HEWLETT PACKARD

HP 4195A
Network/Spectrum Analyzer
User's Guide

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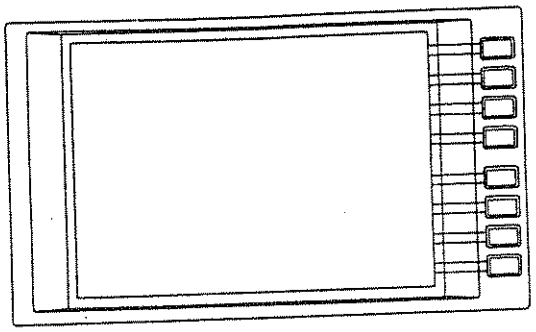
Chapter 1

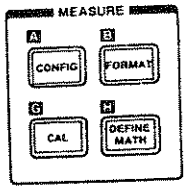
Operating the HP 4195A

Function Keys



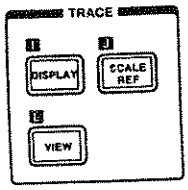
A simple and easy to use set of keys and softkeys, make using the HP 4195A for measurement and analysis an easy task. When a key is pressed, the related set of softkeys are displayed, and when a softkey is pressed, an additional set of related softkeys may be displayed (the softkeys are arranged in a tree format) depending on the function selected. Consequently, operation is made easier by the reduced number of front panel keys, and by the context sensitive displayed set of softkeys. The keys are grouped by function, Measure, Sweep, Marker/Line-Cursor, etc. The softkeys are displayed by pressing the appropriate key in the related function key group. The following is a summary of the HP 4195A's primary functions and their related keys.

To Prepare for a Measurement



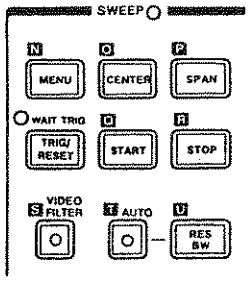
- Network/Spectrum/Impedance/S-parameter selection (**CONFIG**)
- S11/S21/S12/S22 selection (**CONFIG**)
- Input Port selection (**CONFIG**)
- Display parameters, T/R-θ, T/R-τ, $|\Gamma|$-θ, SWR, dBμV, dBm/Hz selection (**FORMAT**)
- Normalize, 1-port partial CAL, 1-port full CAL selection (**CAL**)
- User math definition, ON/OFF (**DEFINE MATH**)

To Modify the Display Scale



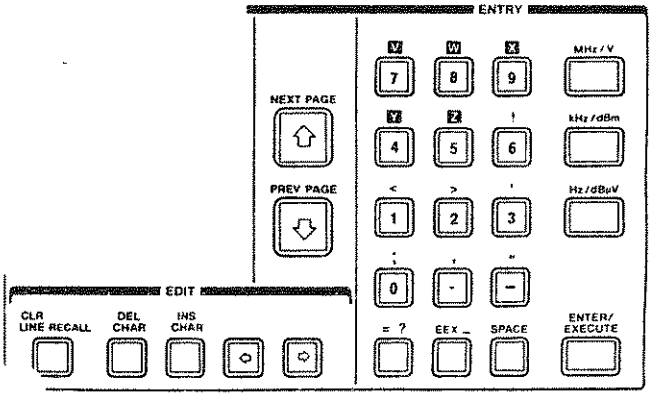
- Rectangular/Smith/Polar/Table selection (**DISPLAY**)
- COMMENT, Phase Expand (**DISPLAY**)
- Autoscale, Log Scale (**SCALE REF**)
- Superimpose, Storage (**VIEW**)
- Trace A/B ON/OFF (**DISPLAY**)
- Trace C/D ON/OFF (**VIEW**)

To Modify a Sweep



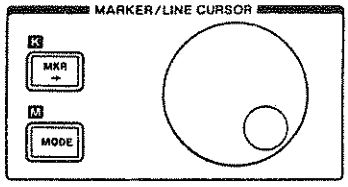
- Frequency/DC Bias/Power Sweep selection (**MENU**)
- SPOT frequency entry (**MENU**)
- Lin/Log Sweep selection (**MENU**)
- Partial Sweep/Program Sweep (**MENU**)
- Continuous/Single/Manual Sweep selection (**MENU** o **TRIG/RESET**)
- **TRIG/RESET** key initiates a sweep when the WAIT TRIG lamp is on while in the SINGLE sweep mode. In the CONT sweep mode pressing the **TRIG/RESET** key re starts the sweep.
- **VIDEO FILTER** performs four time avaraging.

To Enter Data



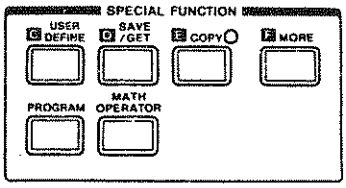
Frequency, Resolution Bandwidth, and Input attenuator are set with the ⇧ and ⇩ keys or the numeric entry keys When data is entered using the numeric entry keys, the **ENTER**, **MHz/V** or other unit keys must be used to termi nate the entry.

To Use the Markers



- MKR→MAX, MKR→CENTER, MKR→REF, MKR→SPAN, NEXT PEAK (**MKR→**)
- Single Marker, Dual Marker, Cursor, Cursor with Marke selection (**MODE**)
- Noise Marker (**MODE**)

To Extend Functions



- User Defined Function (**USER DEFINE**)
- CATALOG, SAVE, GET, PURGE (**SAVE/GET**)
- PLOT, PRINT, DUMP (**COPY**)
- TALK ONLY, HP-IB Address (**COPY** or **MORE**)
- Impedance Equivalent Circuit Analysis (**MORE**)
- Partial Analysis (**MORE**)
- User Program edit/execution (**PROGRAM**)
- +, *, /, (,) selection (**MATH OPERATOR**)
- SIN, COS, LOG, LN, SQR, MAX, MIN, complex, selectio (**MATH OPERATOR**)

Blue key and Green key

- Blue key enables shiftkey operations while the blue ke is set to on.
- Green key enables only single shiftkey operation aft the green key is pressed.

General Measurement Sequence

With simple, easy, operation procedures, the HP 4195A can perform many types of measurement and analysis. The following basic operation sequence is common to all functions.

CONFIG Press the **CONFIG** key to select between network, spectrum, impedance and S-parameter.

PRESET Initialize the HP 4195A

CONNECTIONS Connect the required accessories to the HP 4195A.

CONTROLS Set up the HP 4195A as follows.

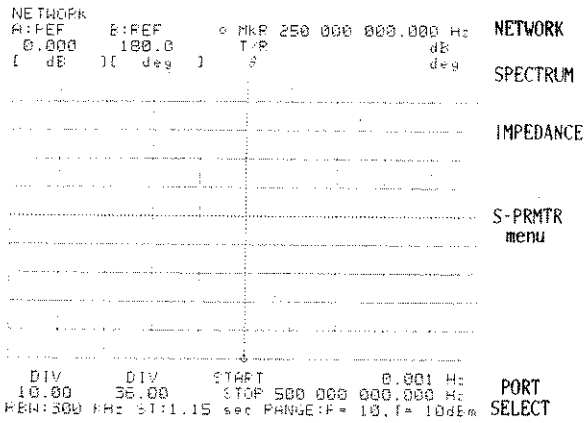
1. Press the **FORMAT** key to select dBm, dBμV, V and other measurement parameters.
2. Press DISPLAY key to select displayed format. (**RECT, TABLE, SMITH, POLAR**)
3. Press the **SWEEP** keys to set frequency range. (**START, STOP, CENTER, SPAN**).

CALIBRATE Remove errors that can affect the quantity of the measurement.

DEVICE UNDER TEST Connect the device under test (**DUT**).

AUTOSCALE Optimize display setting.

Step1: CONFIG



Select network, spectrum, impedance or S-parameter measurement function. Press **CONFIG** key for this selection.

Step 2: PRESET

When the **PRESET** key is pressed, the HP 4195A is initialized for network, spectrum, impedance or S-parameter measurements.

Initialization using the PRESET key

MEASURE group

FORMAT	T/R(dB)-θ (network/S21/S12)
	dBm (spectrum)
	$\|Z\|$-θ (impedance)
	RL-θ (S11/S22)
PORT	R1 (spectrum)
	T1/R1 (network/impedance/S11)
	T2/R1 (S21), T1/R2 (S12),T2/R2 (S 22)

TRACE group

DISPLAY	rectan X-A&B
SCALE REF	REF= 0 dB, 10 dB/div (network)
	REF= 0 dBm, 10 dB/div (spectrum)

SWEEP group

Sweep mode	CONT (SINGLE in program)
Sweep type	LIN Sweep
Parameter	FREQ Sweep
Range	0.001 Hz ~ 500 MHz, sweep of 401 points
RBW	AUTO, 300 kHz

Measurement unit (lower box)

Source amplitude	0 dBm
Atten	20 dB
DC Bias	OFF

Settings not affected by the PRESET key

- CONFIG (Network/Spectrum/Impedance/S-parameter)
- User math function and user defined function settings
- User Program
- Data stored in the registers (except A and B)

Step 3: CONNECTIONS

The HP 4195A has two output and four input terminals which can be configured to perform different measurements. The following accessories are used with the hp 4195A.

Transmission Measurements
Power splitter or Transmission/Reflection Test set

Reflection Measurements
Transmission/Reflection Test Set

Spectrum Measurements
No special equipment required

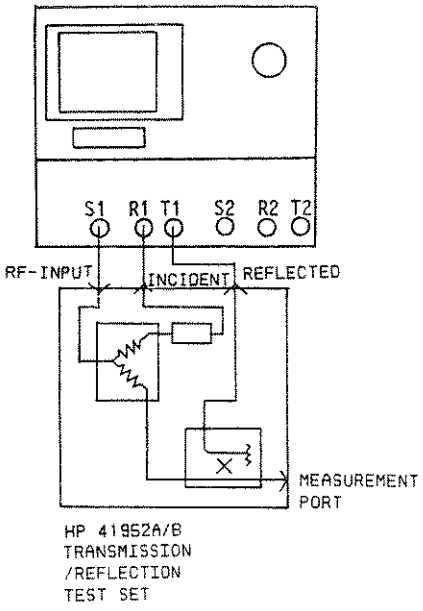
Direct Impedance Measurements
HP 41951A Impedance Measurement Kit

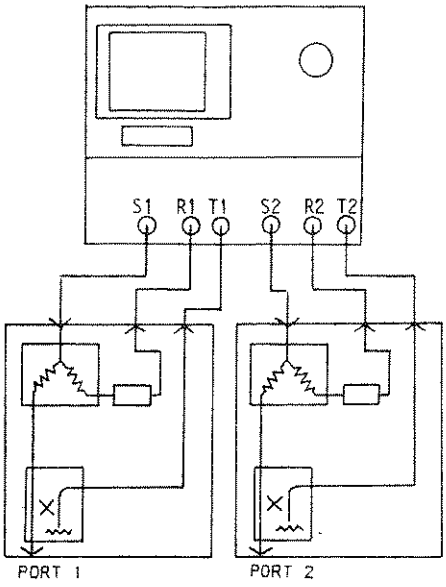
S-parameter Measurements
Two Transmission/Reflection Test Sets

The following examples use one HP 41952A Transmission/ Reflection Test Set, two HP 41952A Transmission/ Reflection Test Sets, and the HP 41951A Impedance Measurement Kit.

HP 41952A Transmission /Reflection Test Set

Power splitters are normally used for transmission measurements. However, if reflection measurements are also performed, the HP 41952A Transmission/Reflection Test Set should be used.

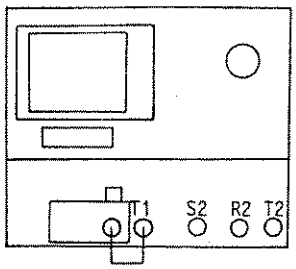




HP 41952A/B TRANSMISSION /REFLECTION TEST SETS

When two HP 41952A Transmission/Reflection Test Sets are used, the DUT's forward and reverse transmission and reflection factors can be measured. These measurements are made without disconnecting and changing the direction of the DUT, making S-parameter measurement is an easy process.

HP 41951A
Impedance Measurement Kit

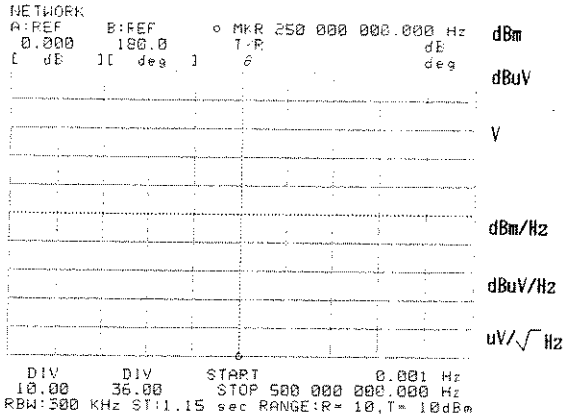


HP 41951A IMPEDANCE TEST KIT

Connect the HP 41951A Impedance Measurement Kit to the HP 4195A as shown in the figure. The 4195A can be used to measure impedance directly when used with the HP 41951A.

Step 4: CONTROLS

1. FORMAT



Select the display measurement parameters. When th **FORMAT** key is pressed, softkeys like those shown in th example to the left will be displayed. The softkeys di played upon the screen depends on the existing setting Select the required measurement parameters.

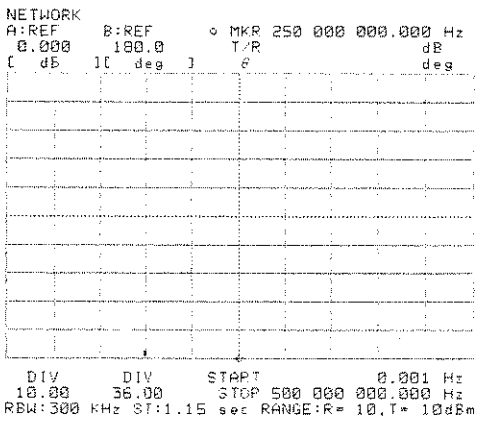
2. DISPLAY

Select displayed format from RECT, TABLE, SMITH an POLAR. When rectan A-B is selected, horizontal axis rep resents measured data A and vertical axis represents mea sured data B.

3. SWEEP

Select the measurement frequency range using the **CEN TER** and **SPAN** keys, or by using **START** and **STOP** keys The ⇧ and ⇩ keys are used to aid entry data. Note tha the marker/cursor control knob ◎ cannot be used fo this purpose.

Frequency, signal level, and DC bias level can be swept b selecting the proper softkey in the **SWEEP MENU**.



Select either linear or log sweep.

Select the sweep direction.

Set the sweep points, steps, and time.

Select the sweep parameter - frequency, signal level, or DC bias.

Press this softkey to perform a programmed points sweep.

Press this softkey to perform a partial sweep.

Press this softkey to select the trigger mode - CONT, SINGLE or MANUAL.

Step 5: CALIBRATE

In the case of high frequency network and impedance measurement, the cables and test sets will greatly affect the measurement results. To obtain the most accurate measurements, it is necessary to reduce the errors caused by the measurement system. The HP 4195A analyzer is equipped with a variety of calibration modes to meet different measurement requirements.

Transmission Measurement
- Normalize
- Normalize + Isolation

Reflection Measurement
- Normalize (OPEN)
- 1-port Partial (OPEN, LOAD)
- 1-port Full (OPEN, SHORT, LOAD)

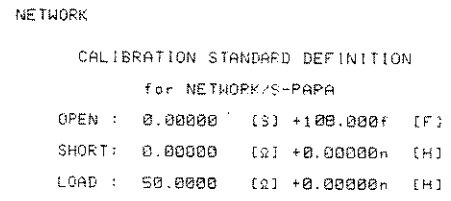
Impedance Measurements
- Calibration (CAL: OPEN, SHORT, LOAD)
- Compensation (COMPEN: 0S, 0Ω)

Calibration is not allowed during spectrum measurement. However, when a high loss probe is used, the User Math Function should be used to compensate for the loss.

Typical calibration procedures for different types of measurement will be described next.

Calibration Standard

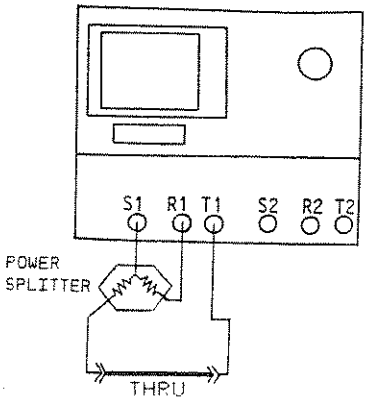
Any types of calibration standard can be used for calibration but their calibrated data must be entered correctly. For example, if a 7 mm OPEN standard is used, 0.108pF of its capacitance value should be entered using the following procedure.



1. Press **CAL** key.
2. Press **more 1/2** softkey.
3. Press **CAL STD** modify softkey.
4. Press **OPEN CAL STD** softkey.
5. Type **OPENSTD=0, 108E-15** and press **ENTER**.

Use the same procedure to modify 0Ω and 50Ω standard values.

Transmission Measurement - Normalization



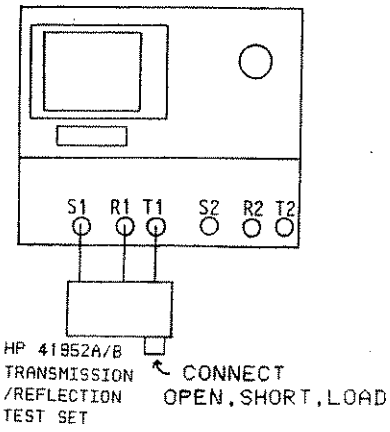
Normalization is an easy and commonly used calibration method. It eliminates transmission measurement errors. Make a "thru" connection to establish the 0 dB and 0 degree references as shown in the figure, then perform the following procedure.

