3-2. NETWORK MEASUREMENT EXAMPLE

In this example you are going to observe the transmission frequency response of a Bandpass Filter. Prepare a bandpass filter with the following specifications, and then follow the given procedure.

Center Frequency	100 MHz or higher, and 400 MHz or lower
Input/Output Impedance	50Ω or 75Ω

Recommended Accessories Used In The Following Example:

For 50Ω device measurement:

50Ω N(m)-N(m) Cable	11851B (4 cables included)
Power Splitter	11667A (two-way) or 11850C (three-way)

For 75Ω device measurement:

75Ω N(m)-N(m) Cable	11857B (2 cables included)
50Ω N(m)-N(m) Cable	11851B (4 cables included)
Power Splitter	11850D (three-way)
50Ω-75Ω Minimum Loss Pad	11852B (furnished with the 11850D)

Procedure:

1. Leave all front panel **OUTPUT/INPUT** connectors open.

2. Press the **CONFIG** key.

   The **CONFIG** key is located in the **MEASURE** section of the control unit (upper unit of the 4195A) front panel.

   You will see the softkey labels that includes **'NETWORK'**, **'SPECTRUM'**, etc. The 4195A measurement configuration can be selected on this page.

3. Press the **'NETWORK'** softkey.

   The **'NETWORK'** softkey is located at the first key from the top at the right hand edge of the CRT. When the **'NETWORK'** softkey is pressed, the softkey label will change to **green**.

   NETWORK will be displayed in the Function Area (the upper left corner of the CRT). This indicates that the 4195A is in network configuration.

4. Press the **PRESET** key.

   The **PRESET** key is located at the lower center of the control unit front panel. The **PRESET** key will clear most of the previous control settings and return them to the default settings. The **PRESET** key will not clear control settings that are unique to unselected configurations.

5. Connect the bandpass filter as shown in Figure 3-1.

6. Press the **CENTER** key.

   CENTER= 250000000.000 HZ will be displayed on the keyboard input line.

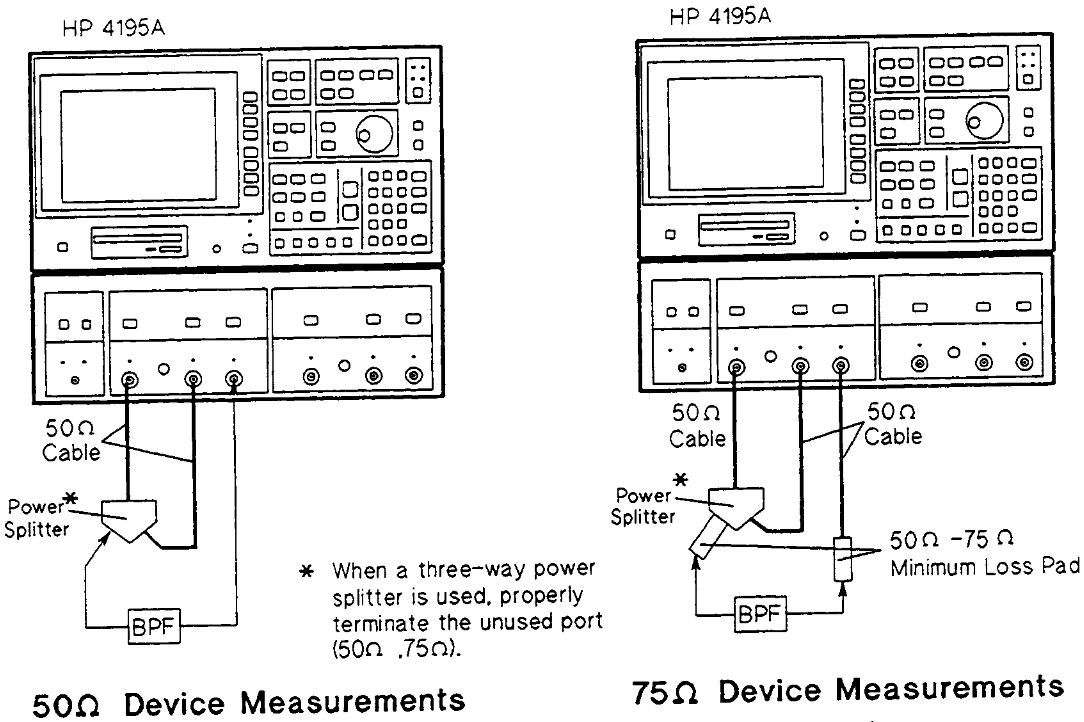

Figure 3-1. Network Measurement Example Setup

7. Enter the center frequency of your bandpass filter using the numeric and unit keys.

   The center frequency can be changed using the **arrow up** and **arrow down** keys instead of numeric and unit keys.

8. Press the **SPAN** key and change the frequency span as appropriate for measuring your bandpass filter.

9. Press the **RES BW** key.

   RBW= (the currently set resolution bandwidth) will be displayed on the keyboard input line.

10. Press the **arrow down** key.

    Every time you press the **arrow down** key, the resolution bandwidth will be narrowed, the time required for measurement will be increased, and you will observe less fluctuation on the traces.

11. Press the **VIDEO FILTER** key.

    The indicator located at the center of **VIDEO FILTER** turns **ON**. You will observe less fluctuation in the resulting measurement traces on the CRT, and the measurement time will increase.

12. Using the resolution bandwidth filter and the video filter settings, find the best measurement stability and the sweep time for your measurement.

13. Press the **MKR** → key and **'MKR→ MAX'** softkey.

    The marker will move to the maximum value of the yellow trace. The frequency at which the insertion loss of the bandpass filter is minimum, the yellow trace maximum value (insertion loss) and the phase shift at the frequency are displayed above the graph area of the screen.

14. Press the **MODE** key and the **'oMKR & LCURS'** softkey.

15. Press the **'Δmode on off'** softkey so that **on** changes to **green.**

16. Press the **'more 1/2'** and **'WIDTH on off'** softkey to select **on.**

    The difference between the marker and the line cursor in dBs and the frequency width between the two intersection points of the yellow trace and the line cursor will be displayed.

17. Rotate the **knob** in both directions.

    The line cursor will move up and down. You can read the difference between the o marker and the line cursor to determine the bandwidth of the filter.

18. Press the **'ΔVALUE entry'** softkey.

    DLCURS= will be displayed on the keyboard input line.

19. Press the minus (-), **3**, and **ENTER/EXECUTE** keys in sequence.

    The line cursor will move to the point which is -3 dB from the insertion loss level, and the -3 dB bandwidth will be displayed.

20. Press the **'Q VALUE'** softkey.

    The quality factor value of the filter at the -3 dB point will be displayed.

21. Press the **MODE** key and **'off'** softkey.

    The marker and the line cursor will disappear.

22. Press the **FORMAT** key and **'T/R-τ (dB)'** softkey.

    The blue trace shows the group delay, not the phase shift.

23. Press the **SCALE REF** key and **'SCALE forA forB'** softkey to select **forB** (change to green).

24. Press the **'B AUTO SCALE'** softkey.

    The display scale for the group delay measurement result will be optimized.

NOTE

This example simply shows measurement operation, the calibration capability of the 4195A was not used. Refer to paragraph 4-8, MEASUREMENT CALIBRATION, for useful techniques when high accuracy measurements are required.

