for 0^{o}). See Table 3-2.

The system is now calibrated for the frequency of the signal source. If measurements are to be made at more than one frequency, check for equal reference and test channel electrical lengths by changing the frequency of the signal source. If the electrical lengths are equal, the phase will not change with a change in frequency. To equalize the electrical lengths, adjust the 8405A PHASE ZERO to the appropriate phase reference indication at the lowest frequency, then adjust the 8745A REFERENCE PLANE EXTENSION for the same phase reference indication at the highest frequency of interest. Repeat these adjustments for minimum change in phase.

SEMICONDUCTOR BIASING. The semiconductor under test must be biased for a given collector-emitter or drain-source voltage and a given collector or drain current. The two voltages required may be furnished either by the HP Model 8717A Transistor Bias Supply, or by a dual dc power supply. Instructions for connecting either bias supply to the 8745A and adjusting it to bias the unit under test are given in Paragraph 3-13.

MEASUREMENT. To measure the s parameters of the semiconductor under test, perform the following:

1. Select INPUT PORT A or B as indicated on the transistor fixture.

2. Select the S PARAMETER to be measured.

3. Adjust the signal source RF output to return the 8405A Channel A signal to the magnitude noted in step 5 of the calibration procedure.

4. Compute the s parameter magnitude from

$$\text{Magnitude} = \frac{\text{measured channel B voltage}}{\text{reference channel B voltage}}$$

5. Read the phase directly on the 8405A phase meter.

Figure 3-10. Semiconductor Measurement with 8405A Vector Voltmeter Readout (Sheet 2 of 2)