1. Press the **CAL** key.
2. Press the **TRANS CAL menu** softkey.
3. Press the **NORMALIZE (THRU)** softkey.
4. Press the **THRU** softkey.
5. Press the **ENTER** key
6. Press the **return** softkey when the HP 4195A beeps and displays "THRU CAL completed".
7. Press the **CORRECTION on/off** softkey to enable correction (on/off).

After the preceding procedure is completed, the HP 4195A will display the measurement data normalized to the 0 dB and 0 degree reference established during the "Thru" calibration.

Normalization, however, does not eliminate errors such as leakage between a DUT's input and output. To eliminate such errors as this, perform the Isolation CAL in addition to the normalize CAL. To perform Isolation CAL, press the **NORM & ISN CAL** softkey instead of the **NORMALIZE (THRU)** softkey. To perform an "Isolation" CAL, disconnect the DUT and terminate the input/output terminal connected to the DUT with the correct characteristic impedance (50Ω or 75Ω).

Reflection Measurement - 1 port Full CAL



To perform 1-port Full CAL, three reference terminations: "OPEN", "SHORT" and "LOAD" are required. With reference to these three terminations connected one by one to the measurement terminal, the HP 4195A can minimize the errors in reflection measurements. The calibration procedure for the 1-port Full CAL is as follows.

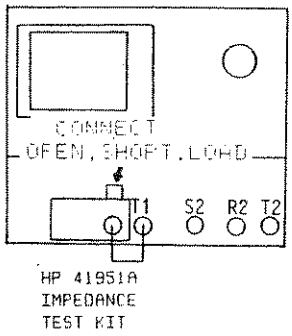
1. Press the **CAL** key.
2. Press the **REFLECTN CAL menu** softkey.
3. Press the **ONE PORT FULL CAL** softkey.
4. Press the **OPEN** softkey.
5. Connect the "OPEN" termination to the measurement port and press the **ENTER** key.
6. Press the **SHORT** softkey.
7. Replace the "OPEN" termination with the "SHORT" termination and press the **ENTER** key.
8. Press the **LOAD** softkey.
9. Connect the "LOAD" termination (50Ω or 75Ω termination) and press the **ENTER** key.
10. Press the **return** softkey.
11. Press the **CORRECTION on/off** softkey to enable correction (on/off).

Now the HP 4195A is ready to make calibrated reflection measurements.

Other than 1-port Full CAL, the HP 4195A can perform 1-port Partial CAL, and Normalize CAL for calibrating reflection measurements. These two calibrations require fewer terminations to perform, but produce less accuracy than performing the 1-port Full CAL.

Two independent 1-port Full CALs can be performed. This allows S11 and S22 measurements to be performed without recalibrating.

Impedance Measurement
- Calibration and Compensation



The HP 4195A and HP 41951A can be used to perform impedance measurements. A reflection coefficient measurement method is used when making impedance measurements. Therefore, the calibration procedure is almost the same as 1-port Full CAL and is performed as follows.

1. Press the **CAL** key.
2. Press the **CAL menu** softkey.
3. Press the **ONE PORT FULL CAL** softkey
4. Press the **OPEN** softkey.
5. Connect the 0S (**OPEN**) termination to the 41951A's 7 mm connector and press the **ENTER** key.
6. Press the **SHORT** softkey.
7. Replace the 0S (**OPEN**) termination with the 0Ω (**SHORT**) termination and press the **ENTER** key.
8. Press the **LOAD** softkey
9. Connect the 50Ω (**LOAD**) termination and press the **ENTER** key.
10. Press the **return** softkey.
11. Press the **CORRECTN on/off** to enable correction (**on**/off).

After the preceding procedure (**Calibration**) is performed, the HP 4195A will eliminate the measurement errors due to the HP 41951A Impedance Test Kit, and give the best impedance measurement accuracy at the 7 mm connector.

When a test fixture is connected to the 7 mm connector, error **COMPENSATION** for the test fixture is required. To compensate for fixture induced error, use the following procedure.

1. Press the **CAL** key.
2. Press the **COMPEN menu** softkey.
3. Press the **0S** & **0Ω OFFSET** softkeys.
4. Press the **0S** softkey.
5. Connect the test fixture leaving its test terminal open, and press the **ENTER** key.
6. Press the **0Ω** softkey.

7. Short the test terminal of the test fixture, and press the **ENTER** key.

8. Press the **return** softkey.

9. Press the **CORRECTN on/off** softkey to enable correction (**on**/off).

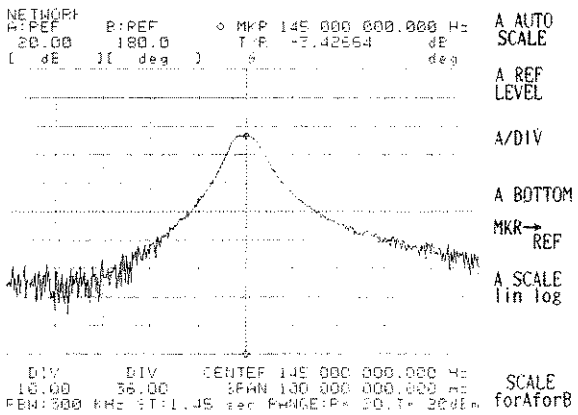
NOTE Compensation must be performed after Calibration is completed.

Step 6: DUT

Connect the DUT (device under test) and perform the measurement.

Step 7: AUTO SCALE

When the measurement results are too large or too small press the **SCALE REF** key to select the **AUTO SCALE** softkey (see figure). The scale of the display can be modified either by entering a new value with the **REF LEVEL** softkey the **/DIV** softkey, or by incrementing or decrementing the scale values using the ⇧ and ⇩ keys. This will adjust the scale of either trace A or B. Scale adjustment of the trace B display scale can be performed using the **SCALE for A/B** softkey.



Measurement Enhancements

The following functions enable the HP 4195A analyzer to be used more efficiently.

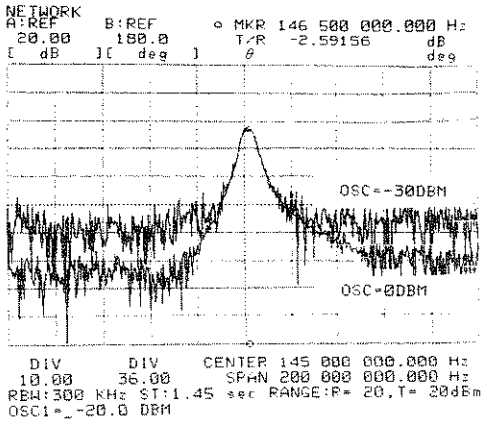
- Dynamic range
- Marker
- Recording of measurement data

The HP 4195A has many additional convenient functions. Refer to the APPENDIX and the HP 4195A's operation manual for the most complete description of the available functions.

Dynamic Range

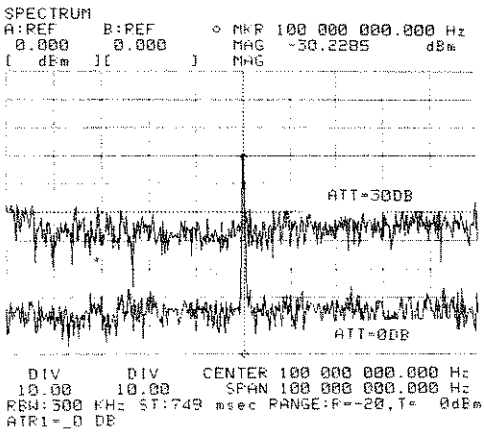
The HP 4195A uses the following methods to improve its dynamic range (the difference between the maximum level of the input signal compared with the noise level).

1. Increasing Output Signal Level (Transmission Measurement Only)



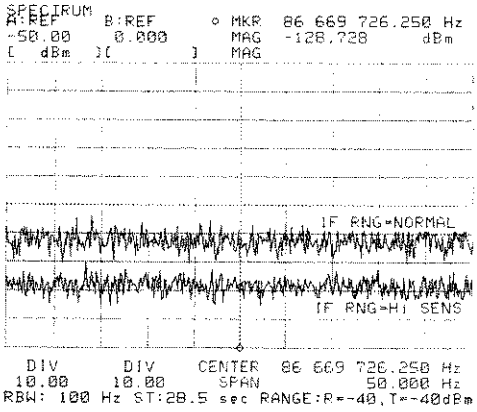
The HP 4195A's signal level can be changed by entering a new value after pressing the **AMPLITUDE** key, or by using the ⇧ and ⇩ keys. The default value is 0.0 dBm, and can be increased to +15.0 dBm. This method is particularly effective with transmission/reflection test sets where the losses are high. Raising the signal level is equivalent to raising the input level and may cause waveform distortion. In this case, reduce the signal level so it does not exceed the allowable input value (RANGE value displayed on the CRT).

2. Changing the Input Attenuators



The input attenuators can be set by entering a new value after pressing the **REF ATTEN** or the **TEST ATTEN** keys, or by using the ⇧ and ⇩ keys. The 4195A's maximum allowable input level is the RANGE values displayed in the lower right corner of the CRT. For example, the figure shows RANGE values at the time when the R1 input attenuator is changed. These values mean that the maximum allowable input is +10 dBm for R1 and -20 dBm for T1.

If the input level exceeds the allowable input range, the displayed waveform could be distorted.

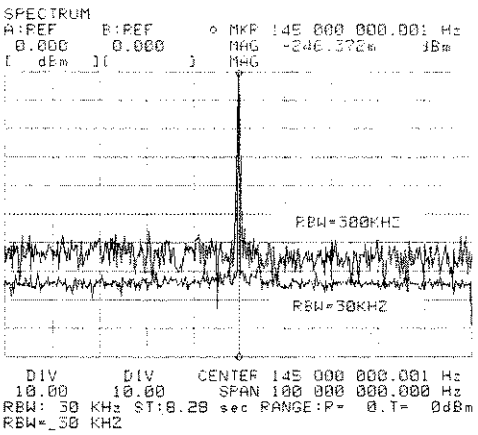


3. Changing the IF Range

The HP 4195A has 3 IF ranges - normal, low distortion, an high sensitivity - they are described below.

Normal Mode:	This mode is normally use (default mode).
Low distortion Mode:	This mode reduces distortio within the analyzer and i used for low distortio measurement.
High Sensitivity Mode:	This mode reduces the inter nal noise of the analyzer, an is suitable for measurement c low level signals.

The IF range can be changed by pressing the **ATTEN** ke and selecting the required softkey.



4. Narrowing the Resolution Bandwidth

The Resolution bandwidth (RBW) of the HP 4195A can b set in increments of 1 and 3 within the range of 3 Hz ~ 30 kHz. RBW can be set by entering a new value after press ing the **RES BW** key, or by pressing the ⇧ and ⇩ keys.

Note that the time increases as the dynamic range is in creased by narrowing the IF bandwidth (i.e. lowering th value). When the RES BW is set to AUTO, the I bandwidth is automatically set according to the frequenc SPAN.

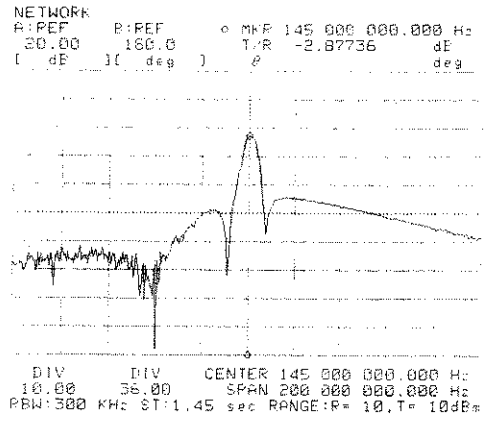
5. Using a Video Filter

When the VIDEO FILTER is set to ON, the measuremer data is displayed after the average of four measurements i taken. This operation reduces random noise and improve the effective dynamic range.

The Marker

The marker functions of the HP 4195A help to reduce the time needed to make complicated measurements. The following describes the basic operation of the marker functions (refer to Chapter 2 and beyond for more information). One marker is initially displayed. The frequency and the measurement data at the marker's position are shown in the upper right corner of the display.

Press the **MKR→** key and the softkeys shown to the left will be displayed.



Moves the marker to the maximum value (peak) displayed.

Moves the marker to the minimum value displayed.

Modifies the **REF LEVEL** value so that the marker is positioned at the reference level.

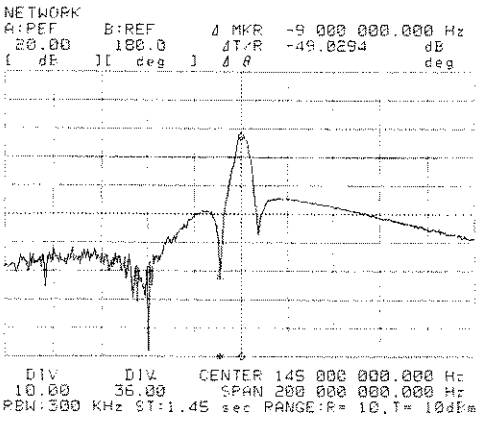
Modifies the center value so that the marker is positioned at the center.

Moves the marker to the next highest peak.

This makes it possible to use the marker on trace B.

"More" indicates that additional softkeys are available. These additional softkeys make it possible to use a marker's position as the START or STOP value, or to display the noise level at a marker's position.

When the **MODE** key is pressed the softkeys shown to the left will be displayed.



Normal Marker Mode

This causes an additional marker (*) - the sub-marker - to appear. It is used for zooming, partial sweep, partial analysis and deviation display (delta marker).

This causes the marker to toggle the cursor off/on the screen. The value of measurement data intersected by the cursor is displayed.

This makes it possible to determine the cursor's position with reference to the marker position. This is convenient when searching for the -3 dB bandwidth.

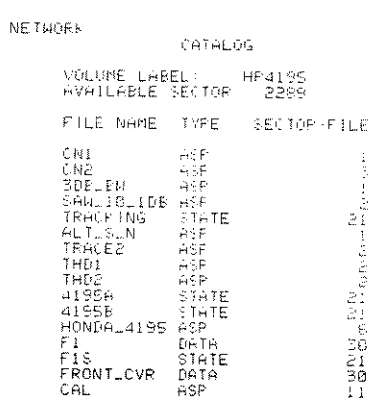
This turns the marker and cursor off. This function is used to reduce the measurement time.

Flexible Disc Drive (FDD)

The HP 4195A can save/recall the following files using its internal FDD.

- Instrument's setting state (**STATE file**)
  User Defined Function keys, User Math Function and Calibration data are also included.
- Program Point Table (**TABLE file**)
- Measurement Data (**DATA file**)
- User Program (**ASP file**)

All files are recorded in LIF format. The figure below shows the screen after the **CAT** softkey is pressed.



CAT — Displays disc content.

SAVE — Records instrument setup, measurement data or user program.

RE-SAVE — Rewrites an existing file and saves it.

GET — Reads a recorded file.

PURGE — Deletes files. RECOVER is used to recall files deleted by mistake.

more 2/2 — Used with RECOVER, and to format a disc.

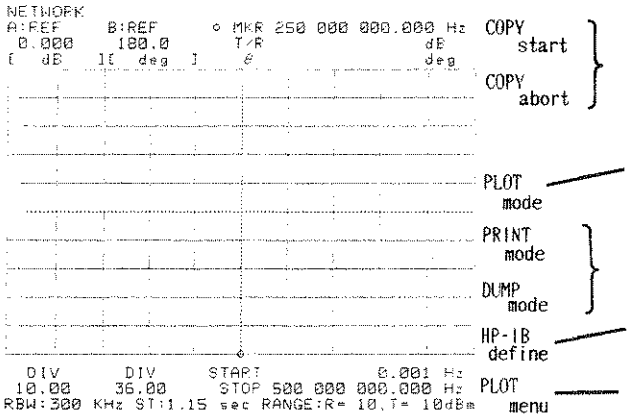
When the **SAVE** and **RE-SAVE** softkeys are selected, softkeys which indicate the type of file to be saved are displayed: STATE (instrument setting), PROG TABLE (program point table), DATA (measurement data), and PROGRAM (User program). One of these keys must be selected. When the stored files cannot be displayed on the screen, use the ⇧ and ⇩ keys or the **NEXT PAGE** and **PREV PAGE** keys to see the other files that are not being displayed on the present screen. When the **GET**, **RE-SAVE** and **PURGE** keys are pressed, the file name at the top is displayed within " ". If a desired file is moved to the top, it is no longer necessary to press the alphabetic keys.

Recording Measurement Data

Measurement data can be recorded by printing/plotting the data or storing it on the HP 4195A's internal flexible disc drive (**FDD**).

Hard Copy

The HP 4195A's display data can be copied to a printer or HP-GL compatible plotter. When the **COPY** key is pressed, the softkeys shown in the figure below will be displayed. To produce a hard copy, the analyzer must be in the TALK ONLY mode and the printer or plotter must be in the LISTEN ONLY mode.



Start or stop the hardcopy function.

Outputs screen data to plotter.

Outputs measurement data, program lists, and CAT to the printer.

Used in the TALK ONLY mode.

Specifies how data is to be sent to the plotter.

DUMP Procedure

Use the following prcedure to dump the current display to an HP-IB printer.

1. Connect the HP-IB printer to the HP 4195A. The printer must be set to **LISTEN ONLY** or **LISTEN ALWAYS** mode.
2. Press HP-IB define softkey.
3. Press Talk Only softkey. TLK lamp will turn on.
4. Press return softkey.
5. Press DUMP mode softkey.
6. Press COPY start softkey.