3-3. SPECTRUM MEASUREMENT EXAMPLE

In this example you are going to observe the harmonic distortion of a 10 MHz signal. The 10 MHz signal available from the control unit's rear panel is used for this example.

Recommended Accessories Used In The Following Example:

50Ω BNC(m)-BNC(m) Cable, 122 cm	HP PN 8120-1840
N(m)-BNC(f) Adapter	HP PN 1250-1476

Procedure:

1. Leave all front panel **OUTPUT/INPUT** connectors open.

2. Press the **CONFIG** key.

   The **CONFIG** key is located in the **MEASURE** section of the control unit (upper unit of the 4195A) front panel.

   You will see the softkey labels that includes **'NETWORK'**, **'SPECTRUM'**, etc. The 4195A measurement configuration can be selected on this page.

3. Press the **'SPECTRUM'** softkey.

   The **'SPECTRUM'** softkey is located at the second key from the top of the Soft-key Area (the right hand edge of the CRT). When the **'SPECTRUM'** softkey is pressed, the softkey label will change to **green**.

   SPECTRUM will be displayed in the Function Area (the upper-left corner of the CRT) indicating that the 4195A is in spectrum configuration.

4. Press the **PRESET** key.

   The **PRESET** key is located at the lower center of the control unit front panel. The **PRESET** key will clear most of the previous control settings and return them to the default settings. The **PRESET** key will not clear control settings that are unique to unselected configurations.

5. Press the **CHANNEL 1 RECEIVER REF ATTEN** key.

   ATR1= 10 DB will be displayed on the keyboard input line, and the softkey labels are changed for IF Range selection. The **'IF RNG NORMAL'** softkey label will be change to **green**.

6. Press the **arrow up** key three times.

   The R1 input attenuator will be set to 40 dB and the RANGE display for the R1 input (displayed on the right hand side of the system message line) will change to +20 dBm. This is for measuring a maximum amplitude signal of +20 dBm.

7. Connect the **10 MHz OUTPUT** connector on the control unit rear panel and the **R1** connector on the measurement unit front panel as shown in Figure 3-2.

   You will see the 10 MHz fundamental signal and some spurious signals traces on the CRT. The 10 MHz OUTPUT signal is not a pure sine wave, because the purpose for which this signal is intended does not require high spectral purity.

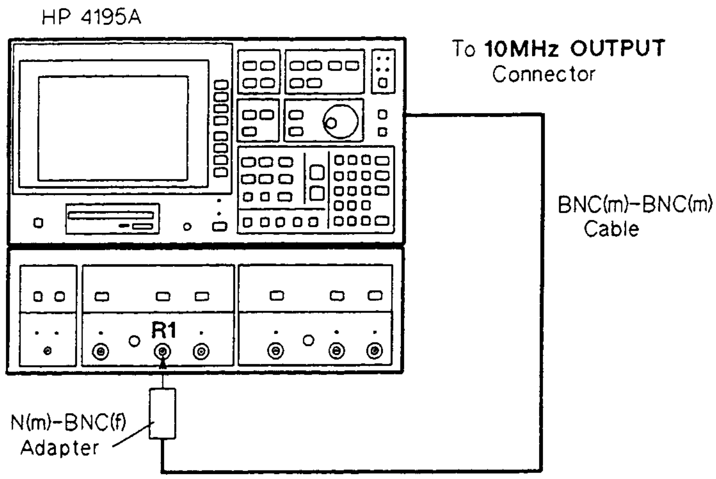

Figure 3-2. Spectrum Measurement Example Setup

8. Press the **SCALE REF** key and the **'A AUTO SCALE'** softkey.

9. Press the **START** key.

   START= 0.001 HZ will be displayed on the keyboard input line. This reports that the currently set **START** frequency (the most left of the measurement trace) is 1 mHz.

10. Press the **5** and **MHz/V** keys.

    When you press the **5** key, the previously displayed **0.001 HZ** will disappear. When you press **MHz/V** key, the start frequency is changed to 5 MHz and **START= 50000000.000 HZ** will be displayed. The currently set **START** and **STOP** frequencies are displayed below the displayed graph.

11. Press the **STOP**, **1**, **0**, **5**, and **MHz/V** keys in sequence.

12. Press the **MKR →** key and the **'MKR→ MAX'** softkey.

    The marker will move to the 10 MHz point on the trace.

13. Press the **'NEXT PEAK'** softkey.

    The marker will move to the next lower peak, each time you press **'NEXT PEAK'**.

14. Disconnect the input signal from the R1 connector.

15. Press the **'more 1/2'**, and **'NOISE on off'** softkeys to select **on**.

16. Rotate the **knob** to select a frequency at which to read the noise level.

    The noise level (normalized per hertz) will be displayed above the graph area of the CRT.

3-4. IMPEDANCE MEASUREMENT EXAMPLE

This example shows how to measure the impedance characteristics of a chip type component under the following measurement conditions.

Test Frequency	100 kHz to 500 MHz (log sweep)
Output Level	0 dBm

Recommended Accessories Used In The Following Example:

Impedance Test Kit	41951A
Test Fixture	16092A

Procedure:

1. Connect the impedance test adapter from the HP 41951A to the front panel of the 4195A.

   Figure 3-3 shows the impedance test adapter connected to the 4195A.

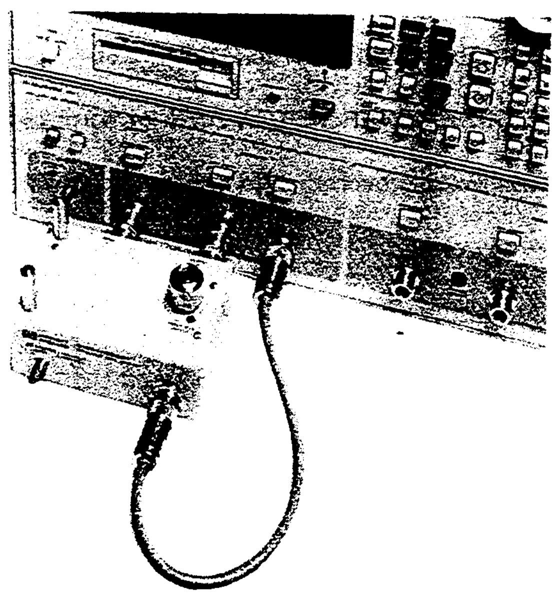

Figure 3-3. Impedance Test Adapter Connection

2. Press the **CONFIG** key and **'IMPEDNCE'** softkey, then press the **PRESET** key.

3. Press the **START** key.

   START= 0.001 HZ will be displayed on the keyboard input line. This reports that the currently set **START** frequency (the most left of the measurement trace) is 1 mHz.

4. Press the **1**, **0**, **0**, and **kHz/dBm** keys.

   When you press the **1** key, the previously displayed **0.001 HZ** will disappear. When you finaly press the **kHz/dBm** key, the start frequency is changed to 100 kHz and **START= 100000.000 HZ** will be displayed. The currently set **START** and **STOP** frequencies are displayed below the displayed graph.

5. Press the **MENU** key and the **'TYPE lin log'** softkey.

   When you press the **'TYPE lin log'** softkey, the **'log'** of the **'TYPE lin log'**softkey label will change to intensified **green**, and log sweep is set.

NOTE

Steps 10 and 11 set the 4195A's output level to 12 dBm so that the output level at the 41951A impedance test adapter's measurement terminal will be 0 dBm (insertion loss of the 41951A is approximately 12 dB). Steps 6 to 9 set the input attenuators to 20 dB so that the input ports will not be overloaded by the 12 dBm input level.

