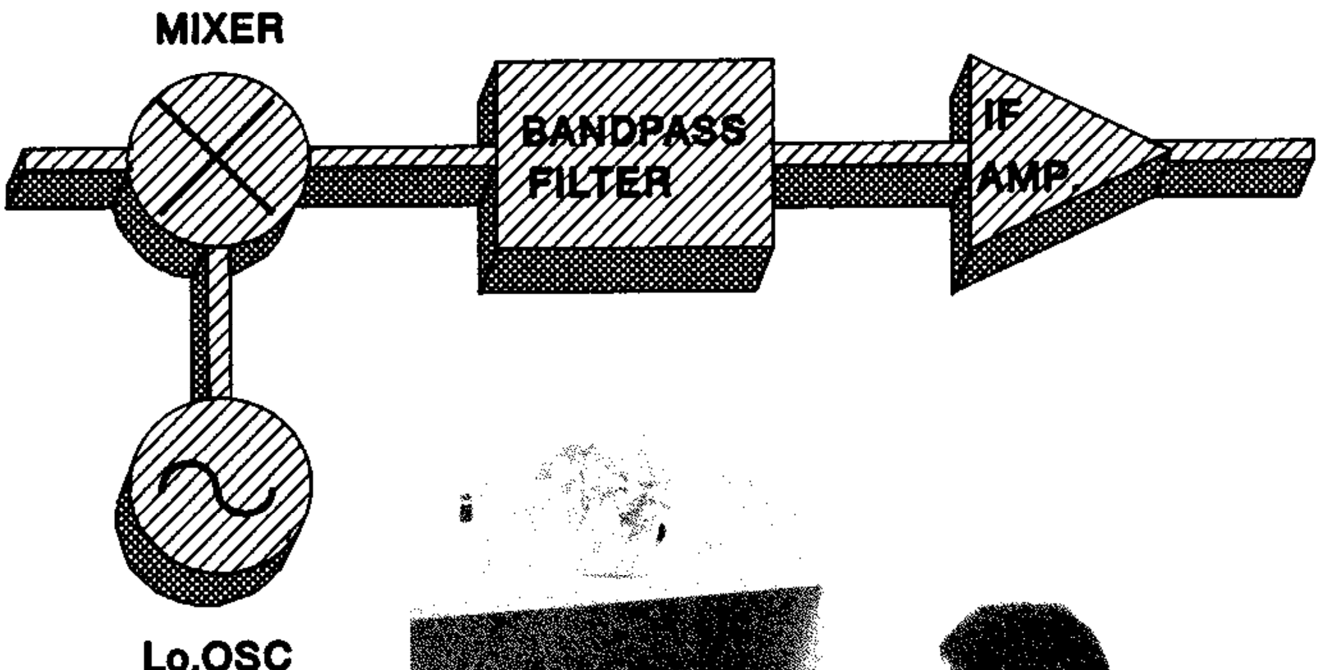
NETWORK, SPECTRUM, AND

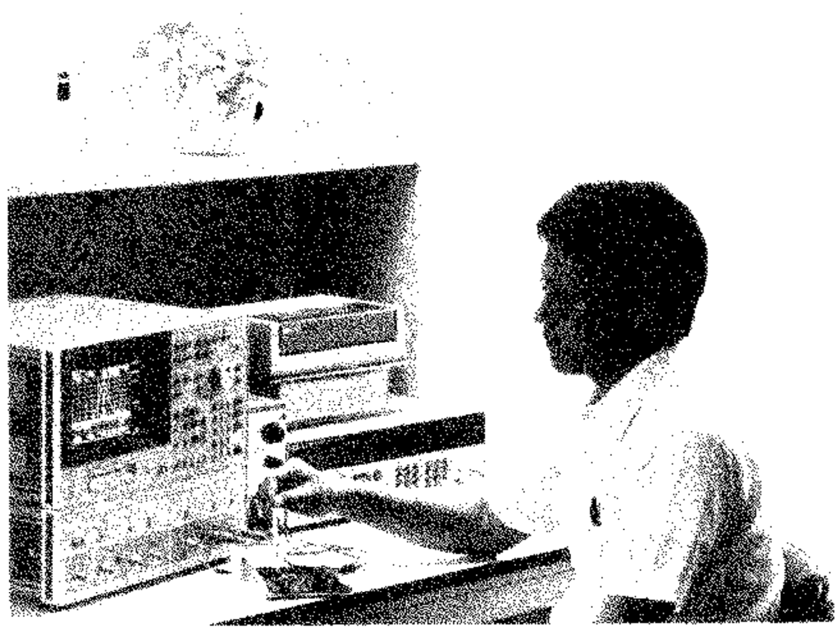
IMPEDANCE EVALUATION

OF

IF CIRCUITS

HP 4195A NETWORK/SPECTRUM ANALYZER





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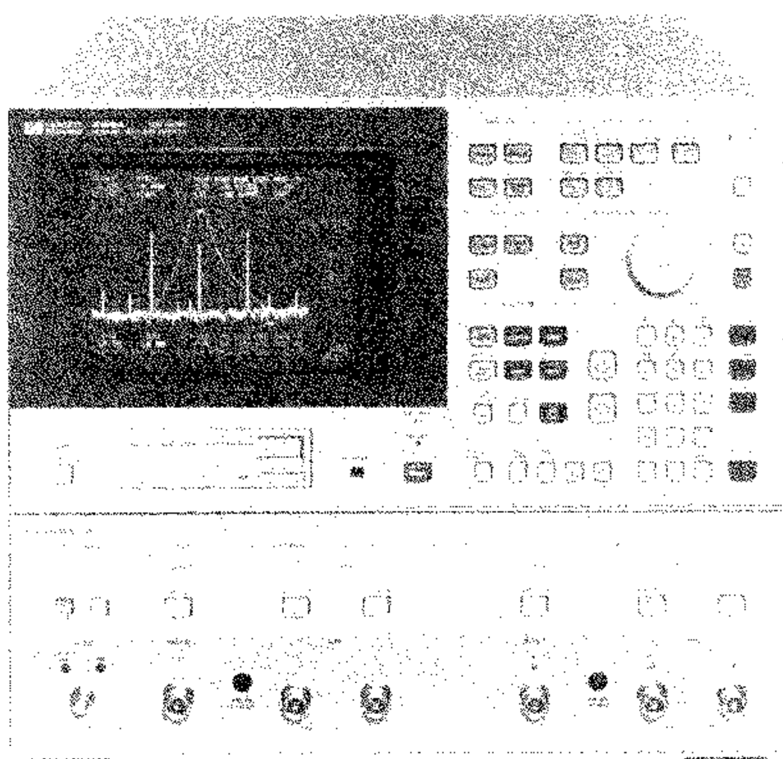


HP 4195A NETWORK/SPECTRUM ANALYZER

1. The HP 4195A's Role in Circuit Design and Evaluation

As shown in the flow chart in Figure 1, the development procedure involves designing the overall architecture, evaluating parts, building prototypes, checking circuit operation, and production. It is essential when checking circuit operation to measure the following parameters: harmonics and noise, transfer characteristics (gain and phase), and reflection characteristics (line input and output impedance). In addition, it is also essential to measure the characteristics of the circuit components, such as operational amplifiers, filters, resonators, delay lines and other devices. You can use the HP 4195A's network, spectrum, and impedance measurement and analysis functions to design and fully evaluate circuits. The analyzer's multiple measurement capability will increase design efficiency and reduce the cost of circuit design.