Chapter 2

Transmission Measurements with the HP 4195A

Basic Setup

The following measurement examples use a power splitte or the HP 41952A Transmission/Reflection Test Set (directional bridge or other setup can be used to suit you particular needs). The DUT used in these examples is 145 MHz bandpass filter.

Measuring Insertion Loss (Gain)

CONFIG

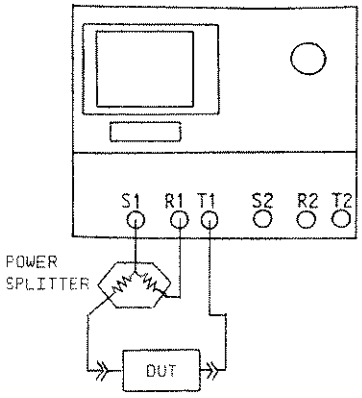
Press **CONFIG** key and select **NETWORK**

PRESET

Press the **PRESET** key to set the analyzer to its initial state.

CONNECTIONS

Set up the power splitter as shown in the figure.



CONTROLS

1. FORMAT T/R (dB) - θ (Initial state)
2. DISPLAY Rectan X-A&B (Initial state)
3. SWEEP CENTER 145 MHz
   SPAN 100 MHz

CALIBRATE

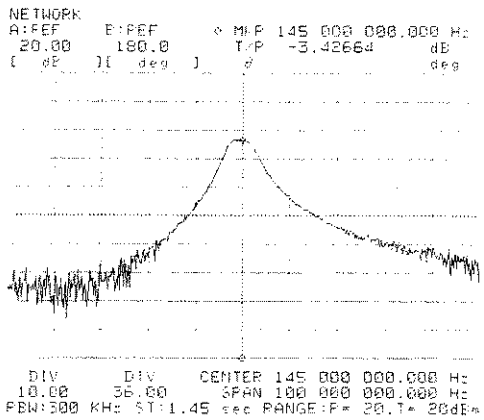
Perform the **normalization** calibration as described on pag 1-10. Connect the output and the input cable to the DU together to create a **thru** connection. Press the HP 4195A **CAL** key, select the **TRANS CAL menu**, and press the **NOI MALIZE (THRU)** softkey. Then press the **THRU** softke and the **ENTER/EXECUTE** key to perform normalizatio After measuring a thru, press **CORRECTN on/off** softkey.

DEVICE UNDER TEST

Connect the DUT as shown in the figure, and press **TRIG RST** key to initiate a sweep.

AUTOSCALE

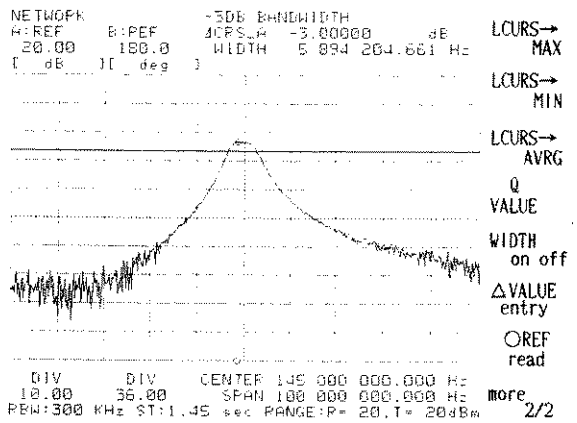
Press the **SCALE REF** key and select the **AUTO SCAL** softkey. The measurement result shown in the figure w then be displayed. The yellow trace (trace A) indicates th amplitude ratio of the two inputs (dB) and the light blu trace (trace B) indicates the phase difference (θ).



Insertion Loss

Use the **MKR→MAX** softkey to read the insertion loss a the frequency.

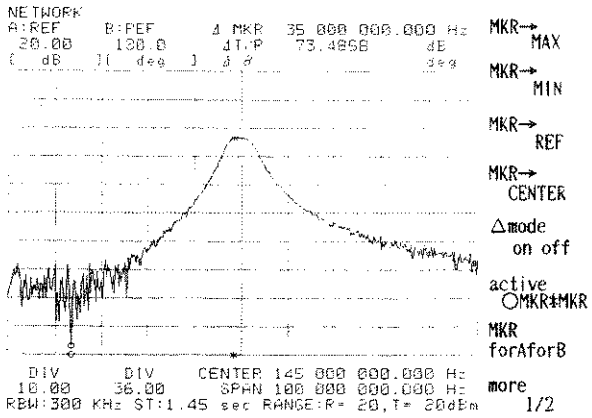
3 dB Bandwidth



The bandwidth can easily be determined with the marker and line-cursor.

1. Press the **MODE** key and select the **oMKR&LCURS** softkey.
2. Press the **MKR→MAX** softkey.
3. Press the Δ **mode on/off** softkey.
4. Press the **more 1/2** softkey, then press the Δ **VALUE entry** softkey. DLCURS= will be displayed.
5. Enter -3 dB.
6. Set the **WIDTH on/off softkey** to **on**/off, the -3 dB bandwidth is displayed at WIDTH on the upper right corner of the screen.

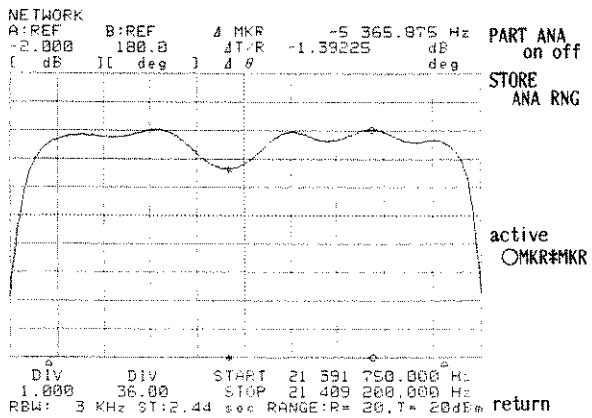
Out-of-Band Rejection



Use the double marker mode (o&*MKRS) to determine out-of-band rejection.

1. Press the **MODE** key and select the **o&*MKRS** softkey.
2. Press the **MKR→MAX** softkey. * MKR moves to the MAX position.
3. Set the Δ **mode on/off** softkey to **on**/off the difference between o MKR and * MKR will be displayed on the screen.
4. Press the active **oMKR/*MKR** softkey to make the oMKR active.
5. Press the **MKR→MIN** softkey and the oMKR will seek the point of greatest insertion loss. The Δ T/R shown here is the out-of-band rejection (dB).

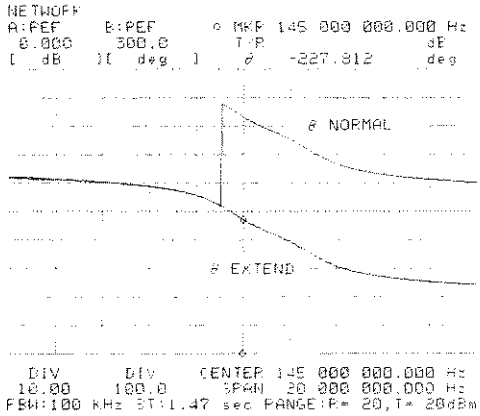
Passband Ripple



Passband ripple can be measured when a partial analysis function is used (The figure shows an example of a filter with ripple).

1. Enter the double marker mode (o&*MKRS) and alternately move the two markers to within the passband region with the rotary knob as shown in the figure to the left.
2. Press the SPECIAL FUNCTION **MORE** key, select the **ANA RANGE** softkey and the softkeys shown in the figure to the left will appear.
3. Press the **STORE ANA RNG** softkey, set the **PART ANA on/off** softkey to ON (**on**/off), and the Δ symbols appear at the bottom of the screen. The area indicated by these symbols is subjected to the partial analysis.
4. Make the o MKR active, press the **MKR→MAX** softkey, make also * MKR active and perform MKR→MIN. When the Δ mode is set to ON, the magnitude of the ripple is displayed as Δ T/R(dB).

Measuring Phase Characteristics



The HP 4195A's vector network measurement functior makes it possible to measure phase characteristics at th same time as amplitude ratio measurements are performe The phase measurement data is displayed on trace B. A shown in the figure to the left, trace B data can be phas extended to more than ±180°. Also the phase unit can b changed to radians. In the next section we will measu group delay, important in determining phase distortion.

Group Delay Measurement

Group delay (τ) is defined as follows.

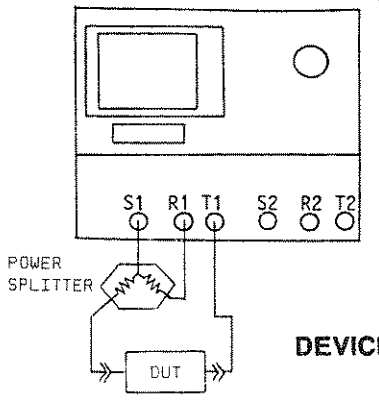
$$\tau = \frac{\Delta\,\theta\ (\text{radian})}{\Delta\omega} = \frac{\Delta\,\theta\ (°)}{360° * \Delta F}$$

Δ F is the frequency difference between the two freque cies and Δ θ is the phase difference between the tv frequencies. Thus the group delay is the degree of chan in phase relative to a change in frequency. When th group delay is constant, the phase change is linear ar there is no phase distortion. Δ F is called aperture and expressed as a percentage of measurement frequen range (SPAN frequency).

CONFIG **NETWORK**

PRESET Press the **PRESET** key.

CONNECTIONS Used the same connections used for measuring insertio loss.



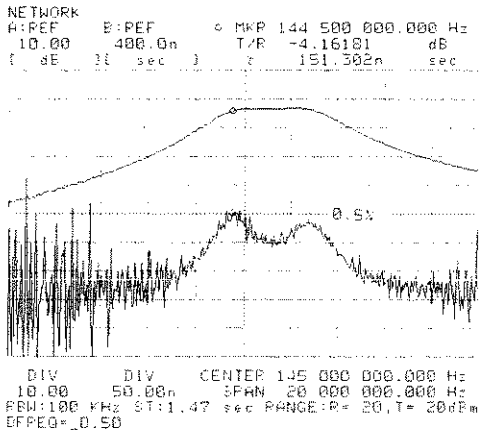
CONTROLS

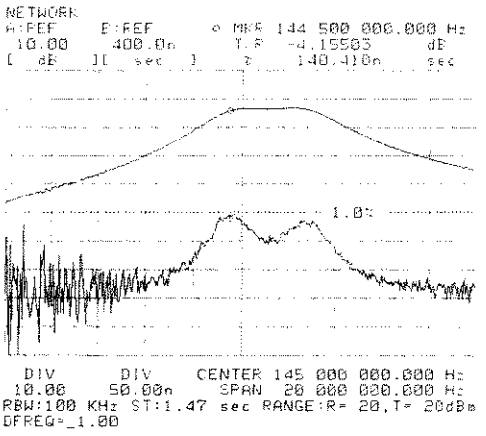
1. FORMAT Select T/R - τ
2. DISPLAY Rectan X-A&B (Initial state)
3. Sweep CENTER 145 MHz
   SPAN 20 MHz

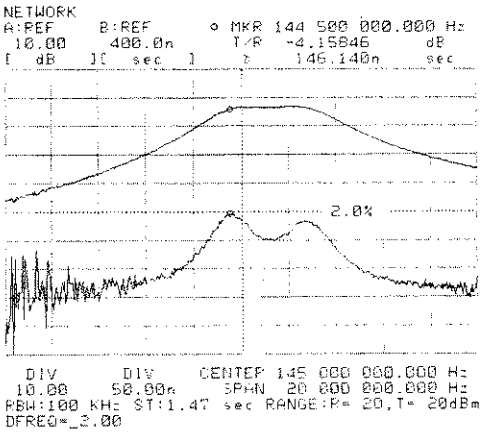
CALIBRATE Setup the analyzer in thru connection and conduct a n **malization** calibration (same as insertion loss).

DEVICE UNDER TEST Connect the DUT as shown in the figure to the left, a press the **TRIG/RST** key.

AUTOSCALE Press the **SCALE REF** key, and select **SCALE for A** for and **B AUTO SCALE** softkeys.







The default aperture value for group delay measurements is 0.5% of the frequency span width. It can be changed up to maximum of 100%. To set the aperture, press the **FORMAT** key, select the **APERTURE entry** softkey. When DFREQ = is displayed, enter a value between 0.5 and 100.

The figure to the left shows the effect of different aperture settings on group delay measurements. The trace will gradually become smoother as the aperture span width is increased from 0.5%, to 1% and then 2%. The aperture setting must be made with care when group delay measurements are performed, because it influences the measurement values and the resolution. When the aperture is increased, measurement resolution increases, but the accuracy along the lateral axis (frequency) decreases. In group delay measurements it is necessary to know at which aperture a measurement value was obtained.

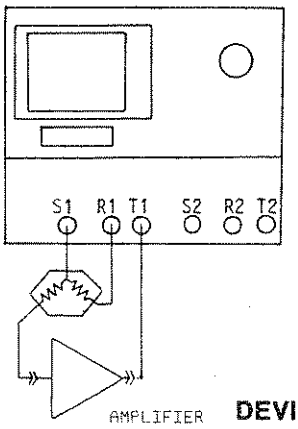
Measuring Gain Compression

All measurements so far have been frequency swept mea surements. However, signal source output (OSC level and DC bias can also be swept and measured with the H 4195A. In the following the OSC level will be swept t obtain the maximum input level at which the output lev does not change linearly (Gain Compression).

CONFIG **NETWORK**

PRESET Press the **PRESET** key.

CONNECTIONS Set up as shown in the figure on the left.



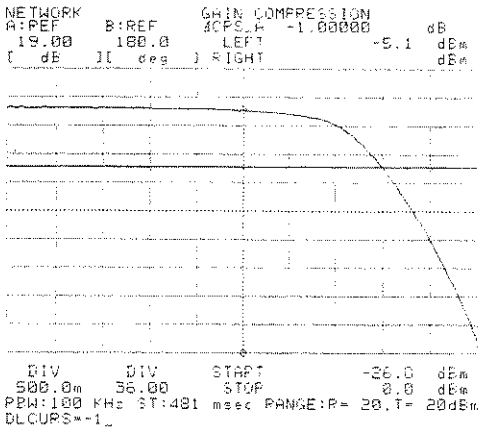
CONTROLS

1. FORMAT T/R (dB) - θ (Initial State)
2. DISPLAY rectan X-A&B (Initial State)
3. SWEEP Press the **MENU** key and the **PRMTR** ke Select OSC LVL (dBm).
   START -26 dBm
   STOP 0 dBm

CALIBRATE Make a thru connection and perform a normalization ca bration as described in the first setup in this chapter (inse tion loss measurements).

DEVICE UNDER TEST Connect the DUT (amplifier) as shown in the figure on th left, and press **TRIG/RST** key.

AUTOSCALE Press the **AUTO SCALE** softkey.



The amplifier's characteristics are shown in the figure the left. (The figure shows trace A only.) In this measur ment, the spot frequency was 10 MHz. The frequency ca be changed by pressing the **SWEEP MENU** key to sele the **PRMTR menu** and using the **SPOT FREQ** softkey.

The 1 dB gain compression point of the amplifier can obtained by the following operation sequence.

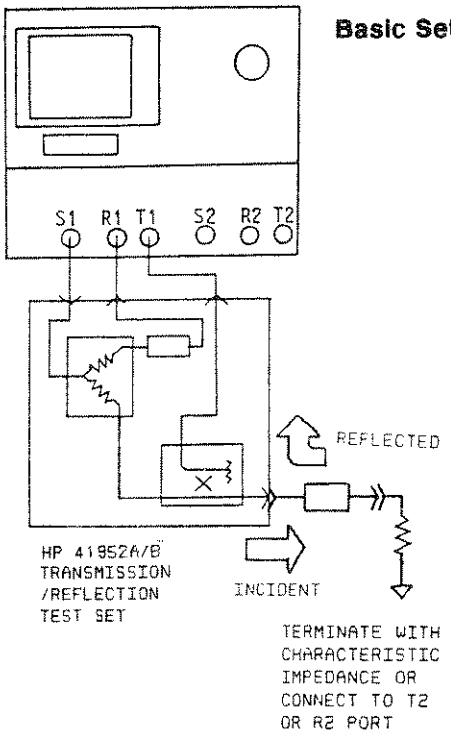
1. Press the **MODE** key and select the **o MKR&LCUI** softkey.
2. Press the **MKR→MAX** softkey.
3. Set the Δ **mode on/off** softkey to **ON** (on/off).
4. Press the **more** key and select the Δ **VALUE en** softkey. DCURS= will appear on the screen, enter and the input level at which the gain is reduced by 1 can be determined.

Chapter 3

Reflection Measurements with the HP 4195A

Chapter 2 demonstrated how to use the HP 4195A analyzer for transmission measurements. This chapter will describe how to use the HP 4195A to make reflection measurements, another important aspect of network analysis.

Basic Setup



To measure reflection parameters, a directional coupler or bridge is required to pick up the reflected signal. A power splitter is also required to feed the signal to both the reference channel and the directional coupler (bridge). The setup is for this measurement is accomplished by connecting the HP 41952A/B Transmission/ Reflection test set as illustrated in the figure at the left. The HP 85044A is used in the measurement examples given in this chapter.