6. Press the **CHANNEL 1 RECEIVER REF ATTEN** key on the lower unit's front panel.

   ATR1= 10 DB will be displayed on the keyboard input line.

7. Press the **arrow up** key once.

   The R1 input attenuator will be set to 20 dB.

8. Press the **CHANNEL 1 RECEIVER TEST ATTEN** key on the lower unit's front panel.

   ATT1= 10 DB will be displayed on the keyboard input line.

9. Press the **arrow up** key once.

   The T1 input attenuator will be set to 20 dB.

10. Press the **CHANNEL 1 SOURCE AMPLITUDE** key on the lower unit's front panel.

    OSC1= 0.0 DBM will be displayed on the keyboard input line.

11. Press the **1**, **2** and **kHz/dBm** keys.

    The output level value displayed on the keyboard input line will be changed to **OSC1= 12.0 DBM.**

12. Press the **CAL** key and the **'CAL menu'** softkey.

13. Press the **'ONE PORT FULL CAL'** softkey.

14. Connect the **OPEN** termination furnished with the 41951A (labeled as 0S) atop the APC-7 connector of the Impedance Test Adapter.

    Rotate the coupling nut of the APC-7 connector CW (clockwise) so that the coupling sleeve protrudes fully. **Do not touch the terminal contact surface with your fingers (to maintain optimum contact cleanliness).** Place the **OPEN** termination on the APC-7 connector. Hold the center brass part of the termination so it will not rotate, and rotate the termination cap nut CW (clockwise) until fully tightened, **DON'T OVER TIGHTEN.**

15. Press the **'OPEN'** softkey and the **ENTER/EXECUTE** key.

    Measuring OPEN will be displayed, and **SHORT CAL required** will be displayed after a short time.

16. Disconnect the **OPEN** termination and connect the **SHORT** termination furnished with the 41951A (labeled as 0Ω) atop the APC-7 connector of the Impedance Test Adapter.

    Place the **SHORT** termination on the APC-7 connector. **Carefully handle the termination so as not to damage or contaminate its precision contact surface.** Hold the center brass part of the termination so it will not rotate, and rotate the termination cap nut CW (clockwise) until fully tightened, **DON'T OVER TIGHTEN.**

17. Press the **'SHORT'** softkey and the **ENTER/EXECUTE** key.

    Measuring SHORT will be displayed, and **LOAD CAL required** will be displayed after a short time.

18. Disconnect the **SHORT** termination and connect the **LOAD** termination furnished with the 41951A (labeled as 50Ω) atop the APC-7 connector of the Impedance Test Adapter.

    Rotate the coupling nut of the 50Ω termination so that the coupling sleeve of the termination is at its innermost free position. Place the 50Ω termination on the APC-7 connector. Hold the termination body so it will not rotate, and rotate the outer nut of the termination CW (clockwise) until fully tightened, **DON'T OVER TIGHTEN.**

19. Press the **'LOAD'** softkey and the **ENTER/EXECUTE** key.

    Measuring LOAD will be displayed, and **Calculating CAL coefficient** will then be displayed after a short time.

NOTE

To confirm that calibration is being perfomed properly, press the **'CORRCTN on off'** softkey to set calibration function to on, and the **TRIG/RESET** key to measure the 50Ω termination. If measurement result is approximately 50Ω, calibration is being perfomed properly, and you can proceed to step 20 after the **CAL** key is pressed.

20. Disconnect the 50Ω termination and place the test fixture atop the Impedance Test Adapter as shown in Figure 3-4.

    After use, leave the 50Ω termination coupling sleeve screw protruding to prevent possible impairment to the termination surface.

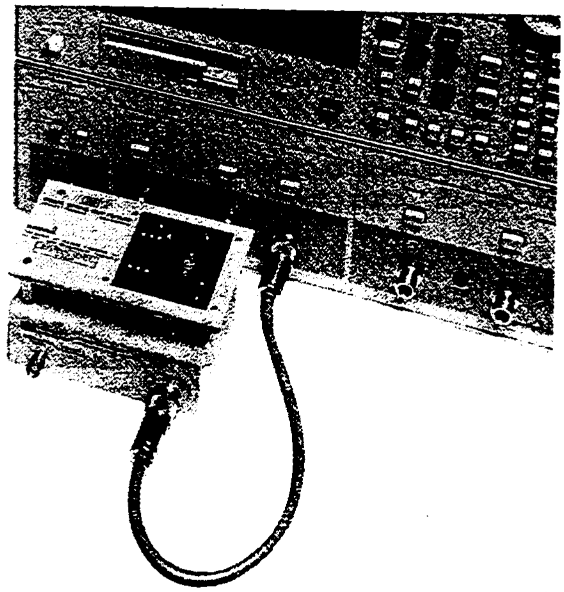

Figure 3-4. Test Fixture Connection

21. Press the **'COMPEN menu'** softkey and **'0S&0Ω OFFSET'** softkey.

22. Open the measurement terminal of the test fixture.

    Set the attachment as shown in Figure 3-5 open position so that the center conductor does not short to the outer conductor.

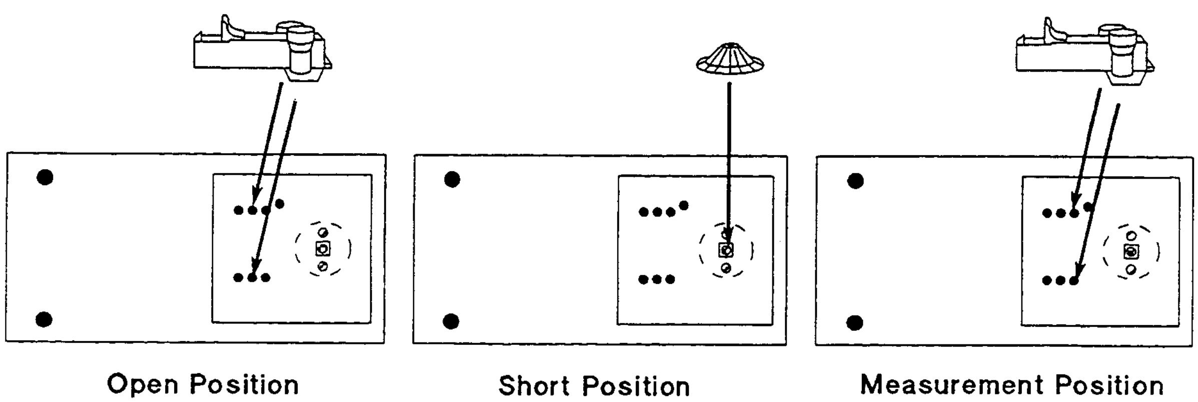

Figure 3-5. Attachment Connection

23. Press the **'0S'** softkey and the **ENTER/EXECUTE** key.

    Measuring 0S will be displayed, and **0Ω compen required** will be displayed after a short time.

24. Short the measurement terminal of the test fixture.

    Remove the attachment from the 16092A, and set the short ring (furnished with the 16092A) to the 16092A's center conductor as shown in Figure 3-5 short position.

25. Press the **'0Ω'**softkey and the **ENTER/EXECUTE** key.

    Measuring 0Ω will be displayed, and **Compen completed (TURN ON "CORR" KEY)** will be displayed after a short time.