2. The HP 4195A's Features and Benefits

Linear and Non-Linear Analysis Performed with a Single Instrument

The HP 4195A can analyze linear and non-linear characteristics important in designing circuits. The analyzer can measure harmonic and inter modulation distortion, important measurements for developing mobile transmitters, ISDN, high-definition TV and other communication media. The HP 4195A can also measure phase and group-delay of filters and amplifiers, significant measurements for providing higher quality data transmission. Finally, its frequency range is 10 Hz to 500 MHz, making it useful for the audio and video base band, plus the IF, HF and VHF bands.

High Accuracy and Resolution Network Analysis

The HP 4195A can perform amplitude ratio and phase measurements with an accuracy of ±0.05 dB / ±0.3° and resolution of 0.001 dB / 0.01°. Small changes in amplitude and phase values of components can be detected with the HP 4195A.

Multiple Terminals

The HP 4195A has two channels, each with one output and two input ports. S-Parameter measurements are performed using two transmission/reflection test sets. Switching from forward to reverse S-Parameters is accomplished by simple softkey operations, eliminating the need to change the connection direction of the device under test. The four inputs can be used to perform spectrum measurements. This allows you to connect the inputs to four different points in a circuit and make spectrum measurements, you save time by not having to probe one point after another.

SoftKeys and User Functions

The HP 4195A's softkeys make it a versatile, yet compact analyzer that is easy to operate and understand. Based on the design concept, "to make an analyzer that more closely reflects user needs", the HP 4195A is equipped with three user functions: User program, user defined and user math functions. These functions greatly increase the measuring efficiency since they allow Carrier Noise (CN) and Total Harmonic Distortion (THD) measurements, and automatic evaluation of filters and amplifiers, without using an external controller.

3.5 inch Flexible Disc and Direct Copy Function

Measurement data, instrument settings, including calibration data and user programs, can be independently stored using the HP 4194A's built-in micro floppy disc drive, this is convenient when several engineers share an HP 4195A. Measurement data or analysis results can be output directly to an external plotter or printer via HP-IB to further facilitate the storage and comparison of data.

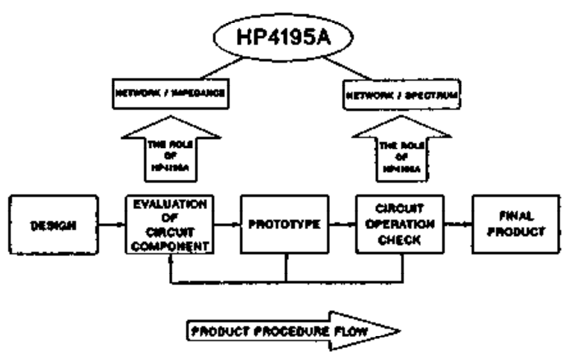


Figure 1. Product Procedure and the Role of the HP 4195A

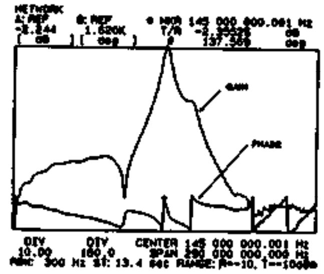
3. Using the HP 4195A for IF Circuit Design

The following paragraphs give a detailed example of using the HP 4195A to evaluate IF circuits (which are indispensable in analog transmission and video circuits).

3-1. IF Circuit Measurement Parameters

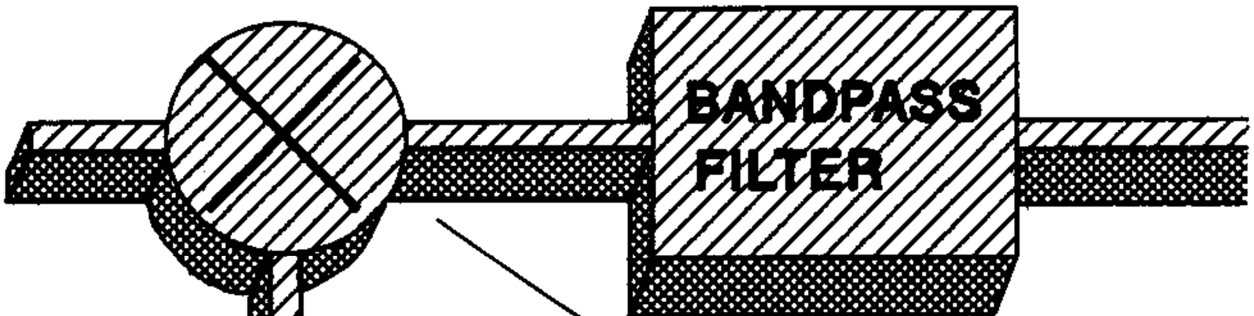
The following describes the results of evaluating components in an IF circuit and the analysis of signals at different points in an IF circuit.

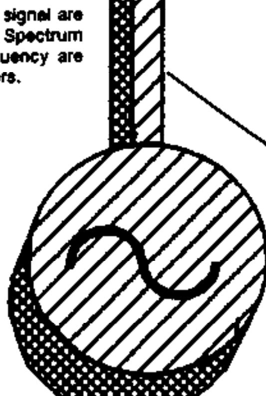
NETWORK MEASUREMENT



Band-pass Filter Transmission Characteristics

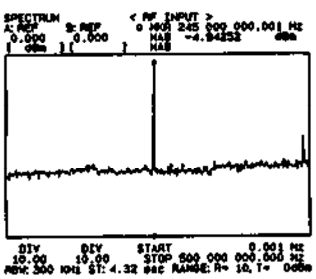
Network analysis displays the gain and phase frequency characteristics of a filter. Using the marker function, insertion loss, rejection ratio, 3 dB bandwidth, and other parameters are easily determined. Phase characteristics are easily measured also.





Input Signal

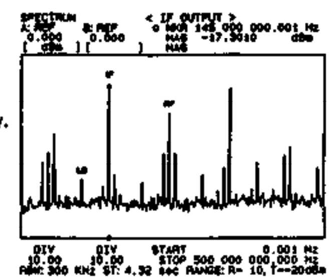
The frequency components of the input signal are easily measured using the HP 4195A's Spectrum Analysis function. Signal level and frequency are read directly by using the 4195A's markers.



SPECTRUM MEASUREMENT

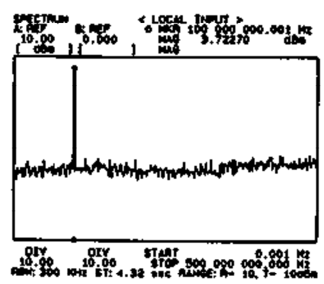
Mixer IF Output

The signal output from the mixer contains the desired IF signal as well as unnecessary spurious components.



Local Oscillator Signal

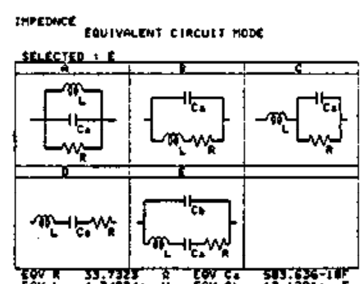
The local oscillator frequency can be read directly.