Measuring Return Loss, Reflection Coefficient and SWR

The reflection characteristics of a device is normally measured in the form of return loss, reflection coefficient, and SWR. The relationship between these three factors is as follows.

$$\text{Reflection Coefficient } (\Gamma) = \frac{\text{Reflection Voltage}}{\text{Input Voltage}}$$

$= S11 \text{ (or } S22 \text{)} = \rho\angle\theta$

(ρ is the absolute value of Γ, and θ is phase angle)

Return loss (dB) = -20 log (ρ)

$$SWR = \frac{1 + \rho}{1 - \rho}$$

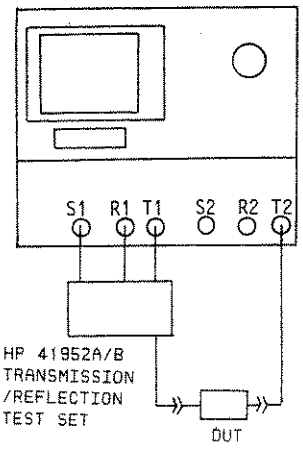
An example of a reflection measurement is given next.

CONFIG S11 of S-PARAMTR

Make sure to select S-parameter S11 with the **CONFIG** ke Parameters indicating reflection such as RL - θ, $|\Gamma|$ - Γx - Γy, SWR - θ can only be used when S11 or S22 mea surements are made.

PRESET Press the **PRESET** key to initialize the analyzer.

CONNECTIONS Connect the HP 41952A as shown in the figure on the left.



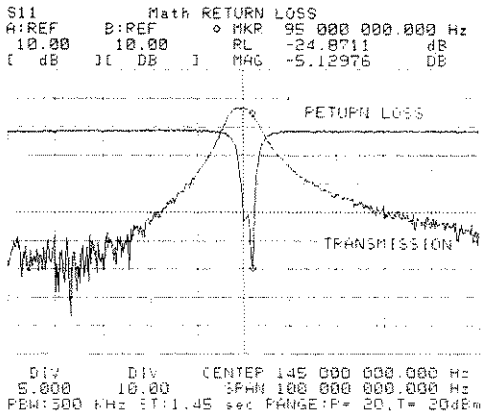
1. FORMAT RL - θ (Initial state)
2. DISPLAY rectan X-A&B (Initial state)
3. SWEEP CENTER 145 MHz
   SPAN 100 MHz

CALIBRATE Perform 1-port Full Calibration as follows. Press th **CAL** key and select the **S-PRMTR CAL menu** softkey. The press the **ONE PORT FULL CAL** softkey. Connect a OPEN, SHORT and 50 Ω standard in sequence to the H 85044A's test PORT and press the corresponding softke and the **ENTER/EXECUTE** key. Then press the **retu** softkey to display previous softkeys and press the **COR RECTION on/off** softkey.

DEVICE UNDER TEST Connect the DUT (a 145 MHz bandpass filter) as shown i the figure and press **TRIG/RST** key.

AUTOSCALE Press the **SCALE REF** key and select the **AUTO SCAL** softkey.

Measuring Return Loss



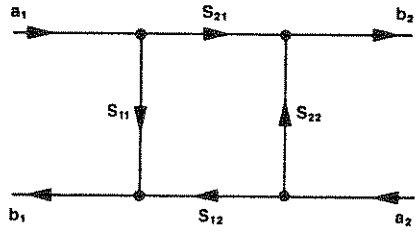
The figure to the left indicates the return loss for th 145 MHz bandpass filter with previously measured tran mission characteristics.

Measuring Reflection coefficient Press the FORMAT key and select the $|\Gamma|$ - θ softkey start the reflection coefficient measurement.

Measuring SWR Press the **FORMAT** key and select the **SWR - θ** softkey start the SWR measurement.

Measuring S-Parameters

S-parameters (S11, S21, S12, S22) characterize a two port device. Measurements of S-parameters can be made only by terminating the circuit with a resistor. This facilitates measurements of incident and reflection voltages as the circuit need not be opened or shorted, as in the case of h-parameters. These advantages make them specially suited to measure circuit systems at high frequencies. Each S-parameter can be defined as follows.



S-parameter	Definition	Significance	Direction	Input
S11	$\frac{b1}{a1}\Big\vert_{a2=0}$	Input reflection coefficient	Forward	T1/R1
S21	$\frac{b2}{a1}\Big\vert_{a2=0}$	Forward Gain (loss)	Forward	T2/R1
S12	$\frac{b1}{a2}\Big\vert_{a1=0}$	Reverse Gain (loss)	Reverse	T1/R2
S22	$\frac{b2}{a2}\Big\vert_{a1=0}$	Output reflection coefficient	Reverse	T2/R2

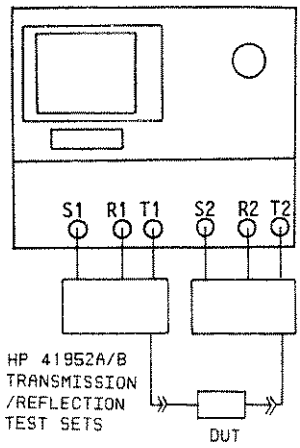
S11 Measurements

S11 can be measured using the following procedure.

CONFIG S-PRMTR, S11

PRESET **PRESET** key

CONNECTIONS Connect the HP 41952A as shown in the figure on the left.



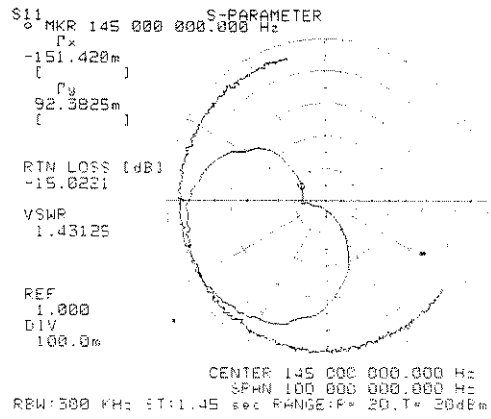
CONTROLS

1. FORMAT Γx - Γy (When POLAR or SMITH is selected, it is automatically selected.)
2. DISPLAY POLAR
3. SWEEP CENTER 145 MHz
   SPAN 10 MHz

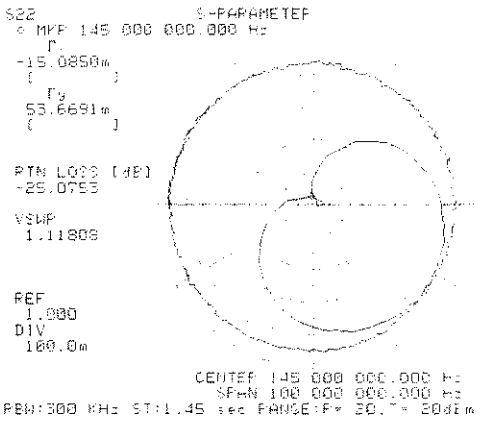
CALIBRATE Perform a 1-port full CAL. Use the same procedure as described in the previous setup. Connect the standards to the left test set.

DEVICE UNDER TEST Connect the DUT (145 MHz bandpass filter) as shown in the figure and press **TRIB/RST** key.

AUTOSCALE Press the **SCALE REF** key and select the **AUTO SCALE** softkey. The figure to the left shows a POLAR display of the 145 MHz bandpass filter's S11 characteristics. Each point of the measurement trace indicate the phase and amplitude of the reflection coefficient Γ of the DUT. The display of the reflection coefficient in the center of the POLAR display is 0 which indicates that there is no reflection at all. The outermost circle is $|\Gamma|=1$ which indicates that all of the signal is being reflected back from the device (100% reflection).

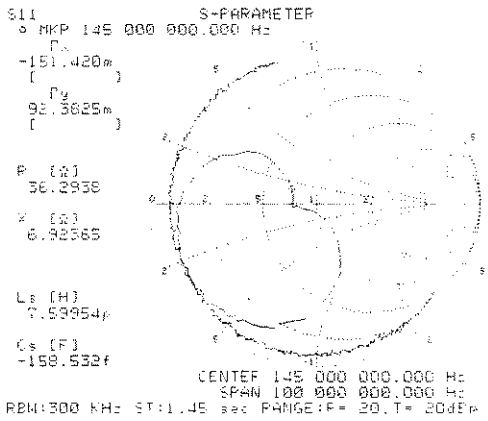


S22/S21/S12 Measurement



To measure S22, press the **CONFIG** key and select th **S22** softkey. Perform a 1-port full CAL, the same as for th S11 measurement. Connect the standards to the right te set. The characteristics shown in the figure on the left a displayed. Measuring the S21 or S12 can be performed b pressing respective softkey, however it would be necessa to first setup the DUT for a thru connection and then pe form a normalize calibration.

Impedance Measurement



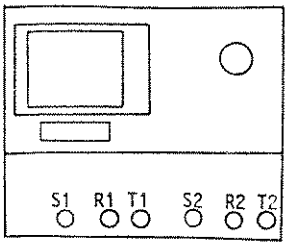
Once the reflection coefficient Γ has been measured, th DUT's impedance is easily determined. Use the sam setup as used to measure the S11 and S22 parameters, s the display to Smith chart, then the R-X value, inductanc (L) and capacitance (C) can be read from the Smi Chart by using the marker. The figure on the left show the 145 MHz bandpass filter measured input impedance.

Chapter 4

Spectrum Measurements with the HP 4195A

In chapters 2 and 3 the relationship between input, output, and reflected waveforms were measured using a sine wave, in which only the amplitude or phase differed. In an actual circuit, pure sine waves are seldom realized due to the circuit non-linearity, (i.e. distortion or noise). Non-linear circuits are widely used for modulation and mixing. The HP 4195A's spectrum analysis function is used to measure such non-linearity. This chapter will describe level, distortion and noise measurement using the HP 4195A's spectrum analysis function.

Basic Setup



No external test sets are required to perform spectrum measurements. The DUT is connected directly to one of the HP 4195A's four input ports: R1, R2, T1 or T2. An RF amplifier is used for the DUT in the examples. Modify the instrument setups shown to suit the DUT being measured. In the case of measurements involving amplifiers, use an attenuator if the amplifier output exceeds +20 dBm.

Switching Between Input Ports

Press the **CONFIG** key and select the **PORT SELECT** softkey to switch the HP 4195A's input ports. Then select port R1, T1, R2 or T2.

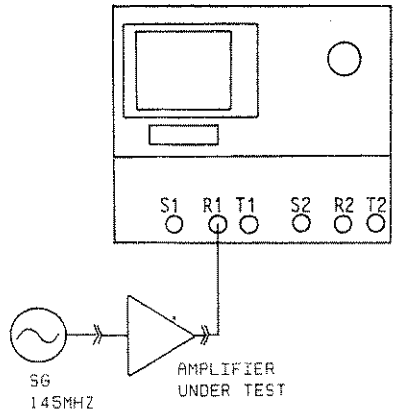
Level Measurements

The HP 4195A's spectrum function measures the absolute value of the input level. In the following example we will measure an amplifier's output level. The measurement sequence is as follows.

CONFIG SPECTRUM

PRESET Press the **PRESET** key to set the analyzer to an initial state.

CONNECTIONS Set up as shown in the figure on the left.

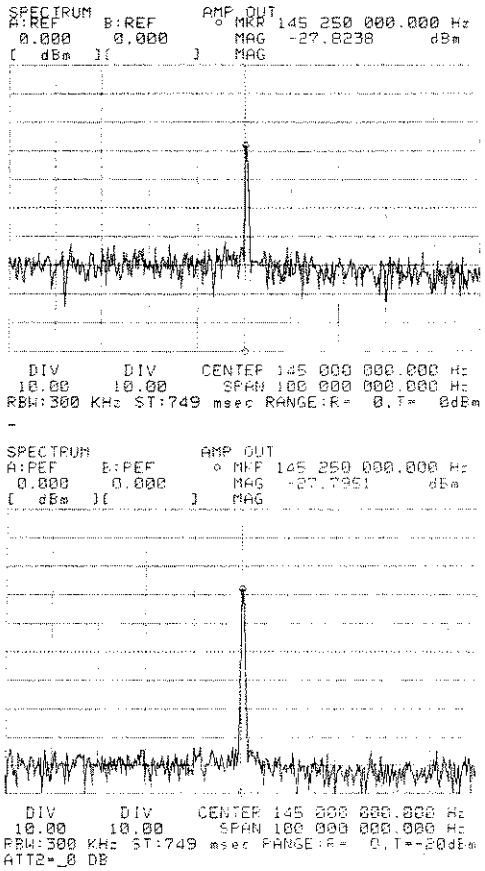


CONTROLS

1. FORMAT dBm
2. DISPLAY rectan X-A&B (Initial state)
3. SWEEP CENTER 145 MHz
   SPAN 100 MHz

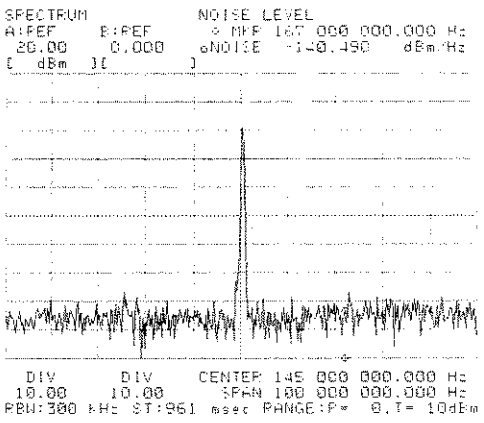
AUTOSCALE

Press the **SCALE REF** key and select the **AUTO SCAL** softkey.



When the measurement results shown in the figure to th left are displayed, press the **MKR→** key and select th **MKR→MAX** softkey. The marker (oMKR) on the trace the moves to the peak point on the displayed trace. The absc lute amplitude level (dBm), and the frequency at th marker position are displayed in the upper right corner c the screen. Press the **ATTEN** key of the input port bein used to change the setting of the attenuator so the wave form displayed will be measured with the maximur dynamic range.

Measuring Noise Level



By using the HP 4195A's noise marker function the spec trum density of the normalized noise at a bandwidth of Hz can be read directly. The measurement is performed a follows:

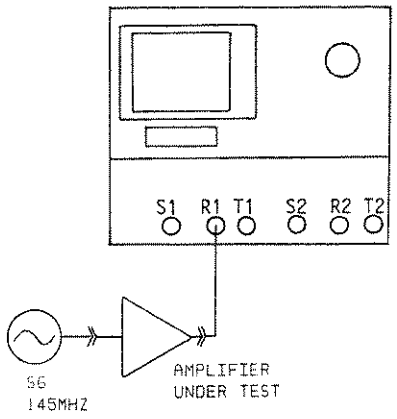
1. Set the marker to the desired frequency.
2. Press the **MKR→** key, and select the **more 1/2** softkey t display the **more 2/2** menu.
3. Set the **NOISE on/off** softkey to ON (**on**/off), to sta reading the noise levels.

Measuring Total Harmonic Distortion

CONFIG SPECTRUM

PRESET Press the **PRESET** key to initialize the HP 4195A.

CONNECTIONS Set up as shown in the figure on the left.



CONTROLS

1. FORMAT dBm (Initial state)
2. DISPLAY rectan X-A&B (Initial state)
3. SWEEP START 100 MHz
   STOP 450 MHz

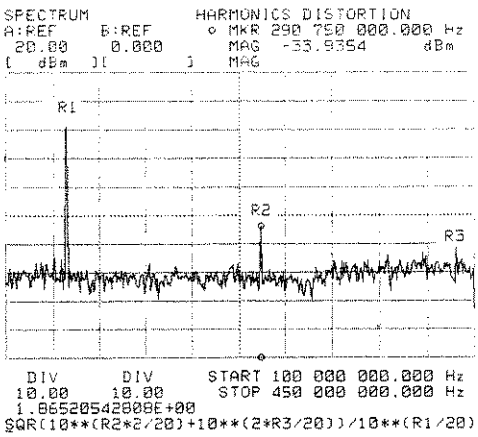
AUTOSCALE Press the **SCALE REF** key and select the **AUTO SCALE** softkey.

Operate the marker as described in the following sequence.

1. Press the **MKR→** key and select the **MKR→MAX** softkey.
2. Type R1=MKRA and press the **ENTER** key. The amplitude value of the fundamental is assigned to variable register R1.
3. Select the **NEXT PEAK** softkey.
4. Type R2=MKRA and press the **ENTER** key. The amplitude of the second harmonic is assigned to register R2.
5. Select the **NEXT PEAK** softkey.
6. Type R3=MKRA and press the **ENTER** key. The amplitude of the third harmonic is assigned to register R3.
7. Type as follows and press the **ENTER** key.

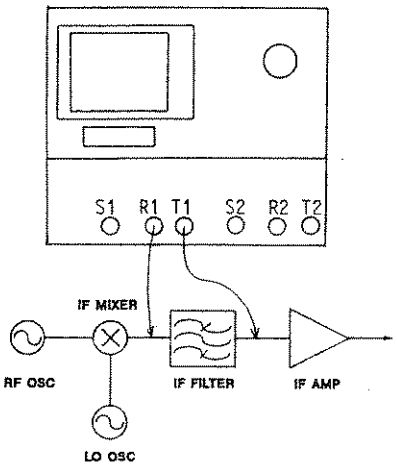
   SQR (10**(R2*2/20)+10**(R3*2/20))/10**(R1/20)*100

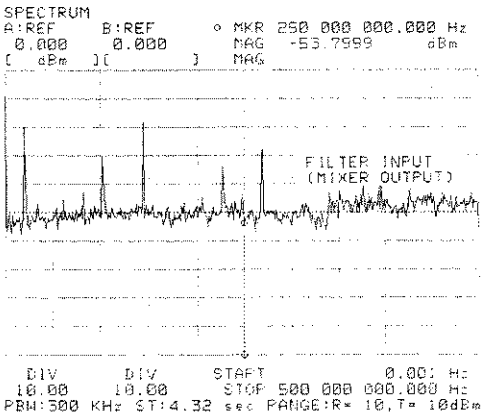
   The ratio of distortion (%) of the second and third harmonic is displayed at the bottom of the screen.