26. Press the **'CORRECTN on off'** softkey.

    Calculating CAL coefficient will be displayed, and the **'on'** of the **'CORRECTN on off'** softkey label will changed to green after a short time.

NOTE

Refer to paragraph 4-8, for details about Calibration.

27. Connect the component to be measured to the test fixture.

    Set the attachment on the 16092A as shown in Figure 3-5 measurement position, and connect the component to the attachment.

28. Press the **TRIG/RESET** key to measure the device under test.

3-5. S-PARAMETER MEASUREMENT EXAMPLE

In this example you will measure the S-Parameters of a network.

Recommended Accessories Used In The Following Example:

For 50Ω device measurement:

Transmission/Reflection Test Set	41952A, 2 set

For 75Ω device measurement:

Transmission/Reflection Test Set	41952B, 2 set

Procedure:

1. Connect two Transmission/Reflection Test Sets (two HP 41952A/Bs) to the 4195A's front panel output/input connectors as shown in Figure 3-6.

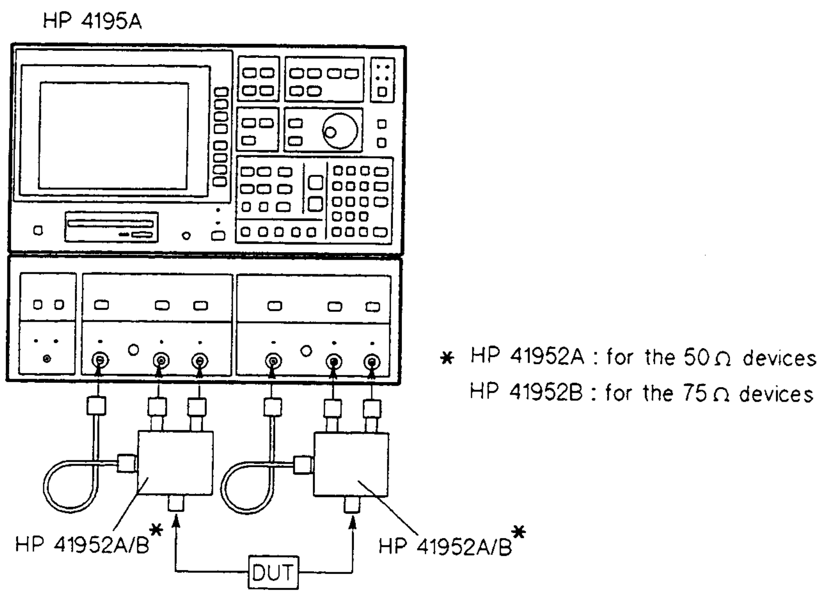

Figure 3-6. S-Parameter Configuration Setup Example

2. Connect the network under test between the TEST PORTs of the two HP 41952A/Bs.
3. Press the **CONFIG** key and **'S-PRMTR'** softkey, then press the **'S11'** softkey.
4. Press the **PRESET** key.

   The yellow LED indicators at connectors **S1**, **R1**, and **T1** will turn **ON**.

5. Press the **DISPLAY** key and **'SMITH'** softkey.

   The measurement **FORMAT** (parameter) is automatically changed to Γx-Γy. Now the 4195A displays S11 (forward reflection) on the Smith chart.

6. Press the **CONFIG** key and **'S21'** softkey, then press the **PRESET** key.

   The yellow LED indicators at connectors **S1**, **R1**, and **T2** will turn **ON**. Now the 4195A displays S21 (forward transmission) frequency response characteristics.

7. Press the **FORMAT** key and the **'T/R-τ (dB)'** softkey.

   Now the 4195A displays S21 (forward transmission) group-delay frequency response characteristics.

8. Press the **SCALE REF** key, and the **'SCALE forA forB'** and **'B AUTO SCALE'** softkeys.

   The display scale for the group delay measurement result will be optimized.

9. Press the **CONFIG** key and the **'S12'** softkey, then press the **PRESET** key.

   The yellow LED indicators at the **T1**, **S2**, and **R2** connectors will turn **ON**. Now the 4195A displays S12 (reversed transmission) frequency response characteristics.

10. Press the **CONFIG** key and the **'S22'** softkey, then press the **PRESET** key.

    The yellow LED indicators at connectors **S2**, **R2**, and **T2** will turn **ON**.

11. Press the **DISPLAY** key and **'POLAR'** softkey.

    The measurement **FORMAT** (parameter) is automatically changed to Γx-Γy. Now the 4195A displays S22 (reversed reflection) on the polar chart.

12. Press the **SCALE REF** key and the **'AUTO SCALE'** softkey.

13. Press the **CONFIG** key. Then press **'S11'**, **'S21'**, **'S12'**, and **'S22'** softkeys in sequence.

    As you can see, the 4195A remembers the measurement format (parameter) and the display format for each S-parameter configuration.

14. Select the measurement conditions (frequency range, resolution bandwidth, etc.).

    You can measure all four S-parameters by just selecting the **'S11'**, **'S21'**, **'S12'**, and **'S22'** softkeys.

NOTE

This example simply shows measurement operation, the calibration capability was not used. Refer to paragraph 4-8, MEASUREMENT CALIBRATION, for techniques you can use to make more accurate measurements.

4-4. NETWORK CONFIGURATION

The network configuration is selected by pressing the **'NETWORK'** softkey or sending the **FNC1** command.

In the Network configuration the amplitude ratio and phase difference between two the input signals are measured. When used with a power splitter, the network configuration is used for measuring transmission gain/loss and phase shift. When used with a directional bridge, the network configuration is used for measuring the reflection characteristics of the circuit under test.

4-4-1. NETWORK CONFIGURATION PORT SELECTION

Pressing the **CONFIG** key and the **'PORT SELECT'** softkey displays the set of port selection softkeys used to define the output/input connectors used for network measurements. There are five possible port selection combinations which are listed in Table 4-1. For example, when **'T1/R1'** is selected, the **T1** and **R1** connectors are used for test and reference inputs, respectively, and the **S1** connector is used to output the test signal. The default setting is **'T1/R1'**.

Table 4-1. Network Configuration Port Selection

Softkey	Test	Reference	Source	Command
'T1/R1'	T1	R1	S1	PORT1
'T2/R1'	T2	R1	S1	PORT2
'R2/R1'	R2	R1	S1	PORT3
'T1/R2'	T1	R2	S2	PORT4
'T2/R2'	T2	R2	S2	PORT5

4-4-2. NETWORK CONFIGURATION MEASUREMENT PARAMETERS

Pressing the **FORMAT** key when in the network configuration displays the set of measurement format (parameter) selection softkeys used to define the trace A and B data. There are four possible measurement formats (parameters) available in the network configuration. The default setting is **'T/R(dB)-θ'** (or **'R2/R1(dB)-θ'**).

1. 'T/R(dB)-θ' or **'R2/R1(dB)-θ'** (Command is GPP1)

The amplitude ratio between the selected test input and the selected reference input is measured and displayed in dB units as trace A. When the 4195A is used for transmission measurement, trace A represents the gain or attenuation of the network under test. When the 4195A is used for the reflection measurement, trace A represents the return loss of the network under test.

The phase difference between the selected test input and the selected reference input is measured and displayed as trace B. The measurement unit is degrees (**deg**) or radians (**rad**), which is determined by the angle mode setting. Refer to paragraph 5-5, ANGLE MODE. The default unit is degrees.