PORT B SELECTED

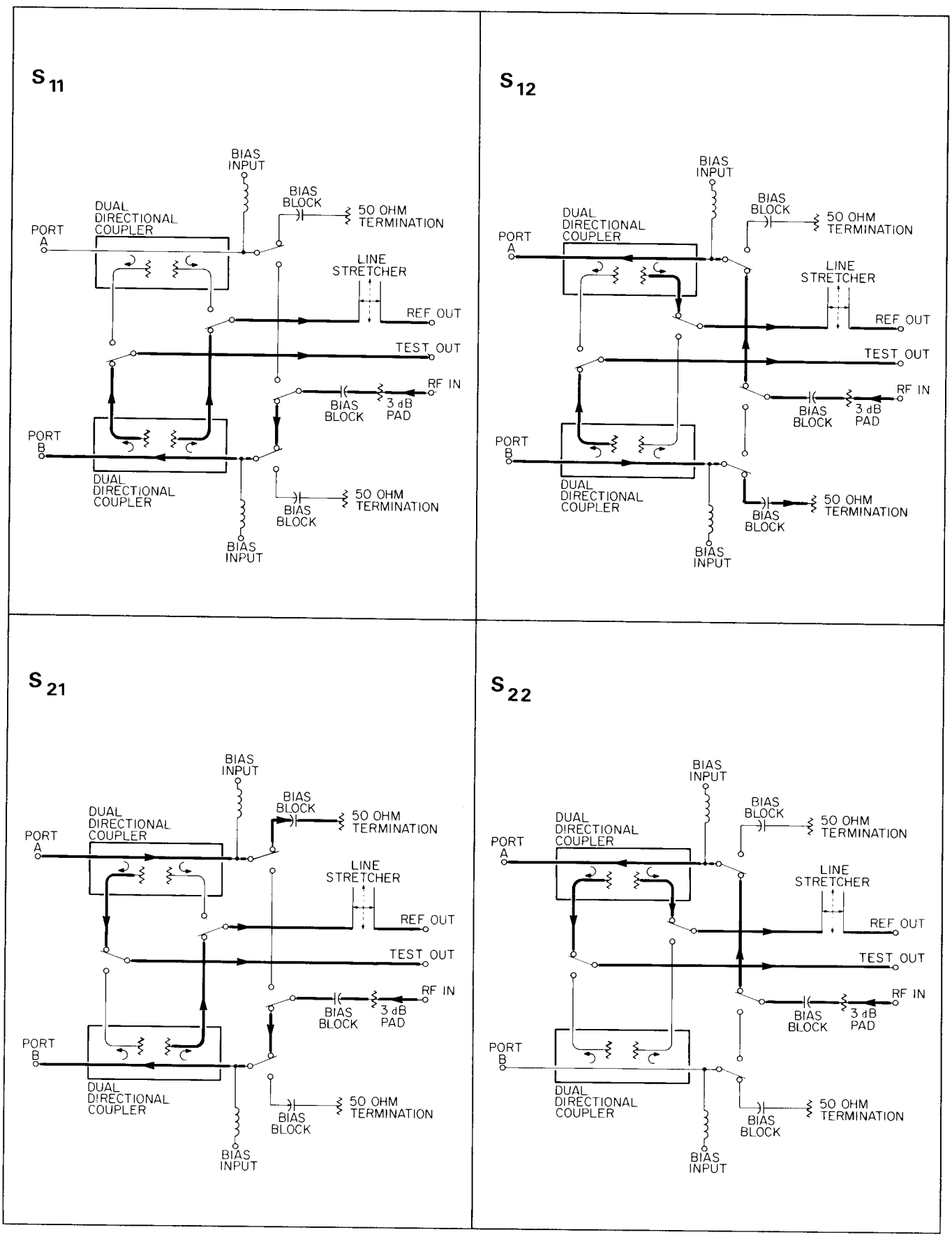