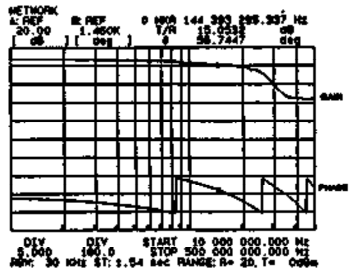


IMPEDANCE MEASUREMENT

Crystal Oscillator Equivalent Circuit Analysis

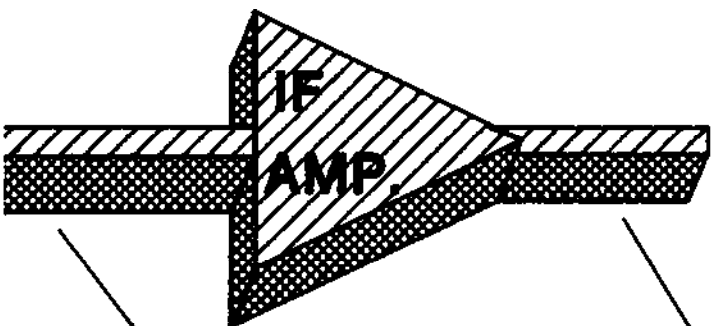
Equivalent circuit analysis of a crystal oscillator can be performed quickly and easily. The equivalent circuit and the circuit constants are displayed on the screen, and the equivalent circuit constants can be used to simulate the frequency characteristics of a crystal oscillator. Oscillator circuits can be designed quickly and reliably by using equivalent circuit analysis and constants.





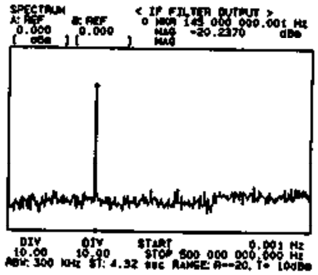
IF Amplifier Gain and Phase Characteristics

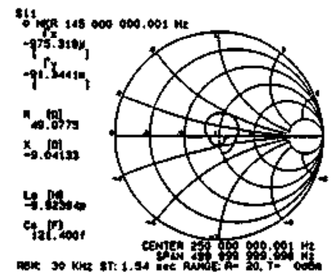
Gain and phase characteristics can be checked at a glance, so the 3 dB cutoff frequency, and gain and phase margins are measured quickly and easily.



Band-pass Filter Output

Only the IF signal should pass through the IF (band-pass) filter. This Figure shows the IF signal attenuated by about 2.9 dB relative to the mixer output (filter input). This is primarily caused by the filter's insertion loss. The lower the insertion loss, the better the filter is. Insertion loss varies with the type of filter; it is 2-3 dB for LC and Crystal filters and 20 dB for SAW filters.



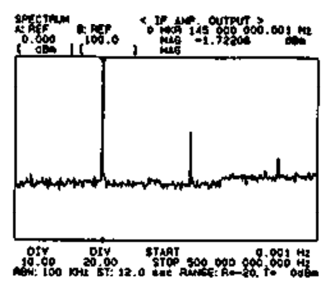


IF Amplifier Output

The IF signal is shown amplified by about 18.5 dB relative to IF filter's output. In addition to the IF signals which are within the band-pass of the IF filter, the IF amplifier's output also contains second and third-order harmonics not present at the amplifier's input.

IF Amplifier S-Parameters

Using S-Parameter measurements, the transmission and reflection characteristics can be obtained. This Figure shows S_{22} plotted on a Smith chart, (Smith chart indicates the reflection characteristics of the output).



3-2. IF Mixer Measurements

3-2-1. IF Mixer Input and Output

The **RF** and **LO** signals are input to the mixer, which outputs the sum and difference (in addition to a number of other highly undesirable characters such as **RF** and **LO** feedthrough, images, spurs, noise, ...) of these input frequencies as the **IF** signal. These signals are easily measured using the HP 4195A's Spectrum Analysis function. Figure 2 shows an example of a spectrum measurement of mixer's input and output signals.

In this example, the Superimpose function **(▸ 1)** of the HP 4195A is used to display 2 signals simultaneously. The **RF** input signal (**A**) shows the spectrum of carrier. The carrier frequency in (**A**) is read out using the marker function as 245 MHz. In the spectrum display of the **IF** output signal (**B**), mixing components of the **LO** input signal and the RF input signal can be observed and measured. Since the **RF** input and the **IF** output signal are displayed simultaneously, the conversion loss of the mixer is easily established. The conversion loss is determined using the following formula.

$$\text{Loss} = P_{RF} - P_{IF}$$

The conversion loss for the example shown in Figure 2 is determined by measuring the input and output signal spectrum (the conversion loss is approximately 12.4 dB).

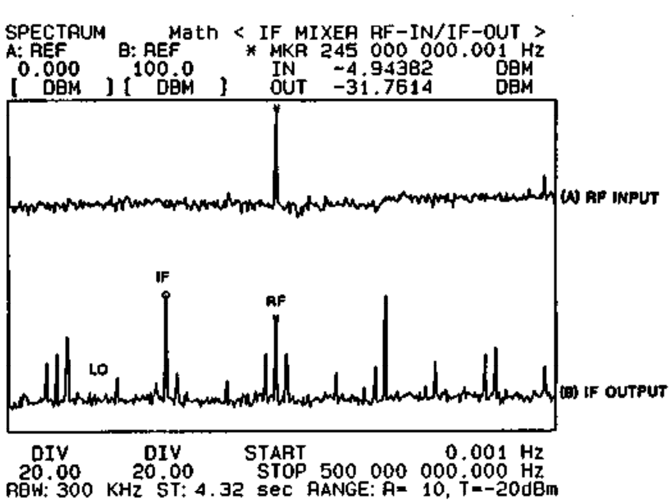


Figure 2. Mixer Input and Output Spectrum Measurement Example

3-2-2. Third Order Intermodulation Distortion

The HP 4195A can measure intermodulation distortion by using the setup shown in Figure 3. Normally, the intermodulation distortion is proportional to the input signal level. In this example, both the mixer input level and the intermodulation distortion are measured. The **RF** input consists of two signals, 244.5 MHz and 245.5 MHz, the frequency of the local signal is 100 MHz and the level is 3 dBm. The **RF** input signal of 245 MHz ±500 kHz and the 100 MHz **LO** input signal produce 145 MHz ±500 kHz and 345 MHz ±500 kHz **IF** output signals.

Figure 4 shows an intermodulation distortion in the mixer output. The intermodulation distortion value is easily obtained with the marker function. The intermodulation distortion obtained in the Δ mode **(▸ 2)** is displayed at the position of the marker in Figure 4. As shown in Figure 4, the intermodulation distortion is -57 dB at an input level of -20 dBm (**A**) and -44 dB at an input level of -15 dBm (**B**).