2. 'T/R-θ' or 'R2/R1-θ' (Command is GPP2)

The voltage ratio between the selected test input and the selected reference input is measured and displayed as trace A. When the 4195A is used for the reflection measurement, trace A represents the absolute value of the reflection coefficient ($|\Gamma|$) of the network under test.

The phase difference is the same as in the **'T/R(dB)-θ'** format and is displayed as trace B.

3. 'T/R Re-Im' or 'R2/R1 Re-Im' (Command is GPP3)

The vector voltage ratio between the selected test input and the selected reference input is measured and displayed. The real and imaginary components of the ratio are displayed as trace A and B, respectively. When the 4195A is used for reflection measurement, trace A and B data are the real and imaginary components of the reflection coefficient (Γx and Γy) of the network under test, respectively.

4. 'T/R(dB)-τ' or 'R2/R1(dB)-τ' (Command is GPP4)

The amplitude ratio as same as **'T/R(dB)-θ'** format is measured and displayed as trace A.

Group delay is measured and displayed as trace B. Refer to paragraph 4-4-3. GROUP DELAY MEASUREMENT.

4-4-3. GROUP DELAY MEASUREMENT

When the **'T/R(dB)-τ'** or **'R2/R1(dB)-τ'** measurement format is selected, the 4195A internally performs a **'T/R(dB)-θ'** (or **'R2/R1(dB)-θ'**) measurement and calculates the group delay (τ in seconds) using the following formulas.

$$\tau = \Delta\theta \, / \, (360 \times \Delta f) \quad \text{in the degree mode, or}$$
$$\tau = \Delta\theta \, / \, (2 \times \pi \times \Delta f) \quad \text{in the radian mode}$$

Where Δf is the delay aperture in Hz,
$\Delta\theta$ is the phase difference of the two frequency points, the frequency points are specified by Δf.

For the 4195A the group delay at point **n**, $\tau(n)$ is represented by the following equation. (Only the degree mode equation is shown.)

$$\tau(n) = \frac{\{ \theta(n - \Delta n) - \theta(n + \Delta n) \}}{360 \times \Delta f} \quad \text{(seconds)}$$

Where **n** is the current measurement point for which the group delay is to be measured.

Δn is the number of measured points from the center point and is calculated using the following equation.

$$\Delta n = (NOP - 1) \times (\Delta f / SPAN) / 2$$

NOP is the total number of measurement points in the sweep span, and can be selected from 2 to 401.

SPAN is the frequency span of the sweep measurement.

Δf is the delay aperture in Hz.

$\theta(n - \Delta n)$ is the measured phase at the lowest point in the aperture.

$\theta(n + \Delta n)$ is the measured phase at the highest point in the aperture.

Figure 4-1 shows an example relationship of the above factors, when Δn is 2.

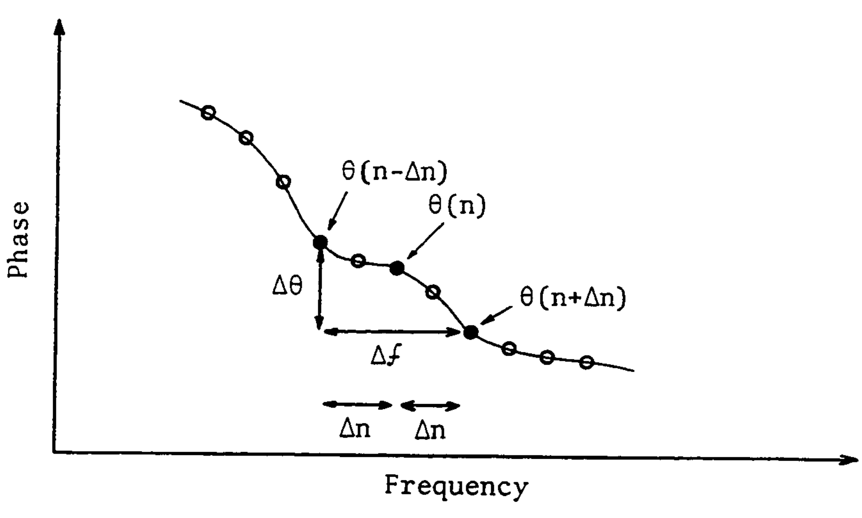

Figure 4-1. Relationship of Factors

NOTE

When (n - Δn) is less than or equal to 1, θ(n - Δn) is θ(1) (measured phase data at the start frequency point). When (n + Δn) is greater than or equal to NOP, θ(n + Δn) is θ(NOP) (measured phase data at the stop frequency point).

The delay aperture is selected using **'APERTURE entry'** softkey (or the **DFREQ=** command). The aperture is in percent-of-span which can be set from 0.5% to 100% in 0.5% steps. The default value is 0.5%.

NOTE

The minimum aperture is limited by the NOP (number of measurement points), and is 200 ≈ NOP (in percent).

A large aperture has more of a smoothing effect on the trace than a smaller aperture, but small changes in group delay may not be observable.

To review and change the aperture in percent-of-span, use the following procedure.

1. Press the **FORMAT** key and **'APERTURE entry'** softkey.
2. **DFREQ=** (current aperture) will be displayed on the keyboard input line.
3. If you press one of the number keys, the currently set aperture value will be erased and the number you pressed will be displayed. If you press the left or right arrow key, the cursor will move and you can change aperture value digit by digit.
4. Press the **ENTER/EXECUTE** key.

4-4-4. NETWORK MEASUREMENT CALIBRATION

This paragraph describes the network measurement calibration procedures. For details about 4195A calibration, refer to paragraph 4-8. MEASUREMENT CALIBRATION.

1. Transmission Calibration Procedure

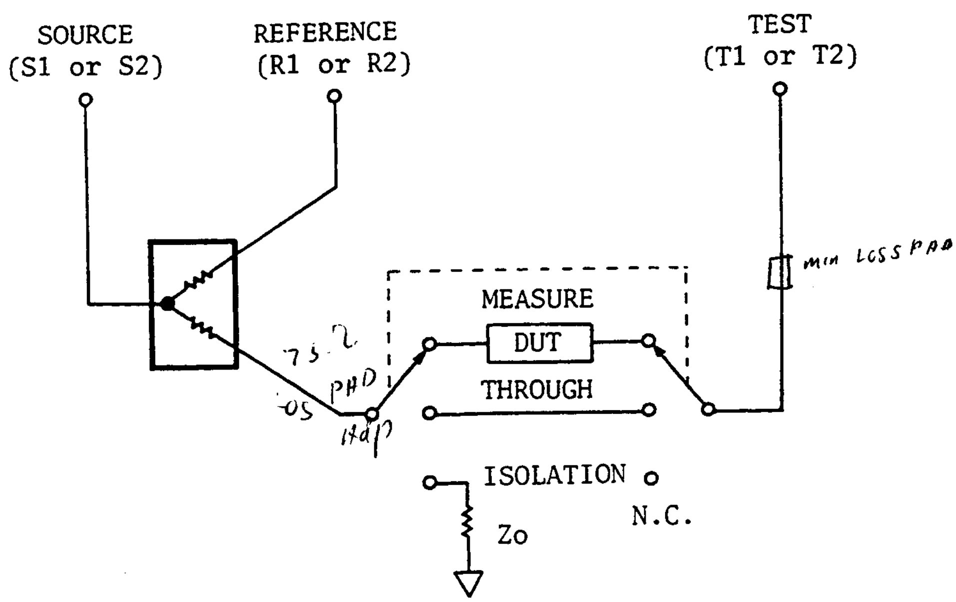

Figure 4-2. Transmission Calibration Diagram

1. Press the **CONFIG** key, the **'NETWORK'** softkey, and the **PRESET** key, in sequence.
2. Connect a power splitter, and a network as appropriate -- the MEASURE position shown in Figure 4-2.
3. Set the 4195A's stimulus and receiver settings as appropriate for the selected measurement.
4. Press the **CAL** key and the **'TRANS CAL menu'** softkey.
5. Press the **'NORM&ISN CAL'** softkey.