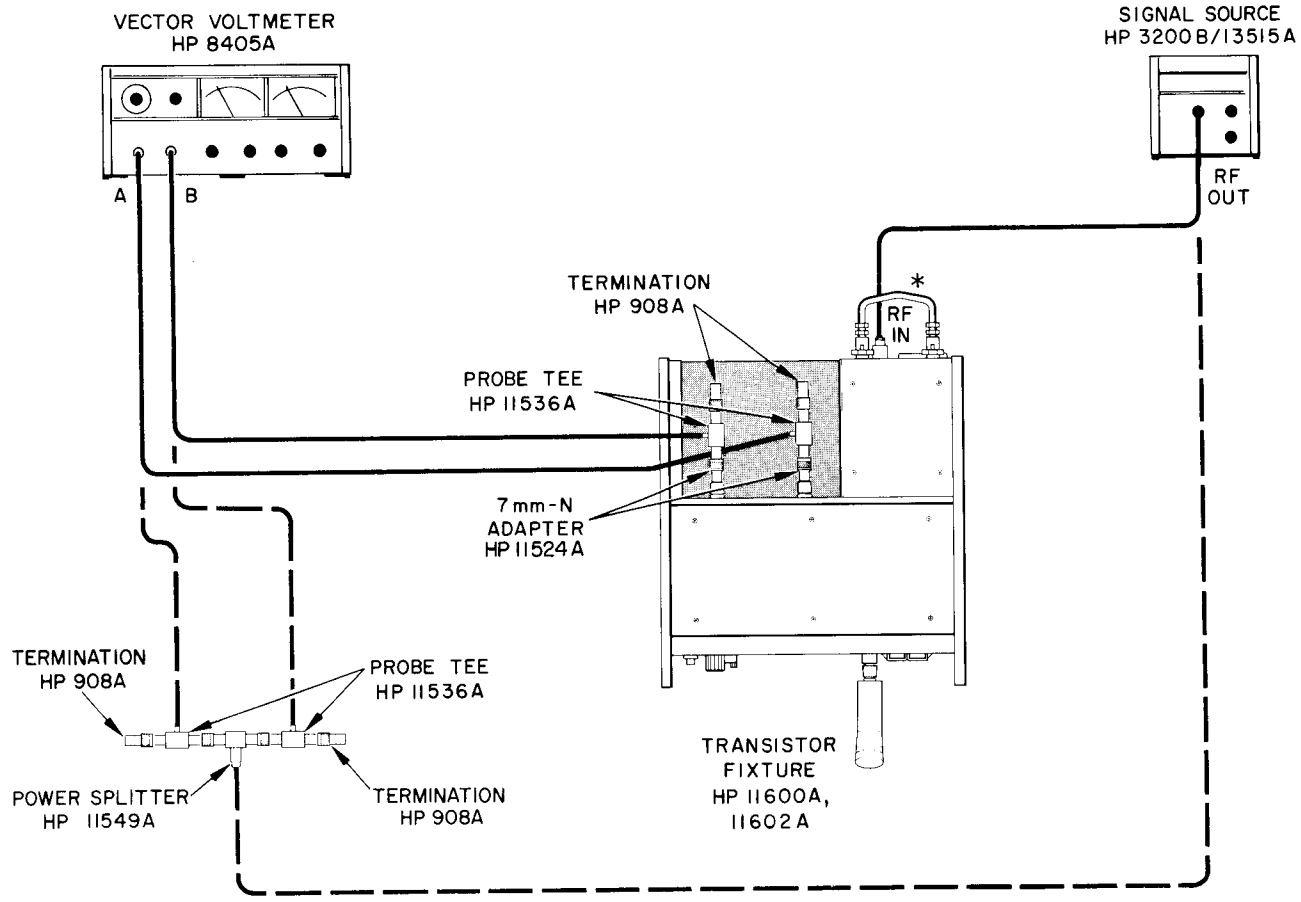