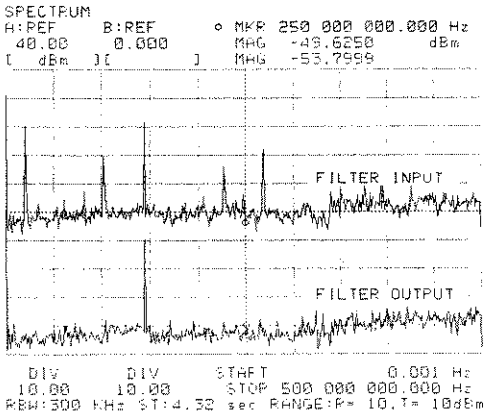


Operations 1 ~ 7 above can be programmed to be executed by using the user program function. Refer to the example given in APPENDIX B.

Multi-Channel Spectrum Measurement







The HP 4195A can switch between the four input ports fo spectrum measurements, eliminating the need for recon necting to different points on a circuit. The HP 4195A ca display a maximum of four traces simultaneously. Th setup shown on the left permits simultaneous display c two spectrum waveforms.

Proceed as follows.

1. Press the **PRESET** key, the **CONFIG** key, and select th **SPECTRUM** softkey. The measurement result made b R1 port is displayed. R1 Port is selected when th analyzer is initialized.

2. Press the **DISPLAY** key, and set the **TRACE B on/o** softkey to ON (on/off).

3. Type B=A and press the **ENTER** key. The measure ment data in register A is transferred to register B, an the result is displayed as trace B (light blue).

4. Press the **CONFIG** key, select the **PORT SELECT** sof key, and press the **T1** softkey to make port T1 th measurement port.

5. The signal input to port T1 is displayed as trace (yellow). At this time, note that trace B looks like it being overwritten on every sweep, but actually it mai tains the same data.

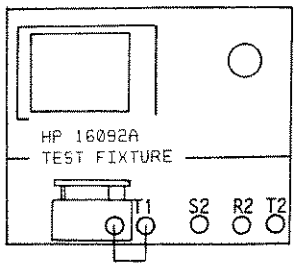
6. Press the **SCALE REF** key and input the value with th **REF LEVEL** or **/DIV** softkeys or modify the value wi the ⇧ and ⇩ keys to display trace A in the top ha of the screen. Then press the **SCALE for A/B** softke and use the same manner to display trace B in th lower half of the screen.

Note: Traces C and D can be used when 3 or 4 trac displays are required. Refer to APPENDIX C, pag C-3, for four trace display.

Chapter 5

Impedance Measurements with the HP 4195A

When the HP 41951A impedance test kit is used with the HP 4195A, a devices impedance parameters between 100 kHz and 500 MHz ($|Z|$, $|Y|$, θ, R, X, C, L, Q, D etc.) can be displayed directly. In this chapter, a crystal resonator with a resonant frequency of 80 MHz will be measured.



Basic Setup

To perform impedance measurements, the HP 41951A impedance test kit and a test fixture suitable for the DUT are required. The HP 16092A clip test fixture is used in this example.

CONFIG

IMPEDANCE

PRESET

Press the **PRESET** key to initialize the 4195A.

CONNECTIONS

Connect the HP 41951A adaptor as shown in the figure. Do not connect the HP 16092A test fixture.

CONTROLS

1. FORMAT $|Z|$-θ (Initial state)
2. DISPLAY rectan X-A&B (Initial state)
3. SWEEP CENTER 80.0014 MHz
   SPAN 10 kHz

CALIBRATE

Calibration must be performed to remove measurement errors induced by the 41951A test kit. Perform a 1-port full CAL by connecting 0 Ω, 0 S, 50 Ω standards respectively to the 7 mm connector of the Impedance Test Adapter.

COMPENSATION

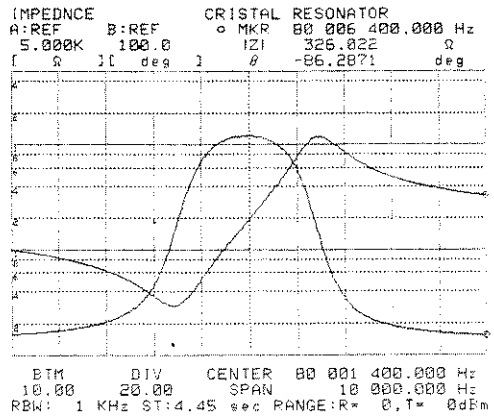
To obtain the best accuracy, the test fixture residuals should be compensated for. Connect the HP 16092A test fixture and perform OPEN/SHORT offset compensation.

DEVICE UNDER TEST

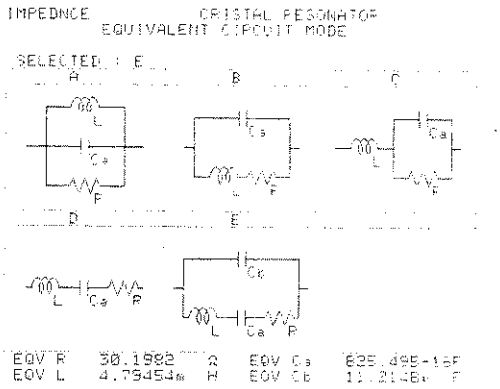
Connect the DUT to the HP 16092A and press **TRIG/RST** key.

AUTOSCALE

Press the **SCALE REF** key and select the **AUTO SCALE** softkey. The measurement results are displayed as shown in the figure to the left. Trace A displays the absolute value of impedance $|Z|$ and trace B displays the phase angle θ.



EQUIVALENT CIRCUIT PARAMETER CALCULATION



With the equivalent circuit function of the HP 4195A, par meters L, R, Ca and Cb of the crystal resonator's equiv lent circuit are automatically calculated by the HP 419 The calculation is performed using the measured i pedance data.

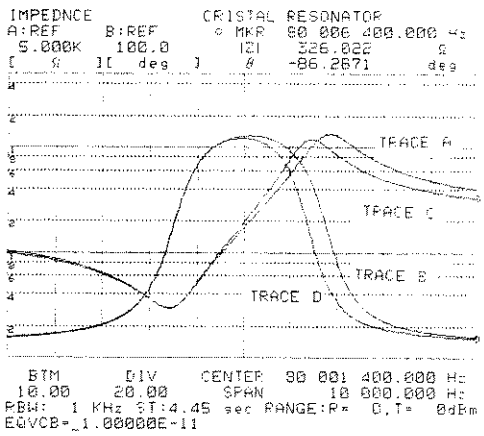
Proceed as follows to perform the calculation.

1. Press the **MORE** key in the **SPECIAL FUNCTION** se tion, and select the **EQV CKT** softkey.

2. Press the **CKT E** softkey. (Because the DUT is a cr tal. In case of an inductor, select CKT A or B. In ca of a capacitor, select CKT D.)

3. When the **CALC EQV para** softkey is pressed, a beep generated to indicate that the equivalent circuit valu are displayed in the lower part of the screen (as sho in the figure on the left).

FREQUENCY CHARACTERISTIC SIMULATION



The equivalent circuit analysis function is used to simula impedance and admittance frequency dependent charact istics. Proceed as follows.

1. Select the **EQV para entry** softkey.

2. Enter the value of each equivalent circuit parameter a press the **return** softkey.

3. When the **SIMULATE f-char** softkey is pressed, t 4195A beeps as the simulated frequency characteristi (traces C and D) are displayed with traces A and B (and D display are simulated results, A and B are act measurements).

Turn off traces A and B to more clearly view traces C a D. To turn off traces A and B, press the **DISPLAY** key a set the **TRACE A on/off** and **TRACE B on/off** softkeys OFF (on/**off**). To turn off traces C and D, press the **VIE** key and set the **VIEW C on/off** and **VIEW D on/off** softke to OFF (on/**off**).

APPENDIX A

INTERNAL REGISTERS

An HP 4195A "Internal Register" is a memory location to or from which the user can write or read numeric data. By using these registers, the HP 4195A can easily solve various measurement and computational problems. Refer to APPENDIX F for the internal register listing.

Registers Types

The 4195A has the following four types of registers:

	Array Register Contains 401 elements (values)	**Single Register** Contains only one element (value)
General Purpose Open to users. The HP 4195A will not change the data in these registers.	E ~ J, RA ~ RF	R0 ~ R99
Limited Purpose Opened to users but their application are limited. The HP 4195A may change the data or may be changed by the data in these registers.	Examples: A ~ D, MA, MB, X ...	Examples MKR, MKRA, CENTER ...

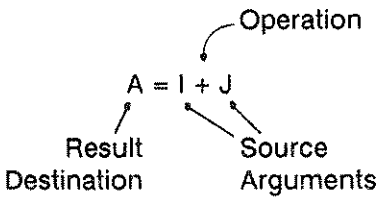
Data Storage

The typical applications for the registers are the storage of measurement data. Array Registers C thru J and RA thru RJ are suitable to this purpose because each of them has a maximum of 401 elements. To store or recall the data, use register operation described below. Also, Example 4) shows an example of storing/recalling the data.

Register Operations

Mathematical operations can be performed using the registers. The syntax for operations is similar to that found in BASIC.

Example)

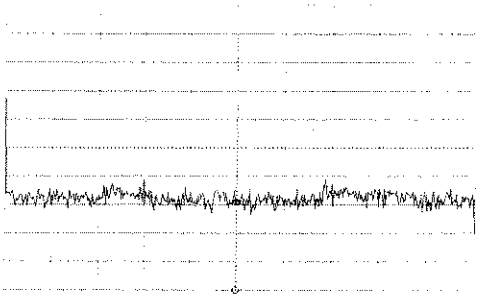


Register operations can be performed from the front panel, in a User Program, in a User Defined Function and in with User Math. During front panel execution, the **ENTER** key should be pressed to execute the operation. Front panel execution is simple, but note that when the SWEEP mode is set to CONT, the data in registers A and B are refreshed during each sweep. The following are examples of array registers operations and marker-related single registers definition.

Example 1) Mathematical Operation

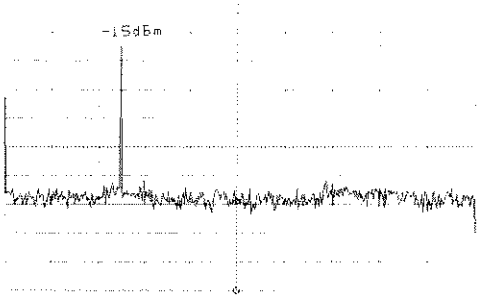
Mathematical operation can be performed for either a) Indivisual element of array register or b) Entire element of array register.

CONFIG ..... SPECTRUM
PRESET
TRIG/RST..... SINGLE mode



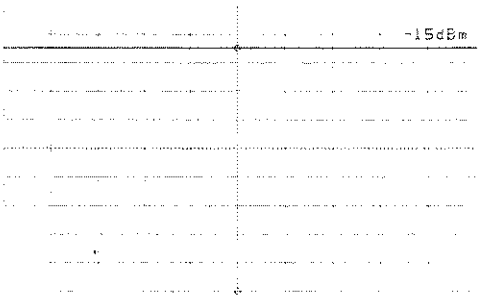
a) Elements within array register can be changed individually.

A(100) = - 15 **ENTER**

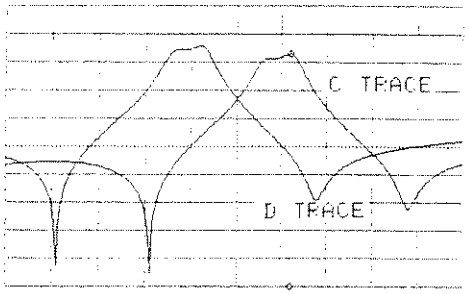


b) Entire register array can be changed very simply.

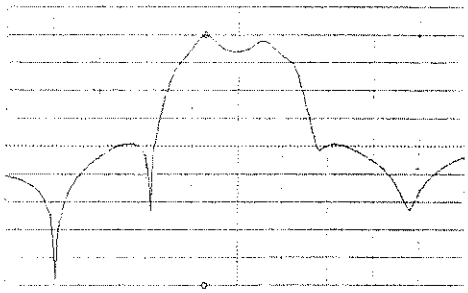
A = -15 **ENTER**



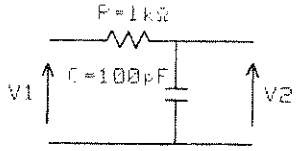
Example 2) Simulation of two filters connected in series



A = C + D **ENTER**



Example 3) Simulation of transmission characteristic of RC filter

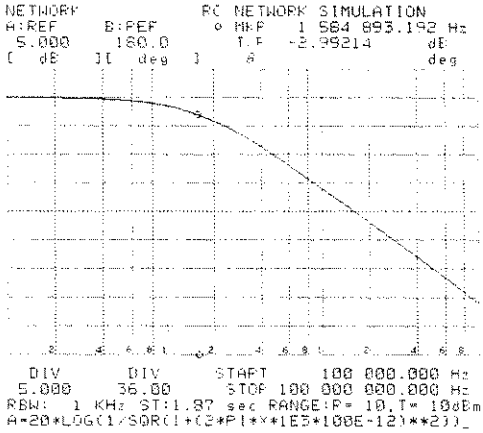


$$T(\omega) = 20 \log \left(\frac{V2}{V1} \right) = 20 \log \left(\frac{1}{\sqrt{1+(\omega RC)^2}} \right)$$

HP 4195A Register Operation:

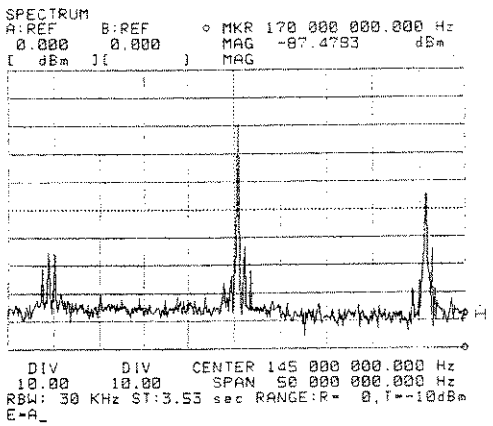
A=20*LOG(1/SQR(1+(2*PI*X*1E3*1E-10)**2)) **ENTER**

Where PI: Single Register containing π value
X: Array register containing freq.values



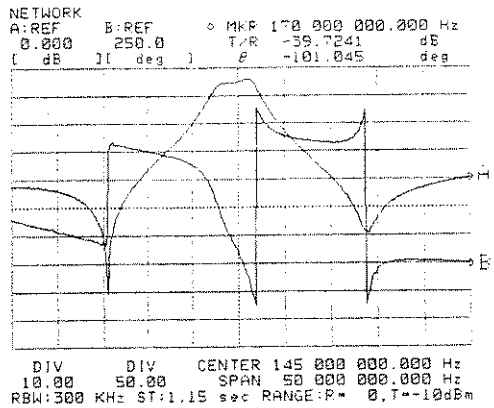
Example 4) Using register E as a waveform memory

CONFIG: SPECTRUM

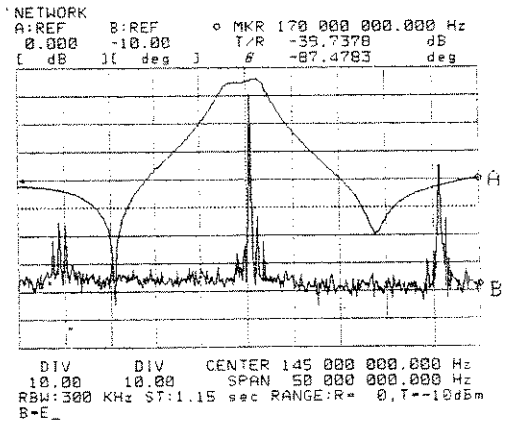


E = A **ENTER**

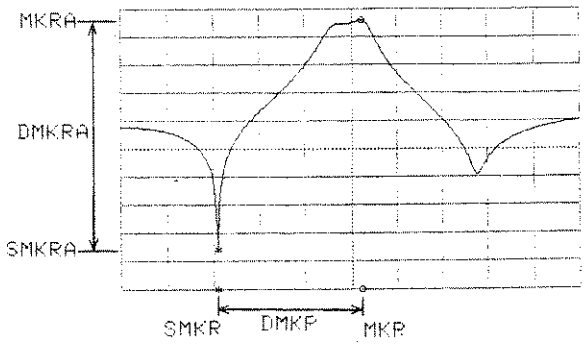
CONFIG: NETWORK

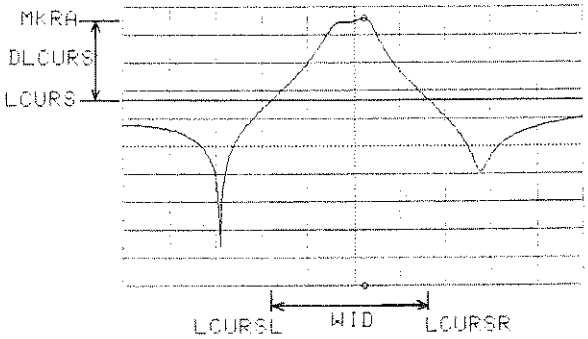


SWEEP Mode: SINGLE
B = E **ENTER**
Autoscale for B



Marker/Cursor Related Registers





APPENDIX B

USER PROGRAM

User Programs can control almost all HP 4195A functions. These User Programs enable automated measurements, complicated calculations and analysis to be performed quickly and easily. How to write a program, and sample programs are covered next.