NOTE

If you don't need to perform the isolation calibration, press the **'NORMALIZE (THRU)'** softkey instead and skip to step 8.

6. Terminate the source signal with an impedance matched load, and disconnect the network under test from the setup, leave the test channel open -- the ISOLATION position shown in Figure 4-2.
7. Press the **'ISOLATN'** softkey and the **ENTER/EXECUTE** key, and wait until **THRU CAL required** is displayed.

8. Short circuit the test cables to make a through connection -- the THROUGH position shown in Figure 4-2.

9. Press the **'THRU'** softkey and the **ENTER/EXECUTE** key, and wait until **Cal complet-ed (TURN ON "CORR" KEY)** is displayed.

10. Connect the network under test as appropriate for the selected measurement -- the MEASURE position shown in Figure 4-2.

11. Press the **'CORRECTN on/off'** softkeys. **'on'** in the **'CORRECTN on/off'** softkey will change to intensified **green** and **Cor** will be displayed in the function area of the screen. Succeeding measurements are corrected using this calibration measurement data.

2. Reflection Calibration Procedure

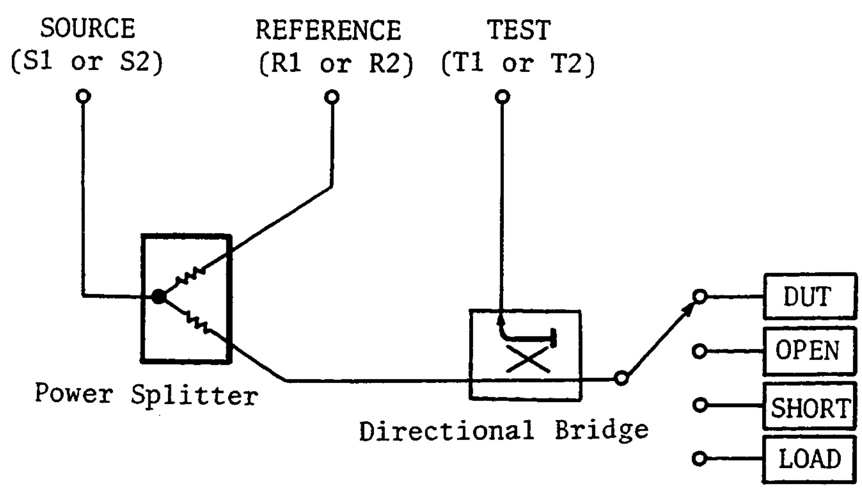

Figure 4-3. Reflection Calibration Diagram

1. Press the **CONFIG** key, the **'NETWORK'** softkey, and the **PRESET** key in sequence.

2. Connect a directional bridge, a power splitter and the network under test as appropriate for the selected measurement -- the DUT position shown in Figure 4-3.

3. Set the 4195A's stimulus and receiver settings as appropriate for the measurement.

4. Press the **CAL** key and **'more 1/2'** softkey.

5. Select the characteristic impedance of your measurement system -- 50Ω or 75Ω -- using the **'Z0 50Ω 75Ω'** softkey. Each time the **'Z0 50Ω 75Ω'** softkey is pressed, the selected impedance will be toggled to intensified **green.**

6. Press the **'CAL STD modify'** softkey. Previously set (or default setting) calibration values for the reference calibration standards will be displayed.

7. Press the **'OPEN CAL STD'** softkey. **OPNSTD** will be displayed on the keyboard input line.

8. Enter a good estimation of the OPEN standard's calibrated conductance in Siemens (S) and parallel capacitance in Farads (F) units separated by a comma (,). For example, you would press the following keys if the calibrated value is 0S + 310fF.

OPNSTD= [0] [,] [3] [1] [0] [EEX] [-] [1] [5] [ENTER/EXECUTE]

NOTE

If you need to perform only the calibration using OPEN, skip to step 13.

9. Press the **'LOAD CAL STD'** softkey. **LDSTD** will be displayed on the keyboard input line.

10. Enter a good estimation of the LOAD standard's calibrated series resistance in ohms (Ω) and the series inductance in Henries (H) separated by a comma (,). For example, you would press the following keys, if the calibrated value is 50Ω + 5 nH.

LDSTD= [5] [0] [,] [5] [Blue Shift] [N] [ENTER/EXECUTE]

NOTE

If you need to perform only the OPEN and LOAD calibration, skip to step 13.

11. Press the **'SHORT CAL STD'** softkey. **SHTSTD** will be displayed on the keyboard input line.

12. Enter a good estimation of the SHORT standard's calibrated series resistance in ohms (Ω) and the series inductance in Henries (H) separated by a comma (,). For example, you would press the following keys, if the calibrated value is 0Ω + 5 nH.

SHTSTD= [0] [,] [5] [Blue Shift] [N] [ENTER/EXECUTE]

13. Press the **'return'** and the **'REFLECTN CAL menu'** softkey.

14. Press the **'ONE PORT FULL CAL'** softkey.

NOTE

If you don't need to perform the SHORT calibration, press the **'ONE PORT PART CAL'** softkey instead and skip to step 17. If you don't need to perform the SHORT and LOAD calibration, press the **'NORMLIZE (OPEN)'** softkey instead and skip to step 19.

15. Disconnect the network under test, and connect the SHORT reference termination -- the SHORT position shown in Figure 4-3.

16. Press the **'SHORT'** softkey and the **ENTER/EXECUTE** key, and wait until **OPEN CAL required** is displayed.

17. Disconnect the SHORT reference termination, and connect the LOAD reference termination -- the LOAD position shown in Figure 4-3.

18. Press the **'LOAD'** softkey and the **ENTER/EXECUTE** key, and wait until **OPEN CAL required** is displayed.

19. Disconnect the LOAD reference termination, and connect the OPEN reference termination -- the OPEN position shown in Figure 4-3.

20. Press the **'OPEN'** softkey and the **ENTER/EXECUTE** key, and wait until **Cal completed (TURN ON "CORR" KEY)** is displayed.

21. Connect the network under test -- the DUT position shown in Figure 4-3.

22. Press the **'CORRECTN on/off'** softkeys. **'on'** in the **'CORRECTN on/off'** softkey will be change to intensified green and **Cor** will be displayed in the function area of the screen. Succeeding measurements are corrected using this calibration measurement data.

4-7. S-PARAMETER CONFIGURATION

The 4195A is configured for S-Parameter measurement by pressing the **'S11'**, **'S21'**, **'S12'**, or **'S22'** softkeys or when a **FNC4**, **FNC5**, **FNC6**, and **FNC7** command is sent. When the S-Parameter configuration is selected, the **'S-PRMTR'** softkey label will change to intensified **green.**

The S-Parameter configuration is used to measure all network parameters -- both transmission and reflection (S11, S21, S12, and S22). Two signal dividers (or directional bridges) are required for making S-Parameter measurements. Figure 4-4 shows a typical S-Parameter measurement setup.