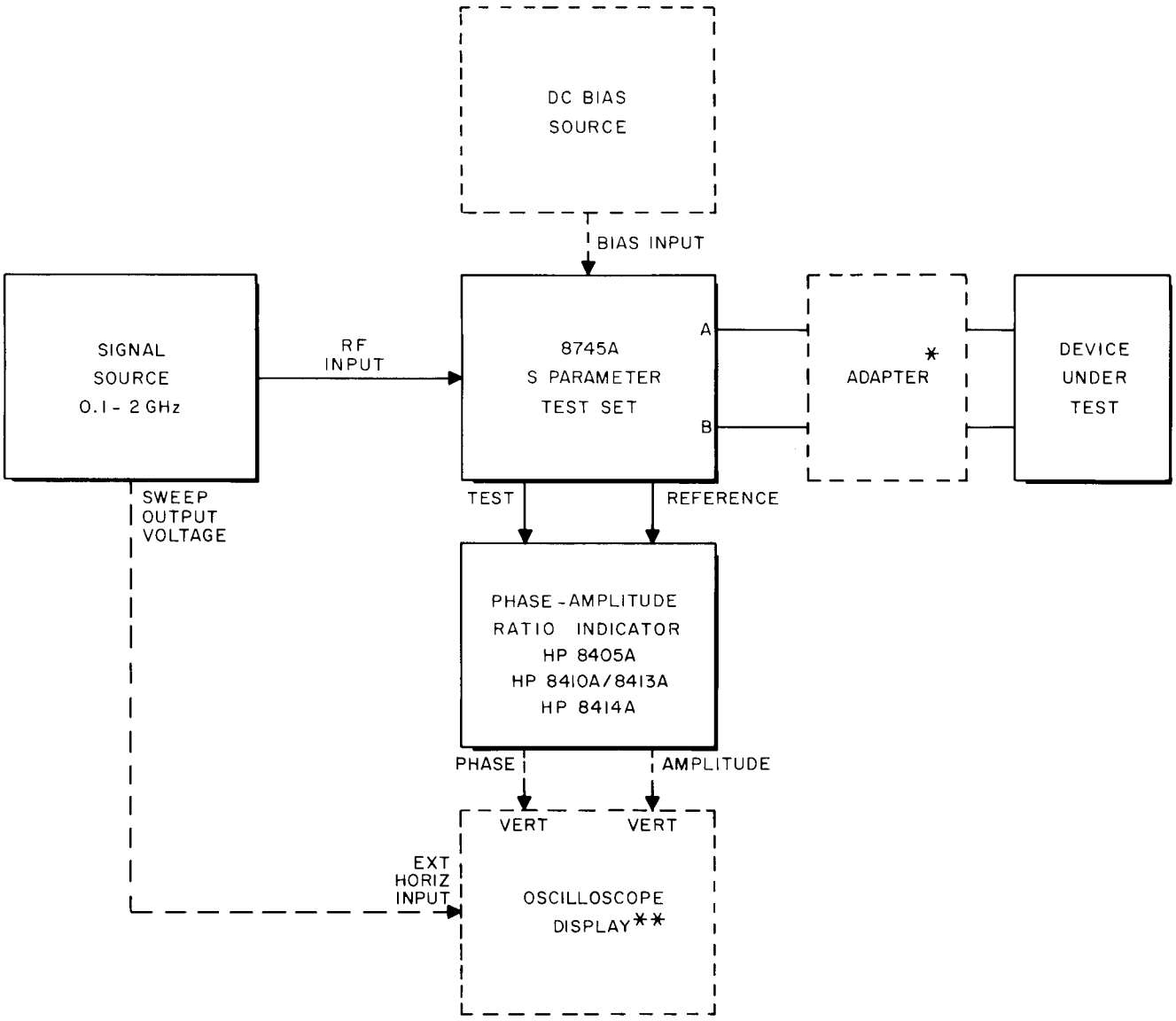