How to Write a User Program

Writing User Programs is easy. User programs are created and modified in the "Editor mode". Once you are in the editor, the HP 4195A will automatically generate the command in the program when you push the function keys. You create a User Program in the same way you would perform a manual measurement. The following example is a procedure to write and run a simple program.

Sample Procedure for making and running a program:

Procedure	Key Strokes
1. Scratch the current program	[PROGRAM] [SCRATCH] [ENTER]
2. Select the Editor	[EDIT] [EXECUTE]
3. Select Spectrum mode	[CONFIG] [SPECTRUM] [ENTER]
4. Preset	[PRESET] [ENTER]
5. Select the input port	[PORT SELECT] [SPECTRUM] [T1] [ENTER]
6. Select frequency	[START] 50MHZ [ENTER] [STOP] 250MHZ [ENTER]
7. Trigger	[TRIG/ RST] [ENTER]
8. Move the marker to the higher peak	[MKR→] [oMKR menu] [MKR→ MAX] [ENTER]
9. End the program	[PROGRAM] [END] [ENTER]
10. Quit the Editor	[QUIT EDITOR]
11. Run the Program	[RUN]

Sample Programs

The following programs show typical applications of user Programs. Although the key strokes are not given for these programs, commands are entered by pressing the related keys. Also refer to APPENDIX E where the commands are given with corresponding softkeys.

Example 1) Alternate Transmission/Reflection measurement

This program changes the measurement port for every sweep and is suitable for the measurement setup given on page 3-2.

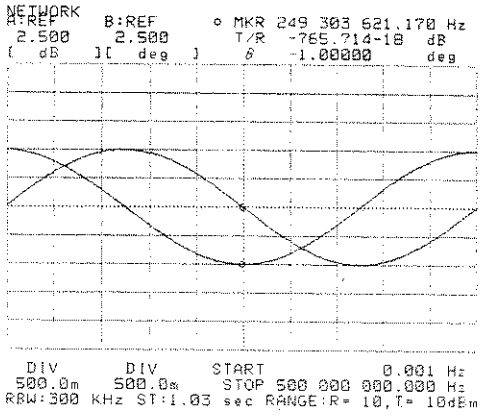
```
 10 FNC1             ! Select Network Measurement
 20 RST              ! Preset the 4195A
 30 CENTER=145 MHZ   ! Set center frequency to 145MHz
 40 SPAN=100 MHZ     ! Set span frequency to 100MHz
 50 PORT1            ! Select port T1/R1 for reflection measurement
 60 SWTRG            ! Initiate a sweep (Sweep Triger)
 70 PORT2            ! Select port T2/R1 for transmission measurement
 80 SWTRG            ! Initiate a sweep (Sweep Triger)
 90 GOTO 50
100 END
```

Example 2) SIN wave, COS wave display

```
 10 SWM2             ! Select sweep mode to SINGLE
 20 NOP=360          ! Set number of displayed points to 360
 30 FOR R0=1 TO 360
 40 A(R0)=SIN(R0)    ! Substitute SIN value for the R0th element of A register
 50 B(R0)=COS(R0)    ! Substitute COS value for the R0th element of B register
 60 NEXT R0
 70 SCL1             ! Scale for A
 80 AUTO             ! Autoscale
 90 SCL2             ! Scale for B
100 AUTO             ! Autoscale
110 END
```

When you run the program, SIN and COS waves are displayed on the CRT. It will take more than 1 min. to complete this program, because traces A and B are re-written each time as are the A and B registers. The following program shortens the time by using register operations. This program also uses multi-statement technique to shorten execution time and program length.

```
10 SWM2;NOP=360
20 FOR R0=1 TO 360
30 RA(R0)=SIN(R0);RB(R0)=COS(R0)
40 NEXT R0
50 A=RA;B=RB;SCL1;AUTO;SCL2;AUTO
60 END
```



Example 3) 3 dB Bandwidth of the filter

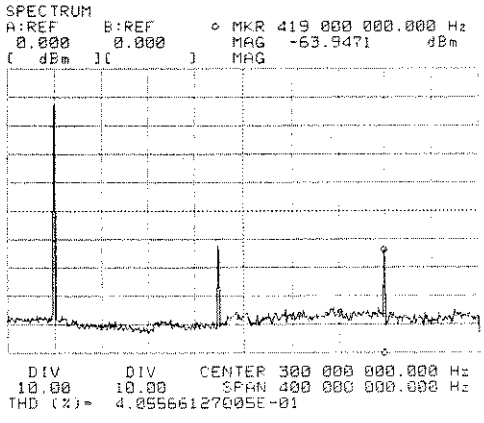
This program measures and displays the 3dB Bandwidth value. Refer to pages 2-1 and 2-2 for measurement sequence.

```
 10 FNC1              ! Select Network Measurement
 20 RST               ! Preset the 4195A
 30 CENTER=145 MHZ;SPAN=100 MHZ
 40 SWTRG             ! Initiate a sweep (Sweep Triger)
 50 MCF4              ! Select marker and line cursor mode
 60 MKMX              ! Marker to MAX
 70 DELT1             ! Delta mode ON
 80 MKACT0            ! Enable line cursor
 90 DLCURS=-3         ! Move line cursor to -3dB down from marker
100 R0=WID            ! Input -3dB bandwidth into R0
110 DISP '3 DB BANDWIDTH (HZ)=',R0
120 END
```

Example 4) Total Harmonic Distortion

This program calculates 2nd and 3rd harmonic distortion. Refer to page 4-1 for measurement setup and sequence.

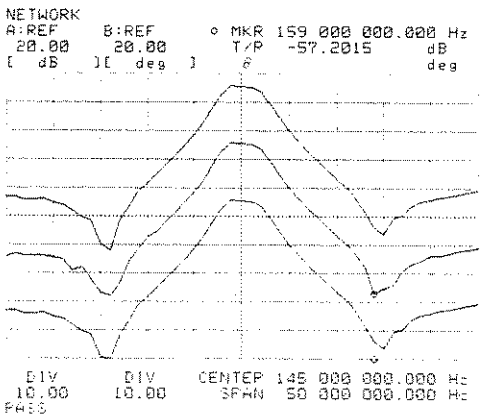
```
 10 MCF1              ! Select single marker mode
 20 MKMX;R1=MKRA      ! Marker to MAX (Fundermantal)
 30 NXTPK;R2=MKRA     ! Search the next peak (2nd Harmonics)
 40 NXTPK;R3=MKRA     ! Search the next peak (3rd Harmonics)
 50 R0=SQR(10**(2*R2/20)+10**(2*R3/20))/10**(R1/20)*100
 60 DISP 'THD (%)=',R0
 70 END
```



Example 5) Go/No-Go Testing with Limit Line

This program specifies upper/lower limit lines +20 dB appart from the actual measurement value (Line No. 40 ~ 100), and checks if the measured value exceeds the limit (Line No. 120 ~ 240). Decision is made by checking if register B (not displayed), which contains difference between the actual value and limit value, has any negative value (Line No. 130 ~ 160).

```
 10 !
 20 ! GO/NO-GO WITH LIMIT LINE
 30 !
 40 FNC1
 50 RST
 60 CENTER=145 MHZ ;SPAN=50 MHZ;NOP=51;OPB0
 70 SWTRG
 80 SPSTR;OPA0;AUTO
 90 SCL1;R0=REF;R1=DIV;SCL2;REF=R0;DIV=R1
100 C=A+20;D=A-20;OPA1;SPC1;SPD1;MKCR2
110 !
120 SWTRG
130 B=C-A;MKMN
140 IF MKRB<0 THEN GOTO 210
150 B=A-D;MKMN
160 IF MKRB<0 THEN GOTO 210
170 !
180 DISP "PASS"
190 GOTO 120
200 !
210 BEEP
220 DISP "*** FAIL *** PRESS CONT"
230 PAUSE
240 GOTO 120
250 END
```



APPENDIX C

USER DEFINED FUNCTION

The HP 4195A's User Defined Function can be used to define a softkey which will perform a sequence of key strokes. This reduces key strokes needed to obtain Total Harmonic Distortion, for instance. Five softkeys can be individually defined. In addition, three **SE** (Sweep End Function) softkeys can be used for operations at the end of every sweep. These **SE** softkeys are used for applications such as Signal Tracking and Alternate Sweep. The following example shows how to define a "3 dB Bandwidth" softkey.

Defining Procedure:

1. Press **USER DEFINED** key.
2. Press the **DEFINE FCTN** softkey.
3. Select the **FCTN1** softkey.

   DF1"

   will be displayed at the bottom of the CRT.
4. Define a softkey to obtain the -3 dB bandwidth. Refer to page 2-2 for the required key strokes. Each command should be separated by a ";".
5. The following commands should be displayed.

   DF1" MCF4;MKMX;DELT1;DLCURS=-3;WIDTH1"
6. Press the **ENTER** key.

Notes:

1. To define SE softkeys, press SWP END FCTN softkey and then press DEFINE SE fctn softkey.
2. Up to 85 characters can be defined for one softkey.
3. The syntax for User Defined Functions is the same as that of a user Program. This means that execution commands such as RST and SWTRG cannot be used in combination with other commands.

Execution:

Preset the HP 4195A and measure the transmission characteristics of the bandpass filter. Refer to page 2-1 for the measurement procedure. Press the **USER DEFINE** key and the softkey numbered "1". The -3 dB bandwidth is displayed as the WIDTH value.

Entering Key Labels:

Any key label (name) can be assigned to a User Defined key. The following procedure shows how to label softkey #1 as "3DB BW".

1. Press the **USER DEFINE** key.
2. Press the **KEL LBL entry** softkey.
3. Select the **fctn 1 KEY LBL** softkey

   LBL1"

   will be displayed.
4. Input the following using alphanumeric keys

   LBL1" 3DB BW"

   Up to 15 characters can be used for a label.
5. Press the **ENTER** key.

Examples

Example 1) Filter Parameters

```
DF1"MCF1;MKMX"
DF2"MCF4;MKMX;DELT1;DLCURS=-3;WIDTH1;R2=WID;R0=LCURSL;R1=LCURSR"
DF3"MCF2;MKACT1;MKMX;DELT1;MKACT0;DMKR=20 KHZ"
DF4"MCF4;MKMX;DELT1;DLCURS=-60;WIDTH1;R3=WID/R2;DISP 'SHAPE FACTOR=',R3"
DF5"MCF2;MKR=R0;SMKR=R1;ARSTR;ANA1;LMX(A);ARSTR;MKACT1;MKMX;MKACT0;MKMN;ANA0"


LBL1"INSERTN LOSS   "
LBL2"3dB     BW"
LBL3"OUTBAND REJEC  "
LBL4"SHAPE   FACTOR "
LBL5"PASSBANDRIPPLE "
```

Example 2) Signal Track (Application of Sweep End Function)

```
DFA"MKMX;MKCTR"


LBLA"SIGNAL  TRACK  "
```

Example 3) **Alternate Transmission/Reflection Measurement** (Application of Sweep End Function)

```
DFA"SPCHG;PORT1;SEFA0;SEFB1"
DFB"SPCHG;PORT2;SEFB0;SEFA1"
```

Example 4) **Four-channel Spectrum Measurement (Defined by User Program)**

If the User Defined Functions are defined by a User Program, there are several merits for the user.

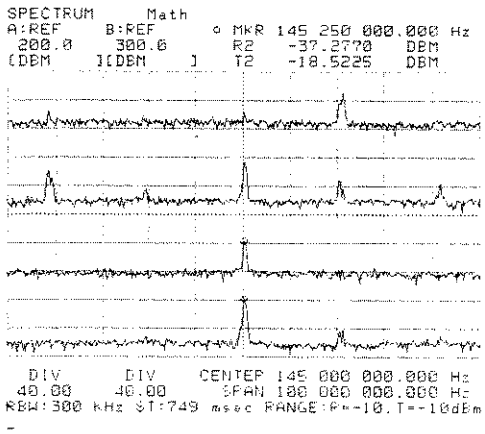
1) Setup of the 4195A can be made easily.

2) User Defined Functions can be stored as an ASP file on the flexible disc. This saves disc space when compared with a STATE file.

3) User Program Editor can be used to edit keys.

When you run the following program, instrument setup and key definition are made in one time.

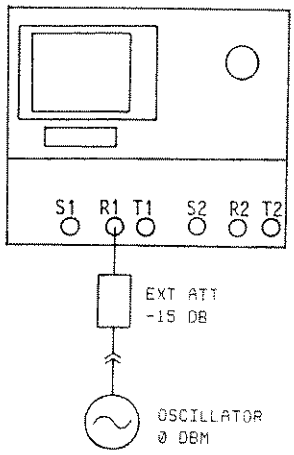
```
 10 FNC2
 20 RST
 30 CENTER=145 MHZ ;SPAN=100 MHZ ;DIV=40;SCL2;DIV=40;DPB1;SPC1;SPD1
100 DF1"PORT1;SCL1;REF=0;C=A-200;DMA=MA;DMB=B;MTHA1;MTHB1;PRMA'R1'"
110 DF2"PORT2;SCL2;REF=100;D=B-200;DMB=MA;DMA=A;MTHA1;MTHB1;PRMB'T1'"
120 DF3"PORT3;SCL1;REF=200;C=A+200;DMA=MA;DMB=B;MTHA1;MTHB1;PRMA'R2'"
130 DF4"PORT4;SCL2;REF=300;D=B+200;DMB=MA;DMA=A;MTHA1;MTHB1;PRMB'T2'"
140 DF5""
150 LBL1"R1"
160 LBL2"T1"
170 LBL3"R2"
180 LBL4"T2"
190 LBL5""
210 SWM1;UNITA"DBM";UNITB"DBM"
220 END
```

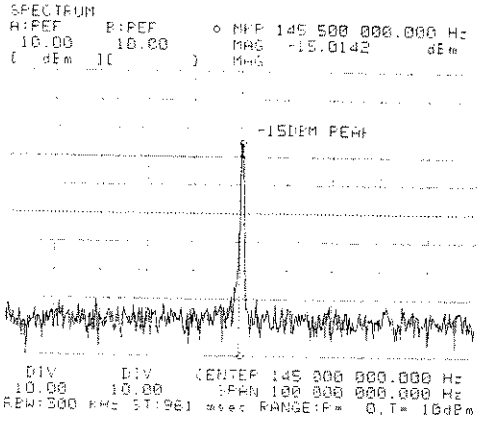


APPENDIX D

USER MATH FUNCTION

The User Math Function of the HP 4195A enables the displayed data to be as a function of the measurement data. This facilitates applications which require real-time calculations such as unit conversion, MAX HOLD, and compensation of external attenuators. The figure below shows an example of a +15 dB offset being applied to the measurement value by using the User Math function.





Defining Procedure:

1. Press the **DEFINE MATH** key.
2. Press the **DEFINE MATH A** softkey.

   DMA=

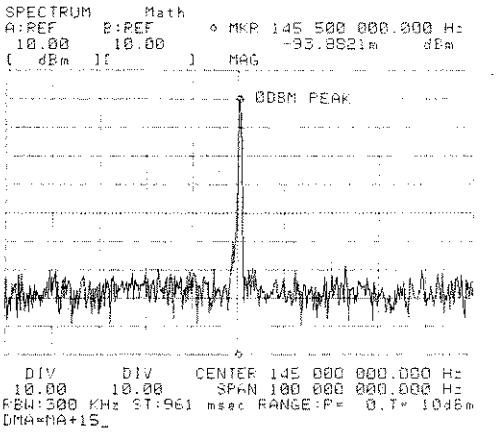
   is displayed on the bottom of the CRT.
3. Input the following using the alphanumeric keys.

   DMA=MA+15

   Where DMA (Defined Math A) means displayed data and MA means measured data.
4. Press the **ENTER** key.

Execution:

Press the **DEFINE MATH** key and set the **MATH->A on/off** softkey to ON (on/off). "Math" is displayed on the top line of the CRT and the displayed data is offset by +15 dB.



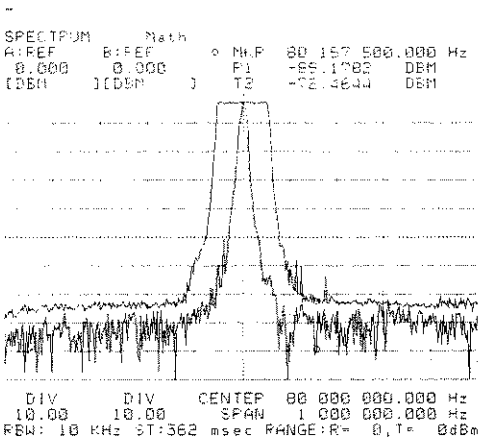
Sample Definitions

Example 1) Max Hold

DMA=MA

DMB=MAX(MA,B)

(Display B ON)



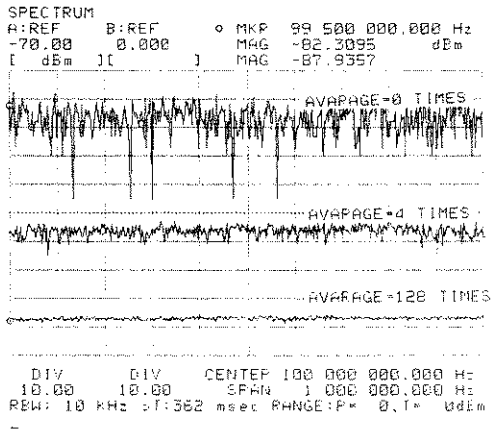
Example 2) Averaging

Averaging 4 times:

DMA=A*3/4+MA/4

Averaging 128 times

DMA=A*127/128+MA/128



Example 3) 75Ω Environment Measurement

When the HP 4195A is used with an HP 11852B Minimum Loss Pad (5.7 dB Loss) to convert 50 Ω to 75 Ω, it is necessary to set dBm referenced to 75 Ω. Following equation converts measured dBm (in 50 Ω) to dBm in 75 Ω.

```
DMA=MA+5.7
```

Example 4) Vp-p Measurement

While the HP 4195A measures voltage in Vrms, it can be converted into Vp-p using the following equation.