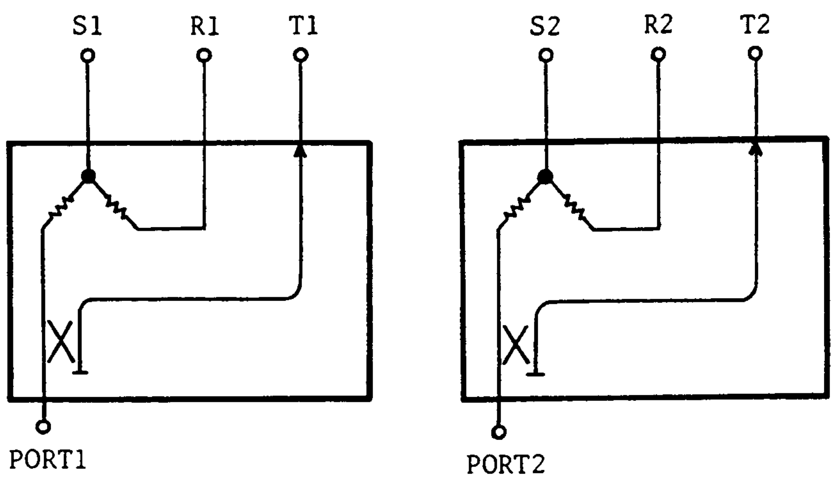

Figure 4-4. Typical S-Parameter Setup

Most of the S-Parameter configuration details are the same as those for the Network Configuration. The S-Parameter configuration features are:

1. Measurement format (measurement parameter and display format) can be selected independent of other S-Parameter measurements.

2. Calibration data is independent of other S-Parameter measurements.

Refer to paragraph 4-4. NETWORK CONFIGURATION, for details.

4-8. MEASUREMENT CALIBRATION

The 4195A Network, S-Parameter, and Impedance measurement configurations have measurement calibration capabilities which can be selected and used by using the softkeys displayed when the **CAL** key is pressed. Measurement calibration is an accuracy enhancement procedure that transfers the measured accuracy and uncertainty of standard devices to the measurement accuracy and uncertainty of a test device. Since the characteristics of standards are known to a high degree of accuracy, the system (HP 4195A plus external devices needed to measure a test device) can measure one or more standards, then use the results of these measurements to greatly enhance the measurement accuracy. The 4195A has the following measurement calibration capabilities.

for REFLECTION MEASUREMENTS (Network, S11, and S22 configurations)

1. Normalize (open) calibration
2. One port partial calibration
3. One port full calibration

for TRANSMISSION MEASUREMENTS (Network, S12, and S21 configurations)

1. Normalize (through) calibration
2. Normalize and Isolation calibration

for IMPEDANCE MEASUREMENTS (Impedance configuration)

1. One port full calibration
2. Offset compensations
   - 2-1. 0S offset compensation
   - 2-2. 0Ω offset compensation
   - 2-3. 0S and 0Ω offset compensation

for all measurements except for spectrum measurements

1. Port extension

NOTE

The port extension capability can theoretically offset the phase shifts that occur when a port is extended. Port extension is not measurement calibration, but it is included in the measurement calibration group because its purpose is similar to measurement calibration.

All calibration and offset compensation requires a target value (or accurately measured standards' values) to be corrected. When measurement calibration is turned on (**on** in the **'CORRECTN on off'** softkey label is intensified green), the measurement results of the standards will be equal to the target values.

4-8. MEASUREMENT CALIBRATION

The 4195A Network, S-Parameter, and Impedance measurement configurations have measurement calibration capabilities which can be selected and used by using the softkeys displayed when the **CAL** key is pressed. Measurement calibration is an accuracy enhancement procedure that transfers the measured accuracy and uncertainty of standard devices to the measurement accuracy and uncertainty of a test device. Since the characteristics of standards are known to a high degree of accuracy, the system (HP 4195A plus external devices needed to measure a test device) can measure one or more standards, then use the results of these measurements to greatly enhance the measurement accuracy. The 4195A has the following measurement calibration capabilities.

for REFLECTION MEASUREMENTS (Network, S11, and S22 configurations)

1. Normalize (open) calibration
2. One port partial calibration
3. One port full calibration

for TRANSMISSION MEASUREMENTS (Network, S12, and S21 configurations)

1. Normalize (through) calibration
2. Normalize and Isolation calibration

for IMPEDANCE MEASUREMENTS (Impedance configuration)

1. One port full calibration
2. Offset compensations
   - 2-1. 0S offset compensation
   - 2-2. 0Ω offset compensation
   - 2-3. 0S and 0Ω offset compensation

for all measurements except for spectrum measurements

1. Port extension

NOTE

The port extension capability can theoretically offset the phase shifts that occur when a port is extended. Port extension is not measurement calibration, but it is included in the measurement calibration group because its purpose is similar to measurement calibration.

All calibration and offset compensation requires a target value (or accurately measured standards' values) to be corrected. When measurement calibration is turned on (**on** in the **'CORRECTN on off'** softkey label is intensified green), the measurement results of the standards will be equal to the target values.

NOTE

The description starting with the next paragraph assumes that the 4195A is in frequency sweep mode. For more information about the dc source level sweep and the oscillator amplitude sweep, refer to paragraph 4-8-6. CALIBRATION HINTS.

4-8-1. TRANSMISSION CALIBRATION

Transmission calibration can eliminate two error causes -- Frequency Response Error and Crosstalk Error. Transmission Calibration applies to 4195A measurements in Network (when **'TRANS CAL menu'** softkey label is intensified **green**), S21 and S12 configurations.

Normalize (also called Through calibration or Response calibration) eliminates frequency response error. To perform **Normalize** calibration, a through connection (no-loss/no-phase-shift network) is required. To make a through connection, connect the cables together that will be connected to input and output of the network under test.

Isolation calibration is used to eliminate crosstalk error. An isolation setup is required to perform an isolation calibration. To make an isolation setup, terminate the end of the source cable (that will be connected to input of the network under test) with an impedance matched load, and leave the receiver test input cable open

NOTE

When performing an Isolation calibration the noise level must at a low enough level (compared to the crosstalk level) that the noise will not add significantly to the corrected measurement result.

The 4195A has two types of transmission calibration, and Table 4-6 lists the purpose and use of each type. Normalize is the simplest error correction to perform, but also is the least accurate. Normalize and Isolation may be adequate for well matched *high-loss* devices.

Table 4-6. Purpose and Use of Transmission Calibration Types

Calibration Type	Corresponding Measurement	Errors Removed	Standard Devices
Normalize	Well matched low insertion loss devices	Frequency response	Through
Normalize & Isolation	High insertion loss devices OR using of high leakage test fixture	Frequency response and Crosstalk	Through and Load

The calibration type is selected as follows.

1. Press the **CAL** key, and press the **'TRANS CAL menu'** softkey when in the NETWORK configuration or press the **'S-PRMTR CAL menu'** softkey when in the S21 or S12 configuration.

2. Press the **'NORMLIZE (THRU)'** softkey (or send the **CALT4** command) to select Normalize calibration. Press the **'NORM&ISN CAL'** softkey (or send the **CALT5** command) to select Normalize & Isolation calibration.