Figure 3-4. Internal Connections with INPUT PORT B and One S-Parameter Pushbutton Pressed



*Rear-panel coaxial link (HP Part Number 08745-20064). See Paragraph 3-12a.

Figure 3-10. Semiconductor Measurement with 8405A Vector Voltmeter Readout (Sheet 1 of 2)



* Optional HP 11600A or 11602A Transistor Fixtures or HP 11604A Universal Extension.
**For swept measurements with 8410A/8413A.

Figure 3-5. Block Diagram of Equipment Setup for S-Parameter Measurement

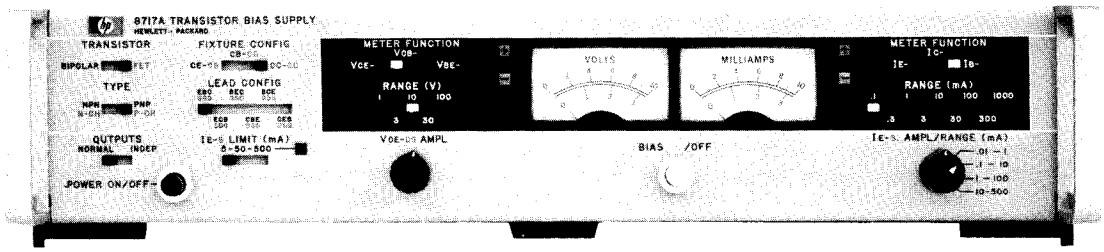
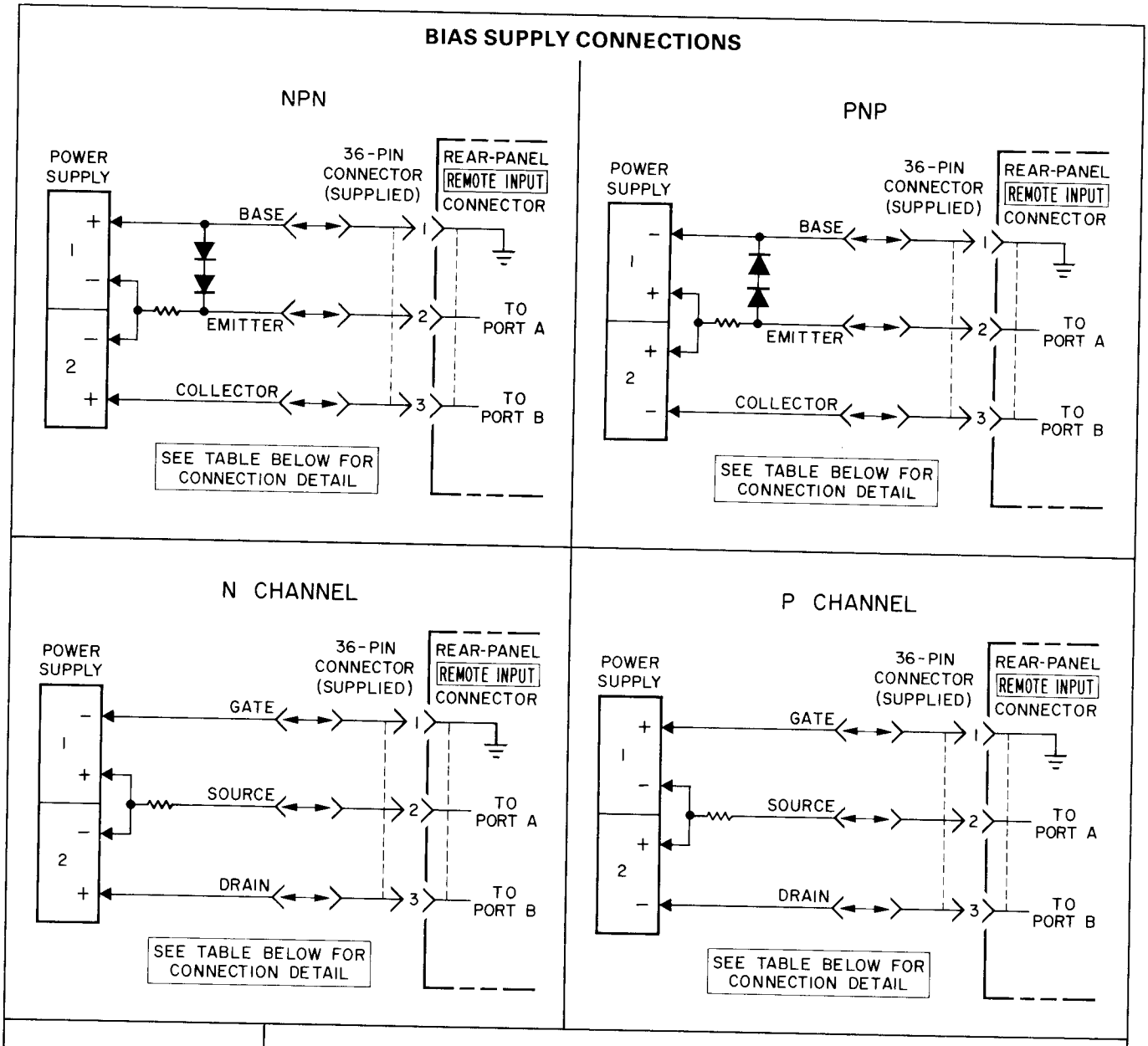


Figure 3-6. HP Model 8717A Transistor Bias Supply



	REMOTE INPUT Connector Pin Numbers					
	EBC (SGD) Base Pattern			BEC (SDG) Base Pattern		
	Common Emitter (Source)	Common Base (Gate)	Common Collector (Drain)	Common Emitter (Source)	Common Base (Gate)	Common Collector (Drain)
BASE (GATE)	Pin 2	Pin 1	Pin 3	Pin 3	Pin 1	Pin 2
EMITTER (SOURCE)	Pin 1	Pin 3	Pin 2	Pin 1	Pin 2	Pin 3
COLLECTOR (DRAIN	Pin 3	Pin 2	Pin 1	Pin 2	Pin 3	Pin 1

*HP PART NO. 1251-0084

Figure 3-9. Bias Supply Connections for Bipolar and FET Transistors

3-13. SEMICONDUCTOR BIAS SUPPLY CONNECTION AND ADJUSTMENT.

3-14. A semiconductor under test may be biased by either a Model 8717A Transistor Bias Supply or by a dual dc power supply. Instructions for connecting and adjusting these power supplies are given in the following paragraphs. An 8745A simplified internal bias circuit is shown in Figure 3-7.