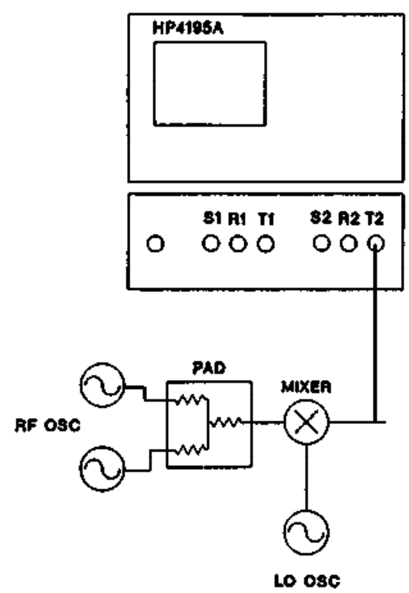
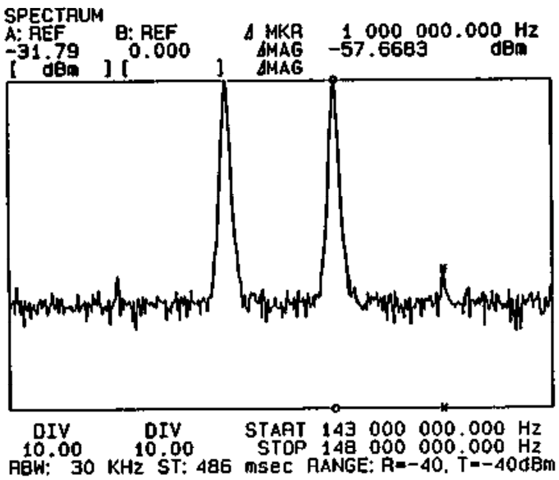
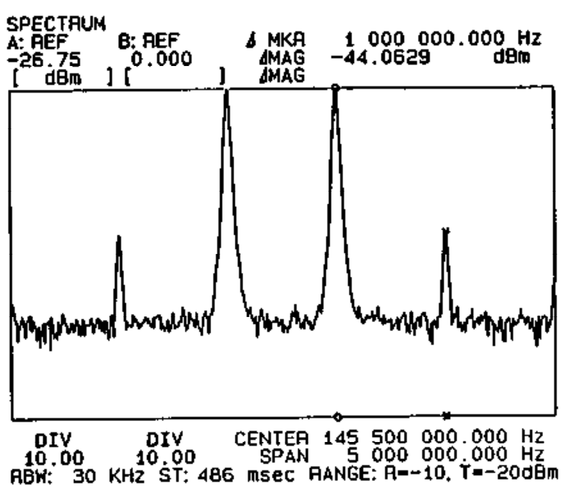


Figure 3. Measurement Circuit Configuration for Intermodulation Distortion.



(A) Input level -20 dBm



(B) Input level -15 dBm

Figure 4. Measurement Example of Intermodulation Distortion

3-2-3. Measuring Reflection Characteristics

Measurements of reflection characteristics are performed with the HP 4195A's Network Analysis function (► 3). Reflection coefficient, return source, **SWR** and other reflection characteristic parameters can be selected by simply pressing a softkey. Figure 5 indicates the setup of the measurement circuit. A transmission/reflection test set is used with the HP 4195A to make Network measurements. Figure 6 shows an example of an **SWR** measurement. The superimpose function of the HP 4195A allows simultaneous display of the **SWR** of each **RF**, **LO**, and **IF** terminal.

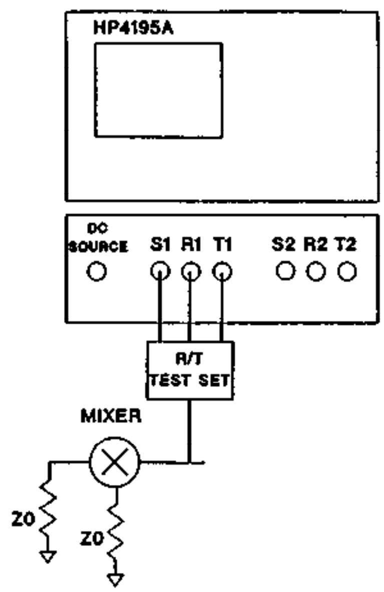


Figure 5. Reflection Characteristics Measurement Setup.

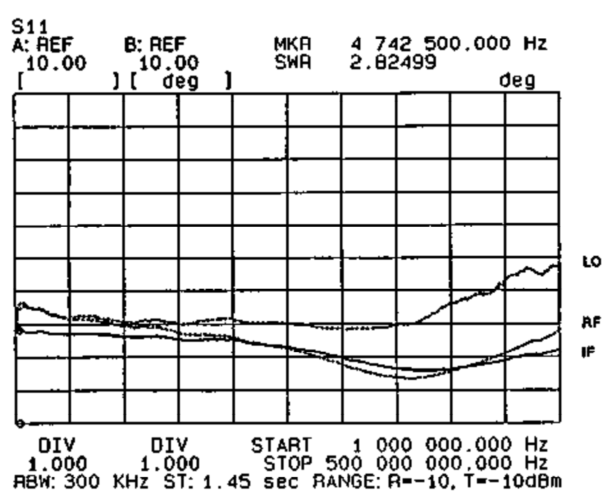


Figure 6. **SWR** Measurement

3-3. IF Filter Measurements

3-3-1. The Role of the IF Filter

IF filters are used to selectively pass a band of frequencies and attenuate all frequency components outside of the IF frequency band (bandpass filter). When an RF input signal is mixed with the LO output signal to produce the IF signal, the output of the IF filter is not a nice clean signal because the IF filter's center frequency drifts or there is insufficient attenuation of out of band frequencies. For such problems Figure 7 shows a circuit configuration for using the HP 4195A to measure the spectrum of the input and output signals of an IF filter to determine its transmission and attenuation characteristics.

3-3-2. IF Filter Input and Output Signals

The input and output spectrum of an IF filter are shown in Figure 8. Signal **A** is the input and the signal **B** is the output. The IF filter input signal contains many signal components as a result of mixing the RF and LO signals. The difference in the IF filter's input and output levels is caused by the insertion loss of the filter. In this case, the difference is 2 dB. Figure 8 shows how the IF filter attenuates the harmonics. However, the signal in the 400 MHz region is not sufficiently attenuated and so the transmission characteristics of the IF filter need to be checked.

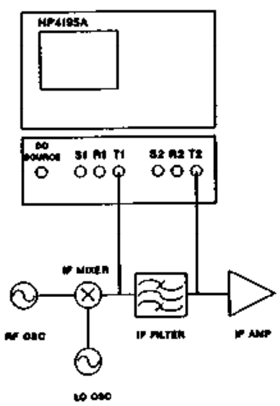


Figure 7. IF Filter Spectrum Analysis Circuit Setup

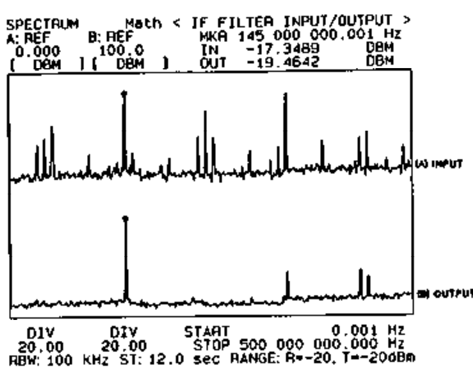


Figure 8. IF Filter Input and Output Spectrum

3-3-3. Measuring Transmission Characteristics

Improving Filter Characteristics

IF filter characteristics are measured with the HP 4195A's network function. First, the result of the filter's output signal spectrum measurement is stored using the superimpose function. Then the transmission characteristics of the IF filter are measured with the network function. Figure 9 shows the components of the measurment circuit, and Figure 10 shows the transmission characteristic measurement of the filter. Since the superimpose function was used to store the spectrum measurement result on the display, the transmission characteristics and the spectrum of the output signal can be viewed simultaneously.