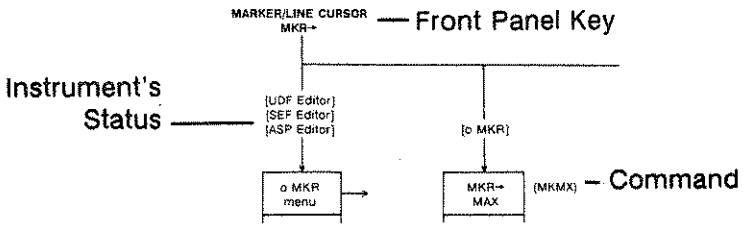
```
DMA= 2*SQR(2)*MA
```

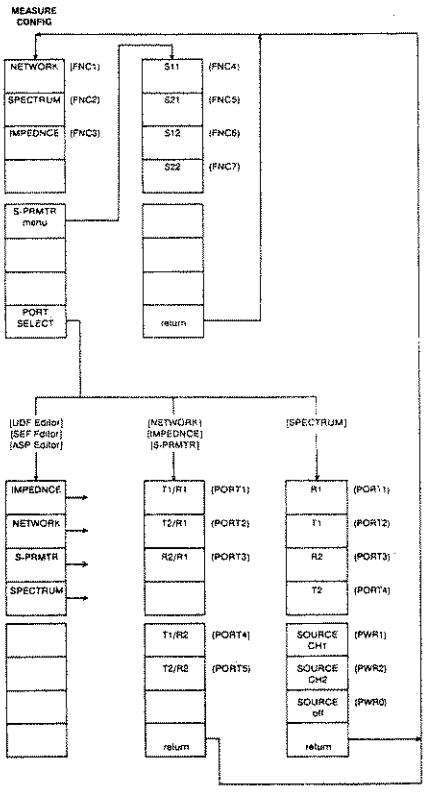
Also unit should be changed as follows.

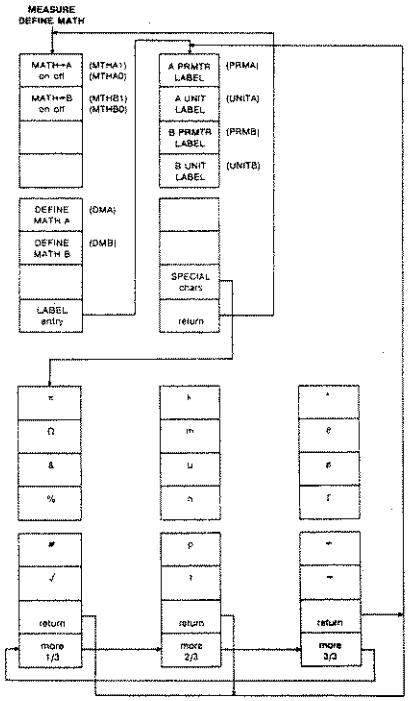
```
UNITA"Vp-p"
```

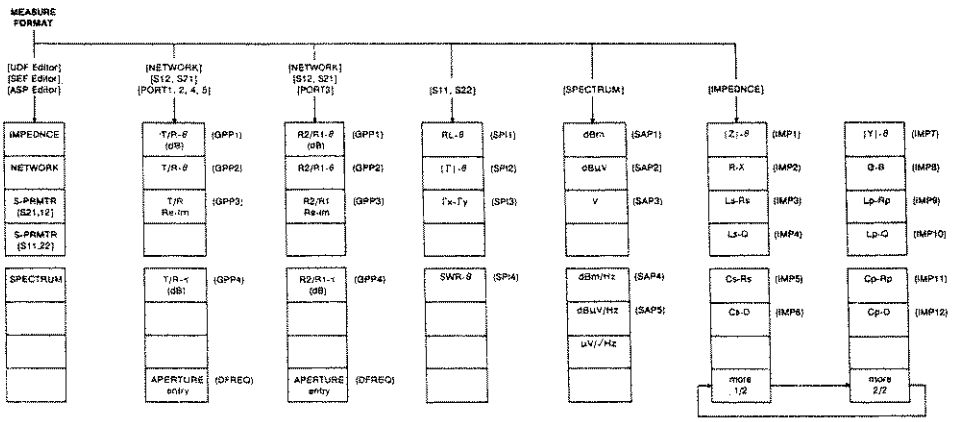
APPENDIX E

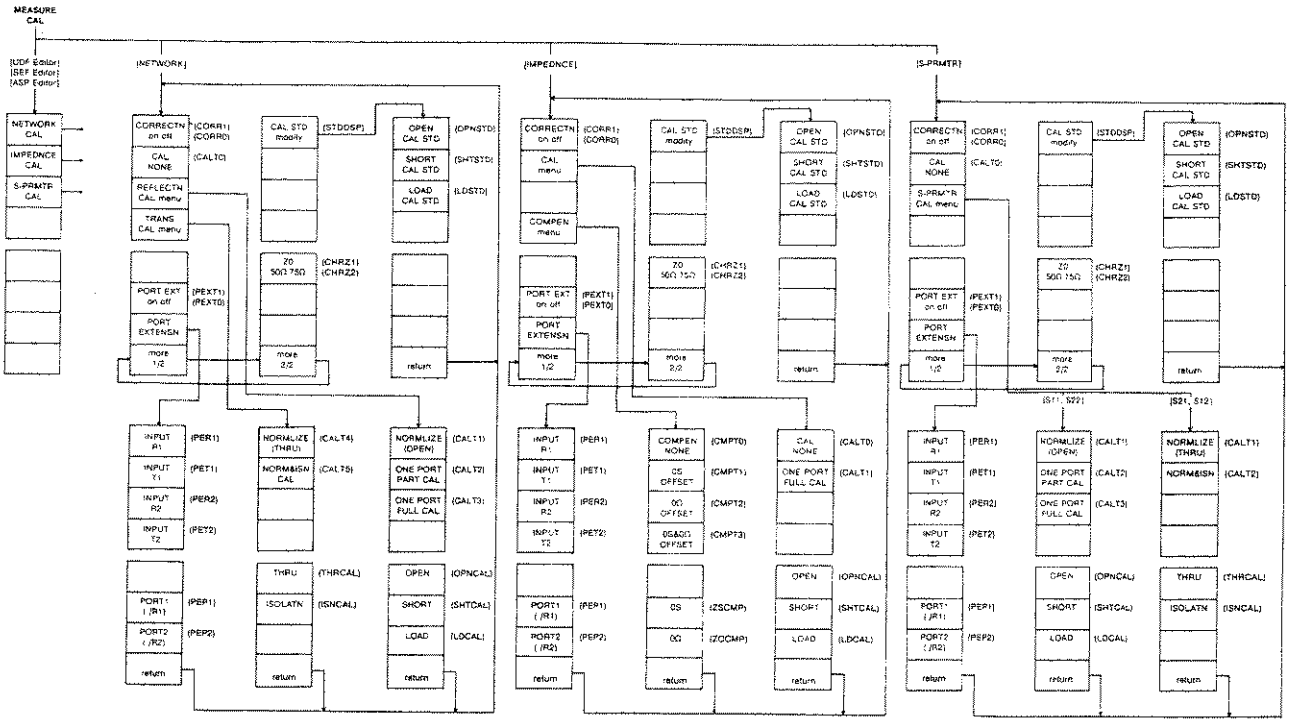
SOFTKEY TREE

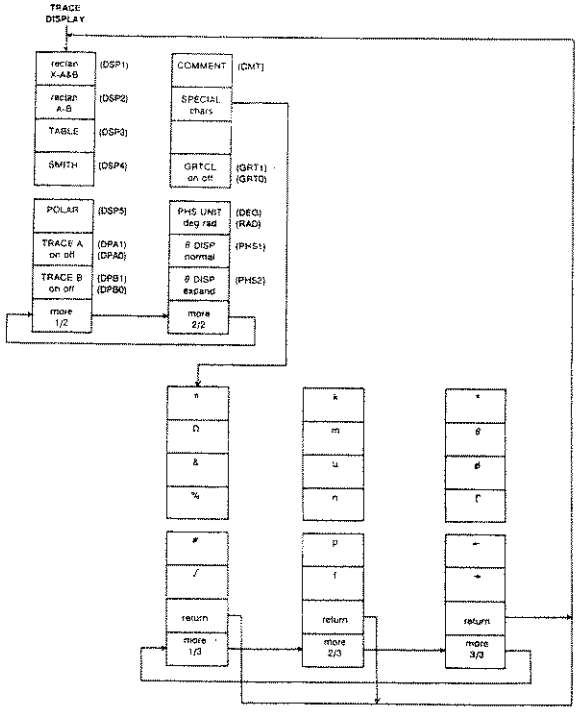


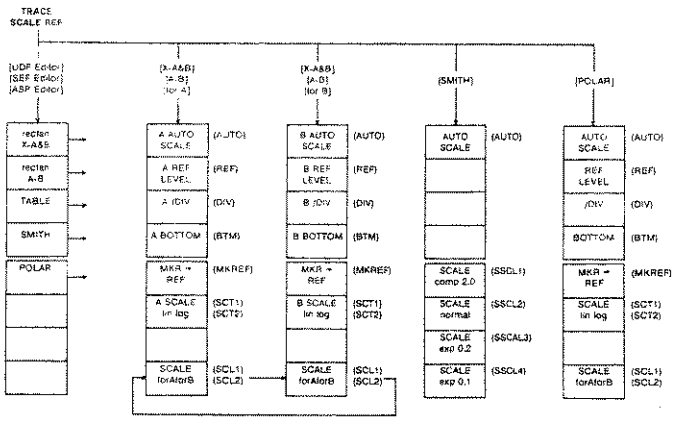


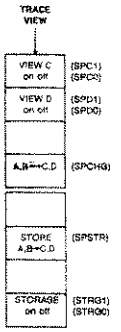


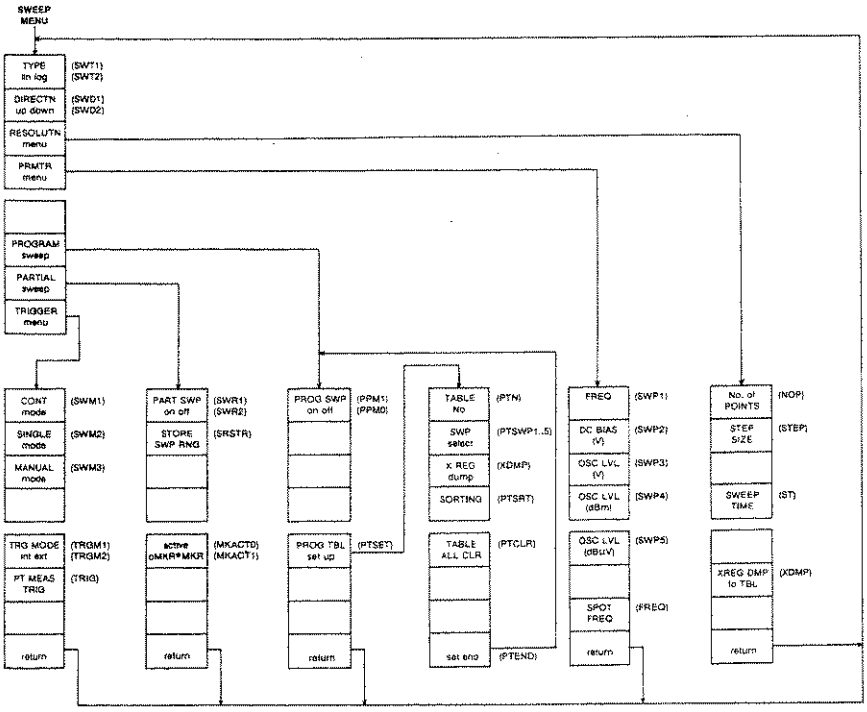


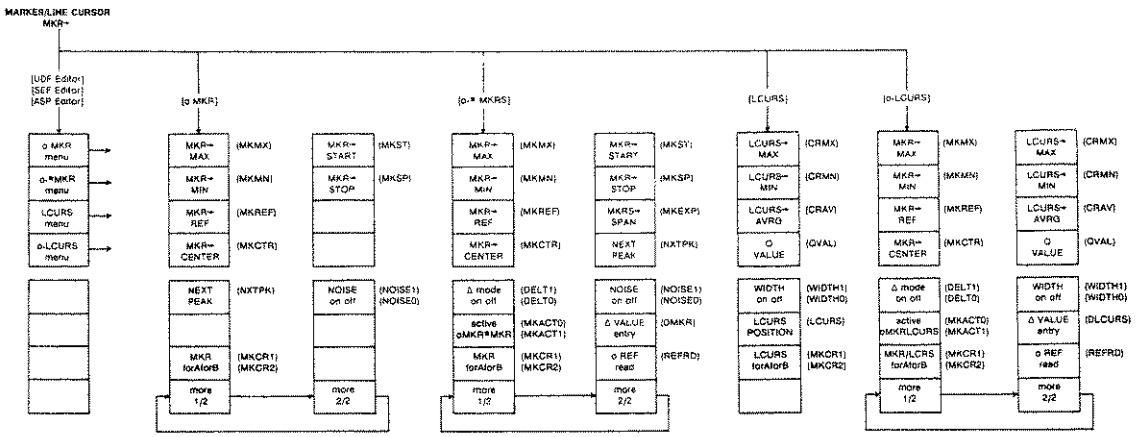

MEASURE CAL
[UDF Editor]
[SEF Editor]
[ASP Editor]
NETWORK CAL
IMPEDNCE CAL
S-PRMTR CAL
[NETWORK]
CORRECTN on off
CAL NONE
REFLECTN CAL menu
TRANS CAL menu
PORT EXT on off
PORT EXTENSN
more 1/2
CAL STD modify
Z0 50Ω 75Ω
more 2/2
OPEN CAL STD
SHORT CAL STD
LOAD CAL STD
return
INPUT R1
INPUT T1
INPUT R2
INPUT T2
PORT1 (/R1)
PORT2 (/R2)
NORMALIZE (OPEN)
ONE PORT PART CAL
ONE PORT FULL CAL
NORMALIZE (THRU)
NORM&ISN CAL
THRU
ISOLATN
OPEN
SHORT
LOAD
[IMPEDNCE]
CAL menu
COMPEN menu
0S OFFSET
0Ω OFFSET
0S&0Ω OFFSET
CAL NONE
ONE PORT FULL CAL
0S
0Ω
[S-PRMTR]
S-PRMTR CAL menu
[S11, S22]
[S21, S12]

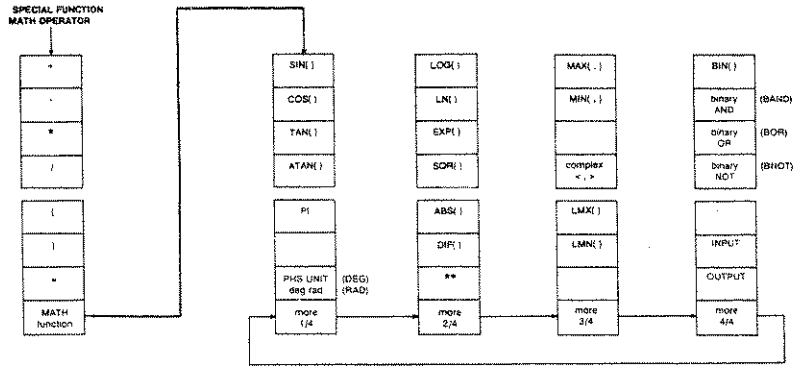

TRACE DISPLAY
rectan X-A&B
rectan A-B
TABLE
SMITH
POLAR
TRACE A on off
TRACE B on off
more 1/2
COMMENT
SPECIAL chars
GRTCL on off
PHS UNIT deg rad
θ DISP normal
θ DISP expand
more 2/2
Ω
&
%
/
return
more 1/3
m
u
n
p
f
more 2/3
θ
ø
Γ
←
→
more 3/3

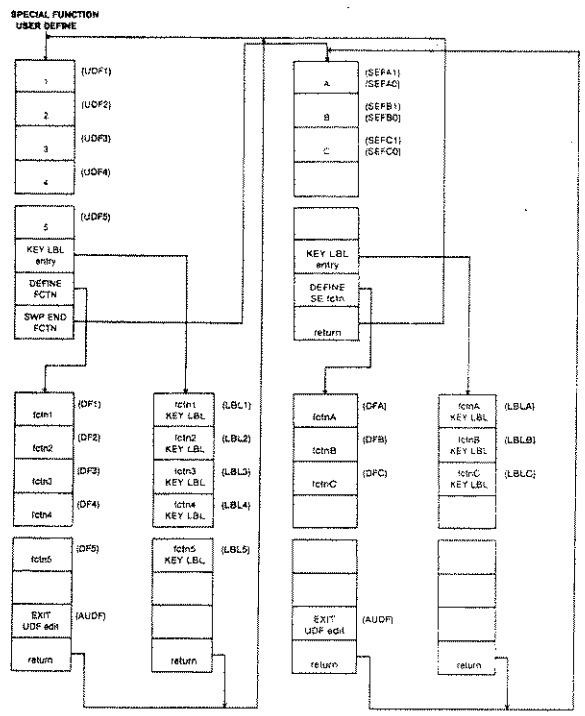

TRACE SCALE REF
[UDF Editor]
[SEF Editor]
[ASP Editor]
rectan X-A&B
rectan A-B
TABLE
SMITH
POLAR
[X-A&B] [A-B for A]
[X-A&B] [A-B for B]
A AUTO SCALE
A REF LEVEL
A /DIV
A BOTTOM
MKR → REF
A SCALE lin log
SCALE forAorB
B AUTO SCALE
B REF LEVEL
B /DIV
B BOTTOM
MKR → REF
B SCALE lin log
SCALE forAorB
[SMITH]
AUTO SCALE
SCALE comp 2.0
SCALE normal
SCALE exp 0.2
SCALE exp 0.1
[POLAR]
AUTO SCALE
REF LEVEL
/DIV
BOTTOM
MKR → REF
SCALE lin log
SCALE forAorB