3-15. With the HP Model 8717A Transistor Bias Supply, bias and bias-sensing connections are selected with the 8717A front-panel switches, (see Figure 3-6.) A cable furnished with the 8717A connects the bias supply to the rear panel of the 8745A. To apply bias to the semiconductor under test, perform the following steps.

a. Make bias and sense connections from 8745A J1 (see Table 3-1) to 8717A output. Turn the 8717A bias output off.

b. Select the dial that matches the semiconductor under test and snap the dial on the transistor fixture. If a diode is being tested, insert diode into fixture in either shunt or series configuration.

c. Rotate the dial to the desired common lead configuration.

d. Set the 8717A front-panel switches for the same configuration.

e. Plug the semiconductor into the exposed holes in the fixture.

f. Turn the 8717A bias output on.

g. Set the 8717A voltage meter function switch to monitor V_{CE-DS} and adjust the V_{CE-DS} control to the desired collector-emitter or drain-source voltage for the semiconductor under test.

h. Set the 8717A current meter function switch to monitor I_{E-S} and adjust the I_{E-S} control to the desired emitter or source current. The maximum emitter or source current can be limited to 5, 50, or 500 mA.

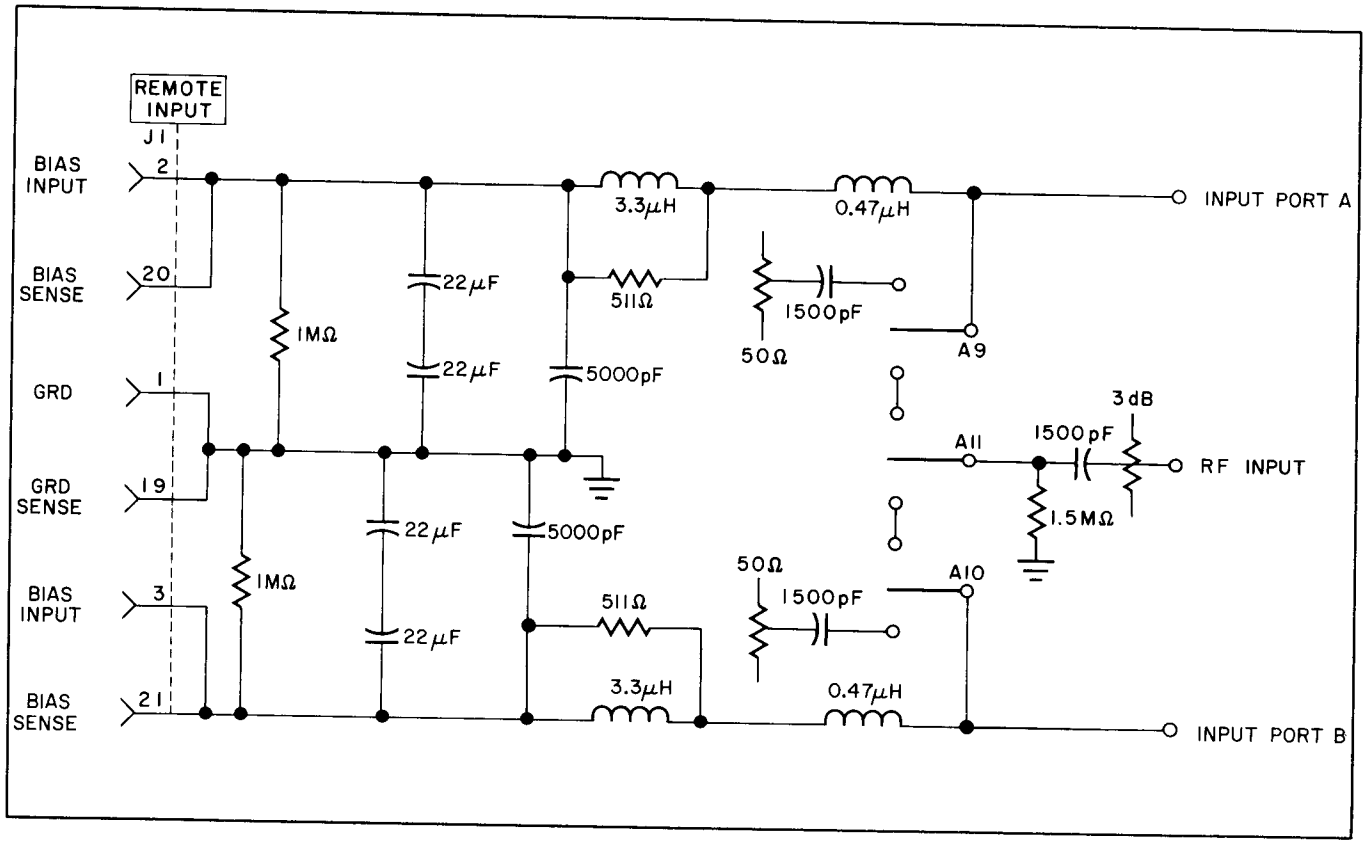


Figure 3-7. Simplified Internal Bias Circuit

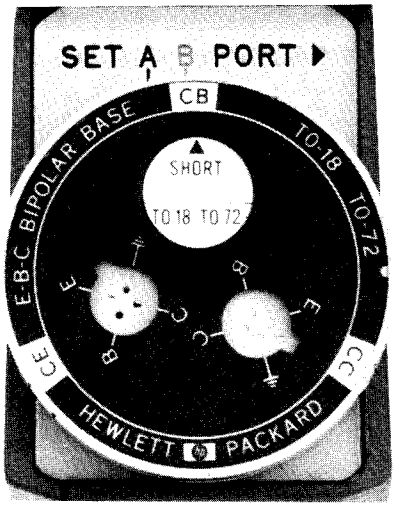


Figure 3-8. Correct Position of Snap-on Dial when Using Calibrator

3-16. Bias with a Dual dc Power Supply. Semiconductors may also be biased with a dual dc power supply. For this method a transistor under test can be protected against excessive current and excessive forward bias with a resistor and two diodes. Two series-connected diodes between emitter and base of a bipolar transistor as shown in Figure 3-9 will prevent the forward bias voltage from exceeding the voltage drop across the two diodes. A resistor in the emitter (source) circuit, selected to limit collector (drain) current to a safe amount, will also provide temperature stabilization of the bias point.