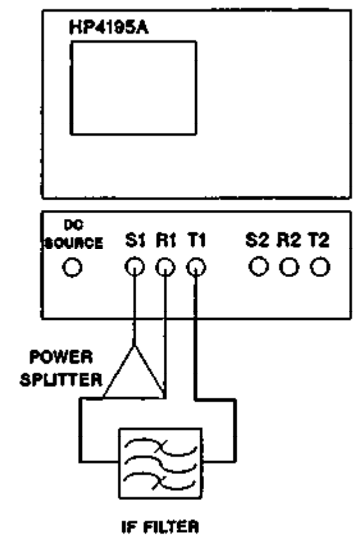


Figure 9. IF Filter Transmission Characteristics Measurement Circuit

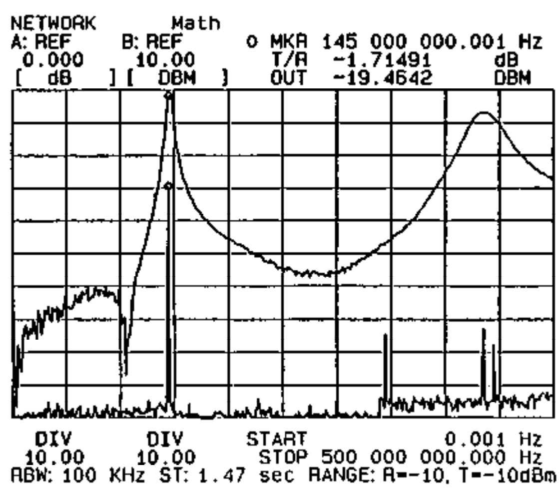


Figure 10. IF Filter Transmission Characteristics and Output Spectrum

The transmission characteristics of this IF filter is not sufficient in the 430 MHz region. The component in the 400 MHz region is caused by the transmission characteristics of the filter. To compensate for this, the transmission characteristics of the IF filter were modified by adding a low pass filter with the characteristics shown in Figure 11.

The transmission characteristics and output signal of the modified IF filter is shown in Figure 12. The attenuation in the 400 MHz region is now sufficient, as shown in the Figure 12. The result of output signal spectrum measurements indicate that the IF filter only generates the IF signal components. Thus the HP 4195A can perform both spectrum and network measurements, and also display several measurement results at the same time. This greatly simplified the comparison and analysis of measurement results for design, temperature and adjustment changes.

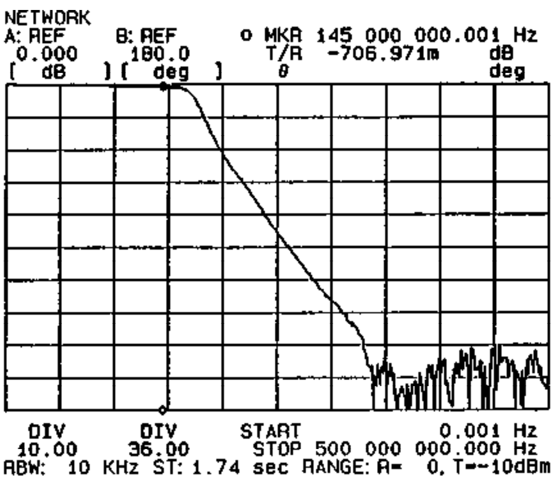


Figure 11. Lowpass Filter Transmission Characteristics

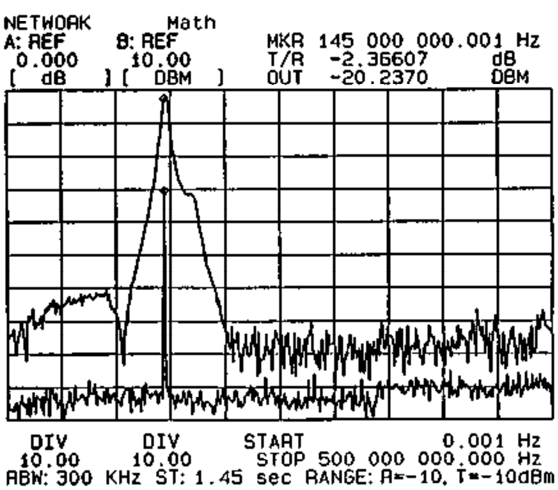


Figure 12. Modified IF Filter Transmission Characteristics and Output Spectrum

The Significance of Group Delay Characteristics

The increasing sophistication and complexity of signals handled by instruments with IF circuits raises the importance of phase characteristics, and makes the problem of phase distortion more acute. Normally, group delay characteristics are used to indicate linearity of phase distortion. Group delay is calculated as shown below.

$$GD = - \frac{\Delta\phi}{360^\circ \Delta f}$$

where Δ f is aperture frequency and $\Delta\phi$ is the phase difference.

The formula clearly indicates that highly accurate phase measurements and frequency stability are required to accurately derive a group delay value. The HP 4195A can measure phase to ±0.3° accuracy and ±0.01° resolution. The analyzer's synthesized signal source allows speedy and stable group delay measurements, which has greatly increased the reliability of phase distortion evaluation of transmission circuits.

Figure 13 shows an example of measuring the group delay characteristics of an IF filter. Here group delay ripple is derived to show how the phase value changes linearly (i.e. how flat the group delay value is) in relation to frequency.

The group delay ripple value in Figure 13 is obtained with the Δ mode of the o and * marker.

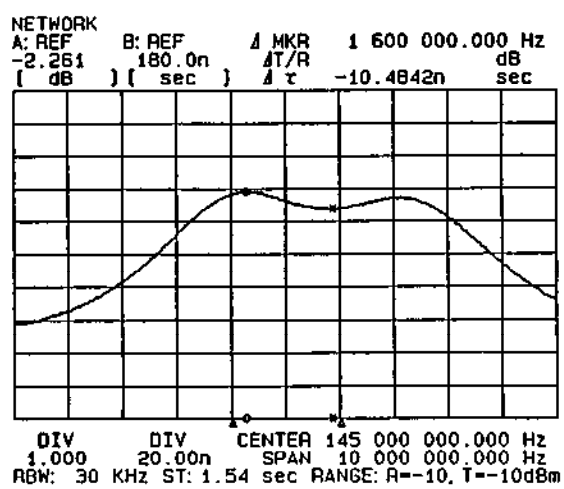


Figure 13. Measurement of Group Delay Characteristics of an IF Filter

3-4. IF Amplifier Measurements

3-4-1. IF Amplifier Input and Output Signals

After the IF filter removes the unwanted components, the signal now contains only frequency components that are within the IF band pass. The IF filter's output is feed into the IF amplifier. Although the output of the IF amplifier consists of amplified IF components, there are also harmonics of the IF signal due to the nonlinear nature of the IF amplifier. Figure 14 shows an example of an IF amplifier's input and output signal spectrum measurement. Input signal **A** consist of a 145 MHz IF signal only, whereas output signal **B** displays the fundamental of 145 MHz, a second harmonic of 290 MHz, and a third harmonic of 435 MHz. Since the level of the 145 MHz fundamental harmonic is -20 dBm at the input and -1.7 dBm at the output, the gain is approximately 18 dB.