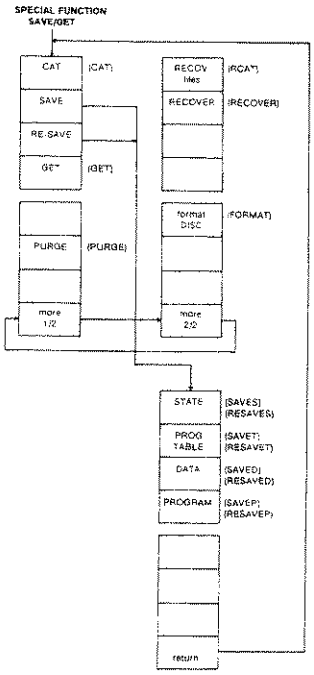

TRACE VIEW
VIEW C on off
VIEW D on off
A,B→C,D
STORE A,B→C,D
STORAGE on off

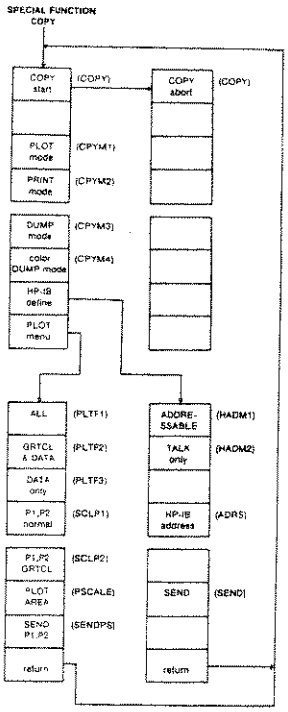

SWEEP MENU
TYPE lin log
DIRECTN up down
RESOLUTN menu
PRMTR menu
PROGRAM sweep
PARTIAL sweep
TRIGGER menu
CONT mode
SINGLE mode
MANUAL mode
TRG MODE int ext
PT MEAS TRIG
return
PART SWP on off
STORE SWP RNG
active σMKR*MKR
PROG SWP on off
PROG TBL set up
TABLE No
SWP select
X REG dump
SORTING
TABLE ALL CLR
set end
FREQ
DC BIAS (V)
OSC LVL (V)
OSC LVL (dBm)
OSC LVL (dBuV)
SPOT FREQ
No. of POINTS
STEP SIZE
SWEEP TIME
XREG DMP to TBL

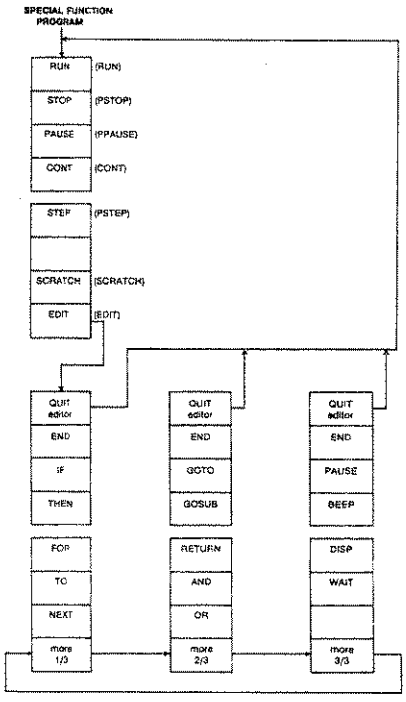

MARKER/LINE CURSOR MKR→
[UDF Editor] [SEF Editor] [ASP Editor]
σ MKR menu
σ*MKR menu
LCURS menu
σ-LCURS menu
[σ MKR]
[σ* MKRS]
[LCURS]
[σ-LCURS]
MKR→ MAX
MKR→ MIN
MKR→ REF
MKR→ CENTER
MKR→ START
MKR→ STOP
MKR→ STARY
MKR5→ SPAN
NEXT PEAK
MKR forAforB
more 1/2
more 2/2
more 1/3
LCURS→ MAX
LCURS→ MIN
LCURS→ AVRG
σ VALUE
WIDTH on off
LCURS POSITION
LCURS forAforB
Δ mode on off
active σMKR*MKR
Δ VALUE entry
σ REF read
active σMKR/LCRS
MKR/LCRS forAforB
MARKER/LINE CURSOR MODE
σ MKR
σA* MKRS
LINE CURSOR
σMKR & LCURS
off

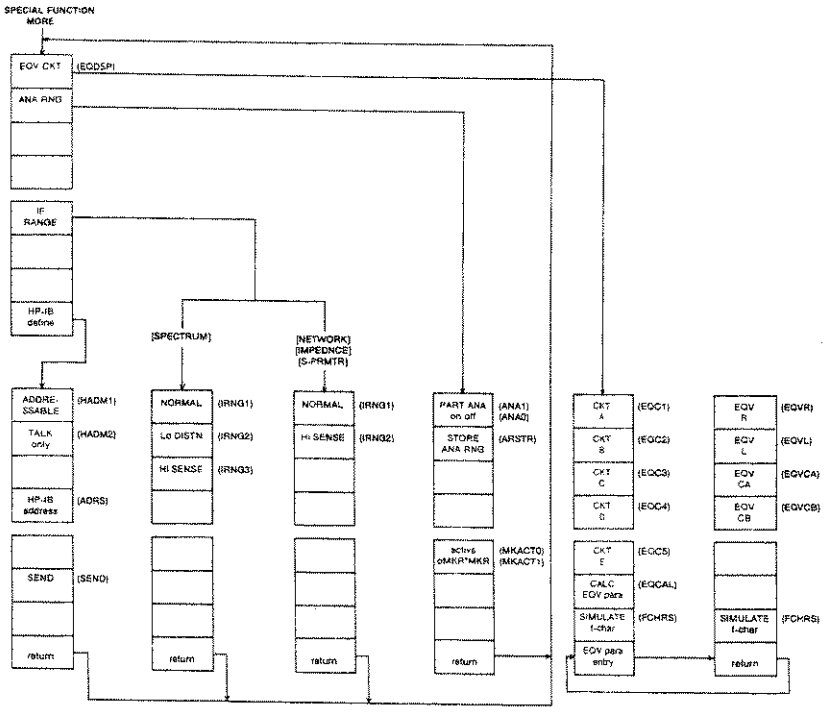

SPECIAL FUNCTION MATH OPERATOR
+
-
*
/
(
)
^
MATH function
SIN( )
COS( )
TAN( )
ATAN( )
PI
PHS UNIT deg rad
more 1/4
LOG( )
LN( )
EXP( )
SQR( )
ABS( )
DIF( )
**
more 2/4
MAX(,)
MIN(,)
complex < , >
LMX( )
LMN( )
more 3/4
BIN( )
binary AND
binary OR
binary NOT
INPUT
OUTPUT
more 4/4


SPECIAL FUNCTION
USER DEFINE
1
2
3
4
5
KEY LBL entry
DEFINE FCTN
SWP END FCTN
(UDF1)
(UDF2)
(UDF3)
(UDF4)
(UDF5)
fctn1
fctn2
fctn3
fctn4
fctn5
EXIT UDF edit
return
(DF1)
(DF2)
(DF3)
(DF4)
(DF5)
(AUDF)
fctn1 KEY LBL
fctn2 KEY LBL
fctn3 KEY LBL
fctn4 KEY LBL
fctn5 KEY LBL
(LBL1)
(LBL2)
(LBL3)
(LBL4)
(LBL5)
A
B
C
KEY LBL entry
DEFINE SE fctn
return
(SEFA1) (SEFA0)
(SEFB1) (SEFB0)
(SEFC1) (SEFC0)
fctnA
fctnB
fctnC
EXIT UDF edit
return
(DFA)
(DFB)
(DFC)
(AUDF)
fctnA KEY LBL
fctnB KEY LBL
fctnC KEY LBL
return
(LBLA)
(LBLB)
(LBLC)


SPECIAL FUNCTION
SAVE/GET
CAT
SAVE
RE-SAVE
GET
PURGE
more 1/2
(CAT)
(GET)
(PURGE)
RECOV files
RECOVER
format DISC
more 2/2
(RCAT)
(RECOVER)
(FORMAT)
STATE
PROG TABLE
DATA
PROGRAM
return
(SAVES) (RESAVES)
(SAVET) (RESAVET)
(SAVED) (RESAVED)
(SAVEP) (RESAVEP)


SPECIAL FUNCTION
COPY
COPY start
PLOT mode
PRINT mode
DUMP mode
color DUMP mode
HP-IB define
PLOT menu
COPY abort
(COPY)
(CPYM1)
(CPYM2)
(CPYM3)
(CPYM4)
ALL
GRTCL & DATA
DATA only
P1,P2 normal
P1,P2 GRTCL
PLOT AREA
SEND P1,P2
return
(PLTF1)
(PLTF2)
(PLTF3)
(SCLP1)
(SCLP2)
(PSCALE)
(SENDPS)
ADDRESSABLE
TALK only
HP-IB address
SEND
return
(HADM1)
(HADM2)
(ADRS)
(SEND)


SPECIAL FUNCTION
PROGRAM
RUN
STOP
PAUSE
CONT
STEP
SCRATCH
EDIT
QUIT editor
END
IF
THEN
FOR
TO
NEXT
more 1/3
GOTO
GOSUB
RETURN
AND
OR
more 2/3
PAUSE
BEEP
DISP
WAIT
more 3/3
(RUN)
(PSTOP)
(PPAUSE)
(CONT)
(PSTEP)
(SCRATCH)
(EDIT)


SPECIAL FUNCTION
MORE
EQV CKT
ANA RNG
IF RANGE
HP-IB define
ADDRESSABLE
TALK only
HP-IB address
SEND
return
(EQDSPI)
(HADM1)
(HADM2)
(ADRS)
(SEND)
[SPECTRUM]
[NETWORK] [IMPEDNCE] [S-PRMTR]
NORMAL
LO DISTN
HI SENSE
(IRNG1)
(IRNG2)
(IRNG3)
PART ANA on off
STORE ANA RNG
active MKR*MKR
(ANA1) (ANA2)
(ARSTR)
(MKACT0) (MKACT1)
CKT A
CKT B
CKT C
CKT D
CKT E
CALC EQV para
SIMULATE f-char
EQV para entry
(EQC1)
(EQC2)
(EQC3)
(EQC4)
(EQC5)
(EQCAL)
(FCHRS)
EQV R
EQV L
EQV CA
EQV CB
SIMULATE f-char
(EQVR)
(EQVL)
(EQVCA)
(EQVCB)
(FCHRS)

APPENDIX F

INTERNAL REGISTER/COMMAND LISTING

The following are frequently-used registers and commands. This listing does **not** cover all registers and commands used in the HP 4195A. Refer to APPENDIX E for complete listing of softkey-related registers and commands.

ARREY REGISTERS

A	Measurement data register displayed on the CRT as a bright yellow trace.
B	Measurement data register displayed on the CRT as a bright cyan trace.
C	Superimpose data register. Displayed when View C is set to ON.
D	Superimpose data register. Displayed when View D is set to ON.
E ~ J, RA ~ RF	General purpose registers.
MA	Measurement data registers for the User Math Function.
MB	Measurement data registers for the User Math Function.
X	Contains the sweep point data.

SINGLE REGISTERS

ATR1	Contains R1 attenuator value.
ATR2	Contains R2 attenuator value.
ATT1	Contains T1 attenuator value.
ATT2	Contains T2 attenuator value.
BTM	Contains the bottom of the display scale.
CENTER	Contains CENTER value.
DFREQ	Contains APERTURE value.
DIV	Contains scale division value.
DLCURS	Contains the difference value between MKRA and LCURS. Refer to page A-3.
DMKR	Contains the difference value between MKR and SMKR. Refer to page A-3.
DMKRA	Contains the difference value between MKRA and SMKRA. Refer to page A-3.
DMKRB	Contains the defference value between MKRB and SMKRB.
LCURS	Contains the LINE CURSOR position (height) value. Refer to page A-3.
LCURSL	Contains the value of left most intersect point. Refer to page A-3.
LCURSR	Contains the value of right most intersect point. Refer to page A-3.
MANUAL	Contains manual sweep point value.
MKR	Contains the value of o MARKER position in horizontal axis. Refer to page A-3.
MKRA	Contains data A value specified with the o MARKER. Refer to page A-3.
MKRB	Contains data B value specified with the o MARKER.
NOP	Contains number of sweep points.
PI	Contains value of 3.14159265359.
QV	Contains Q value.
R0 (~ R99)	General purpose single registers.
RBW	Contains RBW value.
REF	Contains the top of the display scale.
SMKR	Contains the value of * MARKER position in vertical axis. Refer to page A-3.
SMKRA	Contains data B value specified with the * MARKER. Refer to page A-3.
SMKRB	Contains data B value specified with the * MARKER.
SPAN	Contains SPAN value.
START	Contains START value.
STOP	Contains STOP value.
WID	Contains width value (=LCURSR-LCURSL). Refer to page A-3.
Z	Contains numeric value resultant from front-panel mathematical operation.

COMMANDS

ANA1/ANA0	Partial Analysis ON/OFF.
ARSTR	Store Partial Analysis range.
AUTO	Autoscale to the active scale.
CMT	Comment.
COPY	Starts or aborts hardcopy operation.
CORR1/CORR0	Correction ON/OFF.
DELT1/DELT0	Delta(Δ) mode ON/OFF.
DF1 (~ DF5)	Defines User Defined Function #1 (~ #5).
DFA (~ DFC)	Defines the Sweep End Function #A (~ #C).
DISP	Displays a character string, R0 ~ R99 register data or both.
DMA (DMB)	Defines User Math A (or B) equation.
DPA1/DPA0	Trace A ON/OFF.
DPB1/DPB0	Trace B ON/OFF.
DSP1 (~ DSP5)	Selects the rectan X-A&B (or other) display format.
FNC1	Selects the Network configuration.
FNC2	Selects the Spectrum configuration.
FNC3	Selects the Impedance configuration.
FNC4 ~ FNC7	Selects the S-Parameter configuration.
GPP1 (~ GPP4)	Selects T/R-θ (or other) format.
HADM1/HADM2	HP-IB Addressable/Talk-only.
IMP1 (~ IMP12)	Selects the |Z|-θ (or other) format.
LBL1 (~ LBL5)	Defines the User Defined Function #1 (~ #5) softkey label.
LBLA (~ LBLC)	Defines the Sweep End Function #A (~ #C) softkey label.
LMN	Moves the markers to the local-minimum points.
LMX	Moves the markers to the local-maximum points.
MCF0	Turns MARKER function off.
MCF1	Selects the o MARKER mode.
MCF2	Selects the o and * MARKERS mode.
MCF3	Selects the LINE CURSOR mode.
MCF4	Selects the o-LCURS mode.
MKACT0	Selects the active marker to * MARKER.
MKACT1	Selects the active marker to o MARKER.
MKACT2	Selects the LCURS to active.
MKCR1	Selects the MARKER or LCURS reading object to data A (for A).
MKCR2	Selects the MARKER or LCURS reading object to data B (for B).
MKCTR	MKR → CENTER
MKEXP	MKRS → SPAN
MKMN	MKR → MIN
MKMX	MKR → MAX
MKREF	MKR → REF
MKSP	MKR → STOP
MKST	MKR → START
MTHA1/MTHA0	Math A ON/OFF.
MTHB1/MTHB0	Math B ON/OFF.
NXTPK	MEXT PEAK.
PORT1 (~ PORT5)	Selects input port.
PRMA (PRMB)	Enters the User Math A (or B) label.
RST	PRESET.
QVAL	Calculates Q value at the LINE CURSOR.
REV?	Displays the firmware revision code.
SAP1 (~ SAP6)	Selects dBm (or other) format.
SCL1	Selects the active scale change data to data A (SCALE for A).
SCL2	Selects the active scale change data to data B (SCALE for B).
SCT1 (SCT2)	Selects the linear (or log) scale display.
SEFA1/SEFA0	Sweep End Function #A ON/OFF.
SEFB1/SEFB0	Sweep End Function #B ON/OFF.
SEFC1/SEFC0	Sweep End Function #C ON/OFF.
SPC1/SPC0	View C ON/OFF.
SPCHG	A,B ↔ C,D
SPD1/SPD0	View D ON/OFF.
SPI1 (~ SPI4)	Selects RL-θ (or other) format.
SPSTR	STORE A,B → C,D.
SRSTR	Store Partial Sweep range.
SWM1	CONT sweep mode.
SWM2	SINGLE sweep mode.
SWM3	MANUAL sweep mode.
SWP1 (~ SWP5)	Selects Frequency (or other) sweep.
SWR1/SWR0	Partial Sweep ON/OFF.
SWT1 (SWT2)	Selects linear (or log) sweep.
SWTRG	Sweep Trigger (=TRIG/RST).
TRIGM1 (TRIGM2)	Trigger mode int (ext).
TRIG	Triggers when trigger mode is set to ext.
UNITA (UNITB)	Enters User Math A (or B) unit label.
WIDTH1/WIDTH0	WIDTH ON/OFF.
VFTR1/VFTR0	Video Filter ON/OFF.

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