4-8-2. REFLECTION CALIBRATION

Reflection calibration can be used to eliminate three error factors -- Frequency Response, Directivity, and Source Match. Reflection Calibration applies to Network (when the **'REFLECTN CAL menu'** softkey label is intensified **green**) S11, S22, and Impedance measurements

Frequency response error can be eliminated by using **Normalize** calibration. In order to perform the Normalize calibration, an open termination must be connected to the test port.

Directivity error and frequency response error can be eliminated by using **One Port Partial** calibration. To perform this calibration, an open termination and a load termination must be sequentially connected to the test port.

Source matching error, directivity error, and frequency response error can be eliminated using **One Port Full** calibration. To perform this calibration, an open termination, a load termination, and a short termination must be sequentially connected to the test port.

NOTE

Only the **One Port Full** calibration is available in the Impedance configuration.

The 4195A has three types of reflection calibration which are listed and described in Table 4-7. Normalize is the simplest error correction to perform, but also is the least accurate. One port partial calibration may be adequate of high-return-loss devices. One port full calibration is adequate for any one-port device or a well terminated two-port device.

Table 4-7. Purpose and Use of Reflection Calibration Types

Calibration Type	Corresponding Measurement	Errors Removed	Standard Devices
Normalize	Measurement when the highest accuracy is not required.	Frequency response	Open
One Port Partial	High return loss devices	Frequency response and Directivity	Open and Load
One Port Full	Any of one-port device or well terminated two-port device	Frequency response, Directivity, and Source match	Open, Load and Short

The calibration type is selected as follows.

Network, S11, or S22 Configuration

1. Press the **CAL** key, and the **'REFLECTN CAL menu'** softkey when in NETWORK configuration or press the **'S-PRMTR CAL menu'** softkey when in the S11 or S22 configuration.

2. Press the **'NORMLIZE (OPEN)'** softkey (or send the **CALT1** command) to select the Normalize calibration. Press the **'ONE PORT PART CAL'** softkey (or send the **CALT2** command) to select the One port partial calibration. Press the **'ONE PORT FULL CAL'** softkey (or send the **CALT3** command) to select the One port full calibration.

Impedance Configuration

1. Press the **CAL** key, and the **'CAL menu'** softkey.

2. Press the **'ONE PORT FULL CAL'** softkey (or the send the **CALT1** command) to select Normalize calibration.

4-12. MEASUREMENT DATA DISPLAY

This paragraph explains the HP 4195A's display capabilities.

4-12-1. MEASUREMENT DATA STORAGE

Data A and B stored in array registers A and B, respectively, are plotted on the 4195A's screen. The details of array registers A and B are described in Section 5. Data B is not measured during spectrum measurement, so the data in resister B is not overwritten.

NOTE

The sweep points data is stored in array register **X**.

4-12-2. DISPLAY FORMAT

The HP 4195A has five display formats to choose from: Rectangular X-A&B, Rectangular A-B, TABLE, Smith chart, and Polar chart.

1. Rectangular X-A&B

The Rectangular X-A&B display format displays data A and B on the vertical axis, and the sweep parameter (data X) on the horizontal axis. Data A is displayed in yellow, and data B is displayed in greenish blue. The Rectangular X-A&B display format is available in all of the 4195A's measurement configurations (Network, Spectrum, Impedance, and S-Parameter).

2. Rectangular A-B

In the Rectangular A-B display format the value of data A is read on the horizontal axis, and the value of measurement data B is read on the vertical axis.

3. TABLE

The TABLE display format lists the measurement data (data A and B) and the sweep parameter (data X) in a tabular table of numeric data. The TABLE display format is available for all of the 4195A's measurement configurations.

4. Smith Chart

The Smith Chart display format displays the data on a Smith Chart, and is available for Network or S-Parameter measurements (S11, S12, S21, or S22). When this display format is selected for a Network, S12, or S21 measurement, the measurement parameter is changed to "T/R Re-Im". For a S11 or S22 measurement, the measurement parameter is changed to "Γx-Γy". Data A and B , R(Ω), X(Ω), Ls(H), and Cs(F), can be read using a marker. Data R, X, Ls and Cs are stored in registers **SMTHR**, **SMTHX**, **SMTHL** and **SMTHC**, respectively.

5. Polar Chart

The Polar Chart display format plots the data on a Polar Chart. The Polar Chart display format is available for Network, and S-Parameter measurements. When this display format is selected for Network (S12, or S21) measurement, the measurement parameter is changed to "T/R Re-Im". For S11 or S22 measurement, the measurement parameter is changed to " Γx-Γy ". Data A and B , Return Loss(dB), and VSWR, can be read using a marker. The Return Loss and VSWR data are stored in registers **RLOSS** and **VSWR**, respectively.

4-12-3. DISPLAY CONTROL KEY/SOFTKEYS

Three DISPLAY area front panel keys (**DISPLAY**, **SCALE REF**, and **VIEW**) are used to control the 4195A's display. When one of these keys is pressed, the softkeys used to control the display are displayed in the Softkey Area. To control the 4195A's operation by using an HP-IB controller, User Program, User Defined Function or Sweep End Function, use the command which corresponds to the softkey. The commands are included in APPENDIX D, Softkey Tree. Refer to APPENDIX D, Softkey Tree, before going on to the following paragraphs.

4-12-4. CHANGING THE DISPLAY FORMAT

1. Selecting the Display Format

To select the display format, press the **DISPLAY** key to display the softkeys used to set the display format, and press the appropriate softkey.

2. Eliminate/Recall the Grid Display

To eliminate/recall the grid on the display, use the **'GRTCL on off'** softkey which toggles the grid **on** and **off**. When the **'GRTCL on off'** softkey is set to **off**, the grid will be erased. To recall the grid, set the **'GRTCL on off'** softkey to **on**. This capability is available for all display formats except for the TABLE display format which does not use a grid.

2. Parameters Coupled to the Measurement Configurations

This paragraph describes the initial setting of the parameters which are measurement configuration dependent. When the instrument is turned on, or the CLEAR statement (device clear) is entered, the settings for all measurement configurations are initialized. But when the **PRESET** key is pressed (the "RST" command is entered), the setting for the current measurement configuration is initialized (ex. when the **PRESET** key is pressed during a S11 measurement, the setting for the Network, Impedance, Spectrum, S12, S21, and S22 measurement are not initialized).

(1) NETWORK measurement

Parameter	Initial Setting
Measurement Format	T/R[dB]-θ
Input Port	T1/R1
AUTO (Coupled to Span) on/off	off
Resolution Bandwidth (RBW)	10 kHz
Correction mode on/off	off
Calibration mode	none
IF Range	normal
Display Format	X-A&B
Trace A on/off	on
Trace B on/off	on
Scale Type lin/log	lin
Reference Value for data A	0 dB
Division Value for data A	10 dB
Bottom Value for data A	-100 dB
Reference Value for data B	180 deg
Division Value for data B	36 deg
Bottom Value for data B	-180 deg

(2) SPECTRUM measurement

Parameter	Initial Setting
Measurement Format	dBm
Input Port	R1
AUTO (Coupled to Span) on/off	on
Resolution Bandwidth (RBW)	300 kHz
Source off/CH1/CH2	off
IF Range	normal
Display Format	X-A&B
Trace A on/off	on
Trace B on/off	off
Scale Type lin/log	lin
Reference Value for data A	-10 dBm
Division Value for data A	10 dB
Bottom Value for data A	-110 dBm
Reference Value for data B	-10 dBm
Division Value for data B	10 dB
Bottom Value for data B	-110 dBm