3-4-2. Harmonic Distortion

Harmonic distortion is caused by the nonlinear characteristics of an amplifier. Parameters measured as harmonic distortion include second harmonic, third harmonic, and total harmonic distortion (**THD**). Harmonics can be measured using the HP 4195A's marker function, and **THD** can be measured using the user-defined program function (► 4). Figure 15 shows an example of measuring harmonic distortion at an amplifiers output. The third harmonic, measured using the marker function, is about 55.1 dB relative to the fundamental. Figure 16 shows the list of the user program employed in determining **THD**. As shown in Figure 17 the **THD** value derived with this program is displayed at the bottom of the screen of the HP 4195A. The **THD** value here is 1.24 %.

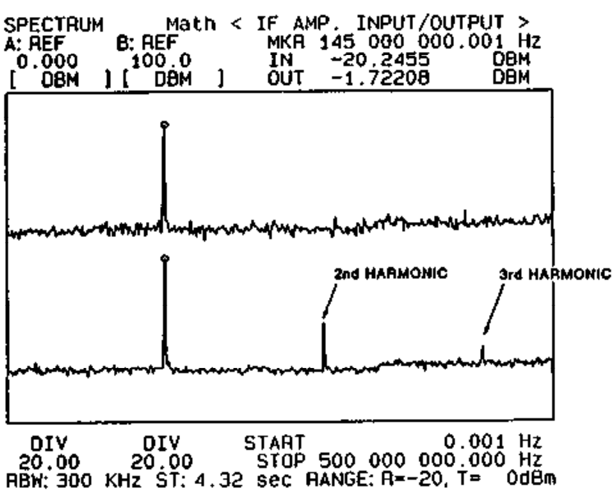


Figure 14. IF Amplifier Input and Output Spectrum Measurement

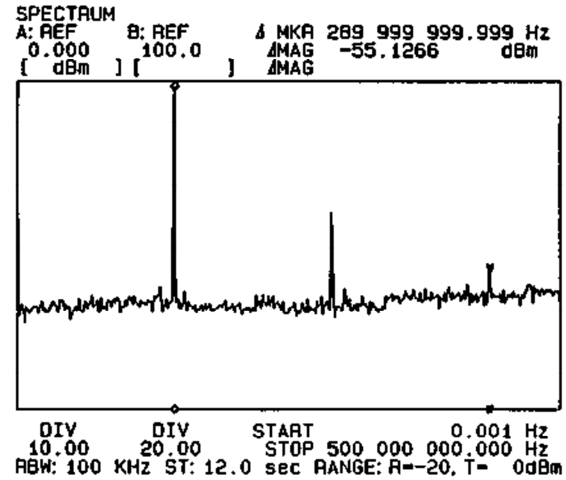


Figure 15. Output Harmonic Distortion Measurement

```
SPECTRUM
                PROGRAM EDITOR
 FILE NAME: F1_16_P


    1   !  THD
   10  SWM2              !TRIG,SINGLE MODE
   20  R2=0
   30  MCF1              !0-MKR MODE
   40  MKMX              !MKR→MAX
   50  IF MKR<1  THEN  NXTPK
   60  R1=MKRA
   70  FOR R0=2 TO 3

   80  R10=MKR
   90  NXTPK             !NEXT PEAK
  100  IF MKR<R10 THEN NXTPK:GOTO 100
  110  R2=R2+10**((MKRA-R1)/10)
  120  NEXT R0
  130  R3=100*SQR(R2)
  140  DISP "THD(%)=",R3
  150  END
```

Figure 16. User-Defined Program for Deriving **THD**

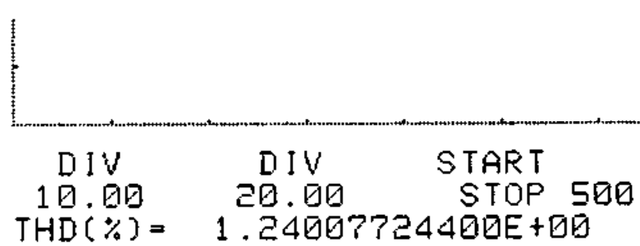


Figure 17. User-Defined Program Derived **THD** Value

3-4-3. Noise Measurements

Noise Figure (NF)

NF expresses the degree of noise generated in an amplifier. The **NF** value for an ideal amplifier, with 0 internal noise, is 1 (= 0 dB). The **NF** value for an IF amplifier is determined with the following formula.

$$NF = \frac{C_{IN} / N_{in}}{C_{OUT} / N_{OUT}} = \frac{C_{IN} / kTB}{C_{IN}G / N_{OUT}}$$

$$= \frac{N_{OUT}}{GKTB}$$

Where:

C_{IN} = input signal level
N_{IN} = input noise level
C_{OUT} = output signal level
N_{OUT} = output noise level

K = Bolzmann's constant

$= 1.381 \times 10^{-23} (J/°K)$

T = absolute temperature (°K)
B = noise bandwidth (Hz)
G = amplifier gain

The **NF** value can be displayed on the **log** scale by using the following formula.

$$NF [dB] = 10 \text{ Log } \frac{N_{OUT}}{GKTB}$$

$$= 10 \text{ Log } \frac{N_{OUT}}{B} - \text{Log}(G) - 10 \text{ Log}(KT)$$

The third item is a constant which becomes 10 log (KT) = 174 dBm if the temperature is 23°C. Thus, only the first item (i.e. noise level) and the second item (an amplifier's gain) have to be measured. The formula for determining **NF** can be expressed as follows.

$$NF [dB] = N [dBm] - G [dB] + 174 [dBm]$$

(at 23°C)

N and **G** are the noise level and amplifier gain as measured by the HP 4195A. Since the HP 4195A measures noise directly, the resolution bandwidth or **log** amplifier calculation of conventional spectrum analyzers are not required (▸ 5). Proceed according to the following sequence to measure **NF** with the HP 4195A.

1. Use the Network function to measure amplifier gain.
2. Terminate the input terminal of amplifier with the correct characteristic impedance for the amplifier.
3. Select the Spectrum function and set INPUT ATT. = 0 dB.
4. Measure the noise level.
5. Calculate **NF** using the preceding given formula.

Figure 18 shows a **NF** measurement. The HP 4195A has a powerful arithmetic function (▸ 6) and programming function, so the **NF** value can quickly and easily be derived. Using the line cursor, the average **NF** value, (17.5 dB in this case,) can be displayed on the screen. Figure 19 shows a User Program list for determining **NF**.