3-17. Connect the power supply to the 8745A as shown in Figure 3-9. To prevent ground loop problems do not connect power supply common to chassis. Adjust the power supply as follows:

a. Set both power supplies to zero V dc.

b. Select the dial that matches the semiconductor under test and snap the dial on the transistor fixture. If a diode is being tested, remove dial and insert diode into fixture in either shunt or series configuration.

c. Rotate the dial to the desired common lead configuration.

d. Plug the semiconductor into the exposed holes.

e. Set supply No. 2 to obtain the desired collector-emitter (drain-source) voltage. If a stabilizing resistor is used, set supply to desired voltage plus the voltage drop across the stabilizing resistor.

f. Adjust supply No. 1 until the desired collector (drain) current is obtained. Recheck voltage set in step e. When operating with power applied to the semi-conductor over an extended period of time, supply No. 1 may have to be readjusted slightly to maintain the desired collector (drain) current.

Table 3-1. Remote Input (J1) Connector Contact Identification

Pin Number	Function
1	Chassis ground
2	Port A Bias
3	Port B Bias
6	Remote S Parameter Select
17	Remote Control Common
18	Chassis Ground Sense
19	Chassis Ground Sense
20	Port A Bias Sense
21	Port B Bias Sense
24	Remote S Parameter Select
36	Remote control common
All others	No connection

Table 3-2. Calibration Readout Values

S-Parameter	Termination	Magnitude	Phase
S_{11}, S_{22}	Open	1	0^{o}
S_{11}, S_{22}	Short	1	180^{o}
S_{21}, S_{12}	Through Section	1	0^{o}