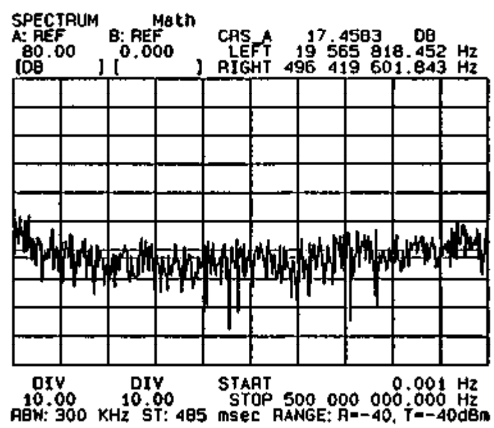


Figure 18. Measuring an IF Amplifier's **NF**

```
SPECTRUM
                 PROGRAM EDITOR
 FILE NAME: NF

   1 RST
  10 R11=10*LOG((1.381E-23*(273+23))*1000)
  20 FNC1:PORT1
  30 OSC1=-10 DBM
  35 ATR1=0:ATT1=10
  40 SWTRG
  50 C=A
  60 !
  70 FNC2:PORT2:SAP4
  90 IRNG3:ATT1=0

 110 !
 120 DMA=MA-C-R11
 130 PRMA" NF"
 140 UNITA"DB"
 150 MTHA1
 180 DFA"AUTO:MCF3:CRAV"
 190 SEFA1
 200 SWM1
 210 END
```

Figure 19. User Defined Program for Determining **NF**

3-4-4. Measuring Transmission Characteristics

Gain and Phase Characteristics

Use the Network function of the HP 4195A and the Transmission/Reflection test set to perform the measurement using set up shown in Figure 20. Figure 21 shows an example of a Gain/Phase measurement, the results of which indicate the gain of the IF amplifier is approximately 15 dB in the 145 MHz range.

Gain Compression

Knowing an amplifiers Gain Compression is necessary for determining its the dynamic range of input levels. The input signal has to be swept in order to determine gain compression. Gain compression values are measured using the HP 4195A's Amplitude Sweep function (▸ 7). Figure 22 shows an example of a gain compression measurement. At a measurement frequency of 145 MHz, the o line marker **DELTA** mode function determines the compression loss at 145 MHz measurement frequency at an input level of 1 dB (compression loss is -7.6 dB).

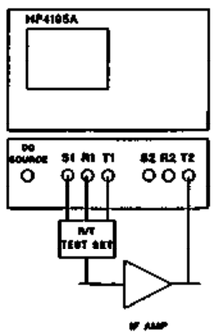


Figure 20. Gain and Phase Measurement Setup

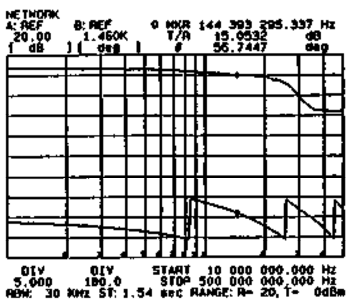


Figure 21. Gain and Phase Characteristics Measurement

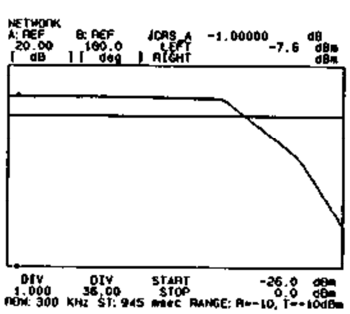


Figure 22. Gain Compression Measurement

3-4-5. Measuring Reflection Characteristics

Reflection Characteristics

Although the input and output in a high frequency circuit are matched with a characteristic impedance, the input and output impedance may drift from the ideal characteristic impedance depending on frequency, this change in characteristic impedance will causes reflections. Parameters which indicate reflection are reflection coefficient (Γ), return loss (R_L), **SWR** and input and output impedance (**Z**), are related as follows:

Return loss: $R_L = -20 \log \rho$

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

Characteristic impedance $$Z_\theta = \frac{1+\Gamma}{1-\Gamma}$$

Z_θ is the characteristic impedance, Γ is the reflection coefficient and ρ is the absolute value of Γ.

Reflection coefficient is:

$$\Gamma = \rho \angle\theta = \frac{Z - Z\theta}{Z + Z\theta}$$

Thus when the input and output are perfectly matched, there is no reflection, **Z** = **Z**θ So,

$\Gamma = 0$ ($\rho = 0$, $\theta = 0°$)

$R_L = -\infty$

SWR = 1

When open, **Z** = , so

$\Gamma = -1$ ($\rho = 1$, $\theta = 180°$)

$R_L = 0$

SWR = ∞

When shorted, **Z = 0**

$\Gamma = 1$ ($\rho = 1$, $\theta = 0°$)

$R_L = 0$

SWR = ∞

The HP 4195A can measure directly reflection coefficient, return loss and **SWR**.

Measuring Reflection Characteristics

The HP 4195A is used with a transmission/ reflection test set to measure return loss, SWR and other reflection characteristics. Figure 23 shows the setup of a measurement circuit for measuring reflection characteristics. Figure 24 shows an example of measuring return loss (A) and SWR (B) up to 500 MHz.

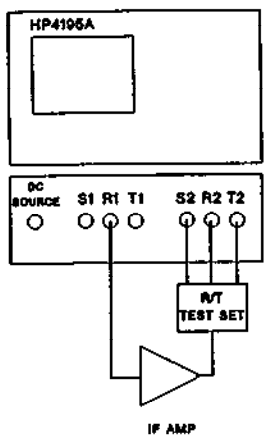
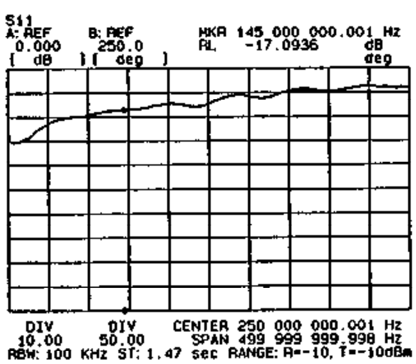
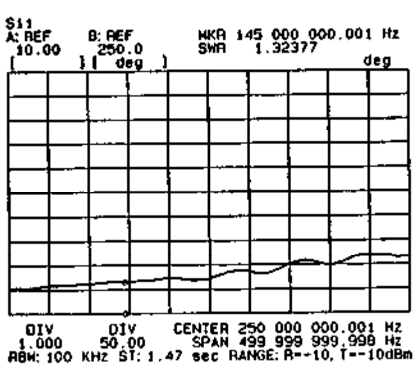


Figure 23. Setup for Measuring Reflection Characteristics



(A) **Return Loss**



(B) **SWR**

Figure 24. Example of Reflection Characteristic Measurement

3-4-6. S-Parameters

S-parameters are used to measure the a high frequency circuit network characteristics. As shown in Figure 25, S-parameters are measured by connecting two transmission/ reflection test sets to the HP 4195A. Figure 26 shows the result of an S_{11} measurement (reflection characteristics) of an IF amplifier. For a more detailed description of S-Parameters, refer to Application Note 357-2.

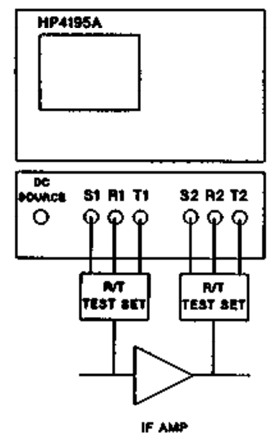


Figure 25. S-parameter Measurement Setup

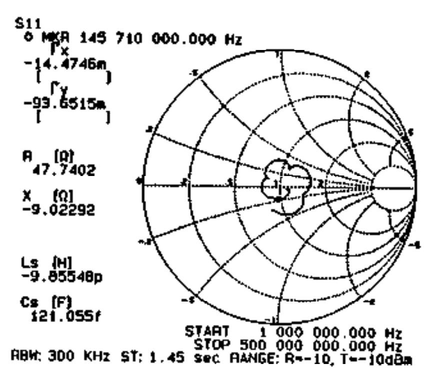


Figure 26. IF Amplifier S-parameter Measurement

3-5. Impedance Measurements

Crystal Oscillator Measurements

As shown in Figure 27, when the HP 4195A is used with the HP 41951A, the impedance of devices can be measured over a range of from 100 kHz to 500 MHz (► 8). Using the HP 4195A's equivalent circuit function, it is easy to derive the value of each component of the Crystal oscillator's equivalent circuit. Figure 28 shows the result of a crystal oscillator impedance measurement and the equivalent circuit analysis results.

4. Conclusion

As described above, the HP 4195A can not only perform network and spectrum measurements, but also impedance measurements. It has four ports, marker functions, user functions and many other powerful functions that it an extremely versatile analog circuit analyzer of IF circuits. Using the HP 4195A to evaluate circuits and components will raise the reliability and efficiency of IF circuit design and evaluation.

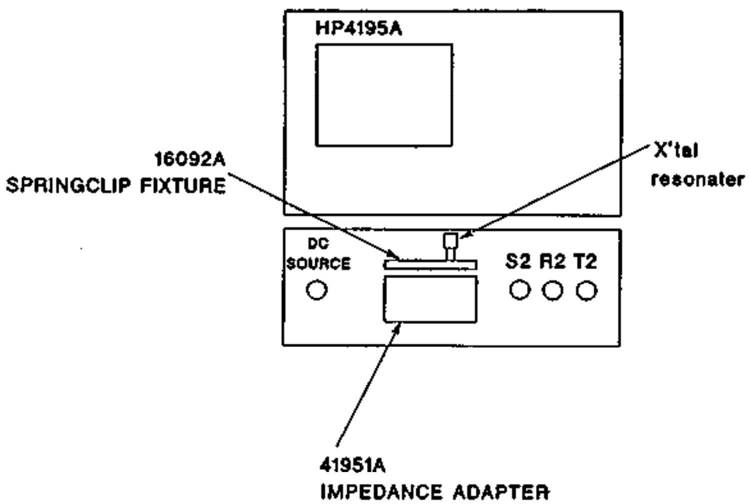
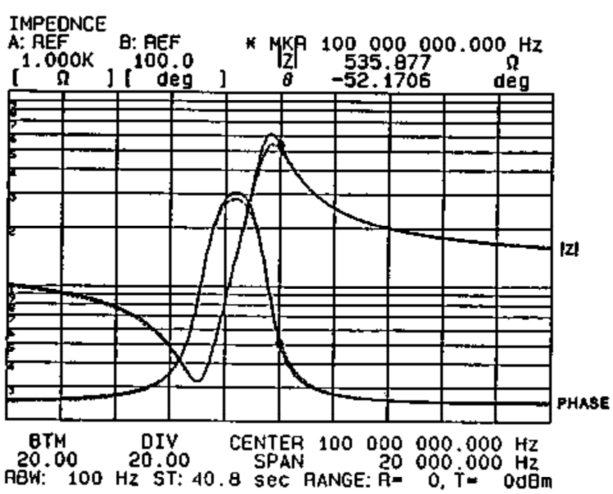
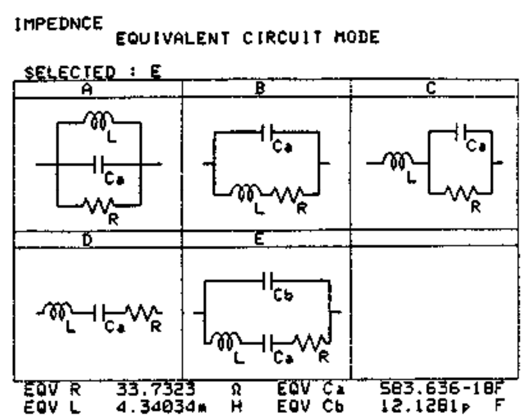


Figure 27. Crystal Oscillator Impedance Measurement Setup



A. Measurement Results



B. Equivalent Circuit Analysis Results

Figure 28. Crystal Oscillator Impedance Measurement and Equivalent Circuit Simulation Results

HP 4195A's One Point Feature

This is a brief description of HP 4195A functions marked with a " ► " in the text. For a more detailed description of these functions, refer to the Operation Manual.

► 1 Superimpose Function

The HP 4195A can superimpose a maximum of four traces on the display simultaneously. This enables the simultaneous display of many measurement points using parameter measurements or simultaneous display of input and output signal spectrum measurements, and network measurement transmission characteristics. The superimpose function allows easy comparisons and observations of measurement results.

► 2 Marker Function Δ Mode

The HP 4195A has three markers: **o**, * and **LINE**. There is also a Δ mode in which the **o** marker value is used as reference to derive the difference between the **o**, *, and **LINE** markers. This function allows the analyzer to directly measure parameters such as intermodulation distortion, harmonic distortion, CN ratio. Filter gain and ripple.

► 3 Parameters for Measuring Reflection Characteristics

The following reflection characteristic parameters can be measured directly.

R_L-θ (Return Loss)

$|\Gamma|$-θ (Reflection Constant)

Γ_X - Γ_Y

SWR - θ (Standing-Wave Ratio)

The Γ_X - Γ_Y measurement results can be plotted and displayed on a Smith chart. Using a Smith chart display, Γ_X - Γ_Y, R-X, and L_S-C_S values can be read with the marker function.

► 4 User Program Function

The program is easily input by using the keys for the measurement sequence. Since BASIC type commands are provided, highly sophisticated automatic measurements are performed without using an external controller. The program can use the following commands:

IF, THEN, FOR, NEXT, GOTO, GOSUB, RETURN, AND, OR, PAUSE, WAIT, BEEP, DISP

► 5 Direct Noise Measurements

The HP 4195A can directly measure the noise level. The following noise level units can be measured.

dBm/Hz, dBμV/Hz, μV/Hz

► 6 Arithmetic Function

The HP 4195A is equipped with a built-in function to calculate measurement data. This function is capable of performing not only the arithmetical operations, but other fundamental functions as well. The following are some of the 4195A's functions:

Trigonometric functions:

SIN, COS, TAN, ATAN

Logarithmic and exponential functions:

LOG, LN, EXP

Other functions:

ABS, DIF, MAX, MIN, COMPLEX, LMX, LMN, BIN, AND, OR, NOT

► 7 Amplitude Sweep

The Amplitude Sweep function is used for sweeping output levels. The parameters which can be swept are V, dBm and dBμV, and there are two types of sweep: **Linear** sweep and **Log** sweep. This function permits measurements of nonlinear characteristics of components such as gain compression.

► 8 Impedance Measurement Function

The HP 4195A can measure the following complex impedance parameters.

$|Z|$-θ, R-X, L_S-R_S, L_S-Q, C_S-R_S, C_S-D

$|Y|$-θ, G-B, L_P-R_P, L_P-Q, C_P-R_P, C_P-D

The HP 41951 impedance test set is required for conducting impedance tests.

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